

CAN  
1824

# The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada



Volume 126, Number 1

January–March 2012

# The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

## Patron

His Excellency the Right Honourable David Johnston, C.C., C.M.M., C.O.M., C.M.  
Governor General of Canada

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

## Honorary Members

Ronald E. Bedford	Michael D. Cadman	John M. Gillett	Joyce Reddoch
Edward L. Bousfield	Paul M. Catling	Christine Hanrahan	Allan Reddoch
Charles D. Bird	Francis R. Cook	C. Stuart Houston	Jeff Saarella
Donald M. Britton	Bruce Di Labio	Theodore Mosquin	Dan Strickland
Fenja Brodo	R. Yorke Edwards	Robert W. Nero	John B. Theberge
Irwin M. Brodo	Anthony J. Erskine	E. Franklin Pope	Sheila Thomson
Daniel F. Brunton			

## 2012 Council

<b>President:</b> Ann MacKenzie	Daniel F. Brunton	Diane Kitching	Henry Steger
<b>1<sup>st</sup> Vice-President:</b> Fenja Brodo	Carolyn Callaghan	Diane Lepage	Chris Traynor
<b>2<sup>nd</sup> Vice-President:</b> Jeff Skevington	Barbara Chouinard	Karen McLachlan-Hamilton	Eleanor Zurbrigg
<b>Recording Secretary:</b> Annie Bélair	Julia Cipriani	Rémy Poulin	Yi Zhang
<b>Treasurer:</b> Ken Young	David Hobden	Jeff Saarella	

To communicate with the Club, address postal correspondence to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2, or e-mail: ofnc@ofnc.ca. For information on Club activities, go to [www.ofnc.ca](http://www.ofnc.ca)

## The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

**Website:** [www.canadianfieldnaturalist.ca/index.php/cfn](http://www.canadianfieldnaturalist.ca/index.php/cfn)

**Editor-in-Chief:** Dr. Carolyn Callaghan

**Assistant Editor:** Trina Rytwinski

**Copy Editor:** Elizabeth Morton

**Typographer:** Wendy Cotie

**Treasurer:** Ken Young, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2

**Journal Manager:** Jay Fitzsimmons: [subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca) or via postal address above.

**Book Review Editor:** Roy John

<b>Associate Editors:</b>	Robert R. Anderson	Paul M. Catling	Thomas Jung	Claude Renaud
	Warren B. Ballard	Francis Cook	Donald F. McAlpine	Jeffery M. Saarella
	Charles D. Bird	Anthony J. Erskine	David Nagorsen	David C. Seburn

**Chair, Publications Committee:** Daniel F. Brunton

All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by e-mail: [editor@canadianfieldnaturalist.ca](mailto:editor@canadianfieldnaturalist.ca) or postal mail (with disk): 611 Chemin Cregheur, Luskville, QC J0X 2G0; (819) 455-1087; Book-review correspondence should be sent to the Book Review Editor by e-mail: [r.john@rogers.ca](mailto:r.john@rogers.ca) or postal mail: 2193 Emard Crescent, Ottawa, Ontario K1J 6K5.

### Subscriptions and Membership:

Subscription rates for individuals are \$40 (online only), \$50 (print only), or \$60 (print + online) for volume 126. Libraries and other institutions may subscribe for \$60 (online only or print only) or \$90 (print + online) for volume 126. All foreign print subscribers and members (including USA) must add \$10 to cover postage. The Ottawa Field-Naturalists' Club annual membership fee of \$40 (individual), \$45 (family), or \$20 (student) includes an online subscription to *The Canadian Field-Naturalist*. Members can receive printed issues of CFN for an additional \$30 per volume (four issues). For further details, including discounts for members of the Canadian Museum of Nature, see <http://ofnc.ca/member.php>. The club's regional journal, *Trail & Landscape*, covers the Ottawa District and regional Club events and field trips. It is mailed to Ottawa area members, and is available to those outside Ottawa on request. It is available to libraries at \$33 per year. Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be sent to [subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca) or mailed to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O., Ottawa, ON, Canada, K1Z 1A2. Canada Post Publications Mail Agreement number 40012317. Return postage guaranteed.

COVER: Reproductive female Vancouver Island Marmot (*Marmota vancouverensis*), aged two, eats *Veratrum viride* on Green Mountain, Vancouver Island, British Columbia, on 16 June 2002. Conspicuous bite marks on leaf tips (foreground) were made by this individual moments previous. Photo: J. Werner (300 mm telephoto, 1/500 sec, f/4). See article by Jeffery R. Werner, pages 55–58.

## The Canadian Field-Naturalist

Volume 126, Number 1

January–March 2012

Occurrence of the Maritime Shrew (*Sorex maritimensis*) in Black Spruce (*Picea mariana*) Forest Stands in Southeastern New BrunswickJULIE HENDERSON<sup>1</sup> and GRAHAM FORBES<sup>2</sup><sup>1</sup>Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton, New Brunswick E3C 5H3 Canada<sup>2</sup>Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton, New Brunswick E3C 5H3 Canada; email: forbes@unb.caHenderson, Julie, and Graham Forbes. 2012. Occurrence of the Maritime Shrew (*Sorex maritimensis*) in Black Spruce (*Picea mariana*) forest stands in southeastern New Brunswick. *Canadian Field-Naturalist* 126(1): 1–5.Twenty-one specimens of *Sorex maritimensis* (Maritime Shrew) were collected in coniferous forest of central New Brunswick, a habitat considered atypical for the species. We suggest *S. maritimensis* uses a wider range of habitat types than previously documented.Key Words: *Sorex maritimensis*, Maritime Shrew, *Picea mariana*, Black Spruce, forest wildlife, New Brunswick.

The disjunct eastern population of the Arctic Shrew (*Sorex arcticus*) has recently been recognized as a separate species, the Maritime Shrew (*S. maritimensis*) (Wilson and Reeder 2005), based on genetic analysis by Stewart et al. (2002). Before the taxonomic division, most information on either species was based on studies conducted in the western population (*S. arcticus*), and few publications exist on habitat use by the eastern population, now *S. maritimensis*.

*Sorex arcticus* occurs in meadow environments and wet Tamarack (*Larix laricina*)–Black Spruce (*Picea mariana*) forest (Clough 1963; Buckner 1966; Wrigley et al. 1979), whereas *S. maritimensis* has been characterized as an associate of grass–sedge marshes, low-lying floodplain, wet meadows, and marsh margins (Herman and Scott 1994; Perry et al. 2004; Scott and Hebda 2004; McAlpine et al. *in press*).

The type specimen of *Sorex maritimensis* was captured in marsh (Smith 1939), and the sampling by Perry et al. (2004) focused on alder (*Alnus* sp.) in wet areas. A recent study (Dawe and Herman 2005\*) working in open wetland habitat concluded that *S. maritimensis* is associated with open wetlands with abundant graminoids, particularly *Calamagrostis canadensis* (Bluejoint Reedgrass), and low tree cover.

Maritime Shrew specimens were collected during a study of the effects of pre-commercial forest thinning on small mammals in southern New Brunswick.

### Study Area

Our work was conducted in Black Spruce forests of southeastern New Brunswick, a habitat considered atypical for *S. maritimensis*.

Maritime Shrews were collected from nine naturally regenerating clear-cuts, ranging in age from 16 to 29 years since harvest. The sites were open coniferous forest on moist substrates with minimal grass. The sites would not be categorized as wet forest or wetlands (Warner and Rubec 1997), and there were no grassy meadows for a distance of at least several kilometres that would be typical of sites where Dawe and Herman (2005\*) reported capturing *S. maritimensis*.

Dominant tree species were Black Spruce, Balsam Fir (*Abies balsamea*), and Eastern White Pine (*Pinus strobus*), with smaller amounts of Red Maple (*Acer rubrum*), birches (*Betula* spp.), and alders (*Alnus* spp.). Four of nine capture sites had been pre-commercially thinned 5 to 10 years prior to the survey.

Our study sites are characterized by moist, semi-productive soils on moderate–poorly drained sites and would be classified as Eco-site 2 in the New Brunswick Ecological Land Classification (Zelazny 2007).

### Methods

We surveyed relative abundance of small mammals in 45 sites with 16 Sherman (H. B. Sherman Inc., Tallahassee, Florida) live traps (dimensions 7.6 × 8.9 × 22.9 cm) and 16 pitfall traps (8.9 cm diameter, 10.8 cm depth) per site, spaced at 20-m intervals along a single 300-m transect. Trapping was conducted between June and September 2005 and between May and early October 2006. Traps were set for seven consecutive nights in each site. Shrews were removed from the sites unless captured alive (<5% captured alive).

*Sorex maritimensis* specimens were identified by examining external morphology and dentition (van Zyll

de Jong 1983), in particular evenly graded unicuspid with the third larger than the fourth; distinctive tri-coloured pelage with the back very dark brown, sides lighter brown, and underparts greyish brown; bi-coloured tail with dark tip hairs; and relatively large feet compared to other congenics (i.e., *Sorex cinereus* (Cinereus Shrew), *S. hoyi* (American Pygmy Shrew), and *S. fumeus* (Smoky Shrew)). Cranial measurements were taken from five specimens. Sampling methods were approved by the University of New Brunswick Animal Care Committee (Permit # 06019). We compared stand age and 14 stand structure variables measured in sites where Maritime Shrews were captured and sites where Maritime Shrews were not captured using two sample *t*-tests to compare means. Statistical tests were performed using the program R - 2.4.1 (R Development Core Team 2006\*). We measured stand structures and understory herbaceous ground vegetation (<1m tall) within the trapping area in each site using a range of sample plots. Percent cover of herbaceous ground vegetation (totalveg), fine woody debris (FWD) (1-10 cm diameter), moss (moss), seedlings and low branches (lowbranch), and leaf litter (hwleaves) were estimated within 50, 1 m<sup>2</sup> quadrats spaced randomly along four transects running parallel to the 300 m trapping transect. Deciduous and coniferous canopy closure (hwcan, swcan) (%) was measured using a spherical densiometer on all four sides of the quadrat and averages were calculated from the 4 measurements. Characteristics of the overstory tree layer were measured in six, 5.64-m fixed radius (100 m<sup>2</sup>) plots per site, spaced 60 m apart on alternating sides of the 300 m trapping transect. Plot centers were established  $\geq 10$  m from the trapping transect to avoid disturbing traps when habitat variables were measured during the trapping period. In each fixed radius plot I counted the number of deciduous and coniferous trees (hwstem, swstem) (>1.3 m height, alive), measured the diameter at breast height (hwdbh, swdbh) (dbh), and identified to species and measured the diameter and height of all stumps and snags. The height of one representative tree (height) was measured using a Suunto clinometer at each plot. Volume of CWD (logs  $\geq 10$  cm dbh diameter) was sampled using the perpendicular distance sampling (PDS) method (Williams and Grove 2003). Downed logs are sampled with probability proportional to their volume; thus, the greater the log's volume, the more likely it was to be sampled. Estimated stand volume of downed wood was determined by multiplying the volume factor (VF) by the number of logs sampled at each plot. A log was sampled if a right angle (90 degrees) can be made with the log and the sample point and the distance from the log to the sample point is within the limiting distance. The limiting distance (LD) is determined by the volume factor (20m<sup>3</sup>/ha) and the diameter of the log at the perpendicular point. Volumes of stumps and snags were calculated using the diameters and heights measurements ( $V = \pi r^2 h$ ) and

the total volume of CWD for each site was calculated as volume of CWD logs + volume of stumps and snags (CWDvol).

## Results

Fifteen of the 21 Maritime Shrews were captured in pitfall traps and 6 were captured in Sherman live traps. External measurements (Table 1) corresponded to *S. arcticus*/*S. maritimensis*: average total length 106 mm (SD 7.5), average tail length 40 mm (SD 3.2), average hind foot 13 mm (SD 1.0), and an average mass of 6.4 g (SD 1.3). Average skull length was 19.0 mm (SD 0.4), average skull width was 9.5 mm (SD 0.1), and the postmandibular canal was present (van Zyll de Jong 1983). Sex was not recorded but two specimens (433 and 638) were lactating. Other species collected at sites where *Sorex maritimensis* were captured included *S. fumeus* (present in four of nine capture sites), *S. hoyi* (present in eight of nine capture sites), *S. cinereus* (present in all capture sites), *Blarina brevicauda* (Northern Short-tailed Shrew) (present in one capture site), *Myodes gapperi* (Southern Red-backed Vole) (present in eight of nine capture sites), and *Peromyscus maniculatus* (Deer Mouse) (present in five of nine capture sites).

Density of softwood trees >10 cm dbh ( $P = 0.002$ ), total basal area ( $P = 0.002$ ), and softwood canopy cover ( $P = 0.04$ ) were significantly lower in sites where Maritime Shrews were captured than in sites where Maritime Shrews were not captured (Table 2). The amount of total vegetation cover <1 m in height ( $P = 0.001$ ) and low branches ( $P = 0.06$ ) were higher in sites where Maritime Shrews were captured than in sites where Maritime Shrews were not captured (Table 2).

## Discussion

Our results indicate that *Sorex maritimensis* is also associated with young coniferous forest containing low tree density and low overhead canopy cover combined with greater amounts of near-ground cover provided by herbaceous vegetation, shrubs, and low branches. The capture of *S. fumeus* in half of the sites containing *S. maritimensis* weakens the hypothesis that *S. maritimensis* is competitively excluded from habitats occupied by this closely related shrew (Perry et al. 2004).

Moisture has been proposed as the primary factor affecting local abundance of shrews (Getz 1961; Miller and Getz 1977; Wrigley et al. 1979). Shrubs and understory vegetation can trap moisture, thus increasing local humidity (Harmon et al. 1986; Yahner 1986; Tallmon and Mills 1994). In the young, regenerating Black Spruce forests in our study sites, the combination of moist soils and abundant understory cover seems to provide suitable habitat for *S. maritimensis*.

It has been suggested that the viability of *S. maritimensis* populations could be an issue because the fragmented condition of open wetlands within its range could limit dispersal and the quantity of available

TABLE 1. Details on location, trap type and body measurements of Maritime Shrew captured in central New Brunswick, 2005-2006.

Shrew no.	Site no.	Capture date	Stand age (years)	Silviculture treatment	Trap type	weight (n = 21)	total length (n = 18)	tail length (n = 18)	hind foot length (n = 18)	skull length (n = 5)	skull width (n = 5)	Location
124	35	18 July 2006	16	control	pitfall	5.7	104	40	13	—	—	45°98.048'N, 66°32.499'W
21	36	18 July 2006	18	control	pitfall	6.4	115	45	12	19.20	9.45	46°00.146'N, 66°32.927'W
129	36	19 July 2006	18	control	pitfall	6.1	103	38	13	18.95	9.50	46°00.146'N, 66°32.927'W
147	36	24 July 2006	18	control	pitfall	6.6	107	41	13	19.55	9.60	46°00.146'N, 66°32.927'W
153	25	4 June 2006	18	PCT	pitfall	6.7	90	30	11.5	—	—	46°11.045'N, 65°15.327'W
710	48	25 August 2006	18	PCT	pitfall	6.7	109	41	14	—	—	46°04.582'N, 66°25.179'W
714	48	26 August 2006	18	PCT	pitfall	6.4	106	38	14	—	—	46°04.582'N, 66°25.179'W
720	48	27 August 2006	18	PCT	Sherman	5.8	104	41	13	—	—	46°04.582'N, 66°25.179'W
721	48	27 August 2006	18	PCT	Sherman	5.8	106	42	15	—	—	46°04.582'N, 66°25.179'W
727	48	28 August 2006	18	PCT	pitfall	6.3	109	42	14	—	—	46°04.582'N, 66°25.179'W
730	48	28 August 2006	18	PCT	pitfall	6.7	105	41	15	—	—	46°04.582'N, 66°25.179'W
734	48	28 August 2006	18	PCT	pitfall	6.5	104	43	14	—	—	46°04.582'N, 66°25.179'W
570	44	16 August 2006	20	control	pitfall	6.5	101	36	14	18.75	9.30	46°01.530'N, 66°29.299'W
638	47	23 August 2006	22	control	pitfall	6.5	107	39	14	—	—	46°02.393'N, 66°13.390'W
639	47	23 August 2006	22	control	pitfall	5.8	107	40	13	—	—	46°02.393'N, 66°13.390'W
657	47	27 August 2006	22	control	Sherman	6.0	—	—	—	—	—	46°02.393'N, 66°13.390'W
661	47	27 August 2006	22	control	Sherman	6.1	—	—	—	—	—	46°02.393'N, 66°13.390'W
882	14	1 August 2005	22	PCT	pitfall	2.9	—	—	—	—	—	46°09.382'N, 65°27.105'W
434	28	20 June 2006	24	PCT	pitfall	6.0	112	42	14	—	—	46°18.473'N, 65°61.916'W
433	28	20 June 2006	24	PCT	Sherman	9.6	117	40	14	18.60	9.40	46°18.473'N, 65°61.916'W
784	51	23 September 2006	29	control	Sherman	3.5	86	38	12	—	—	46°15.250'N, 65°50.337'W
					Average	6.4	106	40	13	19.0	9.5	
					SD	1.3	7.5	3.2	1.0	0.4	0.1	

TABLE 2. Comparison of mean (+/- S.E.) stand structure variables of Maritime Shrew capture and non-capture sites in New Brunswick, 2005-2006. Values in bold are significant at  $p = 0.05$ .

Variable	Sites		<i>t</i>	<i>P</i> value
	where Maritime Shrews were captured	where Maritime Shrews were not captured		
Stand age (years)	21 ± 2	28 ± 1	3.67	<b>0.0033</b>
Number of small softwood trees <10 cm/ha	3909 ± 1331	3123 ± 443	0.81	0.4328
Number of small hardwood trees <10 cm dbh/ha	2385 ± 417	2461 ± 286	0.15	0.8800
Number of softwood trees >10 cm dbh/ha	533 ± 153	1188 ± 87	3.72	<b>0.0024</b>
Number of hardwood trees >10 cm dbh/ha	120 ± 90	174 ± 30	1.09	0.2997
Total basal area (m <sup>3</sup> /ha)	10.4 ± 2.5	19.7 ± 1.4	3.72	<b>0.0018</b>
Hardwood canopy cover (%)	8.1 ± 1.2	11.5 ± 1.4	1.09	0.2911
Softwood canopy cover (%)	44 ± 8.5	61.5 ± 2.4	2.36	<b>0.0414</b>
Fine woody debris (1–10 cm) (%)	4.4 ± 0.7	4.4 ± 0.4	0.14	0.8926
Total Vegetation Cover (<1 m)	54.4 ± 10.0	28.7 ± 3.4	4.01	<b>0.0001</b>
Moss cover (%)	36.7 ± 4.2	30.3 ± 3.2	0.84	0.4126
Leaf litter cover (%)	40.2 ± 6.7	41.6 ± 3.2	0.01	0.9923
Herbaceous ground vegetation (%)	54.4 ± 10.0	28.7 ± 3.4	4.01	<b>0.0014</b>
Low branch cover (%)	15.9 ± 7.7	8.6 ± 1.2	2.17	0.0559
Volume of coarse woody debris (m <sup>3</sup> /ha)	15.1 ± 7.2	19.1 ± 2.4	0.35	0.7304
Number of stumps/ha	490.7 ± 60.1	594.4 ± 51.5	1.37	0.1828

habitat (Dawe 2005; Dawe and Herman 2005\*). We found *S. maritimensis* in forested areas, but those forests contained comparatively less tree cover than control sites. Small patches of moist ground may therefore be important.

The inclusion of moist Black Spruce forest (an abundant vegetation type in the region) in the habitat of *S. maritimensis*, based on our results, suggests that the amount of available habitat for the species could be considerable. Quantification of this moist forest is difficult, however, because wet areas or small grassy openings in forest stands are generally too small to be delineated in forest inventories. Wet area mapping, a new technology that uses digital elevation models (DEMs) and hydrographic data to identify wet areas and depth to surface water across forested landscapes beyond waterways and wetlands (Murphy et al. 2008), may be helpful in detecting the potential distribution of *Sorex maritimensis*.

It is unlikely that our results indicate a shift in habitat use to forested areas but rather reflect the fact that most previous research on these shrews has been done in wet meadows. Significant trapping effort is required to document rare species, and we suspect that wet forest sites have not been adequately sampled in the past. McAlpine et al. (*in press*) summarized a range of habitat use besides wetlands, including drier agricultural fields (Smith 1940), but the habitat use was still generally near grassy areas. Our results suggest that *S. maritimensis* is not restricted to open wetland or grass-dominated types and that this species' use of habitat in moist coniferous forest is similar to that recorded for *S. arcticus*.

#### Documents Cited (marked \* in text)

**Dawe, K., and T. Herman.** 2005. Conserving our only endemic mammal: habitat associations and genetic diversity of the maritime shrew, *Sorex maritimensis*. Unpublished report submitted to the Nova Scotia Department of Natural Resources.

**R Development Core Team.** 2006. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0. <http://www.R-project.org>.

#### Literature Cited

**Buckner, C. H.** 1966. Populations and ecological relationships of shrews in tamarack bogs of southeastern Manitoba. *Journal of Mammalogy* 47: 181-193.

**Clough, G. C.** 1963. Biology of the Arctic shrew, *Sorex arcticus*. *American Midland Naturalist* 69: 69-81.

**Dawe, K. L.** 2005. Habitat associations and genetic diversity of the maritime shrew, *Sorex maritimensis*. M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.

**Getz, L. J.** 1961. Factors influencing the local distribution of shrews. *American Midland Naturalist* 65: 67-88.

**Harmon, M. E., J. F. Franklin, F. J. Swanson, P. Sollins, S. V. Gregory, J. D. Lattin, N. H. Anderson, S. P. Cline, N. G. Aumen, J. R. Sedell, G. W. Lienkaemper, K. Cromack Jr., and K. W. Cummins.** 1986. Ecology of coarse woody debris in temperate ecosystems. *Advances in Ecological Research* 15: 133-302.

**Herman, T. B., and F. W. Scott.** 1994. Protected area and global climate change: assessing the regional or local vulnerability of vertebrate species. Pages 13-27 in *Impacts of Climate Change on Ecosystems and Species: Implications for Protected Areas*. Edited by J. C. Pernetta, R. Leemans, D. Elder, and S. Humphrey. International Union for the Conservation of Nature.

**McAlpine, D. F., H. Huynh, and K. Vanderwolf.** *In press*. Biogeographic and conservation significance of the occur-

- rence of the Canadian endemic Maritime Shrew (*Sorex maritimensis*) in northern New Brunswick. *Northeastern Naturalist*.
- Miller, D., and L. Getz.** 1977. Factors influencing the local distribution and species diversity of forest floor small mammals in New England. *Canadian Journal of Zoology* 55: 806-814.
- Murphy, P. N. C., J. Ogilvie, M. Castonguay, C. Zhang, F. Meng, and P. A. Arp.** 2008. Improving forest operations planning through high-resolution flow channel and wet-areas mapping. *Forestry Chronicle* 84: 568-574.
- Perry, N. D., D. T. Stewart, E. M. Madden, and T. J. Maier.** 2004. New records for the Arctic shrew, *Sorex arcticus*, and the newly recognized maritime shrew, *Sorex maritimensis*. *Canadian Field-Naturalist* 118: 400-404.
- Scott, F., and A. Hebda.** 2004. Annotated list of the mammals of Nova Scotia. *Proceedings of the Nova Scotia Institute of Science* 42: 189-208.
- Smith, R. W.** 1939. A new race of *Sorex arcticus* from Nova Scotia. *Journal of Mammalogy* 20: 244-245.
- Smith, R. W.** 1940. The land mammals of Nova Scotia. *American Midland Naturalist* 24(1): 213-241.
- Stewart D. T., N. D. Perry, and L. Fumagalli.** 2002. The maritime shrew, *Sorex maritimensis* (Insectivora: Soricidae): a newly recognized Canadian endemic. *Canadian Journal of Zoology* 80: 94-99.
- Tallmon, D., and L. S. Mills.** 1994. Use of logs within home ranges of California red-backed voles on a remnant of forest. *Journal of Mammalogy* 75: 97-101.
- van Zyll de Jong, C. G.** 1983. *Handbook of Canadian Mammals*. Vol. 1. Marsupials and Insectivores. National Museums of Canada, Ottawa.
- Warner, B., and C. Rubec. (Editors).** 1997. *The Canadian Wetlands Classification System*. Second edition. Wetlands Research Centre, Waterloo, Ontario. 75 pages.
- Williams, M., and J. Grove.** 2003. Perpendicular distance sampling: an alternative method for sampling downed coarse woody debris. *Canadian Journal of Forest Research* 33: 1564-1579.
- Wilson, D., and D. Reeder.** 2005. *Mammal Species of the World: A Taxonomic and Geographic Reference*. Vol. 1. Johns Hopkins University Press, Baltimore, Maryland. 743 pages.
- Wrigley, R. E., J. E. Dubois, and H. W. R. Copland.** 1979. Habitat, abundance, and distribution of six species of shrews in Manitoba. *Journal of Mammalogy* 60: 505-520.
- Yahner, R. H.** 1986. Microhabitat use by small mammals in even-aged forest stands. *American Midland Naturalist* 115: 174-180.
- Zelazny, V. F.** 2007. Our landscape heritage; the story of ecological land classification in New Brunswick. New Brunswick Department of Natural Resources, Fredericton, New Brunswick.

Received 21 October 2011

Accepted 9 December 2011

# Body Condition and Survival of Vagrant Long-billed Murrelets, *Brachyramphus perdix*, in North America

SPENCER G. SEALY<sup>1</sup> and HARRY R. CARTER<sup>2</sup>

<sup>1</sup>Department of Biological Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2 Canada

<sup>2</sup>Carter Biological Consulting, 1015 Hampshire Road, Victoria, British Columbia V8S 4S8 Canada

Sealy, Spencer G., and Harry R. Carter. 2012. Body condition and survival of vagrant Long-billed Murrelets, *Brachyramphus perdix*, in North America. *Canadian Field-Naturalist* 126(1): 6–14.

From 1979 through 2009, 81 records of long-distance vagrancy in the Long-billed Murrelet (*Brachyramphus perdix*) in North America south of Alaska were examined to assess body condition and survival after first observation. Sixty-one records were of live birds, of which 38 (62.3%) were discovered at sea along the west coast of North America, 18 (29.5%) were encountered inland, and 5 (8.2%) were encountered along the Atlantic coast. Fifteen of the 20 individuals salvaged (19 adults, 1 juvenile) were discovered on lake shores (75.0%) and the other 5 (25.0%) on marine coasts; 85.0% were dead when initially found (15 dead, 2 shot), and 3 (15.0%) were moribund (2 died within one day, 1 later released). Of 10 sexed individuals, 5 were adult males, 4 were adult females, and 1 was a juvenile female. Eight of 10 murrelets observed foraging were diving on lakes, but 2 others surfaced with fish; two species of common freshwater fish were removed from stomachs of 2 birds shot by hunters. Most birds (72.1%,  $n = 61$ ) disappeared after one observation, which suggests survival and moving on; one bird stayed at the same location for at least 25 days before disappearing. Dead or dying Long-billed Murrelets found on shorelines of fresh water may have been too emaciated to regain lost mass after arrival—they weighed less than those shot, presumably because they were not able to locate prey or too weak to capture it. Survival for weeks or longer on freshwater stopover sites better explains how Long-billed Murrelets move across North America, with some reaching the Atlantic Ocean. Long-surviving vagrants may establish a new breeding population of Long-billed Murrelet on the west coast of North America.

Key Words: *Brachyramphus perdix*, Long-billed Murrelet, body condition, freshwater habitat, foraging, length of stay, marine habitat, prey, stopover sites, survival, vagrancy.

What are the fates of vagrant birds? Almost a century ago, Grinnell (1922) pondered this question, wondering whether all vagrants (or “accidentals”, as they were usually called then) perished or some individuals founded new populations. Data on survival of vagrants and return to populations of origin have been gathered, mainly through banding of land birds, at widespread localities in Europe (Newton 2008) and at Southeast Farallon Island, about 43 km west of San Francisco, California (DeSante 1973; DeSante and Ainley 1980). Some authors have considered the implications of vagrants in the dynamics of bird populations (e.g., DeSante 1983; Patten and Marantz 1996; Fraser 1997; Veit 1997; Newton 2008), but short-term survival of obligate marine birds inland with possible eventual return of individuals to the sea, and possibly home, has not been considered.

More than 80 records of long-distance vagrancy in the Long-billed Murrelet (*Brachyramphus perdix*), which breeds in eastern Russia, have been reported since the first specimen was taken in North America, in 1979 (Sealy et al. 1982, 1991; Mlodinow 1997; Svingen 2009). At that time, and through the mid-1990s, this form was recognized as a subspecies of the Marbled Murrelet (*B. marmoratus*), that is, *Brachyramphus marmoratus perdix*, until Friesen et al. (1996), using molecular techniques, confirmed it to be a species, as originally described by Pallas in 1811 (Stejneger 1886). Vagrancy has not been reported in the Marbled Mur-

relet beyond its normal range in western North America, before or since 1979, despite careful scrutiny of all out-of-range murrelets encountered by birders and other field workers (see Svingen 2009). The recentness of the vagrancy of the Long-billed Murrelet appears to reflect in part enhanced prevailing westerly winds across the North Pacific Ocean during warm phases of the Pacific Decadal Oscillation (Sealy et al. 1991; Mlodinow 1997; Carter et al. 2011).

Long-billed Murrelets breed in eastern Russia in the northern Sea of Okhotsk and Karaginsky Gulf in the southwestern Bering Sea (~60–63° N; Kamchatka Krai [territory] south to Vladivostok (~43° N; Primorsky Krai) (Gaston and Jones 1998; Kondratyev et al. 2000), but individuals have been reported in coastal waters in winter as far south as southern Japan (~30° N) (Nelson et al. 2002). The size of the global breeding population is not accurately known but is likely less than 10 000 breeding pairs (Kondratyev et al. 2000).

An intriguing aspect of vagrancy by the Long-billed Murrelet is that some individuals are emaciated and apparently die soon after arriving in North America, whereas others are in better condition and, if feeding opportunities are located, they replenish their reserves and move on, possibly eastward as far as the Atlantic Ocean, or back to the Pacific Ocean. Long-billed Murrelets are known to feed on fresh water year round (Konyukhov and Kitaysky 1995; Oka and Hamosoto 2001); therefore, the key to their survival inland is find-



ing a body of water with suitable prey on which to feed while also avoiding predators.

To gain a better understanding of survival for extended periods by vagrant Long-billed Murrelets, inland or at sea, we compiled (1) observations of foraging, prey capture, and prey taken by vagrants; (2) information on body condition of birds found dead or living when first encountered; and (3) data on length of stay and, hence, survival of birds that were alive when initially encountered. We assessed the potential for survival and successive movements of vagrants that might explain occurrence of some individuals along the east coast of North America. We also consider the possibility of long-term survival and establishment of a new breeding population on the west coast of North America.

## Methods

### *Records of vagrants*

In North America, observers now distinguish between the Long-billed Murrelet and the resident Marbled Murrelet of the west coast on the basis of differences in plumage (some differences are subtle, particularly in the fall and early winter) and the larger size of the Long-billed Murrelet (e.g., Sibley 1993; Erickson et al. 1995; Mlodinow 1997; Lethaby 2000; Maumary and Knaus 2000; Thompson et al. 2003; Svingen 2009). In one case, the identity of a Long-billed Murrelet, salvaged in New Mexico, was confirmed by molecular analysis (Witt et al. 2010). For this paper, we examined reports of Long-billed Murrelets in North America through 2009 (Svingen 2009) from the west and east coasts and the interior of North America.

We compiled information on use of marine and freshwater habitats by vagrant Long-billed Murrelets from (1) published accounts of occurrences in North America (see summaries and literature cited in Sealy et al. 1982, 1991; Mlodinow 1997; Svingen 2009); (2) persons who originally observed and/or salvaged specimens; and (3) managers of collections with specimens of Long-billed Murrelet. Data from records with insufficient documentation and records from the Bering Sea, the Aleutian Islands, and Europe were not included in our compilation (Mlodinow 1997; Maumary and Knaus 2000; Hopkins et al. 2006; Svingen 2009). Museums from which information referred to in this paper was obtained are listed in the acknowledgements and in Tables 2 and 3. Minimum straight-line distances of travel were determined using Google Maps.

### *Body condition and length of stay*

Data on sex, age, mass, and body condition were derived from information in published reports of occurrences and from labels on specimens and information in museum catalogues. Ages were reported as (1) "adults" (after-hatching-year (AHY) birds), or (2) "juveniles" (hatching-year (HY) birds). We hypothesized that individuals found dead were exhausted after a long flight and were too emaciated to exploit prey, even if

available, and therefore would weigh less. By contrast, birds that were shot apparently were healthy enough to feed after finding water and had thus regained lost mass; these birds were expected to weigh more. Body mass (nearest 0.1 g in most cases) was usually measured after birds had been frozen, in some cases for weeks or more. We compared body mass of Long-billed Murrelet vagrants to Long-billed Murrelets weighed in Russia (Konyukhov and Kitaysky 1995).

The date of arrival of a Long-billed Murrelet at a particular location was usually uncertain, as it is for many vagrants (e.g., Armistead and Iliiff 2003). Because we did not know how long individuals had been present at their original sites before disappearing, the length of stay was recorded as a minimum number of days. For example, we considered a Long-billed Murrelet first observed on day one but gone the next or, in some cases, if no further observations were made, to have spent a minimum of two days at that location (the bird likely was present for at least 12–24 hours before the first observation and for at least another 12–24 hours before departing, without being observed the next day, and so on). Vagrants probably did not spend fewer than 24 hours at one location, unless they were disturbed or they died.

### *Foraging on fresh water and prey consumed*

Using the literature and museum specimens, we summarized details of observations of vagrant Long-billed Murrelets foraging on fresh water and at sea and, when available, included information on prey removed from digestive tracts (hereafter "stomachs"). We accepted authors' descriptions of the following behaviour as evidence of foraging and/or feeding: (1) diving, often repeatedly, which some authors interpreted as feeding (some also construed from this activity that the bird was in good condition), and (2) birds surfacing with and swallowing a fish. Prey items removed from stomachs of birds found dead or shot by hunters provided further evidence of feeding.

## Results

### *Records of vagrants*

Excluding two early coastal records from Alaska, in 1845 and 1897 (Mlodinow 1997; also see Svingen 2009), the Long-billed Murrelet was not reported in North America until 1979, when an adult was shot by a hunter in southern Quebec (Sealy et al. 1982, 1991). Eighty-one records in North America (south of Alaska) were available from 1979 through 2009 (20 specimens and 61 sightings; Table 1).

Thirty-eight live individuals (62.3%) were discovered at sea along the west coast of North America, from Washington (~48° N) to California (~38° N); 18 (29.5%) were encountered inland and 5 (8.2%) were found along the Atlantic coast from Newfoundland and Labrador (~48° N) to Florida (~27° N). One of the 5 specimens salvaged at sea was from California, and the other 4 were from Florida (Tables 1 and 2). Fifteen

TABLE 1. Habitat type of 81 vagrant Long-billed Murrelets salvaged or observed in North America south of Alaska.

Habitat type	Records		
	Observation made	Specimen collected	Total
Ocean	43 <sup>a</sup>	5 <sup>b</sup>	48
Freshwater lake	13	10 <sup>c</sup>	23
Reservoir/dam	1	0	1
River/creek	4	0	4
Street/road/railway tracks	0	4	4
Brine pool	0	1	1
Total	61	20	81

<sup>a</sup> Thirty-eight birds, including 36 individuals and one case with two birds together (treated as separate records) were observed within 1 km of shore along the coast of Washington, Oregon, and California, and single individuals were observed in each of Newfoundland and Labrador, Massachusetts, New Jersey, South Carolina, and Florida.

<sup>b</sup> One bird was salvaged from the coast of California, one from the Atlantic coast of Florida, and three from the Gulf coast of Florida.

<sup>c</sup> One bird was salvaged from a marsh near the ocean in Massachusetts.

of 20 specimens (75.0%) were salvaged inland, most on lake shores (Table 1); most of these 20 (85.0%) were dead when salvaged (15 found dead, 2 shot) and the other 3 (15.0%) were moribund (2 died within one day, 1 was later released). These 20 specimens were aged as follows: 95.0% were adults and 1 (5.0%) was a juvenile (12 of these specimens are included in Table 2). Five of 10 individuals sexed were adult males, 4 were adult females, and 1 was a juvenile female (all sexed specimens are included in Table 2).

#### *Body condition and length of stay*

Mass of 8 vagrants found dead ( $n = 7$ ) or found alive but died the next day ( $n = 1$ ) averaged 193.7 g (SD 20.6, range 154.2–217.8) (Table 2). Seven were adults; the single juvenile weighed 207.2 g, near the upper end of the range of body mass for adult vagrants. All masses were below the mean of Long-billed Murrelets reported from Russia—295.8 g (range 258–357) (sample size and season unknown) (Konyukhov and Kitaysky 1995). Authors variously described vagrants found dead as emaciated with no subcutaneous fat, with empty and shrivelled (flaccid) digestive tracts, and with relatively low body weights (Table 2). We assumed dead birds found on lake shores were too emaciated to be able to feed after arrival. Most grounded Long-billed Murrelets also probably soon died, regardless of condition; however, one grounded bird was rescued and released to fresh water. Two adults shot in November weighed 285.9 g with "... considerable subcutaneous fat" (Canadian Museum of Nature 69845; Sealy et al. 1982: 779) and 303.8 g (Smithsonian National Museum of Natural History 582506; Mumford 1982: 191). These values are 68.1 g and 86.0 g more than the heaviest bird found dead (217.8 g; Table 2), respectively. These individuals had fed before being shot (Table 2) and may have survived inland for many days or weeks. Many individuals encountered inland apparently attempted to forage before moving on after the observation was made.

The most frequent minimum length of stay was 2 days (72.1%;  $n = 61$  records), equivalent to a "one-day-bird" of Fraser (1997: 100). Most individuals were gone the day following first observation, having moved either to another part of the same body of water or elsewhere. Some individuals (9.8%) stayed for at least 3 or 4 days, and the longest minimum stay was 25 days. Some vagrants that moved on apparently were observed elsewhere, i.e., were observed more than once. For example, a bird observed in coastal South Carolina on 19 November 1994 was gone the next day (Davis 1995), but three weeks later (9–11 December) an individual with similar plumage was photographed on a reservoir about 250 km directly north, in North Carolina (Davis and Carter 1996). The bird recovered at the edge of a marsh just inland from the coast of Massachusetts in September 1982 was molting and flightless (Table 2), which suggests arrival in eastern North America at least 1–2 weeks earlier, before its wing molt rendered it flightless (see Carter and Stein 1995).

Complicating our attempts to identify other possible re-sightings, however, is the clustering of many inland records in time and space. During intense El Niño conditions in July and August 1983, for example, three birds were found dead at Mono Lake, California, and one at Railroad Lake, Alaska (Sealy et al. 1991). In March–December 1994 and July–November 1996, 10 and 5 records, respectively, were scattered across North America from the west coast to Florida (Mlodinow 1997). In any case, the short length of stay recorded for most individuals and the low number later found dead suggest that a high proportion moved on after they were first observed.

#### *Foraging on fresh water and prey consumed*

Fish of freshwater origin removed from stomachs and observations of ingestion of fish confirmed feeding by Long-billed Murrelets at inland bodies of water (Table 3). Both of the individuals shot by hunters had consumed multiple individuals of at least two genera of

TABLE 2. Twelve specimens of Long-billed Murrelet taken in North America, with age, sex, body mass, and notes on body condition. M = male, F = female; ND = no data. AHY = after-hatching-year birds (adults); HY = hatching-year birds (juveniles). CMN = Canadian Museum of Nature, Ottawa, Ont.; CRCM = Charles R. Conner Museum of Zoology, School of Biological Sciences, Washington State University, Pullman, Wash.; DMNH = Denver Museum of Nature and Science, Denver, Colo.; GEW = Glen E. Woolfenden (personal collection), University of South Florida, Tampa, Fla.; MSW = Museum of the Southwest, Midland, Texas; MVZ = Museum of Vertebrate Zoology at Berkeley, University of California, Berkeley, Calif.; SDNHM = San Diego Natural History Museum, San Diego, Calif.; USNM = Smithsonian National Museum of Natural History, Washington, D.C.; and UF = Florida Museum of Natural History, University of Florida, Gainesville, Fla. Records were coded as FD = found dead; FAD = found alive but died by next day; and S = shot by hunter.

Location	Date	Sex	Age	Mass (g)	Specimen no.	Record type	Condition	Source
Quebec Lac des deux montagnes [Lake of Two Mountains]; lake	11 November 1979	M*	AHY**	285.9	CMN #69845	S	"... appeared to be in good condition, with considerable subcutaneous fat (3 on a scale of 0-4)"	Sealy et al. (1982: 779); see Table 3
California Mono Co.; lake shore	9 August 1981	M*	AHY	204.0	SDNHM #41544	FD	Dead for ~1.5 days; "... emaciated, lacking subcutaneous fat, and its stomach was empty"	Jehl and Jehl (1981: 911)
Indiana Montroe Co.; lake	29 November 1981	ND	AHY	303.8	USNM #582506	S	ND	Mumford (1982: 191); R. E. Mumford in litt. 29 July 1982; see Table 3
Colorado Pitkin Co.; road	22 August 1982	M*	AHY**	206.0	DMNH #37691	FAD	"... lacked subcutaneous fat"	Sealy et al. (1991: 148); J. R. Demboski email 2 June 2011
Massachusetts Plymouth Co.; edge of marsh inland from ocean	17 September 1982	F*	AHY**	184.2	USNM #599498	FD	Apparently flightless, possibly killed by a cat, with extensive body molt and molt of secondaries and most primaries; "... bird was thin"	Anderson (1982: 350- 351); C. Angle email 12 February 2011
California Mono Co.; lake shore	2 August 1983	M	AHY	ND	MVZ #169134	FD	"... emaciated individual's stomach was empty ..."	Sealy et al. (1991: 148)
Florida Pinellas Co.; sea shore	27 December 1986	F*	AHY	199.4	GEW #5848	FD	"... stomach was empty, and the bird was emaciated ... no subcutaneous fat"	Hoffman and Woolfenden (1988: 37); R. Bowman email 2 June 2011
Florida Levy Co.; sea shore	4 December 1993	F*	HY	207.2	UF #2081	FD	ND	Muschlitz (1995); Anderson (1995: 40); B. H. Anderson in litt. 16 April 1994
Florida Pinellas Co.; sea	28 November 1994	M	AHY**	154.2	UF #39297	FD	"... lack of fat, and reduced pectoral muscles indicated that it had probably been sick for some time; no sign of injury"	Kratter et al. (2002: 124)

TABLE 2. (continued)

Location	Date	Sex	Age	Mass (g)	Specimen no.	Record type	Condition	Source
Washington Garfield Co.; road	14 August 2001	F	AHY**	217.8	CRCM #01-37	FD	little fat, heavy body molt	Thompson et al. (2003: 157-158); K. M. Cassidy email 2 June 2011
Florida Broward Co.; sea	22 November 2003	F*	AHY	177.0	UF #44170	FD	"... no fat, and was emaciated. The stomach was empty"	A. W. Kratter email 18 May 2011
New Mexico Eddy Co.; brine pool	12 July 2009	ND	AHY**	ND	MSW #29200	FD	"... not weighed but noted as not emaciated ... its fat [was noted] as 'light'"	Witt et al. (2010: 161)

\* Sex confirmed by gonad examination

\*\* Specimen or photograph examined by SGS

freshwater fish (Table 3), which could have been taken where the birds were shot (southern Quebec (Sealy et al. 1982) and northern Indiana (Mumford 1982)) or from previous foraging sites (Table 3). The two fish species identified—Emerald Shiner (*Notropis atherinoides*) and Gizzard Shad (*Dorosoma cepedianum*)—are common and widely distributed in freshwater habitats in central and southeastern North America (Scott and Crossman 1973). Long-billed Murrelets surfacing with fish on the Moses Saunders Power Dam, St. Lawrence River (Di Labio 1996), and a reservoir in Ohio (Fazio and Webb 1997), in addition to prey identified above, lend credence to equating "repeated dives," described by several observers, to foraging dives (Table 3). The condition of the Long-billed Murrelet observed foraging at sea off Florida (Muschlitz 1995) apparently was adequate for survival after crossing an ocean and a continent, possibly facilitated by successive stopovers, regardless of the direction travelled from eastern Russia.

## Discussion

Long-billed Murrelets travelled at least 4700 km from the nearest breeding area in Karaginsky Gulf (northeast Kamchatka) to Cape Flattery, Washington, and some individuals survived long enough to continue southeast across North America, reaching Florida, which would be another 4600 km (to Miami). Travel across North America along a roughly northwest to southeast pathway from Washington to Florida was probably facilitated by a continuation of the winds and storms that initially carried individuals from eastern Russia to the west coast of North America (from Washington to northern California), followed by successive stopovers once in North America (Sealy et al. 1991).

Length of stopover likely depended on the degree of emaciation, availability of prey at the site, and presence of predators, as various lengths of stay were reported. However, three of four individuals salvaged in Florida were underweight (Table 2) and, no doubt, in poor condition when recovered, regardless of whether they had fed along the way. Survival appeared greater for individuals found farther north along the east coast, from Virginia to Newfoundland and Labrador, in the cooler waters of the southern Labrador Current. These individuals may have altered course along the Washington–Florida pathway, possibly assisted by changes in wind direction or other conditions in certain years, and more easily found prey along the way.

We assumed that vagrants did not come to North America directly from Europe, although Maumary and Knaus (2000) hypothesized a direct route from Asia to Europe to explain the occurrence of a Long-billed Murrelet in Switzerland. We would have expected many more Long-billed Murrelets to have been reported inland in Europe or on the coast, and along the east coast of North America, if the direction of travel had been westward from eastern Russia, across Europe, and across the Atlantic Ocean.

TABLE 3. Foraging observations and prey taken by 10 vagrant Long-billed Murrelets in North America. S = shot; O = observation; ND = no data.

Location and habitat	Year	Month	Record type	Prey and foraging observations	Minimum stay (days)	Sources
Quebec Lac des deux montagnes [Lake of Two Mountains]; fresh water	1979	November	S	partial specimen of Emerald Shiner ( <i>Notropis atherinoides</i> ) plus 3 partial specimens (+ 20 pharyngeal arches) identified as minnows, Cyprinidae	ND	Sealy et al. (1982: 779)
Indiana Yellowwood Lake, Brown Co.; fresh water	1981	November	S	8 Gizzard Shad ( <i>Dorosoma cepedianum</i> ) plus 3 unidentified minnows, probably <i>Notropis</i>	ND	Mumford (1982: 191)
Ontario and New York Moses-Saunders Power Dam, St. Lawrence River; fresh water	1993	October	O	"[In]urrel[e] appeared to be in good condition, frequently diving and surfacing with small fish"	20	Di Labio (1996: 16); Sibley (1993)
Newfoundland and Labrador Little Codroy River, southwestern Newfoundland and Labrador; sea	1989	July	O	"[a]pparently healthy and in full breeding plumage, it was well studied as it fed near shore for most of a morning"	ND	Mactavish (1989: 1286)
Florida Cedar Key, Levy Co.; sea	1994	March	O	"... where it dove repeatedly" but no fish brought to surface	13	Muschlitz (1995: 30)
North Carolina Chatham Co., Jordan Reservoir; fresh water	1994	December	O	murrelet dove repeatedly "and once surfaced with a small fish"	3	Davis and Carter (1996: 28)
California Humboldt Co., Humboldt Bay; sea	1995	December	O	"... foraged just outside the jetty"	3	Bailey and Singer (1996: 220)
Ohio Seneca Co., Clyde (Beaver Creek) Reservoir; fresh water	1996	November	O	... bird "seemed to enjoy good health throughout its stay [at least 1 week], frequently diving, retrieving fish ..."; foraging dives averaging 18 seconds differed from dives traversing distances of 200–250 m from point of submergence, lasting 50–55 seconds; fish 3–5 cm long brought to surface, then swallowed	7	Fazio and Webb (1997: 4–5)
New York Cayuga Lake, Tompkins Co.; fresh water	2001	December	O	... recorded "... lithely rais[ing] its body out of the water and spread[ing] its wings to begin its dive ... individual repeatedly d[ive], spending more time below than on the surface"	4	Kelling and Kelling (2002: 38)
New Jersey Sandy Hook, Monmouth Co.; sea	2007	January	O	"... spent a fair amount of time feeding, thus out of view"	2	Barnes (2009: 2)

Some vagrant Long-billed Murrelets certainly survive for weeks during long-distance travel, even though survival of vagrants for more than a few days has traditionally been assumed to be low or zero (but see DeSante 1973; Newton 2008). Long-billed Murrelets may have stopped to feed along the west coast of the United States, whether they arrived directly from eastern Russia or returned from inland sites, and they may have survived for some time before and/or after being observed, as has been recorded for some other vagrant alcids (Sealy and Carter 2012). Once they replenished their reserves, some individuals on the west coast may have flown inland, continuing in the same (wrong) direction, that is, away from eastern Russia; some may have returned to eastern Russia. "Refuelled" individuals may have survived better inland or developed sufficient stores to attempt to return to Russia and possibly re-join Russian populations. On the other hand, those found dead or in poor condition inland may have flown non-stop from Asia and possibly landed because they were near death.

By highlighting these survival scenarios for the Long-billed Murrelet, we emphasize potential difficulties with interpreting our data, despite the relatively high number of occurrences of this species across North America. We could not directly determine routes used by individuals before or after being recorded in North America, but many individuals on the west coast apparently survived after observation, because only one dead Long-billed Murrelet was salvaged there (Table 2). In the absence of apparent direct lines of travel, determining exact routes and time required for individuals to fly from place to place will require use of satellite radios or GPS systems (e.g., Jouventin and Weimerskirch 1990; Landers et al. 2011). General routes and patterns of movements across North America, however, can be surmised by examining samples of records of vagrants (Sealy et al. 1991; Sealy and Carter 2012).

The proportion of individuals in a population that become vagrants (see Fraser 1997), and whether all die or some establish new populations or even return to their original breeding populations, is a gap in our understanding of mortality and population changes in species. For the Long-billed Murrelet, the relatively high degree of long-distance vagrancy in North America, exhibited only since 1979, is remarkable in comparison with other alcids and likely reflects changes in weather patterns that assist movements across the North Pacific Ocean, as well as changes in breeding habitats and populations in eastern Russia (see Carter et al. 2011). In addition, the ability of vagrant Long-billed Murrelets to survive for long periods enhances the chances of discovering vagrants in North America and increases the likelihood of moving long distances across the continent. Although this species is one of the rarest alcids, we do not consider the actual numbers of vagrant individuals recorded, even if we

assume that all perish, to have a significant impact on the breeding population. We also do not know, however, how many individuals become vagrants but are not recorded.

A high level of vagrancy may reflect undetected population-level impacts being experienced in eastern Russia due to natural and anthropogenic factors, such as climate change, changes in prey and distribution of predators, and loss of coastal old-growth forests (Nelson et al. 2002). Ranges may change because pioneering individuals that were originally vagrants survive and breed successfully in new areas. Perhaps Long-billed Murrelets will breed in North America some day or possibly a few already have, without our knowledge, along the west coast where most birds have been observed and prey and forest habitat are similar to those of eastern Russia.

### Acknowledgements

We thank the many birders and other field workers who carefully observed murrelets and recorded their behaviour, in some cases over several days, or salvaged dead and dying birds. Many individuals published their observations with detailed descriptions of the plumage, often accompanied by photographs, and notes on the condition of specimens, or information on habitat, weather conditions, and behaviour at the time of observation. Many workers responded to requests for additional details on body condition and prey of Long-billed Murrelets: R. Bowman, B. Di Labio, K. Garrett, J. Hudon, F. Huettmann, J. Kendall, K. McGowan, S. Mlodinow, B. Muschilitz, H. Nevins, W. Schmoker, P. Svingen, and G. van Vliet. Several museum curators and others provided additional information on specimens in their care: C. Angle (Smithsonian National Museum of Natural History), C. Cicero and N. Johnson (Museum of Vertebrate Zoology, University of California, Berkeley); A. Kratter (Florida Museum of Natural History, University of Florida, Gainesville); R. Johnson (Washington State University, Pullman); and H. Nevins (Moss Landing Marine Laboratory, Moss Landing, California). This work was funded by grants to SGS from the Natural Sciences and Engineering Research Council of Canada.

### Literature Cited

- Anderson, K. S. 1982. Marbled Murrelet: a first Massachusetts record. *Bird Observer* 10: 349-352.
- Anderson, B. H. 1995. Eleventh report of the Florida Ornithological Society Records Committee. *Florida Field Naturalist* 23: 38-43.
- Armistead, G. L., and M. J. Iliff. 2003. The vagrancy of Gray Kingbird in North America. *North American Birds* 57: 148-161.
- Bailey, S. F., and D. Singer. 1996. Middle Pacific Coast. *North American Birds* 50: 218-220.
- Barnes, S. 2009. New Jersey's first record of Long-billed Murrelet. *New Jersey Birds* 35: 2-3.
- Carter, H. R., and J. L. Stein. 1995. Molts and plumages in the annual cycle of the Marbled Murrelet. Pages 99-109

- in Ecology and conservation of the Marbled Murrelet. Edited by C. J. Ralph, G. L. Hunt Jr., M. G. Raphael, and J. F. Piatt. U.S. Forest Service, General Technical Report PSW-GTR-152, Pacific Southwest Research Station, Albany, California. 420 pages.
- Carter, H. R., S. K. Nelson, S. G. Sealy, and G. B. van Vliet.** 2011. Occurrences of Kittlitz's Murrelets south of the breeding range along the west coast of North America. *Northwestern Naturalist* 92: 186-199.
- Davis, R.** 1995. Southern Atlantic Coast region. *National Audubon Society Field Notes* 49: 135-139.
- Davis, R., and D. Carter.** 1996. First record of Marbled Murrelet in North Carolina. *Chat* 60: 27-28.
- DeSante, D. F.** 1973. An analysis of the fall occurrences and nocturnal orientation of vagrant wood warblers (Parulidae) in California. Ph.D. dissertation, Stanford University, Palo Alto, California.
- DeSante, D. F.** 1983. Annual variability in the abundance of migrant landbirds on Southeast Farallon Island. *Auk* 100: 826-852.
- DeSante, D. F., and D. G. Ainley.** 1980. The avifauna of the South Farallon Islands, California. *Studies in Avian Biology*, Number 4. 104 pages.
- Di Labio, B. M.** 1996. First record of the Asiatic Marbled Murrelet in Ontario. *Ontario Birds* 14: 15-22.
- Erickson, R. A., R. A. Hamilton, S. N. G. Howell, P. Pyle, and M. A. Patten.** 1995. First record of the Marbled Murrelet and third record of the Ancient Murrelet for Mexico. *Western Birds* 26: 30-45.
- Fazio, V. W., III, and D. Webb.** 1997. A Long-billed Murrelet (*Brachyramphus perdix*) in Ohio. *Ohio Cardinal* 20: 1-6.
- Fraser, P. A.** 1997. How many rarities are we missing? Weekend bias and length of stay revisited. *British Birds* 90: 94-101.
- Friesen, V. L., J. F. Piatt, and A. J. Baker.** 1996. Evidence from cytochrome *B* sequences and allozymes for a 'new' species of alcid: the Long-billed Murrelet (*Brachyramphus perdix*). *Condor* 98: 681-690.
- Gaston, A. J., and I. L. Jones.** 1998. *The Auks: Alcidae*. Oxford University Press, Oxford, U.K. 349 pages.
- Grinnell, J.** 1922. The role of the "accidental." *Auk* 39: 373-380.
- Hoffman, W., and G. E. Woolfenden.** 1988. A specimen of the Asiatic Marbled Murrelet from Florida. *Florida Field Naturalist* 16: 37-38.
- Hopkins, D., D. Stone, and K. Rylands.** 2006. The Long-billed Murrelet in Devon—a new British bird. *Birding World* 19: 457-464.
- Jehl, D. R., and J. R. Jehl Jr.** 1981. A North American record of the Asiatic Marbled Murrelet (*Brachyramphus marmoratus perdix*). *American Birds* 35: 911-912.
- Jouventin, P., and H. Weimerskirch.** 1990. Satellite tracking of Wandering Albatrosses. *Nature* 343: 746-748.
- Kelling, S., and T. Kelling.** 2002. Long-billed Murrelet (*Brachyramphus perdix*) at Ithaca, New York. *Kingbird* 52: 38-40.
- Kondratyev, A. Ya., N. M. Litvinenko, Y. V. Shibaev, P. S. Vyatkin, and L. F. Kondratyeva.** 2000. The breeding seabirds of the Russian Far East. Pages 37-81 in *Seabirds of the Russian Far East*. Edited by A. Y. Kondratyev, N. M. Litvinenko, and G. W. Kaiser. Special Publication, Canadian Wildlife Service, Environment Canada, Ottawa. 141 pages.
- Konyukhov, N. B., and A. S. Kitaysky.** 1995. The Asian race of the Marbled Murrelet. Pages 23-29 in *Ecology and conservation of the Marbled Murrelet*. Edited by C. J. Ralph, G. L. Hunt Jr., M. G. Raphael, and J. F. Piatt. U.S. Forest Service, General Technical Report PSW-GTR-152, Pacific Southwest Research Station, Albany, California. 420 pages.
- Kratter, A. W., T. Webber, T. Taylor, and D. W. Steadman.** 2002. New specimen-based records of Florida birds. *Bulletin of the Florida Museum of Natural History* 43: 111-161.
- Landers, T. J., M. J. Rayner, R. A. Phillips, and M. E. Hauber.** 2011. Dynamics of seasonal movements by a trans-Pacific migrant, the Westland Petrel. *Condor* 113: 71-79.
- Lethaby, N.** 2000. The identification of Long-billed Murrelet in alternate plumage. *Birding* 32: 438-444.
- Mactavish, B.** 1989. Atlantic Provinces region. *American Birds* 43: 1285-1288.
- Maumary, L., and P. Knaus.** 2000. Marbled Murrelet in Switzerland: a Pacific Ocean auk new to the Western Palearctic. *British Birds* 93: 190-199.
- Mlodinow, S. G.** 1997. The Long-billed Murrelet (*Brachyramphus perdix*) in North America. *Birding* 29: 461-476.
- Mumford, R. E.** 1982. The Marbled Murrelet in Indiana. *Indiana Audubon Quarterly* 60: 190-191.
- Muschlitz, B. P.** 1995. Asiatic Marbled Murrelet: first spring record in North America. *Florida Field Naturalist* 23: 30-32.
- Nelson, S. K., Y. Fukuda, and N. Oka.** 2002. The status and conservation of the Long-billed Murrelet in Japan. *Journal of the Yamashina Institute for Ornithology* 33: 88-106.
- Newton, I.** 2008. *The migration of birds*. Academic Press, New York. 976 pages.
- Oka, N., and H. Hamasoto.** 2001. Nutritional condition and muscular features of wintering Long-billed Murrelets in Japan. *Condor* 103: 874-878.
- Patten M. A., and C. A. Marantz.** 1996. Implications of vagrant southeastern vireos and warblers in California. *Auk* 113: 911-923.
- Scott, W. B., and E. J. Crossman.** 1973. *Freshwater fishes of Canada*. Fisheries Research Board of Canada, Ottawa, Ontario. Bulletin 184. 966 pages.
- Sealy, S. G., and H. R. Carter.** 2012. Rare inter-ocean vagrancy in Crested Auklet and Parakeet Auklet. *Waterbirds* 34: 64-73.
- Sealy, S. G., H. R. Carter, and D. Alison.** 1982. Occurrences of the Asiatic Marbled Murrelet (*Brachyramphus marmoratus perdix* [Pallas]) in North America. *Auk* 99: 778-781.
- Sealy, S. G., H. R. Carter, W. D. Shuford, K. D. Powers, and C. A. Chase III.** 1991. Long-distance vagrancy of the Asiatic Marbled Murrelet. *Western Birds* 22: 145-155.
- Sibley, D.** 1993. An Asiatic Marbled Murrelet in Ontario. *Birders Journal* 2: 276-277.
- Stejneger, L.** 1886. On *Brachyramphus perdix* (Pall.) and its nearest allies. *Zeitschrift für die Gesamte Ornithologie* 3: 210-219.
- Svingen, P. H.** 2009. First Minnesota record of the Long-billed Murrelet (*Brachyramphus perdix*). *Loon* 81: 55-60.
- Thompson, C. W., K. J. Pullen, R. E. Johnson, and E. B. Cummins.** 2003. Specimen record of a Long-billed Murrelet from eastern Washington, with notes on plumage

- and morphometric differences between Long-billed and Marbled murrelets. *Western Birds* 34: 157-168.
- Veit, R. R.** 1997. Long-distance dispersal and population growth of the Yellow-headed Blackbird *Xanthocephalus xanthocephalus*. *Ardea* 85: 135-143.
- Witt, W. C., M. S. Graus, and H. A. Walker.** 2010. Molecular data confirm the first record of the Long-billed Murrelet for New Mexico. *Western Birds* 41: 160-167.

Received 29 November 2011

Accepted 9 May 2012



# Greater Scaup, *Aythya marila*, Nest Site Characteristics on Grassy Island, New Brunswick

JON T. McROBERTS<sup>1</sup>, NICOLE T. QUINTANA<sup>1</sup>, W. ANDREW SMITH<sup>2</sup>, WARREN B. BALLARD<sup>3</sup>, F. PATRICK KEHOE<sup>4</sup>, and TIMOTHY G. DILWORTH<sup>5</sup>

<sup>1</sup>Department of Natural Resources Management, Texas Tech University, Lubbock, Texas 79409 USA

<sup>2</sup>Department of Biology, University of New Brunswick, Bag Service #45111, Fredericton, New Brunswick E3B 6E1 Canada; current address: Building B18, Canadian Forces Base Gagetown, P.O. Box 17000 Station Forces, Oromocto, New Brunswick E2V 4J5 Canada; email: Andy.Smith@forces.gc.ca

<sup>3</sup>Department of Natural Resources Management, Texas Tech University, Lubbock, Texas 79409 USA (deceased)

<sup>4</sup>Ducks Unlimited Canada, 1606 4th Avenue, P.O. Box 4465, Regina, Saskatchewan S4P 3W7 Canada

<sup>5</sup>Department of Biology, University of New Brunswick, Bag Service #45111, Fredericton, New Brunswick E3B 6E1 Canada

McRoberts, Jon T., Nicole T. Quintana, W. Andrew Smith, Warren B. Ballard, F. Patrick Kehoe, and Timothy G. Dilworth. 2012. Greater Scaup, *Aythya marila*, nest site characteristics on Grassy Island, New Brunswick. Canadian Field-Naturalist 126(1): 15–19.

We studied Greater Scaup (*Aythya marilla*) nest site selection on Grassy Island, New Brunswick, during 1995 and 1996 by describing site selection in relation to habitat characteristics and association with larids using univariate comparisons. We pooled nesting data from both years and found that nesting sites were significantly closer to larid colonies and the edge of the patch of vegetation in which the nests were situated, had less forb canopy cover, more sedge cover, greater overhead concealment and lateral cover at 0–0.25 m, and less ground moisture than random sites. We evaluated Greater Scaup nests delimited as close to or far from larid colonies at 30 m and documented that nests closer to larid colonies were found in shorter vegetation that was closer to the edge of the patch of vegetation with less lateral cover at 0.25–0.5 m, but had greater overhead concealment than nests farther away. Advancements in the ecological understanding of the species, including habitat use patterns and species associations, will increase the likelihood of conservation successes.

**Key Words:** Greater Scaup, *Aythya marila*, nests, larids, Grassy Island, New Brunswick, waterfowl.

Habitat selection occurs when an animal uses a habitat in greater proportion than its availability (Johnson 1980). Nest site selection can dominate other forms of habitat selection due to the functional importance and relatively long-term commitment made to the site (Orians and Wittenberger 1991). Additionally, production of offspring is related to the quality of the surrounding habitat selected by the parent (Orians and Wittenberger 1991). Nest site selection may also be influenced by the presence of other species (Hilden 1965). Koskimies (1957) considered larids to be a releasing feature of habitat recognition for waterfowl and other birds nesting within their colonies, and it has been suggested that ducks will choose nesting sites with poor cover in order to be near larids (Koskimies 1957; Hilden 1964; Long 1970; Gerell 1985).

Greater Scaup (*Aythya marila*) often nest on treeless islands or treeless portions of islands and exhibit sociality towards larids (Hilden 1964; Weller et al. 1969; Bengtson 1972; Johnsgard 1975; Bellrose 1980; Fournier and Hines 2001). Objectives of this study were to document the habitat characteristics of nesting sites of Greater Scaup and to determine whether the proximity of larids affected Greater Scaup nest site selection. We hope that our study of nesting ecology will serve as a resource that may assist Greater Scaup conservation efforts.

## Study Area

Our research took place on Grassy Island, New Brunswick, the southernmost documented nesting location of the Greater Scaup (McAlpine et al. 1988; Smith 1999; Tatman et al. 2009). Grassy Island is a 32-ha floodplain island located mid-channel (approximately 0.7 km from shore) in the Saint John River in Kings County, southern New Brunswick (45°31'N, 66°04'W). Island vegetation was dominated by grasses (*Calamagrostis* sp., *Phalaris* sp.), forbs (predominately *Lythrum salicaria*), sedges (*Carex* spp. and *Cyperus* spp.), and a few small stands of shrubs (*Cornus* spp. and *Ahnus* spp.) and trees (*Fraxinus* spp. and *Acer* spp.). The surrounding area is deltaic, containing islands, coves, and widespread patches of aquatic vegetation. River levels fluctuate by several metres seasonally, completely submerging Grassy Island during the spring. Common Terns (*Sterna hirundo*), Ring-billed Gulls (*Larus delawarensis*), and Great Black-backed Gulls (*Larus marinus*) also nested on Grassy Island.

## Methods

We conducted systematic searches for Greater Scaup nests on four occasions in 1995 (15, 22, and 27 June and 6 July) and three occasions in 1996 (18 and 25 June and 3 July). Five to 10 people participated in each search, which took place mid-morning. Nests were

also found opportunistically during field work. We mapped located nests and classified forb, sedge, grass, dead, and other canopy cover on a scale of 1–6 (sparse to dense; Daubenmire 1959) and overhead concealment of the nest (Choate 1967). We estimated percentage lateral cover from nests at a distance of 10 m (height intervals of 0.0–0.25 m, 0.26–0.5 m, 0.51–1.0 m, and 1.1–1.5 m) (Nudds 1977; Krasowski and Nudds 1986). We also measured vegetation height (m) and distance to the edge of the patch of vegetation (m). We recorded ground moisture (scaled from 1–10; driest to wettest) and distance to larid colony at nesting sites as habitat variables. We grouped estimated distance to larid colony into one of four classes: 0–10 m, 11–30 m, 31–60 m, and  $\geq 61$  m. To ensure habitat data were similar to the habitat at the time of nest initiation (and nest site selection), we included only nests less than 14 days old (from initiation to time of measurement) in the analysis.

Using the variables listed above, we compared habitat characteristics of nesting sites with characteristics of paired random sites to determine nest site selection by Greater Scaup. We excluded small stands of shrubs and trees from possible random site assignment because Greater Scaup generally do not nest in this type of habitat (Hilden 1964; Bengtson 1970). Additionally, we included only terrestrial sites in the random pairings. We compared variables using Wilcoxon rank sum or *t*-tests, depending on the normality of the data. To determine whether Greater Scaup nesting sites had less cover when Greater Scaup were nesting in association with larids, we combined distance classes 1 and 2 (0–30 m = “close to”) and classes 3 and 4 (31 to  $\geq 61$  m = “far from”) to analyze distance from larid colonies. We used Wilcoxon rank sum tests to compare overhead concealment, vegetation height, distance to patch edge, and lateral cover.

## Results

We found significant differences between nesting sites ( $n = 100$ ) and random sites ( $n = 111$ ) in 7 of 12 variables assessed (Table 1). Greater Scaup selected nesting sites with more sedge cover ( $P = 0.0001$ ), less forb cover ( $P = 0.0001$ ), and greater overhead concealment ( $P = 0.0001$ ) than random sites. We found that distance to the edge of the patch of vegetation at nesting sites was smaller than at random sites ( $P = 0.0390$ ) and that lateral cover at 0.0–0.25 m was greater at nests than at random sites ( $P = 0.0254$ ). Nesting sites were also drier than random sites ( $P = 0.0001$ ; Table 1).

We found that Greater Scaup selected nest locations closer to larid colonies ( $P = 0.0001$ ) than random sites (Table 1). When we compared sites close to and far from larid colonies, we found that nests closer ( $\leq 30$  m) had significantly more overhead concealment ( $P = 0.0234$ ), were located in shorter vegetation ( $P = 0.0080$ ), were closer to the edge of the patch of vegetation ( $P = 0.0176$ ), and had less lateral cover at 0.51–

1.0 m ( $P = 0.0001$ ) than nests  $> 30$  m from larid colonies (Table 2).

## Discussion

Studies in traditional breeding areas suggest that Greater Scaup tend to nest in clumps or patches of vegetation in open areas or with openings nearby (Hilden 1964; Weller et al. 1969; Bengtson 1970). During our study, Greater Scaup on Grassy Island selected sites that provided overhead concealment, provided more vegetation lateral cover at 0.0–0.25 m, and were closer to the edge of the patch of vegetation or opening. Waterfowl may select sites with overhead concealment as an anti-predator adaptation (Choate 1967; Guyn and Clark 1997), for favourable micro-climatic conditions (Gloutney and Clark 1997), or a combination of both. Conversely, Hilden (1964) reported that at Valassaaret, Finland, between 58% and 84% of Greater Scaup nests were half or completely exposed, and suggested this was a relic from nesting in tundra regions and could vary geographically.

Greater Scaup have been found to nest in grass, sedge, forb, and shrub habitats (Hilden 1964; Weller et al. 1969; Bengtson 1970). However, forb cover did not appear as desirable nesting cover for Greater Scaup on Grassy Island during our study. Forbs did not mature until late in the nesting season (W. A. Smith, personal observation), and they may not have provided adequate cover during the nest initiation period. Tatman et al. (2009) reported significantly lower temperatures and increased precipitation during the late incubation, hatching, and early brood rearing periods on Grassy Island in 1996, and these conditions could have had an impact on vegetation growth during our study. Meta-analysis striated among Greater Scaup breeding regions may expose nesting vegetation preferences.

We found that ground moisture was a significant predictor of nesting sites selected by Greater Scaup. Greater Scaup likely selected dry sites because it was possible for hens to control the thermal environment of the eggs (which is critical to the development of embryos) (Afton and Paulus 1992). Additionally, by selecting dry nesting sites, hens would also reduce the risk of nests being flooded by changing water levels (the Saint John River is tidal at Grassy Island).

Greater Scaup nesting sites on Grassy Island were often associated with larid nesting sites. Other studies have found associations between nesting Greater Scaup and larids (Hilden 1964; Weller et al. 1969; Fournier and Hines 2001). Nesting associations have also been reported between larids and Lesser Scaup (*Aythya affinis*; Vermeer 1968), Tufted Ducks (*Aythya fuligula*; Newton and Campbell 1975), Redheads (*Aythya americana*) and Canvasbacks (*Aythya valisineria*; Featherstone 1975), suggesting that these relationships may be common among members of the genus *Aythya*. Although large gulls may be predators of waterfowl

TABLE 1. Mean characteristics of Greater Scaup nesting sites ( $n = 100$ ) and random sites ( $n = 111$ ) on Grassy Island, New Brunswick, mean for 1995 and 1996 combined.

Habitat characteristic	Nesting site	Random site	<i>P</i>
Grass cover (1–6) <sup>a</sup>	3.18	3.42	0.3744
Sedge cover (1–6) <sup>a</sup>	3.12	1.56	0.0001
Forb cover (1–6) <sup>a</sup>	1.69	2.64	0.0001
Overhead concealment (1–4) <sup>b</sup>	3.339	2.43	0.0001
Height (m)	0.80	0.74	0.4646
Distance to patch edge (m)	1.12 <sup>f</sup>	1.74 <sup>g</sup>	0.0390
Ground moisture (1–10) <sup>c</sup>	4.32	6.04	0.0001
Lateral cover (0.0–0.25 m) (1–5) <sup>d</sup>	4.99	4.85	0.0254
Lateral cover (0.26–0.50 m) (1–5) <sup>d</sup>	4.55	4.30	0.4208
Lateral cover (0.51–1.0 m) (1–5) <sup>d</sup>	2.33	2.61	0.2605
Lateral cover (1.1–1.5 m) (1–5) <sup>d</sup>	1.09	1.16	0.2197
Distance to larid colony (1–5) <sup>e</sup>	2.65	3.59	0.0001

<sup>a</sup>Measured within 0.25 m<sup>2</sup> of nest: class 1 = 0–5%, 2 = 6–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–95%, 6 = 96–100% (Daubenmire 1959).

<sup>b</sup>Portion of nest concealed when viewed from above: class 1 = 0–25%, 2 = 26–50%, 3 = 51–75%, 4 = 76–100% (Choate 1967).

<sup>c</sup>Scaled 1–10, from driest to wettest.

<sup>d</sup>Portion of a layer of vegetation profile board concealed at a distance of 10 m: class 1 = 0–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, 5 = 81–100% (Nudds 1977; Krasowski and Nudds 1986).

<sup>e</sup>Distance to nearest larid colony: class 1 = 0–10 m, 2 = 11–30 m, 3 = 31–60 m, 4 = ≥61 m.

<sup>f</sup> $n = 99$

<sup>g</sup> $n = 110$

TABLE 2. Vegetative characteristics of Greater Scaup nesting sites on Grassy Island, New Brunswick, that were close to ( $\leq 30$  m) and far from ( $> 30$  m) larid nests, mean for 1995 and 1996 combined.

Habitat characteristic	Nesting site		<i>P</i> <sup>a</sup>
	Close to larids ( $\leq 30$ m) ( $n = 47$ )	Far from larids ( $> 30$ m) ( $n = 52$ )	
Overhead concealment (1–4) <sup>c</sup>	3.60	3.23	0.0234
Height (m)	0.72	0.86	0.0080
Distance to patch edge (m)	0.73	1.50 <sup>b</sup>	0.0176
Lateral cover (0–0.25 m) (1–5) <sup>d</sup>	4.98	5.00	0.3023
Lateral cover (0.25–0.5 m) (1–5) <sup>d</sup>	4.21	4.85	0.0001
Lateral cover (0.5–1.0 m) (1–5) <sup>d</sup>	2.09	2.54	0.0714
Lateral cover (1.0–1.5 m) (1–5) <sup>d</sup>	1.02	1.15	0.3553

<sup>a</sup>*P* values from a Wilcoxon rank sum test.

<sup>b</sup> $n = 51$

<sup>c</sup>Portion of nest concealed when viewed from above; class 1 = 0–25%, 2 = 26–50%, 3 = 51–75%, 4 = 76–100% (Choate 1967).

<sup>d</sup>Portion of a layer of vegetation profile board concealed at a distance of 10 m: class 1 = 0–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, 5 = 81–100% (Nudds 1977; Krasowski and Nudds 1986).

nests and ducklings (Dwernychuk and Boag 1972; Swennen 1989; Walker and Lindberg 2005), management and conservation of larids—preferentially smaller gulls or terns that do not prey on eggs or ducklings—may be useful to maintain local nesting duck populations.

Nesting in open habitat by colonial birds is believed to be an anti-predator strategy which allows the birds to observe approaching predators and allows for the aggressive and communal defense of nests, as in larids (Dyrce et al. 1981). Waterfowl and other birds have been found to use relatively open habitats with reduced

cover when nesting with larids (Hilden 1965; Featherstone 1975; Gerell 1985). Our study found that Greater Scaup nesting sites near larids were closer to the edge of the patch of vegetation or were in an opening with shorter vegetation and less lateral cover; however, these sites had greater overhead concealment than nests further from larids.

Differences between this study and others may be due to sampling techniques. Gerell (1985) did not differentiate between overhead and lateral cover, using only a single subjective measurement of concealment (i.e., poor, fair, good). Ultimately, nesting association

with larids and subsequent nesting success must be assessed on a site-by-site basis,<sup>1</sup> because larids can serve as a predator of Greater Scaup eggs or they can lessen the effects of other predators (Flint et al. 2006).

Lastly, an important factor affecting our nesting results was the presence of cattle grazing on Grassy Island during the study period. Moderate grazing likely shaped the vegetative structure of the island and affected Greater Scaup nesting. The duration of our study prevented us from identifying the magnitude of the effect of grazing on nest site selection; however, the presence of grazing should be recognized in ecological or conservation implications generated from our study.

We found that habitat characteristics were important predictors of Greater Scaup nesting sites at Grassy Island, New Brunswick; we also found evidence that Greater Scaup selected nesting sites near larid colonies and that nest site habitat of Greater Scaup nesting near larids was different from the habitat of those nesting further away. When conducting nest site selection studies, researchers should be aware of the presence of other species and their potential influence on the behavior and nesting patterns of the subject species.

### Acknowledgements

We thank the students and staff of the University of New Brunswick and the staff of the New Brunswick Department of Natural Resources and Energy who assisted with data collection. We gratefully acknowledge the financial support of the New Brunswick Department of Natural Resources and Energy, the University of New Brunswick, and the New Brunswick Cooperative Fish and Wildlife Research Unit. A. W. Diamond and R. A. Mureika provided helpful comments on the manuscript.

### Literature Cited

- Afton, A. D., and S. L. Paulus. 1992. Incubation and brood care. Pages 62-108 in *Ecology and management of breeding waterfowl*. Edited by B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu. University of Minnesota Press, Minneapolis.
- Bellrose, F. C. 1980. *Ducks, geese and swans of North America*. Stackpole Books, Harrisburg.
- Bengtson, S. A. 1970. Locations of nest-sites of ducks in Lake Myvatn area, north-east Iceland. *Oikos* 21: 218-229.
- Bengtson, S. A. 1972. Reproduction and fluctuations in the size of duck populations at Lake Myvatn, Iceland. *Oikos* 23: 35-58.
- Choate, J. S. 1967. Factors influencing nesting success of eiders in Penobscot Bay, Maine. *Journal of Wildlife Management* 31: 769-777.
- Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. *Northwest Science* 33: 43-64.
- Dwernychuk, W., and D. A. Boag. 1972. How vegetative cover protects duck nests from egg-eating birds. *Journal of Wildlife Management* 36: 955-958.
- Dyrcz, A., J. Witkowski, and J. Okulewicz. 1981. Nesting of 'timid' waders in the vicinity of 'bold' ones as an antipredator adaptation. *Ibis* 123: 542-545.
- Featherstone, J. D. 1975. Aspects of nest site selection in three species of ducks. Ph.D. dissertation, University of Toronto, Toronto.
- Flint, P. L., J. B. Grand, T. F. Fondell, and J. A. Morese. 2006. Population dynamics of greater scaup breeding on the Yukon-Kuskokwim Delta, Alaska. *Wildlife Monographs* 162: 1-22.
- Fournier, M. A., and J. E. Hines. 2001. Breeding ecology of sympatric greater and lesser scaup (*Aythya marila* and *Aythya affinis*) in the subarctic Northwest Territories. *Arctic* 54: 444-456.
- Gerell, R. 1985. Habitat selection and nest predation in a common eider population in southern Sweden. *Ornis Scandinavica* 16: 129-139.
- Gloutney, M. L., and R. G. Clark. 1997. Nest-site selection by mallards and blue-winged teal in relation to microclimate. *Auk* 114: 381-395.
- Guyn, K. L., and R. G. Clark. 1997. Cover characteristics and success of natural and artificial duck nests. *Journal of Field Ornithology* 68: 33-41.
- Hilden, O. 1964. Ecology of duck populations in the island group of Valassaaret, Gulf of Bothnia. *Annales Zoologici Fennici* 1: 153-279.
- Hilden, O. 1965. Habitat selection in birds: A review. *Annales Zoologici Fennici* 2: 53-75.
- Johnsgard, P. A. 1975. *Waterfowl of North America*. Indiana University Press, Bloomington.
- Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology* 61: 65-71.
- Koskimies, J. 1957. Terns and gulls as features of habitat recognition for birds nesting in their colonies. *Ornis Fennica* 34: 1-6.
- Krasowski, T. P., and T. D. Nudds. 1986. Microhabitat structure of nest sites and nesting success of diving ducks. *Journal of Wildlife Management* 50: 203-208.
- Long, R. J. 1970. A study of nest site selection by island nesting anatids in central Alberta. M.Sc. thesis, University of Alberta, Edmonton.
- McAlpine, D. F., S. Makepeace, and M. Phinney. 1988. Breeding records of Greater Scaup, *Aythya marila*, in New Brunswick. *Canadian Field-Naturalist* 102: 718-719.
- Newton, I., and C. R. G. Campbell. 1975. Breeding of ducks at Loch Leven, Kinross. *Wildfowl* 26: 83-102.
- Nudds, T. D. 1977. Quantifying the vegetative structure of wildlife cover. *Wildlife Society Bulletin* 5: 113-117.
- Orians, G. H., and J. F. Wittenberger. 1991. Spatial and temporal scales in habitat selection. *American Naturalist* 137, supplement, pages S29-S49.
- Smith, W. A. 1999. Nest site selection and nest fate of Greater Scaup on Grassy Island, New Brunswick: the influence of habitat, larids and weather. M.S. thesis, University of New Brunswick, Fredericton.
- Swennen, C. 1989. Gull predation upon eider *Somateria mollissima* ducklings: destruction or elimination of the unfit? *Ardea* 77: 21-45.
- Tatman, N. M., J. T. McRoberts, W. A. Smith, W. B. Ballard, F. P. Kehoe, and T. G. Dilworth. 2009. Nest success

<sup>1</sup>Nesting success at Grassy Island, New Brunswick, was 61% and 21% in 1995 and 1996, respectively (Tatman et al. 2009).

- and duckling survival of Greater Scaup, *Aythya marila*, at Grassy Island, New Brunswick. Canadian Field-Naturalist 123: 323-328.
- Vermeer, K.** 1968. Ecological aspects of ducks nesting in high densities among larids. Wilson Bulletin 80: 78-83.
- Walker, J., and M. S. Lindberg.** 2005. Survival of scaup ducklings in the boreal forest of Alaska. Journal of Wildlife Management 69: 592-600.
- Weller, M. W., D. L. Trauger, and G. L. Krapu.** 1969. Breeding birds of the West Mirage Islands, Great Slave Lake, N.W.T. Canadian Field-Naturalist 83: 344-360.

Received 1 December 2011

Accepted 17 January 2012

# Abundance and Habitat Selection of Breeding Scoters (*Melanitta* spp.) in Ontario's Hudson Bay Lowlands

RODNEY W. BROOK<sup>1,3</sup>, KENNETH F. ABRAHAM<sup>1</sup>, KEVIN R. MIDDEL<sup>1</sup>, and R. KENYON ROSS<sup>2</sup>

<sup>1</sup>Wildlife Research and Development Section, Ontario Ministry of Natural Resources, Trent University, DNA Building, 2140 East Bank Drive, Peterborough, Ontario K9J 7B8 Canada

<sup>2</sup>Canadian Wildlife Service, Ontario Region, Environment Canada, 335 River Road, Ottawa, Ontario K1A 0H3 Canada; current address: 1732 Dorset Drive, Ottawa, Ontario K1H 5T8 Canada

<sup>3</sup>Corresponding author (email: rod.brook@ontario.ca)

Brook, Rodney W., Kenneth F. Abraham, Kevin R. Middel, and R. Kenyon Ross. 2012. Abundance and habitat selection of breeding scoters (*Melanitta* spp.) in Ontario's Hudson Bay Lowlands. *Canadian Field-Naturalist* 126(1): 20–27.

Concern about declining populations of sea ducks counted on the wintering grounds prompted a survey of sea ducks on the breeding grounds in the Hudson Bay Lowlands of Ontario in spring 2009. We estimated densities of breeding scoters (Surf Scoter, *Melanitta perspicillata*, White-winged Scoter, *M. fusca*, and Black Scoter, *M. americana*) and found the average estimates of Surf Scoters ( $\bar{x} = 0.11$  indicated pairs/km<sup>2</sup>) and Black Scoters ( $\bar{x} = 0.16$  indicated pairs/km<sup>2</sup>) to be as high as some of the highest reported for North America. We also conducted a habitat association analysis using resource selection functions (RSF) for indicated pairs of all scoter species combined at a scale of 250 m. Breeding pairs of scoters in the Hudson Bay Lowlands appear to have an affinity for smaller wetlands ( $\leq 100$  ha) disproportionate to what is available, also avoiding lakes (i.e., wetlands  $>100$  ha). Pairs were also found in areas with less forest cover and fen area than was available. An estimate of the area under the curve of the receiver operating characteristic suggests that these habitat association models have some utility. Once tested and validated with surveys beyond the current study area, these models can be refined and used to predict habitat use by breeding pairs of scoters in the Hudson Bay Lowlands; this information will be particularly useful for population estimation and land use planning.

Key Words: Black Scoter, *Melanitta americana*, Surf Scoter, *Melanitta perspicillata*, White-winged Scoter, *Melanitta fusca*, density estimate, habitat selection, resource selection function, Hudson Bay Lowland, Hudson Bay Lowlands, Ontario.

Increasing concern about declines in winter indices of abundance of sea ducks (Anatidae: Mergini) has prompted researchers and agencies to devote more resources to their study and monitoring (Sea Duck Joint Venture 2007\*, 2008). However, determining the causes of the apparent decline (Bordage and Savard 1995; Savard et al. 1998; Caithamer et al. 2000\*) is a challenge because few breeding baseline indices exist for most sea duck species. The breeding densities and distribution of North American sea ducks have received relatively little attention compared to other waterfowl groups because most breed in remote locations, making monitoring and research relatively difficult.

The Hudson Plains ecozone (Ecological Stratification Working Group 1996) contains the third largest wetland complex in the world (374,000 km<sup>2</sup>) (Keddy and Fraser 2005) and the largest wetland complex in North America (Abraham and Keddy 2005; Riley 2011). Approximately 68% of the Hudson Plains ecozone is in Ontario. Ontario ecological land classification roughly equates the Hudson Plains ecozones, with the Hudson Bay Lowlands ecozone (Crins et al 2009\*), and it is known to support many breeding waterfowl species (Thomas and Prevett 1982; Ross 1982; Cadman et al. 2007). Attempts to quantify densities of waterfowl other than geese have been limited (e.g., Ross 1987). Surveys for geese and many ducks are typically too early for species like scoters (*Melanitta* spp.) that breed

late in the season, and such counts are not thought to produce an annually comparable index for them in other areas (Ross 1987).

The Hudson Bay Lowlands are known to be home to breeding scoters (Surf Scoter, *Melanitta perspicillata*, White-winged Scoter, *M. fusca*, and Black Scoter, *M. americana*), but the abundance of and habitat use by these three species are poorly documented (Ross 2007a, 2007b, 2007c, respectively). There are known concentrations of moulting scoters nearby in Hudson Bay and James Bay that suggest reasonably large local breeding populations (Ross 1994). The relative contribution of the Hudson Plains ecozone to the breeding populations of scoters and other sea ducks in the eastern half of North America is not known, but it may be considerable. Further, little is known about habitat selection for any of the three scoter species, and most accounts are simply descriptions of where the species were observed or a micro-habitat description of a nest observation (see Brown et al. 1997; Bordage and Savard 1995; Savard et al. 1998; but see Traylor et al. 2004).

In 2009, we conducted aerial surveys in a large study area centrally located in the Hudson Bay Lowlands to quantify the abundance of breeding sea ducks. The survey was timed to survey these species at nest initiation. We report densities of breeding scoters and quantify their habitat association using a resource selection function analysis.

## Methods

### Surveys

In 2009, we established 10 transects of 100 km each within a study area of 10 000 km<sup>2</sup> (Figure 1). The area surveyed was 2% of the total study area. Observations were recorded from a Eurocopter A-Star B2 helicopter at 30 m above ground level. To help us assess the detection rate, we recorded observations as being between 0 and 50 m (inner band), >50 to 100 m (middle band), and >100 m (outer band). We compared the relative number of observations in each band (not a formal distance sampling method, however). For density calculations, observations within a perpendicular distance of up to 100 m from each side of the aircraft were used. The right side observer was RWB, the left side was KFA, and RKR was the middle observer, data recorder, and navigator. We flew at an average speed of 78 km/hr and georeferenced each observation using a Garmin 296 GPS. Transects were flown on 7–10 June 2009 and timing was based on the personal experience of RKR and KFA using information from a previous survey (Ross 1987) and from another waterfowl survey flown in the same area earlier the same year by RWB.

We estimated the number of indicated pairs (IP) for scoters based on general guidelines for other species, as no specific guidelines have been published for scoters (e.g., Dzubin 1969; Gilliland et al. 2009\*). For groups of four or fewer males, each male was counted as an indicated pair. Groups of five or more males were not considered to be locally breeding. Males were distinguished by plumage markings and general body colour for more distant birds. A lone female or a female with a male or a female together with a group of males was considered an indicated pair. We assumed that scoters were uniformly distributed throughout the study area, and we calculated an average density for each species on the transect survey area.

### Analysis

Habitat analysis was performed using the 48 class Provincial Land Cover (PLC) dataset for Ontario (Spectranalysis Inc. 1997) as the principal habitat layer. The Provincial Land Cover was derived through supervised classification based on spectral reflectance analysis of Landsat Thematic Mapper (TM) imagery with 30 m resolution collected between 1986 and 1997. Although more recent landcover products are available and with fewer classes, this particular version was created with special emphasis on wildlife habitat mapping and wetland delineations for ecoregions 215 and 217 (Ecological Stratification Working Group 1996).

A resource selection function is any model that provides values proportional to the probability of use of a resource unit (Boyce et al. 2002). To estimate resource selection functions (RSF) (Manly et al. 1993; Boyce et al. 2002) for scoters from observations of scoter indicated pairs, we overlaid the location of each presence/absence observation on the Provincial Land Cover dataset using ArcMap 9.3.1 (ESRI 2009\*) to extract

habitat data. To reduce the total number of variables for modelling, we combined some habitat types on the classified image that were similar (e.g., treed wetland, conifer swamp, and treed bog were combined under treed wetland; open fen and shrub rich fen were combined under fen; lichen rich bog and shrub rich bog were combined under bog).

We determined the proportion of each habitat type from the classified image at a spatial scale of 250 m (a circle with a radius of 250 m centered on each location where indicated pairs were recorded). The area of each site was approximately 20 ha. We did a parallel analysis at a 500 m scale as well, but found results to be so similar that we do not present them here. We calculated the proportion of each habitat type for each non-overlapping site where no indicated pairs were recorded as well. Locations where no indicated pairs were observed were randomly selected within the flown transect. Because almost all variables were expressed as a proportion of area, we transformed them using an arc sine transformation to help improve normality of errors (Sokal and Rohlf 1998). Wetlands were also identified as either water or deep water from the imagery, based on spectral reflectance (i.e., deep water was clear and dark, shallow water was light colored from sediment), and so we included a binary variable of deep water occurrence. Deep water is defined using reflectance only, so no depth boundaries are available.

Attempts to calculate resource selection functions for indicated pairs of any one species (e.g., Black Scoter) failed because total observations were too sparse for models to converge; therefore, we calculated resource selection functions for observations of all indicated pairs of scoter species combined. We used generalized logistic regression (PROC LOGISTIC: version 9.2, SAS Institute, Cary, N.C.) and proportion of habitat type data to model probability of indicated pairs being observed in various habitats by comparing sites where indicated pairs were observed to sites where no indicated pairs were observed.

We hypothesized that breeding scoters would have a stronger affinity for wetland habitats. We used a hierarchical process whereby we first tested the fit of candidate models composed of wetland habitat types only (Table 1). We selected the best fitting wetland model and used this model as the null model (or base model) on which to build subsequent candidate models using proportions of non-wetland habitat types. Wetland variables in the first analyses were scaled to the total of all wetland habitats, then rescaled for the second analysis to the total of all habitat variables (including wetland variables). All candidate models were constructed based on the authors' prior knowledge of scoter breeding habitat associations (e.g., Ross 2007a, 2007b, 2007c; Abraham et al. 2008), along with the use of summary statistics of the comparison of sites where indicated pairs were present/absent for each habitat type reported herein.

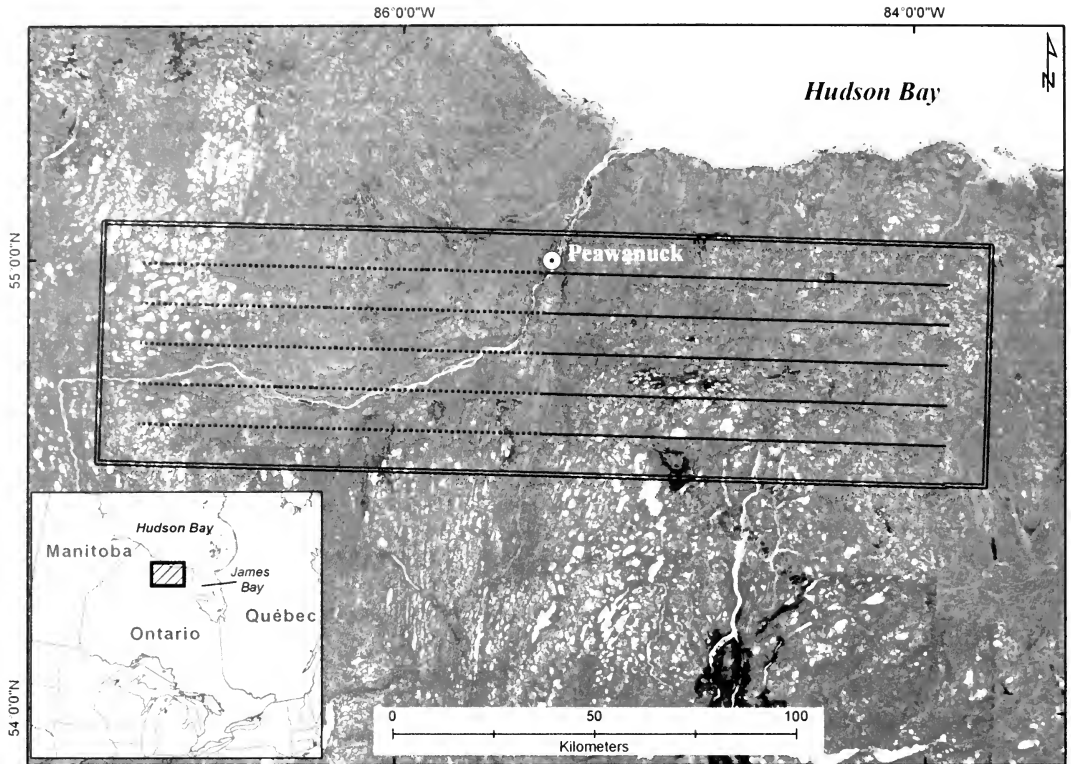


FIGURE 1. Location of the transects 100 km in length used to survey breeding Black Scoters, Surf Scoters, and White-winged Scoters in the Hudson Bay Lowlands, Ontario, 7–10 June 2009. Dashed and solid lines indicate separate transects flown.

We used Akaike's Information Criterion ( $AIC_c$ ; Akaike 1973) corrected for small sample size (Burnham and Anderson 1998) to select among candidate models, and we estimated the area under the curve for the receiver operating characteristic (ROC) to assess model performance (Cumming 2000). Area under the receiver operating characteristic curve is considered an index of whether the model can reliably classify a site, with a value of 0.5 being a worthless model and 1.0 being a perfect model. We present all models  $\leq 4 \Delta AIC_c$  units (Burnham and Anderson 1998). The fit of each global model was determined by a likelihood ratio test (test of the global null hypothesis that  $\beta = 0$ ;  $\alpha = 0.05$ ). We used an ANOVA to test for a difference in the number of observations between observation bands.

## Results

### Scoter average density

We compared the number of observations in each of the three observation bands we established but found no statistical difference in the number of indicated pairs of scoters observed ( $F_{2,55} = 0.76$ ,  $P = 0.47$ ; inner band  $\bar{x} = 2.06$ ,  $SE = 0.337$ ; middle band  $\bar{x} = 1.89$ ,  $SE = 0.351$ ; outer band  $\bar{x} = 2.48$ ,  $SE = 0.371$ ).

There were 59 observations of scoter indicated pairs. Black Scoters were the most abundant of the three scoter species counted during the breeding pair survey ( $\bar{x} = 0.16$  indicated pairs/ $km^2$ ,  $SE = 0.036$ ). Surf Scoters were next most abundant ( $\bar{x} = 0.11$  indicated pairs/ $km^2$ ,  $SE = 0.035$ ) and White-winged Scoter were least abundant ( $\bar{x} = 0.06$  indicated pairs/ $km^2$ ,  $SE = 0.023$ ). Black Scoter indicated pairs made up 45.8% of all scoter observations, Surf Scoters made up 32.2%, White-wing Scoters 6.8%, and unidentified scoter species 15.2%. We combined all scoter observations for habitat analyses ( $\bar{x} = 0.35$  indicated pairs/ $km^2$ ,  $SE = 0.071$ ) because indicated pair data were too sparse for modelling individual species.

### Site characteristic comparison

Comparison of the average area of each habitat type associated with sites where indicated pairs were observed and sites where no indicated pairs were observed indicates that sites where indicated pairs were present have more area of the small wetlands ( $\leq 100$  ha; Figure 2). Sites where an indicated pair was observed had, on average, 18.5% small wetland landcover, whereas those with no indicated pairs observed had only 5.6% small wetland landcover (Figure 3). Sites where indi-



TABLE 1. Definitions of predictor variables used to build candidate models to estimate resource selection functions for indicated pairs of Black Scoters, Surf Scoters, and White-winged Scoters combined, surveyed in the Hudson Bay Lowlands, Ontario, 7–10 June 2009. All variables were calculated as a proportion of area.

Variable	Description (area = m <sup>2</sup> )
Wetlands ≤5 ha	Area of wetlands between 1 and 5 ha
Wetlands >5 to ≤100 ha	Area of wetlands between 5 and 100 ha
Wetlands ≤100 ha	Area of wetlands between 1 and 100 ha
Wetlands >100 ha	Area of wetlands >100 ha
Deep water	Area of water indicated as deep water on imagery based on spectral reflectance (i.e., deep water was clear and dark, shallow water was light colored from sediment). No depth boundaries are available.
Bog	Area of bog, including lichen rich bog and shrub rich bog
Fen	Area of fen, including shrub rich fen and open fen
Treed wetland	Area of trees growing in wet habitats, including conifer swamp and treed bog
Fen pools	Area of fen with interspersed pools of less than 0.5 ha each

cated pairs were present have less area of the large wetlands (>100 ha) (sites where an indicated pair was observed had only 0.7% large wetland landcover, whereas sites where no indicated pairs were observed had 2.7% large wetland landcover). Also, the average site where indicated pairs were observed had less coverage of fen than sites where no indicated pairs were observed (sites where an indicated pair was observed had 22.6% of fen landcover, whereas sites where no indicated pairs were observed had 30.3% fen landcover). Also, sites where indicated pairs were observed had less treed wetland coverage (sites where indicated pairs were observed had 12.2% treed wetland landcover, whereas sites where no indicated pairs were observed had 18.4% treed wetland landcover).

#### Wetland resource selection functions

We compared 59 sites where indicated pairs were present to 1544 sites where indicated pairs were absent using nine candidate models. The global model fit the data ( $\chi^2 = 33.62$ ,  $P < 0.0001$ ). The most parsimonious model (Table 2, intercept  $\beta = -4.49$ , SE = 0.505) included the proportion of wetlands ≤100 ha ( $\beta = 1.29$ , SE = 0.308) and the occurrence of deep water ( $\beta = -0.43$ , SE = 0.228); however, the addition of the deep water binomial variable was uninformative (i.e., 95% confidence limits of  $\beta$  coefficients included 0). Therefore, we included the proportion of the variable wetlands ≤100 ha in subsequent habitat selection candidate models and considered the model with this variable alone ( $\beta = 1.30$ , SE = 0.307, intercept  $\beta = -4.88$ , SE = 0.462) to be the null model in the assessment of candidate models assessing non-wetland variables.

#### Habitat resource selection functions

We assessed four candidate models. The global model fit the data ( $\chi^2 = 43.94$ ,  $P < 0.0001$ ) and was the most parsimonious. All variables in the most parsimonious model were informative, with the exception of area of fen (intercept = -2.89, SE = 0.299; wetlands ≤100 ha  $\beta = 3.22$ , SE = 0.629; treed wetland  $\beta = -2.45$ , SE = 0.949; and fen  $\beta = -1.27$ , SE = 0.684). We considered one other model that was similar to the most

parsimonious but did not include the variable area of fen. The model averaged coefficients were similar to those of the most parsimonious model (intercept = -3.04, SE = 0.274; wetlands ≤100 ha  $\beta = 3.36$ , SE = 0.619; and treed wetland  $\beta = -2.15$ , SE = 0.949). The most parsimonious model had an area under the receiver operating characteristic curve of 0.77 (95% CL = 0.72–0.82).

#### Discussion

Although we made assumptions about high detection rates of scoter indicated pairs during aerial surveys and the similarity of the habitat selected by the three species, we feel we introduced negligible bias in the analysis results. Sea ducks are known to be highly visible during aerial breeding pair surveys (Ross 1987) and so we assumed that areas where scoter indicated pairs were not observed during our survey were not being used by breeding scoters during the survey. Finding no statistical difference in the number of observations per observation band during the survey provides support for our assumption. We believe that grouping the species was justified, as there is evidence that they have similar breeding habitat requirements in the Hudson Bay Lowlands (Ross 2007a, 2007b, 2007c; Abraham et al. 2008). Both the Black Scoter and the Surf Scoter use relatively small wetlands (<10 ha) and tend to avoid large lakes for breeding (Bordage and Savard 1995; Savard et al. 1998). The White-winged Scoter uses larger wetlands (>50 ha) (Brown et al. 1997; Traylor et al. 2004), preferring to nest on islands when in prairie habitat. However, breeding habitat in the Hudson Plains ecozone for these species has been described based on only scant evidence, with the exception of the Black Scoter, and each species has a relatively wide (continental) breeding range, making it difficult to compare the published descriptions of breeding sites for these species.

Ross (unpublished data) estimated a Black Scoter breeding density of 0.026 indicated pairs/km<sup>2</sup> with a peak of 0.08 pairs/km<sup>2</sup> in 1987 and 1988 in the general vicinity of our 2009 survey. The peak was only half

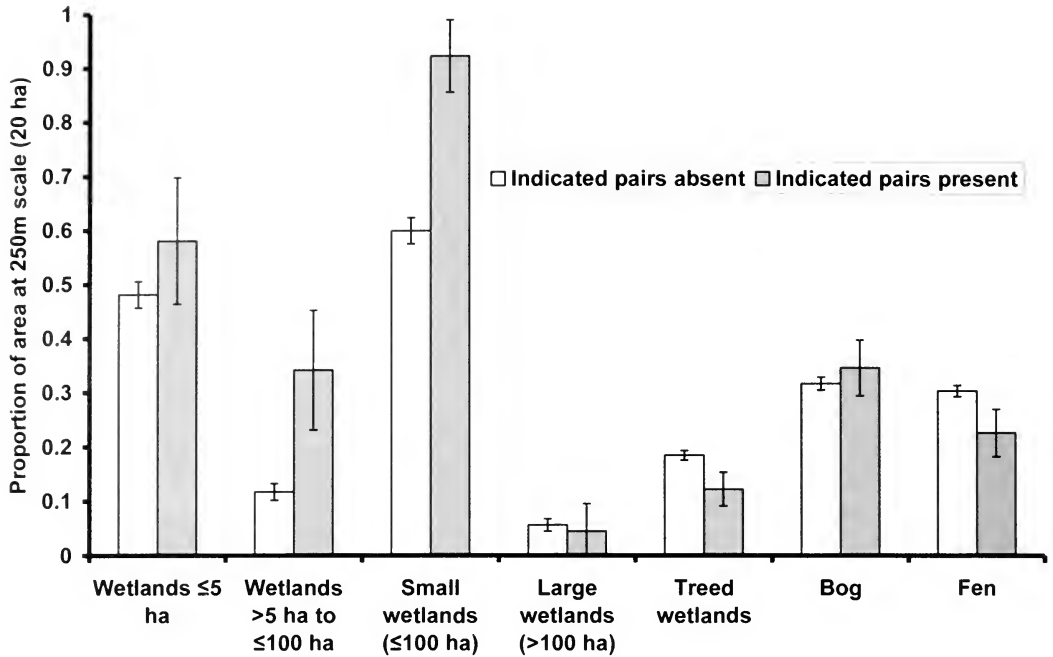


FIGURE 2. Mean proportion of habitat types. Wetland proportions are based on the total wetland habitat only. Proportions of non-wetland habitats are based on total of all habitat types. "Indicated pairs present" indicates area of habitat for sites where indicated pairs of Black Scoters, Surf Scoters, and White-winged Scoters combined were observed during aerial surveys of the Hudson Bay Lowlands, Ontario, 7–10 June 2009.

the density that we estimated ( $0.16$ ,  $SE = 0.036/km^2$ ), likely because the 1987 and 1988 surveys were not timed for scoters (they were conducted earlier in the season and were better suited to observe dabbling ducks). Our Black Scoter densities are comparable to the estimate of  $0.12$  indicated pairs/ $km^2$  for the highest density areas of northern Quebec (Savard and Lamothe 1991).

Likewise, our estimated densities of indicated pairs of Surf Scoters ( $0.11/km^2$ ) are double the peak estimate of  $0.05$  pairs/ $km^2$  of Ross (1987) and are comparable with estimates of  $0.10/km^2$  for the highest density areas of northern Quebec (Gauthier and Aubry 1996). Savard and Lamothe (1991) reported Surf Scoter brood densities as high as  $0.05/km^2$  in northern Quebec (this would be an underestimate of breeding pairs, as not all nests are successful).

Our estimated densities of indicated pairs of White-winged Scoter were the lowest of the three species that we observed ( $0.06/km^2$ ) and were similar to the estimated peak abundance of  $0.042$  indicated pairs/ $km^2$  reported by Ross (1987) from the area to the immediate west of our study area. Unlike the estimated densities for the two other scoter species, this estimate was much lower than densities observed inland from the James Bay coast in Quebec of  $0.80$  pairs/ $km^2$  (Gauthier and Aubry 1996).

We report results for the 250 m spatial scale only, but we found that selection for wetland habitat was similar between the two scales we analyzed. At the 250 m scale (20 ha), breeding scoters were observed at sites with disproportionately more area of small wetlands ( $\leq 100$  ha). When we investigated models that contained only the variable wetlands  $\leq 5$  ha, the coefficient was uninformative, suggesting there was no significant preference for sites with these smallest wetlands. There was also no indication that there was selection for areas with deep water or lakes (i.e., wetlands  $> 100$  ha), as these variables produced a negative coefficient but were uninformative.

The dominant forest cover in the study area was treed wetland (Table 1). Other dry forest cover types made up less than 2% of the study area. Treed wetland included conifer swamp with dominant cover species of Tamarack (*Larix laricina*) and Black Spruce (*Picea mariana*) and an understory dominated by willow (*Salix* spp.). Treed bog (also included in treed wetland) was similarly dominated by Black Spruce with an understory dominated by Leatherleaf (*Chamaedaphne calyculata*) and Common Labrador Tea (*Rhododendron groenlandicum*). Treed wetland appeared to be avoided by breeding scoters, as indicated by the negative coefficient we detected. Treed wetland was uninformative only after model averaging. Fen was com-

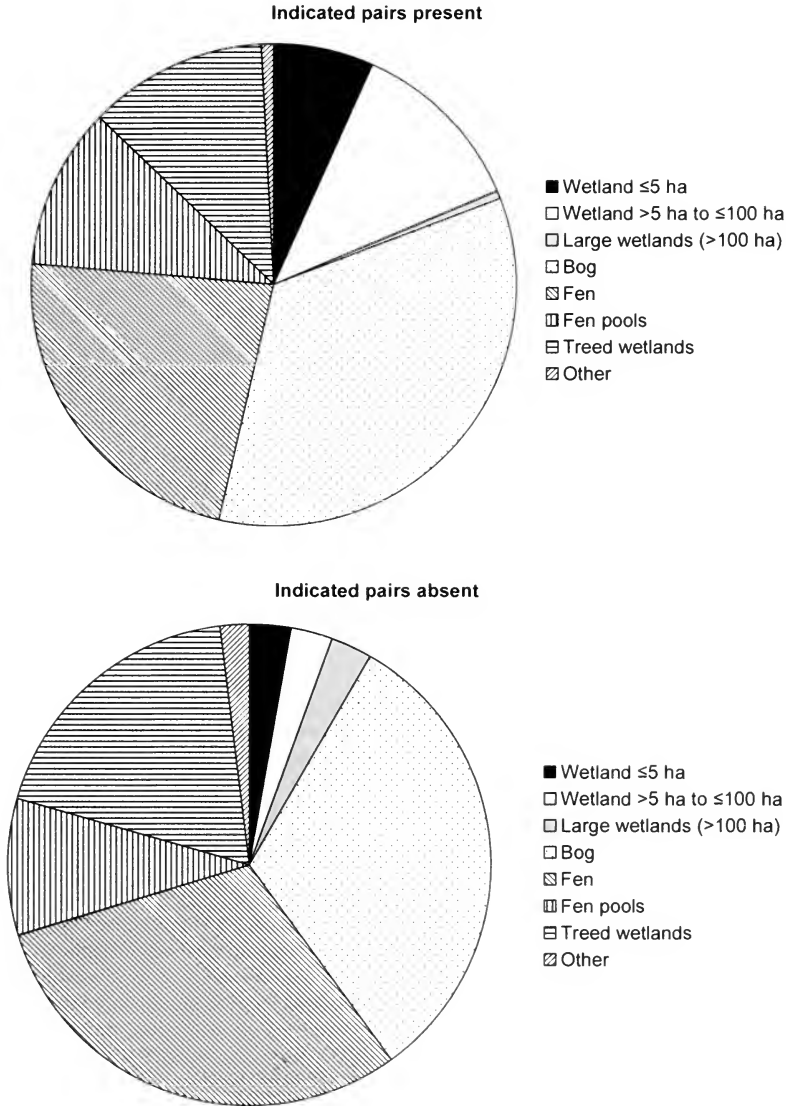


FIGURE 3. Pie charts showing average proportion of each habitat type at sites where at least one indicated pair of Black Scoters, Surf Scoters, and White-winged Scoters combined were observed (Indicated pairs present) or for sites where none were observed (Indicated pairs absent) during aerial surveys of the Hudson Bay Lowlands, Ontario, 7–10 June 2009.

posed of open fen habitat dominated by sedges (*Carex* spp.) and grasses/rushes (*Scirpus* spp.) and shrub rich fen dominated by Tamarack, willow, and dwarf birch (*Betula* spp.). There was also a negative correlation with fen, suggesting scoter indicated pairs were observed in sites with less fen area. The habitat selected appears to be less fen and forest area in favor of more area of small wetlands ( $\leq 100$  ha).

We estimated model performance of the resource selection functions using area under the curve of the receiver operating characteristic. We considered mod-

els with values ranging between 0.7 and 0.9 as having useful application (Manel et al. 2001; Boyce et al. 2002). The area under the curve for the most parsimonious model suggests useful application, but its performance was not stellar (i.e., low end of the useful range).

Our surveys provide evidence of some of the highest densities of Black Scoter and Surf Scoter observed in northern Canada. Delineating the area over which these densities are applicable is important for understanding the overall contribution of the Hudson Bay

TABLE 2. Model selection results. Candidate models were fit to data describing presence in wetland habitats of indicated pairs of Black Scoters, Surf Scoters, and White-winged Scoters combined, surveyed in the Hudson Bay Lowlands, Ontario, 7–10 June 2009 (i.e., models included only wetland variables). Table includes only models  $\leq 4 \Delta AIC_c$  units.  $\Delta AIC_c$  = difference between Akaike's Information Criterion corrected for small sample size for most parsimonious model and the model in question; cumulative  $w$  = cumulative model weight (model weight is an indication of relative model importance);  $K$  = number of estimable parameters;  $-2LL = -2 * \text{the model log likelihood}$ .

Model	$\Delta AIC_c$	Cumulative $w$	$K$	$-2LL$
Presence of indicated pairs in wetland habitat				
Wetlands $\leq 100$ ha + deep water	0.000	0.574	3	471.83
Wetlands $\leq 100$ ha	0.603	0.998	2	474.73
Presence of indicated pairs in habitats <sup>1</sup>				
Treed wetland + fen	0.000	0.582	4	461.51
Treed wetland	1.507	0.855	3	465.31

<sup>1</sup> All models contain the variable wetlands  $\leq 100$  ha.

Lowlands to the continental population of each species. If the densities are similar elsewhere in the vast Lowlands, it indicates a high conservation value for this remote and pristine area and suggests it may be a major source of the moulting scoters in nearby James Bay and Hudson Bay. Once we have tested and validated our resource selection functions outside our study area to determine their overall utility, we will use them to help refine distribution estimates. These estimates and models will be useful for land use and waterfowl conservation planning application in the entire Hudson Bay Lowland ecozone, as there are currently no predictive habitat models for breeding scoters in northern Canada.

### Acknowledgements

We thank the Sea Duck Joint Venture for funding. We also thank pilot Andrew Fitch for his expert flying and Mike Hunter for radio operation. We thank two anonymous reviewers for their helpful comments.

### Documents Cited (marked \* in text)

- Caithamer, D. F., M. Otto, P. I. Padding, J. R. Sauer, and G. H. Haas.** 2000. Sea ducks in the Atlantic Flyway: population status and a review of special hunting seasons. Unpublished report. U.S. Fish and Wildlife Service, Laurel, Maryland.
- Crins, W. J., P. A. Gray, P. W. C. Uhlig, and M. C. Webster.** 2009. The ecosystems of Ontario, Part 1: ecoregions and ecoregions. SIB Report TER IMA TR 01. Ontario Ministry of Natural Resources, Inventory, Monitoring and Assessment Section. Peterborough, Ontario.
- ESRI (Environmental Systems Resource Institute).** 2009. ArcMap Release 9.3.1. Environmental Systems Research Institute, Redlands, California.
- Gilleland, S., C. Lepage, J-P. L. Savard, D. Bordage, G. J. Robertson, and E. Reid.** 2009. SDJV Project #115: Developmental surveys for breeding scoters in eastern North America. <http://seaduckjv.org/studies/pro3/pr115.pdf>. (Accessed 15 July 2012.)
- Sea Duck Joint Venture.** 2007. Recommendations for monitoring distribution, abundance and trends for North American sea ducks. December 2007. U.S. Fish and Wildlife

Service, Anchorage, Alaska, and Canadian Wildlife Service, Sackville, New Brunswick. <http://seaduckjv.org/monitor.htm>. (Accessed 19 December 2011.)

### Literature Cited

- Abraham, K. F., and C. E. Keddy.** 2005. The Hudson Bay Lowland: a unique wetland legacy. (Chapter 4). Pages 118-148 in *The World's Largest Wetlands: Ecology and Conservation*. Edited by L. H. Fraser and P. A. Keddy. Cambridge University Press, Cambridge.
- Abraham, K. F., D. M. Filliter, and D. A. Sutherland.** 2008. First documentation of Black Scoter breeding in Ontario. *Ontario Birds* 26: 108-118.
- Akaike, H.** 1973. Information theory as an extension of the maximum likelihood principle. Pages 267-281 in *Second International Symposium on Information Theory*. Edited by B. N. Petrov and F. Csaki. Akademiai Kiado, Budapest, Hungary.
- Bordage, D., and J-P. L. Savard.** 1995. Black Scoter (*Melanitta nigra*). In *The Birds of North America*, No. 177. Edited by A. Poole and F. Gill. Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.
- Boyce, M. S., P. R. Vernier, S. E. Nielsen, and F. K. A. Schmiegelow.** 2002. Evaluating resource selection functions. *Ecological Modelling* 157: 281-300.
- Brown, P. W., and L. H. Fredrickson.** 1997. White-winged Scoter (*Melanitta fusca*). In *The Birds of North America*, No. 274. Edited by A. Poole and F. Gill. Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.
- Burnham, K. P., and D. R. Anderson.** 1998. *Model Selection and Inference: A Practical Information-Theoretic Approach*. Springer-Verlag, New York.
- Cadman, M. D., D. A. Sutherland, G. C. Beck, D. LePage, and A. R. Couturier (Editors).** 2007. *Atlas of the Breeding Birds of Ontario 2001-2005*. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto.
- Cumming, G. S.** 2000. Using between-model comparisons to fine-tune linear models of species ranges. *Journal of Biogeography* 27: 441-455.
- Dzubin, A.** 1969. Assessing breeding populations of ducks by ground counts. Pages 178-237 in *Saskatoon Wetlands*

- Seminar: Transactions of a seminar on small water areas in the prairie pothole region, held February 20 to 22, 1967, to mark the opening of the Prairie Migratory Bird Research Centre in Saskatoon, Saskatchewan. Canadian Wildlife Service Report Series, Number 6.
- Ecological Stratification Working Group.** 1996. A National Ecological Framework for Canada. Centre for Land and Biological Resources Research, Research Branch, Agriculture and Agri-Food Canada, and State of the Environment Directorate, Environment Conservation Service, Environment Canada, Ottawa. <http://sis.agr.gc.ca/cansis/publications/ecostrat/intro.html#report> and <http://ecozones.ca/english/>.
- Gauthier, J., and Y. E. Aubry.** 1996. The Breeding Birds of Québec: Atlas of the Breeding Birds of Southern Québec. Association québécoise des groupes d'ornithologues; Province of Quebec Society for the Protection of Birds; and Canadian Wildlife Service, Environment Canada, Quebec Region, Montreal.
- Keddy, P. A., and L. H. Fraser.** 2005. Introduction: big is beautiful. Pages 1-10 in *The World's Largest Wetlands: Ecology and Conservation*. Edited by L. H. Fraser, and P. A. Keddy. Cambridge University Press, Cambridge, U.K.
- Manel S., H. Ceri Williams, and S. J. Ormerod.** 2001. Evaluating presence/absence models in ecology: the need to account for prevalence. *Journal of Applied Ecology* 38: 921-931.
- Manly, B. F. J., L. L. McDonald, and D. L. Thomas.** 1993. *Resource Selection by Animals: Statistical Design and Analysis for Field Studies*. Chapman & Hall, London.
- Riley, J. L.** 2011. Wetlands of the Hudson Bay Lowland: An Ontario Overview. Nature Conservancy of Canada, Toronto.
- Ross, R. K.** 1982. Duck distribution along the James and Hudson Bay coasts of Ontario. *Le Naturaliste canadien* 109: 927-932.
- Ross, R. K.** 1987. Interim report on waterfowl breeding pair surveys in northern Ontario. Canadian Wildlife Service Progress Note 168.
- Ross, R. K.** 1994. The Black Scoter in northern Ontario. *Ontario Birds* 12: 1-7.
- Ross, R. K.** 2007a. Surf Scoter. Pages 100-101 in *Atlas of the Breeding Birds of Ontario 2001-2005*. Edited by M. D. Cadman, D. A. Sutherland, G. C. Beck, D. LePage, and A. R. Couturier. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto.
- Ross, R. K.** 2007b. White-winged Scoter. Pages 102-103 in *Atlas of the Breeding Birds of Ontario 2001-2005*. Edited by M. D. Cadman, D. A. Sutherland, G. C. Beck, D. LePage, and A. R. Couturier. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto.
- Ross, R. K.** 2007c. Black Scoter. Pages 104-105 in *Atlas of the Breeding Birds of Ontario 2001-2005*. Edited by M. D. Cadman, D. A. Sutherland, G. C. Beck, D. LePage, and A. R. Couturier. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto.
- Savard, J.-P. L., and P. Lamothe.** 1991. Distribution, abundance, and aspects of breeding ecology of Black Scoters, *Melanitta nigra*, and Surf Scoters, *M. perspicillata*, in northern Québec. *Canadian Field-Naturalist* 105: 488-496.
- Savard, J. L., D. Bordage, and A. Reed.** 1998. Surf Scoter (*Melanitta perspicillata*). In *The Birds of North America*, No. 363. Edited by A. Poole and F. Gill. Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.
- Sea Duck Joint Venture.** 2008. Sea Duck Joint Venture Strategic Plan 2008-2012. U.S. Fish and Wildlife Service, Anchorage, Alaska, and Canadian Wildlife Service, Sackville, New Brunswick.
- Sokal, R. R., and F. J. Rohlf.** 1998. *Biometry: The Principles and Practice of Statistics in Biological Research*. Third edition. W. H. Freeman and Co., New York.
- Spectranalysis Inc.** 1997. User manual on the Ontario provincial land cover data base with recommendations for data base management. Spectranalysis Inc., Oakville, Ontario.
- Thomas, V. G., and J. P. Prevett.** 1982. The roles of the James and Hudson Bay lowland in the annual cycle of geese. *Le Naturaliste Canadien* 109: 913-925.
- Traylor, J. J., R. T. Alisauskas, and F. P. Kehoe.** 2004. Nesting ecology of White-Winged Scoters (*Melanitta fusca deglandi*) at Redberry Lake, Saskatchewan. *The Auk* 121: 950-962.

Received 5 January 2012

Accepted 30 June 2012

## Notes

### Implantation and Parturition Dates of North American River Otters, *Lontra canadensis*, in Southern Missouri

NATHAN M. ROBERTS<sup>1,3</sup>, SHAWN M. CRIMMINS<sup>2</sup>, DAVID A. HAMILTON<sup>1</sup>, and ELSA GALLAGHER<sup>1</sup>

<sup>1</sup>Missouri Department of Conservation, Central Regional Office and Conservation Research Center 3500 East Gans Road, Columbia, Montana 65201 USA

<sup>2</sup>Department of Forest Management, University of Montana, Missoula, Montana 59812 USA

<sup>3</sup>Present address: United States Fish and Wildlife Service, Alaska Region, 1011 East Tudor Avenue, Anchorage, Alaska, USA

Roberts, Nathan M., Shawn M. Crimmins, David A. Hamilton, and Elsa Gallagher. 2012. Implantation and parturition dates of North American River Otters, *Lontra canadensis*, in southern Missouri. *Canadian Field-Naturalist* 126(1): 28–30.

Despite numerous studies of reproductive dynamics of the North American River Otter (*Lontra canadensis*), relatively little information exists on the implantation or parturition dates of North American River Otters in the wild. We collected carcasses of North American River Otters that had been legally harvested in southern Missouri, USA, between 1997 and 1999 as part of a larger population dynamics study. Embryos ( $n = 28$ ) were removed from a subset of North American River Otters ( $n = 9$ ) during necropsy. Using harvest dates and crown–rump length measurements of embryos, we estimated implantation dates, which ranged from 7 December to 12 January, and parturition dates, which ranged from 8 February to 15 March (assuming an implantation time of 63 days). Our results are similar to other studies that have reported parturition dates ranging from mid-January to early May in more extreme latitudes. Our results suggest that variation in implantation and parturition dates among populations are likely related to factors affected by latitude such as photoperiod and winter weather severity.

**Key Words:** North American River Otter, *Lontra canadensis*, implantation, parturition, reproduction, Missouri.

North American River Otters (*Lontra canadensis*) are one of the most widespread and commercially valuable furbearers in North America (Melquist et al. 2003). Although unregulated trapping and habitat destruction reduced North American River Otter populations throughout much of their historical range (Anderson 1977), reintroduction programs throughout North America have restored North American River Otter populations in many areas (Raesly 2001). North American River Otter populations in many areas have recovered and in some cases have increased beyond post-settlement levels (Hamilton 1998\*).

Because of the variety of habitats in which North American River Otters occur and the abundance of translocated populations throughout North America (>20), there is extreme variability in reproductive dynamics (Chilelli et al. 1996, Raesly 2001). Implantation and parturition dates of North American River Otters have been estimated primarily from native populations at extreme northern or southern latitudes (McDaniel 1963; Woolington 1984; Polechla 1987). Relatively little information exists on the reproductive timing of North American River Otters in introduced or restored populations, or in areas of middle latitude. It is unknown whether reproductive timing in restored populations is driven by factors related to geographic location, such as photoperiod and habitat quality, or by remnant behavioral and genetic patterns from source populations.

Knowledge of parturition timing is of interest to wildlife managers, as harvest regulations often consider the consequences of removing adult animals with dependent offspring. Our objectives were to estimate implantation and parturition dates of North American River Otters in a restored population occurring at mid-range latitudes in southern Missouri.

#### Study Area and Methods

We conducted our study in the Ozark region of southern Missouri (37°19'N, 91°58'W). The area is characterized by deeply dissected sandstone, limestone, and dolomite hills. There is moderate to high relief near the rivers, with limestone formations dominating much of the riparian area. Upland areas are primarily oak (*Quercus* spp.) and hickory (*Carya* spp.) woodlands with occasional pine (*Pinus* spp.) and oak woodland and cleared agricultural land. Streams of the region are influenced by numerous springs that contribute to significant base flow and limit overwinter freezing. Streams are also characterized by low turbidity and well-defined riffle–pool complexes. As such, river systems of the region tend to support high densities of North American River Otter prey and structural habitat (Hamilton 1998\*; Roberts 2003).

Between 1982 and 1992, the Missouri Department of Conservation released 845 North American River Otters into various rivers in Missouri, with the majority being released in the Ozarks (Hamilton 1998\*). A

TABLE 1. Estimated implantation and parturition dates for North American River Otters harvested in the Missouri Ozarks between 1997 and 1999. Mean length is crown-rump length of embryos.

ID	Age (years)	Number of embryos	$\bar{x}$ length (mm)	Harvest date	Estimated implantation date	Estimated parturition date
299	5	4	29.75	20 January 1997	7 January 1997	11 March 1997
288	1	4	124.25	February 1997	December 1996	late February 1997
248	3	4	111.25	February 1997	December 1996	late February 1997
294	4	3	124.33	February 1997	December 1996	late February 1997
647	1	1	42.00	8 January 1998	21 December 1997	22 February 1998
639	1	4	80.00	11 January 1998	7 December 1997	8 February 1998
657	4	3	51.33	17 January 1998	26 December 1997	27 February 1998
642	1	2	65.00	17 January 1998	20 December 1997	5 March 1998
1051	1	3	19.00	20 January 1999	12 January 1999	15 March 1999

small remnant population of approximately 20 individuals was thought to exist at the onset of re-introduction efforts. Most North American River Otters used during the reintroduction were live-captured and translocated from free-ranging populations in Arkansas and Louisiana in the United States and in Ontario in Canada (Raesly 2001). In 1996, the Missouri Department of Conservation determined that the North American River Otter population in Missouri was recovered, based on increasing incidental harvest and public sightings, and a public trapping season was opened.

We collected North American River Otter carcasses from trappers during the 1996-1997 ( $n = 140$ ), 1997-1998 ( $n = 124$ ), and 1998-1999 ( $n = 123$ ) trapping seasons. All carcasses were collected within one week of harvest to reduce tissue degradation. Carcasses were aged using radiograph (Kuehn and Berg 1983) and cementum annuli analysis of canine teeth (Stephenson 1977). We collected reproductive data by examining the reproductive tracts from a random subset of carcasses. Carcasses were visually examined for the presence of embryos (Harder and Kirkpatrick 1996). Embryos were aged by measuring crown-rump length, according to Hill and Lauhachinda (1981). Implantation and parturition dates were estimated assuming an implantation time of 63 days (Cocks 1881; Polechla 1987; Larivière and Walton 1998).

## Results and Discussion

Embryos were recovered from nine North American River Otters, ranging in age from one to five years (Table 1). The number of embryos ranged from one to four ( $\bar{x} = 3.11$ ,  $SD = 1.05$ ). Estimated implantation dates ranged from 7 December to 12 January (Table 1). Estimated parturition dates ranged from 8 February to 15 March (Table 1). The exact harvest dates for three of the North American River Otters were unknown, and implantation and parturition dates were estimated as December and February, respectively.

Implantation dates in North American River Otters vary latitudinally and are thought to be triggered by photoperiod (Melquist and Dronkert 1987). At southern latitudes (which have longer photoperiods), implantation may occur as early as mid-November (McDaniel 1963), while at northern latitudes (which have extremely short photoperiods) implantation can occur as late as mid-February (Woolington 1984). Parturition dates in North American River Otters can also exhibit extreme variability across latitudes. At southern latitudes, parturition can occur as early as mid-January (McDaniel 1963). Conversely, at extreme northern latitudes, parturition may not occur until May (Woolington 1984; Noll 1988). Our estimated implantation and parturition dates fall within the range of values reported by previous researchers; this would be expected, given the mid-range latitude of our study area.

Our study population exhibited high reproductive rates (~3 young per adult) and a young age at first reproduction (Gallagher 1999). Reported reproductive rates in other populations are typically below three corpora lutea per adult (e.g., Hamilton and Eadie 1964; Lauhachinda 1978; Docktor et al. 1987), with juvenile reproduction considered anomalous (Chillelli et al. 1996). Differences in the timing and duration of estrus among age groups may affect breeding and implantation dates (Harder and Kirkpatrick 1996). Extrinsic factors such as habitat quality and forage abundance, which were very high in our study area (Roberts 2003), may also affect reproductive dynamics (Melquist et al. 2003) and thus implantation and parturition dates. We did not have a sufficiently large sample to determine age-related differences in implantation or parturition dates, but our estimated dates were well within the range of reported values, despite the high quality of habitat in our study area, suggesting that factors related to latitude (e.g., photoperiod, winter weather severity) may be more important than habitat quality in dictating reproductive timing of North American River Otters.

### Acknowledgements

Support for this project was provided by the Missouri Department of Conservation and the University of Missouri. We thank the many trappers who assisted this project by donating carcasses.

### Documents Cited (marked \* in text)

**Hamilton, D. A.** 1998. Missouri otter population assessment. Missouri Department of Conservation, Columbia, Missouri.

### Literature Cited

- Anderson, S.** 1977. Geographic ranges of North American terrestrial mammals. *American Museum Novitates* 2629: 1-15.
- Chilelli, M. E., B. Griffith, and D. J. Harrison.** 1996. Interstate comparisons of river otter harvest data. *Wildlife Society Bulletin* 24: 238-246.
- Cocks, A. H.** 1881. Notes on the breeding of the otter. *Proceedings of the Zoological Society of London* 1881: 249-250.
- Docktor, C. M., R. T. Bowyer, and A. G. Clark.** 1987. Number of corpora lutea as related to age and distribution of river otter in Maine. *Journal of Mammalogy* 68: 182-185.
- Gallagher, E.** 1999. Monitoring trends in reintroduced river otter populations. M.S. thesis, University of Missouri, Columbia, Missouri.
- Hamilton, W. J. Jr., and W. R. Eadie.** 1964. Reproduction in the otter, *Lutra canadensis*. *Journal of Mammalogy* 45: 242-252.
- Harder, J. D., and R. L. Kirkpatrick.** 1996. Physiological methods in wildlife research. Pages 275-306 in *Research and Management Techniques for Wildlife and Habitats*. Edited by T. Bookhout. Allen Press, Lawrence, Kansas.
- Hill, E. P., and V. Lauhachinda.** 1981. Reproduction in river otters from Alabama and Georgia. Pages 478-486 in *Proceedings of the Worldwide Furbearer Conference*. Edited by J. Chapman and D. Pursley. Frostburg State University, Frostburg, Maryland.
- Kuehn, D. W., and W. E. Berg.** 1983. Use of radiographs to identify age-classes of fisher. *Journal of Wildlife Management* 45: 1009-1010.
- Larivière, S., and L. R. Walton.** 1998. *Lontra canadensis*. *Mammalian Species* 587: 1-8.
- Lauhachinda, V.** 1978. Life history of the river otter in Alabama with emphasis on food habits. Ph.D. dissertation, Auburn University, Auburn, Alabama.
- McDaniel, J. C.** 1963. Otter population study. *Proceedings of the Southeastern Association of Fish and Game Commissioners* 17: 163-168.
- Melquist, W. E., and A. E. Dronkert.** 1987. River otter. Pages 625-641 in *Wild Furbearer Management and Conservation in North America*. Edited by M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch. Ontario Trappers Association, North Bay, Ontario.
- Melquist, W. E., P. J. Polechla Jr., and D. Toweill.** 2003. River otter. Pages 708-734 in *Wild Mammals of North America: Biology, Management, and Conservation*. Edited by G. A. Feldhamer, B. C. Thompson, and J. A. Chapman. Johns Hopkins University Press, Baltimore, Maryland.
- Noll, J. M.** 1988. Home range, movement, and natal denning of river otters (*Lontra canadensis*) at Kelp Bay, Baranof Island, Alaska. M.S. thesis, University of Alaska, Fairbanks, Alaska.
- Polechla, P. J.** 1987. Status of river otter populations in Arkansas with special reference to reproductive biology. Ph.D. dissertation, University of Arkansas, Fayetteville, Arkansas.
- Raesly, E. J.** 2001. Progress and status of river otter reintroduction projects in the United States. *Wildlife Society Bulletin* 29: 856-862.
- Roberts, N. M.** 2003. River otter food habits in the Missouri Ozarks. M.S. thesis, University of Missouri, Columbia, Missouri.
- Stephenson, A. J.** 1977. Age determination and morphological variation of Ontario otters. *Canadian Journal of Zoology* 55: 1577-1583.
- Woolington, J. D.** 1984. Habitat use and movements of river otters at Kelp Bay, Baranof Island, Alaska. M.S. thesis, University of Alaska, Fairbanks, Alaska.

Received 15 April 2009

Accepted 14 May 2012



## Kudzu Vine, *Pueraria montana*, Adventive in Southern Ontario

GERALD E. WALDRON<sup>1</sup> and BRENDON M. H. LARSON<sup>2</sup>

<sup>1</sup>7641 County Road 20, R.R. #1, Amherstburg, Ontario N9V 2Y7 Canada; email: waldronmsc@cdpwise.net

<sup>2</sup>Department of Environment and Resource Studies, University of Waterloo, Waterloo, Ontario N2L 3G1 Canada; email: blarson@uwaterloo.ca

Waldron, Gerald E. and Brendon M. H. Larson. 2012. Kudzu Vine, *Pueraria montana*, adventive in southern Ontario. *Canadian Field-Naturalist* 126(1): 31–33.

Kudzu is reported for the first time in Canada. A population was found covering about 3500 m<sup>2</sup> on a bank above Lake Erie near the town of Leamington, Ontario. We detected high seed viability and germination rates but no evidence that the population has been expanding beyond this site. Nonetheless, we recommend that measures be taken to prevent its continued expansion.

Key Words: invasive species, Kudzu, *Pueraria montana*, seed set, Soybean Rust, *Phakopsora pachyrizii*, Canada.

On 11 May 2009, while conducting a floral inventory in a ravine near the Town of Leamington, Ontario, the senior author and field assistant P. J. Hurst observed an area along the Lake Erie shore that supported a rank growth of woody vine (Figure 1). Based on the senior author's experience with the flora of the southern United States, the vine was tentatively identified as Kudzu, *Pueraria montana* (Lour.) Merr. (*Pueraria*

*lobata* (Willd.) Ohwi, *Glycine javanica* L.), a perennial vine in the family Fabaceae.

Kudzu is considered one of the 100 worst bioinvasaders in the world (Global Invasive Species Database 2007\*). It was introduced to North America from eastern Asia in 1876 as a feature in the Japanese exhibit at the Centennial International Exposition held in Philadelphia, Pennsylvania. Initially introduced as an orna-



FIGURE 1. Kudzu growing on a slope above Lake Erie near Leamington, Ontario.

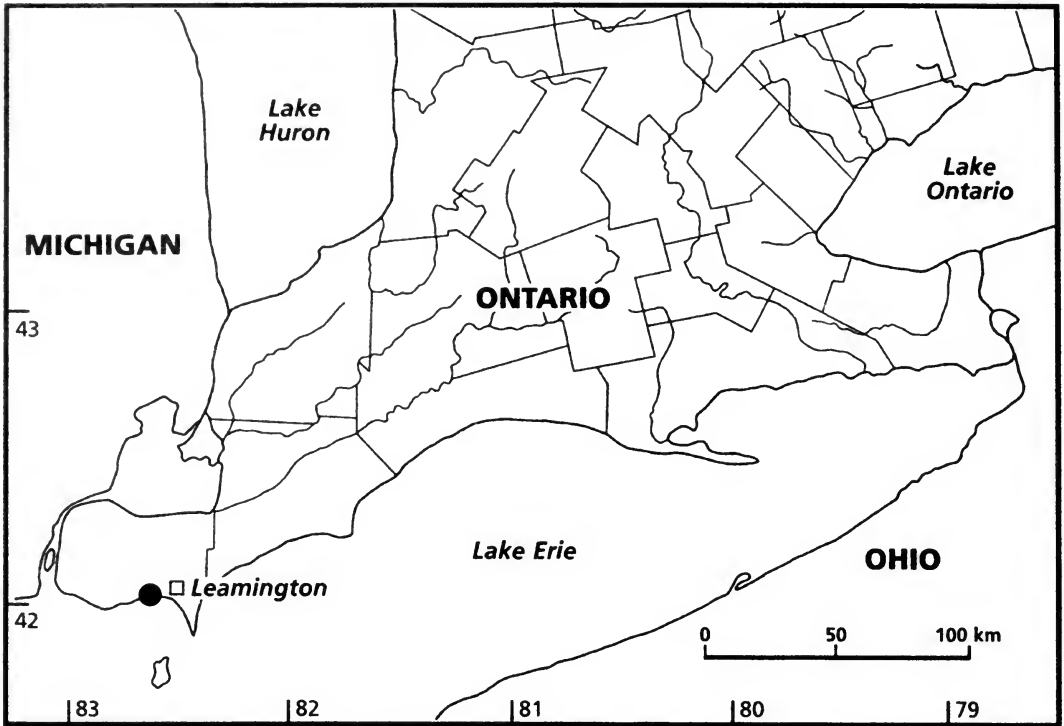


FIGURE 2. Location of Kudzu in southern Ontario, 2009.

mental, the species was later promoted as a forage crop and for stabilizing eroding banks (Winberry & Jones 1973; Alderman 2004). It is now estimated to occupy approximately 3000 km<sup>2</sup> in the southeastern United States and is increasing its coverage by over 500 km<sup>2</sup> a year (Sage et al. 2008). Kudzu is classified in most states where it occurs as a noxious weed. It is prohibited and banned as potentially invasive in Connecticut and Massachusetts (United States Department of Agriculture Natural Resources Conservation Service\*). In Canada it is the subject of a fact sheet in the series 'Ontario's Least Wanted' produced by the Ontario Invasive Plant Council but it has no official status and is not designated a noxious weed under the Weed Control Act (M. Irvine, personal communication to G.E.W.).

The discovery near Leamington is the first reliable observation of Kudzu in Canada. Winberry and Jones (1973) state that Kudzu had been reported in Nova Scotia, but it is neither included in the Flora of Nova Scotia (Zinck 1998\*) nor are there specimens in the E. C. Smith Herbarium at Acadia University in Wolfville, Nova Scotia (R. Newell, personal communication to G.E.W.). The Atlantic Canada Conservation Data Centre considers it reported but unconfirmed and it has not been officially listed in the flora of Nova Scotia (S. Blaney, personal communication to G.E.W.).

The Lake Erie shore at this location (Figure 2) consists of a steep south-facing bank approximately 12

m in height. The tableland soils are classified as Fox Sandy Loam (Richards 1989\*). Outwash sands compose most of the bank face; the underlying compact, gritty glacial till is exposed at the base of the bank just above a narrow sand-gravel beach.

At the site, Kudzu vines form a solid blanket from the beach to the top of bank, a distance of 31 m, along 113 m of shoreline. The following species were observed growing with the Kudzu: Manitoba Maple (*Acer negundo* L.), Hackberry (*Celtis occidentalis* L.), Lamb's Quarters (*Chenopodium album* L.), White Mulberry (*Morus alba* L.), Eastern Cottonwood (*Populus deltoides* Bartram ex Marshall), and Burr Cucumber (*Sicyos angulatus* L.). Kudzu vines had climbed the woody plants to a height of 8 m. Bank vegetation to either side of the Kudzu growth included Tree-of-heaven (*Ailanthus altissima* (Miller) Swingle), Sugar Maple (*Acer saccharum* Marshall), Large-tooth Aspen (*Populus grandidentata* Michaux), Red Oak (*Quercus rubra* L.), Black Cherry (*Prunus serotina* Ehrh.), Black Locust (*Robinia pseudo-acacia* L.), Staghorn Sumac (*Rhus typhina* L.) and Riverbank Grape (*Vitis riparia* Michaux).

Kudzu is reported to set seed only infrequently in North America (Ahlgren 1949; Winberry and Jones 1973), but the Leamington plants produced abundant seed in 2009. On 21 September 2009, the Kudzu was in full flower and heavily scented. Several bees were observed visiting the flowers, including the exotic

*Megachile sculpturalis* Smith, a giant resin bee. Seeds gathered in the first week of November, after a killing frost, had an 80% germination rate (16 of 20 seeds) using the method described by Susko et al. (1999, 2001). These seeds were viable even though 2009 was cooler than average at 3359 heat units (compared to average from 10 May to 30 September of 3459, based on data from the nearby Agriculture and Agrifood Research Station at Harrow, Ontario [G. Stasko, personal communication to G.E.W.]). This area averages 815 cm of precipitation and the mean annual frost-free period is about 185 days (Sanderson 1980\*).

There is concern that Kudzu could function as an alternative overwintering host to Soybean Rust (*Phakopsora pachyrizi*) and thus provide an inoculum reservoir (T. Anderson, personal communication to G.E.W.). In 2009, the tableland above the lake bank was planted to Soybean, *Glycine max*. Although Kudzu vines had grown 14 m into the Soybean field there was no evidence that they were infected with rust (T. Anderson, personal communication to G.E.W.).

The provenance of this station is unknown as the present owner states that it was extant when he acquired the property over a decade ago. It may have been planted to stabilize the eroding bank. Kudzu is found in the adjacent state of Michigan at two locations along the Lake Michigan shore at a distance of over 300 km from the Ontario site. It also occurs in Ohio near the south shore of Lake Erie in East Cleveland about 100 km distant across the lake (A. A. Reznicek, personal communication to G.E.W.). In these locations it does not appear to be aggressively expanding from the original site. Given the high seed viability, it is likely that Kudzu will spread within the immediate area and perhaps further into southern Ontario, especially with climatic warming, unless measures are taken to prevent its dispersal.

**Specimen vouchers:** ONTARIO: Essex: shore of Lake Erie near Leamington, 42°02'07.01"N, 82°39'19.11"W. G. E. Waldron and P. J. Hurst, 11 May 2009 (MICH); shore of Lake Erie, Leamington 42.03509, -82.65474, D. Mooij, 22 September 2009 (DAO 844785, DAO-CFIA 525, 543, 544).

### Acknowledgements

We thank George Stasko at the Agriculture and Agrifood Canada Greenhouse and Processing Crops Research Centre in Harrow, Ontario for providing recent weather data; Terry Anderson, retired plant

pathologist of the same institution, for insights into Kudzu and Soybean Rust; Cory Sheffield of the Department of Biology, York University for identifying the pollinating bee species; and Ruth Newell, Curator of the E. C. Smith Herbarium, Acadia University; and Sean Blaney, Botanist and Assistant Director of the Atlantic Canada Conservation Data Centre, for providing information on Kudzu's status in Nova Scotia.

### Documents Cited (marked \* in text)

- Global Invasive Species Database.** 2007. 100 of the World's Worst Weeds. Invasive Species Specialist Group. I.U.C.N. – The World Conservation Union Species Survival Commission. University of Auckland, New Zealand. Available online at <http://www.issg.org/database/welcome>.
- Richards, N. R., A. G. Caldwell, and F. F. Morwick.** 1989. Soil Survey of Essex County. Report Number 11 of the Ontario Soil Survey. Ontario Ministry of Agriculture and Food. 85 pages.
- Sanderson, Marie.** 1980. The Climate of the Essex Region. Canada's Southland. Department of Geography, University of Windsor. 106 pages.
- United States Department of Agriculture, Natural Resources Conservation Service Plants Database.** Available online at <http://plants.usda.gov/java/profile>.
- Zinck, M.** 1998. Roland's Flora of Nova Scotia. Nimbus Publishing and The Nova Scotia Museum.

### Literature Cited

- Ahlgren, G. H.** 1949. The kudzu vine. Forage Crops. McGraw-Hill, New York.
- Alderman, D. H.** 2004. Channing Cope and the making of a miracle vine. *Geographical Review* 94: 157-177.
- Sage, R. F., H. A. Coiner, D. A. Way, G. B. Runion, S. A. Prior, H. A. Torbert, R. Sicher, and L. Ziska.** 2009. Kudzu [*Pueraria montana* (Lour.) Merr. variety *lobata*]: A new source of carbohydrate for bioethanol production. *Biomass and Bioenergy* 33: 57-61.
- Susko, D. J., J. P. Mueller, and J. F. Spears.** 1999. Influence of environmental factors on germination and emergence of *Pueraria lobata*. *Weed Science* 47: 585-588.
- Susko, D. J., J. P. Mueller, and J. F. Spears.** 2001. An evaluation of methods for breaking seed dormancy in kudzu (*Pueraria lobata*). *Canadian Journal of Botany* 79: 197-2003.
- Winberry, J. J., and D. M. Jones.** 1973. Rise and decline of the "miracle vine": Kudzu in the southern landscape. *South-eastern Geographer* 13: 61-70.

Received 11 February 2010

Accepted 6 June 2010

## First Observations of Mormon Metalmark (*Apodemia mormo*) Oviposition Behaviour in Canada

ASHLEY ANNE WICK<sup>1,4</sup>, JOHANE JANELLE<sup>2</sup>, SHELLEY PRUSS<sup>3</sup>, and NADIR ERBILGIN<sup>1</sup>

<sup>1</sup>Department of Renewable Resources, University of Alberta, Edmonton, Alberta T6G 2E3 Canada; email: awick@ualberta.ca

<sup>2</sup>Box 218, Val Marie, Saskatchewan S0N 2T0 Canada

<sup>3</sup>Parks Canada Agency, Western and Northern Service Centre, Calgary, Alberta T2P 3M3 Canada

<sup>4</sup>Corresponding author

Wick, Ashley Anne, Johane Janelle, Shelley Pruss, and Nadir Erbilgin. 2012. First observations of Mormon Metalmark (*Apodemia mormo*) oviposition behaviour in Canada. *Canadian Field-Naturalist* 126(1): 34–37.

We present new information on oviposition behaviour in the Mormon Metalmark, *Apodemia mormo* Felder and Felder, 1859, documented in Grasslands National Park of Canada, Saskatchewan, in August 2011. The Mormon Metalmark is found throughout the U.S. southwest; little is known about its life history in the northern populations found in Canada. We provide photographic documentation of the butterfly laying single eggs directly on soil or rocks. These observations differ from those recorded in the southern part of its range, where it lays eggs in groups of 2–4 on various locations of the host plant, Branched Umbrella-Plant, *Eriogonum pauciflorum* Pursh. This is the first published account of oviposition behaviour of this species in Canada in the most northern part of its range.

Key Words: Mormon Metalmark, *Apodemia mormo*, Grasslands National Park of Canada, Saskatchewan, Lepidoptera, oviposition, eggs.

The Mormon Metalmark, *Apodemia mormo* Felder and Felder, 1859, is a butterfly of the primarily neotropical family Riodinidae. Its range extends from northwestern Mexico through much of the western United States, but its distribution becomes patchy in the northwestern U.S. and southern Canada (Scott 1986; Layberry et al. 1998). The Canadian prairie populations of the Mormon Metalmark comprise the most northerly documented extent of the species' range.

The species was first observed in Canada in August 1974, when lepidopterist Ronald Hooper documented the Mormon Metalmark in what is now the east block of Grasslands National Park of Canada (GNP) in southern Saskatchewan (Hooper 2002\*). Surveys were sporadic, but in 1983 search efforts yielded two new colonies, in the west block of Grasslands National Park. In 2002, six additional colonies were discovered (Hooper 2002\*). The species was assessed as threatened in Saskatchewan (Hooper 2002\*), and the Prairie population of the Mormon Metalmark was assessed as threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC 2003\*). With these assessments, increased search efforts have led to the documentation of 40 colonies in GNP, as well as the federal Val Marie Community Pasture managed by Agriculture and Agri-Food Canada, which is located northwest of the park.

There is a second population in Canada located in the Similkameen River valley in southern British Columbia (the Southern Mountain population); this population was assessed as endangered by COSEWIC (COSEWIC 2003\*). Both populations are on the List of Wildlife Species at Risk of the federal Species at Risk Act, the Prairie population as threatened and the Southern Mountain population as endangered.

Recent work on the population genetics of the Mormon Metalmark in the northern part of its range has reinforced the listings of endangered and threatened under the Species at Risk Act and has uncovered new information that the British Columbia and Saskatchewan populations are only distantly related (Proshek et al. 2012). This suggests that further research should investigate whether these populations may warrant a separate taxonomic status (Proshek et al. 2012). Little is known about the biology and population dynamics of the northern prairie populations, and much of the information currently available refers to observations in the U.S. southwest.

Mormon Metalmark larvae in Saskatchewan are known to feed on the Branched Umbrella-Plant (also known as Few-flowered Buckwheat) (*Eriogonum pauciflorum* Pursh), which grows almost exclusively on eroded or heavy clay soils, found on hillsides, slopes, and embankments (COSEWIC 2003\*). The Branched Umbrella-Plant is common under these conditions in badlands habitat, of which there are roughly 290 km<sup>2</sup> within the current and proposed boundaries of Grasslands National Park (Pruss et al. 2008\*). Rubber Rabbitbrush, *Ericameria nauseosa* (Pall. ex Pursh) G. L. Nesom & Baird, is also used by Mormon Metalmark adults, which feed on the nectar and perch on the plants. In 2010, the first observations of Mormon Metalmark caterpillars in Grasslands National Park provided valuable information about the early life history of this butterfly in Canada (Peterson et al. 2010). However, there was no documented evidence of oviposition behavior of the Mormon Metalmark in Canada. Given the importance of Grasslands National Park in this species' Canadian range and the lack of biological information specific to northern populations, further



FIGURE 1. Female Mormon Metalmark, *Apodemia mormo*, ovipositing in cracks in the soil in Timmons coulee. Grasslands National Park of Canada (west block), near Val Marie on August 21, 2011. Photo: Johane Janelle.

understanding of the life history and behaviour of this species is vital for effective conservation planning.

### Observations

On several occasions in August 2011, we observed Mormon Metalmark females ovipositing in Timmons coulee in the west block of Grasslands National Park, near the town of Val Marie. On August 21, between noon and 5:00 P.M., we followed several females that would find an area of exposed soil or rock within the host plant's habitat. One in particular began curling her abdomen underneath her and walking forward until she located a suitable spot under a rock (Figure 1). All the individuals we observed laid a single amber-coloured egg approximately the size of a pinhead, either in cracks in the soil or under small rocks. In the instances where the eggs were laid in soil cracks, more than one egg may have been laid, but we did not observe this. While these locations were all near (<2 m) Branched Umbrella-Plants, we did not observe any eggs being laid on the lower leaves of the host plant in groups of 2–4, as previously described (Arnold and Powell 1983; Scott 1986; Pyle 2002). The entire oviposition process took anywhere from 5 to 30 seconds.

### Discussion

Evidence that this oviposition behaviour differs from that which has been documented in the southern portion of the species' range suggests that different eco-

logical adaptations may be at work at the northern periphery of its range. These adaptations may be the result of alternate reproductive strategies. The physiology of ectotherms such as butterflies and other arthropods is largely dependent on optimal temperature ranges, and natural and experimental manipulations reveal that these organisms are capable of phenotypic plasticity in response to temperature differences (Fischer et al. 2003a, 2003b, 2004; Steigenga and Fischer 2007; Berger et al. 2008). Specifically, in certain species of butterfly, females raised in cooler temperatures tend to produce a smaller number of larger eggs than conspecifics raised under warmer conditions (Fischer et al. 2003b; Geister et al. 2009).

Atypical Mormon Metalmark egg deposition numbers and sites may also reflect the colder temperatures found in northern parts of its range. In studying other butterfly species, Berger et al. (2008) suggest that both egg placement and maturation are limited by temperature: egg development times are also influenced by direct solar radiation (Bryant et al. 2002). Eggs laid in open habitat developed more quickly (Bryant et al. 2002), and those eggs with an orientation to morning sun had higher survivorship in the coldest years (Bonebrake et al. 2010). In cooler climates, where development time is limited, the position of an egg can have a profound influence on survival and maturation (Bonebrake et al. 2010).

Experiments with other butterfly species also indicate significant temperature effects on egg and larval development as well as on mortality rates (Fischer et al. 2004; Koda and Nakamura 2010). Thus, Mormon Metalmark eggs laid in the ground and covered with snow may be subject to more moderate temperature ranges as well as lower rates of desiccation than eggs laid above ground on the host plant. However, at this point, it is unclear whether eggs or early instar caterpillars overwinter in the Saskatchewan population.

Other studies have shown that eggs placed away from the host plant on alternate substrates may also benefit from decreased predation. For example, in a study of the neotropical butterfly *Oleria onega*, significant increases in survival were found when the eggs were transferred to alternate substrates (De-Silva et al. 2011). However, De-Silva et al. (2011) state that this anti-predation strategy must outweigh the cost to the larvae of finding the host plant. Additionally, the Mormon Metalmark may not suffer from extremely high predation from ants, as it does in the southern parts of its range, such as California, where the endangered subspecies Lange's Metalmark (*Apodemia mormo langei*) resides (Johnson et al. 2011\*).

The differences in oviposition behaviour reported here add important biological information for this species of conservation concern and may affect the residence description under the Species at Risk Act and the way in which critical habitat is designated and protected under that legislation. This reproductive strategy diverges from what we currently know about the species in other parts of its range. Further investigation will elucidate the mechanisms driving this behavioral difference across the species' range.

### Acknowledgements

Many thanks to our faithful full-time field assistant/local guide, Heather Sauder, as well as to volunteers from across North America and the ever-helpful staff at Grasslands National Park. Thanks also to the reviewers for their helpful comments. This project was funded by the Parks Canada Agency and the University of Alberta.

### Documents Cited (marked \* in text)

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2003. COSEWIC assessment and update status report on the Mormon Metalmark *Apodemia mormo* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ont. vii + 22 pages.

Hooper, R. R. 2002. Status Report of *Apodemia mormo* (C. R. Felder) in Saskatchewan. 4 pages.

Johnson, J. J., J. Jones, M. Baudour, M. Wagner, D. Flannery, D. Werner, D. Holden, K. Virun, T. Wilson, J. Delijani, J. Delijani, B. Newton, D. Gundell, B. Thummar, C. Blakey, K. Walsh, Q. Sweeney, T. Ware, A. Adams, C. Taylor, and T. Longcore. 2011. Captive rearing of Lange's Metalmark butterfly, 2010-2011. Final Report to National Fish and Wildlife Foundation. The Urban Wildlands Group, Los Angeles, California.

Pruss, S. D., A. Henderson, P. Fargey, and J. Tuckwell. 2008. Recovery strategy for the Mormon Metalmark (*Apodemia mormo*) prairie population in Canada. Species at Risk Act Recovery Strategy Series. Parks Canada Agency, Ottawa, Ontario. vi + 23 pages.

### Literature Cited

- Arnold, R. A., and J. A. Powell. 1983. *Apodemia mormo langei*. Chapter 6 in Ecological studies of six endangered butterflies (Lepidoptera, Lycaenidae): Island biogeography, patch dynamics and design of habitat preserves. University of California Publications in Entomology 99: 1-161.
- Berger, D., R. Walters, and K. Gotthard. 2008. What limits insect fecundity? Body size- and temperature-dependent egg maturation and oviposition in a butterfly. *Functional Ecology* 22: 523-529.
- Bonebrake, T. C., C. L. Boggs, J. M. McNally, J. Ranganathan, and P. R. Ehrlich. 2010. Oviposition behaviour and offspring performance in herbivorous insects: consequences of climatic and habitat heterogeneity. *Oikos* 119: 927-934.
- Bryant, S. R., C. D. Thomas, and J. S. Bale. 2002. The influence of thermal ecology on the distribution of three nymphalid butterflies. *Journal of Applied Ecology* 39: 43-55.
- De-Silva, D. L., A. S. Vasquez, and J. Mallet. 2011. Selection for enemy-free space: eggs placed away from the host plant increase survival of a neotropical ithomiine butterfly. *Ecological Entomology* 36: 667-672.
- Elrod, Morton J. 1970. The Butterflies of Montana with Keys for Determination of Species. The Mid-continent Lepidoptera Series, no. 17. Association of Minnesota Entomologists. (Reprint from 1906 University of Montana, Missoula, Montana)
- Fischer, K., A. N. M. Bot, P. M. Brakefield, and B. J. Zwaan. 2003a. Fitness consequences of temperature-mediated egg size plasticity in a butterfly. *Functional Ecology* 17: 803-810.
- Fischer, K., E. Eenhoorn, A. N. M. Bot, P. M. Brakefield, and B. J. Zwaan. 2003b. Cooler butterflies lay larger eggs: developmental plasticity versus acclimation. *Proceedings of the Royal Society of London B* 270: 2051-2056.
- Fischer, K., A. N. M. Bot, and P. M. Brakefield. 2004. Genetic and environmental sources of egg size variation in the butterfly *Bicyclus anynana*. *Heredity* 92: 163-169.
- Geister, T. L., M. W. Lorenz, K. H. Hoffmann, and K. Fischer. 2009. Energetics of embryonic development: effects of temperature on egg and hatchling composition in a butterfly. *Journal of Comparative Physiology* 179: 87-98.
- Koda, K., and H. Nakamura. 2010. Effects of temperature on the development and survival of an endangered butterfly, *Shijimieoides divinus barine* (Leech) (Lepidoptera: Lycaenidae). *Entomological Science* 13: 29-34.
- Kohler, Steve. 1980. Checklist of Montana butterflies (Rhopalocera). *Journal of the Lepidopterists' Society* 34: 1-19.
- Layberry, Ross A., P. W. Hall, and J. D. Lafontaine. 1998. The Butterflies of Canada. University of Toronto Press, Toronto, Ontario. 280 pages.
- Peterson, K., E. Amosa, S. Pruss, and N. Erbilgin. 2010. First caterpillar observations of the Mormon metalmark (*Apodemia mormo*) (Lepidoptera: Riodinidae) butterfly in Grasslands National Park, Saskatchewan, Canada. *Blue Jay* 68: 37-40.
- Proshok, B., L. A. Crawford, C. S. Davis, S. Desjardins, A. E. Henderson, and F. A. H. Sperling. 2012. *Apodemia mormo* in Canada: population genetic data support prior

- conservation ranking. *Journal of Insect Conservation*. Published online 15 May 2012. DOI10.1007/s10841-012-9494-z.
- Pyle, R. M.** 2002. *The Butterflies of Cascadia: A field guide to all the species of Washington, Oregon, and surrounding territories*. Seattle Audubon Society, Seattle. 420 pages.
- Scott, James A.** 1986. *The Butterflies of North America, a Natural History and Field Guide*. Stanford University Press, Palo Alto, California. 581 pages.
- Steigenga, M. J., and K. Fischer.** 2007. Ovarian dynamics, egg size, and egg number in relation to temperature and mating status in a butterfly. *Entomologia Experimentalis et Applicata* 125: 195-203.

Received 11 November 2011

Accepted 3 June 2012

# Barn Owl (*Tyto alba*) Predation on Big Brown Bats (*Eptesicus fuscus*) in Pennsylvania

SUZANNE M. KHALAFALLA<sup>1</sup> and CARLOS A. IUDICA<sup>1,2</sup>

<sup>1</sup>Department of Biology, Susquehanna University, Selinsgrove, Pennsylvania 17870 USA

<sup>2</sup>Corresponding author (e-mail: casaiud@susqu.edu)

Khalafalla, Suzanne M., and Carlos A. Iudica. 2012. Barn Owl (*Tyto alba*) predation on Big Brown Bats (*Eptesicus fuscus*) in Pennsylvania. *Canadian Field-Naturalist* 126(1): 38–40.

Diet of the Barn Owl, *Tyto alba*, was determined through examination of pellets collected from a roost site in Port Trevorton, Snyder County, Pennsylvania (40°42'26"N, 76°51'58"W). Remains of a Big Brown Bat, *Eptesicus fuscus*, were positively identified in one of the 80 pellets from our site. To our knowledge, this is the first documented case of a Barn Owl preying on a bat in Pennsylvania.

Key Words: Barn Owl, *Tyto alba*, Big Brown Bat, *Eptesicus fuscus*, Pennsylvania.

Barn Owls (*Tyto alba*) are medium-sized predatory birds found on all continents except Antarctica. During the summer months, they are present in Pennsylvania, where they breed before migrating for the winter as far south as Georgia (Bent 1938). Barn Owls hunt strictly after dark over open grasslands. They will perch in the open and then drop down to capture prey. The size and strength of the talons of Barn Owls suggest that these owls have adapted to pin prey to the ground rather than to scoop prey like hawks (Sage 1962). However, Barn Owls have been known for some time now to prey on bats (Chiroptera) as well (see Twente (1954) and Escarlate-Tavares and Pessôa (2005), among many).

To feed on bats, Barn Owls must adjust their hunting methods to scoop prey. Evidence suggests that they are able to do so, as Barn Owls have been spotted in Iraq capturing House Sparrows (*Passer domesticus*) by the drop-down and scoop method (Sage 1962), which may also be used in the capture of bats. Documented studies in Great Britain (Speakman 1991; Love et al. 2000), the Bahamas (Buden 1974), Poland (Ruprecht 1979), and Madagascar (Goodman et al. 1993; Goodman and Griffiths 2006; Rasoma and Goodman 2007) have shown that Barn Owls are able to hunt bats effectively elsewhere.

Although bats are not common prey of Barn Owls, the opportunistic hunting style of Barn Owls allows them to make the best use of any available prey (Tores et al. 2005; Charter et al. 2009; Frey et al. 2011). In areas or times of low rodent population, Barn Owls must find alternate prey items. Despite the numerous reports of Barn Owls preying on bats in other countries (Glue 1974; Lopez-Forment and Urbano 1977; Morton et al. 1977; Bosé and Guidali 2001; Vargas et al. 2002; Sommer et al. 2005; Scheibler 2007; Wiley 2010) and in the U.S. (Hall and Blewett 1964; Colvin and McLean 1986; Hoetker and Gobalet 1999; Marti et al. 2005), there has been no documented report of Barn Owls feeding on bats in Pennsylvania.

## Study Area and Methods

In 2005, 80 Barn Owl pellets were analyzed to determine their content. Pellets were collected during the spring of 1998 from a barn located within a rural area bordering the Susquehanna River. The barn that was being used by a pair of Barn Owls is more than 100 years old. It is part of a small farm within the town of Port Trevorton, Snyder County, central Pennsylvania (40°42'26"N, 76°51'58"W). No bat colonies were confirmed in the barn. Standard methodology was used to process the pellets, and identifications were done using comparative materials from the Carnegie Museum of Natural History, the Museum of Zoology at the University of Michigan, and the vertebrate collection at the State Museum in Harrisburg, Pennsylvania.

## Results and Discussion

Analyses of the pellets indicated that approximately 74% of the diet was composed of rodent species and 26% was composed of insectivores. Remains of a Big Brown Bat (*Eptesicus fuscus*) made up 0.38% of the total collected. The most common species found in the pellets were Meadow Vole (*Microtus pennsylvanicus*) and Northern Short-tailed Shrew (*Blarina brevicauda*).

Accounts from southern North America and from Central and South America, Africa, Europe, and Asia report that the proportion of bats in Barn Owl diets ranges from 0.02% to over 60% of the total number of prey species (Vargas et al. (2002), among others). Within the continental U.S., studies from California, Colorado, Missouri, Kansas, Oklahoma, and Ohio report the presence of the bat genera *Myotis*, *Tadarida*, and *Antrozous* in Barn Owl diets (Huey 1926; Twente 1954; Hall and Blewett 1964; Marti 1974; Colvin and McLean 1986; Hoetker and Gobalet 1999).

The drop-down hunting technique described by Twente (1954) for hawks could be used to capture a bat at this location if the bat was caught when emerging from the barn or a nearby cave (Hall and Blewett



1964). In order to capture bats, owls must use a specialized method of hunting that requires more energy and is less beneficial than simply hunting prey that is not as difficult to capture (Sage 1962; Twente 1954). In a location such as Port Trevorton, where rodent and insectivore species are common, it is unlikely that Barn Owls would typically prey on bats, but Barn Owls are opportunistic feeders and it is possible that the captured bat was an inexperienced flier or was injured, allowing the owl to capture it with little trouble. In circumstances where preferred prey are rare, Barn Owls appear to be able to adapt to the type of prey that is available (Garcia et al. 2005).

Previous studies provide evidence that Barn Owls can prey on bats, and it is possible that this occurs more often than has been documented. In late summer, when young bats reach initial independence, they lack flying experience and become easy prey for Barn Owls. A large maternity colony of Little Brown Bats (*Myotis lucifugus*) and Big Brown Bats is located 13 km north of Port Trevorton. The number of bats emerging from the barn during the summer could provide Barn Owls with ample opportunities for practicing this method and capturing bats (Garcia et al. 2005). The abundant numbers of bats would provide the owls with an alternate prey source. In times of scarcity of otherwise more common prey items, such as rodents and insectivores, this food source may justify the extra energy required to develop a specialized hunting method.

### Acknowledgements

We thank Dr. George Boone for providing the 80 owl pellets that we used for this study and Sarah Ignelzi for her early work on the original samples. Reference material was made available to us thanks to the generosity of Philip Myers (Museum of Zoology, University of Michigan), Suzanne McLaren and John Wible (Carnegie Museum of Natural History), and Walter Meshaka (State Museum of Pennsylvania). Two anonymous reviewers provided useful comments and we are thankful to them. Funding and other support were provided in part by grants and logistics from the Degenstein Foundation, the Susquehanna River Heartland Coalition for Environmental Studies, and Susquehanna University. This is contribution number 2 from the Susquehanna River Heartland Coalition for Environmental Studies (SRHCES).

### Literature Cited

- Bent, A. C. 1938. American barn owl. Pages 141-169 in *Life Histories of North American Birds of Prey*, Part 2. U.S. National Museum Bulletin Number 170. Reprinted 1961, Dover Publications, New York, USA.
- Bosé, M., and F. Guidali. 2001. Seasonal and geographic differences in the diet of the barn owl in an agro-ecosystem in northern Italy. *Journal of Raptor Research* 35: 240-246.
- Buden, D. W. 1974. Prey remains of barn owls in the southern Bahamas Islands. *Wilson Bulletin* 86: 336-343.
- Charter, M., I. Izhaki, K. Meyrom, Y. Motro, and Y. Leshem. 2009. Diets of barn owls differ in the same agricultural region. *Wilson Journal of Ornithology* 121: 378-383.
- Colvin, B. A., and E. B. McLean. 1986. Food habits and prey specificity of the common barn owl in Ohio. *Ohio Journal of Science* 86: 76-80.
- Escarlate-Tavares, F., and L. M. Pessôa. 2005. Bats (Chiroptera, Mammalia) in barn owl (*Tyto alba*) pellets in northern Pantanal, Matto Grosso, Brazil. *Mastozoologia Neotropical* 12: 61-67.
- Frey, C., C. Sonnay, A. Dreiss, and A. Roulin. 2011. Habitat, breeding performance, diet and individual age in Swiss barn owls (*Tyto alba*). *Journal of Ornithology* 152: 279-290.
- García, A. M., F. Cervera, and A. Rodríguez. 2005. Bat predation by long-eared owls in Mediterranean and temperate regions of southern Europe. *Journal of Raptor Research* 39: 445-453.
- Goodman, S. M., and O. Griffiths. 2006. A case of exceptionally high predation levels of *Rousettus madagascariensis* by *Tyto alba* (Aves: Tytonidae) in western Madagascar. *Acta Chiropterologica* 8: 553-556.
- Goodman, S. M., O. Langrand, and C. J. Raxworthy. 1993. The food habits of the barn owl *Tyto alba* at three sites on Madagascar. *Ostrich: Journal of African Ornithology* 64: 160-171.
- Glue, D. E. 1974. Food of the barn owl in Britain and Ireland. *Bird Study* 21: 200-210.
- Hall, J. S., and C. H. Blewett. 1964. Bat remains in owl pellets from Missouri. *Journal of Mammalogy* 45: 303-304.
- Hoetker, G. M., and K. W. Gobalet. 1999. Predation on Mexican free-tailed bats by burrowing owls in California. *Journal of Raptor Research* 33: 333-335.
- Huey, L. M. 1926. Bats eaten by short-eared owl. *The Auk* 43: 96-97.
- Lopez-Forment, W., and G. Urbano. 1977. Restos de pequeños mamíferos recuperados en regurgitaciones de lechuza, *Tyto alba*, en México. *Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zología* 48: 231-242.
- Love, R. A., C. Webbon, D. E. Glue, and S. Harris. 2000. Changes in the food of British barn owls (*Tyto alba*) between 1974 and 1997. *Mammal Review* 30: 107-129.
- Marti, C. D. 1974. Feeding ecology of four sympatric owls. *The Condor* 76: 45-61.
- Marti, C. D., A. F. Poole, and L. E. Bevier. 2005. Barn owl (*Tyto alba*). *The Birds of North America online*. Edited by A. Poole. <http://bna.birds.cornell.edu/bna/species/001>, doi:10.2173/bna.1. (Accessed February 2012).
- Morton, S. R., M. Hapold, A. K. Lee, and R. E. McMillen. 1977. The diet of the barn owl, *Tyto alba*, in south-western Queensland. *Australian Wildlife Research* 4: 91-97.
- Rasoma, J., and S. M. Goodman. 2007. Food habits of the barn owl (*Tyto alba*) in spiny bush habitat of arid south-western Madagascar. *Journal of Arid Environments* 69: 537-543.
- Ruprecht, A. L. 1979. Bats (Chiroptera) as constituents of the food of barn owls *Tyto alba* in Poland. *Polish Academy of Sciences* 121: 489-494.
- Sage, B. L. 1962. Barn owls catching sparrows at roost. *British Birds* 55: 237-238.

- Scheibler, D. R.** 2007. Habitat associations of small mammals in southern Brazil and use of regurgitated pellets of birds of prey for inventorying a local fauna. *Brazilian Journal of Biology* 67: 65-71.
- Sommer, R., H. Zoller, D. Kock, W. Böhme, and A. Griesau.** 2005. Feeding of the barn owl, *Tyto alba* with first record of the European free-tailed bat, *Tadarida teniotis* on the island of Ibiza (Spain, Balearics). *Folia Zoologica* 54: 364-370.
- Speakman, J. R.** 1991. The impact of predation by birds on bat populations in the British Isles. *Mammal Review* 21: 123-142.
- Tores, M., Y. Motro, U. Motro, and Y. Yom-Tova.** 2005. The barn owl: A selective opportunist predator. *Israel Journal of Zoology* 51: 349-360.
- Twente, J. W.** 1954. Predation on bats by hawks and owls. *Wilson Bulletin* 66: 135-136.
- Vargas, J., C. Landaeta A., and J. A. Simonetti.** 2002. Bats as prey of barn owls (*Tyto alba*) in a savanna in Bolivia. *Journal of Raptor Research* 36: 146-148.
- Wiley, J. W.** 2010. Food habits of the endemic ashy-faced owl (*Tyto glaucops*) and recently arrived barn owl (*T. alba*) in Hispaniola. *Journal of Raptor Research* 44: 87-100.

Received 7 July 2011

Accepted 2 January 2012

# An Anomalous Northern Saw-whet Owl (*Aegolius acadicus*) Egg

THERESA M. BURG<sup>1</sup> and RANDOLPH F. LAUFF<sup>2,3,4</sup>

<sup>1</sup>Department of Biological Sciences, University of Lethbridge, Lethbridge, Alberta T1K 3M4 Canada; email: theresa.burg@uleth.ca

<sup>2</sup>Department of Biology, St. Francis Xavier University, Antigonish, Nova Scotia B2G 2W5 Canada; email: rlauff@stfx.ca

<sup>3</sup>Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6 Canada

<sup>4</sup>Author to whom correspondence should be addressed.

Burg, Theresa M., and Randolph F. Lauff. 2012. An anomalous Northern Saw-whet Owl (*Aegolius acadicus*) egg. *Canadian Field-Naturalist* 126(1): 41–45.

An anomalously large and coloured egg was found within a clutch of the Northern Saw-whet Owl (*Aegolius acadicus*) in Nova Scotia; all other eggs of the clutch were within the normal size and colour range for the species. Analysis of three mitochondrial genes suggests all eggs in the clutch were laid by Northern Saw-whet Owl(s) with similar genetic make-up. This is the first report of an anomalous egg from this species, and a rare example of added pigment.

**Key Words:** Northern Saw-whet Owl, *Aegolius acadicus*, egg, Nova Scotia.

For most birds species, some variation in size and pigmentation of eggs laid by an individual female is common and expected (Williams 1994; Takagi 2003). Such variation may result from natural variations in food availability (Hakkarainen and Korpimäki 1994; Aparicio 1999) or food supplementation (Wiebe and Bortolotti 1995). However, unusual eggs can sometimes be found in a bird's clutch, either as a result of interspecific brood parasitism (Lowther 1993) or intraspecific brood parasitism ("egg-dumping"), e.g., in ducks (Semel et al. 1988; Yom-Tov 2001; Evans et al. 2002).

Reports of anomalous eggs contained within a clutch include that of a Mallard (*Anas platyrhynchos*) laying an egg in the nest of a Short-eared Owl (*Asio flammeus*) (Wiggins et al. 2006) and a Hooded Merganser (*Lophodytes cucullatus*) laying an egg in the nest of a Northern Flicker (*Colaptes auratus*) (Wiebe 2000). These latter cases probably do not involve brood parasitism, but rather competition for nest sites, or simply misplaced laying by the female.

Within clutches laid by a single female, unusually small or large eggs may appear which are outside the typical range for the species (e.g., Sharp 1904; Ken-deigh et al. 1956; Rothstein 1973; Jenkins 1984; Petty and Anderson 1989). Unusually large eggs may have two yolks or embryos (e.g., Petty and Anderson 1989), whereas small eggs may be missing a yolk (e.g., Ricklefs 1975). Such small "runt" eggs are very common among some woodpeckers and may represent an adaptive breeding strategy (Koenig 1980). Frequently, these unusually sized eggs have poor hatching success, but occasionally they are fertile (hatchings have been documented from Western Bluebird (*Sialia mexicana*) (Hayes 1985), as well as the hybrids of Carrion Crow (*Corvus corone corone*) and Hooded Crow (*C. c. cornix*) (Saino and Villa 1992).

In addition to differences in size, oddly coloured eggs have been extensively reported. Almost all of these

reports are of pale or achromatic eggs (e.g., Sprunt 1926; Hayes 1985; Radke and Radke 1988; Saino and Villa 1992), or eggs lacking their characteristic markings (Rowan et al. 1919). Such size and colour differences may be the result of developmental anomalies (Sprunt 1926; Jenkins 1984; Hayes 1985; Rhymer 1988; Saino and Villa 1992).

Here we describe an egg, anomalous in both size and colour, from a Northern Saw-whet Owl (*Aegolius acadicus*) nest in Nova Scotia.

## Methods

### *Study site and general methods*

Near the community of Bay Road Valley (46°58'N, 60°28'W), on Cape Breton Island, Nova Scotia, we have placed 17 nest boxes (Korpimäki 1985) for owls. The box in which the unusual egg was laid was erected in February 2008, and it was found occupied on 3 May 2008; only the adult female Saw-whet Owl was seen in the box. The box was not opened to inspect the contents until 13 June, when a clutch of six eggs was found abandoned. The clutch, including the anomalous egg (Figure 1), was brought to the laboratory and held at 4°C. Maximum length and diameter of all the eggs were measured using Marathon digital Vernier callipers. Because the size and shape of the anomalous egg did not match the eggs of other cavity-nesters on our study site, the clutch of six eggs underwent genetic analysis.

### *DNA sequencing*

To identify the egg, two genes in the mitochondrial genome were amplified and sequenced: NADH dehydrogenase 2 (ND2) and cytochrome *b* (*cyt b*). Genomic DNA was isolated from egg membranes and egg contents using a modified Chelex extraction (Walsh et al. 1991; Burg and Croxall 2001).

Portions of the ND2 (1.5 kb) and cytochrome *b* (150 bp) genes were amplified with 5 pmol of each primer (L5215 5'-TATCGGGCCCATACCCCGAATAT-3'

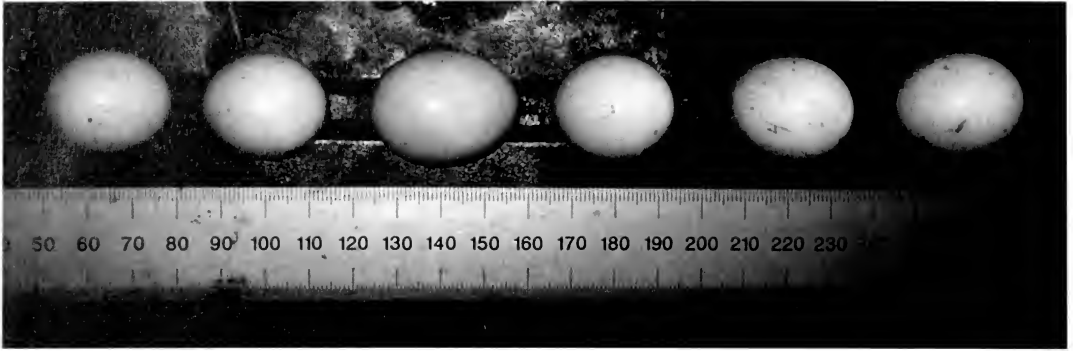


FIGURE 1. The clutch of Northern Saw-whet Owl eggs. The anomalous egg is third from the left. Photo: R. F. Lauff.

(Hackett 1996) and HT<sub>1</sub>p 5'-CGGACTTTAGCAGA AACTAAGAG-3' (Eberhard and Bermingham 2004) for ND2 and L15560 5'-GYGAYAARATCCCATTCCACCC-3' (Marthinsen et al. 2009) and H15646 5'-GGGGTGAAGTTTTCTGGGTCTCC-3' (Sorenson et al. 1999) for *cyt b* in 2.5 mM MgCl<sub>2</sub>, 1 unit (U) *Taq* polymerase, 200 μM dNTP, and Promega Flexi Taq buffer (Promega Corporation, Madison, Wisconsin) in a 25 μL reaction. Both loci were amplified using one cycle for 2 minutes at 94°C, 45 seconds at 54°C, and 60 seconds at 72°C; 37 cycles of 30 seconds at 94°C, 45 seconds at 54°C, and 60 seconds at 72°C; and one final cycle of 5 minutes at 72°C. Samples were sent for sequencing to Génome Québec, Montreal, Quebec. The samples were compared with sequences in GenBank using blastx (National Center for Biotechnology Information, National Library of Medicine, Bethesda, Maryland).

A third gene, the control region, was also sequenced. Typically the control region mutates at a higher rate than either ND2 or *cyt b* and is often used to examine differences within a population (e.g., Friesen et al. 2002; Steeves et al. 2005). By examining the control region, we sought to determine whether the egg was the result of intraspecific brood parasitism by an unrelated female. A portion of the control region, approximately 2 kb in length, was amplified using N1 (5'-AACATTGGTCTTGTAAGCCAA-3') and D16 (5'-AGTGCATCAGTGTCTAGGTGATTC-3') primers from Barrowclough et al. (1999) using the same polymerase chain reaction (PCR) conditions as above except with a final extension step at 72°C for 10 minutes.

## Results

### *Egg size and colour*

The anomalous egg measured 33.9 mm in length × 25.9 mm in diameter. The mean length (± standard error) of the other five eggs was 29.0 mm (± 0.41) and the mean diameter was 24.0 mm (± 0.06). Therefore, the anomalous egg was 17% longer but only 8% wider than the mean of the remaining eggs, i.e., it was not

just larger than the other eggs but it also had a different shape. All the eggs had only one embryo ( $n = 4$ ) or no visible embryo ( $n = 2$ , including the anomalous egg). In coloration, five of the eggs were not different from typical Northern Saw-whet Owl eggs—dull and off-white. The anomalous egg was pale blue with brown flecking.

### *DNA analysis*

A 133 bp fragment of *cyt b* and a 407 bp fragment of ND2 were obtained from the contents and shell membranes for each of the six eggs. The sequences from all six samples were identical (Table 1). The *cyt b* sequence showed a 93% match to *Aegolius acadicus* sequences from British Columbia and Alaska (Table 2). The ND2 sequence was a 99% match to the same species. None of the other sequences in GenBank had as high a match as the Northern Saw-whet Owl sequences.

The 1584 bp fragment of the control region was identical for the four eggs from which we were able to obtain a sequence (eggs 1, 4, 5, and 6), with egg 6 being the anomalous egg. All four sequences were identical.

## Discussion

### *Genetic analysis*

The high degree of similarity between the sequences from the study eggs and known Northern Saw-whet Owl sequences, combined with visual observation of a female Northern Saw-whet Owl incubating the eggs, suggests that all the eggs were of that species. The fact that all sequences for the three mitochondrial genes were identical does not rule out the possibility that a second female from the same mitochondrial lineage laid the anomalous egg. The nest box was erected the previous winter, so the possibility that the anomalous egg was laid the previous year can be eliminated.

Our DNA results rule out interspecific brood parasitism because the minor differences (1–3 bp) between published Northern Saw-whet Owl sequences and those we obtained are typical of intrapopulation variation. For the *cyt b* data, Topp and Winker (2008) found two variable sites within a 971 bp fragment from 30 North-

ern Saw-whet Owls from western North America. Similarly, Proudfoot et al. (2006) found up to 1% sequence difference in Northern Pygmy Owls (*Glaucidium gnoma*,  $n = 103$ ).

#### Egg size and colour

Within a bird species, variation among clutches laid by different females is typically greater than variation within clutches laid by a single female (Christians 2002), and size differences in eggs have been used to identify intraspecific nest parasitism, or "dumped eggs" from other females in the same population (Pöysä 2006). We are unable to distinguish between two likely explanations for the anomalous owl egg. It may have been a dumped egg laid by a conspecific with the same matrilineal lineage. However, the extreme length of the anomalous egg (longer than the mean sizes reported for Saw-whet Owls) (Rasmussen et al. 2008) and the fact that it appeared infertile could also mean it was a developmentally abnormal egg laid by the same female.

The eggs of all North American owls are normally white (Baicich and Harrison 1997), which may represent the ancestral condition in birds (Kilner 2006). Oniki (1985) suggested that only cavity-nesting birds should lay unspotted white eggs because cryptic or heat-absorbing coloration is not needed in a cavity nest. The anomalous egg in this study was pale blue, more typical of birds using thick cup nests in isolated bushes (Oniki 1985).

Whatever the explanation for normal variation in spotting and ground colour in some species, anomalous eggs, such as the one reported here, stand out from others in the same clutch as well as from the species' standard. Most reported cases of miscoloured eggs involve the complete or partial loss of pigment, i.e., the anomalous eggs are typically white (e.g., Hayes 1985; Radke and Radke 1988). Gross (1968) summarized the occurrence of albinistic eggs and found 18 species in only three orders (Falconiformes, Charadriiformes, and Passeriniiformes) that laid these pigment-free eggs, sometimes as one anomalous egg among the clutch, sometimes as a whole clutch.

The egg we found had additional pigment, both as ground colour and as spotting. An extensive review of the literature revealed no other case in which a species which normally lays an immaculate egg of one ground colour has laid a spotted egg with a different ground colour. Biliverdin is responsible for the blue in the eggshells of many species, and is likely synthesized in the shell gland (Zhao et al. 2006). White eggs, including those of owls, are not necessarily devoid of these pigments; they may be present in minute quantities serving structural roles (Kennedy and Vevers 1976; Mikšfik et al. 1994). For unknown reasons, the large egg in the study nest had much more pigment added to it than normal; whether this was related to the egg also being over-sized or to some general developmental problem is not known.

TABLE 1. Mitochondrial ND2 sequences for egg contents (E) and shell membrane (S) from eggs from the Northern Saw-whet Owl nest. Dots indicate matches with Northern Saw-whet (*Aegolius acadicus*, GenBank EU601051) and Asian Banded Owllet (*Glaucidium cuculoides*, GenBank EU601047); upper-case letters indicate mismatches and dashes indicate missing sequence. Variable sites are listed along the top.

	11111111	111111111	1111222222	2222222222	2233333333	3333333344	4
E1	445556889	990001122	233344556	7899011223	3344455577	9901122234	5555677800
S1	7923891785	7834906835	7068269571	0737658460	3815901728	3977903681	0468519906
E3	TGTGTCGGCT	TTCGTGTTGG	TGTAATCGTA	ATACTGTGGT	CGCTGTATCG	TTGTGGATAT	TATGACCTTC
E3	.....	.....	.....	.....	.....	.....	.....
S3	.....	.....	.....	.....	.....	.....	.....
E4	.....	.....	.....	.....	.....	.....	.....
S4	.....	.....	.....	.....	.....	.....	.....
E5	.....	.....	.....	.....	.....	.....	.....
E6	.....	.....	.....	.....	.....	.....	.....
S6	.....	.....	.....	.....	.....	.....	.....
<i>Aegolius acadicus</i>	.....	.....	.....	.....	.....	.....	.....
<i>Glaucidium cuculoides</i>	CACACTATG	AGTACAGGTT	CAGGGGTAGT	CGCTGAGTAG	GTTGACGGTT	A..ACATGCCA	GGGAGGTGGG

TABLE 2. Cytochrome *b* alignment for shell membranes (S) from eggs from the Northern Saw-whet Owl nest. Highest sequence matches were with Northern Saw-whet Owl (*Aegolius acadicus*, GenBank EU75412; *A. a. acadicus* EU348959, *A. a. brooksi* Y15686), Boreal Owl (*A. funereus*, GenBank AJ004061), Rufous-legged Owl (*Strix rufipes*, GenBank AJ004353), and Spectacled Owl (*Pulsatrix perspicillata*, GenBank AJ004044). Numbers along the top refer to positions of variable sites.

	122335666 7358012014	1 6667777990 5673578182	111111111 000112233 469284701
S1	GTCCTAGGGT	GTTAAATGAT	TATGTC?AC
S3	.....	.....	.....?..
S4	.....	.....	.....?..
S5	.....	.....	.....G..
S6	.....	.....	.....??.
<i>Aegolius acadicus</i>	.....	.....	...AC.A..
<i>A. a. brooksi</i>	.....G	.....	...AC.A..
<i>A. a. Acadicus</i>	.....G	.....	...AC.A..
<i>A. funereus</i>	.....GT.AG	..GTGGCA.A	.G...AG.
<i>Strix rufipes</i>	ACACGG....	AGCGGC..A	AGG..TG..
<i>Pulsatrix perspicillata</i>	..ACG..A..	AGGTGGC.GA	AGG..TGGG

## Acknowledgements

The study was funded by a Discovery Grant from the Natural Sciences and Engineering Research Council of Canada to TMB. Bird Studies Canada (the Baillie Fund), the Nova Scotia Department of Natural Resources (Nova Scotia Habitat Conservation Fund – Contributions from Hunters and Trappers), and a Research Grant from the Board of Governors of the Nova Scotia Museum are acknowledged by RFL. We thank Fritz McEvoy and David Rasmussen for their help in erecting and monitoring the nest boxes, Amanda Lowe for enthusiastic field assistance, and Linda Lait for help in the lab. Barry Taylor, A. J. Erskine, and Karen Wiebe provided comments from which this manuscript benefited.

## Literature Cited

- Aparicio, J. M. 1999. Intraclutch egg-size variation in the Eurasian Kestrel: advantages and disadvantages of hatching from large eggs. *Auk* 116: 825-830.
- Baicich, P. J., and J. O. Harrison. 1997. *A Guide to the Nests, Eggs, and Nestlings of North American Birds*. Princeton University Press.
- Barrowclough, G. F., R. J. Gutiérrez, and J. G. Groth. 1999. Phylogeography of Spotted Owl (*Strix occidentalis*) populations based on mitochondrial DNA sequences: gene flow, genetic structure, and a novel biogeographic pattern. *Evolution* 53: 919-931.
- Burg, T. M., and J. P. Croxall. 2001. Global relationships amongst Black-browed and Grey-headed Albatrosses: analysis of population structure using mtDNA and microsatellites. *Molecular Ecology* 10: 2647-2660.
- Christians, J. K. 2002. Avian egg size: variation within species and inflexibility within individuals. *Biological Reviews* 77: 1-26.
- Eberhard J. R., and E. Bermingham. 2004. Phylogeny and biogeography of the *Amazona ochrocephala* (Aves: Psittacidae) complex. *Auk* 121: 318-332.
- Evans, M. R., D. B. Lank, W. S. Boyd, and F. Cooke. 2002. A comparison of the characteristics and fate of Barrow's Goldeneye and Bufflehead nests in nest boxes and natural cavities. *Condor* 104: 610-619.
- Friesen, V. L., D. J. Anderson, T. E. Steeves, H. Jones, and E. A. Schreiber. 2002. Molecular support for species status of the Nazca Booby (*Sula granti*). *Auk* 119: 820-826.
- Gross, A. O. 1968. Albinistic eggs (white eggs) of some North American birds. *Bird-Banding* 39:1-6.
- Hackett, S. J. 1996. Molecular phylogenetics and biogeography of tanagers in the genus *Ramphocelus* (Aves). *Molecular Phylogenetics and Evolution* 5: 368-382.
- Hakkarainen, H., and E. Korpimäki. 1994. Environmental, parental and adaptive variation in egg size of Tengmalm's Owls under fluctuating food conditions. *Oecologia* 98: 362-368.
- Hayes, D. 1985. Unusual Western Bluebird eggs. *Western Birds* 16: 146.
- Jenkins, M. A. 1984. A clutch of unusually small Peregrine Falcon eggs. *Journal of Raptor Research* 181: 151-153.
- Kendeigh, S. C., T. C. Kramer, and F. Hammerstrom. 1956. Variations in egg characteristics of the House Wren. *Auk* 73: 42-65.
- Kennedy, G. Y., and H. G. Vevers. 1976. A survey of avian eggshell pigments. *Comparative Biochemistry and Physiology B* 55: 117-23.
- Kilner, R. M. 2006. The evolution of egg colour and patterning in birds. *Biological Reviews* 81: 383-406.
- Koenig, W. D. 1980. The determination of runt eggs in birds. *Wilson Bulletin* 92: 103-107.
- Korpimäki, E. 1985. Clutch size and breeding success in relation to nest-box size in Tengmalm's Owl *Aegolius funereus*. *Holarctic Ecology* 8: 175-180.
- Lowther, P. E. 1993. Brown-headed Cowbird (*Molothrus ater*) in *The Birds of North America*. Edited by A. Poole. Cornell Lab of Ornithology, Ithaca. <http://bna.birds.cornell.edu/bna/species/047>, DOI 10.2173/bna.47.
- Marthinsen, G., L. Wennerberg, R. Solheim, and J. T. Lifjeld. 2009. No phylogeographic structure in the circumpolar Snowy Owl (*Bubo scandiacus*). *Conservation Genetics* 10: 923-933.
- Mikšik, I., V. Holá, and Z. Deyl. 1994. Quantification and variability of eggshell pigment content. *Comparative Biochemistry and Physiology A* 109: 769-772.
- Oniki, Y. 1985. Why Robin eggs are blue and birds build nests: statistical tests for Amazonian birds. *Ornithological Monographs* 36: 545-546.

- Petty, S. J., and D. I. K. Anderson. 1989. Egg measurements from a Northern Goshawk (*Accipiter gentilis gentilis*) including one abnormally large egg with twin embryos. *Journal of Raptor Research* 23: 113-115.
- Pöysä, H. 2006. Public information and conspecific nest parasitism in goldeneyes: targeting safe nests by parasites. *Behavioral Ecology* 17: 459-465.
- Proudfoot, G. A., R. L. Honeycutt, and D. R. Slack. 2006. Mitochondrial DNA variation and phylogeography of the Ferruginous Pygmy-owl (*Glaucidium brasilianum*). *Conservation Genetics* 7: 1-12.
- Radke, W. R., and M. F. Radke. 1988. Unusual Greater Sandhill Crane egg. *Wilson Bulletin* 100: 504-506.
- Rasmussen, J. L., S. G. Sealy, and R. J. Cunnings. 2008. Northern Saw-whet Owl (*Aegolius acadicus*) in The Birds of North America. Edited by A. Poole. Cornell Lab of Ornithology, Ithaca. <http://bna.birds.cornell.edu/bna/species/042>; DOI 10.2173/bna.42.
- Rhymer, J. M. 1988. The effect of egg size variability on thermoregulation of Mallard (*Anas platyrhynchos*) offspring and its implications for survival. *Oecologia* 75: 20-24.
- Ricklefs, R. E. 1975. Dwarf eggs laid by a Starling. *Journal of Field Ornithology* 46: 169.
- Rothstein, S. I. 1973. The occurrence of unusually small eggs in three species of songbirds. *Wilson Bulletin* 85: 340-342.
- Rowan, W., E. Wolff, P. L. Sulman, K. Pearson, E. Isaacs, E. M. Elderton, and M. Tildesley. 1919. On the nest and eggs of the Common Tern (*S. fluviatilis*): a cooperative study. *Biometrika* 12: 308-354.
- Saino, N., and S. Villa. 1992. Pair composition and reproductive success across a hybrid zone of Carrion Crows and Hooded Crows. *Auk* 109: 543-555.
- Semel, B., P. W. Sherman, and S. M. Byers. 1988. Effects of brood parasitism and nest-box placement on Wood Duck breeding ecology. *Condor* 90: 920-930.
- Sharp, C. S. 1904. A set of abnormally large eggs of the Golden Eagle. *Condor* 6: 164-168.
- Sorenson, M. D., J. C. Ast, D. E. Dimcheff, T. Yuri, and D. P. Mindell. 1999. Primers for a PCR-based approach to mitochondrial genome sequencing in birds and other vertebrates. *Molecular Phylogenetics and Evolution* 12: 105-114.
- Sprunt, A. Jr. 1926. An unusual set of eggs of the Black Skimmer (*Rynchops nigra*). *Auk* 43: 532.
- Steeves, T. E., D. J. Anderson, and V. L. Friesen. 2005. The Isthmus of Panama: a major physical barrier to gene flow in a highly mobile pantropical seabird. *Journal of Evolutionary Biology* 18: 1000-1008.
- Takagi, M. 2003. Seasonal change in egg-volume variation within a clutch in the Bull-headed Shrike. *Lanius bucephalus*. *Canadian Journal of Zoology* 81: 287-293.
- Topp, C. M., and K. Winker. 2008. Genetic patterns of differentiation among five landbird species from the Queen Charlotte Islands. *British Columbia Birds* 10: 461-472.
- Walsh P. S., D. A. Metzger, and R. Higuchi. 1991. Chelex 100 as a medium for PCR based typing from forensic material. *Biotechniques* 10: 506-513.
- Wiebe, K. L. 2000. Northern Flicker incubates Hooded Merganser egg. *British Columbia Birds* 10: 13-15.
- Wiebe, K. L., and G. R. Bortolotti. 1995. Egg size and clutch size in the reproductive investment of American Kestrels. *Journal of Zoology (London)* 237: 285-301.
- Wiggins, D. A., D. W. Holt, and S. M. Leasure. 2006. Short-eared Owl (*Asio flammeus*) in The Birds of North America. Edited by A. Poole. Cornell Lab of Ornithology, Ithaca. <http://bna.birds.cornell.edu/bna/species/062>. DOI 10.2173/bna.62.
- Williams, T. D. 1994. Intraspecific variation in egg size and egg composition in birds: effects on offspring fitness. *Biological Reviews* 68: 35-59.
- Yom-Tov, Y. 2001. An updated list and some comments on the occurrence of intraspecific nest parasitism in birds. *Ibis* 143: 133-143.
- Zhao, R., G.-Y. Xu, Z.-Z. Liu, J.-Y. Li, and N. Yang. 2006. A study on eggshell pigmentation: biliverdin in blue-shelled chickens. *Poultry Science* 85: 546-549.

Received 23 August 2011

Accepted 3 February 2012

## An Extra-Limital Population of Black-tailed Prairie Dogs, *Cynomys ludovicianus*, in Central Alberta

HELEN E. TREFRY<sup>1</sup> and GEOFFREY L. HOLROYD<sup>2</sup>

<sup>1</sup>Environment Canada, 4999-98 Avenue, Edmonton, Alberta T6B 2X3 Canada; email: helen.trefry@ec.gc.ca

<sup>2</sup>Environment Canada, 4999-98 Avenue, Edmonton, Alberta T6B 2X3 Canada

Trefry, Helen E., and Geoffrey L. Holroyd. 2012. An extra-limital population of Black-tailed Prairie Dogs, *Cynomys ludovicianus*, in central Alberta. *Canadian Field-Naturalist* 126(1): 46–49.

An introduced population of Black-tailed Prairie Dogs, *Cynomys ludovicianus*, has persisted for the past 50 years east of Edmonton, Alberta, over 600 km northwest of the natural prairie range of the species. This colony has slowly expanded at this northern latitude within a transition ecotone between the Boreal Plains ecozone and the Prairies ecozone. Although this colony is derived from escaped animals, it is worth documenting, as it represents a significant disjunct range extension for the species and it is separated from the sylvatic plague (*Yersinia pestis*) that threatens southern populations. The unique northern location of these Black-tailed Prairie Dogs makes them valuable for the study of adaptability and geographic variation, with implications for climate change impacts on the species, which is threatened in Canada.

**Key Words:** Black-tailed Prairie Dog, *Cynomys ludovicianus*, extra-limital occurrence, Alberta.

Black-tailed Prairie Dogs (*Cynomys ludovicianus*) occur from northern Mexico through the Great Plains of the United States to southern Canada, where they are found only in Saskatchewan (Banfield 1974). The current northern limit of natural occurrences for the species is at 49.20°N, 107.56°W, in and around Grasslands National Park of Canada (GNP), near Val Marie in southwestern Saskatchewan. We found no historical reference to the species occurring further north than the general area of Cadillac, Saskatchewan (60 km due north of Val Marie at 49.73°N), before cultivation by European settlers (Soper 1938). Prairie dogs (*Cynomys* spp.) have been subject to poisoning, shooting, plague epizootics, flooding, and overall widespread harassment, such that they currently occupy less than 2% of their previously extensive historical range across the Great Plains of North America (Knowles et al. 2002). Black-tailed Prairie Dog colonies in Saskatchewan covered an area of approximately 500 ha when they were surveyed in 1970 (Kerwin and Scheelhaase 1971), a time when Black-tailed Prairie Dogs were still being killed by local ranchers. By 2009, the colonies ( $N = 18$ ) had expanded to an area of approximately 1230 ha (Pearce and Kirk 2011).

This article documents the history and existence of a colony of free-living Black-tailed Prairie Dogs that escaped from captivity at the former Polar Park, which was owned and operated by Al Oeming near Edmonton, Alberta. This small colony is located over 600 km north of the species' natural range and is the only wild colony in Canada outside of Saskatchewan. Due to its isolated northern location and self-sustaining nature, we believe it is worthwhile to document its circumstances.

### History of the Black-tailed Prairie Dog Colony

Al Oeming opened the 567 ha (1400 acre) Alberta Game Farm, later known as the Polar Park, in 1959.

Among the animals he displayed were three Black-tailed Prairie Dogs, a male and two females, originating from the Dixon ranch colony southeast of Val Marie near Grasslands National Park in 1956. In 1963, he introduced two additional males and three females, taken from near Sioux Falls, South Dakota (Al and Todd Oeming, personal communication). Since the closure of the Polar Park in the late 1990s, the Black-tailed Prairie Dog colony has slowly expanded. The colony is located 12 km from the southeast corner of Edmonton and 300 m north of Highway 14 (53.4284°N, 113.1669°W). The entrance to the old Polar Park is still fenced, making the 567 ha inaccessible to the public without permission from the private landowner. The fence does not impede the movement of ungulates and is not near the colony. The current colony is 120 m east of the enclosure where Black-tailed Prairie Dogs were briefly displayed in 1959 before they escaped by digging under the cement wall and apron. The intervening unoccupied land contains a depression (flooded in April 2011) and a steep 30 degree slope that are not suitable habitat for Black-tailed Prairie Dogs (Knowles 1982). They moved into a pasture clearing in the forest, used to house camels and North American Elk (*Cervus elaphus*) at the time. When the grazers and fencing were removed, the Black-tailed Prairie Dogs took advantage of the post holes to initiate additional new burrows (Todd Oeming, personal communication). The animals were never controlled by poisoning or shooting and were never supplemented with food.

### Current Status of the Black-tailed Prairie Dog Colony

On 23 April 2011, we used a Garmin 76 GPS to measure the colony area by walking the outer perimeter from active burrow to active burrow. The colony covered 1.96 ha and had a perimeter of 819 m. Its shape was irregular, with a maximum north–south extent of



244 m and east–west width of 188 m. We counted 424 active burrows in the colony, including all burrows with sign of digging, recent droppings, or clipped vegetation. Due to the rolling terrain and lack of a high vantage point, we were unable to get a good count of the number of animals. However, we counted 51 animals and estimate there are fewer than 100 animals.

The colony is on a rolling glacial landscape typical of the Cooking Lake Moraine and at 750 m ASL (above sea level) it is about 100 m higher than the surrounding plain. The area is a unique transition zone in the area between the Aspen Parkland ecoregion in the Prairies ecozone and the forest of the Boreal Transition ecoregion in the Boreal Plains ecozone (Ecological Stratification Working Group 1996). Grey Luvisols are the common soil in the wooded areas (Geowest 1997\*). The area receives 20% more precipitation on average than the central parkland or northern boreal forest, but temperatures are comparable. The area contains scattered mature trees, including eight elm trees (*Ulmus* spp.) along a dirt road that bisects the colony. Coniferous trees are interspersed, and some of the burrows are near tree trunks. The colony is bordered by a dense spruce (*Picea* spp.) forest (Figure 1), a lake, mixed aspen (*Populus* spp.) forest, and an occupied yard. However, uninhabited grassland areas still exist for expansion on two sides of the colony. The ground cover was never seeded and currently is a mix of native and introduced grasses and forbs. There are no entirely barren patches other than the burrow mounds themselves. The perimeter of the area is actively mowed by the landowner annually due to the tall vegetation. The area no longer contains large grazers other than White-tailed Deer (*Odocoileus virginianus*). In 2011, the Black-tailed Prairie Dogs appeared to have abandoned areas with tall vegetation growth (>20 cm) around the periphery of the colony, as evidenced by in-filled burrows, but the interior of the colony remained well occupied. We saw domestic cats (*Felis catus*) and Coyotes (*Canis latrans*) in the area but American Badgers (*Taxidea taxus*) have not been seen for many years (Al and Todd Oeming, personal communication).

## Discussion

The Oeming colony has been in existence for about 50 years, originating from eight animals. While the density of burrows is not a reliable indicator of the number of animals in a colony, the density of burrows in the Oeming colony (216 burrows/ha) is higher than the usual range of 30–100 burrows/ha (King 1955). Although it has expanded, the colony remains small in size (~2 ha), suggesting a slow growth rate. Knowles et al. (2002) reported that it is often said that Black-tailed Prairie Dogs can spread quickly. A colony can recolonize rapidly after plague, but it is a long-term process for new colonies to develop. When Stelfox (1966\*) visited the Snake Pit colony in the Val Marie

area following poisoning by local ranchers in 1963, only a few animals and burrows remained. This same colony was estimated to still be small, only 0.6 ha, when it was surveyed in 1970 (Kerwin and Scheelhaase 1971), but by the next survey, in 1975 (Millson 1976 *quoted in* Pearce and Kirk 2011\*), it was estimated at 164 ha. While mapping colonies in North Dakota, Knowles et al. (2002) reported that a new colony that was believed to have appeared in the early 1960s was only 23.5 ha 30 years later. Although Black-tailed Prairie Dogs can reproduce more rapidly in the case of young, expanding colonies, where resources are not limiting, they normally increase relatively slowly due to a combination of reproductive factors (Hoogland 2001).

Severe winters are considered a mild threat to the Black-tailed Prairie Dog populations of Canada, while droughts and plague are considered more severe threats (Tuckwell and Everest 2009\*). Droughts have been documented to reduce populations by up to 80% by affecting body weight of the females to such an extent that they are unable to reproduce (Grasslands National Park data *in* Tuckwell and Everett 2009\*). Food in the form of native and non-native vegetation seems abundant in the Oeming colony area, which receives almost twice as much average rainfall (60.7 cm vs. 34.8 cm) and snowfall (121.4 cm vs. 86 cm) as Grasslands National Park (Geowest 1997\*; Environment Canada 2012\*). Gummer (2005) showed that the use of torpor by Black-tailed Prairie Dogs in Canada was related to daily air temperatures and snow depth and that they use more extensive torpor bouts than southern relatives.

Sylvatic plague is an introduced and recurring bacterial disease transmitted by fleas that decimates prairie dogs in the United States. In May 2010, we discovered a small Black-tailed Prairie Dog colony (South Gillespie) in the west block of Grasslands National Park that had recently become unoccupied. A dead Black-tailed Prairie Dog found in another colony was subsequently tested and confirmed to have died from sylvatic plague (Pat Fargey, Parks Canada, personal communication). The South Gillespie colony was found unoccupied in 1970 (Kerwin and Scheelhaase 1971) but was subsequently recolonized at an unknown date. Three other small colonies reportedly disappeared historically in the east block of Grasslands National Park, where ranchers reported they died out at the same time as ground squirrels (*Spermophilus* spp.) (Stelfox 1966\*); these Black-tailed Prairie Dog colonies never recovered. Due in part to the recent appearance of sylvatic plague, the status of the Black-tailed Prairie Dog was recently upgraded to threatened in Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Pearce and Kirk 2011\*).

The only other free-living Canadian colony we are aware of outside the Frenchman River (Grasslands National Park) area is a small colony at Moose Jaw, Saskatchewan, about 200 km northeast of the closest



FIGURE 1. Dense spruce (*Picea* spp.) forest at the edge of the Oeming Black-tailed Prairie Dog colony, 23 April 2011. Two burrows are visible, one in the centre foreground with a Black-tailed Prairie Dog, and one in the back right near the trees, with a Black-tailed Prairie Dog near it. Photo: Helen Trefry.

wild colony. These animals are another result of escaped animals, in this case from the Moose Jaw Wild Animal Park, which opened in 1929 and closed in 1995. We were unable to find information on the origin of the animals or the status of the colony, other than that the Black-tailed Prairie Dogs still exist and the area is used as an off-leash dog area (K. Epp, personal communication). Elsewhere in the Canadian prairies, all the Black-tailed Prairie Dog colonies in zoos in Edmonton, Calgary, Saskatoon, and Winnipeg are in contained enclosures, fed, and managed, although they are outside and subject to ambient local weather.

The Oeming colony may be protected from sylvatic plague and other diseases by the large distance from the colonies to the south. The Oeming colony also appears to face less predation pressure due to the lack of American Badgers in the area. We do not know what factors may be limiting their population growth, but this extra-limital occurrence of the Black-tailed Prairie Dog demonstrates that the species can persist at more northerly latitudes and with different vegetation and soils than those that occur within the natural range of the species. The resilience to different climatic conditions in the Black-tailed Prairie Dog may also be to

the species' future advantage and highlights the value of this colony in any studies of geographic variation, resilience to climate change, and adaptation.

### Acknowledgements

We wish to thank AI and Todd Oeming for their willingness to permit access to the Black-tailed Prairie Dog colony and to share the history of Polar Park. We thank Pat Fargey and Rob Sissons, Parks Canada, for providing information on the Black-tailed Prairie Dog towns in Grasslands National Park. Finally, we thank three anonymous reviewers for providing useful comments.

### Documents Cited (marked \* in text)

- Environment Canada.** 2012. Canadian climate normals 1971–2000. National Climate Data and Information Archive. Environment Canada, Ottawa, Ontario. [http://www.climate.weatheroffice.gc.ca/climate\\_normals/index\\_e.html](http://www.climate.weatheroffice.gc.ca/climate_normals/index_e.html). (Accessed 16 April 2012).
- Geowest.** 1997. Prioritized landscape ecology assessment of Strathcona County, Alberta. Prepared for Strathcona County, Planning and Engineering Services, Sherwood Park, Alberta.
- Pearce, J. L., and D. A. Kirk.** 2011. *In Press*. COSEWIC assessment and status report on the Black-tailed Prairie Dog

- Cynomys ludovicianus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiii + 58 pages.
- Stelfox, J.** 1966. An investigation of the current status of prairie dogs (*Cynomys ludovicianus ludovicianus* (Ord)) in the Val Marie, Saskatchewan area. CWSC no. 1697, CWS Progress Report 61-41-01.
- Tuckwell, J., and T. Everest.** 2009. Management plan for the black-tailed prairie dog (*Cynomys ludovicianus*) in Canada. Species at Risk Act Management Plan Series. Parks Canada Agency, Ottawa, Ontario. vi + 31 pages.
- Literature Cited**
- Banfield, A. W. F.** 1974. The mammals of Canada. Published by the University of Toronto Press, Toronto, Ontario, for the National Museum of Natural Sciences, National Museums of Canada.
- Ecological Stratification Working Group.** 1996. A National Ecological Framework for Canada. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research. Ottawa, Ontario, and Environment Canada, State of the Environment Directorate, Ecorezone Analysis Branch, Hull, Quebec. Report and national map at 1:7 500 000 scale.
- Gummer, D.** 2005. Geographic variation in torpor patterns: the northernmost prairie dogs and kangaroo rats. Ph.D. dissertation, University of Saskatchewan, Saskatoon, Saskatchewan.
- Hoogland, J.** 2001. Black-tailed, Gunnison's, and Utah prairie dogs reproduce slowly. *Journal of Mammalogy* 82: 917-927.
- Kerwin, L., and C. G. Scheelhaase.** 1971. Present status of the black-tailed prairie dog in Saskatchewan. *Blue Jay* 29: 35-37.
- King, J. A.** 1955. Social behavior, social organization, and population dynamics in a black-tailed prairie dog town in the Black Hills of South Dakota. *Contributions from the Laboratory of Vertebrate Biology, University of Michigan* 67: 1-123.
- Knowles, C. J.** 1982. Habitat affinity, populations, and control of black-tailed prairie dogs on the Charles M. Russell National Wildlife Refuge. Ph.D. thesis, University of Montana, Missoula, Montana. 171 pages.
- Knowles, C., J. P. Proctor, and S. Forrest.** 2002. Black-tailed prairie dog abundance and distribution in the Great Plains based on historic and contemporary information. *Great Plains Research* 12: 219-254.
- Soper, J. D.** 1938. Discovery, habitat and distribution of the black-tailed prairie dog in western Canada. *Journal of Mammalogy* 19: 290-300.

Received 8 January 2012

Accepted 2 April 2012

## A Specimen of the High Arctic Subspecies of Atlantic Puffin, *Fratercula arctica naumanni*, in Canada

ANTHONY J. GASTON<sup>1,2</sup> and JENNIFER F. PROVENCHER<sup>1</sup>

<sup>1</sup>Environment Canada, National Wildlife Research Centre, Carleton University, Ottawa, Ontario K1A 0H3 Canada

<sup>2</sup>Corresponding author email: tony.gaston@ec.gc.ca

Gaston, Anthony J., and Jennifer F. Provencher. 2012. A specimen of the High Arctic subspecies of Atlantic Puffin, *Fratercula arctica naumanni*, in Canada. *Canadian Field-Naturalist* 126(1): 50–54.

A fresh specimen of an adult Atlantic Puffin, *Fratercula arctica*, was obtained from a local hunter at the Minarets (Akpait) on the east coast of Baffin Island on 3 August 2007. The measurements of this bird exceeded those of Atlantic Puffins from Newfoundland and Labrador (*F. a. arctica*) but fell within the limits of the High Arctic subspecies (*F. a. naumanni*). This specimen appears to be the first of the High Arctic subspecies to be collected on a potential breeding site in Canada. This subspecies is highly disjunct from the Low Arctic subspecies and is probably represented in Canada by only a few hundred individuals.

Key Words: Atlantic Puffin, *Fratercula arctica naumanni*, status, Akpait, Baffin Island, large-billed form.

The Atlantic Puffin, *Fratercula arctica* L., is found in temperate, subarctic and arctic waters of the North Atlantic. In Europe, it breeds from the English Channel coasts north to Spitsbergen (in the Svalbard archipelago off the coast of Norway) (Snow and Perrins 1998), and in North America it breeds from Maine in the United States to the Canadian Arctic Archipelago (Lowther et al. 2002) and the Avanersuaq region, Greenland (Boertmann et al. 1996). It is most abundant in Scotland, Norway, Iceland, and Newfoundland and Labrador (Gaston and Jones 1998).

Three subspecies of Atlantic Puffin have been described: *Fratercula arctica grabae*, which is found in Britain and France to southern Norway; *F. a. arctica*, in northern Norway, Iceland, and eastern North America; and *F. a. naumanni*, in Spitsbergen, Jan Mayen Island (possibly), and northern Greenland (Salomonsen 1944; Bedard 1985). All breeding birds in North America to date have been referred to the subarctic subspecies, *F. a. arctica* (Lowther et al. 2002). The arctic subspecies, *F. a. naumanni*, is distinguished from *F. a. arctica* principally by its larger size.

In Canada, the Atlantic Puffin breeds from Machias Seal Island, New Brunswick, north to southern Labrador and in a small number of localities in the eastern Arctic (Gaston and Malone 1980; Nettleship and Evans 1985; Robards et al. 2000; Harris and Wanless 2011). Only one adult specimen was available hitherto from the Canadian Arctic: a bird found dead by AJG on 29 August 1980 near Ivujivik, Quebec, on a known breeding site (the Nuvuk Islands) (see Gaston et al. 1985). The specimen, deposited with the Canadian Museum of Nature (CMNAV 69844), was examined by the late Henri Ouellet, who assigned it to the subspecies *F. a. arctica* (H. Ouellet personal communication to AJG, 1980). Recently, a second specimen, shot on 3 August 2007 close to the large Thick-billed Murre, *Uria lomvia*, colony at the Minarets (also known as Akpait), on

Cumberland Peninsula, eastern Baffin Island (66°54'N, 61°45'W; 10 km south of Reid Bay), was obtained from a local hunter, who mentioned that “a few” puffins occurred annually at the site.

The bird collected at the Minarets was a male, identified on the basis of gonads by JFP, who skinned it. It was in full summer plumage and the bill had three vertical grooves on the upper mandible, suggesting that it was >3 years old (Harris 1981). A brood patch was present, so it was probably breeding at the time. It was measured after skinning. The wing length, flattened along a ruler, was 182 mm; the bill depth at the base, measured with calipers, was 42.6 mm; and the culmen length, from bill tip to the base of the rostrum (as illustrated in Pethon [1967] and shown in Figure 1), was 57.3 mm. The bill was slightly damaged at the base of the lower mandible, presumably by the bird-shot that killed it, and the depth otherwise might have been 1–2 mm greater (Figure 1). Using a Pesola spring balance, the bird weighed 585 g.

The measurements of the Minarets bird can be compared with means for birds from Labrador and the island of Newfoundland (*F. a. arctica*) and with means for birds from Svalbard (*F. a. naumanni*). Average measurements of *F. a. arctica* from the Gannet Islands, Labrador, are wing 172 (SD 4.0) mm, bill depth 37.8 mm (SD 2.0), and culmen length 50.4 mm (SD 2.2) (I. L. Jones, unpublished data). Average measurements of *F. a. arctica* from Newfoundland are wing 169 (SD 5.0) mm, bill depth 37.2 mm (SD 2.2), and culmen length 48.1 mm (SD 2.1) (Lowther et al. 2002). Average measurements of *F. a. naumanni* from Svalbard are wing 185 mm (range 177–195 mm), bill depth 47.1 mm (range 42–51 mm), and bill length 55.4 mm (range 51–59 mm) (Vaurie 1965).

The measurements of the bird from the Minarets fall outside of the 95% confidence limits for all three dimensions for samples of *F. a. arctica* from both

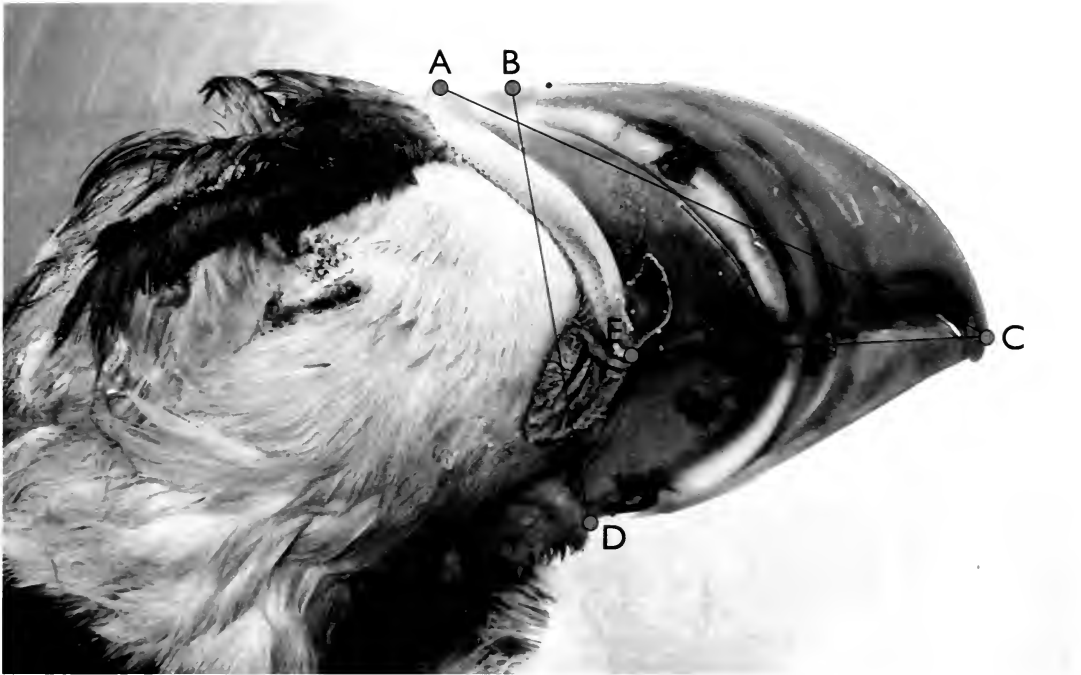


FIGURE 1. Measurements made on the specimen of the Atlantic Puffin collected from the Minarets (Akpait), Baffin Island, in 2007: culmen length measurement used is A–C and depth was B–D, perpendicular to the closure of the two mandibles. See also Appendix 1.

Labrador and the island of Newfoundland. Its mass also falls outside the 95% confidence interval for the mass of birds at the nearest Canadian population of *F. a. arctica*, on the Gannet Islands, Labrador (mean 481 g,  $n = 692$ , CI 420–542 g). When the measurements for the bird from the Minarets are plotted alongside a series of samples from elsewhere (Figure 2), it is clear that the measurements are well above the range for the majority of Atlantic Puffins but within the range for *F. a. naumanni* from Svalbard. Culmen length actually exceeded the range given for Svalbard birds by Pethon (1967); see Appendix 1 for notes on bill measurements of Atlantic Puffins.

Neither Bedard (1985), on morphological grounds, nor Moen (1991), on the basis of measurements and allozyme analysis, found any support for separating the subspecies of Atlantic Puffin, although Bedard (1985), who examined few *F. a. naumanni*, felt that a distinction might be made for this subspecies. Moen (1991) actually had no DNA material from any *F. a. naumanni* population, so was unable to evaluate the subspecies on the basis of allozymes. Currently, the official British List of the British Ornithologists' Union shows *Fratercula arctica* as monotypic (Dudley et al. 2006), but Harris and Wanless (2011), in a recent monograph on the species, supported the idea that *F. a. naumanni* should be considered distinct from the more southern puffins, referring to it as “the large-billed

form”. Harris and Wanless (2011) note the distribution of the large-billed form as including Svalbard (population <10 000 pairs), eastern Greenland (a few pairs), and northwestern Greenland (north of 73°N, <100; Boertmann et al. 1996). Even if the 2500 puffins breeding on Jan Mayen Island, Norway, are considered to be large-billed, it seems unlikely that the world population of this subspecies exceeds 20 000 breeding pairs.

Based simply on bill measurements (Figure 1), it appears that the Svalbard population could meet the “75% non-overlap rule” (75% of population *a* falls outside the 99% confidence interval for population *b*) for separating subspecies based on size (Amadon 1949; Mayr 1969), but data to test this rigorously are not available (only ranges are available in the literature for Svalbard birds). In any case, this criterion has been challenged (e.g., Pethon 1967) and is now, given the increasing availability of DNA evidence, largely ignored.

All of the recognized populations of large-billed Atlantic Puffins are geographically well separated from the populations of *F. a. arctica* in the Atlantic—those on Svalbard by 240 km from the nearest *F. a. arctica* on Bear Island (Bjornoya), the southernmost island in the Svalbard archipelago; those in northwestern Greenland by a 250-km stretch of Melville Bay, where the coast of Greenland is entirely covered by glaciers; and the very small population in east Greenland by >1000 km of Greenland coast (see maps in Harris

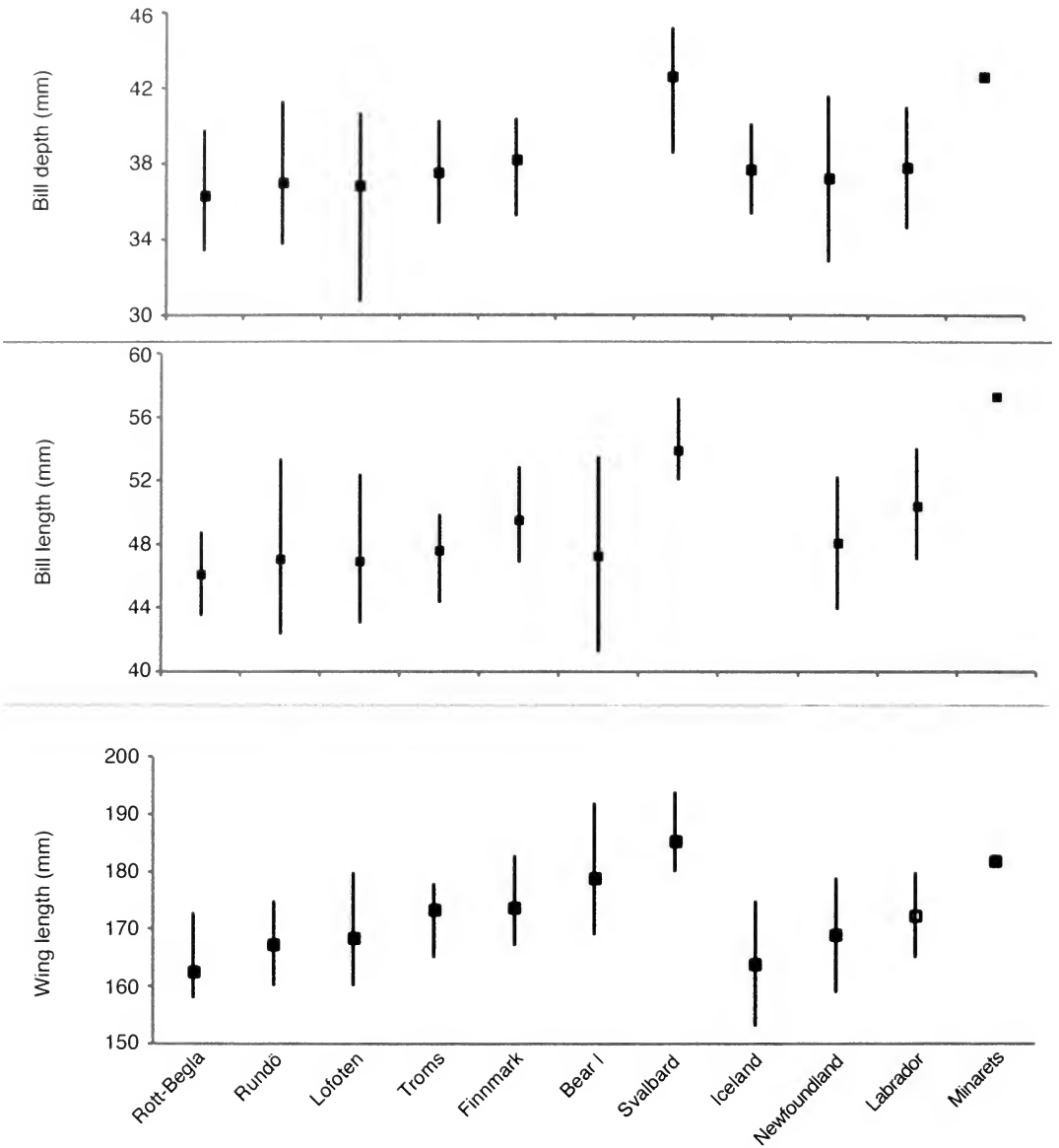


FIGURE 2. Measurements of Atlantic Puffins from five Norwegian localities (Pethon 1967), arranged from south to north (Rott-Begla at 60°N, Rundö, Lofoten, Troms, and Finnmark at 71°N); from Bear Island (Bjørnøya), Svalbard archipelago, Norway (H. Strom, unpublished data); from Spitsbergen, Svalbard archipelago, Norway (Pethon 1967); from Iceland (Petersen 1976); from the island of Newfoundland, Newfoundland and Labrador, Canada (Lowther et al. 2002); and from the Gannet Islands, Labrador, Newfoundland and Labrador, Canada (I. L. Jones, unpublished data). Error bars for all sites from Norway show ranges; error bars for Iceland, Newfoundland, and Labrador show 95% confidence intervals.

and Wanless 2011). If these birds are mainly philopatric, it seems possible that some genetic differentiation could have taken place. Moreover, the distribution and phylogeography of several arctic species suggests the possibility that some may have persisted in refugia in the High Arctic through the last glaciations (e.g., Fedorov and Stenseth 2002). The possibility of such an

origin for large-billed Atlantic Puffins raises the potential of a much deeper phylogenetic separation than would be likely if the differentiation took place post-Pleistocene.

The measurements of the bird collected on the Cumberland Peninsula of Baffin Island in 2007 place it among specimens of the large-billed subspecies, *F.*

*a. naumanni*. The specimen apparently constitutes the first of this subspecies to be collected in Canada. Based on the single specimen collected near Ivujivik in 1980, the small numbers of Atlantic Puffins breeding in Hudson Strait probably belong to the Low Arctic *F. a. arctica*. Hence, the small population at the Minarets, along with a similarly small population on Princess Charlotte Monument, off Coburg Island (at least 14 pairs, presumably of this subspecies; Robards et al. 2000), would therefore represent the only breeding populations of *F. a. naumanni* in North America. There is a possibility that additional breeding locations may be found in the Lancaster Sound/Jones Sound region (Nettleship and Evans 1985; Lepage et al. 1998). However, given the ubiquity of cruise ships, kayak expeditions, and other birdwatching activity in the region, it is unlikely that large numbers remain to be discovered. Consequently, it seems unlikely that the Canadian population exceeds a few hundred pairs, perhaps less than 100. Moreover, if the subspecies constitutes a phylogenetically distinct stock from the rest of the Atlantic Puffins, these small populations may be of some conservation concern. As a High Arctic endemic subspecies with a population of less than 20 000 pairs, it is likely to be vulnerable to the effects of global warming, as well as resource developments increasingly planned for the Arctic (Kelmelis 2011; Parsons et al. 2011). A better understanding of the phylogenetic position of these High Arctic populations of Atlantic Puffins would be highly desirable.

### Acknowledgements

We thank Joshua Alookie for providing us with the Atlantic Puffin specimen and Mark Mallory, Environment Canada, for looking after it for us. Tycho Anker-Nilssen provided a copy of the otherwise hard-to-obtain Pethon (1967) reference, Mike Harris sent a pre-print of his monograph on the Atlantic Puffin, and Ian Jones and Hallvard Strom provided measurements from birds trapped in Labrador and at Bear Island.

### Literature Cited

- Amadon, D. 1949. The seventy-five percent rule for subspecies. *Condor* 51: 250-258.
- Bedard, J. 1985. Evolution and characteristics of the Atlantic Alcidae. Pages 1-51 in *The Atlantic Alcidae*, Edited by D. N. Nettleship and T. R. Birkhead. Academic Press, London, U.K.
- Boertmann D., K. Falk, and K. Kampp. 1996. Seabird colonies in western Greenland. NERI Technical Report 170. National Environmental Research Institute, Denmark.
- Corkhill, P. 1972. Measurements of Puffins as criteria of sex and age. *Bird Study* 19: 193-202.
- Dudley, S. P., M. Gee, C. Kehoe, T. M. Melling, and the British Ornithologists' Union Record Committee. 2006. *The British List: a Checklist of the Birds of Britain*. Seventh edition. *Ibis* 148: 526-563.
- Fedorov, V. B., and N. C. Stenseth. 2002. Multiple glacial refugia in the North American Arctic: inference from phylogeography of the collared lemming (*Dicrostonyx groenlandicus*). *Proceedings of the Royal Society, London, Series B – Biological Sciences* 269: 2071-2077.
- Gaston A. J., and I. L. Jones. 1998. *The auks: Alcidae*. Oxford University Press, Oxford.
- Gaston A. J., and M. Malone. 1980. Range extension of Atlantic Puffin and Razorbill in Hudson Strait. *Canadian Field-Naturalist* 94: 328-329.
- Gaston, A. J., D. K. Cairns, R. D. Elliot, and D. G. Noble. 1985. A natural history of Digges Sound. *Canadian Wildlife Service Report Series No. 46*. Environment Canada, Ottawa. 63 pages.
- Harris, M. P. 1981. Age determination and first breeding of British puffins. *British Birds* 74: 246-256.
- Harris, M. P., and S. Wanless. 2011. *The Puffin*. T. & A. D. Poyser Ltd., London.
- Kelmelis, J. A. 2011. Arctic warming ripples through Eurasia. *Eurasian Geography and Economics* 52: 56-78.
- Lepage, D., D. N. Nettleship, and A. Reed. 1998. Birds of Bylot Island and adjacent Baffin Island. Northwest Territories, Canada, 1979 to 1997. *Arctic* 51: 125-141.
- Lowther, P. E., A. W. Diamond, S. W. Kress, G. J. Robertson, and K. Russell. 2002. The Atlantic Puffin (*Fratercula arctica*). In *Birds of North America*, No. 709. Edited by A. Poole and F. Gill. The Birds of North America Inc., Philadelphia, USA.
- Mayr, E. 1969. *Principles of Systematic Zoology*. McGraw-Hill, New York, USA.
- Moen, S. M. 1991. Morphological and genetic variation among breeding colonies of the Atlantic Puffin (*Fratercula arctica*). *Auk* 108: 755-763.
- Nettleship, D. N., and P. G. H. Evans. 1985. Distribution and status of the Atlantic Alcidae. Pages 53-154 in *The Atlantic Alcidae*, Edited by D. N. Nettleship and T. R. Birkhead. Academic Press, London, U.K.
- Parsons, J., J. Dinwoodie, and M. Roe. 2011. Northern opportunities: a strategic review of Canada's Arctic ice-breaking services. *Marine Policy* 35: 549-556.
- Petersen, A. 1976. Size variation in puffins *Fratercula arctica* from Iceland and bill features as criteria of age. *Ornis Scandinavica* 7: 185-192.
- Pethon, P. 1967. The systematic position of Norwegian Common Murre (*Uria aalge*) and Puffin (*Fratercula arctica*). *Meddelelser fra det Zoologiske Museum, Oslo*, No. 80. Universitetsforlaget, Oslo.
- Robards, M., H. G. Gilchrist, and K. Allard. 2000. Breeding Atlantic Puffins, *Fratercula [sic] arctica*, and other bird species of Coburg Island, Nunavut. *Canadian Field-Naturalist* 114: 72-77.
- Salomonsen, F. 1944. The Atlantic Alcidae – the seasonal and geographical variation of the auks inhabiting the Atlantic Ocean and the adjacent waters. *Goteborgs Kungliga Vetenskaps- och Vitterhets-Samhalles Handlingar Serie B* 5: 4-138.
- Snow, D. W., and C. M. Perrins. 1998. *The Birds of the Western Palearctic*. Volume 1. Oxford University Press, Oxford, U.K.
- Vaurie, C. 1965. *Birds of the Palearctic Fauna*. Volume 2. Non-Passeriformes. H. F. and G. Witherby, London, U.K.

Received 13 February 2012

Accepted 12 April 2012

## Appendix 1.

Not everyone measures puffin bills in the same way. The "bill length" given by Moen (1991) differs from the bill length of Pethon (1967). Pethon's (1967) bill length measurement (= culmen length) is the one used in this paper—it is easier to make on museum specimens. The same measurement is referred to as "bill curve length" by Moen, who cites Corkhill (1972), although Corkhill makes no mention of a bill curve length measurement and instead used line "B" in the diagram below. Bill depth measured by H. Strom at Bear Island, Svalbard archipelago (line C on Figure A1), is not comparable with the measurements of Pethon (1967) or those used here. Likewise, bill length measured in Iceland differs from Pethon's technique. Consequently, Figure 2 does not include length measurements from Iceland or depth measurements from Bear Island.

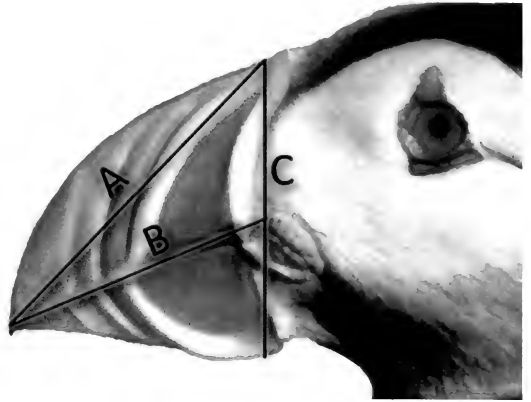


FIGURE A1. Atlantic Puffin bill measurements used in Norway (H. Strom, personal communication). Note difference in bill-depth measurement (line C) from line B–D on Figure 1.



# Vancouver Island Marmots (*Marmota vancouverensis*) Consume Plants Containing Toxic Secondary Compounds

JEFFERY R. WERNER

Centre for Biodiversity Research, Department of Zoology, University of British Columbia, Vancouver, British Columbia V6T 1Z4 Canada; email address: werner@zoology.ubc.ca

Werner, Jeffery R. 2012. Vancouver Island Marmots (*Marmota vancouverensis*) consume plants containing toxic secondary compounds. *Canadian Field-Naturalist* 126(1): 55–58.

I report 68 sightings of Vancouver Island Marmots (*Marmota vancouverensis*) feeding on Green False Hellebore (*Veratrum viride*), a plentiful but highly poisonous plant. Possible explanations for this novel foraging behaviour are presented.

**Key Words:** Vancouver Island Marmot, *Marmota vancouverensis*, plant alkaloids, foraging behaviour, diet, plant defensive compounds, *Veratrum viride*, False Hellebore, marmot foraging.

Plants display a variety of characteristics that provide a degree of protection from herbivores. One characteristic is the production of chemicals that are distasteful or toxic to herbivores (Freeland and Janzen 1974; Iason 2005). Green False Hellebore (*Veratrum viride*), a herbaceous perennial containing high concentrations of over 50 steroidal alkaloids, is considered to be highly poisonous (Taylor 1956). Ingestion of small amounts of this plant causes severe physiological impairment in humans (Underhill 1959; Jaffe et al. 1990; Prince and Stork 2000) and vertebrate herbivores (Fyles 1920; Dayton 1960; Cheeke and Shull 1985), and it can cause death (Gosselin et al. 1976). Small experimental doses of *Veratrum californicum* (California False Hellebore) administered to pregnant livestock have caused embryonic death, abortion, and fetal abnormalities (Binns et al. 1972; U.S. Department of Agriculture 2006\*).

## Study Area and Methods

Observations of Vancouver Island Marmots (*Marmota vancouverensis*) were made during focal behaviour samples conducted at four mountain colonies (Heather Mountain, Green Mountain, Haley Lake, and Mount Washington) between May and October over four years (2002–2005). Werner (2005) and Brashares et al. (2010) detail this sampling methodology. For reporting purposes, multiple observations of a single individual made on the same day were scored as a single record. Green False Hellebore was positively identified in the field using Hitchcock and Cronquist (1973) and later corroborated in a laboratory setting (University of British Columbia Herbarium database; accessed 27 October 2002).

## Results

Vancouver Island Marmots were observed eating Green False Hellebore (Figure 1) on 68 separate occasions, and at least 17 individual Vancouver Island Marmots were identified as having eaten Green False Hellebore on more than one occasion (in 9 of the 68 observations, the individual identity of the animal was not recorded).

On 27 June 2002, a two-year-old female that weaned young (Figure 1) consumed nearly 30 cm of the upper stem and connecting leaves of a single plant over an 11-minute period. This marmot suffered no visible effects, and she was re-sited 22 times during the following month. Similarly, in July 2005, a three-year-old female and one adult male (age unknown, but greater than four years) were observed feeding on the tips of Green False Hellebore leaves, and occasionally the flowers were consumed.

Young shoots were never observed to be eaten, nor were the roots, lower stems, or fruits. Vancouver Island Marmots fed on Green False Hellebore most frequently during July and August, although this may be an artefact of sampling effort (Figure 2). During April, May, and October, Vancouver Island Marmots were never seen consuming Green False Hellebore, despite considerable time spent in observation (nearly 400 hours combined during those months). During some years, snow persisted into late May and this resulted in Green False Hellebore being largely unavailable until June.

## Discussion

These are the first confirmed cases of Vancouver Island Marmots feeding on Green False Hellebore and—to my knowledge—of any marmot species eating substantial quantities of plant parts (see Armitage 1979) containing secondary compounds considered injurious to herbivores and humans.

Marmots are likely capable of detecting plant secondary compounds (including alkaloids), and Yellow-bellied Marmots (*Marmota flaviventris*) are able to avoid ingesting species that contain them (Armitage 1979). Frase and Armitage (1989) report that *Veratrum* species were not eaten by Yellow-bellied Marmots during two years of observation, despite this plant contributing to upwards of 50% of the plant biomass at particular sites. In a 30-year retrospective, Armitage (2003) identified this plant genus as having never been recorded in the diet of Yellow-bellied Marmots.

*Veratrum viride* has been recognized as a possible food plant for marmots (Hansen 1975; Heard 1977;



FIGURE 1. Reproductive female Vancouver Island Marmot (*Marmota vancouverensis*), aged two, eats *Veratrum viride* on Green Mountain, Vancouver Island, British Columbia, on 16 June 2002. Conspicuous bite marks on leaf tips (foreground) were made by this individual moments previous. Photo: J. Werner (300 mm telephoto, 1/500 sec, f/4).

Milko 1984; Nagorsen 1987; Barash 1989), although the authors provide no direct evidence for their claims and appear to have received direction from a single unpublished reference (Gray 1967\*) that does not positively identify *V. viride* as part of marmot diet.

I consider three alternative explanations for Vancouver Island Marmots feeding on *Veratrum viride*: first, this marmot species may not possess sufficient discernment to completely minimize intake of Green False Hellebore during bouts of feeding. During feeding, Vancouver Island Marmots, Hoary Marmots (*Marmota caligulata*), Olympic Marmots (*M. olympus*), Yellow-bellied Marmots, Bobak (or Steppe) Marmots (*M. bobak*), Long-tailed (or Golden) Marmots (*M. caudate*), and Woodchucks (*M. monax*) employ rapid bite patterns between long pauses devoted to vigilance (Blumstein et al. 2001), and the number of plant species browsed often appears to be in proportion to what is immediately available (Werner and Brashares, unpublished data). However, selective foraging has been identified in the Vancouver Island Marmot (Milko 1984; Martell and Milko 1986) and other marmot species

(Hansen 1975; Armitage 1979; Barash 1989; Frase and Armitage 1989; Stallman and Holmes 2002; Armitage 2003). Because Green False Hellebore was plentiful at all study sites and the Vancouver Island Marmots that were observed eating Green False Hellebore were all adults (range of two to six years or more), I assume these foraging choices were "intentional" rather than first-time experiences.

Second, it is possible that Vancouver Island Marmots are immune to the toxic qualities of specific alkaloid compounds. This is unlikely, however, given the widespread observations of lethal and sub-lethal effects of false hellebore intake in birds and amphibians (Christensen and McLean 1939), sheep, goats, and cattle (Fyles 1920; Binns et al. 1972; Cheeke and Shull 1985; Mulligan and Munro 1987), humans (Underhill 1959; Gosselin et al. 1976; Jaffe et al. 1990; Prince and Stork 2000), and other mammal species (Dayton 1960; U.S. Department of Agriculture 2006\*).

A third possibility is that ingesting false hellebore may, at times, be beneficial. Eating plants which contain specific secondary compounds can be a strategy

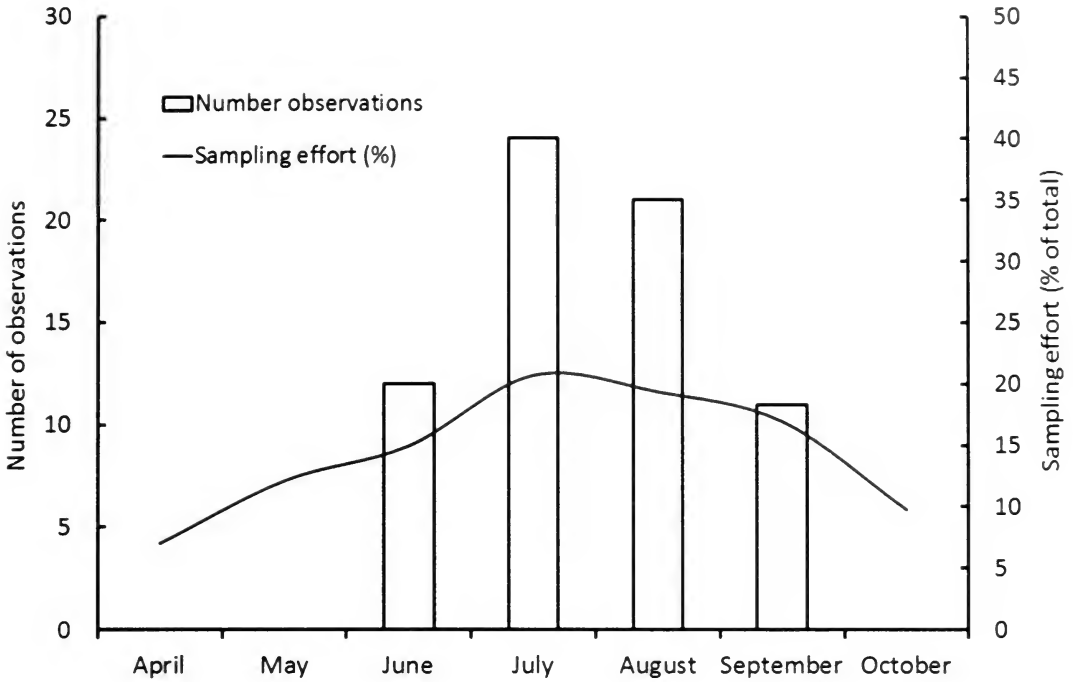


FIGURE 2. The number of independent observations of Vancouver Island Marmots (*Marmota vancouverensis*) consuming Green False Hellebore (*Veratrum viride*) and the percentage of all time (>1300 hours) spent observing across the four active seasons in 2002, 2003, 2004, and 2005 (sampling effort). Vancouver Island Marmots were typically still hibernating during a portion of April/May in each year of study and entered hibernation during October, and this accounts for the low proportion of observations during those months.

to neutralize other toxins (Foley et al. 1999; Rozman and Klaassen 2001), to enhance amino acid absorption (Iason 2005), to strengthen the immune system and/or to fight parasites (Marley et al. 2003) in mammalian herbivores. The consumption of Green False Hellebore by Vancouver Island Marmots likely contributes to a coherent nutritional strategy (Foley et al. 1999; Iason and Villalba 2006), and this finding has important implications for our understanding of marmot ecology and plant-herbivore interactions.

### Acknowledgements

Sixteen field staff contributed to the field component of this study. Particular thanks are due to R. Landucci, F. Iredale, and F. Griffith, whose initial observations led to the identification of this unusual foraging behaviour. A. Bryant, D. Doyle, R. Elner, the Vancouver Island Marmot Science Advisory Group, and the Vancouver Island Marmot Recovery Team provided input and support during the initial planning stages. For funding and logistical support, I thank Environment Canada, the British Columbia Ministry of Water, Land and Air Protection (now Ministry of Environment), the staff at Mount Washington Alpine Resort, TimberWest, and the Department of Zoology and Centre for

Biodiversity Research at the University of British Columbia. Additional funding was provided by the Natural Sciences and Engineering Research Council of Canada.

### Documents Cited (marked \* in text)

- Gray, D. 1967. Behavior and activity in a colony of hoary marmots (*M. caligata*) in Manning Park, B.C., and a comparison of behaviour with other marmot species. Honor's thesis, University of Victoria, Victoria, B.C., Canada.
- U.S. Department of Agriculture. 2006. Poisonous Plant Research: False Hellebore (*Veratrum californicum*). United States Department of Agriculture. <http://www.ars.usda.gov/Services/docs.htm?docid=9992>.

### Literature Cited

- Armitage, K. B. 1979. Food selectivity by yellow-bellied marmots. *Journal of Mammalogy* 60: 628-629.
- Armitage, K. B. 2003. Observations on plant choice by foraging Yellow-Bellied Marmots. *Oecologia Montana* 12: 25-28.
- Barash, D. P. 1980. The influence of reproductive status on foraging by hoary marmots (*Marmota caligata*). *Behavioural Ecology and Sociobiology* 7: 201-205.
- Barash, D. P. 1989. *Marmots: Social Behavior and Ecology*. Stanford University Press, Stanford, Calif.
- Binns, W. M., F. R. Keeler, and L. D. Balls. 1972. Congenital deformities in lambs, calves and goats resulting from

- maternal ingestion of *Veratrum californicum*: hair lip, cleft palate, aplasia and hypoplasia of metacarpal and metatarsal bones. *Clinical Toxicology* 5: 245-261.
- Blumstein, D. T., J. C. Daniel, and A. A. Bryant.** 2001. Anti-predator behavior of Vancouver Island marmots: using congeners to evaluate abilities of a critically endangered mammal. *Ethology* 107: 1-14.
- Brashares, J. S., J. R. Werner, and A. R. E. Sinclair.** 2010. Social 'meltdown' in the demise of an island endemic: Allee effects and the Vancouver Island marmot. *Journal of Animal Ecology* 79(5): 965-973.
- Cheeke, P. R., and L. R. Shull.** 1985. Mycotoxins. Pages 135-139 in *Natural Toxicants in Feeds and Poisonous Plants*. Edited by P. R. Cheeke and L. R. Shull. AVI Publishing, Westport, Conn.
- Christensen, B. V., and A. P. McLean.** 1939. The assay of *Veratrum viride*. *Journal of the American Pharmaceutical Association* 28: 74-82.
- Dayton, W. A.** 1960. Notes on western range forbs: Equisetaceae through Fumariaceae. Forest Service, U.S. Department of Agriculture, Washington, D.C. Agriculture Handbook 161. 254 pages.
- Foley, W. J., G. R. Iason, and C. McArthur.** 1999. The role of plant secondary metabolites in the nutritional ecology of mammalian herbivores: how far have we come in 25 years? Pages 130-209 in *Nutritional Ecology of Herbivores*. Edited by H-J. G. Jung and G. C. Fahey. Proceedings of the Vth International Symposium on the Nutrition of Herbivores. American Society of Animal Science, Savoy, Ill.
- Frase, B. A., and K. B. Armitage.** 1989. Yellow-bellied marmots are generalist herbivores. *Ethology, Ecology and Evolution* 1: 353-366.
- Freeland, W. J., and D. H. Janzen.** 1974. Strategies in herbivory by mammals: the role of plant secondary compounds. *American Naturalist* 108: 269-289.
- Fyles, F.** 1920. Principal poisonous plants of Canada. Dominion of Canada Department of Agriculture, Dominion Experimental Farms Bulletin (second series) 39: 112.
- Gosselin, R. E., H. C. Hodge, R. P. Smith, and M. N. Gleason.** 1976. *Clinical Toxicology of Commercial Products*. Fourth edition. Williams and Wilkin, Baltimore.
- Hansen, R. M.** 1975. Foods of the hoary marmot on Kenai Peninsula, Alaska. *American Midland Naturalist* 94(2): 348-353.
- Heard, D. C.** 1977. The behaviour of Vancouver Island Marmots (*Marmota vancouverensis*). M.Sc. thesis, University of British Columbia, Vancouver, British Columbia, Canada.
- Hitchcock, C. L., and A. Cronquist.** 1973. *Flora of the Pacific Northwest*. University of Washington Press, Seattle.
- Iason, G.** 2005. The role of plant secondary metabolites in mammalian herbivory: ecological perspectives. *Proceedings of the Nutrition Society* 64: 123-131.
- Iason, G., and J. Villalba.** 2006. Behavioral strategies of mammal herbivores against plant secondary metabolites: the avoidance-tolerance continuum. *Journal of Chemical Ecology* 32(6): 1115-1132.
- Jaffe, A. M., D. Gephardt, and L. Courtemanche.** 1990. Poisoning due to ingestion of *Veratrum viride* (false hellebore). *Journal of Emergency Medicine* 8(2): 161-167.
- Marley, C. L., R. Cook, J. Barrett, R. Keatlinge, N. H. Lampkin, and S. D. McBride.** 2003. The effect of dietary forage on the development and survival of helminth parasites in ovine faeces. *Veterinary Parasitology* 118: 93-107.
- Martell, A. M., and R. J. Milko.** 1986. Seasonal diets of Vancouver Island marmots, *Marmota vancouverensis*. *Canadian Field-Naturalist* 100: 241-245.
- Milko, R. J.** 1984. Vegetation and foraging ecology of the Vancouver Island marmot (*Marmota vancouverensis*). M.Sc. thesis, University of Victoria, Victoria, British Columbia, Canada.
- Mulligan, G. A., and D. B. Munro.** 1987. The biology of Canadian weeds. 79. *Veratrum viride* Ait. *Canadian Journal of Plant Science* 67: 777-786.
- Nagorsen, D. W.** 1987. *Marmota vancouverensis*. *Mammalian Species* 270: 1-5.
- Prince, L. A., and C. M. Stork.** 2000. Prolonged cardiotoxicity from poison lilly (*Veratrum viride*). *Veterinary and Human Toxicology* 42(5): 282-285.
- Rozman, K. K., and C. D. Klaassen.** 2001. Absorption, distribution, and excretion of toxicants. Pages 107-132 in *Casarett and Doull's Toxicology: The Basic Science of Poisons*. Edited by C. D. Klaassen. McGraw-Hill, New York.
- Stallman, E. L., and W. G. Holmes.** 2002. Selective foraging and food distribution of high elevation yellow-bellied marmots (*Marmota flaviventris*). *Journal of Mammalogy* 83(2): 576-584.
- Taylor, C. A.** 1956. The culture of false hellebore. *Economic Botany* 10: 155-165.
- Underhill, J. E.** 1959. A case of hellebore poisoning. *Canadian Field-Naturalist* 73: 128-129.
- Werner, J. R.** 2005. The endangered Vancouver Island marmot: Allee effects and reintroduction success. M.Sc. thesis, Centre for Biodiversity Research, Department of Zoology, University of British Columbia, Vancouver, British Columbia, Canada.

Received 16 February 2012

Accepted 15 April 2012

## New Avian Breeding Records for Iqaluit, Nunavut

DAVID J. T. HUSSELL<sup>1,2</sup>, JEREMY A. T. HUSSELL<sup>2</sup>, and ERICA H. DUNN<sup>2,3,4</sup>

<sup>1</sup> Ontario Ministry of Natural Resources, Wildlife Research and Development Section, 2140 East Bank Drive, Peterborough, Ontario K9J 7B8 Canada

<sup>2</sup> 111 Decou Road, Simcoe, Ontario N3Y 4K2 Canada

<sup>3</sup> Environment Canada, National Wildlife Research Centre, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario K1A 0H3 Canada

<sup>4</sup> Corresponding author

Hussell, David J. T., Jeremy A. T. Hussell, and Erica H. Dunn. 2012. New avian breeding records for Iqaluit, Nunavut. *Canadian Field-Naturalist* 126(1): 59–60.

Breeding was documented for the first time in Iqaluit, Nunavut, for Savannah Sparrow (*Passerculus sandwichensis*), White-crowned Sparrow (*Zonotrichia leucophrys*), and Dark-eyed Junco (*Junco hyemalis*), extending the known breeding ranges in the eastern Arctic for all three species.

**Key Words:** Savannah Sparrow, *Passerculus sandwichensis*, White-crowned Sparrow, *Zonotrichia leucophrys*, Dark-eyed Junco, *Junco hyemalis*, breeding, Iqaluit.

We conducted field work in and around Iqaluit, Nunavut, on various dates between 16 June and 5 September in 2007, 2008, 2009, 2010, and 2011. Our main objective was to study the the Northern Wheatear (*Oenanthe oenanthe*) (Bairlein et al. 2012), but we also documented new breeding records for the following three species.

### *Passerculus sandwichensis* (Savannah Sparrow)

This species was recorded only in 2011. An adult was seen and photographed by R. Nagel on 3 July; and on 21 July, JATH saw an adult feeding the fledgling in Figure 1A (63°45.3'N, 68°27.8'W). A bird seen in flight on 10 August may have been a juvenile.

### *Zonotrichia leucophrys* (White-crowned Sparrow)

Single young birds in first basic plumage were seen on 1 September 2007 and on 2 and 3 September 2008. Adults were seen along the shore path between Iqaluit and Apex village on eight days between 30 June and 28 July 2010. One of these White-crowned Sparrows was singing (14 July). JATH saw an adult feeding fledglings on 8 July (63°44.0'N, 68°28.7'W) and photographed one of them. On 28 July, DJTH saw and photographed another adult that was feeding fledglings (Apex, 63°43.6'N, 68°26.3'W) (Figure 1B). On 23 July 2011, JATH and DJTH found a pair feeding recently fledged young and photographed one of the adults (Tarr

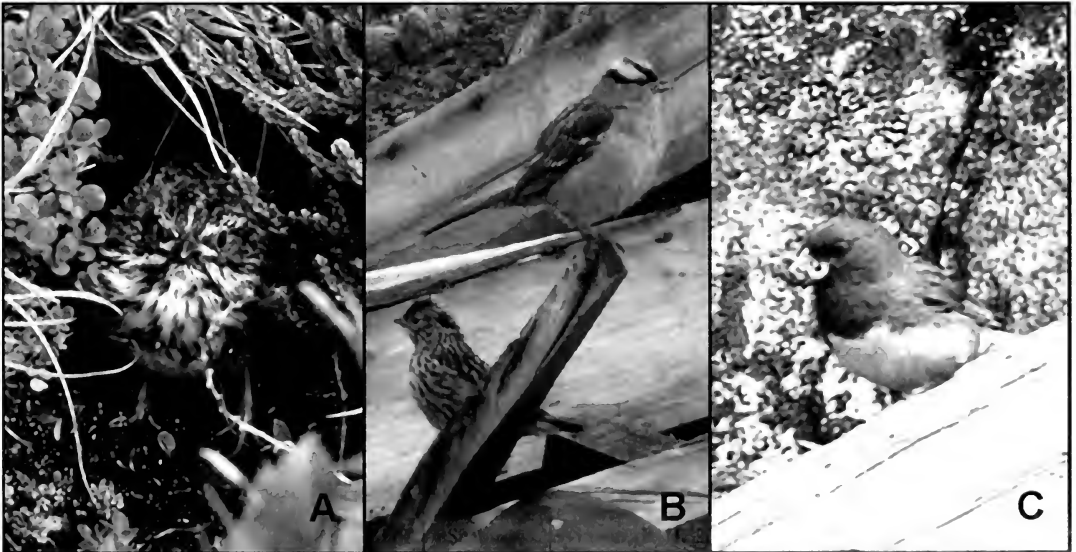


FIGURE 1. Evidence of breeding from Iqaluit, Nunavut. A. Fledgling Savannah Sparrow that was being fed by an adult, 21 July 2011. Photo: J. A. T. Hussell. B. Adult White-crowned Sparrow (upper right) with fledgling it was feeding, 28 July 2010. Photo: D. J. T. Hussell. C. Dark-eyed Junco carrying food for nearby young, 22 July 2011. Photo: J. A. T. Hussell.

Inlet, 63°43.7'N, 68°23.8'W). All adults that were closely observed, including all of those attending fledglings, were of the eastern subspecies, *Z. l. leucophrys*.

#### *Junco hyemalis* (Dark-eyed Junco)

Dark-eyed Juncos were reported to us in 2007 (with a photograph), and we saw them repeatedly between 1 July and 25 July 2010 (five dates) and 25 June and 22 July 2011 (at least nine dates). Many of the latter birds were singing. We estimated that at least five adults were present in late June and early July of 2011. On 22 July, JATH found a pair gathering food and feeding at least two fledglings near Apex (63°43.4'N, 68°26.9'W). He photographed one of the adults carrying food (Figure 1C).

### Discussion

Vagrants of these three species have been reported at scattered locations in the Canadian Arctic Archipelago (Godfrey 1986; Gaston and Ouellet 1997; Northwest Territories/Nunavut Bird Checklist Program\*; eBird\*). In 1957, a White-crowned Sparrow was found on Fletcher's Ice Island (a tabular iceberg used as a research station) (82°37'N, 99°50'W), only 240 km from the North Pole (Godfrey 1986); and a juvenile Dark-eyed Junco was present on Tern Island (75°48'N, 96°18'W) from 4 to 30 August 2011 (Mark Mallory, personal communication).

According to Richards and White (2008\*), all three species have also bred in the arctic islands, but we were able to obtain details for only the Dark-eyed Junco (J. Richards, personal communication). That species has been found tending fledglings on both Coats and East Digges islands, in northeastern Hudson Bay. The White-crowned Sparrow has recently been documented breeding in the western Arctic at Cambridge Bay, Victoria Island (J. Richards, personal communication), a site farther north than Iqaluit.

Although the records from Iqaluit extend known breeding ranges in the eastern Arctic to north of the Hudson Strait, they may not represent recent expansion, and are not necessarily evidence of response to climate change. Our parties of up to six people spent 4–10 hours daily for 2–6 weeks annually searching for nests and broods of Northern Wheatear. The sparse records we have for sparrows and Dark-eyed Junco

indicate that evidence of breeding could easily have been overlooked previously. Moreover, the periphery of the northern range may be occupied only sporadically. Illustrating this is the fact that we saw and suspected breeding of American Robins (*Turdus migratorius*) in Iqaluit each year from 2007 to 2010, but saw no robins at all in 2011.

### Acknowledgements

Some of the observations reported here in 2009–2011 were made by our colleagues F. Bairlein, M. Bulte, R. Nagel, D. R. Norris, and D. Strickland. For help and advice in Iqaluit, we thank M. Mallory (Canadian Wildlife Service, Environment Canada) and M. E. Thomas and R. Armstrong (both with the Nunavut Research Institute). Our research was supported by Bird Studies Canada. Author sequence was determined by drawing lots.

### Documents Cited (marked \* in text)

- eBird. National Audubon Society and Cornell Lab of Ornithology, Ithaca, New York. <http://ebird.org/ebird/eBirdReports?cmd=Start>. Accessed August 2012.
- Northwest Territories/Nunavut Bird Checklist Survey. Canadian Wildlife Service, Environment Canada, Yellowknife, Northwest Territories. <http://www.ec.gc.ca/reom-mbs/default.asp?lang=En&n=60E48D07-1>. Accessed August 2012.
- Richards, J., and T. White. 2008. Birds of Nunavut: a checklist. Revised edition. Published by the authors. [http://avi.base.bsc-eoc.org/links/reports/Nunavut\\_Bird\\_Checklist.pdf](http://avi.base.bsc-eoc.org/links/reports/Nunavut_Bird_Checklist.pdf). Accessed August 2012.

### Literature Cited

- Bairlein, F., D. R. Norris, R. Nagel, M. Bulte, C. C. Voigt, J. W. Fox, D. J. T. Hussell, and H. Schmaljohann. 2012. Cross-hemisphere migration of a 25 g songbird. *Biology Letters* 8: 505–507; published ahead of print February 15, 2012, doi:10.1098/rsbl.2011.1223.
- Gaston, A. J., and H. Ouellet. 1997. Birds and mammals of Coats Island, Northwest Territories. *Arctic* 50: 101–118.
- Godfrey, W. E. 1986. *The Birds of Canada*. Revised edition. National Museum of Natural Sciences, National Museums of Canada, Ottawa.

Received 29 December 2011

Accepted 29 February 2012

ADDENDUM: On 29 June 2012, DJTH found a pair of eastern White-crowned Sparrows feeding 5 young, about 6–7 days old, in a ground nest under a patch of willows (*Salix* sp.) at Apex (63°43.8'N, 68°27.1'W).

# A Tribute to James Herbert Soper, 1916–2012

ERICH HABER

60 Baywood Drive, Stittsville, Ontario K2S 2H5 Canada

Haber, Erich. 2012. A tribute to James Herbert Soper, 1916–2012. *Canadian Field-Naturalist* 126(1): 61–67.

Jim Soper (Figure 1) was born in Hamilton, Ontario, 9 April 1916 to Herbert Armitage Soper (1875–1944) and Anna Eliza Gertrude (née Cooper, 1880–1917). He was the youngest of five children. Jim had three sisters—Dorothy (1903–1910), Phyllis (1906–1936), and Brenda (1908–1947)—and one brother, Robert (1913–2000). Jim’s mother died the year after he was born, and, due to family circumstances, he went to live with his father’s sister, Florence Anna Callahan (1880–1975), her husband, Charles, and Jim’s great-aunt Nancy (his grandmother’s sister). Although Jim grew up as the only child in this extended family, there was a lot of visiting between the families. His father subsequently married Nettie Sophia Webb, who had a daughter, Gladys Thompson, from a previous marriage.

The Callahans, Jim, and his great-aunt lived in the house built by Jim’s grandfather, Robert Soper, in 1914. Robert Soper was a sailmaker from England who originally immigrated to Quebec, but ultimately settled in Hamilton after purchasing a sailmaking company in 1884. Jim’s father was also involved with this company, which later branched out into making tents and awnings. The company, no longer in the family, operates as Soper’s Engineered Fabric Solutions. Jim’s paternal grandmother was an Armitage with roots in the stone quarries of Leeds, Yorkshire, England. This background led the Armitage family to the Welland Canal area of Ontario. Jim’s great-grandfather, Samuel Soper, was a market gardener in the Torbay area of Devon, England, where the Soper farm (Torr Farm) is still located.

Jim attended Hamilton Central Collegiate Institute. He entered McMaster University in 1935, and the yearbook for his freshman year lists his entrance scholarships as the Harold Matthews Memorial Scholarship for First Place Science and the Third Carter Scholarship for Wentworth. Jim completed his undergraduate degree in Honours Chemistry (1938) and his M.A. in Biology (1939). His supervisor arranged to have Jim serve as a field assistant to Hugh M. Raup on his botanical exploration of the Brintnell Lake area (now known as Glacier Lake) in the Mackenzie Mountains in the Northwest Territories (Raup 1939). On this trip, Jim joined the entire Raup family, including Lucy Raup and their two young boys, Karl and David. Jim was greatly influenced by his association with the Raups, who treated him as a member of the family. He learned from Lucy how to bake bread, a skill that he later ex-



FIGURE 1. James Herbert Soper, National Museum of Natural Sciences, Ottawa (now the Canadian Museum of Nature), 24 March 1970. Photo used with permission of the Canadian Museum of Nature.

panded to include a variety of baked goods loved by his own family. Jim completed his Ph.D. at Harvard (1943) under Raup and M. L. Fernald, specializing in plant taxonomy and phytogeography. His thesis was a study of the flora of the Lake Erie region of southern Ontario.

Following his studies at Harvard, Jim served with the Operational Research Section of the Royal Canadian Air Force, and he was on loan to Royal Air Force Headquarters, Coastal Command, in Britain, for eight months. He subsequently joined the same section of the RCAF at Eastern Air Command, Halifax. With the end of World War II in 1945, Jim took a position as an Agricultural Scientist in what is now the old herbarium building in the Arboretum of the Central Experimental Farm, Ottawa. Here he met Jean Morgan of Montreal, the botany librarian, who that winter introduced him to cross-country skiing.

Jim and Jean married in August 1946 and moved in the fall to Toronto, where Jim took up his new teaching position in botany as Special Lecturer and Curator of the Vascular Plant Herbarium at the University of Toronto. Jean resumed library work, becoming secretary-treasurer of the Ontario Library Association. The following years were busy times for Jim and Jean, with Jim preparing botany lectures for the first time and the Sopers settling into a new house they had bought in the Leaside area of Toronto and starting a family.

Shortly after they moved into their new house, their daughter Nancy was born (1948), followed by Mary (1950), and twins Daphne and Ian (1952). Over the years at their Leaside home, Jim enjoyed cultivating a sizeable vegetable garden and planting trees and shrubs. Perhaps gardening was in Jim's genes, his great-grandfather having been a market gardener.

Over the course of the following 21 years, from 1946 to 1967, Jim combined a teaching career with active botanical research on the flora of Ontario. He taught General Botany, Taxonomy, Economic Botany, and Plant Geography. Jim had a special interest in documenting the Carolinian flora of southwestern Ontario and in the shrubs of Ontario. The latter was perhaps fostered through his association with Dr. W. Sherwood Fox, former president of the University of Western Ontario, with whom he collaborated on a number of projects. His fieldwork also took Jim to northern Ellesmere Island, where he participated in a study of the Lake Hazen flora as part of International Geophysical Year projects in 1958. With the completion of the Lake Superior portion of the TransCanada Highway in 1960, Jim undertook field excursions along the newly accessible shoreline of the lake. Subsequently, he published or co-published papers dealing with arctic-alpine elements found along the eastern shore of Lake Superior. He also conducted fieldwork on Vancouver Island, in Revelstoke National Park, and in Glacier National Park. When he was on holidays in the Jeep station wagon (known in the neighbourhood as the Soper's truck), much of his Ontario fieldwork was done with the family in tow. They camped or rented a cottage, and while the kids played, Jim kept busy conducting fieldwork.

To facilitate making herbarium labels and mapping the distribution of Ontario plants, Jim undertook to learn FORTRAN, the computer language then being used to run the university's computers. Having a great facility in math and problem-solving, Jim developed a program for mapping plant records. He was one of the first in North America to promote computer mapping of phytogeographic data (Soper 1964, 1966). He set up a punch-card machine for data entry and a card reader in a small room opposite the herbarium on the third floor of the Botany Building. Herbarium assistants would punch in data that were subsequently mapped using the university plotters.

During Jim's tenure at the University of Toronto herbarium, it grew substantially through an active program of plant collecting by Jim, student projects, and colleagues' work and through an exchange program. The vascular plant collection grew from 60 545 to 156 831, with his personal collections totalling more than 10 000. Jim documented his sight records with preprinted checklist cards that he used in the field. He also compiled a card catalogue of collections and localities (Figure 2).

In his years as professor and curator, Jim mentored graduate students in taxonomy and biogeography and was the primary supervisor of my M.Sc. thesis on Enchanter's Nightshade in Ontario (genus *Circaea*) and of Ph.D. student Gary R. Thaler, who studied the limits of the Carolinian floristic zone using, in part, Jim's biogeographical data.

In 1967, Jim took up the position of Chief Botanist at the National Museum of Natural Sciences, National Museums of Canada in Ottawa. There he continued his efforts to promote the computerization of collections at the Botany Division of the Museum (now the Canadian Museum of Nature). Jim became an avid student of French, developing a working facility in the language that even extended to reading French novels.

In 1981, Jim followed up his early work on the arctic-alpine flora on the shoreline of Lake Superior with post-doctoral fellow David Given (Given and Soper 1981). Work on the shrubs of Ontario, initiated with Margaret Heimburger in 1961, culminated 20 years later in a major publication by the Royal Ontario Museum (Soper and Heimburger 1982). On retirement in 1981, Jim continued his research on the flora of Ontario as Curator Emeritus and assisted me in compiling my georeferenced database on the rare vascular plants of Canada.

Jim is the author or co-author of 3 books and over 60 botanical papers. A sedge (*Carex soperi* Raup) and two varieties of plants (*Celtis tenuifolia* Nutt. var. *soperi* Boivin and *Houstonia longifolia* Gaertn. var. *soperi* Boivin) were named after him. The sedge is now synonymized under the geographically widespread Thick-headed Sedge (*Carex macloviana* d'Urv.), and the two varieties are currently also included with the normal range of variation of their respective species, Dwarf Hackberry (*Celtis tenuifolia*) and Long-leaved Bluet (*Houstonia longifolia*). In 1977, Jim was awarded the Queen's Silver Jubilee Medal honouring Canadians who were considered to have made a significant contribution in important fields of endeavour.

In his early years at Toronto, Jim served as Chairman of the Checklist Committee of the Federation of Ontario Naturalists, along with members W. Sherwood Fox, Monroe Landon, Fred H. Montgomery, and Edmund M. Walker (Cruise 1982). A preliminary checklist of vascular plants of the portion of southern Ontario south of the Canadian Shield and west of Kingston was completed in 1949. Jim was a member of a number



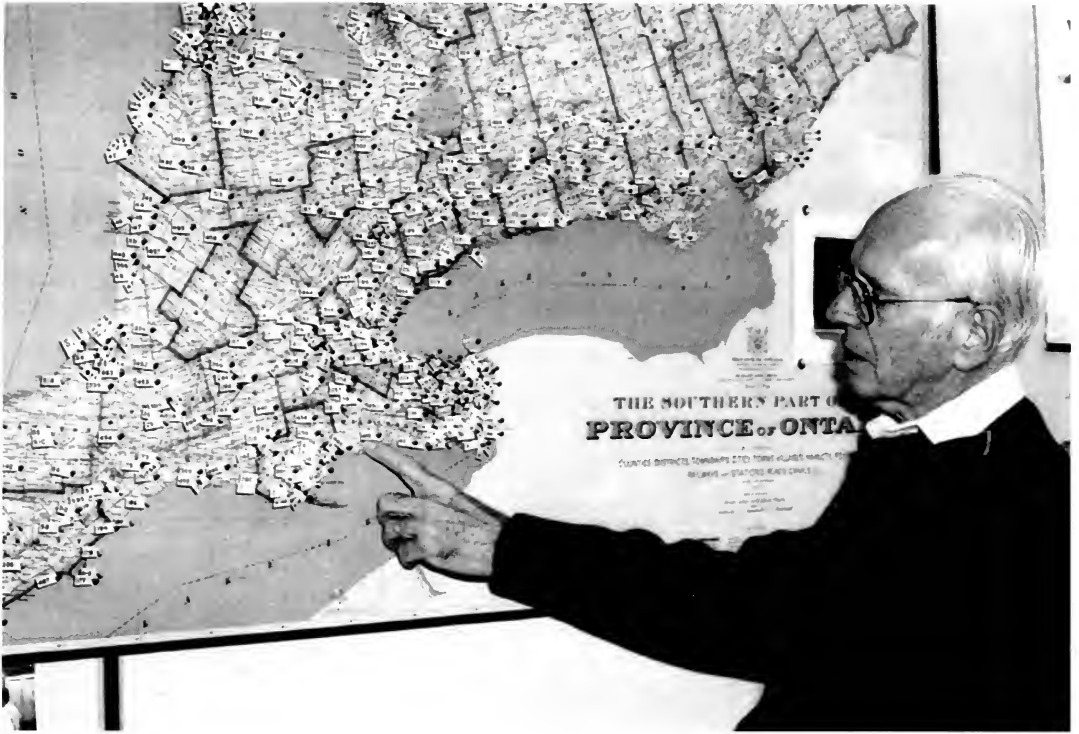


FIGURE 2. Jim Soper several years after retirement in his office at the Botany Division, Canadian Museum of Nature, in front of a map of southern Ontario with pins and labels indicating his numerous collection localities. Photo: E. Haber.

of societies and associations, including the National and Provincial Parks Association of Canada (now the Canadian Parks and Wilderness Society), the Royal Canadian Institute (President, 1962–1963), the Canadian Botanical Association (Treasurer, 1968–1969, and President, 1982–1983), the Federation of Ontario Naturalists, the Royal Botanical Gardens (Hamilton), the Arctic Institute of North America, the Bruce Trail Association, the Ottawa Field-Naturalists' Club, the American Fern Society, the Australia-New Zealand Association, and the Harvard University Club of Ottawa.

The McMaster yearbook for 1938, the year of his graduation, provides insight into some of the young man's talents and interests:

Starting from Central Collegiate on the matriculation scholarship in Science and advancing to win the City of Hamilton scholarship in second year, Jim mixed Chemistry and Botany to get a fine grounding for graduate work. He combined badminton, music and flower collecting for diversions. Weakness—drawing everything he could see and then some.

Women in the family, especially Aunt Flo, played an important role in Jim's early life. During his years

in Hamilton, Jim developed considerable skill in playing the piano, especially classical music, and he made a recording in 1940. It was a love that he maintained all his life. His interest in drawing, and later watercolours, was likely fostered initially by his aunt Flo, who had been Assistant Principal of the Hamilton Art School (1905–1909). She possessed a variety of skills in the arts and crafts of the time, including painting on porcelain, but concentrated on painting landscapes in oils. Jim's love of sketching, already noted in the account from the yearbook from his graduating year at McMaster, is also highlighted in a photograph he took of himself sketching the mountains around Brintnell Lake while sitting on a packing box (Figure 3) (Harris and Loughheed 2002). During his years in Toronto, Jim was also a keen photographer of wildflowers.

To improve his skills in painting and drawing, Jim attended classes at the Ontario College of Art in Toronto in 1965–1966. In retirement, Jim began to specialize more seriously in painting watercolours of botanical subjects, including dried flower bouquets (Figure 4). He took instruction at the Ottawa School of Art (1981–1983) with Morton Baslaw and Leonard Gerbrandt; at Sunbury Shores Arts and Nature Centre, Saint Andrews, New Brunswick (1982), doing landscapes with Henry Purdy; at the Ottawa Board of Education (1986), doing



FIGURE 3. Jim Soper sketching at Brintnell Lake (now Glacier Lake), 10 August 1939. Photo: J. H. Soper.

watercolours with Cécile Loubert; and botanical illustration in watercolour with Dorothy Bovey at the Royal Botanical Gardens, Hamilton (1988 and 1990).

Overall, Jim was a quiet and reserved individual, and always a gentleman. He was tender-hearted when it came to small creatures. He was a highly organized and tidy person, and he loved his Dymo labeller. He was very much disciplined about his health. An early riser, he would take a brief nap after lunch each day, even at work, swim regularly at the YMCA, and do 5BX exercises (Five Basic Exercises, developed for the Royal Canadian Air Force—stretching, sit-ups, back extension, push-ups, and running on the spot). He was creative in building or repairing things, and his fine motor skills are quite evident in his neat handwriting and artistic abilities, as reflected in his beautifully executed artwork. Apparently, needing to keep his hands busy, Jim learned crocheting and made baby jackets for the kids and afghans out of “granny squares”. Jim also liked to do string figures for the kids.

Jim had a dry sense of humour and loved play on words. He and Jean enjoyed bridge, and Jim loved crosswords and even made some up, in retirement, with

his computer. In later years, Jim spent much time reading and was still driving up until a year before his death to get groceries and do banking. After Jean had a fall in November 2011, they moved into a retirement home for a respite visit. Jim was not happy being away from their home overlooking the canal in Ottawa. However, as long as Jim got three meals a day on time, he never complained.

Jim died peacefully after a short illness on 16 February 2012 in his 96th year. He is survived by his loving wife, Jean, his daughters, Nancy (Richard Stoneman), Mary (David Gladwin), and Daphne (James Boyce), his son, Ian (Nicole Ratté), his grandchildren, Kathryn and John Stoneman, and his nieces and nephews. Jim’s beautifully rendered watercolours, in the homes of family and friends, remain as a testament to his love for plants and their beauty.

#### Acknowledgements

I am indebted, in particular, to Jean, daughter Mary, and niece Sharon for providing insights into Jim’s family history and family life. Jennifer Doubt, Botany Collection Manager, Canadian Museum of Nature



FIGURE 4. Jim Soper, after retirement, in his office at the Botany Division, Canadian Museum of Nature, with one of his water-colour paintings depicting a winter bouquet of dried plants. Photo: E. Haber.

(CMN), helped to initiate searches for information at the CMN. CMN archivist, Chantal Dussault, provided leads to information stored by the Museum and at Library and Archives Canada. Deb Metsger and Royal Ontario Museum (ROM) volunteer Marilynn Murphy were most helpful in compiling data on the herbarium collections of vascular plants at the University of Toronto, now held by the ROM. Paul Catling and Gisèle Mitrow, at Agriculture and Agri-Food Canada, provided a bibliographic compilation of Jim's publications that were on file at the Central Experimental

Farm. George Argus, Charles Bird, Irwin Brodo, Daniel Brunton, Paul Catling, and Charles Gruchy read an earlier draft.

#### Literature Cited

- Cruise, J. E. 1982. Foreword in *Shrubs of Ontario*. By J. H. Soper and M. L. Heimburger. Royal Ontario Museum, Toronto. 495 pages.
- Given, D. R., and J. H. Soper. 1981. The arctic-alpine element of the vascular flora at Lake Superior. *Publications in Botany* 10. National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario. 7 pages.

- Harris, J., and V. Lougheed, *Editors*. 2002. *Diary of a Lake: An Intimate Description of the Natural History of Glacier Lake and the Cirque of the Unclimbables*, in the Words of Scientists who were among the Area's First Pioneers. Repository Press, Prince George, B.C. 214 pages.
- Raup, H. M. 1939. Botanical exploration of the Mackenzie Mountains. *Bulletin of Popular Information*. Arnold Arboretum, Harvard University. Series 4 7(13): 69-72.
- Soper, J. H. 1964. Mapping the distribution of plants by machine. *Canadian Journal of Botany* 42: 1087-1110.
- Soper, J. H. 1966. Machine-plotting of phytogeographical data. *Canadian Geographer* 10: 15-26.
- Soper, J. H., and M. L. Heimbürger. 1982. *Shrubs of Ontario*. Life Sciences Miscellaneous Publication. Royal Ontario Museum, Toronto. 495 pages.

### Bibliography of James H. Soper

- Soper, J. H. 1941. The pubescent form of *Ceanothus ovatus*. *Rhodora* 43: 82-83.
- Soper, J. H. 1949. A survey of the aquatic vegetation of White-water Lake, with special reference to its suitability for waterfowl. Ontario Department of Lands & Forests, Toronto. 16 pages.
- Soper, J. H. (*Editor*). 1949. The vascular plants of southern Ontario: a preliminary check list of ferns, fern allies, conifers and flowering plants found growing without cultivation in the Ontario Peninsula south of the Canadian Shield. University of Toronto and Federation of Ontario Naturalists, Toronto. 95 pages.
- Soper, J. H. 1952. Phytogeographic studies in Ontario: 1. The genus *Uvularia* in southern Ontario. *Rhodora* 54: 5767.
- Fox, W. S., and J. H. Soper. 1952. The distribution of some trees and shrubs of the Carolinian zone of southern Ontario: Part I. *Transactions of the Royal Canadian Institute* 29, Part 2(61): 65-84.
- Soper, J. H. 1953. Flowering dogwood in Ontario. *Bulletin of the Federation of Ontario Naturalists* 59: 16-18.
- Fox, W. S., and J. H. Soper. 1953. The distribution of some trees and shrubs of the Carolinian zone of southern Ontario: Part II. *Transactions of the Royal Canadian Institute* 30, Part 1(62): 3-32.
- Soper, J. H., and M. L. Heimbürger. 1953. The button-bush in Ontario. *Bulletin of the Federation of Ontario Naturalists* 61: 5-8.
- Soper, J. H., and M. L. Heimbürger. 1953. Witch-hazel. *Bulletin of the Federation of Ontario Naturalists* 62: 20-22.
- Soper, J. H. 1954. The hart's-tongue fern in Ontario. *American Fern Journal* 44: 129-147.
- Soper, J. H., and L. Garay. 1954. The helleborine and its recent spread in Ontario. *Bulletin of the Federation of Ontario Naturalists* 65: 4-7.
- Soper, J. H., and M. L. Heimbürger. 1954. Leatherwood in Ontario. *Bulletin of the Federation of Ontario Naturalists* 64: 16-17.
- Soper, J. H. 1955. *Asplenium cryptolepis* on Manitoulin Island. *American Fern Journal* 45: 97-104.
- Fox, W. S., and J. H. Soper. 1955. The distribution of some trees and shrubs of the Carolinian zone of southern Ontario: Part III. *Transactions of the Royal Canadian Institute* 30, Part 2(63): 99-130.
- Soper, J. H., and M. L. Heimbürger. 1955. Hobble-bush. *Bulletin of the Federation of Ontario Naturalists* 69: 7-9.
- Soper, J. H. 1956. The bayberry in Ontario. *Our Valley* 2(2): 13-14.
- Soper, J. H. 1956. Some families of restricted range in the Carolinian flora of Canada. *Transactions of the Royal Canadian Institute* 31(65): 69-90.
- Soper, J. H., and M. L. Heimbürger. 1956. Winterberry. *Bulletin of the Federation of Ontario Naturalists* 74: 12-13.
- Soper, J. H., M. L. Heimbürger, and L. A. Garay. 1956. Twenty-five shrubs of southern Ontario. Chapter 8 [following page 70]. 25 pages. *In* Forestry section, Credit Valley Conservation Report. Ontario Department of Planning & Development, Toronto. Reprinted as "25 Native Shrubs of Ontario".
- Soper, J. H. 1957. Poison ivy in Ontario. *Bulletin of the Federation of Ontario Naturalists* 76: 9-12.
- Soper, J. H. 1957. Pawpaw—an interesting shrub. *Our Valley* 3(2): 52-53.
- Soper, J. H., M. L. Heimbürger, and L. A. Garay. 1957. Another thirty shrubs of Ontario. Chapter 10 [following page 72]. 33 pages. *In* Forestry section, Napanee Valley Conservation Report. Ontario Department of Planning & Development, Toronto. Reprinted with "Twenty-Five Shrubs of Ontario" as "Shrubs of Ontario: Part I".
- Soper, J. H., and A. S. Rao. 1958. *Isoëtes* in eastern Canada. *American Fern Journal* 48: 97-102.
- Soper, J. H., and A. S. Rao. 1958. An interesting spring harbinger (*Symplocarpus foetidus*). *Bulletin of the Federation of Ontario Naturalists* 79: 18-22.
- Soper, J. H. 1959. From the park to the pole. *Varsity Graduate* 7(2): 81-85, cover illustration. Account of botanical expedition to Lake Hazen, N.W.T.
- Soper, J. H. 1961. The distribution of Ontario's provincial flower. *Bulletin of the Federation of Ontario Naturalists* 92: 6-8.
- Soper, J. H., and M. L. Heimbürger. 1961. 100 Shrubs of Ontario. Ontario Department of Commerce Development, Toronto. 100 pages, 100 plates.
- Soper, J. H. 1962. The walking fern: a proposed botanical symbol for the Bruce Trail. *Bulletin of the Federation of Ontario Naturalists* 98: 14-17. Reprinted 1977 in *Bruce Trail News* (10th anniversary issue): 18-20.
- Soper, J. H. 1962. Some genera of restricted range in the Carolinian flora of Canada. *Transactions of the Royal Canadian Institute* 34(70): 3-76.
- Soper, J. H. 1963. Ferns of Manitoulin Island, Ontario. *American Fern Journal* 53: 28-40; 71-81; 109-123.
- Soper, J. H. 1963. Botanical observations along the Lake Superior Route. *Proceedings of the Royal Canadian Institute*, Series 5 (10): 12-24.
- Soper, J. H., and P. F. Maycock. 1963. A community of arctic-alpine plants on the east shore of Lake Superior. *Canadian Journal of Botany* 41: 183-198.
- Soper, J. H., W. Dore, and G. Boraiah. 1963. Distribution of rue-anemone and its northern limit in Canada. *Canadian Field-Naturalist* 77: 220-225.
- Soper, J. H. 1964. Mapping the distribution of plants by machine. *Canadian Journal of Botany* 42: 1087-1110.
- Soper, J. H. 1964. The slender cliff brake (*Cryptogramma stelleri*). *Ontario Naturalist* 2: 20-23.

- Soper, J. H.** 1964. [17 maps of the distribution of species of wild shrubs and herbs]. In *Poisonous fruits*. By F. H. Montgomery. Special Publication 1. Federation of Ontario Naturalists. 24 pages.
- Falls, J. B., and J. H. Soper.** 1964. An outline of the vegetation and fauna of Ontario. Pages 19-36 in *A Naturalist's Guide to Ontario*. Edited by W. W. Judd and J. M. Speirs. University of Toronto Press. 210 pages.
- Soper, J. H., and E. G. Voss.** 1964. Black crowberry in the Lake Superior region. *Michigan Botanist* 3: 35-38.
- Soper, J. H.** 1965. Rediscovery of *Cypripedium passerinum* in the Great Lakes region. *Michigan Botanist* 4: 83-86.
- Soper, J. H., E. G. Voss, and K. E. Guire.** 1965. Distribution of *Primula mistassinica* in the Great Lakes region. *Michigan Botanist* 4: 83-86.
- Soper, J. H.** 1966. Machine-plotting of phytogeographical data. *Canadian Geographer* 10: 15-26.
- Britton, D. M., and J. H. Soper.** 1966. The cytology and distribution of *Dryopteris* species in Ontario. *Canadian Journal of Botany* 44: 63-78.
- Soper, J. H., and F. H. Perrine.** 1967. Data processing in the herbarium and museum. *Taxon* 16: 13-19.
- Soper, J. H.** 1969. The use of data-processing methods in the herbarium. *Anales del instituto de biología de la universidad nacional autónoma de México. Serie Botánica* 40: 105-116.
- Beschel, R. E., and J. H. Soper.** 1970. The automation and standardization of certain herbarium procedures. *Canadian Journal of Botany* 48: 547-554.
- Soper, J. H., E. G. Voss, and K. E. Guire.** 1972. Distribution of *Primula mistassinica* in the Great Lakes region. *Quarterly of the American Primrose Society* 30: 108-112. Reprinted from the *Michigan Botanist* (1965) with original map, two new photos, and footnote on a new inland locality in Otsego County, Michigan.
- Soper, J. H.** 1975. The application of electronic data-processing to the mapping of plant distributions. Pages 141-166 in *Computers in Botanical Collections*. Edited by J. P. Brenan, R. Ross, and J. T. Williams. Proceedings of a conference at the Royal Botanical Gardens, Kew, 3-6 October 1973. Plenum Publishing Corporation, London. 216 pages.
- Given, D. R., and J. H. Soper.** 1976. Pioneer vegetation on moraines near Clachnacudainn Snowfield, British Columbia. *Syesis* 8: 349-354.
- Soper, J. H., and A. F. Szczawinski.** 1976. Wild flowers of Mount Revelstoke National Park, British Columbia. *Natural History Series 3*. National Museum of Natural Sciences, National Museums of Canada, Ottawa. 96 pages.
- Soper, J. H.** 1978. The national inventory programme. *Bulletin of the Canadian Botanical Association* 11: 34-35.
- Soper, J. H., and W. J. Cody.** 1978. Alf Erling Porsild, M.B.E., F.R.S.C. (1901-1977). *Canadian Field-Naturalist* 92: 298-304.
- Soper, J. H.** 1979. Nature conservation in Canada. Pages 143-146 in *Systematic Botany. Plant Utilization and Biosphere Conservation*. Edited by I. Hedberg. Almquist & Wicksell, Uppsala. 157 pages.
- Haber, E., and J. H. Soper.** 1980. Vascular plants of Glacier National Park, British Columbia, Canada. *Syllogeus* 24: 1-34.
- Given, D. R., and J. H. Soper.** 1981. The arctic-alpine element of the vascular flora at Lake Superior. *Publications in Botany* 10. National Museum of Natural Sciences, National Museums of Canada, Ottawa. 7 pages.
- Soper, J. H., and E. L. Bousfield.** 1982. A tribute to William Kirwan Baldwin, M.B.E. (1910-1979). *Canadian Field-Naturalist* 96: 92-97.
- Soper, J. H., and M. L. Heimbürger.** 1982. *Shrubs of Ontario*. Life Sciences Miscellaneous Publication. Royal Ontario Museum, Toronto. 495 pages.
- Soper, J. H., and J. H. Soper.** 1982. *Park News: index to volumes 1 to 17 (1965-1981)*. National and Provincial Parks Association of Canada, Toronto. 48 pages.
- Soper, J. H.** 1984. The national repository for checklists and local floras. *Pl. Press (Mississauga)* 2: 48-50.
- Soper, J. H., and M. L. Heimbürger.** 1985. *Shrubs of Ontario*. Second printing with revisions. Life Sciences Miscellaneous Publication. Royal Ontario Museum, Toronto. 495 pages.
- Soper, J. H., and L. Murray.** 1985. Helleborine—a 30-year update and analysis of its distribution in Ontario. *Michigan Botanist* 24: 83-96.
- Soper, J. H., and J. M. Powell.** 1985. Botanical studies in the Lake Hazen region, northern Ellesmere Island, Northwest Territories, Canada. *Publications in Natural Sciences* 5. National Museums of Canada, Ottawa. 67 pages.
- Soper, J. H., C. B. Garton, and D. R. Given.** 1989. Flora of the north shore of Lake Superior (vascular plants of the Ontario portion of the Lake Superior drainage basin). *Syllogeus* 63: 1-61.

Received 23 March 2012

Accepted 30 May 2012

# Book Reviews

**Book Review Editor's Note:** We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Renimbi are CNY, Australian dollars are AUD and so on.

**Editor's Note.** The address of the Birds of Northumberland County website has been changed to <http://www.willowbeach-fieldnaturalists.org/Northumberland-County>. This is part of the Willow Beach Field Naturalists' website, but the URL above will take you directly to the Birds of Northumberland County. Please note that the URL is case sensitive. From Clive Goodwin.

## ZOOLOGY

### How to be a Better Birder

By Derek Lovitch. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 192 pages. 19.95 USD. Paper.

Derek Lovitch has produced a useful volume that focuses on modern ways to become an effective birder and to bird with a purpose. He uses technology and common sense to find birds – including rare birds, like vagrants and overshoots. His mantra is the “whole bird and more” – a simple approach that is certain to help the modern birder enjoy birding while at the same time fulfil a variety of birding goals.

The book is divided into nine chapters, each focusing on a specific aspect of the “whole bird and more” approach: (1) Advanced Field Identification, (2) Birding by Habitat, (3) Birding with Geography, (4) Birding and Weather, (5) Birding at Night, (6) Birding with a Purpose, (7) Vagrants, (8) A New Jersey Case Study, and (9) Patch Listing. In addition to these chapters are five pages of references and a complete index.

A quick review of these chapters will give the reader a general idea of what Lovitch is getting at. Birding is more than getting out to a wild or semi-wild area with a field guide and binoculars in hand. Sure, you will see some birds, but the key is to be an effective birder. With our busy lifestyle, getting the most out of a birding field trip is a goal that can be easily reached by using the tips detailed in the book. For example, birds occupy certain types of habitats and a quick study of habitats and what kinds of birds to expect will make the birding experience that much richer. Understanding the basic natural history and ecology of your target bird is also important. Other tools include checking the geography of a particular area and studying weather patterns. These two go hand in hand. Certain land features attract birds more so than others, such as islands and peninsulas, especially during “fallout” events during migration. Studying the weather the night before (such as viewing NEXRAD Doppler radar on the Internet) will also allow the birder to predict where birds are likely to be found the next day – especially if there are strong winds and rain events. Having the perfect

storm in relation to ideal land features during bird migration has the potential to make a birding field trip very productive. Lovitch explains how to do this very well and points the reader to several useful websites and other resources; the possibility of finding rarities is real and reading these chapters alone make the book worth having.

Lovitch does not just focus on rarities and vagrants. He also wants birders to study the common species. He wants the “watching” part of bird watching to make a comeback. All too often the race to “get that bird” on a list becomes the goal while the enjoyment of seeing the birds in the first place is lost. I can relate to this, because I often hear fellow birders dismiss the common species as they scan an area. Comments such as, “Oh, never mind, it is just a coot” is rather commonplace. Lovitch suggests taking a good hard look at the common species, and really study how individuals differ from one another, and fully understanding the nuances of colour, shape, and where they occur on the landscape.

I enjoyed the last chapter the most. Lovitch talks about visiting a habitat patch and keeping a list of birds observed there. Set a goal of the number of species you want to see and stick to it. The patch should be within a few miles of where you live, easy to get to, small enough to thoroughly survey, but also have several habitat types to attract a variety of birds. Once your goal is met, move onto another patch. I have two patches that I keep track of – my backyard and a local flood control basin down the street. Having these patches nearby keeps me birding even with a busy schedule. These patch study exercises also are useful when participating in several citizen science projects, such as Christmas bird counts, backyard bird counts, and breeding bird surveys. Entering your bird sightings, no matter how humdrum, into eBird is something that everyone should get into the habit of doing. Entering

your data into eBird will provide essential information for regional studies as well as a variety of other applications.

*How to be a better birder* is a quick read and an important addition to a birder's education. Oftentimes easily accessed tools such as weather websites, topographic maps, blogs, and other resources are not taken advantage of by birders. The tips and methods discussed at length in the book take out much of the guess

work in finding a variety of birds on the landscape, including rarities and vagrants. The best part however, is getting out and having fun. Birding is not about getting birds on a list; it is about enjoying birds and seeing them in the wild. Use Lovitch's book as a launching pad to get out and bird with a purpose.

HOWARD O. CLARK, JR.

7815 North Palm Avenue, Suite 310, Fresno, California, USA

## Birds of Algonquin Park

By Ron Tozer. 2012. The Friends of Algonquin Park, Whitney, Ontario. 474 pages. 49.95 CAD.

Algonquin Provincial Park, the oldest park in Ontario, has long been a "must visit" destination for domestic and international tourists, and more recently for the ever-growing coterie of birders. This long awaited book will appeal to both groups. It supersedes the only previous attempt at cataloguing the Park's avifauna, the badly outdated "Birds of Algonquin Provincial Park" (1938) by Duncan MacLulich. Given the author's 40-year history as Park Naturalist at Algonquin and his fame as one of Ontario's most respected birders, it is no surprise that he has produced a work that will stand as a shining example of regional bird inventories, a genre that is growing in popularity, other examples of which include those for the Hamilton region, the Niagara region, Presqu'île Provincial Park, and Tozer's own co-authored book on the Oshawa-Lake Scugog region. Like some of those others, this book does much more than simply listing the birds that have been recorded in the Park. It devotes a few pages to describing the Park and to guiding visitors, both the casual persons with a passing interest in its wildlife and those who wish to go there specifically for birding and who know that there are certain northern specialties for which Algonquin Park is noted. The author offers general bird-finding advice to the former (including a surprising suggestion to use tape recordings to solicit responses from Barred Owls and Spruce Grouse) and more specific instructions for the more devoted birders, with insights that no one else could provide. Forty high quality photographs of typical Algonquin bird species make the book even more attractive to both groups.

The core of the book, more than 300 pages, is devoted to describing the status of the 278 bird species (and a few subspecies) that have been recorded in the Park. Each species account begins with a brief outline of what a non-birding visitor might want to know about the bird, and in many cases a small black-and-white sketch. Frequent sidebars are very informative, especially concerning bird behaviour. For the more serious birders, there is detailed season-by-season information on records dating back fifty years and less detailed information dating back over one hundred years. In the latter case, Tozer relies on records sup-

plied by early naturalists such as, among others, Hoyes Lloyd (former president of the American Ornithologists' Union), Mark Robinson (the first Park Ranger in Algonquin), and his daughter Ottelyn Addison (whose grandson tells me she was "an incredible naturalist"). The bird data include average and extreme arrival and departure dates for migrants as well as whatever is available on their breeding status and on population trends. For some guilds, notably the shorebirds, it is necessarily an arbitrary decision as to what constitutes an extremely late spring departure date as opposed to an early fall arrival date. In the same vein, differentiating between molt migrant Canada Geese and earlier migrants, or between the subspecies of Canada Geese is also necessarily arbitrary. In some cases, the author uses the term "apparent migrants" to indicate that there is no easy way of knowing whether, for example, a bird seen in late fall or late winter is on the one hand an unusually late fall migrant or an early spring migrant or on the other hand a bird that is over-wintering in the Park.

With such an extensive data base available, Tozer has taken the innovative step of separating migration records of the most recent quarter century from those of the preceding one, where the sample sizes allow that, so as to highlight phenological trends. What that reveals is worrisome in many cases, though it is not clear whether changes may be attributed to climate change, as suggested in many of the species accounts, or to the greatly increased number of competent birders who have contributed their sightings to the Park's records. At the very least, those records can be mined by a researcher willing to go beyond simply determining whether the changes are statistically significant, which Tozer has done in collaboration with his son, Doug. Even the simple step of counting the number of species that are arriving earlier in the spring or departing later in the fall and comparing that with the number not showing such a trend could be potentially revealing. A more useful step would discriminate between what Tozer calls "short-distance migrants" and neo-tropical migrants to see whether the trends differ between the two groups. If nothing else, the

details that are provided for all extremely early or late migrants, including locations of the sightings and the names of the observers, should appeal to those birders (and there are many) who are obsessed with delving into records. Bar graphs for each species neatly summarize what is in the text.

That subset of the birding community, often identified as “listers,” will puzzle over the absence of certain species from the exhaustive record of sightings in Algonquin Park. One of the most surprising omissions from the cumulative list is Barrow’s Goldeneye, given that Algonquin Park is not far from other places where it is relatively common, such as the Ottawa River. Birders who regularly frequent Presqu’île Provincial Park are in the habit of sharing their predictions for the next new species to be added to that Park’s bird list. In the case of Algonquin Park, this reviewer would put his money on Barrow’s Goldeneye as the next new species to be added to the Park list, but would offer as other likely candidates Gyrfalcon, Parasitic Jaeger, Willow Flycatcher, Cerulean Warbler, and Willow Ptarmigan. These omissions, clearly not the fault of any observer, least of all the authors of this book, should not detract from the fact that Algonquin Park has welcomed a truly remarkable variety of vagrants, sufficient to make listers reading the book salivate. Coloured photographs taken at the time of observation showing fourteen of those rarities are a further feature of the book. One can only speculate on the reason(s) why so many tantalizing oddities have appeared in the Park. Perhaps the extensive forest comprising most of the Park makes the few clearings and roads serve as oases for species with a different habitat preference. Adding to the appeal of the book is the inclusion of fascinating anecdotes about the circumstances surrounding the discovery of some of the rare species. Those hundreds of

birders who have participated in the Algonquin Park Christmas Bird Counts, as well as many who have not had that pleasure, will delight in seeing the table that shows the results of those 38 counts, as shown in an appendix.

A reviewer of any book, no matter how enthusiastic about it (as this reviewer is), has an obligation to point out its weaknesses. Most of the ones in this book are of a technical nature that do not affect the content of the book. Eight scientific species names are misspelled (all but one in the bibliography), as are eight individuals’ names, a couple of place names, and a remarkably small number of other words. I have not checked all of the references, but at least two of them (Saunders 1947, *Flashing Wings*, page 200 – cited in a footnote to the Olive-sided Flycatcher account; and Weir 2009 – cited in the Green Heron account) are missing from the bibliography, the compiling of which in itself nevertheless represents a prodigious effort on the part of the author. Sixteen items are alphabetically misplaced in the various appendices. There are also numerous instances in which the text of a species account does not correspond with the information presented in tabular form immediately below the text. These and other trivial flaws do not detract from an otherwise excellent book, but should be remedied in any future edition.

Ron Tozer’s “Birds of Algonquin Park” is certain to find a place of honour on the bookshelf of every serious birder in Ontario and may well become a best seller in the bookstore of the Friends of Algonquin Park. It will also serve as a reference book for many years, even as new information on the bird life of the Park continues to accrue.

FRED HELLEINER

186 Bayshore Road, Brighton, Ontario K0K 1H0 Canada

## Birds of Aruba, Curacao and Bonaire

By Bart de Boer, Eric Newton and Robin Restall. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey, 08540-5237 USA. 192 pages. 27.95 USD. Paper.

Aruba, Bonaire and Curacao [known as the ABC islands] are the three western-most islands of the Lesser Antilles or Leeward Antilles and lie just north of Venezuela. They are 800 km west of Trinidad and Tobago. They are outside the coverage of *A Guide to Birds of the West Indies*, by H. Raffaele, J. Wiley, O. Garrido, A. Keith and J. Raffaele. The bird list has a Caribbean flavour and has a South American influence the islands share with Trinidad and Tobago [see a Field Guide to the Birds of Trinidad and Tobago (or T&T), by Martyn Kenefick, Robin Restall, and Floyd Hayes].

As soon as I got this book I looked up Little Egret. Last year I saw a distant bird I thought was this species on Aruba. The distance and heat haze made it difficult to be certain of the identification. The authors say there are only two records, but it “may be overlooked due to

its similarity” with other egrets. So maybe I did see a good record!

The artist is Robin Restall and he took a lot of the illustrations from his other books – *Birds of Trinidad and Tobago* and *Birds of Northern South America*. Restall’s art is a bit stiff for my taste. I much prefer the quality of *Birds of the West Indies*. However, they are more-than-adequate for identification in the field. Only the three *elaenias* might cause you trouble. Restall has included the detailed pages of Wood Warblers from T&T.

The status given for seabirds is sometimes rather vague. For example, the Red-billed Tropicbird has only nine records, but the local fishermen have their own name for this species, suggesting they see it often. I had no trouble seeing several pelagic species on the



ocean between Curacao and Bonaire, including two Red-billed Tropicbirds. I suspect the local birders have not tried many pelagic trips and this would be a real opportunity for exciting discoveries.

This book has two principal virtues. First it is very compact and light so it will easily fit in a pocket. There are no range maps as they are not necessary and this saves much space. Second, the authors give the status of each species. It is remarkable how different the ABC's are from T&T. I photographed a Reddish Egret in T&T last year – the second record in 15 years. These egrets are regular visitors and breed on Bonaire. Last spring I had no trouble finding Troupials on Aruba and

Curacao, yet there are no records for T&T. The Yellow-bellied Sapsucker is a rare visitor to the ABCs – its only woodpecker – and is unknown in T&T [which has six resident species].

If you are planning a visit to the ABCs then this is a valuable purchase. It is a good field tool and the status and distribution information will be extremely useful. Not only will you be able to resolve identification issues, but I suspect that you will be made aware of the significance of any of your sightings.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5 Canada

## A Guide to the Birds of India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, and the Maldives

By Richard Grimmett, Carol Inskipp, and Tim Inskipp. With the collaboration of Sarath Kotagama and Shahid Ali. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 528 pages. 39.50 USD. Paper.

When I purchased the first edition of this book I was very pleased [see Mark Gawn's excellent review in CFN 115-1]. I used it successfully in several parts of India. However, as Mark noted, there were some weak points. As many of the range maps were distant from the text, I found it very frustrating to have to flip back and forth. Each illustration carried a number and you had to match this number to the range map number. While the illustrations were good, they were often crowded at 10, 12 or even more to a page.

The second edition has 73 new, additional plates and others are repainted so that the number of birds per page has been reduced. This makes this edition much clearer and easier to use. In all there are 1,375 species illustrated by 19 artists [seven more than the original] and all are good quality. They have dropped the numbering systems and matching bird and text is intuitive. Also all maps [and the text] are opposite the plates, a far more sensible arrangement. These changes have made the book bigger; 37% by weight. But then this has never been a pocket field guide.

The range maps were somewhat larger; about a third. I found them easier to read. The colour coding is more complex and therefore imparts more detailed information.

There are some name and taxonomic changes. The Common and Black-rumped Flameback are now called the Greater and Lesser Goldenback respectively. The index and the account list the alternative name so it is

easy to reference back to the old name. [They have eliminated the silly misnumbering of the Black-rumped Flameback female in the illustration]. There are several splits. I recently photographed the tree-nesting Slender-billed Vulture, now distinct from the cliff-nesting Long-billed Vulture. I spent a lot of time identifying the migratory Black-eared Kites and the resident Black Kites to be sure I could count the two species. [The Calcutta dump has a thousand or so kites of both species, if you can stand the smell!]

Once again the authors depict subspecies such as the Puff-throated Babbler [*Pellorneum ruficeps mandelli* and *P.r. ruficeps*]. In this case there are several disputable subspecies in various parts of India. Unfortunately the authors do not note the locations for each subspecies. Another failing is the lack of altitudinal information. Some of the hill species have characteristic altitudinal requirements and this information is available and would be most useful.

Overall, the changes have made this a great field guide that is easy to use in the field. While I did not carry it with me because of its size, I keep it handy on the boat or in the car. The only time I had problems was in identifying *Acrocephalus* and *Phylloscopus* warblers, but this had nothing to do with this fine book!

ROY JOHN

2193 Emard Crescent, Beacon Hill North, Ottawa, Ontario K1J 6K5

## ENVIRONMENT

### Assessment of Species Diversity in the Atlantic Maritime Ecozone

Edited by Donald F. McAlpine and Ian M. Smith. 2010. National Research Council Press, 1200 Montreal Road, Ottawa, Ontario K1A 0R6 Canada. 785 pages. 94.00 USD. Cloth.

This book is a great achievement. It is the only hard copy assessment in a series that has been made available online (Smith 1998, Scudder and Smith 1998). It

is a major source for anyone interested in Canada's biodiversity as well as that of northeastern North America.

The purpose is to "provide a comprehensive view by

experts on species diversity and biogeography of selected major taxa of fungi, plants, and animals inhabiting the Atlantic Maritime Ecozone (AME).” This region includes New Brunswick, Nova Scotia, Prince Edward Island, Îles-de-la-Madeleine, and that portion of Quebec extending from the Gaspé Peninsula to the United States border southwest of Sherbrooke. Managing biological resources is an often repeated reason for the work. It is a terrestrial ecozone so marine biodiversity is not considered in depth. In addition to an inventory list of species, many of the chapters include reference to biogeography and to how the postglacial colonization of the land by a particular group occurred. The content is generally of such high quality that there is little to correct and not much to add. However, as well as further discussing the content, it may be possible to provide some information and suggestions of interest to anyone who owns this book. This may also be useful to further biodiversity study in the AME.

The first five chapters are introductory and outside the species inventory purpose but all are valuable. The first chapter by the editors provides an overview and alludes to some of the impacts on biodiversity. Any written work can be made longer and/or more complete. Had time and space been available, an analysis of threats and a summary of the current status of species would also have been useful. The generic recommendations at the end of this chapter are good, but a specific recommendation that comes immediately to mind is the need to increase support for the Atlantic Conservation Data Centre and the maritime museums.

Another introductory chapter provides helpful information on protected areas. This important subject could also benefit from more extensive coverage. The kinds of protected areas, operational mandates such as representivity and ecological integrity, the special problems, and the outstanding work of conservation organizations such as the Island Nature Trust, assessment of what biodiversity is protected, what stewardship is available, and what is needed to fill in the gaps, are all relevant.

While on the subject of more work, what about more chapters? This is a tough task with 31 chapters and 785 pages already! However, I think it true that a chapter about habitat diversity and major themes in this introductory section would have been helpful. The range of habitats in this ecozone is remarkable. There is serpentine tundra on Mont Albert in Gaspé and plants of the southern Coastal Plain at their northern limits in southwestern Nova Scotia. Some of the available information on biodiversity in AME could be informatively organized by places such as Îles-de-la-Madeleine (e.g., not listed anywhere in the book are: Le Gallo 1952; Larochelle 1973; Pilon and Lagacé 1997) and habitats such as sand barrens (Carbyn et al. 2006). A theme that came to my attention only recently is that of the maritime cave faunas (Moseley 2007). An annotated list of information by habitat, theme and place would have been helpful because workers are often looking

for it in this format rather than as a broad regional list or as references for a taxon group.

Another short chapter that would have increased utility could have briefly featured the regular and special sources of information on species, including museums, collections, libraries, journals, newsletters, and clubs representing the region. For example, Nature New Brunswick produces the New Brunswick Naturalist (<http://www.naturenb.ca/nbnaturalistnewsletter.aspx>), an excellent magazine about species in the province. An exemplary copy of this available online contains an article about 2008 botanical field work on the St. John River and the proclamation of 31 new protected areas (on crown land) as well as the very first private-land protected area in the province. See also Nature Nova Scotia ([www.naturens.ca](http://www.naturens.ca)) and the Natural History Society of Prince Edward Island Ltd. (<http://www.isn.net/~nhspei/>). See also “Bio link” – the official Newsletter of the Atlantic Society of Fish and Wildlife Biologists” (<http://www.chebucto.ns.ca/environment/ASFWB>) and a useful review of the present publication in vol. 47(1): 10-11. These are extremely valuable sources for anyone with an interest in AME biodiversity. A bibliography is available for the plants of the region that allows a large amount of information to be traced (Catling et al. 1986). There is more and an introductory chapter on societies and sources might have increased involvement.

The main part of the book, beginning with chapter 6 on page 71 and continuing to chapter 31 on page 693, a total of 27 chapters, includes assessments of mammals, birds, reptiles and amphibians (and turtles), freshwater fishes, freshwater mussels, 12 chapters on various groups of insects, water mites, oribatid mites, earthworms, zooplankton, exotic vascular plants, native vascular plants, mosses, lichens, fleshy fungi and hyphomycetes. The insect groups covered include dragonflies, grasshoppers, true bugs, short-horned bugs, featherwing beetles, ladybird beetles, false darkling beetles, longhorn beetles, water beetles, moths and butterflies, and mosquitoes. Obviously many groups of insects are left out, presumably due to lack of information or lack of an available expert. However, a number of groups of insects have been assessed or are being assessed for part of the region (e.g., Lewis and Bennett 1979, Majka et al. 2007), and some mention of those would have made the biodiversity information more available. The reader should simply bear in mind that, despite the amazing coverage, information available for some groups is not included. For example, although spiders are not included, many groups have been monographed for all of Canada by Charlie (C. D.) Dondale and information relevant to AME is also available in Pickavance and Dondale (2005) and Paquin and Dupéré (2006), as well as from a Canada list indicating provincial distributions (Paquin et al. 2010). Information on this group in Atlantic Canada is also available from the General Status of species in Canada pro-

gram (<http://www.wildspecies.ca/reports.cfm?lang=e>). Although some groups are missing, all of the 27 taxon chapters are helpful and interesting, and a large amount of regional biodiversity, including many key indicator groups, is well covered.

Chapter 11 on exotic and invasive vascular plants provides a good review with an analysis of the extent of invasion and potential invasion in natural communities. Granite and sand barrens might have been considered under the native habitats subject to invasion by Scotch Broom (Catling and Mitrow 2011a). Four species, *Alliaria petiolata*, *Frangula alnus*, *Pinus sylvestris*, and *Phalaris arundinacea* are listed as current pests, each with a paragraph. A more recent source for the potential pest, *Phragmites australis* subspecies *australis* is Catling and Mitrow (2011b). One of the editor's recommendations on page. 9 is to "assess the impact of invasive and alien species within the AME on native biodiversity and ecosystem integrity." There are relatively few examples of impact assessment that could have been referenced. One is the work assessing the impact of *Pinus sylvestris* on the whole *Corema* sand barren ecosystem (Catling & Carbyn 2005). Problems with *Pinus sylvestris*, and another introduced pine, *Pinus nigra*, are not confined to Nova Scotia. On Îles-de-la-Madeleine these species, escaped from plantings, are transforming open dune vegetation with rare native species into a thick forest of introduced pine and little else. The introduced pines now threaten some of the most important dune ecosystems in the AME. As well as the four current pests, 11 potential pests are listed. One of these, *Rosa rugosa*, of seashores, is already a major problem in parts of Nova Scotia on dunes (Hill et al. 2010) and on Brier Island (Garberry personal communication), but these studies and observations were evidently not in time to be included in this chapter.

Chapter 13 on earthworms by John Reynolds is a chapter that stands out with 17 pages of diagnostic illustrations and distribution maps. There are 17 species in the region and because the ecozone covers an extensive area, and these same species occur in adjacent ecozones, the information has broad application. Although 136 new species were described worldwide in the last decade, it is doubtful that any new species occur in the AME. All earthworms in the region are introduced except *Sparganophilus eiseni* which occurs underwater or in mud in saturated soils. Distribution within the AME is given by county and by ecoregion.

Chapter 15 by Valerie Behan-Pelletier, "All you ever wanted to know about Oribatid Mites in the Maritimes," may not jump out at the average field biologist. It should. This group of soil organisms is of major importance with respect to decomposition of organic matter and nutrient cycling and their influence extends up the food chain throughout natural and agricultural ecosystems. There are 196 species known in the AME and another 200 are suspected of being there but are as yet unknown. This is a reminder of the fact that we

may have 100,000 unknown and nameless arthropods in Canada, yet we have far fewer taxonomists than we had 30 years ago. This chapter assesses a group and reports that we know less than half of it. Thinking about this raises some interesting questions. Have we assessed the needs for taxonomists and ecologists to deal with the biodiversity crisis in the AME? Hopefully we will deal with it, as we promised in the International Convention on Biological Diversity. Like many of the chapters, this one provides an important foundation for future research (and part of a basis for keeping promises).

Chapter 16 by Paul-Michael Brunelle features the 142 damselfly and dragonfly species that are known from AME. This chapter includes such complete information on biology, habitat and systematics, all very well illustrated, that with a basic knowledge of its content, and using it as a reference, the reader is well on the way to being an expert on the group in the region. Brunelle has coordinated the Atlantic Dragonfly Inventory Program (ADIP) and has contributed about ten thousand records himself. The value of that program is immediately apparent in the extensive information available for the assessment. The section on recommendations for improvements on monitoring is especially useful. There is a little more to say on the subject of biogeography. Distributions are changing in this region as southern and western species (*Ischnura hastata*, *Enallagma civile*, *Tramea lacerata*), move north as they have further to the west (Catling 2008, Catling et al. 2009, and references therein). There are some notable patterns that correspond to those of other groups and could be obtained from Appendix Table 1. Distributions in saltmarsh have been discussed and more information on occurrence in this habitat is recently available (Catling 2009). There are a few websites that are useful for dragonflies in the region and one is devoted to a portion of the AME (<http://www.odonatanb.com>).

Chapter 17 Grasshoppers (Orthoptera) and allied insects of the Atlantic Maritime Ecozone, benefitted from the earlier work of Vernon Vickery and colleagues. Chandler's (1992) record of the Dusky Cockroach, *Ectobius lapponicus*, on Prince Edward Island, was overlooked. *Neoconocephalus retusus* reported from Sable Island, Nova Scotia, may not be established, but it is nevertheless an interesting record. New information in this chapter includes: the Brown Cockroach, *Periplaneta brunnea*, established in Nova Scotia; the Brown-Banded Cockroach, *Supella longipalpa*, also established in Nova Scotia; the Tree Cricket, *Oecanthus nigricornis*, from New Brunswick; *Conocephalus brevipennis* from the maritime provinces generally and *Allonemobius maculata*. The latter is likely the species included on the basis of a female from Queens County, Nova Scotia (see page. 373) since *A. fasciculatus* was previously reported to have an extensive distribution in the ecozone. A number of other species of cockroaches have been collected in the AME, but may not have

become established. Also deserving of mention is the study of the two endemic grasshoppers by Chapco and Litzenger (2002). Among other things their study suggested the *Melanoplus madeleineae*, endemic to Îles-de-la-Madeleine, diverged from an *M. borealis*-like ancestor 0.68 million years ago. The authors suggested that more work was needed to precisely define the distribution and status of Orthoptera species. Recently some of this work was reported by McAlpine et al. (2012).

Chapter 25 on Butterflies and Moths begins with an extensive and extremely valuable summary of sources of information on the Lepidoptera of AME. The only omission here (and elsewhere in the assessment) was that of information for the U.S. portion of the AME. For butterflies for example, the work of Webster and deMaynadier (2005) is available for Maine (which is surrounded on two sides by the AME). A recent report relevant to the section on threatened species is Doucet's (2009) census of the butterflies of Gulf of St. Lawrence salt marshes. The details of the interesting story of the maritime ringlet on page 497 can be found in status reports and recovery documents on the Species at Risk (SARA) website: [http://www.sararegistry.gc.ca/species/speciesDetails\\_e.cfm?sid=304](http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=304), [http://www.sararegistry.gc.ca/document/default\\_e.cfm?documentID=1809](http://www.sararegistry.gc.ca/document/default_e.cfm?documentID=1809). The Maritimes Butterfly Atlas was launched in 2010 <http://accdc.com/butterflyatlas/About.html> and Maine has an ongoing butterfly survey <http://mbs.umf.maine.edu>.

Chapter 30 on birds is an outstanding contribution and will always serve as a basic reference document for the region. It is cautious and complete. I was slowed down by the suggestion that "the tundra habitats prevalent in the AME ca. 12 ka. ..., probably had a breeding bird fauna similar to that present in the High Arctic region of Canada today." They may just as well have included western prairie species and have no modern analogue. Sabine's complete discussion of occasional nestings of Horned Grebe in the east, outside the Magdalen Islands, makes the Magdalen population seem potentially a little less important, yet it has been suggested that the latter should be recognized as a separate unit on genetic grounds (Boulet et al. 2005). It would have been of interest to know something of the history of the Gannet colonies – a digression as much as a suggestion. The Bird Rocks, off the Magdalen Islands, were visited by early explorers and were famous in the early days and attracted a lot of attention of well-known ornithologists. Jacques Cartier described the Gannets as "infinite" in 1556 and he named the place the "Gannet Islands." Audubon was there in 1833 for two days, but because of a storm he could not land, but the storm is clear in his plate (and the adult Gannet is clearly looking upward). William Brewster says that in 1860 there were 100,000 Gannets (Brewster 1884 quoting Bryant 1861), making it perhaps the largest Gannet colony recorded in North America. It is believed to have been

larger at the time than the well-known gannet colony on Bonaventure Island off Gaspé. This was prior to the construction of a lighthouse on the cliff-top plateau of the largest of the Bird Rocks. The number declined to 5,000 in 1872, after the lighthouse and continuous habitation (and the elevator on a rusty chain that took 27 minutes to be cranked to the top – see illustration in Charles Cory's classic – "A naturalist in the Magdalen Islands (1878). In 1881 there were only 50 nests at the north end that had been robbed a few days before and about which a few birds lingered. The decline may have been largely due to both the use of Gannet flesh to bait hooks for catching cod and to consumption of eggs. Up to 600 birds were clubbed to death by a group of several fishermen within an hour. Somehow the Gannets survived. The Bird Rocks have been protected since 1919 and they now host 15,000 nesting Gannets, currently the second largest colony in North America. Older references regarding the birds of the Magdalen Islands may be found in Gaboriault (1961). The Maritime Breeding Bird Atlas (Bird Studies Canada 2011) became available after the assessment was published.

With a wealth of biodiversity information, this book is a marvellous value. Although it will certainly be useful in the area of management of biological resources, it will also provide a basis for research and teaching and a vast source of general information. Its greatest impact though may be as an example of what can be done in a book to assess Canada's biodiversity since it is the first of its kind. Naturally we hope that its example and standard can be followed.

#### Literature Cited

- Bird Studies Canada.** 2011. Maritime Breeding Bird Atlas. Bird Studies Canada. Sackville. New Brunswick. <http://www.mba-aom.ca/jsp/map.jsp?lang=en>
- Boulet, M., C. Potvin, F. Shaffer, A. Breault, and L. Bernatchez.** 2005. Conservation genetics of the threatened horned grebe (*Podiceps auritus* L.) population of the Magdalen Islands. *Conservation Genetics* 6: 539-550.
- Brewster, W.** 1884. Notes on the birds observed during a summer cruise in the Gulf of St. Lawrence. *The American Naturalist* 18(10): 1014-1917. (see also *Proceedings of the Boston Society of Natural History* 22: 364-412.)
- Carbyn, S., P. M. Catling, S. P. Vander Kloet, and S. Basquill.** 2006. An analysis of the vascular flora of Annapolis Heathlands. *Canadian Field-Naturalist*. 120(3): 351-362.
- Catling, P. M.** 2008. A new northern limit for Citrine Forktail (*Ischnura hastata*), possibly due to climate warming. *Argia* (Newsletter of the Dragonfly Society of the Americas) 20(4):12-17.
- Catling, P. M.** 2009. Dragonflies (Odonata) emerging from brackish pools in saltmarshes of Gaspé, Québec. *Canadian Field-Naturalist* 123 (2): 176-177.
- Catling, P. M., B. S. Brookes, Y. M. Skorupinski, and S. M. Malette.** 1986. Bibliography of vascular plant floristics for New Brunswick, Newfoundland (insular), and Nova Scotia. *Agr. Canada Tech. Bull.* 3E: 28 pages (see also Catling, P. M., S. Porebski, and B.S. Brookes. 1995. *Plants of the Maritimes, a bibliography for agriculture, resource management landscape planning and biological*

- research. CanaColl Foundation, K. W. Neatby Bldg., 1010 Carling Avenue, Ottawa. 65 pages.
- Catling, P. M., and S. Carbyn.** 2005. Invasive Scots Pine (*Pinus sylvestris*) replacing Corema (*Corema conradii*) heathland in the Annapolis valley, Nova Scotia, Canada. *Canadian Field-Naturalist* 119(2): 237-244.
- Catling, P. M., and G. Mitrow.** 2011a. Major invasive alien plants of natural habitats in Canada. 2. Scotch Broom or Common Broom, genet à balais, *Cytisus scoparius* (L.) Link. *Canadian Botanical Association Bulletin*, 44(3): 90-99.
- Catling, P. M., and G. Mitrow.** 2011b. Major invasive alien plants of natural habitats in Canada. 1. European Common Reed, *Phragmites australis* (Cav.) Trin. ex Steud. subsp. *australis*. *Canadian Botanical Association Bulletin* 44(2): 52-61.
- Catling, P. M., Z. Lucas, and B. Freedman.** 2009. New records of Odonata from Sable Island, Nova Scotia. *Argia* (Newsletter of the Dragonfly Society of the Americas) 21: 11-12.
- Chandler, D. S.** 1992. New records of *Ectobius lapponicus* in North America (Dictyoptera: Blatellidae). *Entomology News* 103(4): 139-141.
- Chapco, W., and G. Litzenger.** 2002. A molecular phylogenetic study of two relict species of melanopline grasshoppers. *Genome* 45: 313-318.
- Doucet, D.** 2009. Census of globally rare, endemic butterflies of Nova Scotia Gulf of St. Lawrence Salt Marshes. NS Species at risk conservation fund report project NSSAR-CF07-04. Nova Scotia Natural Resources. [www.gov.ns.ca/natr/wildlife/conservationfund/2008projects.asp](http://www.gov.ns.ca/natr/wildlife/conservationfund/2008projects.asp).
- Gaboriault, W.** 1961. Les oiseaux aux Îles-de-la-Madeleine. *Le Naturaliste Canadien* 88: 166-224.
- Hill, N., L. Beveridge, A. Flynn, and D. J. Garberry.** 2010. *Rosa rugosa* as an invader of coastal sand dunes of Cape Breton Island and mainland Nova Scotia. *Canadian Field-Naturalist* 124(2): 151-158.
- Laroche, A.** 1973. Carabid beetles of the Magdalen Islands, Quebec. *Canadian Entomologist* 105: 139-143.
- Le Gallo, P. C.** 1952. À travers les Îles de la Madelaine. *Le Naturaliste Canadien* 79(6-7) : 205-231.
- Lewis, D. J., and G. F. Bennett.** 1979. An annotated list of the black flies (Diptera: Simuliidae) of the maritime provinces of Canada. *Canadian Entomologist* 111: 1227-1230.
- Lucas, F. A.** 1888. The bird rocks of the Gulf of St. Lawrence in 1887. *Auk* 5(2): 129-135. <http://www.jstor.org/stable/4067146?seq=7>
- Majka, C. G., R. S. Anderson, D. F. McAlpine, and R. P. Webster.** 2007. The weevils (Coleoptera: Curculionidae) of the Maritime Provinces of Canada. 1. New records from New Brunswick. *Canadian Entomologist* 139: 378-396.
- McAlpine, D. F., and J. B. Ogden.** 2012. New and noteworthy records of Orthoptera from Maritime Canada. *Journal of the Acadian Entomological Society* 9: 43-47.
- Moseley, M.** 2007. Acadian biospeleology: composition and ecology of cave fauna of Nova Scotia and southern New Brunswick, Canada. *International Journal of Speleology* 36 (1): 1-21.
- Paquin, P., D. J. Buckle, N. Dupérré, and C. D. Dondale.** 2010. Checklist of the spiders (Araneae) of Canada and Alaska. *Zootaxa* 2461: 1-170.
- Paquin, P., and N. Dupérré.** 2006. The spiders of Quebec: update, additions and corrections. *Zootaxa* 1133: 1-37.
- Pickavance, J. R., and C. D. Dondale.** 2005. An annotated checklist of the spiders of Newfoundland. *Canadian Field-Naturalist* 119(2): 254-275.
- Pilon, J. G., and D. Lagacé.** 1997. Faune odonotologique des Îles-de-la-Madeleine, Quebec. *Notulae Odonatologicae* 4(9): 141-145.
- Scudder, G. G. E., and I. M. Smith.** Editors. 1998. Assessment of species diversity in the Montane Cordillera eozone. Burlington, Ecological Monitoring and Assessment Network. [http://www.naturewatch.ca/eman/reports/publications/99\\_montane/intro.html](http://www.naturewatch.ca/eman/reports/publications/99_montane/intro.html).
- Smith, I. M.** Editor. 1998. Assessment of species diversity in the Mixedwood Plains Eozone. <http://www.naturewatch.ca/MixedWood>.
- Webster, R. P., and P. G. deMaynadier.** 2005. A Baseline Atlas and Conservation Assessment of the Butterflies of Maine. Maine Department of Inland Fisheries and Wildlife, 650 State Street, Bangor, Maine 04401 USA. 127 pages.

PAUL M. CATLING

170 Sanford Avenue, Ottawa, Ontario K2C 0E9

## Ecological Restoration

By Susan M. Galatowitsch. 2012. Sinauer Associates, Inc., 23 Plumtree Road, P.O. Box 407, Sunderland, Massachusetts 01375-0407 USA. 630 pages. 46.00 GBP. Cloth.

Ecological restoration is the fraught and complicated business of undoing some of the massive damage humanity has inflicted on natural ecosystems around the planet. Restoration ecology is the emerging science of how to go about it. Adding lime to Norwegian streams to facilitate passage of Atlantic salmon, re-establishing native grasslands in Kansas, or rebuilding degraded sections of Australia's Great Barrier Reef are all examples of ecological restoration. Those who would learn how to carry out a restoration project, or teach others how to do so, have been hindered by the immense complexity of the field, and by the lack of a solid textbook to draw on. Susan Galatowitsch's excel-

lent new text goes a long way toward solving both these problems.

Ecological restoration, at least as a science-based enterprise, is a relatively new undertaking. Though it has roots, as Galatowitsch eloquently describes, as far back as attempts to revegetate tropical colonies by the great European powers of the 18<sup>th</sup> and 19<sup>th</sup> centuries, modern, ecologically based restoration has emerged as a discipline in its own right only within the last twenty years. Part of the vexing difficulty of restoration arises from the natural complexity of ecosystems, but at least as much arises from the many disciplines involved in the practice. Restoration projects are frequently grand

in scale and decades in duration, and may incorporate aspects of biology, earth science, hydrology, environmental chemistry, sociology, economics and politics.

Unsurprisingly, given the youth and character of the field, textbooks covering ecological restoration, until now, have been few in number and narrow in scope. The few books on my shelf either cover a great deal of theoretical ecology without specific guidance of what to do on the ground, or they provide summaries of multiple case studies, which may be illustrative of the problems restorers face, but again provide no guidance about how to do it. How-to manuals that do provide practical leads on what a restorer should do in the field are generally restricted to a particular habitat, such as small streams or northern prairies. Dr. Galatowitsch's text largely overcomes these limitations.

The book is intended as a textbook for courses in restoration ecology. As such, it is concerned with the reality of restoring ecosystems and the means and procedures for doing so. While there is an abundance of material on the foundation sciences (ecology, soil science, hydrology, landforms), this information is always integrated tightly into the pragmatic business of restoring lands and waters to their pristine condition. This blend of science and pragmatism is one great strength of the text. The other is its comprehensive coverage. Unlike many other texts and guidebooks, this one provides at least some coverage of all kinds of ecosystems: terrestrial, aquatic, marine, estuarine, forest and prairie, river and lake.

More important, Galatowitsch devotes considerable space to the social and political aspects of restoration, which are frequently neglected or glossed in more standard texts. For examples, an entire chapter is devoted to planning a restoration project, which is as much a sociological enterprise as an ecological one. The next chapter, Social and Institutional Support, even has a section on the dynamics of volunteer organizations. Since degraded ecosystems are always near people, understanding the social, economic and political forces that impinge on a particular site is crucial to successfully restoring it.

The text is organized into three sections. The first, Restoration Process, runs through the conceptual steps of a restoration project from initiation to final evaluation. The second, Restoration Approaches, details the nuts and bolts of restoring ecosystems of various kinds. For example, Chapter 6, Landforms and Hydrology, describes how landscapes are shaped by wind and water, how we degrade rivers, streams, wetlands and even estuaries, and then lays out restoration approaches that are applicable to each situation. The technical descriptions of such jobs as removing a dam on a river are of necessity brief, but sufficient to give the reader a clear idea of the exigencies. The procedures in this

section are well supported by background information on earth science, soil chemistry and ecology (biogeochemical cycles are covered in detail in Chapter 7) but again always in the context of ecological restoration.

The third section is a series of 19 case studies drawn from around the world, each described in about 7-8 pages. I said earlier that case studies generally provide more entertainment than education, but Galatowitsch has rather cleverly integrated the case studies into the main text. They are used as examples to illustrate points throughout the text, and appear again in pull-out boxes and illustrations. Finally, the case studies provide background for a series of "Apply What You've Learned" study questions at the end of every chapter. In this way, the case studies become more like worked examples of restoration problems, rather than simple vignettes.

The text is attractively designed and clearly laid out. The writing is crisp, concise and readable, a pleasant rarity in biology textbooks. Appropriate, well-chosen illustrations appear throughout the text; four-colour diagrams are clean and uncluttered, while the full-colour pictures are used to illustrate concepts and not just to make the text look pretty. Each chapter begins with a two-page overview and ends with a useful bulleted summary. The glossary, reference list (chapter by chapter, which I find a tad annoying) and index are all complete and accurate.

I found few deficiencies in the book. The author is clearly more comfortable in some habitats than others; her previous book-length works concerned restoration of prairie wetlands. Thus, Chapter 8, (entitled "Plants") is 50 pages on how to establish native plants and control invasive plants. My own bias would have been pleased by the same attention to river restoration. I concede, however, Dr. Galatowitsch's point that many in-river restoration projects treat a symptom (channel erosion and high peak flows) instead of the broader cause, which is human alteration of the drainage basin.

Galatowitsch emphasizes the importance of statistical analysis of monitoring data, but glosses over the statistics themselves. This is perhaps a sensible compromise in a textbook of reasonable size. I would have liked to see toxicity testing and bioassays included in the sections on pollution and especially soil remediation, where they have proved so useful in tracing the success of clean-up operations. These are minor concerns, however, which do not meaningfully detract from the overall value of this rich and fascinating new textbook. I plan to establish my own course in ecological restoration sometime soon; when I do, Ecological Restoration will be the textbook for the course.

BARRY R. TAYLOR

Department of Biology, St. Francis Xavier University, Antigonish, Nova Scotia, B2G 2W5 Canada.

## Encountering the Wild

By Carol Bennet McCuaig. 2011. Dundurn Press, 3 Church Street, Suite 500, Toronto, Ontario M5E 1M2. 250 pages. 25.00 CAD. Paper.

In the hilly country of Renfrew County, a region of swamps, rock outcrops, small fields, and woodlots, Carol McCuaig and her husband D. W. McCuaig bought a property a number of decades ago and settled there to enjoy the surrounding country and its inhabitants. Their property needed much renovation in the beginning and they installed electricity, running water and other modern necessities. They found that the property also included the residents and visitors from the surrounding forest and wetlands. She named the property *Poison Ivy Acres* in appreciation of the non-productive flora which abounds in the area.

What follows is a captivating series of accounts of the daily sightings of forest visitors to the house and the property. In a modern-day era of managed agricultural properties and artificial natural areas, this book tells of an area close to metropolitan centres which still maintains the flora and fauna of its original ancestors. Birds, mammals, reptiles, amphibians and of course plants are all featured in short entertaining stories usually just over a page long. The book is broken into interesting vignettes which take only a couple of minutes to read and invite the reader with pictures, and personal anecdotes to read further as one story ends and the next one begins.

Clearly the best accounts are about the pets: dogs, cats and adopted animals which surround the author and her house. But with stories of birdfeeders, caches of seeds, bird nesting boxes and feeding sites with bread crumbs on occasion, she is a nurturer of wildlife and even the encounters with potentially destructive animals she treats with the tolerance of an observer

rather than a victim. One such encounter was when a porcupine chewed all of the soft parts of her bicycle and its destruction became another story of which the details seemed to interest her more than the loss of a vehicle.

Squirrels, porcupines, skunks, even fishers, bears and wolves form the first, largest part of the book with the second section devoted to plants and the yearly cycle of the area including happenings like ice storms. Bird stories make up the last section and the author an avid bird-watcher has many more anecdotes to relate on this subject. The book has too many anecdotes about the family pets for my liking but the author gives account of spending much time alone on the property and the constant companionship of a succession of dogs and cats were obviously important to her.

If you have ever experienced the close connection to nature whether it be in the hilly farmland of the Ottawa Valley or in any area bounded by gravel back roads, long laneways, darkness away from city lights and the quiet of wind in the trees, the book is a delightful collection of the familiar or a picture of how life could be experienced. The author does not shun people in favour of nature. Numerous references are made to church, neighbours, visitors and family, even the conversion of one of the former barns into a guesthouse. The setting is the story and the reader is treated to a focus of nature, concern for animals, birds, the country and the future of a life experience less and less experienced among active people.

JIM O'NEILL

26095 Taft Road, Novi, Michigan 48374 USA

## Global Warming. Historical Guides to Controversial Issues in America

By Brian C. Black and Gary J. Weisel. 2010. Greenwood, An Imprint of ABC-CLIO, 130 Cremona Drive, Santa Barbara, California 93117 USA. xv + 188 pages. 37.95 USD.

Global warming is one of those subjects almost everyone thinks they know about, but it is a topic around which there is often profound misunderstanding and confusion. Yet it is also, ironically, a matter on which people frequently hold and express strong opinions. This volume, one of twenty in the Historical Guides series, aims to put this topic into its historical context where that also requires an understanding not just of recent human history, but also of geological events on a much longer time scale. As such, it provides the background material for more informed and worthwhile discussions. Indeed, the authors "hope to leave the reader more able to engage in this crucial debate as a responsible member of a democratic society" (page xiii). The book goes well beyond a simple summary of the science arguments, however, by pre-

senting a historical survey of the debates, showing how the topic of global warming has become such an incendiary issue. Both authors are based at Altoona College, Penn State University, where Brian Black is Professor of History and Environmental Studies and Gary Weisel is Professor of Physics. Black in particular has good credentials for tackling this topic; he has written several other books focusing on the history of energy and petroleum use.

They start, sensibly, with a definition of terms, distinguishing between climate change, global warming, and anthropogenic global warming. Climate change has a broad scope, referring to "the myriad of variations that the Earth has undergone" (page xii). They distinguish two different meanings for the term global warming: "recent trends in average global temperature", on

which the scientific consensus is that they “have trended upward”, and “the hypothesis that human activity has caused the rising temperature trends of the last three decades” (page xii). The latter sense is often summarized by the term “anthropogenic global warming” or AGW. And it is this term that generates most controversy. Although Black and Weisel attribute this time scope to the “climate science community”, I found the temporal scale quite restrictive; by this view, AGW only refers to the temperature trends since 1980. When I checked other literature, I found the term used in various ways, albeit vaguely with reference to “the last few decades”. I have generally considered the anthropogenic signal to have more time depth, extending to the Industrial Revolution but becoming sharper in recent decades. In this sense, I align more with Steffen *et al.* (2011), who define the Anthropocene (the interval of marked human impact on the environment, including climate) as starting around 1800 AD, with the Great Acceleration starting about 1945 AD. Later Black and Weisel do ask the question “are we living in the Anthropocene?” (page 25). By implication, the answer is “yes”, but they do not state that explicitly. Nevertheless, I did welcome their unequivocal characterization of AGW so that the context for their later discussion was clear.

The remaining account is organized in six chapters, arranged in roughly chronologic order and increasingly sharper focus. The first two chapters give the earth science background. Beginning with “What We Know: A Brief History of the Earth and Its Climate” and continuing with “How We Know: A Brief History of Global Warming Research”, the authors provide an overview of climate change evidence and research, tracing the history of ideas and investigative directions, supported by a useful set of references that provide an entry point into the large and disparate literature in these fields. This will be largely familiar ground to anyone who has worked in ecology, natural history, or earth science. The closing section of the second chapter nicely sets up the discussion in the next, which the authors present in the form of a question: “If the hypothesis of anthropogenic global warming is correct, then how did human beings get themselves in a position where they risked changing the Earth’s very climate?” (page 56).

The third chapter (“How Did We Get Here?”) traces the history of the use of fossil fuels as an energy source. After a short acknowledgement of prehistory, their account begins with Domesday and the Medieval Era, when they identify the roots of industrialism and the application of energy in the form of power to drive machinery, initially as water and wind power, leading to urbanization and manufacturing on a wider scale. However, they trace the major impacts of technological change from the Industrial Revolution, beginning in 1750. From here, they consider that “over the next two centuries, human life changed more than it had in its previous 7,000 years” driven by “machines and an entrepreneurial society committed to applying new technology to everyday life, each one relying on new,

flexible, and expandable sources of energy” (page 62). Their view of recent history and energy use is strongly coloured by this mechanistic profit-driven perspective. Interestingly, they do not highlight recent suggestions of considerably more time-depth for an anthropogenic signal in the climate record. The most accessible account of some of these ideas is provided by Ruddiman (2005) in a provocative but compelling work in which he posits that such a signal can be detected and correlated with land-clearance and the transition to agriculture around 5,000 years ago, the effects of this being overprinted and exacerbated by recent fossil-fuel use. From this perspective, recent environmental impacts are different in effect but not essentially different in character from those throughout human history. Perhaps most tellingly, Black and Weisel note the spatial dissociation between energy generation and energy use, beginning in the late 19<sup>th</sup> century with the development of the power grid to carry electricity from coal-fired power plants to places where it could be used, largely, as they point out, for apparently benign applications that made lives better for many people. What this suggests is that the negative impacts of energy generation are not seen or appreciated by the majority of energy consumers. I was left wondering how far this decoupling influences the dissent about AGW.

In the remaining three chapters (“Domestic Politics and Ethics Regarding the Environment”, “The International Response”, and “Present and Future Policy Options”), the authors provide an articulate and clear summary of the AGW debate, beginning with the US perspective and then broadening to consider the international, largely European, viewpoint. As an outside observer, I have always been mystified as to why there is such opposition and hostility in the US towards recognition of an anthropogenic signal in climate change. I found the fourth chapter therefore particularly illuminating. So-called AGW sceptics, often organized around various conservative think tanks, have had, Black and Weisel suggest an “overriding ideological concern...to resist government regulation, which they believed would hurt the U.S. economy” (page 51). Black and Weisel note that “climate change seems to access nerves that are already inflamed by existing cultural and political disagreements” (page 82) and they identify an “apocalyptic” tenor in much of the recent debate. Anyone who has followed the debate in the news media would concur with that statement!

Black and Weisel situate the climate change debate within the envelope of modern environmentalism. As an idea, environmentalism sprang from a growing awareness of nature and landscape and “changing ideas of the human relationship with nature” that can be “traced back to 19<sup>th</sup> century ideas of romanticism and transcendentalism” (page 82). This was an essentially passive appreciation for nature combined with a strong urge towards protectionism. In the 20<sup>th</sup> century, environmentalists have a much more activist approach and are drawn not as much from the wealthy elite and up-



per class. Black and Weisel also trace the development of NGOs in the US and their interaction with various government agencies (especially the EPA) in recent decades. They note some interesting feedback effects: "the climate change debate has led to significant changes in modern environmentalism, including two extremely different developments: first, the broadening of scientific understanding and interest in environmentalism, and second, the demonizing of environmental perspectives as antidevelopment and unpatriotic" (page 82). It is the latter which perhaps drives most of the more strident and vitriolic commentary in the mass media. The discussion has moved beyond pragmatic arguments and into the sphere of moral and the ethical arguments, with unbridled consumption and expansion seen as immoral and unsustainable by some, whereas any effort to restrain or restrict growth of the US economy is seen as immoral by others. Despite seemingly irreconcilable and intractable viewpoints, Black and Weisel do see some prospects for rapprochement, perhaps through a new ethic of stewardship. Whether this has a lasting impact on US domestic policy remains to be seen.

The international experience forms an illuminating contrast to this fractious squabbling, seemingly being less polarized and less strident. The impact of climate-related problems identified in the 1970s onward, such as acid rain and ozone depletion, are not constrained by borders. Clearly, countries outside the US, especially heavily industrialized countries in Europe and rapidly industrializing countries, such as China, Brazil, and India, have vested interests in these debates as well. As do countries, such as small island states and many densely populated Third World nations, which are likely to bear the brunt of any immediate impacts of AGW. Black and Weisel's analysis of the international dimension is limited. They concentrate mainly on summarizing attempts during several Earth Summits, especially Rio in 1992 and Kyoto in 1997, to develop consensus on actions to mitigate the perceived effects of climate change, especially carbon dioxide emissions. They also discuss the establishment of the IPCC (Intergovernmental Panel on Climate Change) in 1988 and its subsequent activities, focusing particularly on the Fourth Report, issued in 2007. Perhaps counter intuitively, Black and Weisel note that the Reagan administration supported the establishment of the IPCC, feeling that, as a committee, it "would hopefully flatten out the more extreme opinions of some of the scientists" (page 115). The consensus opinions expressed by the IPCC, however, have become more sharply defined and less muted with time, as the scientific research has continued, data have accumulated, and outside criticisms and review have led to more scrutiny and verification, including the rigorous avoidance of overstatement. This caution has led to the development of various scenarios for future effects, depending on varying assumptions about societal response and economic activity, combined with climate projections. Even the most con-

servative of these, however, suggests some significant impacts in different areas of the world.

Whatever the magnitude of the role that anthropogenic activity plays, climate trends suggest continued global warming (page 131). This leads into a consideration of what societal response should be, a subject examined in the final chapter and epilogue ("Present and Future Policy Options" and "Integrating Global Warming Into Federal Action"), where the viewpoint switches back to the US. The IPCC report offers some options for various mitigation actions as well as suggestions for adaptation. The bigger question is whether there is the social and political will to adopt any of the strategies or actions. On this, Black and Weisel point on the difficulties of establishing international agreements, as well as the challenges faced by entities that wish to reduce their "carbon footprint". Again, their analysis focuses on energy use. This portion of the book makes for fascinating reading, as Black and Weisel recount how the US public in general, impatient at the lack of action at the federal level, have adopted mitigation and adaptation activities at state, regional, and local levels, such as committing to targets for greenhouse gas reduction. Public opinion is trumping political inertia, with "bottom up" grassroots actions initiating change. Some commentators have also pointed out that "greening" the economy provides new business opportunities for far-sighted entrepreneurs. Black and Weisel's survey therefore ends on a note of cautious optimism, while acknowledging future uncertainties.

Overall, I recommend this book as a clear straightforward read and a good explication of a complex subject. I especially valued Black and Weisel's lucid discussion of the historical background and recent public debates, which I thought was even-handed and presented without hyperbole. Certainly, I came away from this book with a better understanding of the position of AGW sceptics, something I did not expect. I think that anyone interested in climate science or with a concern for our environment would benefit from reading this thoughtful and informative survey of the global warming debate. As someone involved, at least peripherally, in climate change research the take-home message for me is that scientists have to do a better job of explaining complex research to the public. Improved communication of scientific research may, one hopes, elevate the level of public debate, and that can only be a good thing and result in wiser decision-making.

## References

- Ruddiman, William F. (2005) *Plows, Plagues and Petroleum: How Humans Took Control of Climate*. Princeton University Press, Princeton, New Jersey. 224 pages.
- Steffen, Will, Jacques Grinevald, Paul Crutzen, and John McNeill. (2011) The Anthropocene: conceptual and historical perspectives. *Philosophical Transactions of the Royal Society Series A* 369: 842-867.

ALWYNNE B. BEAUDOIN

12845-102nd Avenue, Edmonton, Alberta T5N 0M6 Canada

## Life Without Oil: Why We Must Shift To a New Energy Future

By Steve Hallett with John Wright. 2011. Prometheus Books, 59 John Glenn Drive, Amherst, New York 14228-2197 USA. 435 pages. 21.45 USD.

The world will run out of oil in the foreseeable future and steps need to be taken now to plan for the future of the human race as this disaster unfolds. Steve Hallett, a professor of botany at Purdue University with experience at McGill and the University of Queensland in Australia and John Wright a journalist currently with *Energy News* collaborate on the project of examining the future of energy in the world. There will not be one simple solution, but many different strategies, and change will not come about easily. Before the world self-destructs in a lack of energy or a struggle to maintain itself with a rapidly disappearing resource, societies have to pursue many different alternatives.

The book begins with a succession of studies of ancient civilizations which depended upon a specific energy source, in most cases burning wood. The Easter Island culture, the Mayan Culture and the Roman Empire are all examples of resource-based economies which began with abundant wood resources for a limited number of people. But as their forests were consumed, and the land occupied by the forests began to erode, wars broke out among different groups within the culture and with their neighbours. The last forests were consumed faster until there were no more nearby wood resources to be found, and no way for the society to continue to grow. A decline set in which eventually led to the destruction of the society and the end of the civilization. Years of poor rainfall and diseases which claimed crops often coincided with the end when it came. In the case of the Roman Empire, attacks from outside also hastened the end of the culture. Each culture illustrated a pattern where use of the resource within its boundaries was managed successfully, a peak where the resource was used to its maximum and finally a period of decline where exploitation accelerated the over-use and the resource was depleted until it finally became extinct, causing a rapid collapse of the culture.

From these historical examples, Hallett moves to the use of oil in our culture and the buildup of our present society as oil has fuelled our culture over the past 100 years. In the 1950's Marion King Hubbert published research conclusions which showed that the oil production of the United States was about to decline. Of course his thesis was anathema at the time but within decades was proven true. Hallett continues that we are reaching that peak period of oil extraction worldwide and the world production of oil is in decline even as our demand for oil is increasing on this continent and among the developing nations particularly India and China. New sources of oil have not been discovered and most of the untapped sources of oil in the world are

smaller sources which will be more difficult to extract with smaller returns than the large oil fields already under production. One insight he mentions is the contrast of the rhetoric of oil companies advertising optimism in sustaining our lifestyles in a world of ever-increasing production, but no new refineries have been built nor new oil tankers commissioned by the same oil companies who obviously anticipate no increase in production.

The book also examines alternative sources of energy: nuclear fuel, natural gas, and coal, as well as renewable sources like wind, solar, geothermal, hydro and tidal exploitation. Each is considered in its present use and possibilities for the future. In the same context the effects of carbon dioxide production from fossil fuel consumption is also examined and some predictions are made of the future of the planet with increasing levels of carbon dioxide, methane and other carbon by-product pollutants in the atmosphere. The picture he paints is not optimistic for the world with the current distribution of wealth, resources and expanding populations.

The book is a wake-up call from an ecologist, student of economics and of history. Hallett has good insights into the ways that we are using our energy resources now and how that energy consumption, particularly oil, will change and change us in the future. Our dependence upon cheap, foreign-made goods available at Walmart (he has a particular prejudice against Walmart) and other big-box stores are all dependent upon large freighters crossing the Pacific Ocean fuelled by oil in their tanks and the low prices we enjoy will not be possible as the price of a diminishing resource rises in response to fewer supplies and rising prices.

I was disturbed by the book even from my relatively informed position of teaching ecology, reading the news and reflecting upon climate change. The careful comment on each developing nation using the resource, the location and history of oil in each area of the world and the current distribution pattern is a panorama of a declining resource on which we are accelerating our dependence just as the Roman Empire searched for more and better forests to supply their heat, ore smelting, and construction materials, but were eventually overcome by a lack of resources. Our need is to broaden our energy base before it collapses around us and as Hallett and Wright have presented, the collapse of the oil resource is imminent in our world.

JIM O'NEILL

26095 Taft Road, Novi, Michigan 48374 USA

## Oceanography and Marine Biology: An Introduction to Marine Science

By David W. Townsend. 2012. Sinauer Associates, 23 Plumtree Road, Sunderland, Massachusetts 01375 USA. 512 pages + appendixes. 139.95 USD. Cloth [and available as an eBook].

David Townsend's *Oceanography and Marine Biology* originated in a class he has taught at the University of Maine since 1997. It is intended to present an account of the whole breadth of the marine sciences to undergraduate students, aiming at showing them, as he says, "the oceanographic foundation upon which life in the sea depends." How successful is he, and is his book relevant to the general reader?

During the past quarter century the marine sciences have become increasingly quantitative, the most marked split being between biological oceanography, which has cast its lot with physical oceanography and the mathematical approach to biological problems of the sea, and marine biology, which retains some of its natural history flavor but has increasingly created links with quantitative and theoretical ecology. These are not easy bedfellows, or to use another analogy, Townsend may be attempting to mix the immiscible.

In an attractive large-page format, with the use of abundant, often outstanding, illustrations, Townsend deals briefly with the historical background of the marine sciences, then with the scientific method, the origin of Earth and oceans, the formation and evolution of the seafloor, chemical and physical properties of water, atmospheric circulation and its relation to ocean currents, waves and tides, and the general nature of life in the sea. He includes the importance of photosynthetic processes, nutrients and limiting factors, material cycles (notably of nitrogen and phosphorus), vertical circulation and its importance in limiting production, and environmental factors limiting the distribution of marine organisms. He then deals in some detail with the phytoplankton and other primary producers, the zooplankton, with marine benthic (bottom-dwelling) and nektonic (swimming) invertebrates, and with fish. Marine ecology gets its due in a chapter on marine environments dealing with subjects such as the intertidal zone, estuaries, salt marshes, mangrove forests, coral reefs, and the deep ocean. The concluding chapters survey marine vertebrates other than fishes, marine fisheries and aquaculture, and human impacts

on the oceans, including global warming. Finally, in three interesting appendixes, he deals with the use of satellites for remote sensing, the climatic implications of El Niño and La Niña phenomena, and techniques for exploring the deep sea. There is an extensive and helpful glossary.

The foundation that gives this book unity is its concentration on the sea as a physical, chemical and biological environment. Nearly all the science is up to date and it represents the range of research on the oceans and the knowledge that results from it in a very credible and useful way. This is not to say that all is well. Townsend's introductory chapter on the history of the marine sciences is perfunctory, based on dated or questionable sources not on recent scholarship, and trots out some old and discredited warhorses (including the myth of the Portuguese, Henry "The Navigator"). There are apparently inadvertent lapses, such as the reversal of the definitions of Eulerian and Lagrangian methods in physical oceanography (page 188) and an incorrect caption showing recent and historical ranges of sea otters (page 434). Each chapter has a brief, and generally very useful, reading list, allowing the reader to find a way into the broader literature, but the occasional list, such as that on the deep sea, omits important recent references that could provide better guidance to the reader. These should be easy to correct or modify in new editions, or especially in the eBook version available now.

In answer to my introductory questions, this book presents the marine sciences in a compelling and authoritative way. It can be an important resource to the general reader looking for an attractively-presented introduction to the marine sciences, to the teacher of secondary or undergraduate-level oceanography, and to the professional looking for up to date surveys of topics in oceanography and marine biology. It is worth browsing for the quality of the illustrations alone.

ERIC L. MILLS

Department of Oceanography, Dalhousie University, 1355 Oxford Street, P.O. Box 15000, Halifax, Nova Scotia B3H 4R2 Canada

## Social Networks and Natural Resource Management: Uncovering the Social Fabric of Environmental Governance

Edited by Örjan Bodin and Christina Prell. 2011. Cambridge University Press, Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473 USA. 376 pages. 115.00 USD. Cloth.

Directed at a senior-level academic audience, this book explores the use of social network theory and analysis for studying social structures in natural resource management such as communities of users, decision makers and institutions. While not a conventional

textbook, my interpretation of the material indicates that the book is more technical than a casual educational read but not so technical that the user could fully understand and replicate the methods used without outside information. The prose style employed is very text

dense, such that the book cannot be considered a quick-reference tool. There are some greyscale diagrams, but overall very little illustration. Nevertheless, the book is welcomed for its timely contribution and collection of studies that use social network analysis (SNA) in natural resource management. Much of the existing body of work using SNA is limited to organisational studies, business studies and other traditional social study areas.

Divided into 14 chapters, there is a balance between background information on SNA, the evolution of social network theory and case studies arranged in sections based on level of network studied: individual, subgroup or network levels. Almost every case study is submitted by different authors, providing multiple voices, opinions, geographies and techniques on how SNA can be applied. Usefully, the editors requested contributors answer the same set of questions reflecting on the use of SNA and their experiences, and these are presented after each case study. However, not every contributor saw fit to answer the questions as phrased, so some reflections are wordy and do not serve for cross-comparison of experience. Indeed, it is most unfortunate that the excellent opportunity for comparison is lost given the relative newness of the use of SNA in ecological governance analysis. Helpfully, each chapter contains an extensive list of references, and there are numerous in-text citations.

The book begins with an overview and discussion of social network analysis and its use in the more conventional social theory arena. While well presented, this introduction is not as simple as other SNA texts and the reader is recommended to be at least familiar with SNA concepts and terminology in order to derive the most benefit. The editors state that *'social network analysis comprises diverse methods for the study of how resources, goods and information flow through particular configurations of social ties'* (page 10). Simply put, social network theory is a social anthropology approach to mapping networks of interconnected actors. It distils complex interaction into a web of nodes and ties, enabling analysis of key connections across a broader social landscape. Given that ecosystems are not confined within human-made geographic or institutional boundaries, but are managed piecemeal within them by these same actors, SNA can be used to map social interaction for improved understanding of effective ecological governance. Academic research is shifting towards using the term 'governance' over 'management' or 'government' to reflect and denote the intricacies of human socio-ecosystem interaction.

Case studies include fisheries management in Kenya and Mexico, forestry management in British Columbia, agroforestry in Ghana, as well as park and land management in Europe. Each study presents a brief literature review and frequently introduces the same information as covered in the book's first section – albeit with the case study author's own use and interpretation. Brief methods are presented, followed by results and

discussion. However, these are not as clear as would be expected in a journal article and the overall tone is more discursive than instructional. The major interest is seeing how each author chose to use SNA, why and in what capacity rather than the ease of reproducibility of their work.

Some authors are much more theoretically inclined while others prefer to present information more quickly. As such, the reader is likely to find his or her preferred writing style in several case studies. As previously mentioned, the text is very dense at times in content but especially in format. The font is too small and margins over-large (perhaps for note-taking?) I found this detracted substantially from my reading as I could easily lose my place. The relative paucity of diagrams, maps and other illustrative material also contributed to an ease of 'zoning out' while reading, as text was not broken up. Given I am actively interested in the subject matter, I found these decisions – many of which likely did not fall under author control – detracted from the text and its usefulness as a reference for moving SNA into ecological and agro-ecological social analysis.

I also found that some contributing authors did not take their analysis to the next level, explaining how their determined networks could be used as anything more than hypothetical or informational. From a resource management perspective, tracking information flow is a primary use of SNA in ecology in order to establish who to speak with or how to transfer knowledge effectively. Tests of elaborated networks to determine their usefulness in this capacity, or comparison of network structure between successful and unsuccessful ecosystem management cases still seems to be lacking.

The coverage of researcher bias in SNA was spotty, but present. Bias can be significant as networks, whether ascribed or self-identified, are based on how respondents fit into categories determined by the researcher and how the researcher interprets a word. It is important to incorporate multiple dimensions into any analysis and determination of network structure which is inherently difficult and complex to accomplish. How networks can be graphically represented for analysis to provide the most information clearly is not covered in this book.

I recognise that the aim of the authors is not to produce a how-to text, but a reference tool. However, I do lament the lack of a more expanded critical discussion on researcher bias, the efficacy of using SNA in natural resource management and when it is appropriate, applying SNA beyond network elaboration (which is a time-consuming and complex activity in itself) and how SNA information can be graphically represented or analysed for non-academics. This latter topic is important since collaborative action across disciplines and education levels is vital in natural resource management.

I would rate this book as a 'borrow' over 'purchase', since it does provide a good overview of SNA and theory, in addition to learning in what situations and why authors chose to use SNA. The editors do meet their objective of 'using a social relational approach to gain a deeper understanding of the social dimensions of

*natural resources governance*' (page 5). Such work is the first step for establishing more research using SNA as a tool within natural resource management and ecological governance.

TREMAYNE STANTON-KENNEDY

Ottawa, Ontario

#### CHILDREN'S BOOKS

### Ecosystem Series: *Who Needs a Swamp?, Who Needs a Jungle?, and Who Needs an Iceberg?*

By Karen Patkau, 2012. Tundra Books, 75 Sherbourne Street, Toronto, Ontario M5A 2P9. 32 pages. 19.99 USD. Hardcover.

This delightful series of children's books, written and illustrated by dimensional artist Karen Patkau, are focussed on the ecology and conservation of three ecosystems. Each book introduces an ecosystem and its species, illustrates ecological concepts, provides a distribution map, an illustrated guide to some of the species contained within the book, and a comprehensive glossary. The illustrations are colourful and playful and sidebar illustrations are cleverly used to magnify a section of the main page illustration or reinforce an ecological concept. Inside the jacket sleeve of each book, the reader will discover a hidden poster.

The books are formulaic, beginning with an introduction to the ecosystem featured in the book and its inhabitants, followed by ecological concepts including the food chain and life cycle. Ecological services provided by each ecosystem are presented (such as flood protection and water filtration by swamps, climate control and oxygen production by jungles, and reflection of the sun's energy by the arctic ice) and discussed with reference to human impacts on the featured ecosystem. A global scale map of the ecosystem illustrates its distribution and rarity. The shortfalls of the

books are few; in *Who Needs a Swamp*, the author neglected to clarify that a swamp is an ecosystem, and the title of *Who Needs an Iceberg* is somewhat of a misnomer, as only one page is dedicated to an iceberg. *Who Needs the Arctic* may have been a more appropriate title. A nice addition to these books would have been a profile of the author, who is evidently passionate about nature and its conservation.

The evocative question of who needs these ecosystems is presented at the end of each book. The text presents the ecosystems in a manner that is relevant to the lives of children and thus the answer is self-evident before the end of each book. The ecological concepts are sufficiently complex that the books are most appropriate for 9 – 13 year olds. Younger children will enjoy the illustrations, however, and the concepts can be reinforced with the guidance of an adult. The conservation message in each book is strong without being overly preachy. This series would make a wonderful addition to the library of any young naturalist. My daughters, age thirteen and eight, gave this series two thumbs up.

CAROLYN CALLAGHAN

Luskville, Quebec.

### Who Will Save My Planet?

By Maria Christina Urrutia, 2012. Tundra Books, 75 Sherbourne Street, Toronto, Ontario M5A 2P9 Canada. 32 pages. 10.95 USD. Hardcover.

First published in Spanish in 2007 by Ediciones Tecolote, this is a short picture book of 28 pages, aimed at illustrating human impacts on the environment. Juxtaposing colour photos depict human impacts on one page and pristine conditions on the opposing page. This theme is not consistent throughout the book, however, as the last four pages of the book show negative human impacts.

The book's small format and lack of text is suggestive of a children's book, but don't be fooled by the packaging; this is a book requiring mature comprehension of the role humans have played on the earth. Some of the photos are quite disturbing, such as a heap of dead sea turtles on a beach, and a sea lion sitting on a rock with deep flesh wounds to the neck from

what appears to be ghost fishing gear. Another photo showed the surreal stare of a snarling jaguar – a stuffed mount on a pile of jaguar skins. The high shock value of these photos could easily cause readers to turn off rather than engage in the book's message.

In contrast to the previously described shocking images, one of the photos of human impacts was not convincing enough for me. It depicted a mature tree that had been cut down. Upon closer inspection, one could see that the setting was a city park, that the tree showed plenty of rot, and the upturned roots tipped up suggested that perhaps the tree had fallen over for reasons other than human foible.

The last four images in the book left me feeling quite deflated. I had anticipated a message of hope for the

future – perhaps a depiction of humans redeeming themselves through land stewardship or preservation. Rather, the depiction of polluted, human-dominated landscapes was suggestive of no hope for the future. The photo of a person planting a tree that occurred early in the book would have been a better choice for the parting shot. With a wiser selection of photos and a

final message of hope, the intended conservation message would have been better delivered to readers. As is, this is not a book I would recommend – certainly not for children.

CAROLYN CALLAGHAN

Luskville, Quebec.

## NEW TITLES

Prepared by Roy John

† Available for review \* Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

## ZOOLOGY

**The Amphibians and Reptiles of Michigan – A Quaternary and Recent Faunal Adventure.** By J. Alan Holman. 2012. Wayne State University Press, The Leonard N. Simons Building, 4809 Woodward Avenue, Detroit, Michigan 48201-1309 USA. 312 pages. 50.00 USD. Cloth.

**The Great Animal Orchestra: Finding the Origins of Music in the World's Wild Places.** By Bernie Krause. 2012. Little, Brown & Company, 1271 Avenue of the Americas, New York, New York 10020 USA. 288 pages. 14.99 USD. Cloth.

**The Beauty of Birds.** By Jeremy Mynott. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 2.99 USD. Kindle e-book.

**The World's Rarest Birds.** By Erik Hirschfeld, Andy Swash and Robert Still. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 352 pages. 45.00 USD. Cloth.

**The Unfeathered Bird.** By Katrina van Grouw. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 304 pages. 49.95 USD. Cloth.

**Atlas of Butterflies of MT. Qinling-Bashan in China** [Chinese with Latin name Index]. By Xu Jiazhu and Wei Huanzhi. 2010. China Scientific Book Services, Room No.1120, Tower A, Kingsound (Jiahao) International Center, No.116, Zi Zhu Yuan Road, Haidian District, Beijing 100089 China. 271 pages. 120.00 USD.

**Gifts of the Crow.** By John Marzluff and Tony Angell. 2012. Free Press [Simon and Shuster Inc.], 1230 Avenue of the Americas, New York, New York 10020 USA. 297 pages. 25.00 USD. Cloth.

**Britain's Plant Galls: A Photographic Guide.** By Michael Chinery. 2011. Princeton University Press, 41 William Street, Princeton, New Jersey, 08540 USA. 96 pages. 21.95 USD. Paper.

**A Field Guide to the Wildlife of South Georgia.** By Robert Burton and John Croxall. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 200 pages. 24.95 USD. Paper.

**Britain's Hoverflies: An Introduction to the Hoverflies of Britain and Ireland.** By Stuart Ball and Roger Morris. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 240 pages. 35.00 USD. Paper.

**Fauna Sinica Insecta (Vol. 54) Lepidoptera Geometridae Geometrinae.** [Chinese with English summary]. By Han Hongxiang and Xue Dayong. 2011. China Scientific Book Services, Room No.1120, Tower A, Kingsound (Jiahao) International Center, No.116, Zi Zhu Yuan Road, Haidian District, Beijing 100089 China. 787 pages. 87.00 USD. Cloth.

**Insect Fauna of Henan Lepidoptera: Limacodidae Lasiocampidae Notodontidae Arctiidae Lymantriidae Amatiidae.** [Chinese with Latin name and English Abstract]. By Wu Chunsheng and Fang Chenghai. 2010. China Scientific Book Services, Room No.1120, Tower A, Kingsound (Jiahao) International Center, No. 116, Zi Zhu Yuan Road, Haidian District, Beijing 100089 China. 592 pages. 69.00 USD.

**Fauna Sinica Insecta (Vol. 52) Lepidoptera Pieridae.** [Chinese with English summary]. By Wu Chunsheng. 2010. China Scientific Book Services, Room No.1120, Tower A, Kingsound (Jiahao) International Center, No.116, Zi Zhu Yuan Road, Haidian District, Beijing 100089 China. 416 pages. 43.00 USD. Cloth.

**Microlepidoptera of Qinling Mountains Insecta: Lepidoptera.** [Chinese, Latin name, English Summary]. By Li Houhun. 2011. China Scientific Book Services, Room No. 1120, Tower A, Kingsound (Jiahao) International Center, No. 116, Zi Zhu Yuan Road, Haidian District, Beijing 100089 China. 1271 pages. 109.00 USD. Cloth.

**The Fauna of Hebei, China-Microlepidoptera.** [Chinese with Latin name Index]. By Li Houhun et al. 2009. China Scientific Book Services, Room No. 1120, Tower A, Kingsound (Jiahao) International Center, No. 116, Zi Zhu Yuan Road, Haidian District, Beijing 100089 China. 599 pages. 85.00 USD. Cloth.

**Britain's Sea Mammals: Whales, Dolphins, Porpoises, and Seals and Where to Find Them.** By Jon Dunn, Robert Still and Hugh Harrop. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 120 pages. 19.95 USD. Paper.

**Animals of the Masai Mara.** By Adam Scott Kennedy and Vicki Kennedy. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 144 pages. 27.95 USD. Paper.

**Birds of the Masai Mara.** By Adam Scott Kennedy. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 176 pages. 27.95 USD. Paper.

**Parrots of the World – field guide edition.** By Joseph Forshaw. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 16.97 USD. Kindle e-book.

**Britain's Reptiles and Amphibians.** By Howard Inns. 2011. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 164 pages. 17.95 GBP. Paper.

\* **Snow Leopard-Stories from the Roof of the World.** Edited by Don Hunter. 2012. University Press of Colorado, 5589 Arapahoe Avenue, Suite 206C, Boulder, Colorado 80303 USA. 190 pages. 26.95 USD. Cloth.

**Spiders of the Eastern United States – A Photographic Guide.** By W. Mike Howell and Ronald L. Jenkins. 2012. Pearson Education, 26 Prince Andrew Place, Don Mills, Ontario M3C 2T8 Canada. 363 pages. 33.20 CAD.

**Whales and Dolphins of the European Atlantic: The Bay of Biscay, English Channel, Celtic Sea, and Coastal Southwest Ireland (Fully Updated Second Edition).** By Dylan Walker and Graeme Cresswell. 2011. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 88 pages. 16.95 USD. Paper.

\* **Societies of Wolves and Free-ranging Dogs.** By Stephen Spotte. 2012. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473 USA. 394 pages. 120.00 CAD. Cloth.

#### BOTANY

**Orchids and Wildflowers of Kitulo Plateau.** By Rosalind F. Salter and Tim R. B. Davenport. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 84 pages. 21.95 USD. Paper.

#### ENVIRONMENT

**Biodiversity in Agriculture – Domestication, Evolution, and Sustainability.** By Paul Gepts, Thomas R. Famula, Robert L. Bettinger, Stephen B. Brush, Ardeshir B. Damania, Patrick E. McGuire, and Calvin O. Qualset [Editors]. 2012.

Cambridge University Press, Shaftesbury Road Cambridge CB2 8BS United Kingdom. 630 pages. 70.00 USD. Paper.

† **Advances in Irrigation Agronomy – Plantation Crops.** By Mike K. V. Carr. 2012. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473 USA. 360 pages. 98.00 CAD. Hardback.

**Tree Thinking: An Introduction to Phylogenetic Biology.** By David Baum and Stacey Smith. 2012. Roberts and Company Publishers, 4950 South, Yosemite Street, F2 #197, Greenwood Village, Colorado 80111 USA. 496 pages. 75.00 USD.

**Control of Crop Disease – Third edition.** By William. Carlile and Anne Coules. 2012. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473 USA. 177 pages. 48.00 USD.

**Beyond Earth Day – Fulfilling the Promise.** By Gaylord Nelson. 2012. The University of Wisconsin Press, 1930 Monroe Street, Madison, Wisconsin 53711-2059 USA. 224 pages. 26.95 USD. Paper.

† **Design and Analysis of Long-term Ecological Monitoring Studies.** Edited by Robert A. Gitzin, Joshua J. Millsbaugh, Andrew B. Cooper and Daniel S. Licht. 2012. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473 USA. 560 pages. 76.95 USD. Paper.

**Community Ecology.** By Gary G. Mittelbach. 2012. Sinauer Associates, Inc., 23 Plumtree Road, P.O. Box 407, Sunderland, Massachusetts 01375-0407 USA. 400 pages. Paper.

**The Ecology of Plant Secondary Metabolites – From Genes to Global Processes.** By Glenn R. Jason, Marcel Dicke and Susan E. Hartley [Eds.] 2012. Cambridge University Press, 32 Avenue of the Americas, New York, New York USA. 352 pages. 35.00 GBP. Paper.

† **This Crazy Time – Living Our Environmental Challenge.** By Tzaporah Berman and Mark Leiren-Young. 2011. Knopf Canada /Random House of Canada Limited, 2775 Matheson Blvd. East, Mississauga, Ontario L4W 4P7 Canada. 384 pages. 32.00 CAD. Cloth.

**Evolution: Making Sense of Life.** By Carl Zimmer and Douglas Emlen. 2012. Roberts and Company Publishers, 4950 S. Yosemite Street, F2 #197, Greenwood Village, Colorado 80111 USA. 720 pages. 115 USD. Paper.

**A Visitor's Guide to South Georgia: Second Edition.** By Sally Poncet and Kim Crosbie. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 184 pages. 29.95 USD. Paper.

# News and Comment

## Dr. Warren Baxter Ballard, Jr. 1947–2012

Warren Ballard, wildlife researcher, editor, and professor died at his home at Lubbock, Texas, of pancreatic cancer 12 January 2012. He had a distinguished career in wildlife biology in Alaska, New Brunswick, Arizona, and most recently as Horn Professor in Texas Tech University's Department of Natural Resources. He supervised 44 MS and doctoral students and authored or co-authored over 200 research papers, as well as a dozen book chapters and monographs and over 30 proceedings and miscellaneous publications. Among other

editorial positions for several journals he was Associate Editor of *The Canadian Field-Naturalist* for mammals 1994-2001, 2007-2011, and before and during these periods contributed over 280 individual evaluation reviews of papers submitted to the journal. He was an effective proponent of involving graduate students in the review process as part of their scientific training. Warren is survived by his wife and frequent co-author, Heather A. Whitlaw. A detailed tribute is in preparation for a later issue of *The Canadian Field-Naturalist*.

## On the Discovery of Eastern Leatherwood (*Dirca palustris*)

YASEEN MOTTIAR

Department of Cell & Systems Biology, University of Toronto, 25 Harbord Street, Toronto, Ontario, M5S 3G5, Canada; email: yaseen.mottiar@utoronto.ca

Mottiar, Yaseen. 2012. On the Discovery of Eastern Leatherwood (*Dirca palustris*). *Canadian Field-Naturalist* 126(1): 86–88.

The existing scientific literature dates the discovery of Eastern Leatherwood (*Dirca palustris* L.) to the 1730s and assigns John Clayton, a plant collector in the Virginia Colony, and Dutch botanist Jan Frederik Gronovius as the discoverers. But Michel Sarrazin, an early Canadian naturalist, was apparently the first to report on this species in 1700. Moreover, he also sent a living specimen of leatherwood to France. This case reminds us that the earliest information on some North American species predates the Linnaean binomial name.

La littérature scientifique courante attribue la découverte du bois de plomb (*Dirca palustris* L.) dans les années 1730 à John Clayton, un collectionneur de plantes dans la colonie de Virginie, et au botaniste hollandais Jan Frederik Gronovius. Cependant, le premier rapport sur cette espèce a été rédigé en 1700 par Michel Sarrazin, l'un des premiers naturalistes canadiens. En outre, il a envoyé un spécimen vivant de bois de plomb en France. Ce cas nous rappelle que les premières informations sur certaines espèces d'Amérique du Nord précèdent le nom binomial linnéen.

Key Words: botanical history, Eastern Leatherwood, *Dirca palustris*, Michel Sarrazin.

Eastern Leatherwood (*Dirca palustris* L.), also known as moosewood, wicopy, and *bois de plomb*, is an understory shrub found sporadically across most of eastern North America in rich, mesic soils. This species is well known by field-naturalists for its ephemeral spring flowers and extremely flexible stems. The genus contains three other species: Western Leatherwood (*D. occidentalis* Gray), Mexican Leatherwood (*D. mexicana* Nesom and Mayfield) and a recently identified species from the southern United States, *D. decipiens* Floden (Schrader and Graves 2004; Floden et al. 2009). But as with most North American flora, the eastern member of the genus was the first to be discovered by colonial botanists. Indeed, the botanical history of leatherwood is inherently linked to the history of colonization in North America.

In the scientific literature, a plant collector named John Clayton is credited with “discovering” this new

species in the 1730s when he sent dried specimens from the Virginia Colony to the Dutch botanist Jan Frederik Gronovius (Choquette 1925; Nevling 1968). Gronovius is then recognized as the first to report on leatherwood. In his *Flora Virginica*, he describes the plant as follows (Gronovius 1739):

“*Thymelaea* white flowers, which burst out at the beginning of spring: oblong, tapering leaves: twigs and bark very strong and flexible, hence the name Leather-wood. Grows by the banks of the Roanoke river, other rivers near hills, and in the county of Middlesex. Clayton add.” (translated from the original Latin)

Gronovius then apparently sent some of the specimens he had received from Clayton to Carl Linnaeus in Sweden. In his 1751 dissertation, a student of Linnaeus named Leonhard Johan Chenon was the first to



use the binomial *Dirca palustris* (Chenon 1751). That manuscript also included an original sketch of leatherwood which was presumably drawn by Chenon or Linnaeus himself.

Although this is undoubtedly a true account of the assignment of the binomial name, it does not accurately address the discovery of leatherwood itself<sup>1</sup>. While the British, Dutch, Spanish and others were founding colonies across much of the southeastern range of leatherwood in the 17<sup>th</sup> century, the French established themselves in northeastern North America. By 1697, a surgeon of King Louis XIV named Michel Sarrazin had set about botanising in the wilderness of New France (Vallée 1927). Sarrazin had been a student of the French botanist Joseph Pitton de Tournefort and, once in North America, he took great satisfaction in methodically surveying the unnamed flora, fauna and minerals of the New World (Rousseau 1982). Throughout his industrious career, Sarrazin documented his discoveries through regular communications with colleagues at the Royal Academy of Sciences in Paris. In 1700, he wrote the following in a letter to Tournefort (transcribed in Vaillant 1708 and reproduced in Boivin 1977, 1978):

“This shrub reaches a height of 4 to 5 feet. I do not know why we call it *bois de plomb* [lead wood] because it is very light. Its young stems are gnarled and are so arranged that they seem to be encircled by pieces of one another. The bark is very thick, soft, very strong; and separates very easily from the wood. ... Here, we use the cooked bark applied in the form of a poultice to ease the pains of haemorrhoids and of old ulcers. It is said that it was the remedy of the abbot Mr. Gendron for cancers, but I know well that it is very powerless for this. ... It prefers the shade and has been found between 47 and 40 degrees [latitude] in all sorts of soils. Its flowers are born at the ends of the branches 2 or 3 together like a small bouquet. The leaves are alternate though they are first born in groups at the ends of branches. ...” (translated from the original French)

Besides letters, Sarrazin sent living specimens of many species to France. A surviving catalogue of these shipments confirms that leatherwood was transferred to the King's garden where it was initially misidentified as a tropical species known as princewood (Jussieu 1708). Although many of the plants that Sarrazin shipped died en route as a result of poor care and exposure to salt water (Rousseau 1982), the leatherwood specimen seems to have endured its transatlantic



FIGURE 1. “*Dirca palustris*, *Dirca des marais*”. Watercolour by Pierre-Joseph Redouté originally published in Duhamel du Monceau's 1806 *Traité des arbres et arbustes que l'on cultive en France*.

journey and thrived in Paris. In 1755, Henri-Louis Duhamel du Monceau referred to Sarrazin's notes in his description of a flowering leatherwood plant which had already been growing in the King's garden for “many years” (Duhamel du Monceau 1755). While Du Monceau included his own sketch in the first edition of his treatise, the most remarkable early depiction of leatherwood is surely the watercolour by the Belgian painter Pierre-Joseph Redouté which is featured in the second edition and is reproduced here (Figure 1).

Michel Sarrazin was a father of Canadian botany and was one of the first Canadian field-naturalists. His description of leatherwood predates that of Clayton and Gronovius by nearly 40 years. Moreover, Sarrazin's description precedes the assignment of the binomial name by 50 years. Besides reassigning the discovery to Sarrazin, this new information reminds us that many North American species were well known prior to the assignment of binomial names.

<sup>1</sup>The use of scientific botanical names is governed by an international code which requires that any taxon can have only one correct scientific name and that it is the earliest legitimate name (article 11) with a start date of 1753 and *Species Plantarum* ed. 1 by Linnaeus (article 13.1a). Certain plant taxa were discovered before 1753 and named at the time, but these names are not valid. Recently “the code” has been revised every 6 years. The most recent version, the Melbourne Code, is awaiting publication and is entitled “*International Code of Nomenclature for algae, fungi, and plants (ICN)*.” [http://en.wikipedia.org/wiki/International\\_Code\\_of\\_Nomenclature\\_for\\_algae\\_fungi\\_and\\_plants](http://en.wikipedia.org/wiki/International_Code_of_Nomenclature_for_algae_fungi_and_plants).

Although the early French-Canadian colonists were evidently the first Europeans to document leatherwood, it is worth emphasizing that they were truly not the first to know of it. First Nations peoples have long used leatherwood for natural cordage and naturopathic medicines. Indeed, Sarrazin even described how the colonists learned about this species (Vaillant 1708):

“We say that the abbot Mr. Gendron uses it for cancers and that he learned this use from our savages.” (translated from the original French)

While Sarrazin was most likely referring to the Huron or Algonquin peoples, it is known that many other groups across eastern North America also made use of this plant. Undoubtedly, the true “discoverers” of leatherwood were the ancestors of the First Nations peoples. Indeed, there is archaeological and anthropological evidence that aboriginal North Americans have used this remarkable plant in textiles and medicines for many centuries (Austin 2004).

### Acknowledgements

I am most grateful to my uncle, Grant Dobson, for introducing me to this species and many, many others. Thanks also to M. Dewar (University of Toronto) for help with the Latin translation and to J. Lambert (Laval University) for help in locating the archived letters of Sarrazin.

### Literature Cited

- Austin, D. F. 2004. Florida Ethnobotany. CRC Press, Boca Raton, Florida. Pages 270-271.
- Boivin, B. 1977. La flore du Canada en 1708: Étude d'un manuscrit de Michel Sarrazin et Sébastien Vaillant. Études littéraires 10(1-2): 223-297. (Reprinted with original pagination in *Provancheria* 9: 223-297. 1978.)
- Chenon, L. J. 1751. *Nova plantarum genera*. Ph.D. thesis, Uppsala University, Sweden.
- Choquette, L. 1925. Contribution à l'étude du *Dirca palustris* L. ou “bois du plomb”. Ph.D. thesis, University of Paris, France.
- Duhamel du Monceau, H.-L. 1755. *Traité des arbres et arbustes qui se cultivent en France en pleine terre*. First edition. Volume 1. H. L. Guerin & L. F. Delatour, Paris, France. Pages 211-212.
- Duhamel du Monceau, H.-L. 1806. *Traité des arbres et arbustes que l'on cultive en France*. Second edition. Volume 3. E. Michel, Paris, France. Plate 48.
- Floden, A. J., Mayfield, M. H., and C. J. Ferguson. 2009. A new narrowly endemic species of *Dirca* (Thymelaeaceae) from Kansas and Arkansas, with a phylogenetic overview and taxonomic synopsis of the genus. *Journal of the Botanical Research Institute of Texas* 3(2): 485-499.
- Gronovius, J. F. 1739. *Flora Virginica*. First edition. Cornelium Haak, Leiden, The Netherlands. Page 155.
- Jussieu, A. 1708 (circa). *Plantes envoyées de Canada par M. Sarrazin conseiller du conseil supérieur et médecin du Roy en Canada*. Reproduced in Vallée 1927.
- Nevling, L. L., Jr. 1968. Typification in *Dirca*. *Journal of the Arnold Arboretum* 15(1): 158-159.
- Rousseau, J. 1982. Michel Sarrazin. In Volume 2 of the *Dictionary of Canadian Biography*. University of Toronto Press, Toronto, Ontario.
- Schrader, J. A., and W. R. Graves. 2004. Systematics of *Dirca* (Thymelaeaceae) based on its sequences and ISSR polymorphisms. *SIDA, Contributions to Botany* 21(2): 511-524.
- Vallée, A. 1927. Un biologiste canadien: Michel Sarrazin, 1659-1735 – sa vie, ses travaux et son temps. *LS-A. Proulx*, Quebec City, Quebec.
- Vaillant, S. 1708. *Histoire des plantes de Canada*. Excerpts of letters from Sarrazin in which he describes the plants sent to France between 1698 and 1707. A copy is available in the archives of Bernard Boivin at Laval University, Quebec City, Quebec.

Received 4 November 2011

Accepted 8 March 2012

**Tributes**

- A Tribute to James Herbert Soper, 1916–2012 ERICH HABER 61

**Book Reviews**

- ZOOLOGY: How to be a Better Birder — Birds of Algonquin Park — Birds of Aruba, Curacao and Bonaire  
— A Guide to the Birds of India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, and the Maldives 68

- ENVIRONMENT: Assessment of species diversity in the Atlantic Maritime Ecozone — Ecological Restoration  
— Encountering the Wild — *Global Warming*. Historical Guides to Controversial Issues in America —  
Life Without Oil: Why We Must Shift To a New Energy Future — Oceanography and Marine Biology:  
An Introduction to Marine Science — Social Networks and Natural Resource Management: Uncovering  
the Social Fabric of Environmental Governance 71

- CHILDREN'S BOOKS: Ecosystem Series: *Who Needs a Swamp?*, *Who Needs a Jungle?*, and *Who Needs an  
Iceberg?* — *Who Will Save my Planet?* 83

- NEW TITLES 84

**News and Comment**

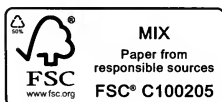
- Dr. Warren Baxter Ballard, Jr. 1947–2012 86  
On the Discovery of Eastern Leatherwood (*Dirca palustris*) YASEEN MOTTIAR 86

Mailing date of the previous issue 125(4): 14 August 2012

## Articles

- Occurrence of the Maritime Shrew (*Sorex maritimensis*) in Black Spruce (*Picea mariana*) forest stands in southeastern New Brunswick JULIE HENDERSON and GRAHAM FORBES 1
- Body condition and survival of vagrant Long-billed Murrelets, *Brachyramphus perdix*, in North America SPENCER G. SEALY and HARRY R. CARTER 6
- Greater Scaup, *Aythya marila*, nest site characteristics on Grassy Island, New Brunswick  
JON T. MCROBERTS, NICOLE T. QUINTANA, W. ANDREW SMITH, WARREN B. BALLARD,  
F. PATRICK KEHOE, and TIMOTHY G. DILWORTH 15
- Abundance and habitat selection of breeding Scoters (*Melanitta* spp.) in Ontario's Hudson Bay Lowlands RODNEY W. BROOK, KENNETH F. ABRAHAM, KEVIN R. MIDDEL, and R. KENYON ROSS 20
- Notes**
- Implantation and parturition dates of North American River Otters, *Lontra canadensis*, in southern Missouri  
NATHAN M. ROBERTS, SHAWN M. CRIMMINS, DAVID A. HAMILTON, and ELSA GALLAGHER 28
- Kudzu Vine, *Pueraria montana*, adventive in southern Ontario  
GERALD E. WALDRON and BRENDON M. H. LARSON 31
- First observations of Mormon Metalmark (*Apodemia mormo*) oviposition behaviour in Canada  
ASHLEY ANNE WICK, JOHANE JANELLE, SHELLEY PRUSS, and NADIR ERBILGIN 34
- Barn Owl (*Tyto alba*) predation on Big Brown Bats (*Eptesicus fuscus*) in Pennsylvania  
SUZANNE M. KHALAFALLA and CARLOS A. IUDICA 38
- An anomalous Northern Saw-whet Owl (*Aegolius acadicus*) egg  
THERESA M. BURG and RANDOLPH F. LAUFF 41
- An extra-limital population of Black-tailed Prairie Dogs, *Cynomys ludovicianus*, in central Alberta  
HELEN E. TREFRY and GEOFFREY L. HOLROYD 46
- A specimen of the High Arctic subspecies of Atlantic Puffin, *Fratercula arctica naumanni*, in Canada  
ANTHONY J. GASTON and JENNIFER F. PROVENCHER 50
- Vancouver Island Marmots (*Marmota vancouverensis*) consume plants containing toxic secondary compounds  
JEFFERY R. WERNER 55
- New avian breeding records for Iqaluit, Nunavut  
DAVID J. T. HUSSELL, JEREMY A. T. HUSSELL, and ERICA H. DUNN 59

(continued on inside back cover)



ISSN 0008-3550

CAN  
1824

# The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada



Volume 126, Number 2

April–June 2012

# The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

## Patron

His Excellency the Right Honourable David Johnston, C.C., C.M.M., C.O.M., C.M.  
Governor General of Canada

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

## Honorary Members

Ronald E. Bedford	Michael D. Cadman	John M. Gillett	Joyce Reddoch
Edward L. Bousfield	Paul M. Catling	Christine Hanrahan	Allan Reddoch
Charles D. Bird	Francis R. Cook	C. Stuart Houston	Dan Strickland
Donald M. Britton	Bruce Di Labio	Theodore Mosquin	John B. Theberge
Fenja Brodo	R. Yorke Edwards	Robert W. Nero	Sheila Thomson
Irwin M. Brodo	Anthony J. Erskine	E. Franklin Pope	
Daniel F. Brunton			

## 2012 Council

<b>President:</b> Ann MacKenzie	Daniel F. Brunton	David Hobden	Jeff Saarela
<b>1<sup>st</sup> Vice-President:</b> Fenja Brodo	Carolyn Callaghan	Diane Kitching	Henry Steger
<b>2<sup>nd</sup> Vice-President:</b> Jeff Skevington	Barbara Chouinard	Diane Lepage	Chris Traynor
<b>Recording Secretary:</b> Annie Bélair	Julia Cipriani	Karen McLachlan-Hamilton	Eleanor Zurbrig
<b>Treasurer:</b> Ken Young	Sandra Garland	Rémy Poulin	

To communicate with the Club, address postal correspondence to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2, or e-mail: [ofnc@ofnc.ca](mailto:ofnc@ofnc.ca). For information on Club activities, go to [www.ofnc.ca](http://www.ofnc.ca)

## The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

**Website:** [www.canadianfieldnaturalist.ca/index.php/cfn](http://www.canadianfieldnaturalist.ca/index.php/cfn)

**Editor-in-Chief:** Dr. Carolyn Callaghan

**Copy Editor:** Elizabeth Morton

**Treasurer:** Ken Young, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2

**Journal Manager:** Jay Fitzsimmons: [subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca) or via postal address above.

**Book Review Editor:** Roy John

**Associate Editors:** Robert R. Anderson

Charles D. Bird

Paul M. Catling

Francis Cook

Anthony J. Erskine

Thomas Jung

Donald F. McAlpine

David Nagorsen

Claude Renaud

Jeffery M. Saarela

David C. Seburn

**Chair, Publications Committee:** Daniel F. Brunton

**All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by e-mail:** [editor@canadianfieldnaturalist.ca](mailto:editor@canadianfieldnaturalist.ca) **or postal mail (with disk):** 611 Chemin Cregheur, Luskville, QC J0X 2G0; (819) 455-1087; **Book-review correspondence should be sent to the Book Review Editor by e-mail:** [r.john@rogers.ca](mailto:r.john@rogers.ca) **or postal mail:** 2193 Emard Crescent, Ottawa, Ontario K1J 6K5.

### Subscriptions and Membership:

Subscription rates for individuals are \$40 (online only), \$50 (print only), or \$60 (print + online) for volume 126. Libraries and other institutions may subscribe for \$60 (online only or print only) or \$90 (print + online) for volume 126. All foreign print subscribers and members (including USA) must add \$10 to cover postage. The Ottawa Field-Naturalists' Club annual membership fee of \$40 (individual), \$45 (family), or \$20 (student) includes an online subscription to *The Canadian Field-Naturalist*. Members can receive printed issues of CFN for an additional \$30 per volume (four issues). For further details, including discounts for members of the Canadian Museum of Nature, see <http://ofnc.ca/member.php>. The club's regional journal, *Trail & Landscape*, covers the Ottawa District and regional Club events and field trips. It is mailed to Ottawa area members, and is available to those outside Ottawa on request. It is available to libraries at \$33 per year. Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be sent to [subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca) or mailed to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O., Ottawa, ON, Canada, K1Z 1A2. Canada Post Publications Mail Agreement number 40012317. Return postage guaranteed.

COVER: Western Yellow-breasted Chat (*Icteria virens auricollis*) in the southern Okanagan River valley, British Columbia. See article and note by René McKibbin and Christine A. Bishop, on pages 135–142, and 152–156 in this issue. Photo by Roberta Olenick.

# The Canadian Field-Naturalist

Volume 126, Number 2

April–June 2012

## Ecology of a Recently Discovered Population Segment of Blanding's Turtles, *Emydoidea blandingii*, in Barren Meadow and Keddy Brooks, Nova Scotia

JOSÉ LEFEBVRE<sup>1</sup>, STEPHEN W. MOCKFORD, and TOM B. HERMAN

Department of Biology, Acadia University, 33 Westwood Avenue, Wolfville, Nova Scotia B4P 2R6 Canada  
<sup>1</sup>Corresponding author email: jose.lefebvre@acadiau.ca

Lefebvre, José, Stephen W. Mockford, and Tom B. Herman. 2012. Ecology of a recently discovered population segment of Blanding's Turtles, *Emydoidea blandingii*, in Barren Meadow and Keddy Brooks, Nova Scotia. *Canadian Field-Naturalist* 126(2): 89–94.

Blanding's Turtles in Barren Meadow Brook and Keddy Brook are part of the Pleasant River population, the easternmost population currently recognized in Nova Scotia. Previous genetic analysis demonstrated restricted gene flow among the populations of Nova Scotia. The conservation of this genetic diversity is important to reduce genetic drift and bottleneck effects in these populations. Between 2006 and 2008, the population in Barren Meadow Brook and Keddy Brook was estimated using visual surveys, trapping, and radio-tracking. Over the three years, surveys yielded 69 individuals (14 females, 22 males, 29 juveniles, 4 undetermined). Capture-mark-recapture analysis using the Chapman variation of Petersen formulas for bi-census yielded population estimates of 88 Blanding's Turtles. The sex ratio did not deviate significantly from 1:1. Applying minimum convex polygon (MCP) and kernel methods to radio-tracking data yielded preliminary estimates of home range size and location for males and females. Females had larger home ranges, probably because of the limited availability of nesting sites in Barren Meadow and Keddy Brooks. New overwintering sites and three new nesting sites were identified. Home ranges of males did not overlap, and males seemed to show territorial behaviour. An expanded sample, particularly of males, is needed to improve the assessment of home ranges, movements, and behaviour. To date, conservation efforts in this population have focused on females. If home ranges of males in an expanded sample also do not overlap, then conservation of this population requires closer scrutiny of males and their population genetic structure.

Key Words: Blanding's Turtle, *Emydoidea blandingii*, population status, ecology, Nova Scotia.

Southwestern Nova Scotia contains three small, genetically distinguishable populations of Blanding's Turtles, *Emydoidea blandingii*, at the northeastern periphery of the species' range (Mockford et al. 1999). These populations have been isolated since the end of the Hypsithermal Interval ~4500 years ago (Bleakney 1958). Mockford et al. (2007) concluded they should be considered evolutionarily significant units (ESU) based on the reduced gene flow among the Nova Scotia populations and their long genetic isolation from the remainder of the species' range.

The landscapes that support the populations in Nova Scotia vary both structurally and in the level of protection they receive. The population in Kejimikujik National Park of Canada occurs on federally regulated land and is therefore protected, and the McGowan Lake populations occur in a combination of private and provincially regulated land, much of which has been designated for conservation (McNeil, 2002). The Pleasant River population, which includes the Blanding's Turtles in Barren Meadow Brook and Keddy Brook,

occurs in a mixed-use working landscape that is afforded less formal protection. The primary threats to Blanding's Turtle in Nova Scotia are human-induced mortality and loss and fragmentation of habitat. Limited migration has been observed among these populations (Herman et al. 1995; personal observation, JL). This may lead to further isolation of existing populations, and the deleterious effects associated with inbreeding and genetic drift could eventually lead to their extinction (Herman et al. 1995, 1999\*).

The Blanding's Turtles in Barren Meadow Brook and Keddy Brook form a discrete component of the Pleasant River population. Previous genetic analysis suggested restricted gene flow between the Barren Meadow Brook and Keddy Brook population and the Pleasant River population (Toews 2005\*). More detailed analysis of these populations is needed for the further evaluation of the diversity within, and gene flow among, these populations. The objectives of this study were to determine abundance, sex ratio, age distribution, seasonal movement patterns, and home range size for the

understudied Barren Meadow Brook and Keddy Brook population.

### Study Area and Methods

The study sites, Barren Meadow Brook (44°26'N, 64°48'W), Keddy Brook (44°25'N, 64°50'W), and the surrounding wetlands, lie within the Medway River drainage basin, in the municipality of Colpton, Lunenburg County, in southwestern Nova Scotia (Figure 1). The study area is divided into three main sites: Barren Meadow Brook, Keddy Brook, and Shingle Lake. The species is associated with shallow water, submerging and emergent vegetation, and deep organic sediments (Ross and Anderson, 1990). In Nova Scotia, the distribution of Blanding's turtle closely parallels that of highly coloured acid waters and peaty soils (Power *et al.*, 1994). Barren Meadow Brook and Keddy Brook were chosen because this area is at greatest risk of disturbance. Barren Meadow Brook and Keddy Brook are in a mix of Crown and privately owned land that supports forestry and outdoor recreational activities. Human settlement and agriculture comprise the principal disturbance regimes.

At first capture, individuals were marked with a unique notch code, following standard procedure used in Kejimikujik National Park (Power 1989). Morphological measurements (maximum straight-line carapace, maximum plastron length and width, weight, tail length pre- and post-cloaca) were recorded for each individual that was encountered during visual surveys or trapped, and morphological, age, and sex data were recorded when they were equipped with radio-transmitters. On older juveniles and adults, sex was assessed using pre-cloaca tail length. Age was determined by counting plastron rings, as described in Lefebvre *et al.* (2011).

### Inventories

Three methods were employed to survey the population: visual surveys, trapping, and radio-telemetry. Visual surveys and trapping occurred between May and September of each year; radio-telemetry was carried out throughout the year.

Visual surveys involved walking parallel to the brooks and searching the open areas from the bank to the edge of the woody vegetation. Effort is estimated in person-hours. At each encounter, the identity of the Blanding's Turtle (notch code noted when present) and location (Universal Transverse Mercator coordinates) determined using a handheld Garmin GPS unit were recorded.

The study area was systematically trapped for 1229 trap-nights between 2006 and 2008, with most effort (934 trap-nights) in 2006; additional trapping in areas not sampled previously occurred in 2007 (245 trap-nights) and 2008 (50 trap-nights). Trapping sessions were composed of a minimum of 25 trap-nights (e.g., five traps for five days) employing baited hoop traps (3 cm mesh and 30 cm mouth) (Bourque 2006), checked daily. Sardines in soy oil were used as bait and were

changed every three days (McNeil 2002; Caverhill 2006).

Ten to 15 individuals (males, females, and juveniles) per year were equipped with radio-transmitters and their positions were recorded as often as possible (every one to three days) to assess movements. Sub-adults and adults were equipped with AI-2F (28 g) transmitters and juveniles were equipped with PD-2 transmitters (3.8 g) (Holohil Systems, Carp, Ontario). All individuals were tracked with an Osprey receiver (HR2600DLT with data logger telemetry, H.A.B.I.T. Research Ltd., Victoria, British Columbia) equipped with a Yagi 3-prong folding directional antenna. Transmitters were affixed to the carapace with PC-7 epoxy paste (Protective Coating Co., Allentown, Pennsylvania). The data were analyzed to determine home range sizes and activity centres.

### Analysis

Population size was estimated using the Chapman variation of the Petersen estimator for bi-census method (Ricker 1975; Borchers *et al.* 2002; Skalski *et al.* 2005). Sex ratio and age distribution were calculated. Deviation from a 1:1 sex ratio was tested using  $\chi^2$ . Daily movements of radio-tracked turtles were mapped using ArcGIS 9.2 software (ESRI, 2006\*). Home ranges of males, females, and juveniles were estimated using the kernel and minimum convex polygon (MCP) methods in the ArcGIS package Hawth's Tools v.3.27, at 95% of sightings (location points). Differences in the sizes of home ranges were tested with a unilateral *t*-test between sexes and with ANOVAs between years using the Tukey test with Holm's correction (Holm, 1977; 1979). Home ranges were calculated for four seasonal activities over the calendar year: dispersal (1 April–1 June), nesting (2 June–3 July), summer activity (4 July–7 September), and overwintering (8 September–31 March).

### Results

During the study, 69 different individuals were identified. In 2006, 39 Blanding's Turtles (25 marked in previous studies and 14 unmarked) were encountered a total of 84 times (72 captures by traps, 12 captures by visual surveys). In 2007, 41 individuals, including 17 new individuals for this population, were handled a total of 76 times (42 captures by traps and 34 by visual surveys). No Blanding's Turtles were captured in trapping sessions in 2008, but visual surveys provided 13 captures. The population was estimated at 87.8 individuals (C.I. 13.9 at 95%). The sex ratio was not significantly different from 1:1 ( $\chi^2 = 0.18$ , *df* = 1, *P* = 0.18). Nearly two-thirds (40 of 65) of the Blanding's Turtles were <30 years old, and nearly one-third (18 of 65) were ≤10 years old (Table 1).

In 2006, 183.5 hours were expended tracking 11 Blanding's Turtles (6 females, 3 males, and 2 juveniles) during the active period (April to September). With the bulk of the trapping already done, more effort (240



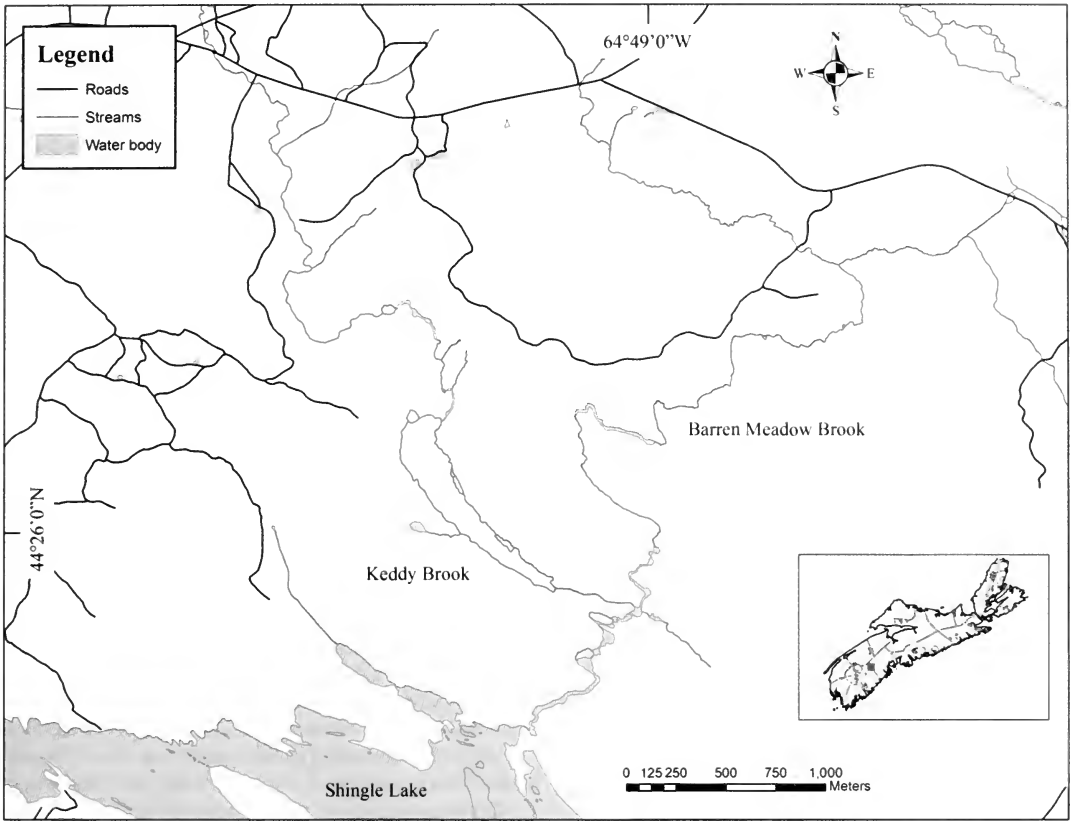


FIGURE 1. Map of the study sites (Barren Meadow Brook, Keddy Brook, and Shingle Lake) in Lunenburg County, Nova Scotia.

TABLE 1. Captures of Blanding's Turtles, *Emydoidea blandingii*, by age category and sex in Barren Meadow Brook and Keddy Brook, Nova Scotia, between 2006 and 2008.

Age category (years)						
Juvenile			Adult		Undetermined	Total
Young juvenile (0–10)	Old juvenile (11–18)	Sub-adult (>18 but not sexually active)	Male	Female	4	
18	8	3	22	14	4	69

hours) was dedicated to radio-tracking in 2007: 14 Blanding's Turtles (7 females, 5 males, and 2 juveniles) were radio-tracked throughout the year. In 2008, 14 Blanding's Turtles (6 females, 7 males, and 1 juvenile) were radio-tracked throughout the year, but the overall effort was reduced (140 hours) in order to spend more time monitoring nesting. Some individuals were tracked for more than one year.

In 2006, home range size differed significantly between the sexes (Table 2). Female home ranges were larger when estimated by both multiple convex poly-

gon ( $t = 20.51$ ,  $df = 7$ ,  $P < 0.001$ ) and kernel methods ( $t = 2.00$ ,  $df = 7$ ,  $P < 0.05$ ). Home range sizes of males and females did not differ in 2007 (multiple convex polygon  $P = 0.366$ ; kernel  $P = 0.54$ ) or 2008 (multiple convex polygon  $P = 0.24$ ; kernel  $P = 0.18$ ).

Home ranges were compared among the three years separately for each sex. Female home ranges differed significantly among years ( $df = 2$ ,  $F = 7.743$ ,  $P < 0.001$ ) and were significantly larger (Tukey test with Holm's correction) in 2006 than in 2007 ( $df = 1$ ,  $t = -3.32$ ,  $P = 0.005$ ) and 2008 ( $df = 1$ ,  $t = -3.62$ ,  $P = 0.002$ ).

TABLE 2. Mean home range size in hectares of radio-tracked Blanding's Turtles, *Emydoidea blandingii*, by sex and method in Barren Meadow Brook and Keddy Brook, Nova Scotia, between 2006 and 2008. Standard deviation is in parentheses.

Year	Female		Male	
	Kernel	Minimum convex polygon	Kernel	Minimum convex polygon
2006	86.82 (39.01)	89.02 (41.72)	47.86 (17.15)	43.93 (24.95)
2007	53.33 (23.41)	40.34 (39.62)	54.85 (27.58)	33.89 (39.62)
2008	41.33 (14.03)	63.63 (65.96)	46.72 (8.35)	44.18 (53.73)

There was no significant difference in the size of home ranges of males among years ( $df = 2$ ,  $F = 0.27$ ,  $P = 0.768$ ).

Four previously unknown overwintering sites were discovered, and all sites were used by multiple individuals. Overwintering sites were all in slow-flowing brooks. All sites were over 1 m in depth, and the bottom was a mix of silt and organic matter. Individual Blanding's Turtles showed strong site fidelity, returning to the same sites in 2007 and 2008.

Prior to this study, only one nesting area had been identified in the Barren Meadow Brook and Keddy Brook area: on a rocky outcrop with a southwest-oriented slope and very thin soil. During the course of the study, females were found nesting in three additional areas, two in rocky outcrops similar to the previously identified site and one in an active agricultural landscape.

## Discussion

Prior to this study, 34 individuals had been identified in inventories carried out in Barren Meadow Brook and Keddy Brook. Systematic trapping and surveying in the current study identified 35 additional individuals, more than doubling the known population. This number falls within the estimate of the population, suggesting that most of the population has now been accounted for. The majority of Blanding's Turtles captured in the study site were  $\geq 5$  years old. Barren Meadow Brook and Keddy Brook contain more than 10% of the estimated adult population of Blanding's Turtles in Nova Scotia (Herman et al. 2004\*), and this area has the highest ratio of juveniles to adults.

The 1:1 sex ratio is consistent with other studies in which Blanding's Turtle habitat is isolated from main roads, which are a major cause of mortality in female turtles (Desroches and Picard 2005; Steen et al. 2006). If and when logging and mining activities are resumed in the Barren Meadow Brook area, the locations of roads should be carefully planned to reduce effects on nesting females and to facilitate the movement of Blanding's Turtles between seasonal use areas. Blanding's Turtles nest occasionally on road shoulders (Power 1989; McNeil 2002; Desroches and Picard 2005; Caverhill 2006), and this makes both females and hatchlings vulnerable to increased mortality from vehicle traffic.

The ratio of capture to search effort from visual surveys in 2006 was relatively low; although nearly 40% of the total effort was expended on visual surveys (117 of 300 hours), these surveys yielded less than 15% of the Blanding's Turtles caught. However, captures during visual surveys increased to almost 45% (34 of 76) in 2007 for a similar total effort. The refinement of a "search image" and improved knowledge of the study area by the observer likely accounted for the higher success rate and argue for continued use of this technique by experienced observers.

Trapping efforts prior to 2006 were limited by Caverhill (2006) (300 trap-nights between 2002 and 2005) but had higher capture rates. In 2006, trapping was systematic across most parts of the study area. This method yielded a lower capture rate but it removes the bias inherent in choosing trap locations; prior to the systematic survey, trapping was concentrated in areas where Blanding's Turtles had been seen. Systematic trapping also yielded captures in areas previously thought unproductive and identified previously unknown travel routes.

The estimated mean home range for males was larger than for Blanding's Turtles in Wisconsin and Massachusetts (Ross and Anderson 1990; Grgurovic and Sievert 2005), but it was similar to estimates from Minnesota (Piedgras and Lang 2000). Mean home range size in Barren Meadow Brook and Keddy Brook was influenced by one individual, whose home range was 1.6 to 3 times larger than that of other males. Even with such a large home range, activity centres among males did not overlap, except during communal activities such as mating and overwintering. This behaviour was consistent with observations by Ross and Anderson (1990).

Some previously unreported aggressive behaviours were observed during mating. Older males chased, mounted, and dominated smaller or younger males, forcing them to flee. The mean home range size for males was smaller than for females; this would be expected if a male is defending a territory from other males. This behaviour has never been reported elsewhere in Blanding's Turtles.

The mean home range size for females was much larger than has been observed in Wisconsin and Massachusetts (Ross and Anderson 1990; Grgurovic and Sievert 2005). This may reflect a paucity of nesting

sites in Barren Meadow Brook. In Kejimikujik National Park, most nesting occurs on lakeshore cobble beaches; in contrast, at McGowan Lake, most nesting occurs both on lakeshores and on slate outcrops, many of which are located well inland (Herman et al., 1999; NcNeil, 2002). In the Barren Meadow Brook area, three of four nesting sites were on rock outcrops where a limited amount of substrate has accumulated in crevices over the years.

The rarity of nesting sites would oblige females to travel long distances, sometimes across atypical terrain, as occurred with one Blanding's Turtle, which, in 2006, went directly overland through the forest to her nesting site (more than 1.0 km) instead of following the stream, as expected. Another female travelled over 5.0 km to reach her nesting area, even with apparently similar habitat nearby. These extensive movements largely explain differences in 2006 between the size of home ranges of males and the size of home ranges of females. All females tracked that year made similar large movements to nesting sites. This was not the case in 2007 and 2008; in both years, only two females nested.

Nesting every second or third year is observed in turtles in habitats with low productivity, where the female cannot accumulate the resources needed to invest in the production of eggs every year (Heppell 1998). The area round Barren Meadow Brook and Keddy Brook is mostly a fen, with relatively low productivity (Bourque 2006). Home range sizes of nesting females were significantly larger than the home range sizes of non-nesting females ( $t = 4.84$ ,  $df = 9$ ,  $P < 0.001$ ), and this finding supports the hypothesis that a paucity of nesting sites adds to the energetic costs of reproduction. This could, in turn, explain the lower frequency of nesting in this population.

Overwintering sites are critical for Blanding's Turtles, particularly in Nova Scotia, which is at the northern limit of the species' range. Because they commonly overwinter for six months or more, the Blanding's Turtles in Nova Scotia spend half of their lives or more at overwintering sites. During unseasonably warm winter temperatures, Blanding's Turtles often become locally active at these sites, and they have even been observed mating in mid-January (Newton and Herman 2009). In the Barren Meadow Brook and Keddy Brook area, Blanding's Turtles were observed using communal overwintering sites, a behaviour that is widely reported for this species (Sajwaj and Lang 2000; Ultsch 2006; Newton and Herman 2009). Communal overwintering provides an opportunity for mating early in the spring, before production and fertilization of eggs.

The number and quality of nesting sites are much lower in the Barren Meadow Brook and Keddy Brook area than in the areas that support the other Nova Scotia populations. The productivity of the habitat is also low. Yet Barren Meadow Brook and Keddy Brook

have the highest proportion of juveniles in the known Nova Scotia populations. One explanation could be lack of predation on juveniles. A high proportion of nests and hatchlings are predated by Raccoons (*Procyon lotor*), and hatchlings are also taken by Northern Short-tailed Shrews (*Blarina brevicauda*) (Power 1989; Standing et al. 2000) and Red Squirrels (*Tamiasciurus hudsonicus*). These predators are rare in or absent from the Barren Meadow Brook and Keddy Brook area (personal observation, JL). They were never encountered in the habitat at the Barren Meadow Brook and Keddy Brook area, which may therefore support higher hatching abundance and survival rates of Blanding's Turtles.

### Acknowledgements

This research was made possible by the Blanding's Turtle Recovery Team, which provided the dataset (Jennifer Ann McNeil). Trevor Avery provided comments and suggestions on the statistical analyses and revisions, and the honours and graduate students in the Herman/Mockford laboratory participated in data collection. Three anonymous reviewers made valuable suggestions on an earlier draft. This project was approved by the Canadian Council on Animal Care committee at Acadia University, and permits were acquired from the Nova Scotia Department of Natural Resources.

### Documents Cited (marked \* in text)

- ESRI. 2006. ArcGIS Desktop: Release 9. Redlands, California: Environmental Systems Research Institute.
- Herman, T. B., J. S. Bleakney, J. S. Boates, C. Drysdale, J. Gilhen, I. Morrison, T. Power, K. L. Standing, and M. Elderkin. 1999. National Recovery Plan for Blanding's Turtle (*Emydoidea blandingii*) Nova Scotia population. Report Number 18. Recovery of Nationally Endangered Wildlife. Ottawa, Ontario. 39 pages.
- Herman, T. B., J. A. McNeil, and D. D. Hurlburt. 2004. Blanding's turtle population viability analysis: development and application of a stage-classified transition matrix. Final report to Parks Canada SARRAEF 03-KEJ03-004.
- Toews, D. P. 2005. Quantification of fine scale genetic structure in a peripheral population of Blanding's turtle (*Emydoidea blandingii*) in Pleasant River, Nova Scotia. Biology Department, Acadia University, Wolfville, Nova Scotia. 38 pages.

### Literature Cited

- Bleakney, J. S. 1958. A zoogeographical survey of the amphibians and reptiles of eastern Canada. Bulletin of the National Museum of Canada 155. 119 pages.
- Borchers, D. L., S. T. Buckland, and W. Zucchini. 2002. Estimating animal abundance: closed populations. Springer-Verlag, Berlin. 314 pages.
- Bourque, G. 2006. Investigating variables affecting Blanding's turtles (*Emydoidea blandingii*) patch occupancy and trapping success in Nova Scotia. M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.
- Caverhill, B. P. 2006. Blanding's Turtle conservation in Nova Scotia: linking science and stewardship through public education. M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.

- Desroches, J.-F., and I. Picard.** 2005. Mortalité des tortues sur les routes de l'Outaouais. *Le Naturaliste canadien* 129(1): 35-41.
- Grgurovic, M., and P. R. Sievert.** 2005. Movement patterns of Blanding's turtles (*Emydoidea blandingii*) in the suburban landscape of eastern Massachusetts. *Urban Ecosystems* 8: 203-213.
- Herman, T. B., T. D. Power, and B. R. Eaton.** 1995. Status of Blanding's Turtles, *Emydoidea blandingii*, in Nova Scotia, Canada. *Canadian Field-Naturalist* 109: 182-191.
- Heppell, S. S.** 1998. Application of life-history theory and population model analysis to turtle conservation. *Copeia* 1998(2): 367-375.
- Holm, S.** 1977. Sequentially rejective multiple test procedures. Statistical Research Report 1977-1. Institute of Mathematics and Statistics, University of Umeå, Sweden.
- Holm, S.** 1979. A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics* 6: 65-70.
- Lefebvre, J., T. A. Avery, and T. B. Herman.** 2011. Size dimorphism and growth rate in distinct populations of Blanding's Turtles (*Emydoidea blandingii*) in Nova Scotia in relation to environment. *Herpetological Conservation and Biology* 6(3): 465-472.
- McNeil, J. A.** 2002. Distribution, movements, morphology and reproduction in a population of Blanding's turtle (*Emydoidea blandingii*) in an unprotected landscape in southwestern Nova Scotia. M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.
- Mockford, S. W., M. Snyder, and T. B. Herman.** 1999. A preliminary examination of genetic variation in a peripheral population of Blanding's turtle, *Emydoidea blandingii*. *Molecular Biology* 8(2): 323-327.
- Mockford, S. W., T. B. Herman, M. Snyder, and J. M. Wright.** 2007. Conservation genetics of Blanding's turtle and its application in the identification of evolutionarily significant units. *Conservation Genetics* 8: 209-219.
- Newton, E. J., and T. B. Herman.** 2009. Habitat, movement and behaviour of overwintering Blanding's turtles (*Emydoidea blandingii*) in Nova Scotia. *Journal of Canadian Zoology* 87: 299-309.
- Piedgras, S. A., and J. W. Lang.** 2000. Spatial ecology of Blanding's turtle in central Minnesota. *Chelonian Conservation and Biology* 3: 589-601.
- Power, T. D.** 1989. Seasonal movements and nesting ecology of a relic population of Blanding's turtle (*Emydoidea blandingii* (Holbrook)) in Nova Scotia. M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.
- Power, T.D., T.B. Herman and J. Kerekes.** 1994. Water colour as a predictor of local distribution of Blanding's turtle *Emydoidea blandingii* in Nova Scotia. *Canadian Field Naturalist* 108(1): 17-21.
- Ricker, W. E.** 1975. Computations and interpretation of biological statistics of fish populations. *Bulletin of the Fisheries Research Board of Canada* 191. Ottawa, Ontario. 382 pages.
- Ross, D. A., and R. K. Anderson.** 1990. Habitat use, movements and nesting of *Emydoidea blandingii* in central Wisconsin. *Journal of Herpetology* 24: 6-12.
- Sajwaj, T. D., and J. W. Lang.** 2000. Thermal ecology of Blanding's turtle in central Minnesota. *Chelonian Conservation and Biology* 3(4): 626-636.
- Skalski, J. R., K. R. Ryding, and J. J. Millspaugh.** 2005. *Wildlife Demography: Analysis of Sex, Age, and Count Data*. Elsevier Academic Press, Burlington, Massachusetts. 636 pages.
- Standing, K. L., T. B. Herman, M. Shallow, T. Power, and I. P. Morrison.** 2000. Results of the nest protection program for Blanding's turtle in Kejimikujik National Park, Canada: 1978-1997. *Chelonian Conservation and Biology* 3: 637-642.
- Steen, D. A., M. J. Aresco, S. G. Beilke, B. W. Compton, E. P. Condon, C. Kenneth Dodd Jr., H. Forrester, J. W. Gibbons, J. L. Greene, G. Johnson, T. A. Langen, M. J. Oldham, D. N. Oxier, R. A. Saumure, F. W. Schueler, J. M. Sleeman, L. L. Smith, J. K. Tucker, and J. P. Gibbs.** 2006. Relative vulnerability of female turtles to road mortality. *Animal Conservation* 9: 269-273.
- Ultsch, G. R.** 2006. The ecology of overwintering among turtles: where turtles overwinter and its consequences. *Biological Reviews* 81: 339-367.

Received 13 September 2011

Accepted 18 June 2012

# An Addition to the Mammalian Fauna of Saskatchewan: The Western Harvest Mouse, *Reithrodontomys megalotis*

GILBERT PROULX and BENJAMIN P. PROULX

Alpha Wildlife Research & Management Ltd., 229 Lilac Terrace, Sherwood Park, Alberta T8H 1W3 Canada

Proulx, Gilbert, and Benjamin P. Proulx. 2012. An addition to the mammalian fauna of Saskatchewan: the Western Harvest Mouse, *Reithrodontomys megalotis*. Canadian Field-Naturalist 126(2): 95–102.

The Western Harvest Mouse (*Reithrodontomys megalotis*) is rare in Canada, and its distribution is believed to be restricted to south-central British Columbia and southeastern Alberta. Between 2008 and 2010, we identified Western Harvest Mouse hairs in 71 of 1424 scats (5%) of Red Fox (*Vulpes vulpes*), Coyote (*Canis latrans*), American Badger (*Taxidea taxus*), and Long-tailed Weasel (*Mustela frenata*) collected in southwestern Saskatchewan. The presence of Western Harvest Mouse was confirmed at the same latitude as populations reported in Alberta and British Columbia, in scats collected in or nearby grasslands. This is the first time that the presence of the Western Harvest Mouse has been confirmed in Saskatchewan.

Key Words: Western Harvest Mouse, *Reithrodontomys megalotis*, hair identification, Saskatchewan.

The current Canadian distribution of the Western Harvest Mouse (*Reithrodontomys megalotis*) is restricted to low-elevation grasslands in the southern Okanagan and Similkameen valleys of south-central British Columbia (*R. m. megalotis*) (Nagorsen 1995) and dry mixed grass prairie within the Canadian Forces Base Suffield National Wildlife Area (CFB Suffield) of southeastern Alberta (*R. m. dychei*) (Reynolds et al. 1999\*) (Figure 1). The *dychei* subspecies of the Western Harvest Mouse is designated endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); the *megalotis* subspecies is designated special concern (COSEWIC 2007\*). Both are protected under the Species at Risk Act.

During a study of Richardson's Ground Squirrel (*Urocyon richardsonii*) populations in southwestern Saskatchewan between 2008 and 2010, we collected scats of Red Fox (*Vulpes vulpes*), Coyote (*Canis latrans*), American Badger (*Taxidea taxus*), and Long-tailed Weasel (*Mustela frenata*). This paper reports on the presence and frequency of Western Harvest Mouse hairs in the scats of these carnivores.

## Methods

Between 2008 and 2010, we collected 1424 scats on privately owned lands in a region extending from Woodrow (49°41'N, 106°43'W) to Neville (49°57'N, 107°38'W) (Figure 1). The identification of scats was based on personal notes gathered in previous studies with animals in captivity and in the wild (e.g., Proulx and Barrett 1990; Proulx and Cole 1998; Proulx et al. 2009\*), and on Murie (1975). Scats were dated, bagged, and kept frozen until they were processed. Scat analyses were conducted at the Alpha Wildlife Research & Management laboratory in Sherwood Park, Alberta. Canid and American Badger scats were soaked overnight in a mild water-bleach solution, washed through a sieve, and oven-dried at 75°C (R. T. Golightly, Hum-

boldt State University, personal communication, 2008). Long-tailed Weasel scats were only washed and oven-dried. Red Fox, Coyote, American Badger, and Long-tailed Weasel scats were collected during surveys of Richardson's Ground Squirrel burrows across fields in Mankota, Hazenmore, and Ponteix. Red Fox scats were also collected at 16 maternal dens between Woodrow and Neville.

The analysis of hairs from scats first involved the examination of cuticular scales, which constitute the surface pattern of the hair. Scale casts were made by squeezing hair between a microscope slide with a fresh acetone smear and a clean slide for approximately one minute to obtain an impregnation of the hair surface pattern. A three-dimensional view of the hair surface was also obtained by wiping the hair with methyl salicylate (Fisher Scientific, Fair Lawn, New Jersey). Casts and hair were examined with a compound light microscope.

Hairs briefly soaked in methyl salicylate were examined under microscope to identify medulla configuration in the basal area (the area of the hair shaft containing the root end) and the shield (the widened, flattened area located at various positions on the hair shaft) and to note the absence or presence of strictures (Moore et al. 1974). The medulla is the central portion of hairs which corresponds to a series of discrete cells or an amorphous spongy mass. The cells may be cornified and shrunken, with intercellular spaces filled with air (as in unbroken with cortical intrusions) (Moore et al. 1974). A stricture is a narrow region of the hair located adjacent to the shield region. It may correspond to a pronounced reduction in the hair shaft diameter, a change in medulla configurations, a change in scale pattern, or a pronounced localized bending causing the hair to appear angular. Microscopic views of hair scales and medullas were photographed with a Fujifilm FinePix F550EXR digital camera (Fujifilm Corporation, Tokyo, Japan).

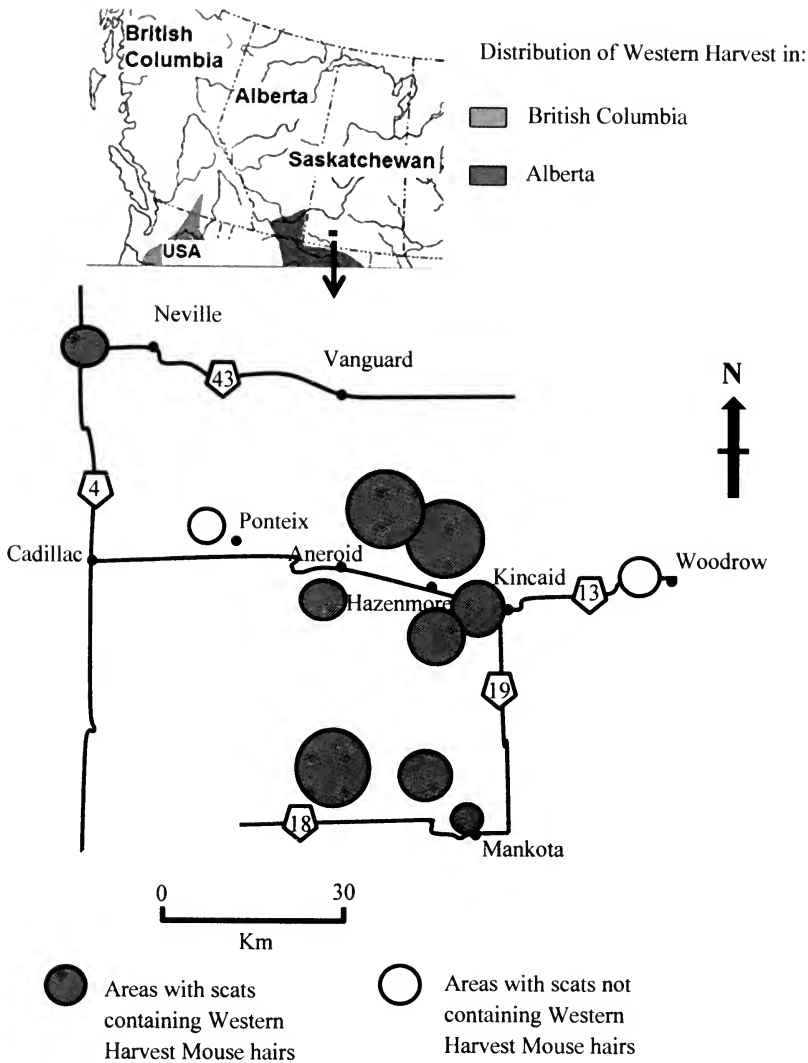
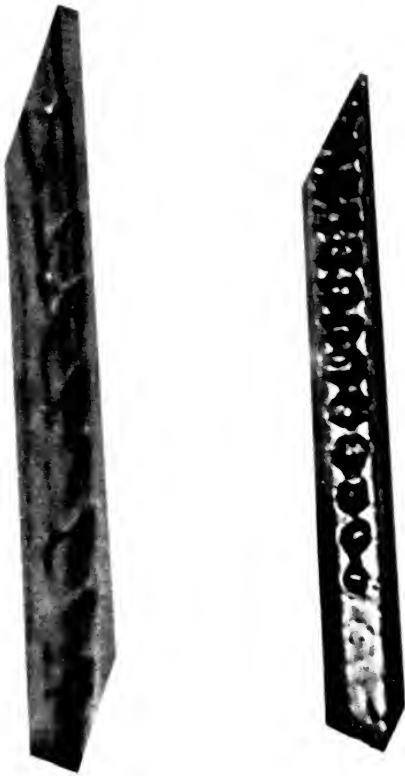


FIGURE 1. Distribution of the Western Harvest Mouse in British Columbia and Alberta (after COSEWIC 2007\*) and in the study area in southwestern Saskatchewan where carnivore scats with Western Harvest Mouse hairs were collected, spring and summer, 2008 to 2010.

The identification of the Western Harvest Mouse hairs from scats was done using three different approaches. Hairs were first examined with a microscope, identified using the keys in Moore et al. (1974), and compared to photographs in Moore et al. (1974) and in Debelica and Thies (2009). Secondly, hair scales and medulla were compared to those of ventral, dorsal, and neck hairs of a female Western Harvest Mouse captured in July 1994 at CFB Suffield (specimen no. 95.8.60, 50°17'N, 110°37'W, Royal Alberta Museum, Edmonton, Alberta). Finally, hairs were identified through an elimination process by comparing them to hairs of species with similar scales or medullas. These species

included the Olive-backed Pocket Mouse (*Perognathus fasciatus*) (Royal Alberta Museum male specimen no. 01.16.10, 50°47'N, 110°25'W), the Northern Grasshopper Mouse (*Onychomys leucogaster*) (Royal Alberta Museum female specimen no. 95.8.70, 50°19'N, 110°40'W), the Northern Pocket Gopher (*Thomomys talpoides*) (Royal Alberta Museum female specimen 95.8.70, 50°19'N, 110°40'W), and the Bushy-tailed Woodrat (*Neotoma cinerea*) (Royal Alberta Museum male specimen no. 04.12.1, 50°38'N, 110°11'W). It is noteworthy to mention that the Bushy-tailed Woodrat is not believed to be present in the southwestern Saskatchewan study area (Bowers et al. 2004), and the



## Petal scales      Basal medulla

FIGURE 2. Basal scales and medulla of Western Harvest Mouse hairs found in Red Fox scats, Hazenmore, 2010.

Northern Pocket Gopher is not well established in southwestern Saskatchewan (Provincial Council of Agriculture Development and Diversification Boards and the Sustainable Production Branch, Saskatchewan Agriculture and Food 2001\*). Also, using Proulx's (2002) criteria to recognize the burrow systems of the Northern Pocket Gopher, we failed to find signs of this species during three consecutive years.

A sample of Western Harvest Mouse hairs from a Red Fox scat collected in Hazenmore was deposited in the Royal Alberta Museum.

## Results

### Identification using keys

Hairs from scats had a shield medulla without a tiserial (columns of cells) or uniserial ladder. The basal medulla was partly uniserial ladder, and one subshield stricture was present. The shield medulla was unbroken with cortical intrusions. Some hair had a colour band; the upper shaft was dark. According to the key in Moore

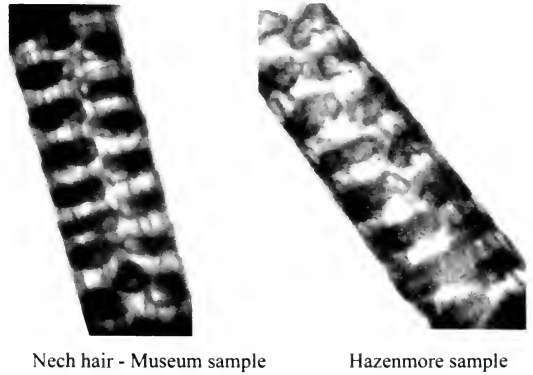


FIGURE 3. Western Harvest Mouse hair shield medullas with cortical intrusions occurring in aggregations of two across in female specimen no. 95.8.70 from the Royal Alberta Museum and in a hair from a Red Fox scat, Hazenmore, 2010.

et al. (1974) for "mammal orders and families", the hairs belonged to "rodents."

The basal medulla did not correspond to an unbroken lattice. A subshield stricture was present. Hairs were charcoal grey and <24 mm long. Basal scales were overlapping like flower petals (Figure 2). According to the key in Moore et al. (1974) for "rodents," the hairs belonged to "native rats and mice."

The basal medulla did not have aggregations of three intrusions across, but rather began as a uniserial ladder immediately becoming unbroken with single cortical intrusions (Figure 2). The shield medulla was unbroken, with cortical intrusions occurring in aggregations of two or three across. According to the key in Moore et al. (1974) for "native rats and mice," the hairs belonged to "mice." Some hair samples were black (although Western Harvest Mouse also has banded hairs) and had a subshield stricture. They were identified as Western Harvest Mouse hairs. Photographs of the basal scales and medullas of hairs from scats matched those of Western Harvest Mouse published by Moore et al. (1974) and Debelica and Thies (2009). For undisputable evidence, however, the hairs were compared to museum specimen hairs.

### Comparisons with museum specimen hairs

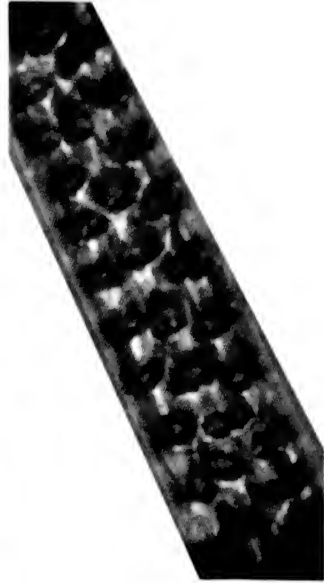
The hairs from scats had unbroken medullas with cortical intrusions in aggregations of two (Figure 3) and three (Figure 4) across that were identical to those of the hairs of the museum Western Harvest Mouse specimen. Their basal medullas also matched those of the hairs from the museum specimen (Figure 5). There is no doubt that the hairs from scats belonged to Western Harvest Mice.

### Elimination process

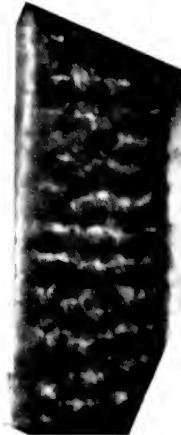
The basal medullas of Western Harvest Mouse hairs from scats differed markedly from those of species

## Museum samples

## Hazenmore samples



## Ventral hair



## Neck hair

FIGURE 4. Western Harvest Mouse hair shield medullas with cortical intrusions occurring in aggregations of three across in female specimen no. 95.8.70 from the Royal Alberta Museum and in a hair from a Red Fox scat, Hazenmore, 2010.

with basal or shield medullas with cortical intrusions (Figure 5). The basal medulla of the hairs has a uniserial ladder at the beginning which gradually becomes unbroken with cortical intrusions (Figure 5). In contrast, the basal medulla of the Bushy-tailed Woodrat hair is unbroken with cortical intrusions usually in aggrega-

tions of three across (Figure 5). The basal medulla of the Northern Grasshopper Mouse corresponds to a thick, uniserial ladder (Figure 5) followed by stout single intrusions. The basal medulla of the Northern Pocket Gopher is a uniserial ladder at the beginning which immediately becomes unbroken with single cortical



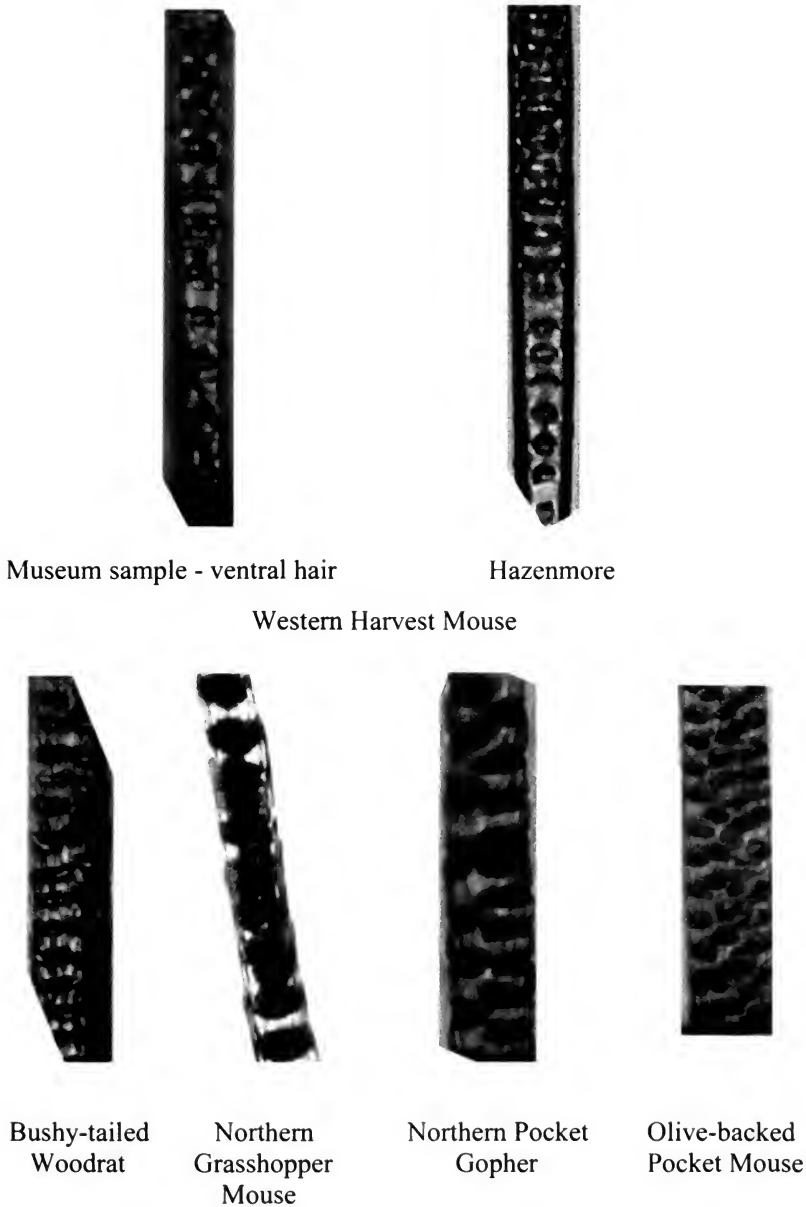


FIGURE 5. Basal medullas of Western Harvest Mouse hairs in female specimen no. 95.8.70 from the Royal Alberta Museum and in a hair from a Red Fox scat, Hazenmore, 2010, and in hairs from other rodents with similar hair characteristics: Bushy-tailed Woodrat (*Neotoma cinerea*), Royal Alberta Museum male specimen no. 04.12.1; Northern Grasshopper Mouse (*Onychomys leucogaster*), Royal Alberta Museum female specimen no. 95.8.70; Northern Pocket Gopher (*Thomomys talpoides*), Royal Alberta Museum female specimen 95.8.70; and Olive-backed Pocket Mouse (*Perognathus fasciatus*), Royal Alberta Museum male specimen no. 01.16.10.

intrusions distributed in a comb-like manner (Figure 5). The basal medulla of the Olive-backed Pocket Mouse is unbroken with cortical intrusions in aggregations of three or four across. It is noteworthy to mention that the

basal scales of the Olive-backed Pocket Mouse correspond to an irregular-waved mosaic with large lumpy scale edges on the hair surface that differ markedly from the basal scales of the Western Harvest Mouse.

TABLE 1. Number of Western Harvest Mouse (*Reithrodontomys megalotis*) hairs found in scats of Red Fox (*Vulpes vulpes*), Coyote (*Canis latrans*), American Badger (*Taxidea taxus*), and Long-tailed Weasel (*Mustela frenata*) collected in southwestern Saskatchewan in spring and summer 2008 to 2010, with frequency (%).

Period	Locations																							
	Kincaid		Mankota		Hazenmore		Aneroid		Ponteix		Vanguard		Woodrow		Neville									
	Hairs	Scats %	Hairs	Scats %	Hairs	Scats %	Hairs	Scats %	Hairs	Scats %	Hairs	Scats %	Hairs	Scats %	Hairs	Scats %								
2008	3	41	7.3	2	41	4.9	-	-	-	-	-	-	-	-	-	-	-							
2009	1	21	4.8	-	-	-	10	181	5.5	2	53	3.8	1	86	1.1	-	-							
2010	-	-	-	-	-	-	24	197	12.2	-	-	-	1	14	7.1	3	101	3.0						
Total	4	62	6.5	2	41	4.9	34	378	9.0	2	53	3.8	2	100	2.0	3	101	3.0						
Coyote																								
2008	-	-	-	3	22	13.6	0	21	0	-	-	-	0	7	0	-	-	-						
2009	-	-	-	-	-	-	5	59	8.5	-	-	-	-	-	-	-	-	-						
2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Total	-	-	-	3	22	13.6	5	80	6.3	-	-	-	0	7	0	-	-	-						
American Badger																								
2008	-	-	-	0	6	0	1	23	4.4	-	-	-	0	13	0	-	-	-						
2009	-	-	-	-	-	-	0	2	0	-	-	-	0	7	0	-	-	-						
2010	-	-	-	-	-	-	3	25	12.0	-	-	-	-	-	-	-	-	-						
Total	-	-	-	0	6	0	4	48	8.3	-	-	-	0	20	0	-	-	-						
Long-tailed Weasel																								
2008	-	-	-	0	30	0	0	12	0	-	-	-	3	159	1.9	-	-	-						
2009	-	-	-	-	-	-	0	11	0	-	-	-	1	6	16.7	-	-	-						
2010	-	-	-	-	-	-	7	258	2.7	-	-	-	-	-	-	-	-	-						
Total	-	-	-	0	30	0	7	281	2.5	-	-	-	4	165	2.4	-	-	-						
Grand total	4	62	6.5	5	99	5.0	50	787	6.3	2	53	3.8	6	292	2.0	3	101	3.0	0	16	0	1	14	7.1

### *Distribution and frequency of scats containing Western Harvest Mouse hairs*

Western Harvest Mouse hairs were found in 71 of 1424 scats (5%). Most Western Harvest Mouse hairs came from scats collected near Hazenmore, where a large number of scat samples were collected, but also from all surrounding areas except in two regions immediately west of Ponteix and Woodrow (Table 1). Western Harvest Mouse remains were relatively more frequent in scats of canids and the American Badger than in the scats of the Long-tailed Weasel (Table 1). Mesocarnivores, which have relatively larger home ranges, may find and consume more Western Harvest Mice. The presence of the Western Harvest Mouse was confirmed at the same latitude as populations reported in Alberta and British Columbia (Figure 1). Scats came mostly from dens and latrines located on abandoned estates and in or near fields with sand and sandy or clay loams with tall grass and shrubs.

### Discussion

This study showed that the Western Harvest Mouse is undoubtedly present in southwestern Saskatchewan. The identification of hairs from scats was thorough. The hairs matched the ventral, dorsal, and neck hairs of a museum specimen, and matches occurred at all levels, i.e., colour, shape, scales, and basal and shield medullas. Also, these hairs could not be confused with those of other species that have medullas with cortical intrusions.

This is the first time that the presence of the Western Harvest Mouse has been confirmed in Saskatchewan despite extensive efforts in the last 15 years to find it during small mammal capture programs and owl pellet studies (R. Poulin, Royal Saskatchewan Museum, personal communication, 2011). This shows that the analysis of carnivore scats is a valuable approach to determining the presence of a relatively rare rodent such as the Western Harvest Mouse in the prairies. This is particularly true when one considers that success in live-trapping Western Harvest Mice may vary considerably from year to year in areas where it is known to occur (Heske et al. 1984; Reynolds et al. 1999\*).

Sullivan and Sullivan (2008) suggested that the Western Harvest Mouse could persist among habitats of diverse quality through dispersal, which is generally <300 m (Clark et al. 1988; Skupski 1995). However, long-distance movements of 375–3200 m have been reported by Clark et al. (1988). In this study, Western Harvest Mouse hairs were found in scats that were collected at 15 different Red Fox dens, and in other locations that were usually less than 1 km apart from each other (Figure 1). Therefore, the Saskatchewan population should be ranked as S2S3 (imperiled to vulnerable, generally consisting of 6 to 100 occurrences) by the Nature Conservancy Data Centre, and it should be designated at least as special concern by COSEWIC, because the species is particularly sensitive to human

activities and natural events. Agricultural practices, including livestock grazing, are likely the greatest threats to the habitat of the Western Harvest Mouse, and the use of rodenticides is likely the greatest threat to the animals themselves (COSEWIC 2007\*; Proulx 2010, 2011).

The confirmed presence of the Western Harvest Mouse in southwestern Saskatchewan warrants further research to delineate the limits of its distribution, identify habitats, and assess the resilience and persistence of populations inhabiting unprotected, private landscapes, where grasslands are highly fragmented by agricultural activities.

### Acknowledgements

Scat analysis studies were funded by Advancing Canadian Agriculture & Agri-Food in Saskatchewan and Alberta, the Saskatchewan Ministry of Agriculture and Rural Development (Agriculture Development Fund), and the Saskatchewan Association of Rural Municipalities (SARM). We are grateful to Neil MacKenzie, Keith MacKenzie, Kara Walsh, Kim Stang, Jill Arnott, Jessy Dubnyk, and Christine Korol for their help in collecting scats. We thank researchers from Environment Canada for their support: Helen Trefry, for bringing to our attention the rare status of the Western Harvest Mouse in western Canada, and Greg Wilson, for providing us with Western Harvest Mouse hairs from CFB Suffield for preliminary comparisons. We are grateful to Bill Weimann, Assistant Curator of Mammals at the Royal Alberta Museum, for supplying hair samples of the Western Harvest Mouse and other rodent species from southern Alberta. We thank Tim Schowalter for reviewing preliminary microscopy photographs. Pauline Feldstein, Carolyn Callaghan, David Nagorsen, and three anonymous reviewers provided useful comments that greatly improved this manuscript.

### Documents Cited (marked \* in text)

- Committee on the Status of Endangered Wildlife in Canada (COSEWIC).** 2007. COSEWIC assessment and update status report on the Western Harvest Mouse *Reithrodontomys megalotis megalotis* and *Reithrodontomys megalotis dychei* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario.
- Proulx, G., N. MacKenzie, B. Proulx, K. MacKenzie, and K. Walsh.** 2009. Relationships among predators, prey and habitat use in southern Saskatchewan, 2008. Alpha Wildlife Research & Management Ltd. report submitted to Saskatchewan Agriculture Development Fund, Regina, Saskatchewan.
- Provincial Council of Agriculture Development and Diversity Boards, and Saskatchewan Agriculture and Food.** 2001. 2001 Saskatchewan "gopher" survey. Report of survey results to Provincial Council of Agriculture Development and Diversity Boards and the Sustainable Production Branch, Saskatchewan Agriculture and Food, Regina, Saskatchewan.
- Reynolds, H. W., S. J. Barry, and H. P. L. Kiliaan.** 1999. Small mammal component report. Canadian Forces Base

Suffield National Wildlife Area wildlife inventory. Unpublished report. Canadian Wildlife Service, Edmonton, Alberta.

### Literature Cited

- Bowers, N., R. Bowers, and K. Kaufman.** 2004. Kaufman Field Guide to Mammals of North America. Houghton Mifflin Company, New York, New York.
- Clark, B. K., D. W. Kaufman, G. A. Kaufman, E. J. Finck, and S. S. Hand.** 1988. Long-distance movements by *Reithrodontomys megalotis* in tallgrass prairie. *American Midland Naturalist* 120: 276–281.
- Debelica, A., and M. L. Thies.** 2009. Atlas and key to the hair of terrestrial Texas mammals. Special Publication of the Museum of Texas Tech University No. 55. Lubbock, Texas.
- Heske, E. J., R. S. Ostfeld, and W. Z. Lidicker, Jr.** 1984. Competitive interactions between *Microtus californicus* and *Reithrodontomys megalotis* during two peaks of *Microtus* abundance. *Journal of Mammalogy* 65: 271–280.
- Moore, T. D., L. E. Spence, and C. E. Dugnolle.** 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Bulletin No. 14, Wyoming Game and Fish Department, Cheyenne, Wyoming.
- Murie, O. J.** 1975. A field guide to animal tracks. Second edition. The Peterson Field Guide Series. Houghton Mifflin Company, Boston, Massachusetts.
- Nagorsen, D.** 1995. Status of the western harvest mouse in British Columbia. Wildlife Working Report No. WR-71. Ministry of Environment, Lands and Parks, Wildlife Branch, Victoria, British Columbia.
- Proulx, G.** 2002. The northern pocket gopher. I – Knowing the species. *Wildlife Control Technology* 9(1): 18–21.
- Proulx, G.** 2010. Factors contributing to the outbreak of Richardson's ground squirrel populations in the Canadian prairies. Pages 213–217 in *Proceedings of the 24th Vertebrate Pest Conference*, Sacramento, California, February 22–25, 2010. Edited by R. M. Timm and K. A. Fagerstone. University of California, Davis, Davis, California.
- Proulx, G.** 2011. Field evidence of non-target and secondary poisoning by strychnine and chlorophacinone used to control Richardson's Ground Squirrels in southwest Saskatchewan. Pages 128–134 in *Patterns of Change: Proceedings of the 9th Prairie Conservation and Endangered Species Conference*, February 2010. Edited by D. Danyluk. Critical Wildlife Habitat Program, Winnipeg, Manitoba.
- Proulx, G., and M. W. Barrett.** 1990. Assessment of power snares to effectively kill red fox. *Wildlife Society Bulletin* 18: 27–30.
- Proulx, G., and P. J. Cole.** 1998. Identification of northern pocket gopher, *Thomomys talpoides*, remains in long-tailed weasel, *Mustela frenata longicauda*, scats. *Canadian Field-Naturalist* 112: 345–346.
- Skupski, M. P.** 1995. Population ecology of the western harvest mouse, *Reithrodontomys megalotis*: a long-term perspective. *Journal of Mammalogy* 76: 358–367.
- Sullivan, T. P., and D. S. Sullivan.** 2008. Dynamics of peripheral populations of Great Basin Pocket Mice, *Perognathus parvus*, and Western Harvest Mice, *Reithrodontomys megalotis*, in southern British Columbia. *Canadian Field-Naturalist* 122: 345–356.

Received 11 August 2011

Accepted 3 March 2012

# Distribution and Relative Abundance of Richardson's Ground Squirrels, *Urocitellus richardsonii*, According to Soil Zones and Vegetation Height in Saskatchewan During a Drought Period

GILBERT PROULX, KEITH MACKENZIE, and NEIL MACKENZIE

Alpha Wildlife Research & Management Ltd., 229 Lilac Terrace, Sherwood Park, Alberta T8H 1W3 Canada

Proulx, Gilbert, Keith MacKenzie, and Neil MacKenzie. 2012. Distribution and relative abundance of Richardson's Ground Squirrels, *Urocitellus richardsonii*, according to soil zones and vegetation height in Saskatchewan during a drought period. *Canadian Field-Naturalist* 126(2): 103–110.

Richardson's Ground Squirrels (*Urocitellus richardsonii*) prefer to establish their burrow systems in fields with shorter vegetation and good visibility. Between 2001 and 2009, warm weather and low precipitation, creating ideal environmental conditions for this species, were common throughout Saskatchewan. We therefore hypothesized that Richardson's Ground Squirrels would be abundant throughout the agricultural region of the province and would be relatively more abundant in fields with shorter vegetation. In May and June 2008, we selected a total of 36 study plots of 0.49 ha each in 12 randomly selected rural municipalities in the Brown, Dark Brown, Black, and Gray soil zones. Using visual counts of Richardson's Ground Squirrels and counts of burrow entrances, we found that Richardson's Ground Squirrels were abundant across the agricultural region of the province, but densities of Richardson's Ground Squirrels and densities of burrow entrances were generally higher in the drier Brown soil zone than in the other soil zones. In 2009 and 2010, in a study of the effect of vegetation height on the abundance of Richardson's Ground Squirrels in the Brown soil zone, we found that densities of burrow entrances in five study plots with vegetation  $\geq 15$  cm in height were significantly ( $P < 0.05$ ) lower than densities recorded in five adjacent study plots with vegetation  $< 15$  cm in height. Our findings warrant more studies on Richardson's Ground Squirrels inhabiting fields with short and tall vegetation to determine whether differences in population densities are due to differences in birth and death rates or immigration and emigration.

Key Words: Richardson's Ground Squirrel, *Urocitellus richardsonii*, *Spermophilus richardsonii*, distribution, drought, Saskatchewan.

Drought is a chronic concern in the Canadian prairies (Liu et al. 2004), and, according to Phillips (2002), it had never been as serious or extensive as in 2001. Drought depresses plant growth (Heath et al. 1973; Glickman 2000) and creates ideal conditions for Richardson's Ground Squirrels (*Urocitellus richardsonii*, changed from *Spermophilus richardsonii* on the basis of craniometric analyses by Helgen et al. 2009), which prefer to establish their burrow systems in fields with shorter vegetation and good visibility (Yensen and Sherman 2003).

Across the prairies, soil zones are classified as Brown, Dark Brown, or Black according to the type of chernozemic soils dominating the particular zone (Figure 1), i.e., the amount of soil organic matter content and color of the surface soil horizons (Pennock 2005\*; Fuller 2010). In the northern regions, soils that have somewhat lighter-coloured surface horizons than the Black soils are classified as Gray (Figure 1), and are characteristic of soils developed in a transitional environment between grassland and forest (Pennock 2005\*). On the basis of telephone interviews, the Provincial Council of Agriculture Development and Diversification Boards and the Sustainable Production Branch, Saskatchewan Agriculture and Food (2001\*) concluded that soil zones have a bearing on the distribution of Richardson's Ground Squirrels in the province: Richardson's Ground Squirrels were more common in the Brown and Black soil

zones, and they were less frequent in the Dark Brown and Gray soil zones.

It appears that vegetation height can also have an impact on the density of Richardson's Ground Squirrels. In Alberta, Downey et al. (2006) found that Richardson's Ground Squirrels avoided pastures with grass  $> 30$  cm in height.

The first objective of this study was to determine the distribution of Richardson's Ground Squirrel populations across the soil zones of Saskatchewan during a drought period and the relative density of each population. Since warm weather and low precipitation were common throughout Saskatchewan from 2001 to 2009 (Proulx 2010), we expected that vegetation would be short in grasslands and pastures in all soil zones and we hypothesized that Richardson's Ground Squirrels would be abundant throughout the agricultural region of the province. The second objective was to correlate the relative densities of Richardson's Ground Squirrels in fields with different vegetation heights within a single soil zone. We hypothesized that Richardson's Ground Squirrels would be relatively more abundant in fields with shorter vegetation.

## Study Area

The study of Richardson's Ground Squirrel populations was conducted in the diverse soil zones of the province's agricultural region, which is primarily found

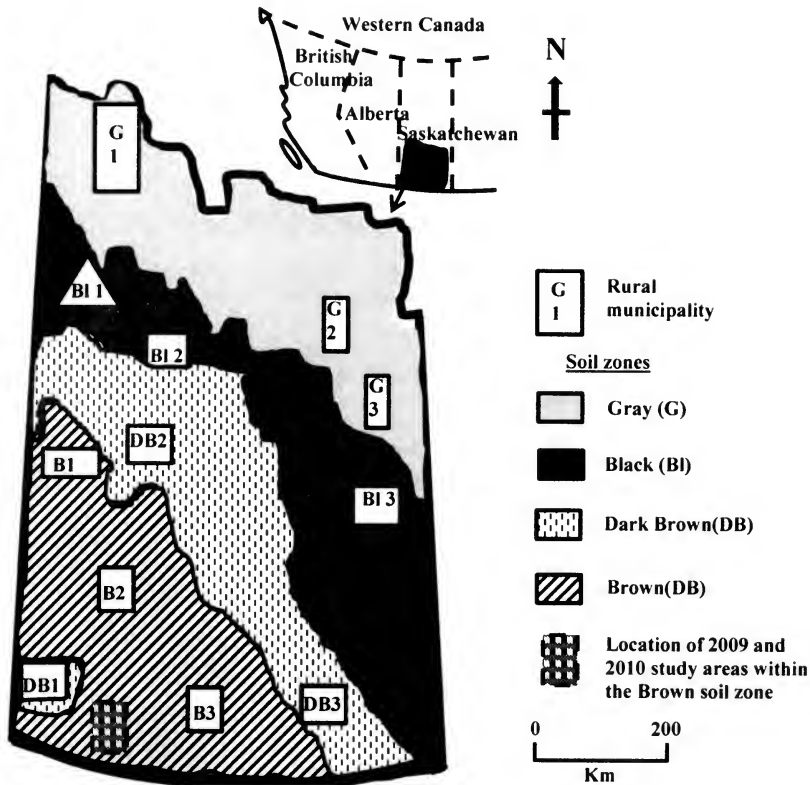


FIGURE 1. Location of study areas in 2008, 2009 and 2010 in Saskatchewan.

south of 54°N and is confined to 265 691 km<sup>2</sup>, or 40.8% of the land mass of Saskatchewan (Harrison 2000\*). We conducted our study in four soil zones (Figure 1), from the southernmost Brown soil zone, with warm temperatures, lack of moisture, and lack of organic matter, to the most intensively cultivated Dark Brown soil zone, the productive Black soil zone with high moisture levels, and the cooler Gray soil zone (including gray-wooded soils) with a shorter growing season (Harrison 2000\*).

There were insufficient data in 2008 to allow a thorough assessment of the impact of vegetation height on Richardson's Ground Squirrel population densities. This assessment was therefore continued in 2009 and 2010, within the Brown soil zone only, in grasslands near the towns of Kincaid, Hazenmore, Aneroid, Ponteix, and Cadillac, in southwestern Saskatchewan (Figure 1).

Study plots corresponded to mixed grasslands of Crested Wheatgrass (*Agropyron cristatum*), brome (*Bromus* spp.), Slender Wheatgrass (*Elymus trachycaulus*), and alfalfa (*Medicago* spp.). Vegetation  $\geq 15$  cm in height interferes with the sight lines of Richardson's Ground Squirrels walking or feeding on the surface (Proulx, unpublished data). We therefore located study areas in grasslands with short (on average,  $< 15$  cm

and tall (on average,  $\geq 15$  cm) vegetation that were adjacent to each other, i.e., with borders touching each other or separated by a gravel road within the same quarter section. Grasslands with tall vegetation had not been grazed for more than two years, except in Aneroid, where the grassland was subject to short periods (i.e., seven days) of rotational grazing, but vegetation was always  $\geq 15$  cm high.

## Methods

### *Distribution of Richardson's Ground Squirrels according to soil zone*

Between 17 May and 15 June 2008, we investigated the distribution and abundance of Richardson's Ground Squirrels. Twelve rural municipalities were randomly selected for field investigations in the four soil zones (Figure 1): three in the Brown soil zone, three in the Dark Brown soil zone, three in the Black soil zone, and three in the Gray soil zone. Since Richardson's Ground Squirrels are more frequent in forage fields and pastures (Provincial Council of Agriculture Development and Diversification Boards and Saskatchewan Agriculture and Food 2001\*), we selected three hayfields or pastures in each rural municipality where farmers had complained to local administrators about high densities of Richardson's Ground Squirrels. In each field, we estab-

lished one study plot of 70 m × 70 m (0.49 ha) in the southwest corner. In total, 36 study plots (9 per soil zone) were inventoried.

We determined relative densities of Richardson's Ground Squirrels with visual counts, i.e., using binoculars, we recorded the number of adult Richardson's Ground Squirrels in each study plot in three scans of 3 minutes each separated by an interval of 5 minutes (Bourne et al. 2002; Johnson-Nistler et al. 2005). We initiated surveys after sunrise and completed them before 1000 hours every morning. To minimize the number of variables affecting counts, the same observer, situated approximately 25 m from the border of the study plot, conducted all the scans. The scans were conducted under similar environmental conditions from day to day to avoid a variation in Richardson's Ground Squirrel activity associated with weather (Bourne et al. 2002). For each study plot, we retained the highest number of Richardson's Ground Squirrels counted among the three scans (Fagerstone 1984).

We also counted the number of Richardson's Ground Squirrel burrow entrances located within 30 cm of each side of the perimeter of the study plots. Only entrances that were well opened and without collapsed dirt or vegetation growing in the entrance were counted (Schmutz and Hungle 1989; Finger et al. 2007\*). Therefore, for each study plot, we tallied burrow entrances along a transect 280 m in length.

#### *Densities of Richardson's Ground Squirrel burrow entrances according to vegetation height*

We carried out field investigations from 5 to 20 May 2009, when all adult Richardson's Ground Squirrels had emerged and most juveniles had not yet emerged, and from 15 to 28 May 2010, when all adults and many juveniles were active above ground. We selected five study areas where grasslands with short and tall vegetation were adjacent to each other. We used the average of 15 measurements taken randomly across grasslands to classify the vegetation as short (<15 cm) or tall (≥15 cm). We established three study plots of 0.49 ha each in each grassland. The study plots were equidistant from each other and from the border of the grassland; they were >10 m from the borders of the grassland, and each study plot was ≥10 m from the other two study plots.

Because we were able to establish a strong correlation between visual counts of Richardson's Ground Squirrels and counts of burrow entrances in the study, we proceeded to compare the density of Richardson's Ground Squirrels among grasslands with the number of burrow entrances/0.49 ha. Burrow entrances were inventoried by five people walking 5 m abreast up and down study plots. For each grassland, we averaged the number of burrow entrances in the three study plots.

#### *Data analyses*

We used analyses of variance followed by a Tukey's honestly significant difference test to compare mean

densities of Richardson's Ground Squirrels and burrow entrances between soil zones (Zar 1999). For 2008, because of the small number of study plots with vegetation ≥15 cm high, the sole influence of vegetation height, i.e., without the influence of soil, on the abundance of Richardson's Ground Squirrels could not be determined. Independent of the soil zone, the mean density of burrow entrances in grasslands with vegetation <15 cm high was compared to the mean density of burrow entrances in grasslands with vegetation ≥15 cm high with a Student *t*-test (Dixon and Massey 1969).

For 2009 and 2010, we also compared the mean densities of Richardson's Ground Squirrel burrow entrances/0.49 ha in grasslands with short vegetation and grasslands with tall vegetation. However, field observations indicated that Richardson's Ground Squirrel population densities varied considerably within the Brown soil zone, i.e., a low density of Richardson's Ground Squirrels within one quarter section can be considered high in another one (Proulx, unpublished data). For this reason, paired sample *t*-tests were also used to compare the mean densities of Richardson's Ground Squirrel burrow entrances/0.49 ha in adjacent grasslands with short and tall vegetation (Zar 1999). Each datum in a study plot with short vegetation was correlated with only one datum in a study plot with tall vegetation.

Simple linear regression models were used to determine the relationship between counts of burrow entrances and visual counts of Richardson's Ground Squirrels, and between counts of burrow entrances and vegetation height. Probability values  $P \leq 0.05$  were considered significantly different.

## Results

### *Distribution of Richardson's Ground Squirrels according to soil zone*

The average number of Richardson's Ground Squirrels/0.49 ha differed significantly ( $F_{3,32} = 4.02$ ,  $P < 0.05$ ) among soil zones. Average densities of Richardson's Ground Squirrels were similar ( $P > 0.05$ ) in the Brown and Black soil zones (Figure 2). However, the average number of Richardson's Ground Squirrels/0.49 ha in the Brown soil zone was significantly ( $P < 0.05$ ) higher than in the Gray and Dark Brown soil zones. There was no significant difference ( $P > 0.05$ ) between the average numbers of Richardson's Ground Squirrels/0.49 ha in the Black, Gray, and Dark Brown soil zones (Figure 2).

The average number of Richardson's Ground Squirrel burrow entrances/280 m of transect differed significantly ( $F_{3,32} = 3.3$ ,  $P < 0.05$ ) among soil zones. The mean number of entrances was significantly ( $P < 0.05$ ) greater in the Brown soil zone than in the other soil zones (Figure 3). The mean number of entrances was also significantly ( $P < 0.05$ ) greater in the Black soil zone than in the Gray soil zone. The mean number of entrances/280 m of transect in the Dark Brown soil

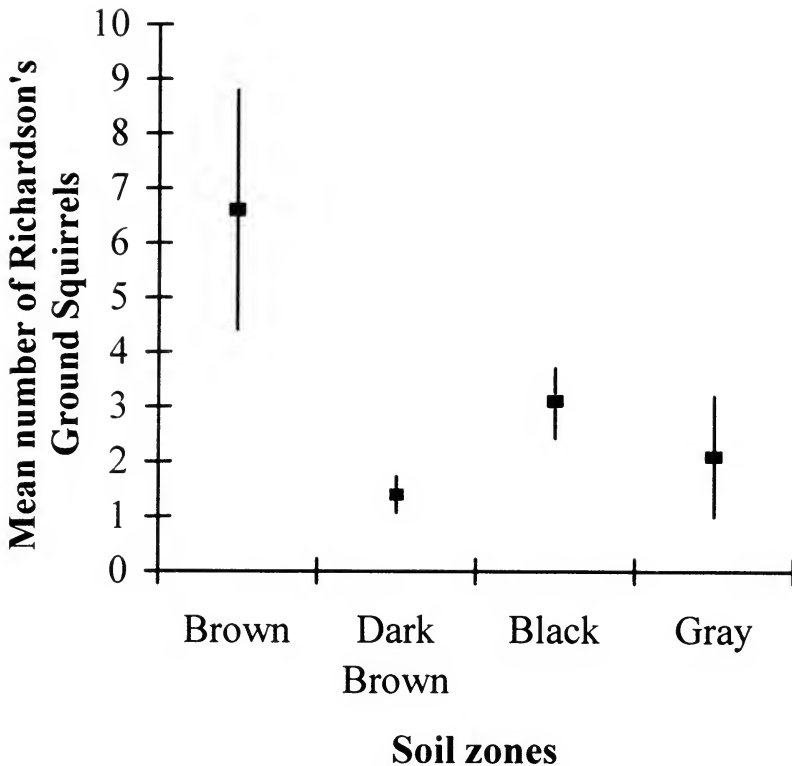


FIGURE 2. Mean number (bars indicate the standard error) ( $n = 9$  study plots/soil zone) of adult Richardson's Ground Squirrels/0.49 ha study plot, in four soil zones of Saskatchewan, spring 2008.

zone was similar ( $P > 0.05$ ) to those in the Black and Gray soil zones (Figure 3).

A significant linear ( $n = 36$ ,  $r = 0.93$ ,  $P < 0.001$ ; statistical power: 1.0) relationship ( $y = 3.680 + 4.021x$ ;  $r^2 = 0.86$ ) existed between visual counts of Richardson's Ground Squirrels and counts of burrow entrances (Figure 4).

#### *Visual and burrow entrance counts vs. vegetation height in 2008*

Seven study plots had a vegetation height  $\geq 15$  cm: 2 in the Brown soil zone, 4 in the Dark Brown soil zone, and 1 in the Black soil zone. The other 29 study plots in the four soil zones had a vegetation height  $< 15$  cm. The average number of Richardson's Ground Squirrels/study plot with vegetation  $\geq 15$  cm high ( $\bar{x} = 1.1$  animals, SD 1.1) was significantly ( $t = 3.11$ ,  $P < 0.005$ ) smaller than that of study plots with vegetation  $< 15$  cm high ( $\bar{x} = 3.8$  animals, SD 4.1). The average number of Richardson's Ground Squirrel burrow entrances/280 m of transect in study plots with vegetation  $\geq 15$  cm high ( $\bar{x} = 9.1$  entrances, SD 6.7) was significantly ( $t = 2.36$ ,  $P < 0.05$ ) smaller than in study plots with vegetation  $< 15$  cm high ( $\bar{x} = 18.9$  entrances, SD 17.7).

#### *Burrow entrance counts vs. vegetation height in 2009 and 2010*

On average, the number of Richardson Ground Squirrel burrow entrances/0.49 ha was significantly higher in grasslands with vegetation  $< 15$  cm high ( $n = 5$ ,  $\bar{X} = 243.7$  entrances, SD 104.6) than in grasslands with vegetation  $\geq 15$  cm high ( $n = 5$ ,  $\bar{X} = 95.9$  entrances, SD 69.2). Within paired study plots, the mean density of Richardson's Ground Squirrel burrow entrances was consistently larger (1.5 to 7 times) in short vegetation (Table 1). There was a significant mean difference ( $n = 5$ ,  $\bar{X} = 147.8$ , SE 34.4) between the paired densities of Richardson's Ground Squirrel burrow entrances in study plots with short vegetation and in study plots with tall vegetation ( $t = 4.4$ ,  $P < 0.005$ ). A significant linear ( $n = 10$ ,  $r = 0.7$ ,  $P < 0.05$ ; statistical power: 0.65) relationship ( $y = 294.9 - 6.7x$ ;  $r^2 = 0.49$ ) existed between burrow entrance counts and vegetation height (Figure 5).

#### **Discussion**

Short vegetation was found across the agricultural region of Saskatchewan, and Richardson's Ground Squirrel populations were found in all soil zones. How-



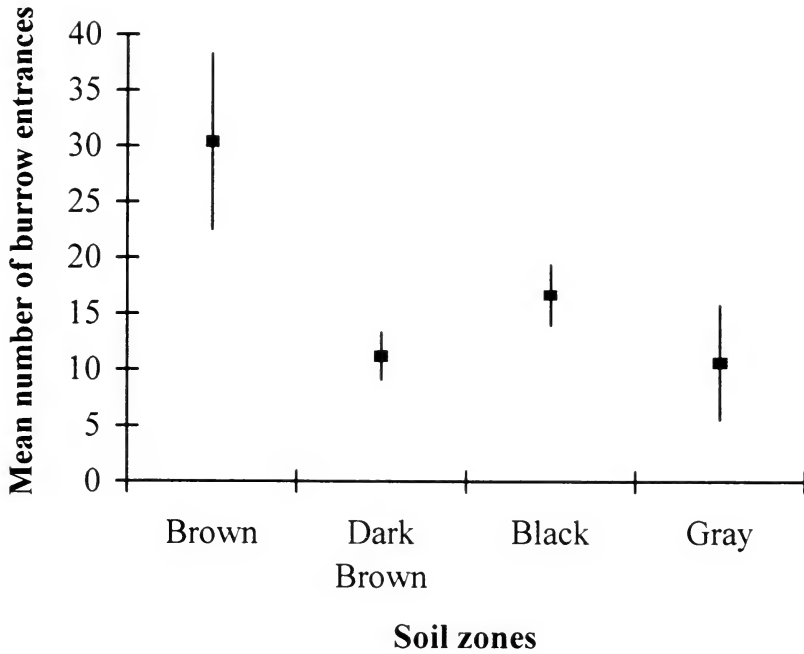


FIGURE 3. Mean number (bars indicate the standard error) ( $n = 9$  study plots/soil zone) of Richardson's Ground Squirrel burrow entrances/280 m of survey transect, in four soil zones of Saskatchewan, spring 2008.

ever, our findings suggest that Richardson's Ground Squirrels were more abundant in the Brown and Black soil zones, particularly in the former. Our findings relate to a short time period within the drought period, which lasted from 2001 to 2009 (Proulx 2010). Therefore, the distribution and abundance of Richardson's Ground Squirrels across the agricultural region could be different under different environmental conditions. Nevertheless, our findings are in agreement with the findings of the Provincial Council of Agriculture Development and Diversification Boards and Saskatchewan Agriculture and Food (2001\*). The abundance of Richardson's Ground Squirrels in the Brown soil zone is well known (Wilk and Hartley 2008\*) and has been consistently associated with the characteristic drought periods of the prairies (Isern 1988).

Our field observations from 2008 suggested a difference in the densities of Richardson's Ground Squirrels associated with vegetation height, i.e., lower densities when vegetation height was  $\geq 15$  cm. It could be argued that it was more difficult to detect Richardson's Ground Squirrels in fields with tall vegetation than in fields with shorter vegetation, but burrow entrance counts supported our visual counts. Because many factors have an impact on Richardson's Ground Squirrel population densities within a single soil zone, namely predation (Proulx and MacKenzie 2012) and agricultural practices (Proulx 2010; Proulx et al. 2010), vege-

tation height explained only 50% of the total variation in the relative density of Richardson's Ground Squirrel burrow entrances. Therefore, pairing adjacent fields with different vegetation heights was necessary to assess the impact of vegetation height on local populations that are subject to similar environmental conditions.

When vegetation is taller, Richardson's Ground Squirrel populations may not disappear, but their densities are significantly lower. Although the densities of burrow entrances recorded in study plots are not absolute estimates of Richardson's Ground Squirrel population densities (e.g., Van Horne et al. 1997), our analyses suggest that there is a positive relationship between the number of burrow entrances and the number of animals. Even with a maximum ratio of 10 burrow entrances per individual Richardson's Ground Squirrel (Berentsen and Salmon 2001; Michener 2007\*), an average difference of 148 burrow entrances/0.49 ha between study plots with low and high vegetation would imply a much higher level of occupancy by Richardson's Ground Squirrels in quarter sections (160 ha) with vegetation  $< 15$  cm high.

Persistence of burrow entrances from the previous year could lead to an overestimation of densities (Van Horne et al. 1997). On the other hand, since all the study plots were located in the same quarter sections and were subject to similar environmental conditions, the relative persistence of entrances would be similar

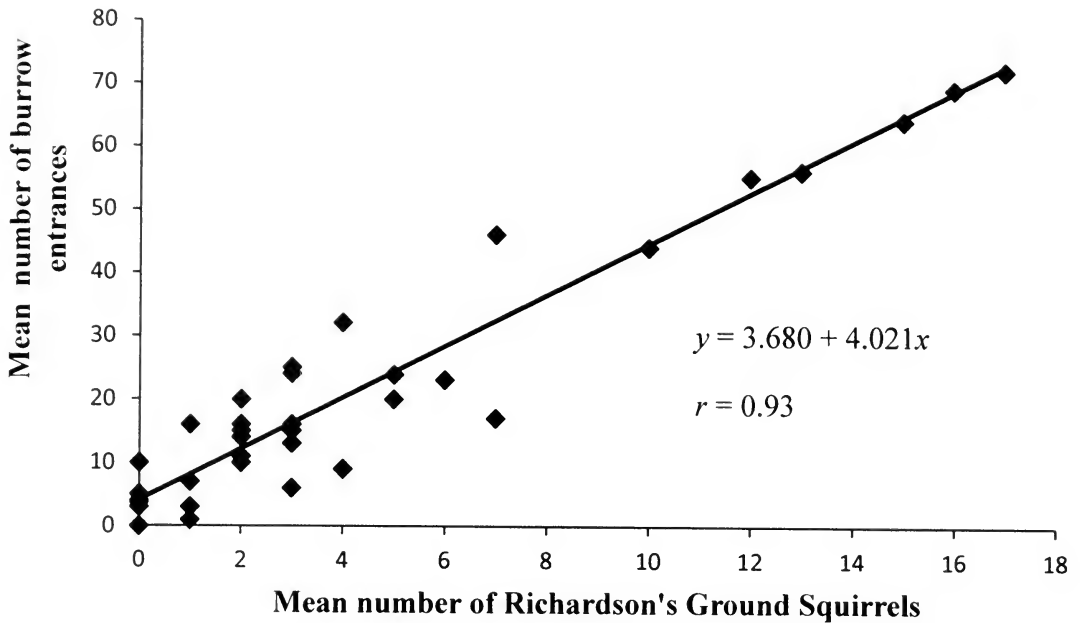


FIGURE 4. Linear regression between the mean number of Richardson's Ground Squirrel burrow entrances/280 m of transect and the mean number of adult Richardson's Ground Squirrels/0.49 ha study plot in the agricultural region of Saskatchewan, spring 2008.

among study plots. Contrary to other studies (e.g., Van Horne et al. 1997), the burrow entrances of Richardson's Ground Squirrels in our study area could be reliably distinguished from those used by other small mammals, because there were no other species that would dig burrow entrances similar to those of the Richardson's Ground Squirrel. In 2009, our surveys missed the peak of juvenile activity and the resulting increase in the digging of burrow entrances. In 2010, the increase in burrow entrances likely reflected the presence of juveniles, but such an increase would have occurred proportionally with the original breeding population of all study plots.

Richardson's Ground Squirrels prefer fields with shorter vegetation and good visibility (Yensen and Sher-

man 2003), and dry soil types are associated with poor vegetation growth (Heath et al. 1973). It is therefore not surprising that Richardson's Ground Squirrels were more abundant in the relatively drier Brown soil zone, particularly in fields with vegetation <15 cm high. However, our findings warrant more studies on Richardson's Ground Squirrels that inhabit fields with short and tall vegetation to determine whether differences in population densities are due to differences in birth and death rates or immigration and emigration.

**Acknowledgements**

We thank the Saskatchewan Ministry of Agriculture (Agriculture Development Fund) for funding the study on the distribution of Richardson's Ground Squirrels in

TABLE 1. Density of Richardson's Ground Squirrel burrow entrances/0.49 ha in grasslands with short vegetation (<15 cm) (n = 15) and tall vegetation (≥15 cm) (n = 15), southwestern Saskatchewan, May 2009 and 2010. Standard deviation in parentheses.

Location of grasslands	Study plots				Difference (d) between mean densities of burrow entrances ± standard error
	Short vegetation		Tall vegetation		
	Mean vegetation height (cm)	Mean number of burrow entrances	Mean vegetation height (cm)	Mean number of burrow entrances	
Ponteix	7.1 (1.3)	395 (109.1)	15.1 (2.4)	173.0 (61.7)	222
Aneroid	7.3 (1.2)	197.7 (72.00)	24.5 (5.1)	53.7 (24.9)	144
Hazenmore	7.6 (2.3)	252 (28.6)	37.1 (4.2)	169.7 (38.2)	82.3
Kindaid III	12.9 (4.1)	108.7 (52.2)	30.4 (8.9)	46.7 (30.5)	62
Cadillac	9.7 (3.7)	265 (75.7)	35 (10.4)	36.3 (9.1)	228.7
Grand mean		243.7 (104.6)		95.9 (69.2)	147.8 ± 34.4

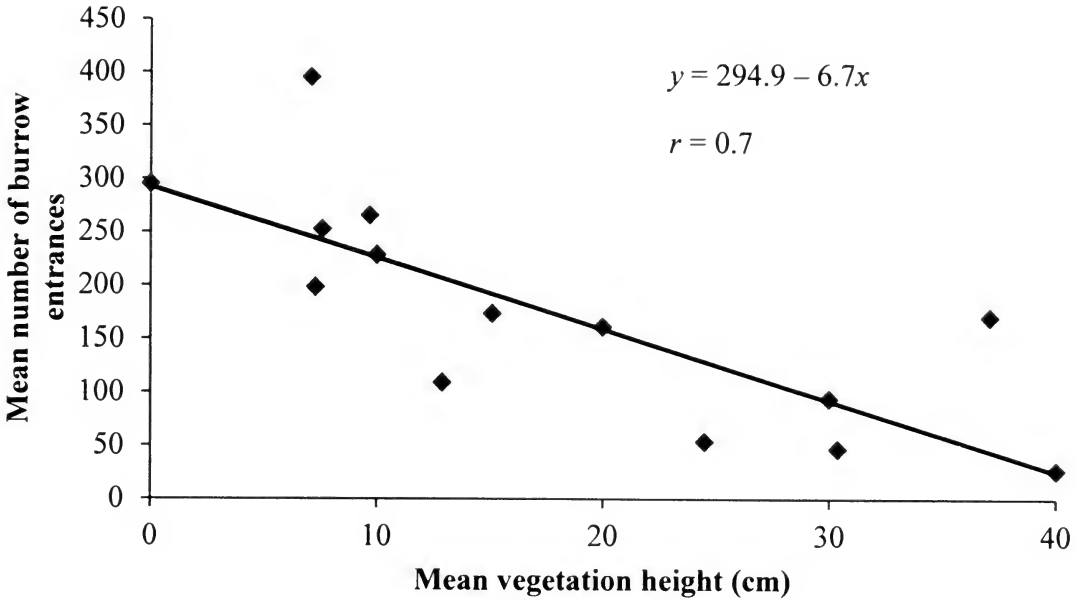


FIGURE 5. Linear regression between the mean number of Richardson's Ground Squirrel burrow entrances/0.49 ha study plot and vegetation height in grasslands of the Brown soil zone of Saskatchewan, May 2009 and 2010.

the agricultural region. Funding for the assessment of the effect of vegetation height on Richardson's Ground Squirrel populations in 2009 was provided by Advancing Canadian Agriculture and Agri-Food in Saskatchewan (as a Collective Outcome Project with Advancing Canadian Agriculture and Agri-Food in Alberta), the Saskatchewan Agriculture Development Fund, and the Saskatchewan Association of Rural Municipalities. Alpha Wildlife Research & Management Ltd. provided funding in 2010. We thank the administrators of the Rural Municipalities of Stonehenge, Saskatchewan Landing, Kindersley, Lomond, Maple Creek, Harris, Orkney, Great Bend, Paynton, Preeceville, Bjorkdale, and Meadow Lake for facilitating research logistics in their region. We are grateful to the following producers for allowing us to survey their property: O. Balas, R. and N. Bryan, C. and J. Flath, L. Ferguson, G. and M. McKeith, B. McKen, D. and H. MacMillan, W. Masley, M. McLeod, C. McFarlane, S. Near, A. and K. Russell, K. and C. Schuweiler, F. Therrien, and S. Vance. We thank Benjamin Proulx, Kim Stang, Jill Arnott, Christine Korol, and Jessy Dubnyk for technical help. Finally, we thank Pauline Feldstein, Alpha Wildlife Research & Management Ltd., for reviewing an earlier version of this manuscript.

**Documents Cited** (marked \* in text)

Finger, R., G. J. Wiles, J. Tabor, and E. Cummins. 2007. Washington ground squirrel surveys in Adams, Douglas, and Grant counties. Washington, 2004. Washington Department of Fish and Wildlife, Olympia, Washington.

Harrison, D. 2000. Saskatchewan. Bi-weekly Bulletin (Agriculture and Agri-Food Canada) 13 (15): 1-6.

Michener, G. R. 2007. Burrow system of Richardson's Ground Squirrels (also known as gophers). In Richardson's Ground Squirrels (also known as gophers). By G. R. Michener. University of Lethbridge, Lethbridge, Alberta. <http://research.uleth.ca/rgs/burrow.cfm>.

Pennock, D. 2005. Field handbook of Saskatchewan soils. By D. Pennock, University of Saskatchewan, Saskatoon. [http://www.usask.ca/saskatoon2010/Saskatoon2010/Soil\\_Judging\\_Manual\\_files/Field%20Handbook%20for%20Saskatchewan%20Soils%20\(Pennock,%202005\).pdf](http://www.usask.ca/saskatoon2010/Saskatoon2010/Soil_Judging_Manual_files/Field%20Handbook%20for%20Saskatchewan%20Soils%20(Pennock,%202005).pdf)

Provincial Council of Agriculture Development and Diversity Boards and Saskatchewan Agriculture and Food. 2001. 2001 Saskatchewan "gopher" survey. Report of survey results to Provincial Council of Agriculture Development and Diversity Boards and the Sustainable Production Branch, Saskatchewan Agriculture and Food, Regina, Saskatchewan.

Wilk, C., and S. Hartley. 2008. Management of Richardson's ground squirrel. *Agriview* 4(2): 7.

**Literature Cited**

Berentsen, A. R., and T. P. Salmon. 2001. The structure of California ground squirrel burrows: control implications. *Transactions of the Western Section of the Wildlife Society* 37: 66-70.

Bourne, J. B., L. D. Roy, M. Hiltz, P. N. Merrill, and W. Hoffman. 2002. Strychnine baits to control Richardson's ground squirrels: an old story, a new twist. *Proceedings of the Vertebrate Pest Conference* 20: 11-16.

Dixon, W. J., and F. J. Massey, Jr. 1969. Introduction to statistical analysis. McGraw-Hill Book Company, New York, New York.

- Downey, B. A., P. F. Jones, R. W. Quinlan, and G. J. Scrimgeour. 2006. Use of playback alarm calls to detect and quantify habitat use by Richardson's ground squirrels. *Wildlife Society Bulletin* 34: 480–484.
- Fagerstone, K. A. 1984. An evaluation of visual counts for censusing ground squirrels. Pages 239–246 in *Vertebrate Pest Control and Management Materials: Fourth Symposium*. Edited by D. E. Kaukiainen. ASTM STP 817, American Society for Testing and Materials, Philadelphia, Pennsylvania.
- Fuller, L. 2010. Chernozemic soils of the Prairie Region of western Canada. *Prairie Soils & Crops Journal* 3: 37–45.
- Glickman T. S., *Editor*. 2000. *Glossary of Meteorology*. Second edition. American Meteorological Society, Boston, Massachusetts.
- Heath, M. E., D. S. Metcalf, and R. F. Barnes, *Editors*. 1973. *Forages: the science of grassland agriculture*. Third edition. Iowa State University Press, Ames, Iowa.
- Helgen, K. M., F. R. Cole, L. E. Helgen, and D. E. Wilson. 2009. Generic revision in the Holarctic ground squirrel genus *Spermophilus*. *Journal of Mammalogy* 90: 270–305.
- Isern, T. D. 1988. Gopher tales: a study in western Canadian pest control. *Agricultural History Review* 36(2): 188–198.
- Johnson-Nistler, C. M., J. E. Knight, and S. D. Cash. 2005. Considerations related to Richardson's ground squirrel (*Spermophilus richardsonii*) control in Montana. *Agronomy Journal* 97: 1460–1464.
- Liu, J., R. E. Stewart, and K. Szeto. 2004. Moisture transport and other hydrometeorological features associated with the severe 2000/01 drought over the western and central Canadian prairies. *American Meteorological Society* 17: 305–319.
- Phillips, D. W. 2002. The top ten Canadian weather stories for 2001. *CMOS Bulletin* 30: 19–23.
- Proulx, G. 2010. Factors contributing to the outbreak of Richardson's ground squirrel populations in the Canadian prairies. Pages 213–217 in *Proceedings of the 24th Vertebrate Pest Conference*, Sacramento, California, February 22–25, 2010. Edited by R. M. Timm and K. A. Fagerstone. University of California, Davis, Davis, California.
- Proulx, G., and N. MacKenzie. 2012. Relative abundance of American badger (*Taxidea taxus*) and red fox (*Vulpes vulpes*) in two landscapes with high and low rodenticide poisoning levels. *Integrative Zoology* 7: 41–47.
- Proulx, G., N. MacKenzie, K. MacKenzie, K. Walsh, B. Proulx, and K. Stang. 2010. Strychnine for the control of Richardson's ground squirrels: efficiency and selectivity issues. Pages 125–128 in *the Proceedings of the 24th Vertebrate Pest Conference*, Sacramento, California, February 22–25, 2010. Edited by R. M. Timm and K. A. Fagerstone. University of California, Davis, Davis, California.
- Schmutz, J. K., and D. J. Hungle. 1989. Populations of ferruginous and Swainson's hawks increase in synchrony with ground squirrels. *Canadian Journal of Zoology* 67: 2596–2601.
- Van Horne, B., R. L. Schooley, S. T. Knick, G. S. Olson, and K. P. Burnham. 1997. Use of burrow entrances to indicate densities of Townsend's ground squirrels. *Journal of Wildlife Management* 61: 92–101.
- Yensen, G. E., and P. W. Sherman. 2003. Ground squirrels: *Spermophilus* and *Amnospermophilus* species. Pages 211–231 in *Wild mammals of North America: Biology, Management, and Conservation*. Edited by G. A. Feldhamer, B. C. Thompson, and J. A. Chapman. Johns Hopkins University Press, Baltimore, Maryland.
- Zar, J. H. 1999. *Biostatistical Analysis*. Fourth edition. Prentice Hall International, Upper Saddle River, New Jersey.

Received 6 October 2011

Accepted 17 March 2012

# Trends and Fluctuations in Bird Populations on the Tundra at Cambridge Bay, Nunavut

C. MARTIN LOK<sup>1</sup> and JAAP A. J. VINK<sup>2</sup>

<sup>1</sup> Vliegenvangerlaan 12, 2566 RN, The Hague, The Netherlands

<sup>2</sup> Tolhuislaan 8A, 3735 KG, Bosch en Duin, The Netherlands

Lok, C. Martin, and Jaap A. J. Vink. 2012. Trends and fluctuations in bird populations on the tundra at Cambridge Bay, Nunavut. *Canadian Field-Naturalist* 126(2): 111–116.

Bird observations from the Cambridge Bay area on Victoria Island, Nunavut, in the summer of 2011 are presented and compared with those from the 1960s and 1980s. A total of 38 species was observed, compared with 42 in 1983 and 47 in 1986. Abundance of species of the High Arctic, such as Black Brant, *Branta bernicla nigricans*, Black-bellied Plover, *Pluvialis squatarola*, and Baird's Sandpiper, *Calidris bairdii*, decreased, whereas numbers of the Red-necked Phalarope, *Phalaropus lobatus*, usually associated with the Low Arctic, increased markedly. Overall, the number of each species observed is rather stable and, for several species, the relative abundance does not seem to have changed significantly.

**Key Words:** Black Brant, *Branta bernicla nigricans*, Black-bellied Plover, *Pluvialis squatarola*, Red-necked Phalarope, *Phalaropus lobatus*, High Arctic, Low Arctic, Cambridge Bay, Victoria Island, Nunavut.

Positioned at latitude 69.1°N and centrally located in the Canadian Arctic, the tundra north of the hamlet of Cambridge Bay (population 1400) is home to a variety of bird species. Here populations of migrant birds from the eastern and western Arctic and from the Low Arctic and High Arctic meet. Species of the High Arctic, such as the King Eider, *Somateria spectabilis*, Baird's Sandpiper, *Calidris bairdii*, Red Phalarope, *Phalaropus fulicarius*, and Black-bellied Plover, *Pluvialis squatarola*, overlap with species of the Low Arctic, such as the Sandhill Crane, *Grus canadensis*, American Golden-Plover, *Pluvialis dominica*, and Red-necked Phalarope, *Phalaropus lobatus*. In addition, bird life is enriched by the presence of some Pacific subspecies like the Black Brant, *Branta bernicla nigricans*. Moreover, some species with a limited distribution can be found, such as the Buff-breasted Sandpiper, *Tryngites subruficollis*, Stilt Sandpiper, *Calidris himantopus*, and Thayer's Gull, *Larus thayeri*. The location of Cambridge Bay puts it at the southern limit of the ranges of northern species and at the northern limit of the ranges of more southern species. This means that any changes in distribution due to climate change (or other factors) should be more visible than in areas more central to a population's distribution.

When we compared our observations made in 1983 (Lok and Vink 1986) and 1986 (Vink et al. 1988) with those of Parmelee et al. (1967), collected in the 1960s in the same area, some trends were observed. For example, the Brant (i.e., Black Brant), the most common goose in the 1960s, has almost disappeared as a breeding bird, whereas numbers of the Greater White-fronted Goose, *Anser albifrons*, and the Cackling Goose, *Branta hutchinsii*, have markedly increased. In addition, the ratio of the Black-bellied Plover to the American Golden-Plover has declined significantly.

In the summer of 2011, we revisited the tundra of Cambridge Bay in the same period as in 1983 and 1986, and we identified and confirmed some trends related to relative abundance in earlier years. Since the 1980s, numbers of a few species associated with the High Arctic have decreased, whereas the Red-necked Phalarope, *Phalaropus lobatus*, associated with the Low Arctic, has increased markedly. This report presents our 2011 observations and compares them to the findings from the 1960s and 1980s. In addition, some possible underlying causes of the changes observed are discussed.

Year-to-year variation in bird numbers in the Arctic can be influenced by a variety of physical and biological factors: temporary changes in the availability of food and/or nesting sites (determined by snow and ice coverage), timing of snow melt, temperature, precipitation, or by the cyclic occurrence of predators or food sources like lemmings. Conditions on the wintering grounds and the migratory routes may also influence bird populations in the Arctic (Donaldson et al. 2000). With these factors in mind, it is clear that differences between years do not necessarily reflect changes in status but rather weather conditions and food availability. Thus, differences in conditions in the census years should be noted (Table 1). A major difference between 2011 and the 1980s was that, in the 1980s, there were hardly any roads outside the settlement, whereas by 2011 there was an extensive infrastructure with gravel roads or tracks to Ovayok (Mount Pelly) and Long Point. In addition, an increased number of summer cabins for hunting and fishing have been constructed. This added human activity may have led to some increased disturbance or hunting pressure. This is likely a significant factor for the larger bird species that are hunted.

The lowland tundra north of the hamlet of Cambridge Bay is rather flat, with a multitude of shallow ponds and

TABLE 1. Mean summer temperatures and number of lemmings observed at Cambridge Bay, Victoria Island, Nunavut, in 1983, 1986, and 2011.

Year	Mean June temperature (°C)	Mean July temperature (°C)	No. of lemmings observed (density)
1983	3.6	9.0	1 (low)
1986	-0.4	7.1	20 (moderate)
2011	+1.1	10.8	4 (low)

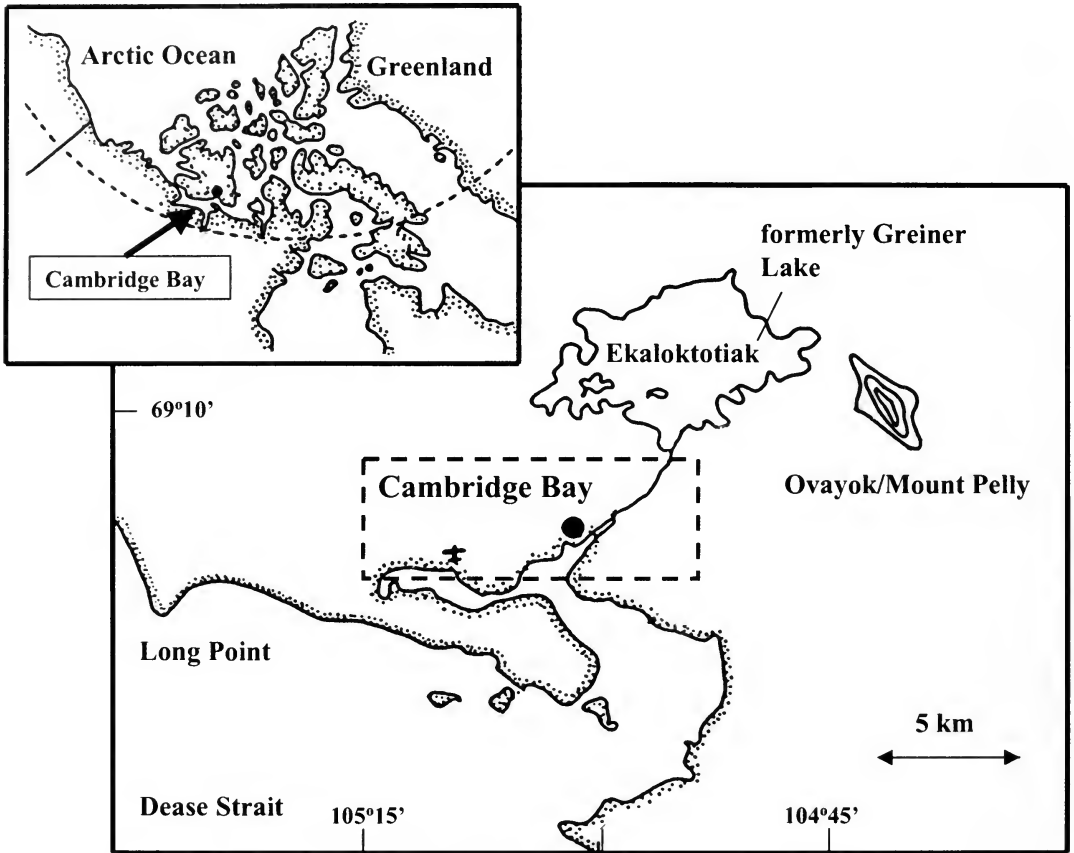


FIGURE 1. The Cambridge Bay area, Victoria Island, Nunavut, Canada. Dashed rectangle indicates the main study area in 2011.

lakes. Well-vegetated zones can often be found near these waters. The poorly drained wetlands are separated by dry, stony ridges with little vegetation. The smaller ponds are usually ice-free at the end of June, whereas the larger lakes and the sea remain frozen until well into July or beyond. In this area, the only higher land is Ovayok (Mount Pelly), with an elevation of over 200 m.

**Study Area and Methods**

Figure 1 shows our main study area in 2011. Each day, all birds seen were counted, and the accumulated totals for the period 25 June to 7 July 2011, collected during 300 person-hours of observation, are given in Table 2. The total number of each species can be used

as an indication of its relative abundance. Table 2 also includes the totals for 23 June to 6 July 1983 and 19 June to 3 July 1986. Unfortunately, the area near Ovayok (Mount Pelly), our main focus in the 1980s, was not accessible in 2011 due to high water levels. Instead, we concentrated mostly on the tundra round the Distant Early Warning (DEW) line road north of the airport (Figure 1). This tundra is similar in structure to the area round Ovayok (Mount Pelly), and the bird population here is very likely similar to that of our 1983 and 1986 study area. In addition, four trips to Long Point and surrounding tundra were made. A clear difference in the study area in 2011 was the absence of high land over 150 m.

TABLE 2. Birds observed near Cambridge Bay, Victoria Island, Nunavut, between 23 June and 6 July 1983, between 19 June and 3 July 1986, and between 25 June and 7 July 2011 (\* includes *Acanthis* (formerly *Carduelis*) species; ++ common, not quantified).

Species observed	1983	1986	2011	
Red-throated Loon	<i>Gavia stellata</i>	3	2	0
Pacific Loon	<i>Gavia pacifica</i>	14	66	43
Yellow-billed Loon	<i>Gavia adamsii</i>	5	5	0
Tundra Swan	<i>Cygnus columbianus</i>	48	184	133
Greater White-fronted Goose	<i>Anser albifrons</i>	130	420	164
Snow Goose	<i>Chen caerulescens</i>	0	107	0
Cackling Goose	<i>Branta hutchinsii</i>	170	298	97
Black Brant	<i>Branta bernicla nigricans</i>	12	28	15
Northern Pintail	<i>Anas acuta</i>	14	48	4
Greater Scaup	<i>Aythya marila</i>	0	2	0
Common Eider	<i>Somateria mollissima</i>	12	390	50
King Eider	<i>Somateria spectabilis</i>	340	501	327
Long-tailed Duck	<i>Clangula hyemalis</i>	260	156	218
Red-breasted Merganser	<i>Mergus serrator</i>	14	8	5
Rough-legged Hawk	<i>Buteo lagopus</i>	6	8	10
Merlin	<i>Falco columbarius</i>	1	0	0
Peregrine Falcon	<i>Falco peregrinus</i>	1	4	1
Willow Ptarmigan	<i>Lagopus lagopus</i>	0	24	0
Rock Ptarmigan	<i>Lagopus muta</i>	4	289	0
Sandhill Crane	<i>Grus canadensis</i>	0	7	26
Ruddy Turnstone	<i>Arenaria interpres</i>	75	90	3
Semipalmated Sandpiper	<i>Calidris pusilla</i>	210	++	187
White-rumped Sandpiper	<i>Calidris fuscicollis</i>	1	0	0
Baird's Sandpiper	<i>Calidris bairdii</i>	110	++	37
Pectoral Sandpiper	<i>Calidris melanotos</i>	70	20	33
Stilt Sandpiper	<i>Calidris himantopus</i>	120	111	17
Buff-breasted Sandpiper	<i>Tryngites subruficollis</i>	1	12	2
Red-necked Phalarope	<i>Phalaropus lobatus</i>	3	23	92
Red Phalarope	<i>Phalaropus fulicarius</i>	175	292	54
American Golden-Plover	<i>Pluvialis dominica</i>	140	174	50
Black-bellied Plover	<i>Pluvialis squatarola</i>	60	24	0
Semipalmated Plover	<i>Charadrius semipalmatus</i>	10	29	18
Glaucous Gull	<i>Larus hyperboreus</i>	170	151	543
Thayer's Gull	<i>Larus thayeri</i>	9	86	3
American Herring Gull	<i>Larus argentatus smithsonianus</i>	0	2	1
Sabine's Gull	<i>Xema sabini</i>	140	268	126
Arctic Tern	<i>Sterna paradisaea</i>	160	92	71
Pomarine Jaeger	<i>Stercorarius pomarinus</i>	6	61	1
Parasitic Jaeger	<i>Stercorarius parasiticus</i>	26	40	2
Long-tailed Jaeger	<i>Stercorarius longicaudus</i>	72	120	78
Snowy Owl	<i>Bubo scandiacus</i>	0	5	0
Short-eared Owl	<i>Asio flammeus</i>	0	1	0
Common Raven	<i>Corvus corax</i>	1	1	22
Mountain Bluebird	<i>Sialia currucoides</i>	1	0	0
Horned Lark	<i>Eremophila alpestris</i>	85	124	112
American Pipit	<i>Anthus rubescens</i>	12	12	9
Arctic Redpoll*	<i>Acanthis</i> (formerly <i>Carduelis</i> ) <i>hornemanni</i>	3	4	26
Lapland Longspur	<i>Calcarius lapponicus</i>	++	++	347
Snow Bunting	<i>Plectrophenax nivalis</i>	70	177	113
Savannah Sparrow	<i>Passerculus sandwichensis</i>	0	1	1

It should be noted that the 2011 data likely include some double counts of, for example, the Glaucous Gull, *Larus hyperboreus*, on the Cambridge Bay waste dump site. We visited this site only once in each of 1983 and 1986 but more often in 2011. As we do not know which birds were transient and which stayed for longer periods, we have not tried to correct the numbers for pos-

sible double counts. In 1983 and 1986, we travelled on foot while changing our base every one or two days. In contrast, in 2011 we had our base in the settlement and mainly patrolled the road and track system round Cambridge Bay from Long Point to part of the Mount Pelly road by all-terrain vehicle (ATV) and on foot on the surrounding tundra.

## Results and Discussion

A total of 38 species was observed in 2011, compared with 42 in 1983 and 47 in 1986. A comparison of our 2011 observations with those in the 1980s shows that the number of each species observed has been rather stable. For several species, the status does not seem to have changed significantly. Some of the changes observed can be explained by temporary factors. Thus in 1986, upon our arrival, snow cover was still 90% and much migration was observed after the onset of snow melt. In 2011, most breeding birds had already arrived and had started nesting or were occupying territories. Tundra Swans, *Cygnus columbianus*, and some ducks still formed concentrations on coastal lakes waiting for the larger lakes to become ice-free, and they started to disperse over the tundra at the end of our visit.

The only significant migration observed in 2011 was that of the Sandhill Crane; this migration explains the higher numbers in 2011. In addition, small groups of Black Brant arrived and spent some time foraging at the coast before moving further within 24 hours.

In 2011, no breeding pairs of Black Brant were observed. In contrast, in the 1960s, the Brant (i.e., Black Brant) was decidedly the most common goose (Parmelee et al. 1967). Already in the 1980s, the species had considerably declined and was outnumbered by Cackling Goose and Greater White-fronted Goose (Lok and Vink 1986; Vink et al. 1988). It is possible that the Cackling Goose has displaced the Black Brant from its favourite breeding sites, small islands in ponds. Indeed, this possibility is supported by observations of interspecific competition between goose species in the Arctic (Fox et al. 1996; Flint et al. 2008).

Our observations suggest a change in status of the Black-bellied Plover. The ratio of the Black-bellied Plover to the American Golden-Plover changed from well over 1 in the 1960s to 0.43 in 1983, 0.14 in 1986, and as low as zero in 2011. A decrease in numbers of Black-bellied Plovers on certain Canadian sites was thought to be a response to a local increase in the number of American Golden-Plovers (Parker and Ross 1973; Pattie 1990; Byrkjedal and Thompson 2002). A clear negative correlation between the two populations on Devon Island has been found, suggesting species replacement or competition (Pattie 1990). In contrast, Gratto-Trevor et al. (1998) found significant decreases for both Black-bellied Plover and American Golden-Plover on Rasmussen Lowlands. Buff-breasted Sandpipers in the Cambridge Bay area have been reported to breed in close association with Black-bellied Plovers (Paulsen and Erkmann 1985). The two nests of Buff-breasted Sandpipers observed on dry tundra west of Cambridge Bay in 2011 obviously had to manage without the presence of Black-bellied Plovers. Another High Arctic species that was seen less often was Baird's Sandpiper. In 1983, we observed 110 Baird's Sandpipers, but in 2011 only 37 were counted. Similarly, the

number of Stilt Sandpipers observed was lower than in the 1980s.

A long-term trend seems to be northward expansion of the Red-necked Phalarope from the Low Arctic. Before the 1960s, the Red-necked Phalarope had not been reported from Cambridge Bay and in the 1960s it was probably a rare breeder (Parmelee et al. 1967). In 1983 and 1986, we counted 3 and 23, respectively. In 2011, with 92 observations, this species outnumbered even the Red Phalarope. The ratio of Red-necked Phalarope to Red Phalarope was 0.02 in 1983, 0.08 in 1986, and 1.7 in 2011.

The Common Raven, *Corvus corax*, has clearly increased, likely due to the increased human activity. There was only one observation each in 1983 and 1986, so the observation of 22 Common Ravens in 2011 suggests a real increase.

As expected for a year with low numbers of lemmings, no Snowy Owls, *Bubo scandiacus*, were seen, and only one Pomarine Jaeger, *Stercorarius pomarinus*, and two Parasitic Jaegers, *Stercorarius parasiticus*, were observed. In years with higher numbers of lemmings, the density of Snowy Owls and Pomarine Jaegers can be high (Parmelee et al. 1967). In contrast, the Long-tailed Jaeger, *Stercorarius longicaudus*, seems to have bred in normal numbers. In addition, Rough-legged Hawks, *Buteo lagopus*, managed to breed (one nest with young and one nest with five eggs were observed).

Striking was the complete absence of both ptarmigan species in 2011. In 1983 and 1986, we observed 4 and 289 Rock Ptarmigans, *Lagopus muta*, respectively, and 0 and 24 Willow Ptarmigans, *Lagopus lagopus*, respectively. Ptarmigan numbers are known to fluctuate. For example, during a 50-year study in Scotland, a 10-year cycle was observed (Watson et al. 2000). In addition, in years with low numbers of lemmings, Arctic Foxes, *Vulpes lagopus*, have been shown to switch from lemmings to ptarmigans (Angelstam et al. 1984).

For other areas in the Canadian Arctic, long-term multi-species studies were summarized recently by Trefry et al. (2010). During a long-term study on Ellesmere Island from 1980 to 2008, the assemblage of breeding bird species appeared to have changed little, except for an increase in the Lapland Longspur, *Calcarius lapponicus* (Trefry et al. 2010). This increase was attributed to increased production of vegetation due to higher temperatures (an increase of 2 Celsius degrees in the average July temperature between 1981 and 2008). So far, it has not been possible to identify key factors for most changes observed, and Trefry et al. (2010) concluded that year-to-year variation remains a poorly understood component of monitoring studies of birds breeding in the Arctic.

Recent analyses of trends in shorebird populations in various parts of Canada and the U.S. indicate that many species are declining, including the Black-bellied Plover, the American Golden-Plover, and both the



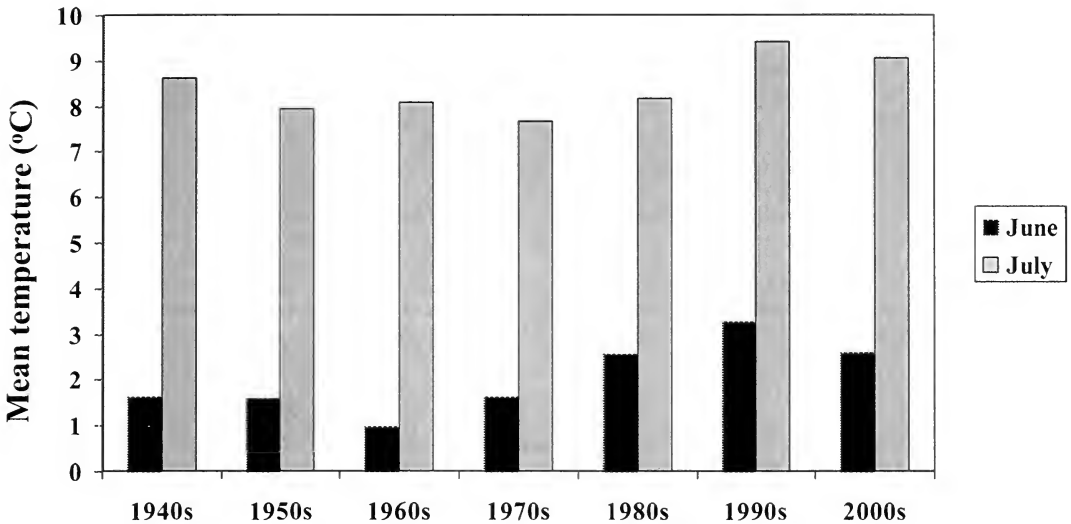


FIGURE 2. Mean June and July temperatures at Cambridge Bay, Victoria Island, Nunavut, per decade (data processed from Monthly Data Report, Environment Canada)

Red-necked Phalarope and the Red Phalarope (Morrison et al. 2001, Gratto-Trevor et al. 2011\*). These range-wide status changes are often attributed to factors outside the breeding grounds in the Arctic (Donaldson et al. 2000). Whereas numbers of some shorebirds in Cambridge Bay have declined, in line with the change in the status of general populations, numbers of the Red-necked Phalarope, which shows a general population decline, have increased markedly at Cambridge Bay. In parallel to this northward expansion, the numbers of this species seem to have decreased at the southern limit of its range (Cramp and Simmons 1983, Del Hoyo et al. 1996, Jehl and Lin 2001).

The question of whether some of the longer term trends at Cambridge Bay are related to climate change (see also Meltofte et al. 2007) is also still open to debate. Compared to the 1960s (1961–1970), the mean June and July temperatures at Cambridge Bay for the period 2001–2010 have risen, but relative to the 1990s these temperatures have decreased slightly (Figure 2). Therefore, it will be interesting to observe whether the northward expansion of the Red-necked Phalarope will continue, stop, or even be reversed.

#### Acknowledgements

We thank A. J. Erskine and one anonymous reviewer for their helpful comments on a previous draft.

#### Documents Cited (marked \* in text)

- Environment Canada. 2011. Monthly data report. National Climate Data and Information Archive. <http://www.climate.weatheroffice.gc.ca>. (Accessed August 2011).
- Gratto-Trevor, C., R. I. G. Morrison, B. Collins, J. Rausch, M. Drever, and V. Johnston. 2011. Trends in Canadian

shorebirds. Canadian Biodiversity: Ecosystem Status and Trends 2010. Technical Thematic Report No. 13. Canadian Councils of Resource Ministers. Ottawa, Ontario iv + 32 pages. <http://www.biodivcanada.ca/default.asp?lang=En&n=137E1147-1> (Accessed September 2012).

#### Literature Cited

- Angelstam, P., E. Lindström, and P. Widén. 1984. Role of predation in short-term population fluctuations and mammals in Fennoscandia. *Oecologia* 62: 199–208.
- Byrkjedal, I., and D. B. A. Thompson. 2002. Tundra Plovers: The Eurasian, Pacific and American Golden Plovers and Grey Plover. T&AD Poyser, London.
- Cramp, S., and K. E. L. Simmons. (Editors). 1983. Waders to Gulls. Vol. III of The Birds of the Western Palearctic. Handbook of the Birds of Europe, the Middle East and North Africa. Edited by Stanley Cramp. Oxford University Press, Oxford, U.K.
- Del Hoyo, J., A. Elliott, and J. Sargatal. (Editors). 1996. Hoatzin to Auks. Vol. 3 of Handbook of the Birds of the World. Lynx Edicions, Barcelona, Spain.
- Donaldson, G., C. Hyslop, G. Morrison, L. Dickson, and I. Davidson. 2000. Canadian Shorebird Conservation Plan. Canadian Wildlife Service, Environment Canada, Ottawa, Ontario, 27 pages.
- Flint, P. L., E. Mallek, R. J. King, J. A. Schmutz, K. S. Bollinger, and D. V. Derksen. 2008. Changes in abundance and spatial distribution of geese molting near Teshekpuk Lake, Alaska: interspecific competition or ecological change? *Polar Biology* 31: 549–556.
- Fox, A. D., C. Glahder, C. Mitchell, D. A. Stroud, H. Boyd, and J. Frikke. 1996. North American Canada Geese (*Branta canadensis*) in West Greenland. *Auk* 113: 231–232.
- Gratto-Trevor, C. L., V. H. Johnston, and S. T. Pepper. 1998. Changes in shorebird and eider abundance in the Rasmussen Lowlands, NWT. *Wilson Bulletin* 110: 316–325.

- Jehl, J. R., and W. L. Lin. 2001. Population status of shorebirds nesting at Churchill, Manitoba. *Canadian Field-Naturalist* 115: 487–494.
- Lok, C. M., and J. A. J. Vink. 1986. Birds at Cambridge Bay, Victoria Island, Northwest Territories, in 1983. *Canadian Field-Naturalist* 100: 315–318.
- Meltofte H., T. Piersma, H. Boyd, B. McCaffery, B. Ganter, V. V. Golovnyuk, K. Graham, C. L. Gratto-Trevor, R. I. G. Morrison, E. Nol, H.-U. Rösner, V. Schamel, H. Schekkerman, M. Y. Soloviev, P. S. Tomkovich, D. Tracy, I. Tulp, and L. Wennerberg. 2007. Effects of climate variation on the breeding ecology of Arctic shorebirds. *Meddelelser om Gronland, Bioscience* 59: 1–48.
- Morrison, R. I. G., Y. Aubry, R. W. Butler, G. W. Beyersbergen, G. M. Donaldson, C. L. Gratto-Trevor, P. W. Hicklin, V. H. Johnston, and R. K. Ross. 2001. Declines in North American shorebird populations. *Wader Study Group Bulletin* 94: 34–38.
- Parker, G. R., and R. K. Ross. 1973. Notes on the birds of Southampton Island, Northwest Territories. *Arctic* 26: 123–129.
- Parmelee, D. F., H. A. Stephens, and R. H. Schmidt. 1967. The birds of southeastern Victoria Island and adjacent small islands. *National Museum of Canada Bulletin* No. 222.
- Pattie, D. L. 1990. A 16-year record of summer birds on True-love Lowland, Devon Island, Northwest Territories. *Arctic* 43: 275–283.
- Paulsen, D. R., and W. J. Erkmann. 1985. Buff-breasted Sandpipers nesting in association with Black-bellied Plovers. *Condor* 87: 429–430.
- Trefry, S. A., B. Freedman, J. M. G. Hudson, and G. H. R. Henry. 2010. Breeding bird surveys at Alexandra Fjord, Ellesmere Island, Nunavut (1980–2008). *Arctic* 63: 308–314.
- Vink, J. A. J., M. Vaughan, R. Vaughan, and C. M. Lok. 1988. Birds at Cambridge Bay, Victoria Island, Northwest Territories, Canada in 1986. *Circumpolar Journal* 3: 13–26.
- Watson, A., R. Moss, and P. Rothery. 2000. Weather and synchrony in 10-year population cycles of Rock Ptarmigan and Red Grouse in Scotland. *Ecology* 81: 2126–2136.

Received 18 November 2011

Accepted 10 April 2012

# Foods of Bats (Family Vespertilionidae) at Five Locations in New Hampshire and Massachusetts

HOWARD H. THOMAS<sup>1</sup>, PAUL R. MOOSMAN, JR.<sup>2</sup>, JACQUES PIERRE VEILLEUX<sup>3</sup>, and JASON HOLT<sup>1,4</sup>

<sup>1</sup>Department of Biology and Chemistry, Fitchburg State University, Fitchburg, Massachusetts 01420 USA

<sup>2</sup>Department of Biology, Virginia Military Institute, Lexington, Virginia 24450 USA

<sup>3</sup>Department of Biology, Franklin Pierce University, Rindge, New Hampshire 03461 USA

<sup>4</sup>Current address: 19 Railroad Street, Acton, Massachusetts 01720 USA

Thomas, Howard H., Paul R. Moosman, Jr., Jacques Pierre Veilleux, and Jason Holt. 2012. Foods of bats (Family Vespertilionidae) at five locations in New Hampshire and Massachusetts. *Canadian Field-Naturalist* 126(2): 117–124.

Diet and feeding relations of six species of bats at five locations in New Hampshire and Massachusetts were studied to improve understanding of foraging niche differentiation. Fecal samples were collected from 100 Big Brown Bats (*Eptesicus fuscus*), 154 Little Brown Myotis (*Myotis lucifugus*), 49 Northern Myotis (*M. septentrionalis*), 54 Eastern Small-footed Myotis (*M. leibii*), 9 Eastern Red Bats (*Lasiurus borealis*), and 1 Hoary Bat (*L. cinereus*) netted during non-hibernation periods from 2004 to 2008 at four locations in southern New Hampshire and one in north-central Massachusetts. Beetles (Order Coleoptera) were the major food of *E. fuscus* (mean percentage volume = 81.6%, 97% occurrence) followed by moths (Order Lepidoptera), with scarabaeid and carabid beetles the most abundant consumed families by volume and frequency. Moths were the most important item by volume and frequency preyed on by the remaining species (*M. lucifugus*, mean percentage volume 30.7%, 82% occurrence; *M. septentrionalis*, mean percentage volume 42.7%, 82% occurrence; *M. leibii*, mean percentage volume 49.4%, 81% occurrence; *L. borealis*, mean percentage volume 62.8%, 100% occurrence; *L. cinereus*, mean percentage volume 82%, 100% occurrence). Little Brown Myotis consumed the largest variety of prey (40); Northern Myotis consumed the highest volume of spiders (8.1%). Community similarity index values indicated diets of the three species of *Myotis* were more similar to each other (similarity = 0.71) than to those of non-*Myotis*. The diet of *E. fuscus* was more similar to that of the *Myotis* cluster (0.58) than to either species of *Lasiurus*. Results suggest that, despite faunal differences between the U.S. Northeast and other parts of North America, foraging relationships among guild members follows a similar pattern.

**Key Words:** Big Brown Bat, *Eptesicus fuscus*, Little Brown Myotis, *Myotis lucifugus*, Northern Myotis, *Myotis septentrionalis*, Eastern Small-footed Myotis, *Myotis leibii*, Eastern Red Bat, *Lasiurus borealis*, Hoary Bat, *Lasiurus cinereus*, Lepidoptera, scarabaeid beetle, carabid beetle, New Hampshire, Massachusetts.

The role of resource partitioning in feeding guilds of insectivorous bats has been examined by a number of authors (e.g. Black 1974; Carter et al. 2003; Whitaker 2004; Feldhamer et al. 2009; Moosman et al. 2012). The diets of temperate insectivorous bats are closely related to factors such as foraging habitat (Aldridge and Rautenbach 1987; Furlonger et al. 1987), climate (Moosman et al. 2012), prey hardness (Aldridge and Rautenbach 1987; Furlonger et al. 1987), characteristics of prey detection systems (Barclay and Brigham 1991), cranial and wing morphology (Belwood and Fenton 1976; Freeman 1981), and jaw musculature (Aldridge and Rautenbach 1987; Furlonger et al. 1987). Since bat species have adapted to these factors differently their diet may reflect such adaptations (Aldridge and Rautenbach 1987).

Most authors have defined guild structure according to differential prey utilization (Whitaker 1972; Kunz 1973; Black 1974; Whitaker et al. 1981; Griffith and Gates 1985; Warner 1985; Carter et al. 2003; Whitaker 2004; and Feldhamer et al. 2009). However, comparing results across studies is difficult because of variation in both bat diet and study methodology. Geographic dietary variation has been detected in well-studied species such as *Eptesicus fuscus* (Big Brown Bat) and *Myotis lucifugus* (Little Brown Myotis) (Moosman et

al. 2012). Studies in western North America reported relatively low volumes of coleopterans in the diet of Big Brown Bats, a species typically considered a coleopteran specialist (Freeman 1981). Additionally, Whitaker and Lawhead (1992) reported high volumes of lepidopterans (71%) relative to other studies, in the diet of the generalist Little Brown Myotis.

Some authors described diets of bats using percentage volume (e. g. Whitaker 2004) whereas others used frequency of occurrence, or estimated number of insects consumed (e.g. Black 1974; Brigham and Saunders 1990). More recently, Whitaker (2004) and Feldhamer et al. (2009) described insectivorous bat feeding guilds by examining relatedness of diets of bat species in a guild. Both studies utilized community similarity and diversity indices to examine the feeding guild relationships of bat communities in the northern contiguous U.S., with Whitaker (2004) reporting on bats from Indiana and Feldhamer et al. (2009) on bats from Illinois.

The bat community of northeastern North America consists of nine species with the genus *Myotis* accounting for the largest portion (three species). In both northern Massachusetts and southern New Hampshire the community typically consists of six or seven species: Big Brown Bat (*Eptesicus fuscus*), Eastern Red Bat (*Lasiurus borealis*), Hoary Bat (*L. cinereus*), Northern

*Myotis septentrionalis*), Little Brown Myotis (*M. lucifugus*), Eastern Small-footed Myotis (*M. leibii*), and Tricolored Bat (*Perimyotis subflavus*). The presence of Eastern Small-footed Myotis and the rarity of the Silver-haired Bat (*Lasionycteris noctivagans*) in northeastern North America make this particular community unique among dietary studies, as does its lack of Indiana Myotis (*Myotis sodalis*). Although others have examined the diets of bat communities containing some of the same species in other localities (e.g., Griffith and Gates 1985; Carter et al. 2003; Whitaker 2004; and Feldhamer et al. 2009) there have been no comprehensive dietary studies of bat communities in New England.

The purpose of this study was to identify prey eaten by bats from north-central Massachusetts and southern New Hampshire, to examine the similarity of prey consumed by bats in this community, and compare our results to those of other studies. This dietary study represents the only one to examine a community of bats that includes the Eastern Small-footed Myotis, which is currently under review to be listed under the U.S. Endangered Species Act.

## Study Area and Methods

### Study areas

Bats were netted, between 2004 and 2008 (May to September in 2004 and 2005, May to October in 2006 and 2007, and April to July 2008) at the following locations in southern New Hampshire and north-central Massachusetts.

New Hampshire—Cheshire County, Pisgah State Park, located in three townships (Chesterfield, Hinsdale, and Winchester), 42°50'N, 72°26'W; Cheshire County, Surry Mountain Dam, Surry Township, 43°00'N, 72°19'W; Hillsborough County, Edward MacDowell Dam, Peterborough Township, 42°54'N, 71°58'W; Hillsborough County, New Boston Air Force Station, New Boston Township, 42°56'N, 71°38'W. Massachusetts—Worcester County, Mt. Watatic, Ashburnham Township, 42°42'N, 71°54'W.

Pisgah State Park is undeveloped and consists of >5380 ha (Veilleux et al. 2008). The landscape is dominated by coniferous, mixed conifer/deciduous and deciduous forests. Most forests are second growth but there are three areas of old growth remnants inside the park. Surry Mountain Lake is an impoundment of the Ashuelot River created by the Surry Mountain Dam, built by the U.S. Army Corps of Engineers. Topography surrounding Surry is steep. In addition to the Surry Mountain Lake (reservoir) and the Ashuelot River proper, there are several oxbow wetlands downstream from the dam. The site has mixed deciduous and coniferous forest types. Edward MacDowell Reservoir is an impoundment of Nubanusitt Brook maintained by the U.S. Army Corps of Engineers. The resulting lake is

relatively shallow and as such has extensive emergent vegetation along its periphery. The surrounding forest is mostly mixed deciduous and coniferous. New Boston Air Force Station is predominantly forested. Its topography is dominated by rolling terrain. Surrounding forest is mostly mixed deciduous. Mt. Watatic is a prominent terrain feature in north-central Massachusetts just south of the New Hampshire state line, with slopes of mixed deciduous forest.

### Capture of bats

Bats were captured using mist nets. Nets were placed across access roads and less often across woodland streams or rivers, or perpendicular to the edges of grassy openings. Following capture each bat was identified and then placed in an individual cloth bag for approximately 20 minutes to collect fecal pellets. Fecal pellets were stored in plastic vials. Bats were released at their site of capture. Methods used to handle bats followed guidelines of the American Society of Mammalogists (Sikes et al. 2011) and were approved by the Animal Care Committee of Fitchburg State University (Fitchburg, Massachusetts).

### Sample analysis and prey identification

Fecal pellets were wetted with 70% isopropyl alcohol and teased apart using dissecting tools while being viewed through a dissecting microscope. All pellets from a single bat were pooled as a single sample. Prey items were identified to order and family (when possible) using a reference collection of arthropods from the sampling locations as well as elsewhere in the region.

The percentage volume of each prey item for each sample was visually estimated and the mean percentage volume for each prey item was calculated for each bat species following methods of Whitaker (1988), which have been widely used across dietary studies. Visual estimation of volume has been the most commonly used method to quantify diet (Moosman et al. 2012) and it was used to facilitate comparison with the greatest number of studies (Whitaker 1972; Whitaker et al. 1981; Griffith and Gates 1985; Whitaker and Lawhead 1992; Whitaker 1995; Agosta and Morton 2003; Carter et al. 2003; Whitaker 2004; Whitaker and Barnard 2005; Johnson and Gates 2007; Moosman et al. 2007; Feldhamer et al. 2009).

Additionally, percentage occurrence of each prey item was calculated for each bat species. A list of prey items with respective mean percentage volume and percentage occurrence values was developed for each bat species (Table 1), and comparisons of prey community similarities were made using Jaccard Similarity Coefficients (Sneath and Sokal 1973). This allowed comparison of our data with those obtained by Whitaker (2004) and Feldhamer et al. (2009).

## Results

During 26 months of sampling, a total of 367 bat fecal samples were collected. The number of samples

TABLE 1. Mean percentage by volume and standard error of foods eaten by six species of bats in north-central Massachusetts and southern New Hampshire, 2004 to 2008. Percentage occurrence of prey in each bat's diet is shown in parentheses.

Prey taxa	<i>Eptesicus fuscus</i> (n = 100)	<i>Myotis lucifugus</i> (n = 154)	<i>Myotis septentrionalis</i> (n = 49)	<i>Myotis leibii</i> (n = 54)	<i>Lasiurus borealis</i> (n = 9)	<i>Lasiurus cinereus</i> (n = 1)
Arachnida						
Araneae	0 (0)	0.4 ± 0.2 (4)	8.1 ± 2.7 (27)	4.7 ± 2.7 (7)	0 (0)	0 (0)
Acari	0.1 ± 0.0 (4)	0.1 ± 0.0 (6)	0 (0)	0 (0)	0 (0)	0 (0)
Total Arachnida	0.1 ± 0.0 (4)	0.5 ± 0.2 (10)	8.1 ± 2.7 (27)	4.7 ± 2.7 (7)	0 (0)	0 (0)
Hexapoda						
Ephemeroptera	0 (0)	0.2 ± 0.1 (3)	0 (0)	0.4 ± 0.4 (2)	0 (0)	0 (0)
Odonata	0.2 ± 0.2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Plecoptera	0 (0)	0.6 ± 0.4 (2)	0.4 ± 0.4 (2)	0.1 ± 0.1 (2)	0 (0)	0 (0)
Orthoptera						
Gryllidae	0.3 ± 0.2	0.3 ± 0.1	0	0.1 ± 0.1	0	0
unidentified	0	0.2 ± 0.2	0	0	1.7 ± 1.7	0
Total Orthoptera	0.3 ± 0.2 (3)	0.5 ± 0.2 (4)	0 (0)	0.1 ± 0.1 (2)	1.7 ± 1.7 (11)	0 (0)
Blattodea (formerly Isoptera)	0 (0)	0.1 ± 0.1 (1)	0 (0)	0 (0)	0 (0)	0 (0)
Psocoptera	0 (0)	0.6 ± 0.6 (1)	0 (0)	0 (0)	0 (0)	0 (0)
Hemiptera						
Cicadellidae	0	0.3 ± 0.1	0	0	0	0
Cercopidae	0	0.1 ± 0.04	0	0	0.9 ± 0.9	0
Corixidae	<0.1	0	0	0	0	0
Cydniidae	0.2 ± 0.2	0	0	0	0	0
Delphacidae	0	0.3 ± 0.3	0	0	0	0
Lygaeidae	0.3 ± 0.3	0.5 ± 0.2	0	0	0	0
Pentatomidae	0.4 ± 0.3	0	0	0	0	0
unidentified	1.2 ± 0.6	1.4 ± 0.4	0.8 ± 0.8	0.2 ± 0.2	0	0
Total Hemiptera	2.1 ± 0.7 (13)	2.5 ± 0.5 (30)	0.8 ± 0.8 (1)	0.2 ± 0.2 (2)	0.9 ± 0.9 (1)	0 (0)
Neuroptera						
Hemeroptera	0.3 ± 0.3	0.8 ± 0.4	0.1 ± 0.1	0	0	0
unidentified	0	0.3 ± 0.2	0	0	1.1 ± 1.1	0
Total Neuroptera	0.3 ± 0.3 (2)	1.1 ± 0.5 (7)	0.1 ± 0.1 (2)	0 (0)	1.1 ± 1.1 (11)	0 (0)
Coloptera						
Carabidae						
<i>Cathartes</i>	0.9 ± 0.6	0	0	1.1 ± 1.1	5.6 ± 5.6	0
unidentified	16.5 ± 2.9	4.9 ± 1.0	1.0 ± 1.0	1.9 ± 1.7	0	0
Total Carabidae	17.4 ± 3.0	4.9 ± 1.0	1.0 ± 1.0	3.0 ± 2.0	5.6 ± 5.6	0
Dytiscidae	1.4 ± 0.9	0.1 ± 0.1	0	0	0	0
Scarabaeidae	34.6 ± 3.8	3.6 ± 1.0	7.1 ± 3.5	2.8 ± 1.7	4.1 ± 3.8	0
Tenebrionidae	0.1 ± 0.1	0.7 ± 0.5	0	0	2.0 ± 2.0	0

TABLE 2. Mean percentage by volume and standard error of foods eaten by six species of bats in north-central Massachusetts and southern New Hampshire, 2004 to 2008. Percentage occurrence of prey in each bat's diet is shown in parentheses.

Prey taxa	<i>Eptesicus fuscus</i> (n = 100)	<i>Myotis lucifugus</i> (n = 154)	<i>Myotis septentrionalis</i> (n = 49)	<i>Myotis leibii</i> (n = 54)	<i>Lasturus borealis</i> (n = 9)	<i>Lasturus cinereus</i> (n = 1)
Elateridae	2.5 ± 1.2	0.7 ± 0.4	0.9 ± 0.9	0.5 ± 0.4	3.3 ± 3.3	0
Chrysomelidae	0	0.2 ± 0.1	0	0.2 ± 0.2	1.7 ± 1.7	0
Curculionidae	3.8 ± 1.4	0.3 ± 0.2	0.1 ± 0.1	1.1 ± 0.6	0	0
unidentified	21.8 ± 2.9	11.1 ± 1.4	9.5 ± 2.4	11.0 ± 2.6	6.3 ± 3.3	0
Total Coleoptera	81.6 ± 2.7 (97)	21.6 ± 2.0 (71)	18.6 ± 4.2 (57)	18.6 ± 3.7 (46)	23.0 ± 8.6 (56)	0 (0)
Hymenoptera						
Ichneumonidae	2.7 ± 1.4	2.8 ± 0.8	1.7 ± 1.5	3.7 ± 2.1	0.8 ± 0.8	0
Formicidae	1.0 ± 0.7	1.6 ± 0.8	0	0	0	18.0
unidentified	0.1 ± 0.1	0.9 ± 0.5	0	0.2 ± 0.2	0.8 ± 0.8	0
Total Hymenoptera	3.8 ± 1.6 (9)	5.3 ± 1.3 (23)	1.7 ± 1.5 (4)	3.9 ± 2.1 (15)	1.6 ± 1.0 (22)	18.0 (100)
Trichoptera	3.3 ± 1.3 (9)	13.1 ± 1.8 (37)	13.3 ± 3.6 (29)	2.6 ± 1.6 (6)	3.3 ± 3.3 (11)	0 (0)
Lepidoptera	4.4 ± 1.1 (29)	30.7 ± 2.5 (82)	42.7 ± 5.1 (82)	49.4 ± 5.4 (81)	62.8 ± 10.0 (100)	82.0 (100)
Diptera						
Sciaridae	0	0.3 ± 0.2	0	0	0	0
Chironomidae	0.1 ± 0.1	10.5 ± 1.9	0.4 ± 0.4	4.8 ± 2.0	0	0
Simuliidae	0	0.1 ± 0.1	0	0	0	0
Culicidae	0	0.6 ± 0.3	0	0.3 ± 0.3	0.6 ± 0.6	0
Tipulidae	0	0.6 ± 0.2	0	1.2 ± 0.9	0	0
unidentified	1.1 ± 0.5	4.3 ± 0.8	2.4 ± 1.4	11.0 ± 3.2	1.3 ± 0.9	0
Total Diptera	1.2 ± 0.5 (9)	16.4 ± 2.2 (49)	2.8 ± 1.8 (8)	17.3 ± 4.0 (39)	1.9 ± 1.3 (22)	0 (0)
Unidentified Arthropoda	1.6 ± 0.5 (19)	5.6 ± 0.8 (41)	9.7 ± 3.3 (35)	1.4 ± 0.4 (33)	3.4 ± 1.2 (67)	0 (0)
Vegetation	0.1 ± 0.1 (1)	0.5 ± 0.2 (5)	0.2 ± 0.1 (6)	0.9 ± 0.5 (7)	0 (0)	0 (0)

collected from each site was as follows: 194 from Surry Mountain Dam, 87 from Pisgah State Park, 42 from Edward MacDowell Lake, 36 from New Boston Air Force Station and the one from Mt. Watatic. Samples from *Eptesicus fuscus*, *Lasiurus borealis*, *Myotis lucifugus*, and *M. septentrionalis* were collected from most (three or four of the five) sites. However, samples from *M. leibii* were restricted to Surry Mountain Dam and New Boston as Air Force Station and the one from *L. cinereus* were restricted to New Boston Air Force Station.

#### Prey consumed

##### *Eptesicus fuscus* (n=100).

Big Brown Bats fed primarily on seven families of beetles (Order Coleoptera). Beetles occurred in the diet of 97 of 100 samples examined (97%) and constituted the greatest volume of food consumed (mean percentage volume and standard error are reported:  $81.6\% \pm 2.7$ ) (Table 1). In most samples a portion of the beetle material reported was identifiable only to the ordinal level ( $21.8\% \pm 2.9$ ). Of the beetle material identified to the family level those in Scarabaeidae and Carabidae were the most prominent. Less often consumed were beetles of the families Curculionidae, Elateridae, Dytiscidae, and Tenebrionidae (Table 1). The carabid beetle genus *Calathus* was identified in the foods of 3 of 100 Big Brown Bats and represented a mean volume of  $0.9\% \pm 0.6$ . Moths (Order Lepidoptera) were the second most commonly consumed arthropods occurring in 29% of the samples and a mean percentage volume of  $4.4\% \pm 1.1$  (Table 1). This was followed by the orders Hymenoptera and Hemiptera, unidentified insect remains, and the order Diptera. Remaining prey were of the orders Acari, Trichoptera, Orthoptera, Neuroptera, and Odonata.

##### *Myotis lucifugus* (n=154)

Little Brown Myotis from our study fed prominently on lepidopteran insects (Table 2). Lepidopterans occurred most frequently (82%) and represented the greatest volume ( $30.7\% \pm 2.5$ ) in the diet of this bat. This species also utilized the widest array of prey in this study. Other important prey (>1% volume) were in descending order: Coleoptera, Diptera, Trichoptera, Hymenoptera, Hemiptera, and Neuroptera. Each of the above orders was similarly arranged in descending order of frequency of occurrence. Occurring in lesser volumes (<1%) were prey from Araneae, Acari, Orthoptera, Ephemeroptera, Plecoptera, Blattodea (formerly Isoptera), and Psocoptera. The following families within the above orders were identified: seven families of Coleoptera, five families of Diptera, four families of Hemiptera, two families of Hymenoptera, and a single family of the order Orthoptera was also found (Table 1).

##### *Myotis septentrionalis* (n=49)

Northern Myotis had a diet similar to Little Brown Myotis with lepidopteran insects representing the high-

est occurrence (82%) and highest mean percentage volume ( $42.7\% \pm 5.1$ ). Other prey occurring with a mean percentage volume of  $\geq 1\%$  were: scarabaeid and carabid beetles as well as unidentified Coleoptera, Trichoptera, Araneae, Diptera, and Hymenoptera. Chironomids and Ichneumonid wasps were the only family of dipterans and hymenopterans identified, respectively. Northern Myotis consumed the highest amount of spiders of the species studied (Table 1) in line with their gleaning behavior.

##### *Myotis leibii* (n=54)

Foods eaten by the Eastern Small-footed Myotis in our study area were previously reported (Moosman et al. 2007) but we have incorporated an additional 15 samples. As with the other two species of the genus *Myotis*, Eastern Small-footed Myotis consumed moths at both high frequency of occurrence and volume (Table 1). After moths, Coleoptera and Diptera were the two most common prey items eaten by the Eastern Small-footed Myotis (Table 1). Of prey items identified to family, chironomid flies, ichneumonid wasps, small scarabaeid, carabid and curculionid beetles, and crane flies (Tipulidae) were the most abundant components (Table 1).

##### *Lasiurus borealis* (n=9)

The Eastern Red Bat fed most frequently on lepidopteran (100%) and coleopteran (56%) insects (Table 1). Both of the above orders of insects also represented the greatest volumes in this bat's diet, with lepidopterans accounting for a mean percentage volume of  $62.8\% \pm 10.0$  and coleopterans  $23.0\% \pm 8.6$ . Other insect prey found in volumes  $\geq 1\%$  included trichopterans, dipterans, orthopterans, hymenopterans, and neuropterans. Hemipteran insects constituted  $0.9\% \pm 0.9$  of the volume of the fecal sample from one Eastern Red Bat. Coleopteran families identified as prey included Scarabaeidae, Carabidae (including the genus *Calathus*), Chrysomelidae, Tenebrionidae, and Elateridae. Scarabaeid beetles accounted for only 3% of the volume in the single sample in which they were found, elaterid beetles represented 30% of the volume of the one sample in which they were found, and the carabid beetle genus *Calathus* accounted for 50% of the volume of the single sample in which it was found (Table 1).

##### *Lasiurus cinereus* (n=1)

The single Hoary Bat sample from our study revealed that 82% of the volume was made up of moths and the remaining volume consisted of hymenopterous insects (Table 1).

#### Prey Community Similarities

All species of bats reported showed a strong tendency to feed on terrestrial insects (i.e., beetles, moths, most of the dipterans, and hymenopterans). All three species of the genus *Myotis* that occurred in the community of bats at our study sites had diets that were relatively similar (Figure 1) (community similarity value

among the three species of 0.71). The diets of Eastern Small-footed and Little Brown Myotis were even more similar (0.78). The diets of the three species of *Myotis* were more similar to each other than to those of other guild members. Dependence on beetles in the diet of the Big Brown Bat made its diet distinct from those of the three species of *Myotis* but more similar to them than to the diets of Eastern Red Bat or Hoary Bat (Table 1). The similarity value of the Big Brown Bat's diet (0.58) places it between the cluster of *Myotis* and the Eastern Red Bat (Figure 1). The two *Lasiurus* species were relatively distinct in comparison to the other species in the guild (Figure 1). The diet of the Eastern Red Bat was more similar to the diet of the Big Brown Bat than to the diet of the Hoary Bat.

## Discussion

Results of the present study add to a limited body of information about food habits of bats from New England. Anthony and Kunz (1977) presented information on foods eaten by Little Brown Myotis in New Hampshire. Moosman et al. (2007) provided some of the first records for foods of the Eastern Small-footed Myotis, and Moosman et al. (2012) reported the four most used categories of food eaten by Little Brown Myotis and the Big Brown Bat in this region in context of the diet of these species throughout their ranges. Our findings represent the first published records of foods for the Northern Myotis, Eastern Red Bat, and Hoary Bat in New England. Our results show how relationships among guild members compare to patterns reported from other North American bat communities.

### *Eptesicus fuscus*

Our data indicated that Big Brown Bats preyed on beetles most frequently and in the highest proportion of volume of any prey items, and our data are in agreement with reports by most other investigators (Hamilton 1933; Whitaker et al. 1981; Griffith and Gates 1985; Brigham and Saunders 1990; Whitaker 1995; Agosta and Morton 2003; Carter et al. 2003; Whitaker 2004; Feldhamer et al. 2009). The predominance of beetles is in keeping with the recognized niche of this bat as a beetle specialist (Freeman 1981) or strategist (Black 1974). High incidence and volume of beetles of the families Scarabaeidae and Carabidae are likewise similar to values reported by Whitaker (1972) and Griffith and Gates (1985). However, moths were the second most important prey item of Big Brown Bats in our study, and this finding differs from most other studies. These differences may have been at least partially influenced by climatic differences between sites or by the time of year the bats were netted. Moosman et al. (2012) offered evidence that moths are used less often by big brown bats in regions with particularly high summer precipitation, such as New England.

### *Myotis species*

Little Brown Myotis in New Hampshire consumed moths most frequently and at the highest percentage

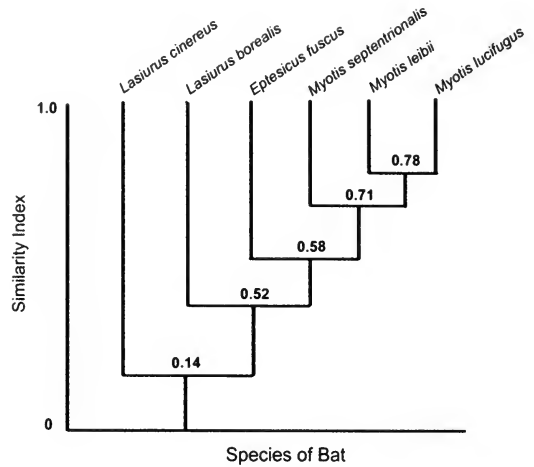


FIGURE 1. Similarity of diets of six species of bats in New England between 2004 and 2008, based on Jaccard similarity coefficient values.

volume of all food items. These results are similar to those reported from Indiana (Whitaker 1972), New Hampshire (Anthony and Kunz 1977), and West Virginia (Carter et al. 2003). Moths were second to beetles in the diet of Little Brown Myotis from western Maryland (Griffith and Gates 1985). However, our results contrast to those of Whitaker (2004) in which moths were found at a lower volume compared to dipterans in the diet of the Little Brown Myotis in Indiana. Our results are similar to those found by Carter et al. (2003), in which the descending percent volume order was Diptera, Trichoptera, Coleoptera, Hymenoptera, and Homoptera.

Our data showed that Northern Myotis fed heavily on moths. These results are similar to those reported by Whitaker (1972) and Griffith and Gates (1985) but in contrast to Carter et al. (2003) and Whitaker (2004). The next most frequently eaten arthropod by Northern Myotis in New Hampshire was beetles. Griffith and Gates (1985) listed beetles as the second most frequently occurring food item for this bat in western Maryland. According to volumetric data, Northern Myotis from New England ate fewer beetles than those in West Virginia (Carter et al. 2003), Indiana (Whitaker 2004), or southern Illinois (Feldhamer et al. 2009).

Remaining prey taxa are similar to other studies with two exceptions. Whitaker (2004) reported dipterans as having the highest percentage volumes in the diet of Northern Myotis from Indiana. Whitaker (2004) and Feldhamer et al. (2009) contain the only other reports of spiders in the diet of this species. Whitaker (2004) reported a lower volume of spiders (2.0%) while Feldhamer et al. (2009) reported higher volumes (15.6%). Our mean percentage volume was 8.1%. Dietary differences between Northern Myotis from Indiana and New Hampshire likely reflect differences in habitat.



Whereas Indiana is primarily an agricultural state, New Hampshire has minimal agriculture and is heavily forested. The Northern *Myotis* is a forest-dwelling bat, and this suggests why it may encounter spiders in forested sites such as New England more frequently than in the more fragmented agricultural landscapes of Indiana.

#### *Lasiurus species*

The diet of the Eastern Red Bat reported here is similar to that reported elsewhere. The predominance, by volume and occurrence, of moths and beetles has been reported for Eastern Red Bats in West Virginia (Carter et al. 2003) and in Indiana (Whitaker 2004). The diet of our single Hoary Bat was similar to that reported elsewhere. Whitaker (1972) reported that the diets two of three Hoary Bats from Indiana consisting of 100% moths. Five individuals from West Virginia consumed moths at a volume of 98% (Carter et al. 2003). The remaining volume of our single hoary bat was unidentified Hymenopteran (not ichneumonid wasps). Warner (1985) is the only other study to report hymenopterans in the diet of Hoary Bats.

Dietary similarity within the feeding guild is in agreement with Whitaker (2004) for bats from Indiana and with Feldhamer et al. (2009) for bats from Illinois. The pattern of dietary similarity between *Myotis* species differs only in that the Indiana *Myotis* is present in data from Indiana and Illinois, whereas the Eastern Small-footed *Myotis* is present in the study area reported here. The diet of Big Brown Bats, reported here, is most similar to the myotine bat cluster than either of the lasiurine species. These results are in contrast to those of both Whitaker (2004) and Feldhamer et al. (2009) who found that the Big Brown Bat's diet was most similar to that of the Evening Bat (*Nycticeus humeralis*) which is absent from the bat community in northern New England.

Differences in diet of bats at our sites relative to other regions could be the result of any number of factors. However, we suspect they reflect the convergence of local climate, prey assemblages, and intraspecific interactions in a bat community with relatively little diversity. Moosman et al. (2012) attributed dietary shifts in such feeding guilds to climate-related differences in the availability of arthropods more than to the diversity of bat species. However, the effects of interspecific competition among insectivorous bats are poorly understood. Thus we encourage authors to report community similarity values in future dietary studies in order to facilitate comparisons across regions.

#### Acknowledgements

Our study was supported by U.S. National Science Foundation grants 0754788 and 0330897. The assistance of the scientists and staff of the U.S. Army Corps of Engineers allowed us access to their lands in Surry and Peterborough Townships. Cooperation of the United State Air Force made it possible to study bats in New

Boston Township. The departments of Fish and Game for Massachusetts and New Hampshire provided us with permits to net bats in various locations in their states, respectively. We recognize the support of K. Austin, C. Cratsley, and L. S. Reynolds for field assistance and providing additional scientific insight. We thank the many undergraduate and graduate students from Fitchburg State University, Franklin Pierce University, and Virginia Military Institute who aided us during many nights in the field.

#### Literature Cited

- Agosta, S. J., and D. Morton. 2003. Diet of the big brown bat, *Eptesicus fuscus*, from Pennsylvania and western Maryland. *Northeastern Naturalist* 10: 89–104.
- Aldridge, H. D. J. N., and I. L. Rautenbach. 1987. Morphology, Echolocation and resource partitioning in insectivorous bats. *Journal of Animal Ecology* 56: 763–778.
- Anthony, E. L. P., and T. H. Kunz. 1977. Feeding strategies of the little brown bat, *M. lucifugus*, in southern New Hampshire. *Ecology* 58: 775–786.
- Barclay, R. M. R., and R. M. Brigham. 1991. Prey detection, dietary niche breadth, and body size in bats: why are aerial insectivorous bats so small? *American Naturalist* 137: 693–703.
- Belwood, J. J., and M. B. Fenton. 1976. Variation in the diet of *Myotis lucifugus* (Chiroptera: Vespertilionidae). *Canadian Journal of Zoology* 54: 1674–1678.
- Black, H. L. 1974. A north temperate bat community: structure and prey populations. *Journal of Mammalogy* 55: 138–157.
- Brigham, R. M., and M. B. Saunders. 1990. The diet of big brown bats (*Eptesicus fuscus*) in relation to insect availability in southern Alberta, Canada. *Northwest Science* 64: 7–10.
- Carter, T. C., M. A. Menzel, S. F. Owen, J. W. Edwards, J. M. Menzel, and W. M. Ford. 2003. Food habits of seven species of bats in the Allegheny Plateau and Ridge and Valley of West Virginia. *Northeastern Naturalist* 10: 83–88.
- Feldhamer, G. A., T. C. Carter, and J. O. Whitaker, Jr. 2009. Prey consumed by eight species of insectivorous bats from southern Illinois. *American Midland Naturalist* 162: 43–51.
- Freeman, P. W. 1981. Correspondence of food habits and morphology in insectivorous bats. *Journal of Mammalogy* 62: 166–173.
- Furlonger, C. L., H. J. Dewar, and M. B. Fenton. 1987. Habitat use by foraging insectivorous bats. *Canadian Journal of Zoology* 65: 284–288.
- Griffith, L. A., and J. E. Gates. 1985. Food habits of cave-dwelling bats in the central Appalachians. *Journal of Mammalogy* 66: 451–460.
- Hamilton, W. J., Jr. 1933. The insect food of the big brown bat. *Journal of Mammalogy* 14: 155–156.
- Johnson, J. B., and J. E. Gates. 2007. Food habits of *Myotis leibii* during fall swarming in West Virginia. *Northeastern Naturalist* 14: 317–322.
- Kunz, T. H. 1973. Resource utilization: temporal and spatial components of bat activity in central Iowa. *Journal of Mammalogy* 54: 14–32.
- Moosman, P. R., Jr., H. H. Thomas, and J. P. Veilleux. 2007. Food habits of eastern small-footed bats (*Myotis*

- leibii*) in New Hampshire. *American Midland Naturalist* 158: 354–360.
- Moosman, P. R., Jr., H. H. Thomas, and J. P. Veilleux.** 2012. Diet of the widespread insectivorous bats *Eptesicus fuscus* and *Myotis lucifugus* relative to climate and richness of bat communities. *Journal of Mammalogy* 93: 491–496.
- Sikes, R. S., W. L. Gannon, and The Animal Care and Use Committee of the American Society of Mammalogists.** 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. *Journal of Mammalogy* 92: 235–253.
- Sneath, P. H. A., and R. R. Sokal.** 1973. *Numerical Taxonomy*. W. H. Freeman and Co., San Francisco. 573 pages.
- Veilleux, J. P., H. H. Thomas, and P. R. Moosman, Jr.** 2008. Bats of Pisgah State Park, New Hampshire. *Northeastern Naturalist* 15: 25–34.
- Warner, R. M.** 1985. Interspecific and temporal dietary variation in an Arizona bat community. *Journal of Mammalogy* 66: 45–51.
- Whitaker, J. O., Jr.** 1972. Food habits of bats from Indiana. *Canadian Journal of Zoology* 50: 877–883.
- Whitaker, J. O., Jr.** 1988. Food habits analysis of insectivorous bats. Pages 171–189 in *Ecological and behavioral methods for the study of bats*. Edited by T. H. Kunz. Smithsonian Institution Press, Washington, D.C.
- Whitaker, J. O., Jr.** 1995. Food of the big brown bat *Eptesicus fuscus* from maternity colonies in Indiana and Illinois. *American Midland Naturalist* 134: 346–350.
- Whitaker, J. O., Jr.** 2004. Prey selection in a temperate zone insectivorous bat community. *Journal of Mammalogy* 85: 460–469.
- Whitaker, J. O., Jr. and S. M. Barnard.** 2005. Food of big brown bats (*Eptesicus fuscus*) from a colony at Morrow, Georgia. *Southeastern Naturalist* 4: 111–118.
- Whitaker, J. O., Jr., and B. Lawhead.** 1992. Foods of *Myotis lucifugus* in a maternity colony in central Alaska. *Journal of Mammalogy* 73: 646–648.
- Whitaker, J. O., Jr., C. Masser, and S. P. Cross.** 1981. Food habits of Eastern Oregon bats, based on stomach and scat analyses. *Northwest Science* 55: 281–292.

Received 29 January 2012

Accepted 14 June 2012

# Bat Populations and Cave Microclimate Prior to and at the Outbreak of White-Nose Syndrome in New Brunswick

KAREN J. VANDERWOLF<sup>1,3,4</sup>, DONALD F. MCALPINE<sup>1,2</sup>, GRAHAM J. FORBES<sup>2</sup>, and DAVID MALLOCH<sup>1</sup>

<sup>1</sup>New Brunswick Museum, 277 Douglas Avenue, Saint John, New Brunswick E2K 1E5 Canada

<sup>2</sup>Biology Department, University of New Brunswick, Fredericton, New Brunswick E3B 6E1 Canada

<sup>3</sup>Current address: Canadian Wildlife Federation, 350 Promenade Michael Cowpland, Kanata, Ontario K2M 2W1 Canada

<sup>4</sup>Corresponding author email: karenv@cwf-fcf.org

Vanderwolf, Karen J., Donald F. McAlpine, Graham J. Forbes, and David Malloch. 2012. Bat populations and cave microclimate prior to and at the outbreak of white-nose syndrome in New Brunswick. *Canadian Field-Naturalist* 126(2): 125–134.

Information on bat populations and hibernacula is important for understanding the impacts of white-nose syndrome (WNS), a fatal fungal disease of bats. Estimates of bat populations prior to the outbreak of white-nose syndrome are presented for 2009–2011 for the most significant bat hibernacula known in New Brunswick. At one of these sites we recorded a major mortality event from white-nose syndrome, the first in the Maritime provinces, late in the winter of 2011. Winter surveys of hibernating bats suggest that a minimum of 7 000 bats overwintered in these hibernacula prior to the outbreak of white-nose syndrome in New Brunswick. The majority of hibernating bats in New Brunswick caves are *Myotis lucifugus* (Little Brown Myotis) and *M. septentrionalis* (Northern Myotis), with low numbers of *Perimyotis subflavus* (Tricolored Bat). The New Brunswick hibernacula that support the greatest numbers of overwintering bats have little temperature variation, winter dark zone temperatures averaging 4–5°C, and minimum dark zone temperatures dropping to no lower than 3.1°C. New Brunswick caves with these temperature patterns characteristically have ≥140 m of main passage and lack both running water and multiple entrances. Few cave sites in the province meet these criteria, and the known winter bat population appears to be smaller than the summer population. Many bats present during the summer in New Brunswick either hibernate in unknown locations in the province or migrate out of the province to locate suitable hibernacula. Such movements may have hastened the arrival of white-nose syndrome in New Brunswick.

**Key Words:** *Myotis lucifugus*, Little Brown Myotis, *Myotis septentrionalis*, Northern Myotis, *Perimyotis subflavus*, Tricolored Bat, white-nose syndrome, cave, microclimate, hibernation, temperature, New Brunswick.

White-nose syndrome (WNS) is a lethal fungal disease affecting cave-dwelling North American bats that was first identified in 2006 in New York (Bleher et al. 2009). The disease affects bats during the hibernation period, and the high mortality rate is predicted to lead to the regional extinction of some bat species (Frick et al. 2010). In eastern Canada, a full understanding of white-nose syndrome is hindered by lack of information on the size of bat populations prior to the outbreak of white-nose syndrome, the locations of hibernacula, and the features that characterize cave and mine sites occupied by bats during the winter. Such information can help support efforts to better understand how white-nose syndrome is spread, allow the magnitude of bat mortality to be assessed, and assist investigators in determining whether the physical characteristics of hibernacula influence the ecology or impact of white-nose syndrome.

Surveys of New Brunswick bat hibernacula have not been conducted for more than 25 years (McAlpine 1983), and initial surveys were relatively superficial. Although there are approximately 25 natural solution caves in New Brunswick (McAlpine 1983; Arsenault et al. 1997), less than half of these are apparently suitable as bat hibernacula. Most of the known hibernacula in Nova Scotia and New Brunswick rarely contain more than a few hundred bats (Moseley 2007a). The

largest known concentration of hibernating bats in the Maritime provinces occurs in Hayes Cave, Nova Scotia, where approximately 10 000 bats, mainly *Myotis* spp., have been recorded (Moseley 2007a).

No studies on the environmental conditions of New Brunswick caves have previously been undertaken. The temperature of the dark zone (zone of no light penetration) in Frenchman's Cave in Nova Scotia has been recorded to range from approximately 4 to 8°C annually (Moseley 2007b). In contrast, the dark zone temperatures of some large European caves varies by 0.1–0.5 Celsius degrees over the course of the year (Hoyos et al. 1998; Laiz et al. 2003; Jurado et al. 2010). Although the data are limited, none of the Nova Scotia caves studied by Moseley (2007b) maintained a constant temperature in the dark zone (the temperature range was approximately 4 Celsius degrees over the year), due to relatively short passage length, the presence of running water, or air flow associated with multiple entrances (Moseley 2007b). New Brunswick caves are similar in structure to the Nova Scotia caves studied by Moseley (2007b) and on this basis they would be expected to show similar temperature patterns.

In 2009, in anticipation of the spread of white-nose syndrome to New Brunswick, we initiated a project to survey bat populations at known hibernacula and to characterize the microclimate in these sites. Here we

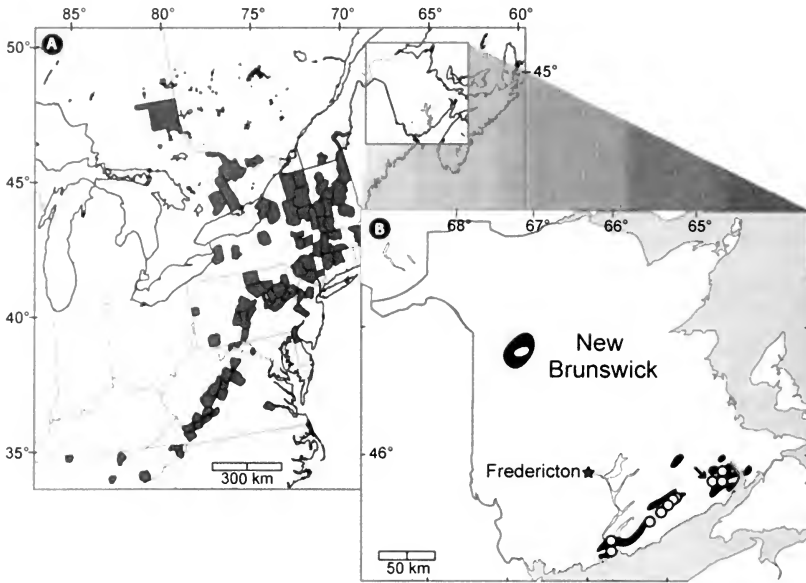


FIGURE 1. A) Grey-shaded polygons indicate state and provincial counties or districts in eastern North America where white-nose syndrome had been confirmed or suspected up to the winter of 2009-2010, based on United States Fish and Wildlife Service data, and prior to its spread into New Brunswick. Three suspected sites, west of the map region shown, are not included. B) The location of the 10 caves and mines surveyed for bats in New Brunswick during the study (open circles). An arrow marks the Berryton Cave site. Black areas show the limited areas of limestone and gypsum in New Brunswick where natural solution caves might develop.

present data on bat numbers at all known New Brunswick hibernacula prior to the outbreak of white-nose syndrome and incorporate data from the outbreak of white-nose syndrome in the province. We also compare data on the microclimate of New Brunswick caves and mines, focusing on those used as hibernacula, to correlate bat abundance with cave environmental features.

### Study Area and Methods

Eight caves and two abandoned manganese mines in southern New Brunswick, including all of the most significant bat hibernacula known in the province, were selected for study (McAlpine 1983) (Figure 1). The caves are natural solution caves (i.e., have developed in limestone and gypsum bedrock). There are few areas of New Brunswick with geology that will support the formation of natural solution caves (Figure 1), and the number of abandoned mines suitable as bat hibernacula appears to be limited (Cory Neumann, Minerals and Petroleum Development Branch, New Brunswick Department of Natural Resources, personal communication to DFM). The dimensions of the caves and one of the mines were previously mapped by McAlpine (1976, 1982, 1983) and Arsenault et al. (1997). Unless stated otherwise, our use of the word "cave" includes both natural solution caves and abandoned mines.

Generally, a single visit per cave per year, in the latter half of the winter hibernation period ("winter" is

here defined as 1 November to 30 April), was undertaken to count bats. We did not distinguish between *Myotis* spp., since most bats were roosting beyond our reach and we wished to minimize disturbance to those hanging lower down on vertical surfaces. However, *Perimyotis subflavus*, Tricolored Bat, could be identified without handling on the basis of size, coloration, and roosting habits. Visits were kept to a minimum because hibernating bats will arouse even with non-tactile human disturbance (e.g., light and sound), and repeated disturbance can lead to increased bat mortality (Thomas 1995). Although at the outset of this work and through 2010 all evidence suggested that white-nose syndrome was not present in the region, all survey participants followed the United States Fish and Wildlife Service protocol to minimize the spread of white-nose syndrome (U.S. Fish and Wildlife Service 2009) when visiting multiple caves.

Bat abundance was estimated based on the mean of independent counts by two to four individuals each using hand-held tally counters. Photography of roosting bats, although initially attempted as a census method (Meretsky et al. 2010), was not found to be practical, since bats were relatively few in number (<300 at most sites), were often widely dispersed in the hibernacula (clusters of <50 bats), or were in passages where photography was not possible (i.e., high on vertical walls in narrow passages). Only live bats were counted,

with the exception of Berryton Cave in 2011, when both live and recently dead bats were counted. Counts were conducted between January 2009 and March 2011.

Temperature/humidity logger iButtons (model DS1923-F5, Maxim Integrated Products, Inc., Sunnyvale, California) were placed in the caves in the fall of 2009 and retrieved in the fall of 2010. iButtons were set to record air temperature and relative humidity twice a day (at 0230 and 1430 hrs.). Two iButtons were deployed in each cave: one was placed 1–2 m from the ground on a wall ledge in the twilight zone (i.e., the entrance area where some light penetrates) and the other was placed under similar circumstances in the dark zone.

iButtons in the dark zone were placed in passage or chamber areas where bats roosted (if bats were present) at distances >1 m from roost sites to minimize disturbance. Willis et al. (2009) reported that iButtons may emit ultrasonic frequencies that may disturb hibernating bats. iButtons in the dark zone were 45 m (SD 26) from the entrance, with placement depending on the length of the cave and the location of hibernating bats. iButtons in the twilight zone were placed 7 m (SD 5) from the entrance.

Temperature and bat count data were not normally distributed, even with transformation. Therefore, a Mann-Whitney test was used to determine whether there were significant differences in average winter temperature in caves with and without hibernating bats. An *F*-test was used to test for differences in winter temperature variation (calculated as the maximum winter temperature minus the minimum). Spearman's rank order correlation (*R*) was used to determine whether bat abundance was correlated with cave length, average winter cave temperature, minimum temperature, or winter temperature variation. A Mann-Whitney test was used to determine whether bat abundance differed between caves with and without running water (i.e., active stream through the cave).

## Results

### Bat counts in hibernacula

A total of 1 988 bats were counted in 2010 and 7 076 in 2011. Data for 2009 were incomplete and preliminary, but they produced numbers similar to those recorded in 2010. The large increase in bat numbers in 2011 was due to behavioural changes in bats associated with the outbreak of white-nose syndrome in Berryton Cave (McAlpine et al. 2011); both live and recently dead bats are included in the total for this cave (Table 1). In March 2011, many bats in Berryton Cave were found to be infected with *Geomyces destructans*. We found large numbers of bats roosting low on the walls near the cave entrance, many of them in an area of highly variable temperature where ice was present. This behaviour, known to be associated with white-nose syndrome (Turner et al. 2011; Langwig et al. 2012), placed bats in easily visible locations and facilitated counting. Bats were not observed overwintering in these areas of Berryton Cave in 2009, 2010, at the outset of the 2011

hibernation period, or in previous decades (DFM, unpublished data). Berryton Cave has narrow, high ( $\geq 7$  m) passages (Figure 2), some of which are inaccessible to investigators. We believe this is where significant numbers of bats were roosting in the March 2010 count and the October 2009 and 2010 visits. Excluding Berryton Cave data, there was no significant difference between bat counts in 2010 and 2011 ( $P = 0.475$ ).

More than 99% of bats counted were *Myotis lucifugus* or *M. septentrionalis*. No *Eptesicus fuscus* (Big Brown Bat) were observed. A small number of Tricolored Bats were observed in Markhamville Mine ( $n = 9$ ; February 2010), Glebe Mine ( $n = 5$ ; February 2010), Berryton Cave ( $n = 2$ ; March 2010), White Cave ( $n = 3$ ; March 2010), Dalling's Cave ( $n = 1$ ; November 2009), and Underground Lake Cave ( $n = 1$ ; March 2010). All *P. subflavus* were observed hibernating individually (i.e., not clustered, as *Myotis* spp.) and low on the cave walls. This tendency of *P. subflavus* to hibernate individually has also been observed in caves in Ontario (Hitchcock 1949), Missouri (Guthrie 1933), Arkansas (Briggler and Prather 2003), and Florida (McNabb 1974).

### Cave temperatures

Due to apparent high humidity in caves, iButton humidity readers malfunctioned and no reliable humidity data were obtained.

The average annual air temperature of our study caves, using both twilight and dark zone data, was 5.5°C (SD 1.6) for hibernacula and non-hibernacula sites combined ( $n = 9$ ) and 5.2°C (SD 2.1) for hibernacula only ( $n = 7$ ). These temperatures approximate the average annual above ground air temperature in southern New Brunswick, where these caves are located (annual average from 1971 to 2000 was 5.1°C (SD 0.8) (Environment Canada 2011\*). The average annual dark zone air temperature was 6.0°C (SD 1.3) for all caves and 5.9°C (SD 1.4) for hibernacula only. The average dark zone air temperature in non-hibernacula ( $n = 2$ ) during winter when bats were present was 3.8°C (SD 2.1), which was not significantly colder than in hibernacula (5.1°C, SD 1.1,  $n = 6$ ,  $W = 29$ ,  $P = 0.617$ ). Also, air temperature in hibernacula was not significantly less variable than in non-hibernacula ( $F = 0.31$ ,  $P = 0.263$ ). The average dark zone air temperature during winter in mines (5.8°C, SD 1.2,  $n = 2$ ) was warmer than in caves (4.8°C, SD 1.0,  $n = 4$  hibernacula only; 4.5°C, SD 1.4,  $n = 6$  (all caves)).

As expected, the air temperature in the twilight zone in all caves was more variable than in the dark zone (Figure 3). During winter, air temperatures in the dark zone were higher than in the twilight zone. Those caves with the largest number of bats (Berryton, White, Underground Lake, and Markhamville) showed the least amount of fluctuation in the dark zone air temperature (compared to the other caves). All of these sites had approximately the same mean dark zone winter air temperature (4.7°C, SD 0.7) (Figure 4).

TABLE 1. New Brunswick caves known to contain bats. Counts are followed by the months they were conducted, when known. Cave lengths and bat counts before 2009 are taken from McAlpine (1979, 1982, 1983) and Arseneault et al. (1997). Bat abundance is presented as the average of independent counts done by multiple people, with the standard deviation in parentheses.

Name	Cave Type	Length (m)	1970s		1983		2009			2010			2011	
			No. of bats	Year	No. of bats	No. of bats	Month	No. of counts	No. of bats	Month	No. of counts	No. of bats	Month	No. of counts
Howes	limestone	80	15	1975	1-25	182	January	3	171 (4.2)	January	2	200.7 (6.8)	February	3
			10	1977		117.3 (8)	April	4						
Underground Lake	gypsum	140	no data		150	336 (7.1)	April	2	237.3 (21.8)	March	3	243 (4.2)	March	2
Kitt's	limestone	154	no data		1-25	no data			24.3 (1.2)	February	3	15 (1)	February	3
Harbell's	limestone	73.5	no data		1-25	10 (0)	April	2	23 (1)	January	3	31.7 (0.6)	February	3
Berryton	limestone	332	>300	1977	>300	no data			934 (2.8)	March	2	6087 (42.4)	March	2
Dalling's	limestone	98	no data		no data	3 (0)*	November	3	0	February	3	0	February	3
					no data				0	November	2	0	November	2
Chantal's	limestone	100	no data		no data	0	November	4	0	March	3	0	March	2
Markhamville Mine	limestone	no data	no data		no data	>100	November	3	226 (7)	February	3	151 (2.8)	March	2
Glebe Mine	limestone	197	no data		no data	>100	November	3	159.7 (10.3)	February	3	155.5 (2.1)	March	2
White	gypsum	515	350	1975	>300	no data			211.8 (7.3)	March	4	192 (17.5)	March	3
			>150	1976										
			>150	1977										

\*The three bats found November 2009 were two *Myotis septentrionalis* and one *Perimyotis subflavus*.

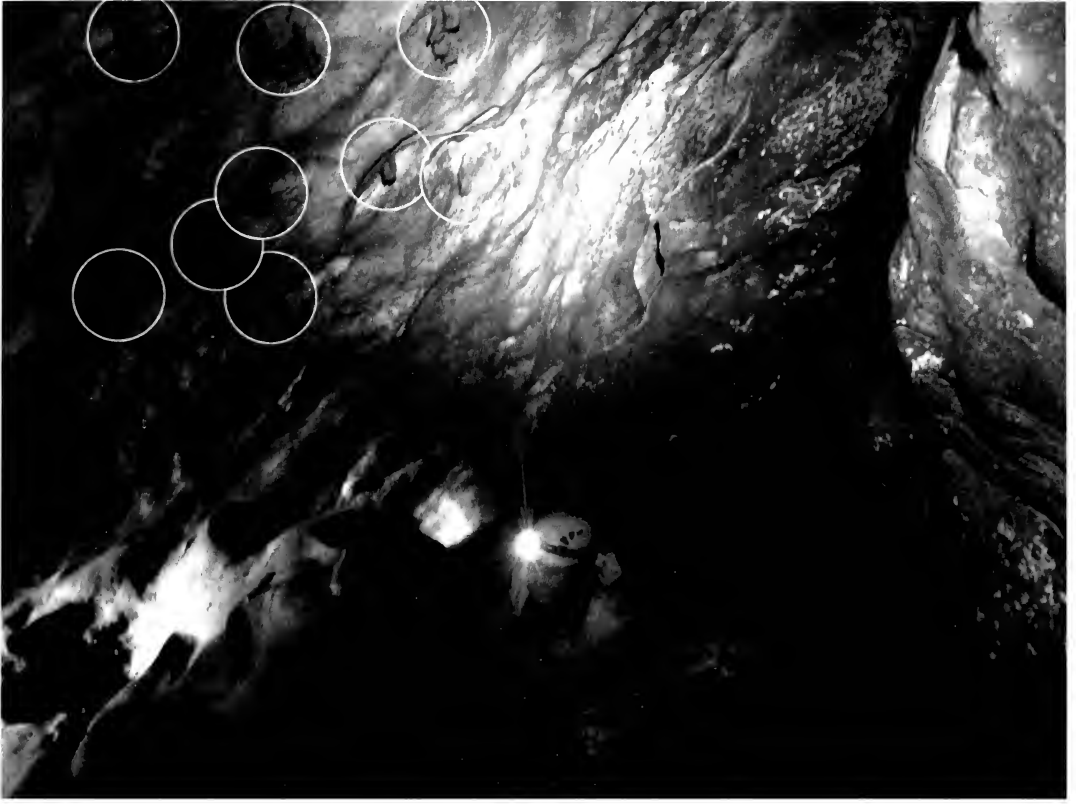


FIGURE 2. *Myotis* spp., both individuals and clusters, can be seen roosting high on the left wall of Berryton Cave, New Brunswick. Circles mark a total of 22 bats. Narrow passages that gradually become restricted as they reach a height of as much as 7 m make it difficult to count bats at this site. Photo: DFM, 14 December 2011.

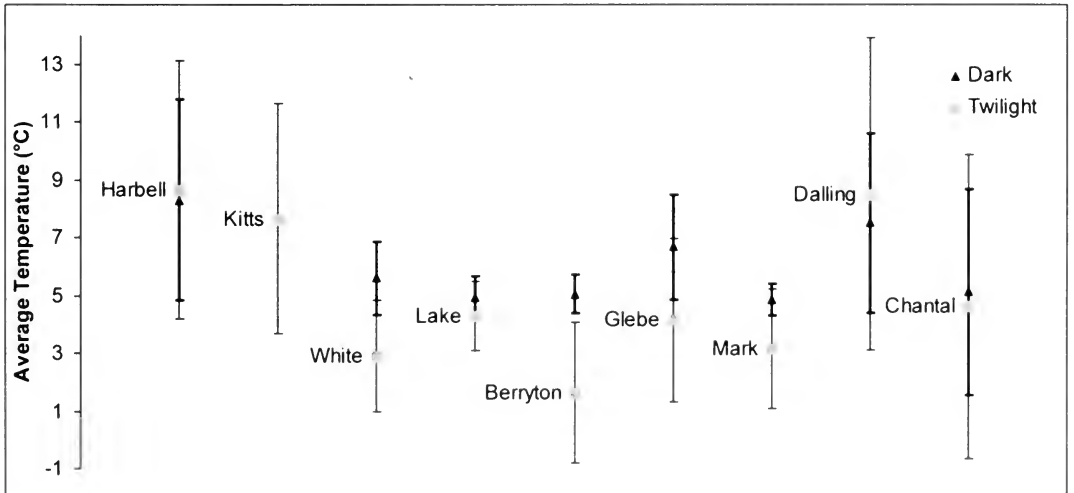


FIGURE 3. Average temperature (SD) of surveyed New Brunswick caves over a one-year period from November 2009 to November 2010. Dark and Twilight refer to the locations of the data loggers within the cave. Mark = Markhamville Mine, and Lake = Underground Lake Cave. Hibernating bats were not recorded in Dalling's or Chantal's caves. Dark zone data were not available for Kitts Cave.

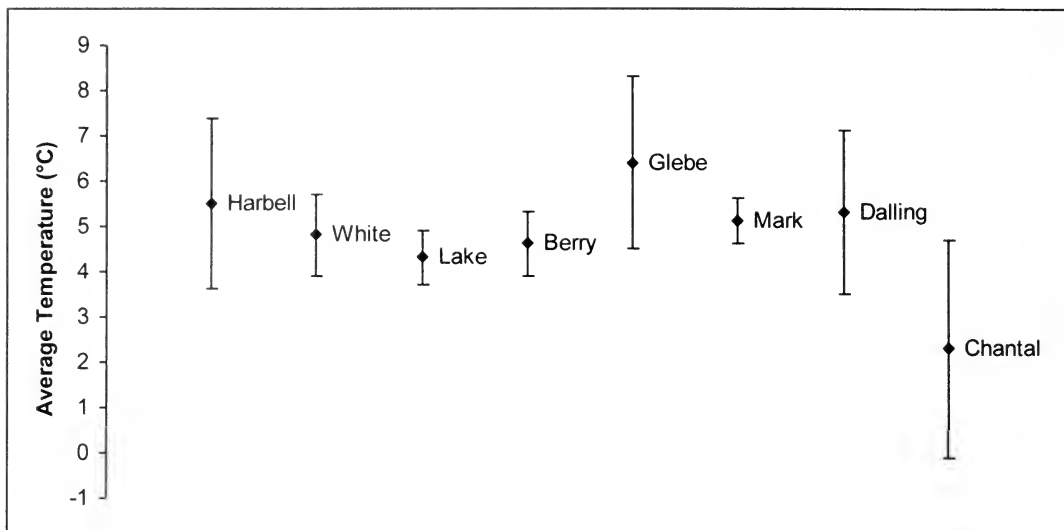


FIGURE 4. The average dark zone temperature (SD) of New Brunswick caves during the winter (1 November 2009 to 30 April 2010) when bats are present. Dalling's and Chantal's caves did not harbor bats. Data for Kitt's Cave were unavailable. Mark = Markhamville Mine, Lake = Underground Lake Cave, and Berry = Berryton Cave.

The dark zone temperature of Berryton Cave, the New Brunswick hibernaculum harbouring the largest number of bats, was particularly stable. When the iButton was first deployed in Berryton Cave on 6 October 2009, a temperature of 5.6°C was recorded twice a day until 8 December 2009, when the temperature gradually began to fall to a low of 3.1°C at the beginning of February. The temperature reached 5.6°C again on 6 July 2010 and remained constant until the iButton was removed on 8 October 2010.

The resistance of Markhamville Mine to outside climatic influence is also notable. This site demonstrated the longest lag time in responding to outside seasonal temperature changes. Markhamville Mine reached its minimum dark zone temperature (4.1°C) on 22 April 2010 and remained at that temperature until 24 July 2010. Maximum temperature in Markhamville Mine was reached on 21 November 2010, while the other caves reached maximum temperatures in early September or early October. Generally, caves reached their minimum temperatures in early February (lowest average temperatures in March) (Figure 5). The magnitude of temperature variation was smallest in late winter/early spring and greatest in the fall.

No hibernating bats were recorded in Chantal's Cave; this was the only cave site where air temperatures below 0°C in the dark zone were recorded (Figure 6). Although three bats were found in Dalling's Cave in November 2009, we do not believe this site is routinely used as a hibernaculum (one freshly dead *Myotis septentrionalis* was recorded in Dalling's Cave in February 2010). These two sites had the greatest dark zone winter air temperature ranges, from 2.6 to 9.1°C

(Dalling's) and -2.9 to 8.1°C (Chantal's) (higher maximum temperatures shown in Figure 6 were reached during the summer). The winter air temperature in the hibernaculum with the greatest dark zone winter air temperature range, Harbell's Cave, varied from 3.6 to 9.6°C. While the winter air temperature range in Harbell's Cave was almost as great as in Dalling's Cave, the minimum dark zone temperature of 3.6°C in Harbell's Cave appears to be high enough that small numbers of bats can successfully overwinter at this site.

Only bat abundance data collected in 2010 were used in our analysis of factors characterizing hibernacula. Data collected in 2009 were preliminary and missing from most sites. By 2011, white-nose syndrome was present in the study area and had clearly affected bat behaviour at the one cave where it was detected (McAlpine et al. 2011).

Bat abundance was not correlated with cave length ( $R = 0.577$ ,  $P = 0.104$ ), minimum dark zone temperature ( $R = 0.341$ ,  $P = 0.408$ ), or average dark zone winter temperature ( $R = -0.252$ ,  $P = 0.548$ ), but it was negatively correlated with dark zone winter temperature variation ( $R = -0.898$ ,  $P = 0.002$ ). When non-hibernacula were excluded from the analysis, bat abundance was negatively correlated with average dark zone winter temperature ( $R = -0.854$ ,  $P = 0.031$ ) but not with minimum dark zone temperature ( $R = -0.598$ ,  $P = 0.210$ ). Caves without running water ( $n = 6$ ) had significantly more bats than caves with running water ( $n = 4$ ) ( $W = 45.0$ ,  $P = 0.014$ ). However, these environmental variables are not independent of each other. The presence of running water in a cave significantly increases the temperature variation ( $W = 15$ ,  $P = 0.037$ ).



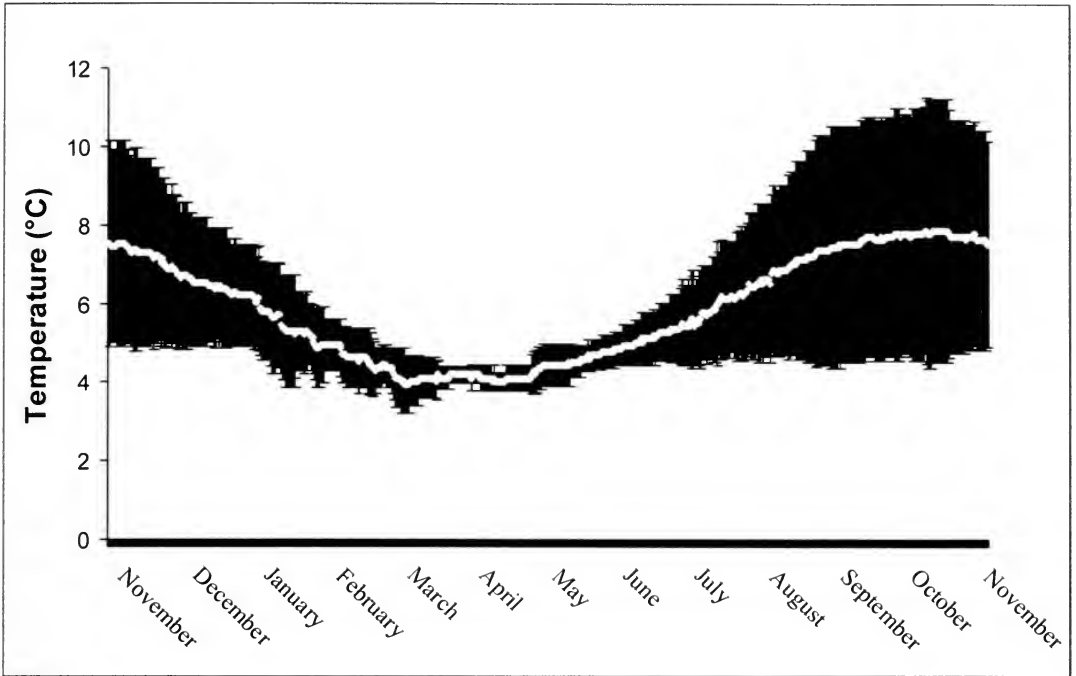


FIGURE 5. The combined average dark zone temperature (SD) in seven New Brunswick caves used as bat hibernacula over a one-year period (November 2009 to November 2010).

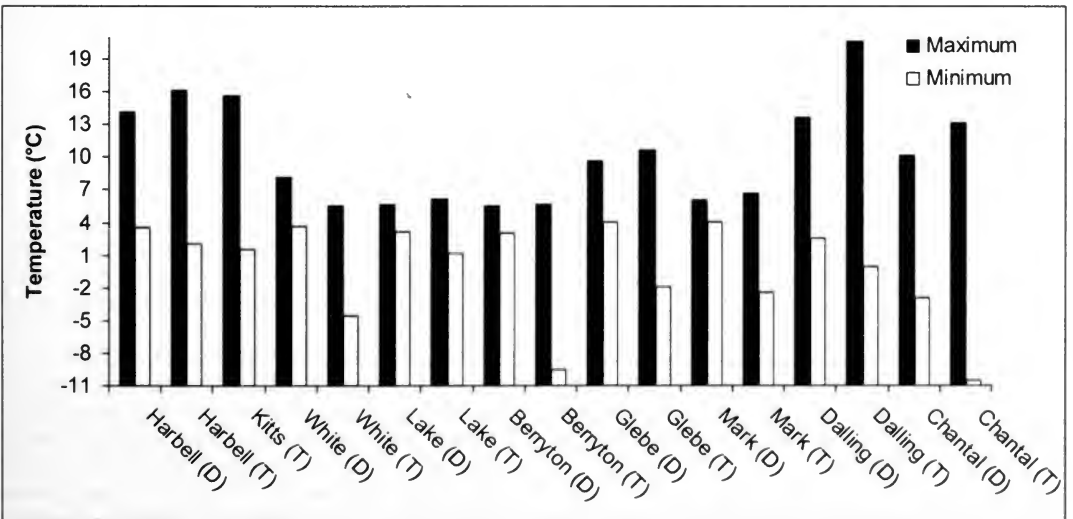


FIGURE 6. The maximum and minimum temperatures of New Brunswick caves over a one-year period from November 2009 to November 2010 in the dark zone (D) and the twilight zone (T). Mark = Markhamville Mine and Lake = Under-ground Lake Cave.

## Discussion

It appears that the number of bats in Berryton Cave was drastically underestimated in 2010. Counts for other caves that were not infected with white-nose syndrome are generally consistent across years, and we believe they provide a reliable index of bat numbers. The structure of the passages in these caves does not suggest large numbers of bats were uncounted. This is confirmed by data collected at these hibernacula in 2012 subsequent to this study (in preparation). Even where white-nose syndrome was present and bat behaviour had changed (winter 2012), we did not record the kind of dramatic increases in bat numbers that we did in Berryton. While the number of bats counted may not reflect the absolute number of bats present, consistency suggests that such counts at some sites may be useful in the long-term monitoring of bat populations.

The maximum number of overwintering bats we counted in New Brunswick was ~7 000 in 2011. This is half the size of the total known overwintering population of *Myotis lucifugus* in Nova Scotia (~15 000; Scott and Hebda 2004). There are no summer bat population estimates for New Brunswick, but the summer population of *M. lucifugus* in Nova Scotia has been estimated at ~300 000 (Scott and Hebda 2004). New Brunswick has 71 450 km<sup>2</sup> of land area and Nova Scotia has 53 338 km<sup>2</sup> (Statistics Canada 2005\*) with similar habitat types (Davis and Browne 1996; Zelazny 2007). Extrapolating from the figures in Scott and Hebda (2004), we believe New Brunswick may support numbers of *M. lucifugus* during the summer months equal to or greater than the number in Nova Scotia.

Several North American studies have noted that known winter populations of cave-dwelling bats are smaller than summer populations (Griffin 1945; Hitchcock 1949; Davis 1959). It is possible that bats may hibernate in rock crevices and caves unknown and inaccessible to investigators. In a Colorado radio-tracking study, Neubaum et al. (2006) found Big Brown Bats hibernating in rock crevices. It is worth adding, however, that this species is noted for its tolerance of low temperatures. Also, a portion of the summer bat population in the Maritimes may possibly overwinter elsewhere, such as the northeastern United States, where suitable hibernacula are more abundant (Wilson 2009\*).

Given the prevalence of white-nose syndrome in the northeastern U.S., such migrations may have hastened the spread of white-nose syndrome to the Maritimes. Wilder et al. (2011) found that caves with many bats (>1 000) were the first to be affected by white-nose syndrome. This pattern was observed in New Brunswick; Berryton Cave bat counts were well above those of other caves in the province, even before white-nose syndrome was detected at this site.

The average annual air temperature of all New Brunswick caves studied (5.5°C, SD 1.6) is similar to that reported for caves in central Nova Scotia (~5.7°C) (Moseley 2007b). Generally, temperatures in the dark

zone of caves worldwide closely approximate the mean annual temperature of the surrounding region (Dwyer 1971).

The stability of the temperature observed in Berryton Cave, Markhamville Mine, and Underground Lake Cave can be attributed to a combination of the length of the cave and the entrance structure. Caves with vertical or inclined entrances act as cold air sumps, which improve the environment for hibernation by lowering the temperature and reducing temperature fluctuations (Daan and Wichers 1968). Berryton Cave has a narrow vertical entrance, Markhamville Mine has a narrow inclined entrance with a sustained deepening of the passages beyond it, and Underground Lake Cave has a large but deeply inclined entrance. The large body of stationary water in Underground Lake Cave (ground-water fed) may also help moderate temperatures at this site.

The temperature variability in Harbell's, Dalling's, Kitt's, and Chantal's caves is the result of the presence of an active stream in each of these caves during the hibernation period. The streams passing through Harbell's and Dalling's caves are particularly active, and the noise of running water can disturb hibernating bats (Speakman et al. 1991). Chantal's Cave has two entrances, and a noticeable draft through this cave results in variable and low winter temperatures that make the site unsuitable for hibernating bats. As well, Glebe Mine and Harbell's, Dalling's, and Chantal's caves do not have inclined entrances, so that, unlike the other caves, they do not trap cold air and are influenced more by outside temperatures. This is particularly obvious when the maximum and minimum temperatures of the caves are considered.

The difference in the magnitude of the variation in air temperature between September and November and between March and June may be due to cave topography. In caves with an entrance that includes a vertical drop, dense, cold air will flow into the cave during cold weather periods and then remain trapped in the cave during warm weather. Once such a body of cold air is established, it appears to be fairly resistant to change as the above ground air warms. Indeed, none of the New Brunswick study caves reached their maximum temperatures until early September or October. At this time, caves no longer appear to be buffered by the internal body of cold air and therefore experience greater temperature variation.

The body of cold air is not re-established until early February or March, when caves reach their minimum temperatures, and this period is accompanied by a reduction in temperature variation. Similarly, in Nova Scotia, maximum cave temperatures were recorded in September and October and minimum temperatures in January and February (Moseley 2007b); in Indiana, maximum cave temperatures were recorded in September and October and minima between January and March (Richter et al. 1993). These results suggest con-

siderable similarity in patterns of seasonal cave temperatures across temperate North America.

Bat abundance in the New Brunswick caves studied was negatively correlated with winter temperature variation and the presence of running water in the main passage. In England, Glover and Altringham (2008) found that bat swarming (mating) activity was negatively correlated with the amount of water passing through a cave. Briggler and Prather (2003) found that bats in Arkansas prefer to hibernate in larger caves because these caves have greater buffering capacity. Bat abundance was not correlated with cave length in New Brunswick.

Sandel et al. (2001) found that minimum cave temperature was a significant microclimate predictor of the abundance of bats in Texas hibernacula, but this was not the case in New Brunswick. Briggler and Prather (2003) found that *Perimyotis subflavus* was significantly more likely to be found in Arkansas caves with higher temperatures (11.4°C vs. 10.5°C), but in New Brunswick we found bat abundance was negatively correlated with increasing average winter dark zone temperature, once non-hibernacula (the two coldest caves) were excluded.

Hibernating at warm temperatures leads to increased energy expenditure but lessens the negative physiological aspects of hibernation (Boyles et al. 2007). It is possible that, in areas with relatively long hibernation periods (like New Brunswick), conserving energy by hibernating at low temperatures is a more effective strategy than reducing the negative physiological aspects of hibernation by roosting at higher temperatures.

The optimal hibernation temperature for *Myotis lucifugus* has been reported as 2°C because metabolic rate is at its lowest at this temperature (Hock 1951; McManus 1974). However, Boyles and McKechnie (2010) argue that the optimal hibernating temperature in environments that are thermally unstable is above the temperature at which the metabolic rate is minimized. Microclimates in hibernacula fluctuate over the winter, and bat energy expenditure is positively correlated with temperature variation (Boyles and McKechnie 2010). *M. lucifugus* incur disproportionately larger energetic costs roosting at temperatures below 2°C than above 2°C (Boyles and McKechnie 2010). Therefore, to accommodate temperature fluctuations, the optimal hibernation temperature for *M. lucifugus* appears to be a few degrees above 2°C.

Wilder et al. (2011) suggest that mines are less likely to be affected by white-nose syndrome than caves, perhaps due to differences in microclimate or the population dynamics of bats occupying mines, and data presented by Langwig et al. (2012) indicated that the impacts of white-nose syndrome are greater in warmer, more humid hibernacula. In the current study, mines in New Brunswick were slightly warmer than caves, but it remains unclear whether such sites offer any kind of refuge from white-nose syndrome in the Maritimes.

In conclusion, hibernacula in New Brunswick that support the greatest number of *Myotis lucifugus*, *M. septentrionalis*, and *Perimyotis subflavus* show little temperature variation, have average winter dark zone temperatures of 4–5°C, and have a minimum dark zone temperature no lower than 3.1°C. New Brunswick caves with these temperature patterns characteristically have a main passage length of ≥140 m, do not have running water, and do not have multiple entrances.

Few cave sites in New Brunswick meet these criteria, and winter bat counts appear to be well below estimated summer bat populations. Clearly many bats either hibernate in unknown and inaccessible locations in the province or migrate out of the province annually to locate suitable hibernacula. Such movements may have hastened the arrival of white-nose syndrome in New Brunswick, first documented in the province's largest hibernaculum in March 2011.

### Acknowledgements

We thank Joel Smith, Lynne Burns, Kelly Sparks, Katie Leger, Evan Young, Hurst Ganon, and Fenning McAlpine for invaluable field assistance. We are grateful to Joan Chown, Tony Gilchrist, and David Roberts for allowing us access to their properties. Research funding was provided by the New Brunswick Wildlife Trust Fund, the New Brunswick Department of Natural Resources, and the University of New Brunswick. KV was in receipt of an Orville Erickson Scholarship from the Canadian Wildlife Federation during a portion of the work and offers her thanks for this support.

### Documents Cited (marked \* in text)

- Environment Canada.** 2011. National Climate Data and Information Archive. Canadian Climate Normals 1971–2000, Saint John and Moncton. New Brunswick. [http://www.climate.weatheroffice.gc.ca/climate\\_normals/result\\_s\\_e.html?stnID=6250&lang=e&dCode=1&province=NB&provBut=&month1=0&month2=12](http://www.climate.weatheroffice.gc.ca/climate_normals/result_s_e.html?stnID=6250&lang=e&dCode=1&province=NB&provBut=&month1=0&month2=12). (Accessed 8 December 2011).
- Statistics Canada.** 2005. Land and freshwater area, by province and territory. Summary tables, Statistics Canada. <http://www.statcan.gc.ca/tables-tableaux/sum-som/101/cst01/phys01-eng.htm>. (Accessed 10 January 2012).
- United States Fish and Wildlife Service.** 2009. Recommended procedures to prevent the possible spread of white-nose syndrome. <http://whitenosesyndrome.org/topics/decontamination> (Accessed September 11, 2012).
- Wilson, Z.** 2009. White nose syndrome and bat hibernacula. Bat Conservation International. <http://batmanagement.com/wns/wns.html>. (Accessed 10 January 2012).

### Literature Cited

- Arseneault, S. P., J. Schroeder, D. Berube, and R. Albert.** 1997. The caves of southeastern New Brunswick (revised and supplemented). Natural Resources and Energy. Open file 97-7: 1–33.
- Blehert, D. S., A. C. Hicks, M. Behr, C. U. Meteyer, B. M. Bertowski-Zier, E. L. Buckles, J. T. H. Coleman, S. R. Darling, A. Gargas, R. Niver, J. C. Okoniewski, R. J. Rudd, and W. B. Stone.** 2009. Bat white-nose syndrome:

- an emerging fungal pathogen? *Science* 323 (5911): 227–227.
- Boyles, J. G., M. B. Dunbar, J. J. Storm, and V. Brack, Jr.** 2007. Energy availability influences microclimate selection of hibernating bats. *Journal of Experimental Biology* 210: 4345–4350.
- Boyles, J. G., and A. E. McKechnie.** 2010. Energy conservation in hibernating endotherms: why “suboptimal” temperatures are optimal. *Ecological Modelling* 221: 1646–1649.
- Briggler, J. T., and J. W. Prather.** 2003. Seasonal use and selection of caves by the Eastern Pipistrelle Bat (*Pipistrellus subflavus*). *American Midland Naturalist* 149(2): 406–412.
- Daan, S., and H. J. Wichers.** 1968. Habitat selection by bats hibernating in a limestone cave. *Zeitschrift für Saugetierkunde* 33: 262–287.
- Davis, W. H.** 1959. Disproportionate sex ratios in hibernating bats. *Journal of Mammalogy* 40: 16–19.
- Davis, D. S., and S. Browne.** 1996. *The natural history of Nova Scotia*. Volume 1: Topics and habitats. Nimbus Publishing, Nova Scotia Museum. 518 pages.
- Dwyer, P. D.** 1971. Temperature regulation and cave-dwelling in bats: an evolutionary perspective. *Mammalia* 35: 424–455.
- Frick, W. F., J. F. Pollock, A. C. Hicks, K. E. Langwig, D. S. Reynolds, G. G. Turner, C. M. Butchkoski, and T. H. Kunz.** 2010. An emerging disease causes regional population collapse of a common North American bat species. *Science* 329: 679–682.
- Glover, A. M., and J. D. Altringham.** 2008. Cave selection and use by swarming bat species. *Biological Conservation* 141: 1493–1504.
- Griffin, D. R.** 1945. Travels of banded cave bats. *Journal of Mammalogy* 26(1): 15–23.
- Guthrie, M. J.** 1933. Notes on the seasonal movements and habits of some cave bats. *Journal of Mammalogy* 14: 1–19.
- Hitchcock, H. B.** 1949. Hibernation of bats in southeastern Ontario and adjacent Quebec. *Canadian Field-Naturalist* 63: 47–59.
- Hock, R. J.** 1951. The metabolic rates and body temperatures of bats. *Biological Bulletin* 101: 289–299.
- Hoyos, M., V. Soler, J. C. Canaveras, S. Sanchez-Moral, and E. Sanz-Rubio.** 1998. Microclimate characterization of a karstic cave: human impact on microenvironmental parameters of a prehistoric rock art cave (Candamo Cave, northern Spain). *Environmental Geology* 33(4): 231–242.
- Jurado, V., E. Porca, S. Cuezva, A. Fernandez-Cortes, S. Sanchez-Moral, and C. Saiz-Jimenez.** 2010. Fungal outbreak in a show cave. *Science of the Total Environment* 408: 3632–3638.
- Laiz, L., M. Gonzalez-Delvalle, B. Hermosin, A. Ortiz-Martinez, and C. Saiz-Jimenez.** 2003. Isolation of cave bacteria and substrate utilization at different temperatures. *Geomicrobiology Journal* 20: 479–489.
- Langwig, K. E., W. F. Frick, J. T. Bried, A. C. Hicks, T. H. Kunz, and A. M. Kilpatrick.** 2012. Sociality, density-dependence and microclimate determine the persistence of populations suffering from a novel fungal disease, white-nose syndrome. *Ecology Letters* 15: 1050–1057.
- McAlpine, D. F.** 1976. Howes Cave, New Brunswick. *Canadian Caver* 8: 28–30.
- McAlpine, D. F.** 1979. Preliminary investigations on the solution caves of New Brunswick. *Journal of the New Brunswick Museum* 1979: 99–107.
- McAlpine, D. F.** 1982. Map surveys of New Brunswick solution caves. *Canadian Caver* 14: 26–31.
- McAlpine, D. F.** 1983. Status and conservation of solution caves in New Brunswick. New Brunswick Museum Publications in Natural Science No. 1. 28 pages.
- McAlpine, D. F., K. J. Vanderwolf, G. J. Forbes, and D. Malloch.** 2011. Consumption of bats (*Myotis* spp.) by Raccoons (*Procyon lotor*) during an outbreak of white-nose syndrome in New Brunswick, Canada: implications for estimates of bat mortality. *Canadian Field-Naturalist* 125: 257–260.
- McManus, J. J.** 1974. Activity and thermal preference of the little brown bat, *Myotis lucifugus*, during hibernation. *Journal of Mammalogy* 55: 844–846.
- McNabb, K.** 1974. The behavior of temperate cave bats in a subtropical environment. *Ecology* 55: 943–958.
- Meretsky, V. J., V. Brack Jr., T. C. Carter, R. Clawson, R. R. Currie, T. A. Hemberger, C. J. Herzog, A. C. Hicks, J. A. Kath, J. R. MacGregor, R. A. King, and D. H. Good.** 2010. Digital photography improves consistency and accuracy of bat counts in hibernacula. *Journal of Wildlife Management* 74(1): 166–173.
- Moseley, M.** 2007a. Records of bats (Chiroptera) at caves and mines in Nova Scotia. Curatorial Report no. 99, Nova Scotia Museum, Halifax, Nova Scotia. 21 pages.
- Moseley, M.** 2007b. Acadian biospeleology: composition and ecology of cave fauna of Nova Scotia and southern New Brunswick, Canada. *International Journal of Speleology* 36(1): 1–21.
- Neubaum, D. J., T. J. O’Shea, and K. R. Wilson.** 2006. Autumn migration and selection of rock crevices as hibernacula by big brown bats in Colorado. *Journal of Mammalogy* 87(3): 470–479.
- Richter, A. R., S. R. Humphrey, J. B. Cope, and V. Brack, Jr.** 1993. Modified cave entrances: thermal effect on body mass and resulting decline of endangered Indiana bats (*Myotis sodalis*). *Conservation Biology* 7(2): 407–415.
- Sandel, J. K., G. R. Benatar, K. M. Burke, C. W. Walker, T. E. Lacher Jr., and R. L. Honeycutt.** 2001. Use and selection of winter hibernacula by the Eastern Pipistrelle (*Pipistrellus subflavus*) in Texas. *Journal of Mammalogy* 82(1): 173–178.
- Scott, F., and A. J. Hebda.** 2004. Annotated list of the mammals of Nova Scotia. *Proceedings of the Nova Scotia Institute of Science* 42(2): 189–208.
- Speakman, J. R., P. I. Webb, and P. A. Racey.** 1991. Effects of disturbance on the energy expenditure of hibernating bats. *Journal of Applied Ecology* 28: 1087–1104.
- Thomas, D. W.** 1995. Hibernating bats are sensitive to non-tactile human disturbance. *Journal of Mammalogy* 76: 940–946.
- Turner, G.R., and D. M. Reeder.** 2009. Update of white-nose syndrome in bats. *Bat Research News* 50: 47–53.
- Wilder, A. P., W. F. Frick, K. E. Langwig, and T. H. Kunz.** 2011. Risk factors associated with mortality from white-nose syndrome among hibernating bat colonies. *Biology Letters* 7: 950–953.
- Willis, C. K. R., J. W. Jameson, P. A. Faure, J. G. Boyles, V. Brack, Jr., and T. H. Cervone.** 2009. Thermocron iButton and iBBat temperature dataloggers emit ultrasound. *Journal of Comparative Physiology B* 179: 867–874.
- Zelazny, V. F.** 2007. *Our landscape heritage: the story of ecological land classification in New Brunswick*. Second edition. New Brunswick Department of Natural Resources, Fredericton, New Brunswick. 359 pages.

# Site Fidelity and Annual Survival of the Western Yellow-breasted Chat (*Icteria virens auricollis*) at the Northern Edge of its Range

RENÉ MCKIBBIN and CHRISTINE A. BISHOP<sup>1</sup>

Environment Canada, 5421 Robertson Road, Delta, British Columbia V4K 3N2 Canada

<sup>1</sup>Corresponding author email: cab.bishop@ec.gc.ca

McKibbin, René, and Christine A. Bishop. 2012. Site fidelity and annual survival of the Western Yellow-breasted Chat (*Icteria virens auricollis*) at the northern edge of its range. *Canadian Field-Naturalist* 126(2): 135–142.

We studied return rates, site fidelity, dispersal, and survivorship of an endangered population of the Western Yellow-breasted Chat (*Icteria virens auricollis*) in the southern Okanagan River valley, British Columbia, between 2001 and 2007. Between 2001 and 2006, we banded a total of 75 adults and 385 nestlings. Apparent survival for male Western Yellow-breasted Chats banded as adults was 65%, and survival and recapture were constant across time. Other results were as follows: 44% of males and 13% of females banded as adults were re-sighted during the period 2002–2007; 33% of males and 10% of females were re-sighted the year after they were banded; 31% of males and 10% of females had fidelity to the study site where they were banded as adults; 10% of Western Yellow-breasted Chats banded as nestlings returned and, of these, 62% of males and 54% of females returned to their natal study site to breed. The dispersal distance for males banded as adults ( $n = 5$ ) that did not return to their sites ranged from 6.4 km to 42.9 km. Natal dispersal ranged from 2.5 km to 15.6 km for males ( $n = 7$ ) and 2.3 km to 2.6 km for females ( $n = 2$ ); 16 males and 7 females banded as nestlings did not disperse. These findings contrast with predictions that species at the northern limit of their range will have low site fidelity and return rates and higher dispersal distances than passerine populations at the core of their range.

**Key Words:** Yellow-breasted Chat, *Icteria virens auricollis*, northern periphery of range, return rates, site fidelity, natal philopatry, apparent local survival, British Columbia.

A population of the western subspecies of the Yellow-breasted Chat (*Icteria virens auricollis*) designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2011\*) occurs within a very restricted area in British Columbia at the northern tip of its range (Eckerle and Thompson 2001). Sites at the periphery of a species' range have occasionally been shown to be very important for conserving endangered species and biodiversity (Chanel and Lomolino 2000).

The breeding range of the Yellow-breasted Chat (*Icteria virens*) extends from Mexico to southern Canada (Eckerle and Thompson 2001). In Canada, the western subspecies breeds in southeastern Alberta, southern Saskatchewan, south-central British Columbia, and the extreme southwestern portion of British Columbia (Eckerle and Thompson 2001). The eastern subspecies (*I. virens virens*) breeds in Canada in southern Ontario (Eckerle and Thompson 2001).

In British Columbia, the Yellow-breasted Chat breeds only within 100 km of the U.S. border, in the Similkameen, Okanagan, and Kootenay river valleys (Eckerle and Thompson 2001; Dulisse et al. 2005). In the southern Okanagan River valley in British Columbia, Yellow-breasted Chats nest exclusively in riparian thickets. At least 87% of this habitat has been converted to urban and agricultural development (Lea 2008). The population size of the Yellow-breasted Chat in British Columbia was estimated to be less than 152 breeding pairs

(COSEWIC 2011\*), but the fecundity of this population is similar to southern populations of Yellow-breasted Chats (Morgan et al. 2007).

To ensure effective management, conservation, and recovery of an endangered species and its habitat, it is essential to have a basic understanding of dispersal dynamics (Saunders et al. 1991; Fahrig and Merriam 1994). Data on demographic variables such as survival, dispersal, and site fidelity are essential for conservation, restoration, and management of species (Woolfenden et al. 2001; Sillett and Holmes 2002; Sedgwick 2004). If site fidelity is low and birds disperse regularly, management strategies for restoring and creating habitat may not be effective because the populations will not necessarily be concentrated in high-quality habitat (Schlossberg 2009). However, if site fidelity is high, management will be more straightforward because the population will be more closed (Robinson and Morse 2000).

There has been very little study of the demography of *I. virens*, and most research has been done on the eastern subspecies (e.g., Thompson and Nolan 1973; Burhans and Thompson 1999; Ricketts and Ritchison 2000; Lehnen and Rodewald 2009). The objective of this study was to fill data gaps on demography of this endangered population to better understand the potential for the population to persist in this fragmented landscape.

## Study Area

The study area (Figure 1) is within the riparian zone of the Okanagan River in the southern Okanagan valley in British Columbia, between Penticton (49°27'N, 119°36'W) and Osoyoos (49°1'N, 119°26'W) on the U.S. border, a distance of 66 km. Elevation of study sites ranged from 297 m to 344 m above sea level. Owing to sensitivity among landowners regarding the occurrence of species at risk on their lands, the nine study sites are not identified on the map of the study area (Figure 1).

The riparian habitat within the Okanagan valley south of Penticton is highly fragmented by urban and agricultural development, and it consists of nine discontinuous patches that, prior to 1938 (Lea 2008), were connected within tributaries and drainage lines of the Okanagan River. A study site was defined as a patch of contiguous riparian habitat containing no shrub-steppe habitat or urban or agricultural development. Each study site consisted of a strip of riparian habitat between 0.05 and 1 km in width and between 0.25 and 4.5 km in length. Study sites contained between 2 and 38 territories.

The tree layer consisted mainly of Black Cottonwood (*Populus trichocarpa*), Water Birch (*Betula occidentalis*), willows (*Salix* spp.), and Mountain Alder (*Alnus incana* subsp. *tenuifolia*), and the shrub layer was dominated by wild roses (*Rosa acicularis*, *R. nutkana*, *R. woodsii*, and *R. gymnocarpa*) with Common Snowberry (*Symphoricarpos albus*), Saskatoon (*Amelanchier alnifolia*), and Red-osier Dogwood (*Cornus stolonifera*). The herbaceous layer included a variety of grass and wildflower species (Morgan et al. 2006). Wild roses are the main shrub species used by Western Yellow-breasted Chats for breeding (McKibbin and Bishop 2010), and suitable breeding habitat was defined as containing wild rose and other riparian species noted above.

The sizes of study sites and dispersal distances were measured with ArcGIS 9.0 (ESRI 1999\*). The combined area of the nine study sites was 189.4 ha. Individually, study sites ranged in size from 1.4 to 89.2 ha (mean of 21.04 ha, SD 28.67). Study sites one to seven were in the south of the study area between 3 and 18 km apart. Study site nine was 28 km north of the nearest site to the south. Study site eight was between the northern and southern study sites.

Three banding stations in the Monitoring of Avian Productivity and Survivorship Program (MAPS) (DeSante et al. 2001) were within our study area. All Western Yellow-breasted Chats ( $n = 8$ ) colour-banded at those stations were included in the study. Western Yellow-breasted Chats banded outside the nine study sites ( $n = 5$ ) were from "other" sites without suitable breeding habitat. Those Western Yellow-breasted Chats, which were banded at the beginning of the breeding season, were not observed again. They were likely moving through and did not breed.

During the study years, >90% of suitable habitat in the southern Okanagan valley (Lea 2008) was surveyed for Western Yellow-breasted Chats, and it was therefore unlikely that Western Yellow-breasted Chats breeding in the study area were not detected. The nine study sites represented the areas where there was a concentration of Western Yellow-breasted Chats.

## Methods

### Field surveys

Each study site was visited approximately every three to four days between mid-May and late July in 2001 to 2007 to determine whether singing males were present. The observer sat quietly for 10 minutes; if no Western Yellow-breasted Chats were detected, the recorded tape of a singing male Yellow-breasted Chat was played for 30 seconds, followed by a 2-minute silence, during which the observer listened and watched for a reaction. If no Western Yellow-breasted Chats were seen or heard, the tape was replayed once before the observer moved 50 m to the next suitable area. A minimum of 20 to 30 minutes was spent in each potential breeding habitat.

If a Western Yellow-breasted Chat was observed or was heard singing, the potential territory was revisited within four days; if the male was still present, territory occupancy was confirmed. A confirmed territory was monitored every three to four days to determine whether a female was present and whether the adults were banded, to locate nests, and to confirm breeding. If adults were banded, we attempted to read the colour bands with binoculars and/or spotting scopes. Band combinations of an individual were accepted as accurate after two consistent observations, preferably by two different observers, on separate visits to the territory. Nests were located by following Western Yellow-breasted Chats that were carrying nesting material or food and by listening for audible clues made by the female when on or near a nest, and then systematically searching through the wild rose patch. Territories and nests were monitored throughout the breeding season following Morgan et al. (2006).

Methodology for mist-netting and colour-banding of adults are described in McKibbin and Bishop (2008). Nestlings were banded at age six days.

### Demographic variables

Methodology for mapping of breeding territories is described in McKibbin and Bishop (2010). Mean territory size was 0.37 ha (SD 0.27,  $n = 66$ ) (McKibbin and Bishop 2010). A territory was considered the same as in previous years if the male sang or defended an area within the boundaries of the territory from other years of the study.

We estimated apparent survival, not actual survival (Baker et al. 1995), because our estimates do not distinguish between mortality and permanent dispersal (Lebreton et al. 1992). Return rate was defined as the

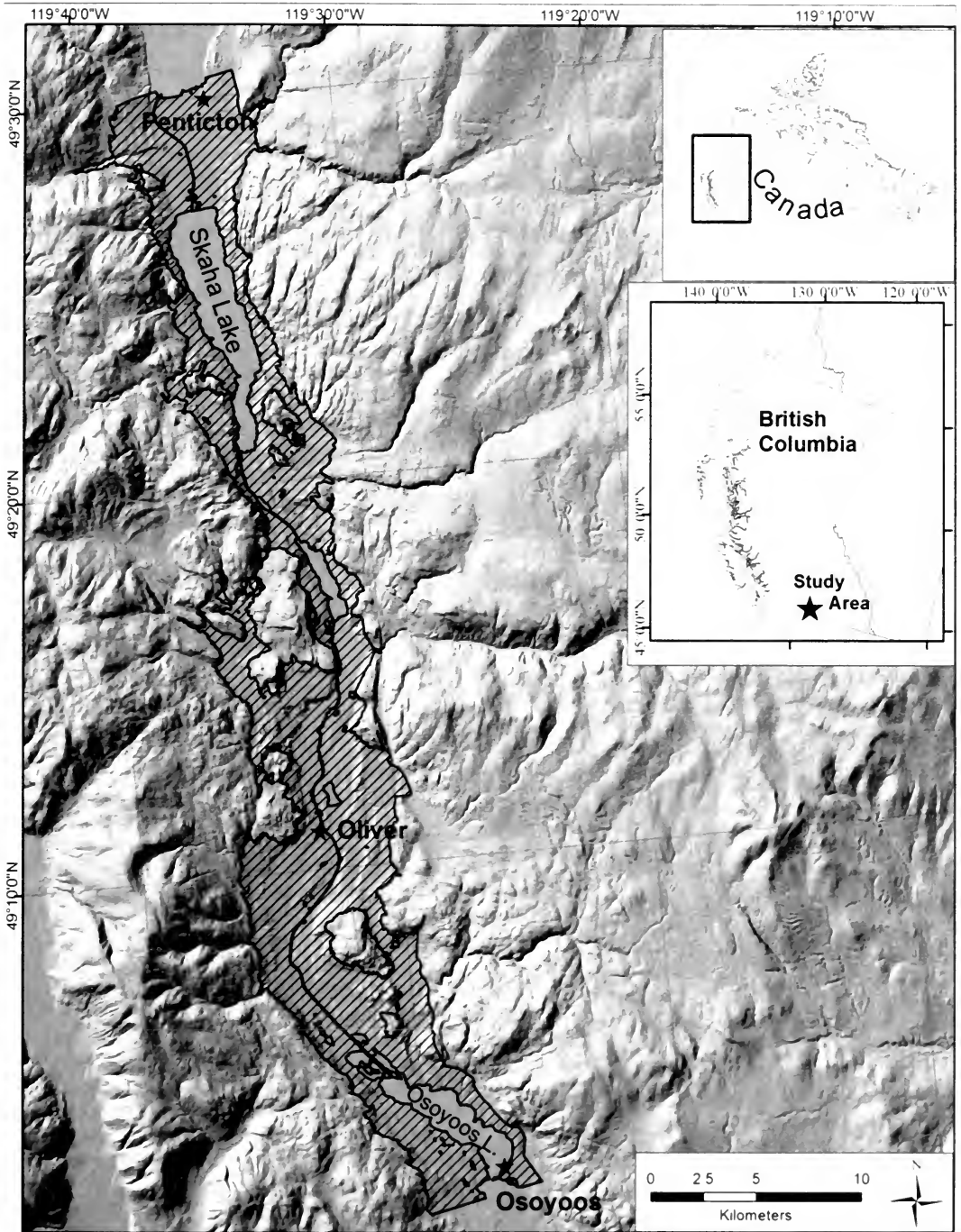


FIGURE 1. Western Yellow-breasted Chat (*Icteria virens auricollis*) study area in the southern Okanagan valley, British Columbia.

percentage of colour-banded Western Yellow-breasted Chats recaptured or re-sighted in the southern Okanagan valley the following year or during the study period

(Sanderecock 2006). Site fidelity was defined as the percentage of colour-banded Western Yellow-breasted Chats originally banded as adults on a particular study

site that returned to the same study site the following year. Dispersal was defined as the distance (km) from the centre of the territory (determined by ArcGIS 9.0) in which the bird was banded to the centre of a new territory in a different study site occupied in later years. A bird was considered to have dispersed if it moved from one of the nine study sites to another, not if it moved to a different territory within the same study site. Natal dispersal was defined as the distance (km) from the centre of the territory where the Western Yellow-breasted Chat was born to the centre of the territory that it occupied the following year (year 1). Territory fidelity was defined as the percentage of adults that used the same breeding territory in consecutive years.

#### Statistical analysis

Apparent survival of male Western Yellow-breasted Chats banded as adults ( $n = 45$ ) based on banding and re-sighting data was estimated using Program MARK and compared by sequential models to test for effect of year on survival estimates and recapture rates (White and Burnham 1999). For this study, only two parameters, namely, apparent survival ( $\phi$ ) and recapture probability ( $p$ ), were used, and therefore four different Akaike information criterion (AIC) models (Burnham and Anderson 1998) were fitted to the data, namely  $\phi(t) p(t)$  (survival and probability of recapture is time dependent),  $\phi(.) p(.)$  (survival and probability of recapture is constant),  $\phi(t) p(.)$  (survival is time-dependent and probability of recapture is constant), and  $\phi(.) p(t)$  (survival is constant and probability of recapture is time-dependent) ( $\phi$  = apparent survival,  $p$  = recapture probability,  $t$  = time (year),  $(.)$  = constant).

We tested the model  $\phi(t) p(t)$  using bootstrapped goodness of fit over 1000 simulations in Program MARK (2010). The same analysis was performed combining the data of the 45 males banded as adults that returned in subsequent years and the 26 males banded as nestlings that returned in subsequent years but excluding their first interval. There were not enough re-sightings of females banded as adults and nestlings to support mark-recapture analysis. Return rates for nestlings were therefore estimated as a percentage of Western Yellow-breasted Chats banded as nestlings and re-sighted or recaptured the following year or during the study period, and return rates for females banded as adults were therefore estimated as a percentage of colour-banded females re-sighted or recaptured the following year or during the study period (Sandercock 2006).

Dispersal distances of males banded as nestlings were compared with those of females banded as nestlings, and dispersal distances of males banded as nestlings were compared with those of males banded as adults. Because of small sample size, non-parametric statistics were used. A Wilcoxon rank sum test was done to determine significant differences between dispersal distances. Statistical analysis was performed using the software JMP IN version 4 (SAS Institute Inc.).

TABLE 1. Number of Western Yellow-breasted Chats (*Icteria virens auricollis*) colour-banded in the southern Okanagan valley, British Columbia, during the period 2001–2006.

Year	Banded as adults			Banded as nestlings
	Males	Females	Total	
2001	6 *	1	7	15
2002	8	4 **	12	46
2003	6	7	13	54
2004	5	5 **	10	47
2005	10	5 **	15	91
2006	10	8	18	132
Total	45	30	75	385

\* Includes 2 banded outside the nine study sites

\*\* Includes 1 banded outside the nine study sites

## Results

### Apparent survival estimate and return rates

In 2001 through 2006, we colour-banded 75 adults and 385 nestlings (Table 1). A goodness of fit test on the data for males banded as adults ( $n = 45$ ) determined that the global model  $\phi(t) p(t)$  (survival and probability of recapture is time-dependent) fit the data (bootstrapped goodness of fit  $P = 0.17$ ). The model that fit our data the best (the model with the lowest  $AIC_c$  for males banded as adults) indicated that survival ( $\phi$ ) and probability of recapture ( $p$ ) were constant (Table 2). Apparent survival estimate for males for the best model was 0.65 (SE 0.07, 95% CI 0.5–0.77).

When the data of the 45 males banded as adults that returned in subsequent years and the 26 males banded as nestlings that returned in subsequent years (excluding their first interval) were combined, a goodness of fit test indicated that the data fit the global model (bootstrapped goodness of fit  $P = 0.12$ ). The best model indicated that survival ( $\phi$ ) and probability of recapture ( $p$ ) were constant (Table 3). Apparent survival estimate for the best model was 0.66 (SE 0.06, 95% CI 0.53–0.77).

To compare (1) adults that may have arrived in the southern Okanagan valley from somewhere else and then remained with (2) fledged birds that survived into adulthood and stayed, we analyzed males banded as adults and the combined group of males banded as adults and nestlings.

Of the 45 males that were banded as adults, 20 (44%) were re-sighted in subsequent years (2002–2007): 15 of the 20 males were first re-sighted the next year after being banded, 4 were first re-sighted two years after being banded, and 1 was first re-sighted three years after being banded. Four (13%) of the 30 females that were banded as adults were re-sighted in the southern Okanagan valley during the period 2002–2007. Three females were re-sighted the year after being banded and 1 female was re-sighted two years after being banded.

### Adult site fidelity and dispersal

Fourteen males (31%) of 45 returned to the same study site the year after being banded [(an additional three males also returned to the same study site between



two and three years after being banded, for a total of 17). (Of the 17 males, 12 males also showed territory fidelity by breeding between two and at least five years in the same territory.)] Of the 17 males, 2 bred at the same study site for at least five years, 5 bred at the same study site for at least three years, and 8 bred at the same study site for at least two years. Finally, 2 of the 17 males dispersed the year after they were banded but then bred for at least two years at the same study.

The males ( $n = 5$ ) that did not show between-year site fidelity were observed between 6.4 and 42.9 km from the sites where they had been banded, and they maintained territories in the years that they were banded. The median dispersal distance was 8.14 km (mean 14.98 km, SD 15.7). These observations were made between one and three years after the males were banded.

The three (10%) of the 30 females that were colour-banded as adults and re-sighted the year after being banded all bred for at least two years in the same study site.

No mate fidelity was observed during the study years 2002 to 2007.

It was uncommon for Western Yellow-breasted Chats to relocate their territories during the breeding season. There was only one known occasion when a male relocated to a different study site during the breeding season. This male was detected 12.3 km from his original territory about 10 days after his first nest failed and the female disappeared. The male stayed and defended his second territory for the remainder of the breeding season. A female was detected in the second territory, but we were unable to locate a nest.

#### *Natal philopatry and dispersal*

None of the colour-banded nestlings returned to breed in their natal territory. Thirty-nine (10%) of the 385 chats banded as nestlings returned to the southern Okanagan valley during the period 2002–2007; 26 were males and 13 were females. Sixteen (62%) of the 26 males and 7 (54%) of the 13 females that were re-sighted in the southern Okanagan valley returned to their natal sites.

Of the 10 males that were banded as nestlings and returned to breed in a study site other than their natal site, 7 were observed in year 1. These 7 males dispersed between 2.5 and 15.6 km. The median dispersal distance was 10.3 km (mean 10.2 km, SD 4.5). Of the 6 females that were banded as nestlings and were re-sighted, 2 were observed in year 1. The dispersal distances were 2.3 and 2.6 km. The median and mean dispersal distances for these females were both 4.2 km (SD 0.2). There was no significant difference between dispersal distances for males ( $n = 7$ ) and females ( $n = 2$ ) banded as nestlings and observed in year 1 (Wilcoxon rank sum test,  $\chi^2 = 3.09$ ,  $df = 1$ ,  $P = 0.079$ ). There was no significant difference in dispersal distance of males banded as adults ( $n = 5$ ) and males banded as nestlings ( $n = 7$ ) (Wilcoxon rank sum test,  $\chi^2 = 0.24$ ,  $df = 1$ ,  $P = 0.63$ ).

TABLE 2. Models for estimating local survival of Western Yellow-breasted Chat (*Icteria virens auricollis*) males banded as adults ( $n = 45$ ) in the southern Okanagan valley, British Columbia, during the period 2001–2007.  $\phi$  = apparent survival,  $p$  = recapture probability,  $t$  = time (year), (.) = constant.

Model	AIC <sub>c</sub>	$\Delta$ AIC <sub>c</sub>	AIC <sub>c</sub> weight	Deviance
$\phi(.)p(.)$	133.57	0.00	0.87	47.42
$\phi(.)p(t)$	137.74	4.18	0.11	39.89
$(t)p(.)$	141.02	7.45	0.02	43.16
$\phi(t)p(t)$	144.82	11.26	0.00	36.06

TABLE 3. Models for estimating local survival of Western Yellow-breasted Chat (*Icteria virens auricollis*) males banded as adults and males banded as nestlings that returned in subsequent years, excluding the first interval ( $n = 71$ ) in the southern Okanagan valley, British Columbia, during the period 2001–2007.  $\phi$  = apparent survival,  $p$  = recapture probability,  $t$  = time (year), (.) = constant.

Model	AIC <sub>c</sub>	$\Delta$ AIC <sub>c</sub>	AIC <sub>c</sub> weight	Deviance
$\phi(.)p(.)$	196.9197	0.0000	0.95508	61.4770
$\phi(.)p(t)$	203.5567	6.6370	0.03458	57.0203
$\phi(t)p(.)$	206.0828	9.1631	0.00978	59.5464
$\phi(t)p(t)$	211.8140	14.8943	0.00056	55.4950

## Discussion

Our estimates of return rates, especially for females, are probably an underestimate. Yellow-breasted Chats are elusive and occur in dense bush habitat (Eckerle and Thompson 2001). They have a skulking and secretive nature and, unless they are detected while singing, are often overlooked (Thompson and Nolan 1973; Eckerle and Thompson 2001). Females are more secretive than males, and in our experience an entire breeding season can pass without a sighting of a "nesting" female. Even males often sing from high perches or dense thickets, and this makes reading of colour bands difficult. For example, in this study, up to six hours were spent in a territory throughout the breeding season without any success reading colour bands of some males.

Even though our return rates are an underestimate, our rates of 44% for males banded as adults and 13% for females banded as adults during the six-year period are higher than the return rates for the Eastern Yellow-breasted Chat in the core of its range in southern Indiana, where only 11% of breeding males returned and none of the females were re-sighted during a five-year study period (Thompson and Nolan 1973). Our return rates are combined for all study sites in an area of 189.4 ha, whereas the study in southern Indiana was conducted at one intensively studied site (three fields, a total of 18 ha). This may account for the higher return rates in the southern Okanagan valley. However, during the three years of the Indiana study, observations were

made as well as mist-netting, and Yellow-breasted Chat tape-recordings were used to detect banded Yellow-breasted Chats on 49 ha of additional nearby fields. Return rates of resident males for the study area (18 ha) and the additional fields (49 ha) were still only 13%, much lower than in the southern Okanagan valley. In southeastern Ohio, the return rate for Yellow-breasted Chats (males and females combined) during a five-year study (2002–2006) in regenerating shrubland patches 4 to 18 ha in size within a 1000 ha state forest was 19.8% (Lehnen and Rodewald 2009).

Our detected return rates might also be higher because there is little riparian habitat left in the southern Okanagan valley and our population is relatively concentrated. These likely increases the chance of detection compared to the other studies, where there might be larger areas of suitable habitat to search. However, the lack of habitat suggests that birds in British Columbia would not be able to find suitable breeding sites and would be less inclined to return, or they might return and be unsuccessful and leave and/or not return again.

The return rate of 44% for males is within the range of 7%–66% reported for other long-term studies of migratory passerines in North America (e.g., Best and Rodenhouse 1984; Lanyon and Thompson 1986; DiQuinzio et al. 2001; Beheler et al. 2003; Howlett and Stutchbury 2003; Sedgwick 2004; Schlossberg 2009), and our site fidelity of 31% is lower than the 50%–76% reported in the same studies. However, comparisons are sometimes difficult to make because some studies do not clearly define the methodology used to determine return rates and site fidelity and because differences in habitat and behaviour could also account for differences in return rates and site fidelity.

While there are no comparable data on apparent survival in Yellow-breasted Chats elsewhere, the apparent survival rate of 65% (66% combined) for male Western Yellow-breasted Chats in the southern Okanagan valley was at the high end of the range of 43%–70% for survival rates for long-term studies of migratory songbirds (e.g., Budnik et al. 2000; Bayne and Hobson 2002; Jones et al. 2004; Ward 2005; Fletcher et al. 2006; Schlossberg 2009; Cox and Jones 2010). Return rate in the Okanagan for adult male chats was 44% and apparent survival was 65%, which is still a minimum survival estimate because it does not account for males that could have survived but dispersed outside of the study area. This also implies that estimated return rates for females (13%) and nestlings (10%) were probably an underestimate of survival. Once again, apparent survival does not account for dispersal outside of the study area or, especially for females, incomplete detection. Other studies (e.g., Cilimburg et al. 2002) also reported return rates to be an underestimate of survival.

The maximum natal dispersal distance of 15.6 km for male Western Yellow-breasted Chats ( $n = 7$ ) was greater than the maximum natal dispersal distance of 2.6 km for females ( $n = 2$ ). It is possible that more

females dispersed beyond the study area or were not re-sighted. This contrasts with Eastern Phoebes (*Sayornis phoebe*), where the average dispersal distance for females (3115 m, SD 958) was slightly greater than for males (1486 m, SD 340) (Beheler et al. 2003). In southeastern Ohio, the dispersal distances for nine shrubland species (males and females combined) tended to be larger in natal dispersers (second-year birds returning) than breeding dispersers (after-second-year birds returning) (Lehnen and Rodewald 2009). This contrasts with our study, where, on average, breeding males moved farther than natal males and females that dispersed, but our sample size for females is small.

Our natal philopatry in the south Okanagan of 10.1% falls at the high end of the range of typical rates (0%–16%) for long-term studies of North American migratory species (e.g., DiQuinzio et al. 2001; Sedgwick 2004; Schlossberg 2009; Ward 2005). None of the Eastern Yellow-breasted Chat nestlings banded in Indiana returned to their natal site in subsequent years (Thompson and Nolan 1973). In southeastern Ohio, 0.8% of banded Eastern Yellow-breasted Chat juveniles returned in subsequent years (Lehnen and Rodewald 2009).

Population densities are not always equal throughout the geographic range of a species, and there is often a higher density in the core area than in peripheral areas (Whittaker 1967; Westman 1980; Maurer and Brown 1989). Populations occurring at the periphery of a species' range may experience more unpredictable environmental conditions (Maurer and Brown 1989) or suboptimal conditions (Sanz 1997); productivity can be more variable (Mahony et al. 2006); populations may experience stronger selection, immigration, and dispersal (Holt and Gomulkiewicz 1997; Kirkpatrick and Barton 1997); and between-year return rates can be lower (Sanz 2001). However, our data indicate that the southern Okanagan valley Western Yellow-breasted Chat population at the northern periphery of this species' range has higher survival, site fidelity, and return rates than other Yellow-breasted Chat populations and rates are comparable to those of migratory passerines in long-term studies throughout North America. These findings suggest that, despite fragmentation and an 87% reduction in riparian habitat (Lea 2008), the quality of the remaining riparian thickets is adequate to support a small population with relatively high rates of return for juvenile and adult Western Yellow-breasted Chats and reasonable rates of productivity (Morgan et al. 2007).

In this narrow agricultural valley, the southern Okanagan Western Yellow-breasted Chat population is small but thriving and may be limited only by availability of suitable habitat. Some evidence of this is the recent expansion in the number of Western Yellow-breasted Chat territories in locations where cattle grazing has been more restricted than in past years. About half of our study area is grazed by cattle in the winter and into the spring before 1 May each year. The live-

stock grazing and movement through the riparian areas cause fragmentation of the understory and damage to the shrub thickets used by Western Yellow-breasted Chats. As a result of the enforcement of the seasonal restrictions on livestock grazing by the British Columbia Ministry of Environment after 2002, wild roses and mixed shrub thickets appear to be recovering, and there was a 42% increase in the number of Western Yellow-breasted Chat territories in study site two between 2002 and 2007. We predict that if additional habitat restoration efforts are initiated, the response will be an expansion in the distribution and population size of the Western Yellow-breasted Chat population in the southern Okanagan valley in future decades.

### Acknowledgements

We thank the Osoyoos Indian band, the En'owkin Centre, Audra Moir, Marta Sutherland, and Jim Heel for access to their land. We also thank Alicia Newbury, Barry Lancaster, Clarence Louie, Dave Nield, Ingrid Pollet, Jason Emery, Jeanette Armstrong, Jukka Jantunen, Lukus Bent, Mario Hall, Michael Bezener, Nancy Mahony, Owain McKibbin, Richard Armstrong, Richard Cannings, Ron Hall, Rosemary Bryan, Steve Bryson and Tawna Morgan for their assistance during data collection and Dan Shervill for GIS analysis. We thank reviewers for valuable suggestions. Scientific permit to capture and band migratory birds 10365 CY and Species at Risk Act permits 59-05-0378, 59-06-0304, and 59-07-0279 were granted to René McKibbin. The project was reviewed by Animal Care Committees at Simon Fraser University and the British Columbia Ministry of the Environment. The study was funded by Environment Canada, the En'owkin Centre, and the Osoyoos Indian Band.

### Documents Cited (marked \* in text)

COSEWIC. 2011. COSEWIC assessment and status report on the Yellow-breasted Chat *auricollis* subspecies *Icteria virens auricollis* and the Yellow-breasted Chat *virens* subspecies *Icteria virens virens* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xvi + 51 pages. ([www.registrelep-sararegistry.gc.ca/default\\_e.cfm](http://www.registrelep-sararegistry.gc.ca/default_e.cfm)). Program Mark. 2010. A Gentle introduction. <http://www.phidot.org/software/mark/index.html> (Accessed 6 August 2010).

ESRI. 1999. ArcGIS, version 9.0. Environmental Systems Research Institute, Redlands, California.

### Literature Cited

- Baker, M., N. Nur, and G. R. Geupel. 1995. Correcting biased estimates of dispersal and survival due to limited study area: theory and application using Wrentits. *Condor* 97: 663–674.
- Bayne, E. M., and K. A. Hobson. 2002. Annual survival of adult American Redstarts and Ovenbirds in the southern boreal forest. *Wilson Bulletin* 114: 358–367.
- Beheler, A. S., O. E. Rhodes, Jr., and H. P. Weeks, Jr. 2003. Breeding site and mate fidelity in Eastern Phoebe (*Sayornis phoebe*) in Indiana. *Auk* 120: 990–999.
- Best, L. B., and N. L. Rodenhouse. 1984. Territory preference of Vesper Sparrows in cropland. *Wilson Bulletin* 96: 72–82.
- Budnik, J. M., M. R. Ryan, and F. R. Thompson, III. 2000. Demography of Bell's Vireos in Missouri grassland-shrub habitats. *Auk* 117: 925–935.
- Burhans, D. E., and F. R. Thompson, III. 1999. Habitat patch size and nesting success of Yellow-breasted Chats. *Wilson Bulletin* 111: 210–215.
- Burnham, K. P., and Anderson, D. R. 1998. Model Selection and Inference: a Practical Information-Theoretic Approach. (Springer-Verlag: New York.)
- Channell, R., and M. V. Lomolino. 2000. Dynamic biogeography and conservation of endangered species. *Nature* 403: 84–86.
- Cilimburg, A. B., M. S. Lindberg, J. J. Tewksbury, and S. J. Hejl. 2002. Effects of dispersal on survival probability of adult Yellow Warblers (*Dendroica petechia*). *Auk* 119: 778–789.
- Cox, J. A., and C. D. Jones. 2010. Estimating probabilities of survival of male Bachman's Sparrows from plot-based, mark-resighting, off-plot surveys and multi-strata models. *Condor* 112: 663–669.
- DeSante, D. F., K. M. Burton, P. Velez, and D. Froehlich. 2001. MAPS Manual: 2001 Protocol. Institute for Bird Populations, Point Reyes Station, California. 67 pages.
- DiQuinzio, D. A., P. W. C. Paton, and W. R. Eddleman. 2001. Site fidelity, philopatry, and survival of promiscuous Saltmarsh Sharp-tailed Sparrows in Rhode Island. *Auk* 118: 888–899.
- Dulisse, J. A., S. K. Ogle, and M. M. Machmer. 2005. First nest record for Yellow-breasted Chat (*Icteria virens auricollis*) in southeastern British Columbia. *Northwest Naturalist* 86: 160–162.
- Eckerle, K. P., and C. F. Thompson. 2001. Yellow-breasted Chat (*Icteria virens*). No. 575 in *The Birds of North America*. Edited by A. Poole and F. Gill. Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington.
- Fahrig, L., and G. Merriam. 1994. Conservation of fragmented populations. *Conservation Biology* 8: 50–59.
- Fletcher Jr., R. J., R. R. Koford, and D. A. Seaman. 2006. Critical demographic parameters for declining songbirds breeding in restored grasslands. *Journal of Wildlife Management* 70: 145–157.
- Holt, R. D., and R. Gomulkiewicz. 1997. How does immigration influence local adaptation? A reexamination of a familiar paradigm. *American Naturalist* 149: 563–572.
- Howlett, J. S., and B. J. M. Stutchbury. 2003. Determinants of between-season site, territory, and mate fidelity in Hooded Warblers (*Wilsonia citrina*). *Auk* 120: 457–465.
- Jones, J., J. J. Barg, T. S. Sillett, M. L. Veit, and R. J. Robertson. 2004. Minimum estimates of survival and population growth for Cerulean Warblers (*Dendroica cerulea*) breeding in Ontario, Canada. *Auk* 121: 15–22.
- Kirkpatrick, M., and N. H. Barton. 1997. Evolution of a species' range. *American Naturalist* 150: 1–23.
- Lanyon, S. M., and C. F. Thompson. 1986. Site fidelity and habitat quality as determinants of settlement pattern in male Painted Buntings. *Condor* 88: 206–210.
- Lea, T. 2008. Historical (pre-settlement) ecosystems of the Okanagan Valley and Lower Similkameen Valley of British Columbia—pre-European contact to the present. *Davidsonia* 19: 3–38.

- Lebreton, J. D., K. P. Burnham, J. Clobert, and D. R. Anderson.** 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. *Ecological Monographs* 62: 67–118.
- Lehnen, S. E., and A. D. Rodewald.** 2009. Dispersal, inter-patch movements, and survival in a shrubland breeding bird community. *Journal of Field Ornithology* 80: 242–252.
- Mahony, N. A., P. G. Krannitz, and K. Martin.** 2006. Seasonal fecundity of Sagebrush Brewer's Sparrow (*Spizella breweri breweri*) at the northern edge of its breeding range. *Auk* 123: 512–523.
- Maurer, B. A., and J. H. Brown.** 1989. Distributional consequences of spatial variation in local demographic processes. *Annales Zoologica Fennici* 26: 121–131.
- McKibbin, R., and C. A. Bishop.** 2008. Capture success rates of the western Yellow-breasted Chat in the south Okanagan valley, British Columbia, Canada during 2005 to 2007. *North American Bird Bander* 33: 179–184.
- McKibbin, R., and C. A. Bishop.** 2010. Habitat characterization of breeding territories of the western Yellow-breasted Chat in the south Okanagan, British Columbia, Canada. *Northwestern Naturalist* 91: 145–156.
- Morgan, T. C., C. A. Bishop, and A. M. Bezener.** 2006. Temporal fluctuation in abundance of Brown-headed Cowbirds and their hosts in riparian habitat in the Okanagan valley, British Columbia, Canada. *Journal of Field Ornithology* 77: 444–451.
- Morgan, T. C., C. A. Bishop, and T. D. Williams.** 2007. Yellow-breasted Chat and Gray Catbird productivity in a fragmented western riparian system. *Wilson Journal of Ornithology* 119: 494–498.
- Ricketts, M. S., and G. Ritchison.** 2000. Nesting success of Yellow-breasted Chats: effects of nest site and territory vegetation structure. *Wilson Bulletin* 112: 510–516.
- Robinson, S. K., and S. F. Morse.** 2000. Conservation insights from demographic studies of migratory songbirds in the American Midwest. Pages 225–232 in *Strategies for Bird Conservation: the Partners in Flight Planning Process*. Edited by R. Bonney, D. N. Pashley, R. J. Cooper, and L. Niles. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah.
- Sandercock, B. K.** 2006. Estimation of demographic parameters from live-encounter data: a summary review. *Journal of Wildlife Management* 70: 1504–1520.
- Sanz, J. J.** 1997. Geographic variation in breeding parameters of the Pied Flycatcher *Ficedula hypoleuca*. *Ibis* 139: 107–114.
- Sanz, J. J.** 2001. Latitudinal variation in female local return rate in the philopatric Pied Flycatcher (*Ficedula hypoleuca*). *Auk* 118: 539–543.
- Saunders, D. A., R. J. Hobbs, and C. R. Margules.** 1991. Biological consequences of ecosystem fragmentation: a review. *Conservation Biology* 5: 18–32.
- Schlossberg, S.** 2009. Site fidelity of shrubland and forest birds. *Condor* 111: 238–246.
- Sedgwick, J. A.** 2004. Site fidelity, territory fidelity, and natal philopatry in Willow Flycatchers (*Empidonax traillii*). *Auk* 121: 1103–1121.
- Sillett, T. S., and R. T. Holmes.** 2002. Variation in survivorship of a migratory songbird throughout its annual cycle. *Journal of Animal Ecology* 71: 296–308.
- Thompson, C. F., and V. Nolan, Jr.** 1973. Population biology of the Yellow-breasted Chat (*Icteria virens* L.) in southern Indiana. *Ecological Monographs* 43: 145–171.
- Ward, M. P.** 2005. The role of immigration in the decline of an isolated migratory bird population. *Conservation Biology* 19: 1528–1536.
- Westman, W. E.** 1980. Gaussian analysis: identifying environmental factors influencing bell-shaped species distributions. *Ecology* 61: 733–739.
- White, G. C., and K. P. Burnham.** 1999. Program MARK: survival estimation from populations of marked animals. *Bird Study* 46 (Suppl.): 120–138.
- Whittaker, R. H.** 1967. Gradient analysis of vegetation. *Biological Review* 42: 207–264.
- Woollenden, B. E., H. L. Gibbs, and S. G. Sealy.** 2001. Demography of Brown-headed Cowbirds at Delta marsh, Manitoba. *Auk* 118: 156–166.

Received 15 February 2012

Accepted 28 June 2012

# Genetic Evidence Supports Boreal Chickadee (*Poecile hudsonicus*) × Black-capped Chickadee (*Poecile atricapillus*) Hybridization in Atlantic Canada

LINDA A. LAIT<sup>1,3</sup>, RANDY F. LAUFF<sup>2</sup>, and THERESA M. BURG<sup>1</sup>

<sup>1</sup>Department of Biological Sciences, University of Lethbridge, Lethbridge, Alberta T1K 3M4 Canada; corresponding author email: linda.lait@uleth.ca

<sup>2</sup>Department of Biology, St. Francis Xavier University, Antigonish, Nova Scotia B2G 2W5 Canada

<sup>3</sup>Current address: Department of Biology, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X9 Canada

Lait, Linda A., Randy F. Lauff, and Theresa M. Burg. 2012. Genetic evidence supports Boreal Chickadee (*Poecile hudsonicus*) × Black-capped Chickadee (*Poecile atricapillus*) hybridization in Atlantic Canada. *Canadian Field-Naturalist* 126(2): 143–147.

Both morphological and genetic evidence support a hybridization event between a Boreal Chickadee (*Poecile hudsonicus*) and a Black-capped Chickadee (*Poecile atricapillus*) in Atlantic Canada. Plumage of the hybrid was intermediate to both parental species, with buffy sides and a dark brown cap on the head. Mitochondrial DNA control region showed the female lineage to be from a Boreal Chickadee, while Z-linked markers showed mixed Boreal Chickadee × Black-capped Chickadee heritage, likely representing an F1 hybrid. This is the first documented case of hybridization between these species in eastern North America, and it adds to the increasing evidence supporting intrageneric avian hybridization.

**Key Words:** *Poecile hudsonicus*, Boreal Chickadee, *Poecile atricapillus*, Black-capped Chickadee, hybridization, mitochondrial DNA, Z chromosomes, nuclear introns, Nova Scotia, Atlantic Canada.

When reproductive isolating mechanisms are incomplete or break down, hybridization can occur (Schluter and Nagel 1995). The presence of hybrid individuals in a population or the presence of an established hybrid zone can confound conservation efforts (e.g., the Red Wolf, *Canis lupus rufus* (Reich et al. 1999), and the Imperial Pheasant *Lophura imperialis* (McCarthy 2006)) and phylogeny construction (Grant and Grant 1992). Due to genetic incompatibilities, hybrid offspring are often inferior to the parental species (i.e., low survival or sterility); the extent and directionality of the hybridization will in part determine whether a hybrid swarm is created and the reproductive capabilities of the hybrid offspring (Grant and Grant 1992; McCarthy 2006).

Hybridization is found in approximately 10% of non-marine avian species, and may be 50% or higher in waterfowl and game birds (see Cockrum 1952; Mayr and Short 1970; Grant and Grant 1992; McCarthy 2006). Hybrids are often found in areas where ranges overlap: examples of well-documented hybrid zones include those of the sapsuckers, *Sphyrapicus* spp. (Walters et al. 2002); the Northern Flicker, *Colaptes auratus* (Moore and Buchanan 1985); the Hermit Warbler, *Setophaga occidentalis* (formerly *Dendroica occidentalis*) × Townsend's Warbler, *Setophaga townsendi* (formerly *Dendroica townsendi*) (Morrison and Hardy 1983); the Golden-winged Warbler, *Vermivora chrysopetra* × Blue-winged Warbler, *Vermivora cyanoptera* (Gill 2004); and the Eastern Meadowlark, *Sturnella*

*magna* × Western Meadowlark, *Sturnella neglecta* (Lanyon 1966). Both intrageneric crosses (see examples above) and intergeneric crosses (e.g., Common House-Martin (also known as Northern House-Martin), *Delichon urbicum* × Barn Swallow, *Hirundo rustica* (McCarthy 2006)), are common in the literature, with intrageneric hybridization occurring more often in passerines (i.e., 48 of 69 known crosses in Parulidae (Valender et al. 2009) and 19 of 28 in Paridae (McCarthy 2006)). Less frequent hybridization events such as interfamily crosses can also be found (McCarthy 2006).

In the Paridae (chickadees, tits, and titmice), two well-studied hybrids are the Black-capped Chickadee, *Poecile atricapillus* × Carolina Chickadee, *Poecile carolinensis* (Sattler and Braun 2000; Bronson et al. 2003; Bronson et al. 2005; Reudink et al. 2007), and the Tufted Titmouse, *Baeolophus bicolor* × Black-crested Titmouse, *Baeolophus atricristatus* (Braun et al. 1984; Curry 2005). A recent study has identified the presence of a Black-capped Chickadee × Mountain Chickadee, *Poecile gambeli*, hybrid zone in British Columbia (Grava et al. 2012). A number of other crosses, based primarily on morphology, have been suggested, both in the popular press and in research labs: Black-capped Chickadee × Tufted Titmouse (Chipper Woods Bird Observatory), Mountain Chickadee × Boreal Chickadee, *Poecile hudsonicus* (Teslin Lake Bird Banding Station 2006), and Black-capped Chickadee × Boreal Chickadee (Sergei Drovetski, unpublished data).

During banding of both Boreal Chickadees and Black-capped Chickadees in Nova Scotia in the 2010 field season, a morphologically intermediate specimen (hereafter referred to as Bird A: 45.7°N, 61.9°W) was identified (Figure 1). Although the distribution of these two chickadee species is generally sympatric, substantial differences exist in habitat preference (e.g., coniferous forest versus deciduous), and no cases of hybridization in eastern North America have been documented. A single hybrid specimen was found in Alaska (Sergei Drovetski, unpublished data) and confirmed using microsatellite analysis. In order to establish whether Bird A was of hybrid origin, a suite of molecular markers were used, including sex-linked, autosomal, and maternally inherited loci.

## Methods

Birds were caught using mist nets and song playback. Birds were measured (mass, wing chord, tarsus length, and bill length), banded, and a blood sample (<100 µL) was taken from the brachial vein. In addition to Bird A, 109 Black-capped Chickadees and 18 Boreal Chickadees were banded over the 2007 and 2010 field seasons. A blood sample was taken from all birds and measurements were taken from a subset (see below). Photographs were taken of the potential hybrid bird (Bird A), and reference photos were taken of both parental species (Figure 1). A principal components analysis (PCA) was performed in JMP version 10.0 (SAS Institute Inc. 2012) on the morphological measurements, comparing the measurements of Bird A to those of Boreal Chickadees ( $n = 12$ ) and Black-capped Chickadees ( $n = 77$ ) from Nova Scotia and New Brunswick.

A combination of mitochondrial DNA (mtDNA), two Z chromosome loci, and a nuclear intron was used to determine the genetic composition of Bird A. DNA was extracted using a modified chelex extraction method (Walsh et al. 1991). Polymerase chain reaction (PCR) was used to amplify the DNA. Sexing primers P2 and P8 (Griffiths et al. 1998) were used to determine whether the specimen was male or female (important for Z chromosome analysis). The sexing PCR was run in a 10 µL reaction with 1.5 mM MgCl<sub>2</sub> and an annealing temperature of 51°C. PCR products were visualized on a 3% agarose gel.

The mtDNA control region was amplified in a 25 µL reaction (2.5 mM MgCl<sub>2</sub> and 54°C annealing temperature) with the primers LmochCR1 and H1015chCR (Lait et al. *in press*). PCR products were visualized on a 0.8% agarose gel. Samples from Boreal Chickadees ( $n = 18$ ) (LAL, unpublished data) and Black-capped Chickadees ( $n = 41$ ) (John Hindley, unpublished data) from Nova Scotia and New Brunswick were available as part of other studies. The Boreal Chickadee samples were amplified with LmochCR1 and H1015chCR; the Black-capped Chickadee samples were amplified with LbcchCR1 and HCRCbox (Grava et al. 2012).

The Z chromosome marker ALDB was amplified using the PCR primers AldB.6F (Cox et al. 2007) and AldB.8R (Hackett et al. 2008), and a second Z chromosome marker, SPIN, was amplified using Spin319F and Spin472R (Handley et al. 2004). The nuclear intron,  $\beta$ -fibrinogen intron 5, was amplified with primers Fib.5F and Fib.6R (Fuchs et al. 2004). Standard PCR protocols were used, with MgCl<sub>2</sub> concentrations of 1.5 mM, 2.0 mM, and 2.5 mM and annealing temperatures of 50°C, 60°C and 54°C, respectively. PCR products were visualized on a 0.8% agarose gel. Two representative samples each from the Boreal Chickadees and Black-capped Chickadees were sequenced at nuclear loci for comparison.

## Results

The PCA of the measurements showed considerable overlap between the two parental chickadee species, particularly in tarsus length and bill length, with Bird A falling in the centre (data not shown). Morphological measurements of Bird A were intermediate to that of the Boreal Chickadee and the Black-capped Chickadee for mass and wing chord, and were similar for tarsus and bill length (Table 1). In Bird A, the crown was dark brown (rich brown in the Boreal Chickadee and black in the Black-capped Chickadee) and the sides were buffy-brown (buffy-brown in the Boreal Chickadee and white to pale buff in the Black-capped Chickadee) (see Figure 1).

A 766 bp fragment of mtDNA from the control region was amplified and sequenced for Bird A (GenBank accession number JN654584) and >10 samples from each pure species (based on phenotype); a 501 bp fragment was aligned between the two species. The mtDNA from the control region from Bird A matched that of the Boreal Chickadee (Table 2). The sexing markers showed that Bird A was male (ZZ), and the Z chromosome markers amplified two fragments of equal length. A 520 bp fragment of ALDB and a 646 bp fragment of SPIN were amplified for Bird A and two females of each pure species. A two base pair insertion/deletion differentiated the parental species in both Z chromosome markers, allowing a direct comparison (Table 2). The Boreal Chickadee and Black-capped Chickadee sequences are distinct (1.7% sequence divergence for ALDB and 2.3% for SPIN), allowing easy separation. In each case, the hybrid sample produced two distinct sequences, one matching the Black-capped Chickadee sequence and one matching the Boreal Chickadee sequence. A 539 bp sequence for the  $\beta$ -fibrinogen intron contained three site variants between the two chickadee species (0.56% sequence divergence). Again Bird A contained two distinct sequences—one matching each species.

## Discussion

Although the intermediate phenotype of Bird A was sufficient to suggest a hybridization event, genetic test-



FIGURE 1. Photographs of a Black-capped Chickadee, *Poecile atricapillus* (left), Bird A (middle), and a Boreal Chickadee, *P. hudsonicus* (right). The Black-capped Chickadee and Bird A photographs were taken on May 29, 2010 in Nova Scotia by RFL. The photographs of the Boreal Chickadee were taken on May 14, 2010 in New Brunswick by Kimberly Dohms.

TABLE 1. Mean morphological measurements (standard deviation in parentheses) for Boreal Chickadees and Black-capped Chickadees from Nova Scotia and New Brunswick and for Bird A.

	Mass (g)	Wing chord (mm)	Tarsus length (cm)	Bill length (cm)
Black-capped Chickadee ( <i>n</i> = 77)	11.7 (0.9)	65.0 (2.5)	1.8 (0.1)	0.9 (0.1)
Boreal Chickadee ( <i>n</i> = 12)	10.3 (0.9)	62.7 (3.2)	1.9 (0.1)	0.8 (0.1)
Bird A	11.0	63.0	1.6	0.8

TABLE 2. Variable sites found in the 501 bp fragment of the mtDNA control region, the 520 bp ALDB fragment, and the 646 bp SPIN fragment of the Z chromosome for samples from Boreal Chickadees, Black-capped Chickadees, and Bird A (a dash represents a deletion).

Sample	Control region	ALDB	SPIN
	111222222222222333444	1223335	11112223344555
	245227114567788999777139	551441580	500582562445679
	0006712406012161689578167	567342630	556938757801830
Black-capped Chickadee	-ACTTAGAGGATCACTCAGCCGACG	TGCCAAGTG	A--GCGTCAGGTGGG
Boreal Chickadee	ATTCCGTGAAGCTGA-YGAATCGTA	--TTCAACA	CCCAATCTTCACAGC
Bird A (sequence 1)	ATTCCGTGAAGCTGA-TGAATCGTA	TGCCAGGTG	A--GCGTCAGGTGGG
Bird A (sequence 2)	n/a	--TTCAGCG	CCCAATCTTCACAAC

Scenario	Female parent	Male parent	Offspring (Bird A)
1	<b>Z<sup>BO</sup></b> W	<b>Z<sup>BC</sup></b> <b>Z<sup>BC</sup></b>	<b>Z<sup>BC</sup></b> <b>Z<sup>BO</sup></b>
2	<b>Z<sup>BO</sup></b> W	<b>Z<sup>BC</sup></b> <b>Z<sup>BO</sup></b> (hybrid)	
3	<b>Z<sup>BO</sup></b> W (hybrid)	<b>Z<sup>BC</sup></b> <b>Z<sup>BC</sup></b>	
4	<b>Z<sup>BO</sup></b> W (hybrid)	<b>Z<sup>BC</sup></b> <b>Z<sup>BO</sup></b> (hybrid)	
5	<b>Z<sup>BC</sup></b> W (hybrid)	<b>Z<sup>BC</sup></b> <b>Z<sup>BO</sup></b> (hybrid)	
6	<b>Z<sup>BC</sup></b> W (hybrid)	<b>Z<sup>BO</sup></b> <b>Z<sup>BO</sup></b>	

FIGURE 2. Possible scenarios explaining the observed genetic patterns in Bird A. Bolded genotypes show the transmission of the Z chromosome (Black-capped Chickadee, *Poecile atricapillus*, Z<sup>BC</sup>, and Boreal Chickadee, *P. hudsonicus*, Z<sup>BO</sup>) from parent to offspring. Hybrid female parents would be the result of a female Boreal Chickadee mating with a male Black-capped Chickadee to retain the Boreal Chickadee mtDNA. As hybrids are not common, the first scenario is the most likely.

ing was required to confirm its genetic origin. The mtDNA, Z chromosome, and nuclear loci strongly support the hybrid origin of Bird A. The possibility exists that one of the parents (Figure 2) could have been a hybrid, but the presence of a Black-capped Chickadee and a Boreal Chickadee  $\beta$ -fibrinogen allele, as well as Z chromosomes from both species, suggest that it is more likely an F1 hybrid with a Boreal Chickadee mother and Black-capped Chickadee father. As Bird A is male (ZZ), it could have received the Black-capped Z chromosome either as the maternal contribution (Figure 2, scenarios 5 and 6) or as the paternal contribution (scenarios 1 to 4), and it could have received the Boreal Z chromosome either as the maternal contribution (scenarios 1 to 4) or as the paternal contribution (scenarios 5 and 6). As the mtDNA shows that the female lineage is of Boreal Chickadee (or hybrid) origin, the most parsimonious explanation is that Bird A is the result of a cross between a female Boreal Chickadee and a male Black-capped Chickadee. All of the other alternatives would require additional hybridization events, and this is unlikely given the lack of hybridization documented between these species.

As with many boreal birds, the Boreal Chickadee is undergoing a severe population decline, most likely due to a combination of habitat loss and climate change (Sauer et al. 2005). The combination of reduced breeding population and habitat availability may be pushing the Boreal Chickadee to increasingly share habitat and resources with the Black-capped Chickadee. Nova Scotia is near the southern edge of the Boreal Chickadee's range, and Boreal Chickadees are less common than Black-capped Chickadees in Nova Scotia; it may be that a lack of available Boreal Chickadee mates triggered the hybridization event.

This is in contrast to the hybridization between Black-capped Chickadees and Carolina Chickadees that occurs extensively along the contact zone between the two species running from Kansas to New Jersey in the United States (Bronson et al. 2005; Reudink et al. 2007). In that case, the two chickadee species are phenotypically indistinguishable, they reside in the same habitat, and, although their song is quite different, they are capable of plasticity in song learning. As many as two-thirds of the chickadees in the hybrid zone are of hybrid origin, suggesting that the only reproductive barrier between the Black-capped Chickadee and the Carolina Chickadee is physical isolation (Reudink et al. 2007).

In another example of a hybridization event involving the Black-capped Chickadee, Grava et al. (2012) found that hybrid offspring of Black-capped Chickadees and Mountain Chickadees were produced through pairing of a more dominant male Black-capped Chickadee with a female Mountain Chickadee.

Hybrids between Black-capped Chickadees and Carolina Chickadees show contrasting patterns: Bronson et al. (2005) found no evidence of assortative mating, yet aviary studies suggested male Carolina Chickadee dominance (Bronson et al. 2003). Reudink et al. (2007) also found evidence of male Carolina Chickadee dominance in Pennsylvania in hybrid crosses, and reciprocal matings were observed. Geographic differences between Black-capped Chickadee and Carolina Chickadee hybrid zones are also apparent (see Reudink et al. 2007 for discussion), although all studies support the notion of a moving hybrid zone, with the range of the Carolina Chickadee expanding at the expense of the Black-capped Chickadee range.



Additional work banding chickadees in Atlantic Canada would be useful to assess whether there are other hybridization events between Black-capped Chickadees and Boreal Chickadees, caused perhaps by the decrease in suitable habitat. In addition to Bird A, the authors banded 109 Black-capped Chickadees and 18 Boreal Chickadees in Nova Scotia and New Brunswick over two field seasons; none were of intermediate phenotype. While the current data strongly suggest that Bird A is an F1 hybrid, we are unable to show definitively whether it is an F1 or later hybrid. Our data do confirm the hybrid origin of this specimen and raise the possibility of the existence of additional hybrid birds.

### Acknowledgements

Thank you to Kimberly Dohms and all other field assistants for their help with sample collection, John Hindley for the sequences of the Black-capped Chickadee samples, and two anonymous reviewers for their comments. This project was supported by the Natural Sciences and Engineering Research Council of Canada (Discovery Grant to TMB, Alexander Graham Bell Canada Graduate Scholarship to LAL) and Alberta Innovates Technology Futures (Graduate Scholarship to LAL and New Faculty Award to TMB).

### Literature Cited

- Braun, D., G. B. Kitto, and M. J. Braun. 1984. Molecular population genetics of Tufted and Black-crested forms of *Parus bicolor*. *Auk* 101: 170–173.
- Bronson, C. L., T. C. Grubb Jr., G. D. Sattler, and M. J. Braun. 2003. Mate preference: a possible causal mechanism for a moving hybrid zone. *Animal Behaviour* 65: 489–500.
- Bronson, C. L., T. C. Grubb, G. D. Sattler, and M. J. Braun. 2005. Reproductive success across the Black-capped Chickadee (*Poecile atricapillus*) and Carolina Chickadee (*P. carolinensis*) hybrid zone in Ohio. *Auk* 122: 759–772.
- Cockrum, E. L. 1952. A check-list and bibliography of hybrid birds in North America north of Mexico. *Wilson Bulletin* 64: 140–159.
- Cox, W. A., R. T. Kimball, and E. L. Braun. 2007. Phylogenetic position of the New World quail (Odontophoridae): eight nuclear loci and three mitochondrial regions contradict morphology and the Sibley-Ahlquist tapestry. *Auk* 124: 71–84.
- Curry, R. L. 2005. Hybridization in chickadees: much to learn from familiar birds. *Auk* 122: 747–758.
- Fuchs, J., R. C. K. Bowie, J. Fjelds , and E. Pasquet. 2004. Phylogenetic relationships of the African bush-shrikes and helmet-shrikes (Passeriformes: Malaconotidae). *Molecular Phylogenetics and Evolution* 33: 428–439.
- Gill, F. B. 2004. Blue-winged Warblers (*Vermivora pinus*) versus Golden-winged Warblers (*V. chrysoptera*). *Auk* 121: 1014–1018.
- Grant, P. R., and B. R. Grant. 1992. Hybridization of bird species. *Science* 256: 193–197.
- Grava, A., T. Grava, R. Didier, L. A. Lait, J. Dosso, E. Koran, T. M. Burg, and K. A. Otter. 2012. Interspecific dominance relationships and hybridization between Black-capped and Mountain Chickadees. *Behavioral Ecology* 23: 566–572.
- Griffiths, R., M. C. Double, K. Orr, and R. J. G. Dawson. 1998. A DNA test to sex most birds. *Molecular Ecology* 7: 1071–1075.
- Hackett, S. J., R. T. Kimball, S. Reddy, R. C. K. Bowie, E. L. Braun, M. J. Braun, J. L. Chojnowski, W. A. Cox, K.-L. Han, J. Harshman, C. J. Huddleston, B. D. Marks, K. J. Miglia, W. S. Moore, F. H. Sheldon, D. W. Steadman, C. C. Witt, and T. Yuri. 2008. A phylogenomic study of birds reveals their evolutionary history. *Science* 320: 1763–1768.
- Handley, L.-J. L., H. Ceglitis, and H. Ellegren. 2004. Evolutionary strata on the chicken Z chromosome: implications for sex chromosome evolution. *Genetics* 167: 367–376.
- Lait, L. A., V. L. Friesen, A. J. Gaston, and T. M. Burg. *In press*. The post-Pleistocene population genetic structure of a western North American passerine: the Chestnut-backed Chickadee (*Poecile rufescens*). *Journal of Avian Biology*.
- Lanyon, W. E. 1966. Hybridization in meadowlarks. *Bulletin of the American Museum of Natural History* 134: 5–25.
- Mayr, E., and L. L. Short. 1970. Species taxa of North American birds: a contribution to comparative systematics. *Bulletin of the Nuttall Ornithology Club* 9: 1–127.
- McCarthy, E. M. 2006. *Handbook of Avian Hybrids of the World*. Oxford University Press, New York, New York.
- Moore, W. S., and D. B. Buchanan. 1985. Stability of the Northern Flicker hybrid zone in historical times: implications for adaptive speciation theory. *Evolution* 39: 135–151.
- Morrison, M. L., and J. W. Hardy. 1983. Hybridization between Hermit and Townsend's Warblers. *Murrelet* 64: 65–72.
- Reich, D. E., R. K. Wayne, and D. B. Goldstein. 1999. Genetic evidence for a recent origin by hybridization of Red Wolves. *Molecular Ecology* 8: 139–144.
- Reudink, M. W., S. G. Mech, S. P. Mullen, and R. L. Curry. 2007. Structure and dynamics of the hybrid zone between Black-capped Chickadee (*Poecile atricapillus*) and Carolina Chickadee (*P. carolinensis*) in southeastern Pennsylvania. *Auk* 124: 463–478.
- Sattler, G. D., and M. J. Braun. 2000. Morphometric variation as an indicator of genetic interactions between Black-capped and Carolina Chickadees at a contact zone in the Appalachian Mountains. *Auk* 117: 427–444.
- Sauer, J. R., J. E. Hines, and J. Fallon. 2005. *The North American Breeding Bird Survey, Results and Analysis 1996–2005*. Version 6.2.2006. Patuxent Wildlife Research Center, United States Geological Survey, Laurel, Maryland.
- Schluter, D., and L. M. Nagel. 1995. Parallel speciation by natural selection. *American Naturalist* 146: 292–301.
- Vallender, R., J.-P. Gagnon, and I. Lovette. 2009. An intra-generic wood-warbler hybrid (*Mniotilta varia* × *Dendroica coronata*) and use of multilocus DNA analyses to diagnose avian hybrid origins. *Wilson Journal of Ornithology* 121: 298–305.
- Walsh, P. S., D. A. Metzger, and R. Higuchi. 1991. Chelex 100 as a medium for simple extraction of DNA for PCR-based typing from forensic material. *Biotechniques* 10: 506–513.
- Walters, E. L., E. H. Miller, and P. E. Lowther. 2002. Yellow-bellied sapsucker (*Sphyrapicus varius*). No. 662 in *The Birds of North America Online*. Edited by A. Poole. Cornell Lab of Ornithology, Ithaca, New York.

Received 7 May 2012

Accepted 10 July 2012

## Notes

### High Spring Mortality of Adult Richardson's Ground Squirrels, *Urocitellus richardsonii*, Associated with a Severe Rainstorm in Southwestern Saskatchewan

GILBERT PROULX

Alpha Wildlife Research & Management Ltd., 229 Lilac Terrace, Sherwood Park, Alberta T8H 1W3 Canada

Proulx, Gilbert. 2012. High spring mortality of adult Richardson's Ground Squirrels, *Urocitellus richardsonii*, associated with a severe rainstorm in southwestern Saskatchewan. *Canadian Field-Naturalist* 126(2): 148–151.

Heavy rains with strong winds in southwestern Saskatchewan from 20 to 29 May 2010 flooded fields where adult Richardson's Ground Squirrels (*Urocitellus richardsonii*) had recently been live-trapped. Natural mortality rates in six marked populations ( $n = 11$  to 29 animals) ranged from 9.1 to 42.9%. The mean mortality rate of populations (28.9%) was significantly greater than that estimated for four populations (8.5%) studied in April and May 2007 and 2008 during drought periods. This finding is in agreement with past studies on other ground squirrel species which showed that spring snowstorms and heavy rains caused an increase in natural mortality rates.

Key Words: Richardson's Ground Squirrel, *Urocitellus richardsonii*, *Spermophilus richardsonii*, natural mortality, spring rainstorm, weather, Saskatchewan.

From 2000 to 2009, the western and central Canadian prairies experienced severe drought conditions, which created ideal environmental conditions for Richardson's Ground Squirrels (*Urocitellus richardsonii*, formerly *Spermophilus richardsonii*; Helgen et al. 2009 revised the genus *Spermophilus* on the basis of craniometric comparisons) (Proulx 2010). In 2010, however, the southwestern region of Saskatchewan received abnormally high amounts of rain which flooded agricultural fields. The scarcity of sunshine and cooler than normal temperatures meant that the fields did not dry out (Environment Canada 2011\*). In the past, late snowstorms and heavy rains have been associated with increased mortality and decreased reproductive success in Belding's Ground Squirrels (*Urocitellus beldingi*, formerly *Spermophilus beldingi*) (Morton and Sherman 1978) and Columbian Ground Squirrels (*Urocitellus columbianus*, formerly *Spermophilus columbianus*) (Neuhaus et al. 1999). Quanstrom (1966) suggested flood tolerance in hibernating Richardson's Ground Squirrels, and Michener (1992) reported two animals drowning when exiting the hibernaculum. However, the effect of seasonally bad weather, including heavy rainfalls, strong winds, cold temperatures, and short-term floods, on the survival of adult Richardson's Ground Squirrels that have emerged from hibernation in spring is poorly known (Yensen and Sherman 2003).

During an assessment of pesticides in southwestern Saskatchewan from 2007 to 2010, I conducted a capture-recapture program of Richardson's Ground Squirrels to estimate natural mortality rates (e.g., Proulx et al. 2011). In spring 2010, heavy rains with strong winds lasted 10 days, and fields where Richardson's Ground

Squirrels had recently been live-trapped were flooded. The recapture of animals immediately after the rainstorm was a unique opportunity to assess the effect of severe weather on the survival of adult Richardson's Ground Squirrels that had emerged from hibernation several days or weeks before. I predicted that natural mortality rates of adult Richardson's Ground Squirrel populations would be higher during spring 2010 with heavy rainfalls and short-term flooding than in previous years with dry environmental conditions.

#### Methods

The study was carried out near the town of Hazenmore (Figure 1), where a pesticide assessment program for Richardson's Ground Squirrels was being planned. The original protocol involved capturing and marking  $\geq 20$  adult Richardson's Ground Squirrels, independently of their sex, in study plots of 1.3 ha each approximately 150 m apart. The study plots were located in mixed grasslands of Crested Wheatgrass (*Agropyron cristatum*), brome (*Bromus* spp.), Slender Wheatgrass (*Elymus trachycaulus*), and alfalfa (*Medicago* spp.).

The effect of the severe rainstorm on marked Richardson's Ground Squirrel populations was determined by comparing the 2010 natural mortality rates estimated with live-trapping to those of adult populations studied in spring 2007 and 2008 in study plots approximately 250 m apart in other similar mixed grasslands in Hazenmore and Mankota (Figure 1). The exact size of study plots, determined on the basis of capture-recapture locations (Proulx et al. 2011), ranged from 0.5 to 1.6 ha (Table 1).

Environmental conditions differed from year to year. Precipitation and maximum wind gusts were greater during the May 2010 rainstorm than during other periods (Table 1). Also, because there was little sunshine and temperatures were cool, water was not evaporating; grasslands were saturated with water and short-term floods were present in low-lying areas. The 2007 and 2008 studies were conducted in April, when temperatures were colder than in May 2010 (Table 1). Both adult and juvenile Richardson's Ground Squirrels were active on the surface in 2010; in 2007 and 2008, spring populations were composed only of adults that had recently emerged from hibernation. The 2010 adult populations were captured a month later than those of 2007 and 2008, and there was a difference in the reproductive status of animals among years.

For this study, the six populations in 2010 consisted of adult Richardson's Ground Squirrels that had been ear-tagged during the last two days of the capture program, i.e., 18 and 19 May, just before the bad weather began. That is to say that these animals were most likely alive when the rainstorm started. Two hundred Tomahawk live-traps  $15 \times 15 \times 48$  cm (Tomahawk Live Trap, Tomahawk, Wisconsin) baited with peanut butter on bread were set and checked early in the morning and in mid-afternoon. Adult Richardson's Ground Squirrels were tagged (Monel # 1 tag, Newport, Kentucky) in both ears. Recaptures occurred from 31 May to 4 June (i.e., 12 days after the end of the original capture program) and from 11 to 14 June to ensure that all animals that were still alive after the rainstorm had been captured. For the purposes of comparison, only the adult Richardson's Ground Squirrels of two populations ear-tagged during the last two days of the 2007 capture program and those of two populations ear-tagged during the last day of the 2008 trapping program were used. These animals were likely alive before a period of no-trapping activity that lasted 12–15 days in 2007 and 14 days in 2008 (Table 1).

A Student *t*-test was used to compare the mean mortality rate of the 2010 populations to that of the 2007 and 2008 pooled populations. Fisher's exact probability test was used to compare sex ratios of captured and recaptured Richardson's Ground Squirrel populations (Zar 1999) and to determine whether differential mortality resulted in a shift in population structure. A 0.05 level of significance was used for all tests.

## Results

One of the two 2007 populations ( $n = 12$  animals) had a female-biased ( $P < 0.05$ ) sex ratio; the other ( $n = 14$  animals) had an even ( $P > 0.05$ ) sex ratio. Together, these populations had a female-biased sex ratio. Both 2008 populations ( $n = 8$  and  $10$  animals) had a non-significant tendency for more males. Together, these populations had a male-biased ( $P < 0.05$ ) population. Five of the six 2010 populations ( $n = 11$  to

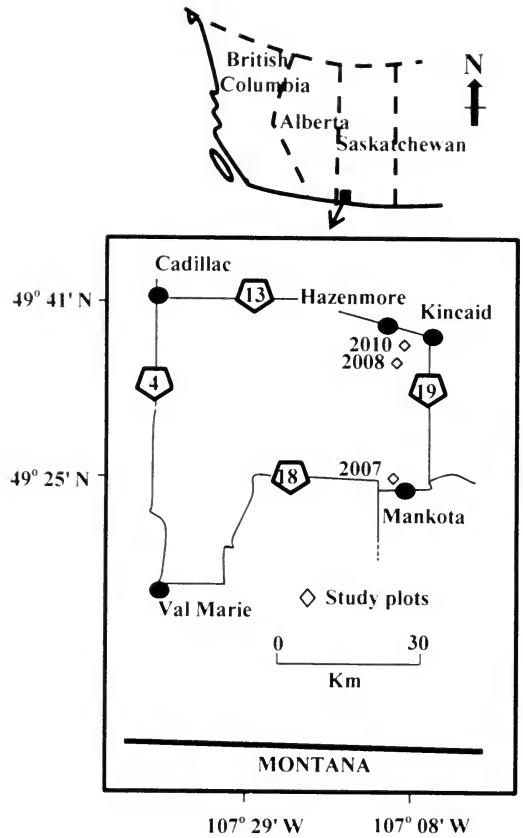


FIGURE 1. Location of study plots (2007 = two plots, 2008 = two plots, and 2010 = six plots) in southwestern Saskatchewan.

29 animals) had a female-biased ( $P < 0.05$ ) sex ratio; one population ( $n = 21$  animals) had an even ( $P > 0.05$ ) sex ratio. Together, the populations had a female-biased ( $P < 0.05$ ) sex ratio.

In 2007 and 2008, mortality rates following a period of no-trapping activity ranged from 0 to 16.7% and averaged 8.5% (SD 6.9). In 2010, after the period of severe weather, mortality rates ranged from 9.1 to 42.9%. The 2010 grand mean mortality rate of populations ( $\bar{X} = 28.9\%$ , SD 12) was significantly greater than that of the 2007 and 2008 populations ( $t = 2.9$ ,  $P < 0.01$ ).

The two 2007 recaptured populations had an even ( $P > 0.05$ ) sex ratio, but there was a tendency for more females, as in the original pooled populations. The sex ratio of the 2008 recaptured populations was identical to that of the captured populations. Two of the 2010 recaptured populations had an even ( $P > 0.05$ ) sex ratio; the others had a female bias ( $P < 0.05$ ). Together, the 2010 recaptured populations had a female-biased ( $P < 0.05$ ) sex ratio.

TABLE 1. Environmental conditions (G. MacKenzie's local weather station in Hazenmore; Environment Canada 2012\*) and study plot characteristics in spring 2007, 2008, and 2010, southwestern Saskatchewan.

	2007	2008	2010	
	Study plots			
<i>n</i>	2	2	6	
Size (ha)	0.5, 1.6	0.2, 0.3	1.3	
	Capture program			
Dates	23 and 24 April	23 April	18 and 19 May	
Single lowest temperature (°C)	2.2	-12.9	11.9	
Single highest temperature (°C)	19.1	2.2	27.5	
Precipitation (mm)	2.2	0	0	
Wind speed (km/h)	≤28	≤20	≤33	
Maximum wind gusts (km/h)	0	37	44–54	
	Severe rainstorm			
Dates	–	–	20–29 May	
Single lowest temperature (°C)	–	–	0.2	
Single highest temperature (°C)	–	–	16.4	
Precipitation (mm)	–	–	55	
Wind speed (km/h)	–	–	≤59	
Maximum wind gusts (km/h)	–	–	<31–85	
	Recapture program			
Dates	6–10 May	7 May	31 May–4 June	11–14 June
Single lowest temperature (°C)	-0.9	1.2	1.1	7.5
Single highest temperature (°C)	25.9	14.6	20.6	24.7
Precipitation (mm)	0	0	3	12.7
Wind speed (km/h)	≤50	≤22	≤54	≤50
Maximum wind gusts (km/h)	–	≤31	50–69	≤31–63

## Discussion

On average, nearly 30% of the Richardson's Ground Squirrels which were most likely alive before the severe rainstorm of May 2010 perished. This finding is in agreement with Morton and Sherman (1978), who found that a spring snowstorm resulted in an increase of approximately 30% in the mortality rate of adult female Belding's Ground Squirrels that had emerged from hibernation. Neuhaus et al. (1999) also reported an increase in the mortality rate of adult female and male Columbian Ground Squirrels of 11% and >22%, respectively, following a late spring snowstorm.

It is unlikely that the disappearance rate observed in spring 2010 was due to dispersal because, at this time of year, Richardson's Ground Squirrels do not disperse (Michener and Locklear 1990) and the fields surrounding the study plots were also flooded. It is also unlikely that predators killed many Richardson's Ground Squirrels during the rainstorm. Low temperatures, rain, and wind are known to have a negative impact on predator activity (e.g., Ables 1969; Doncaster 1985). However, on 30 May, one Striped Skunk (*Mephitis mephitis*) was observed feeding on a Richardson's Ground Squirrel. Although the Striped Skunk was likely scavenging, Richardson's Ground Squirrels suffering from hypothermia move slowly and erratically on the surface

(Proulx, unpublished observations) and could easily be killed by small carnivores.

Since the sex ratio of most of the recaptured Richardson's Ground Squirrel populations was similar to that of their respective captured populations, there was apparently no significant differential mortality of males or females, and population structures remained the same. Reproduction in Richardson's Ground Squirrels imposes high energy demands on both males and females (Michener 1983, 1984, 1989), so adverse conditions caused by the rainstorm and cold temperatures would have led to greater energetic costs and increased mortality rates (e.g., Neuhaus et al. 1999). Independent of the fact that the 2010 populations were in a more advanced reproductive condition than that of the 2007 and 2008 populations, Richardson's Ground Squirrels inhabiting cold, water-saturated burrow systems may die from drowning, hypothermia, and climatic stress (Sauer 1985; Michener 1992; Popovic 2006). On the other hand, some populations lost more animals than others, e.g., the mortality rate of a population inhabiting a study plot that was slightly more elevated than other study plots was 9.1% compared to 19.2–42.9% in other populations. Although study plots were not assessed for variation in the extent of flooding, water did accumulate more in some study plots than in others, and

the impact of the rainstorm certainly varied among sites according to the amount of relief and soil type.

### Acknowledgements

I am grateful to the Saskatchewan Association of Rural Municipalities (SARM) and the Canadian Agriculture Adaptation Program (CAAP) for funding this work. I thank Neil MacKenzie, Keith MacKenzie, Kara Walsh, Benjamin Proulx, Kim Stang, Jill Arnott, Christine Korol, and Jessy Dubnyk for technical help. I also thank Pauline Feldstein, Alpha Wildlife Research & Management Ltd., and two anonymous reviewers for reviewing an earlier version of the manuscript.

### Documents Cited (marked \* in text)

- Environment Canada.** 2011. Canada's top ten weather stories for 2010 – 3. From dry to drenched on the Prairies. Weather and Meteorology, Environment Canada, Gatineau, Quebec. <http://ec.gc.ca/meteo-weather/default.asp?lang=En&n=7E58ECA3-1>.
- Environment Canada.** 2012. National climate data and information archive. Weather and Meteorology, Environment Canada, Gatineau, Quebec. [http://climate.weatheroffice.gc.ca/advanceSearch/searchHistoricData\\_e.html](http://climate.weatheroffice.gc.ca/advanceSearch/searchHistoricData_e.html).

### Literature Cited

- Ables, E. D.** 1969. Activity studies of red foxes in southern Wisconsin. *Journal of Wildlife Management* 33: 145–153.
- Doncaster, P. C.** 1985. The spatial organization of the urban fox, *Vulpes vulpes*, in Oxford. Ph.D. thesis, Oxford University, Oxford, U.K.
- Helgen, K. M., F. R. Cole, L. E. Helgen, and D. E. Wilson.** 2009. Generic revision in the Holarctic ground squirrel genus *Spermophilus*. *Journal of Mammalogy* 90: 270–305.
- Michener, G. R.** 1983. Spring emergence schedules and vernal behaviour of Richardson's ground squirrels: why do males emerge from hibernation before females? *Behavioral Ecology and Sociobiology* 14: 29–38.
- Michener, G. R.** 1984. Sexual differences in body weight patterns of Richardson's ground squirrels during the breeding season. *Journal of Mammalogy* 65: 59–66.
- Michener, G. R.** 1989. Reproductive effort during gestation and lactation in Richardson's ground squirrels. *Oecologia (Berlin)* 78: 77–86.
- Michener, G. R.** 1992. Sexual differences in over-winter torpor patterns of Richardson's ground squirrels in natural hibernacula. *Oecologia* 89: 397–406.
- Michener, G. R., and L. Locklear.** 1990. Differential costs of reproductive effort for male and female Richardson's ground squirrels. *Ecology* 71: 855–868.
- Morton, M. L., and P. W. Sherman.** 1978. Effects of a spring snowstorm on behavior, reproduction, and survival of Belding's ground squirrels. *Canadian Journal of Zoology* 56: 2578–2590.
- Neuhaus, P. R. Bennett, and A. Hubbs.** 1999. Effects of a late snowstorm and rain on survival and reproductive success in Columbian ground squirrels (*Spermophilus columbianus*). *Canadian Journal of Zoology* 77: 879–884.
- Popovic, V.** 2006. Lethargic hypothermia in hibernators and nonhibernators. *Annals of the New York Academy of Sciences* 80: 320–331.
- Proulx G.** 2010. Factors contributing to the outbreak of Richardson's ground squirrel populations in the Canadian prairies. Pages 213–217 in *Proceedings of the 24th Vertebrate Pest Conference*, Sacramento, California, February 22–25, 2010. Edited by R. M. Timm and K. A. Fagerstone. University of California, Davis, California.
- Proulx, G., N. MacKenzie, K. MacKenzie, and K. Walsh.** 2011. Efficacy of aluminum phosphide tablets to control Richardson's ground squirrel (*Spermophilus richardsonii*) populations in southern Saskatchewan, Canada. *Crop Protection* 30: 1039–1042.
- Quanstrom, W. R.** 1966. Flood tolerance in Richardson's ground squirrel. *Journal of Mammalogy* 47: 323.
- Sauer, J. R.** 1985. Mortality associated with severe weather in a northern population of cotton rats. *American Midland Naturalist* 113: 188–189.
- Yensen, G. E., and P. W. Sherman.** 2003. Ground squirrels: *Spermophilus* and *Amnospermophilus* species. Pages 211–231 in *Wild Mammals of North America: Biology, Management, and Conservation*. Edited by G. A. Feldhamer, B. C. Thompson, and J. A. Chapman. Johns Hopkins University Press, Baltimore, Maryland.
- Zar, J. H.** 1999. *Biostatistical Analysis*. Fourth edition. Prentice Hall International, Upper Saddle River, New Jersey.

Received 22 September 2011

Accepted 12 March 2012

## Size of Territories and Home Ranges of Male Western Yellow-breasted Chats (*Icteria virens auricollis*) in British Columbia

RENÉ MCKIBBIN and CHRISTINE A. BISHOP<sup>1</sup>

Environment Canada, 5421 Robertson Road, RR#1, Delta, British Columbia V4K 3N2 Canada

<sup>1</sup>Corresponding author email: cab.bishop@ec.gc.ca

McKibbin, René, and Christine A. Bishop. 2012. Size of territories and home ranges of male Western Yellow-breasted Chats (*Icteria virens auricollis*) in British Columbia. *Canadian Field-Naturalist* 126(2): 152–156.

During 2005 and 2006, radio-transmitters were fitted to a total of 11 male Western Yellow-breasted Chats, *Icteria virens auricollis*, in the southern Okanagan River valley, British Columbia, to compare the area used, as detected by radio-telemetry and as defined by mapped observations of breeding males singing and perching. Data were only collected for 5 males. For 2005 and 2006, the 95% kernel density estimation (KDE) revealed that mean area used by male Western Yellow-breasted Chats, as determined by radio-tracking ( $n = 5$ ), was 1.16 ha, whereas the mean area as defined by observations of breeding males singing and perching was 0.62 ha (no statistical difference). Our hypothesis that the area determined by radio-tracking would be significantly larger than the area defined by observations of males singing and perching was rejected, but the area determined by radio-tracking was almost twice the area defined by observations of breeding males singing and perching.

Key Words: Western Yellow-breasted Chat, *Icteria virens auricollis*, home range, territory, radio-telemetry, endangered species, species at risk, Okanagan valley, British Columbia.

The use of space by a species is important for understanding its ecology (Anich et al. 2009), the function of a singing territory (Naguib et al. 2001), and the social relationships among conspecifics (Catchpole and Slater 1995). In the case of species at risk, this information is necessary in order to be able to map habitat necessary for protection (Anderson 2001; Clark et al. 2002). Territory mapping (defined by observations of males singing and perching) may underestimate the size of the area that is required, especially for secretive species (Anich et al. 2009). However, radio-telemetry is a reliable way to obtain information about movements outside of a male's singing territory and to measure area accurately (Naguib et al. 2001; Anich et al. 2009.)

This is the case for a population of the Western Yellow-breasted Chat (*Icteria virens auricollis*). The status of the Yellow-breasted Chat, *Icteria virens*, in British Columbia is S1S2 (critically imperilled or imperilled), and it is on the British Columbia Red List (which includes any species that is extirpated, endangered, or threatened). Nationally, the Southern Mountain population of the *auricollis* subspecies of the Yellow-breasted Chat (the subpopulation in British Columbia) is designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2011\*) and is on the List of Wildlife Species at Risk under the federal Species at Risk Act (endangered).

Yellow-breasted Chats are elusive and are often overlooked, they have a skulking and secretive nature, and they prefer dense shrubs (Eckerle and Thompson 2001). These characteristics make it a challenging species on which to collect accurate data on land use by Yellow-breasted Chats. We therefore compared territories defined by territory mapping (observations of perching

and singing locations of breeding males) and home range determined through radio-telemetry of breeding males. We predicted that home range as determined by radio-tracking would be significantly larger than the area defined by observations of singing and perching locations of breeding males.

### Study Area and Methods

The study area is described in McKibbin and Bishop (2008). The radio-telemetry and territory research was conducted in two sections of the South Okanagan Wildlife Management Area, which is within a highly fragmented riparian habitat zone (Lea 2008). The research was conducted from mid May to the end of July 2005 and 2006.

The methods for colour banding are described in McKibbin and Bishop (2008). Sex was determined by plumage and presence or absence of a brood patch.

The methods for mapping of territories by observations of males singing and perching are described in McKibbin and Bishop (2010).

To avoid disruption of the incubation process, radio-transmitters were fitted to only a subsample of males that were part of a breeding pair. Colour-banded Western Yellow-breasted Chats were fitted with a 0.90 g radio-transmitter with a lifespan of six weeks (BD-2, Holohil Systems Ltd., Carp, Ontario) following procedures as described in Green (1988), Alexander and Cresswell (1990), and Kenward (2001). Each bird was in holding between 10 and 15 minutes.

The Western Yellow-breasted Chats were tracked for 30 minutes about every second day until the end of July or until the radio-transmitter was removed by the bird. Between two and six observations were made during

each tracking period. Tracking was done between 0500 and 1600 using a LA12-Q portable radio-telemetry receiver and handheld three-element collapsible Yagi antenna (AVM Instruments Co. Ltd., Colfax, California). A Universal Transverse Mercator (UTM) coordinate was taken with a handheld Global Positioning System (GPS) (GPSMAP 76S, Garmin International, Olathe, Kansas) at each point where a male was located.

The UTM coordinates for both the territory mapping and the radio-tracking were input into ArcGIS 10 (ESRI 1999\*) and territory boundaries were determined. Area (ha) was calculated from 95% kernel density estimation (KDE) encompassing the observations using geospatial modelling environment software (Beyer 2001\*).

Due to the small sample size, non-parametric statistics were used. A Kruskal-Wallis test (Zar 1996) was used to determine whether there were significant differences between the mean areas defined by observations of singing and perching by the males that had been fitted with radio-transmitters and by the males without radio-transmitters and secondly to determine whether there were significant differences between the areas defined by observations of breeding males singing and perching and the areas measured with radio-tracking. Analysis was performed using the software JMP IN Version 4 (SAS Institute 2000\*).

## Results

During 2005, radio-transmitters were fitted to 5 males. Two of the Western Yellow-breasted Chats removed their transmitters within one day of being fitted and a third within 14 days of being fitted. The 2 remaining Western Yellow-breasted Chats (males 1 and 2) with radio-transmitters were tracked for four weeks.

The radio-transmitters that were recovered had the gauze and a large number of feathers stuck to them, indicating that the radio-transmitters did not fall off but were actually pulled off. The antennas also had small "bite" marks at the tip.

During 2005, between 30 and 61 locations per bird were made using radio-telemetry, and between 13 and 20 observations of singing and perching per bird were made for the same males during territory mapping. No locations by radio-tracking were recorded for the Western Yellow-breasted Chats that immediately removed their radio-transmitters. Territory mapping by observations of singing and perching was also done for 8 males that were not fitted with radio-transmitters, and between 14 and 21 observations per bird were made.

In 2006, radio-transmitters were fitted to 6 males. The antennas were cut one-third shorter in an attempt to prevent the Western Yellow-breasted Chats from pulling them off. However, this did not prove to be successful, as four radio-transmitters were removed within one day. Male A was tracked for three weeks, and Male B removed the transmitter within 14 days of being fitted.

No locations by radio-tracking were recorded for the Western Yellow-breasted Chats that immediately removed their radio-transmitters; between 7 and 24 locations per bird were recorded during radio-tracking and between 16 and 17 observations of singing and perching were made for the same males during territory mapping. Territory mapping by observations was also done for 11 males that were not fitted with radio-transmitters, and between 13 and 24 observations per bird were made.

The 95% kernel density estimation for indicated mean home range size determined by radio-tracking was 1.16 ha (SD 0.87). The mean territory size defined by observations of singing and perching for the same males was 0.62 ha (SD 0.24). During 2005, for males 1, 2, and 3, territories defined by observations of singing and perching were between 40% and 66% of the home range area determined by radio-tracking. During 2006, for male A, the territory defined by observations of singing and perching was 56% of the home range determined by radio-telemetry, and for male B the territory defined by observations of males singing and perching was 54% larger than the home range determined by radio-tracking (Figures 1 and 2). Male B removed his radio-transmitter within 14 days of being fitted, and only 7 locations were recorded during radio-tracking, whereas a total of 17 observations of singing and perching were made during six visits to the territory.

Due to the large variation in the size of males' home ranges (as determined by radio-tracking) and territory size (as defined by observations of breeding males singing and perching), there was no statistically significant difference between the area used by males fitted with radio-transmitters and the area used by males without radio-transmitters ( $P = 0.30$ ) or between the area defined by observations of singing and perching and the area determined by radio-tracking of males with radio-transmitters ( $P = 0.47$ ). The mean territory size defined by observations of singing and perching for the Western Yellow-breasted Chats where radio-tracking was not done ( $n = 8$  in 2005,  $n = 11$  in 2006) was 0.54 ha (SD 0.15). Combined mean territory size defined by observations of breeding males singing and perching for Western Yellow-breasted Chats with and without radio-transmitters was 0.55 ha (SD 0.17).

During 2005, Male 2 had the largest home range as determined by radio-tracking. He defended two different territories (as defined by observations of males singing and perching) about 700 m apart. Male 2 was singing in both territories and females were heard in both territories.

Forays by males outside of their territories (defined by observations of singing and perching) were mostly silent (68%). Territories defined by observations of singing and perching also seldom overlapped, while home ranges determined by radio-tracking often overlapped (Figures 1 and 2).

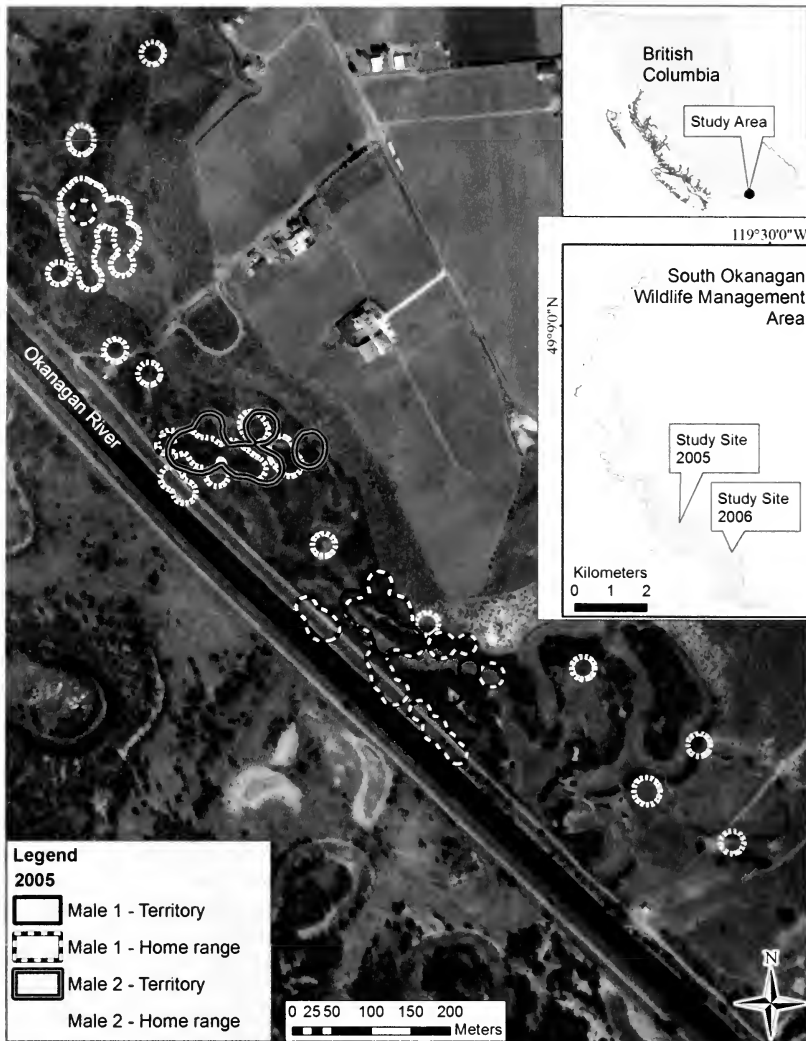


FIGURE 1. Western Yellow-breasted Chat (*Icteria virens auricollis*) territories as defined by observations of males singing and perching and home ranges as determined by radio-tracking (95% kernel density estimation) for males 1 and 2 (four weeks each) in the South Okanagan Wildlife Management Area in British Columbia during 2005.

## Discussion

Even though there was no statistically significant difference between the size of the area defined by observations of singing and perching and the size of the area determined by radio-telemetry, radio-tracking clearly indicated that these areas are highly variable in size and, on average, are almost double the size of the area defined by observations of singing and perching. During 2005 and 2006, mean territory size of Western Yellow-breasted Chats in the South Okanagan Wildlife Management Area as defined by observations of singing and perching was 0.55 ha (SD 0.17, range 0.29–0.95), which is smaller than territory sizes for Yellow-breasted Chats elsewhere. By plotting observations of chat in

southern Indiana, the mean territory size was 1.2 ha (SD 0.51, range 0.4–2.4) (Thompson and Nolan 1973); in Virginia, the territory size ranged from 0.5 to 1.0 ha (Dennis 1958); while in southern Illinois, the mean territory size of 0.13 ha (range 0.06–0.29) (Brewer 1955) was smaller. Our findings are consistent with other studies which reported that territory size defined through territory mapping (observations of males singing and perching) may be an underestimate of territory size (the area used) (e.g., Naguib et al. 2001; Anich et al. 2009).

Our data indicated that Western Yellow-breasted Chat males regularly moved outside their own territories (as defined by observations of males singing and



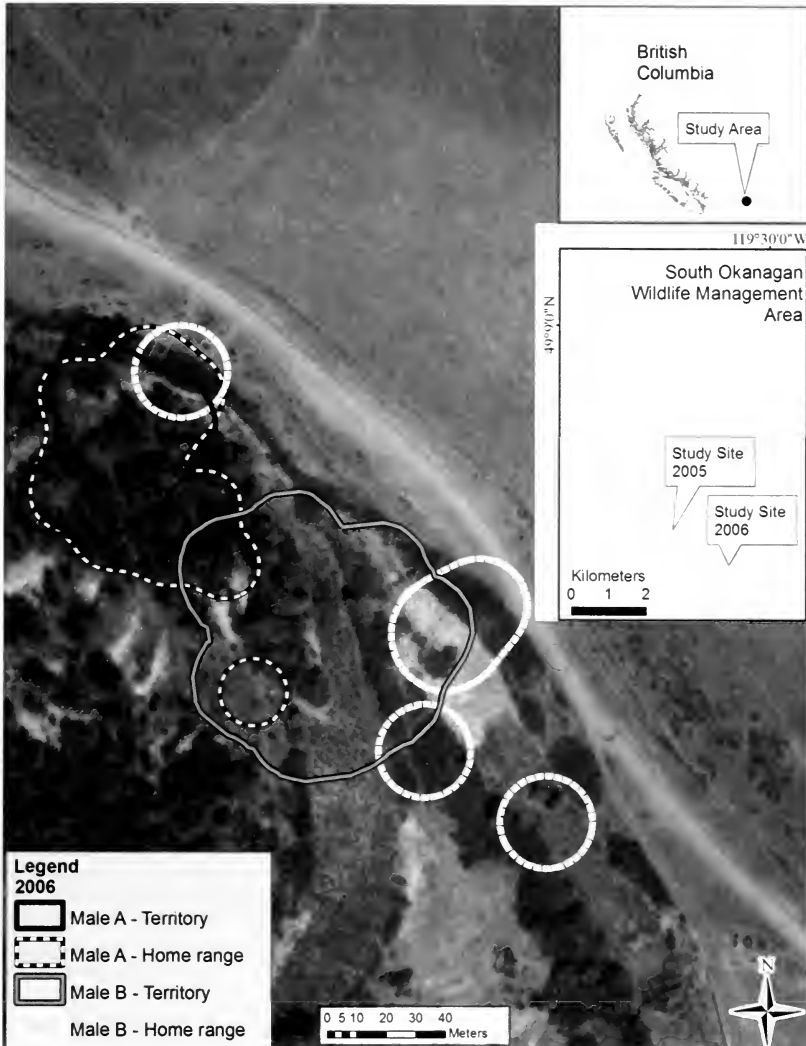


FIGURE 2. Western Yellow-breasted Chat (*Icteria virens auricollis*) territories as defined by observations of males singing and perching and home ranges as determined by radio-tracking (95% kernel density estimation) for Male A (three weeks) and Male B (two weeks) in the South Okanagan Wildlife Management Area in British Columbia during 2006.

perching) into neighbouring territories. Forays outside of the male's territory were mostly silent, and territories seldom overlapped. Home ranges as determined by radio-tracking often overlapped, suggesting forays outside of a male's singing territory were most likely for reasons other than expanding his territory. These forays into neighbouring territories may be for foraging, extra-pair copulations, to test a neighbour's attention, or to investigate a neighbour's breeding stage (Naguib et al. 2001).

Extra-pair paternity commonly occurs in Western Yellow-breasted Chats in the south Okanagan (Mino et al. 2011), and forays into neighbouring territories possibly involve extra-pair copulations with neighbouring females. However, suitable habitat is limited in the

south Okanagan, and males could also have wandered outside of their territory to forage. Regular extra-territorial forays are also documented for Yellow-breasted Chats in Illinois (Alessi 2009) and Kentucky (Mays and Ritchison 2004).

Our research indicated that using only territory mapping (observations of males singing and perching) to determine the area used by Yellow-breasted Chats in the south Okanagan could lead to an underestimate of the total area used. This is an important factor to consider when decisions are made regarding the management and conservation of Western Yellow-breasted Chats involving the determination of the size of a reserve necessary for their survival and designing habitat restoration sites.

## Acknowledgements

We thank Alicia Newbury, Jeanette Armstrong, Lukus Bent, Owain McKibbin, Richard Armstrong and Rosemary Bryan for their assistance during data collection. Dan Shervill performed some of the GIS analysis. Scientific permit to capture and band migratory birds 10365 CY and Species At Risk Act permits 59-05-0378 and 59-06-0304 were granted to René McKibbin. Project was reviewed by Animal Care Committees either of Simon Fraser University or BC Ministry of the Environment. We thank reviewers for valuable suggestions.

## Documents Cited (marked \* in text)

- Beyer, H. L.** 2001. Geospatial modelling environment. <http://www.spatial ecology.com/gme>. (Accessed 9 November 2011).
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC).** 2011. [http://www.cosewic.gc.ca/eng/sect/index\\_e.cfm](http://www.cosewic.gc.ca/eng/sect/index_e.cfm). (Accessed 25 July 2012).
- ESRI.** 1999. <http://www.esri.com>. Revised 2010. (Accessed 9 November 2011).
- SAS Institute Inc.** 2000. <http://www.sas.com>. Revised 2012. (Accessed 9 November 2011).

## Literature Cited

- Alessi, M. G.** 2009. The nocturnal behaviors of Yellow-breasted Chats. M.S. thesis, University of Illinois, Urbana-Champaign, Illinois.
- Alexander, L., and B. Cresswell.** 1990. Foraging by Nightjars *Caprimulgus europaeus* away from their nesting areas. *Ibis* 132: 568–574.
- Anderson, D. R.** 2001. The need to get the basics right in wildlife field studies. *Wildlife Society Bulletin* 29: 1294–1297.
- Anich, N. M., T. J. Benson, and J. C. Bednarz.** 2009. Estimating territory and home-range sizes: do singing locations alone provide an accurate estimate of space use? *Auk* 126: 626–634.
- Brewer, R.** 1955. Size of home range in eight bird species in a southern Illinois swamp-thicket. *Wilson Bulletin* 67: 140–141.
- Catchpole, C., and P. J. B. Slater.** 1995. Bird song: biological themes and variations. Cambridge University Press, Cambridge, U.K.
- Clark, J. A., J. M. Hoekstra, P. D. Boersma, and P. Kareiva.** 2002. Improving U.S. Endangered Species Act recovery plans: key findings and recommendations of the SCB Recovery Plan Project. *Conservation Biology* 16: 1510–1519.
- Dennis, J. V.** 1958. Some aspects of the breeding ecology of the Yellow-breasted Chat (*Icteria virens*). *Bird-Banding* 29: 169–183.
- Eckerle, K. P., and C. F. Thompson.** 2001. Yellow-breasted Chat (*Icteria virens*). No. 575 in *The Birds of North America*. Edited by A. Poole and F. Gill. Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington.
- Green, R.** 1988. Effects of environmental factors on the timing and success of breeding of Common Snipe *Gallinago gallinago* (Aves: Scolopacidae). *Journal of Applied Ecology* 25: 79–93.
- Kenward, R. E.** 2001. A manual for wildlife radio tagging. Academic Press, San Diego, California.
- Lea, T.** 2008. Historical (pre-settlement) ecosystems of the Okanagan Valley and Lower Similkameen Valley of British Columbia—pre-European contact to the present. *Davidsonia* 19: 3–38.
- Mays, H. L., and G. Ritchison.** 2004. The effect of vegetation density on male mate guarding and extra-territorial forays in the yellow-breasted chat (*Icteria virens*). *Naturwissenschaften* 91: 195–198.
- McKibbin, R., and C. A. Bishop.** 2008. Capture success rates of the western Yellow-breasted Chat in the south Okanagan valley, British Columbia, Canada during 2005 to 2007. *North American Bird Bander* 33: 179–184.
- McKibbin, R., and C. A. Bishop.** 2010. Habitat characterization of breeding territories of the western Yellow-breasted Chat in the south Okanagan, British Columbia, Canada. *Northwestern Naturalist* 91:145–156.
- Mino, C. I., I. L. Pollet, C. A. Bishop, and M. A. Russello.** 2011. Genetic mating system and population history of an endangered population of the western yellow-breasted chat (*Icteria virens auricollis*) in British Columbia, Canada. *Canadian Journal of Zoology* 89: 881–891.
- Naguib, M., R. Altenkamp, and B. Griessmann.** 2001. Nightingales in space: song and extra-territorial forays of radio tagged song birds. *Journal of Ornithology* 142: 306–312.
- Thompson, C. F., and V. Nolan, Jr.** 1973. Population biology of the Yellow-breasted Chat (*Icteria virens* L.) in southern Indiana. *Ecological Monographs* 43: 145–171.
- Zar, J. H.** 1996. Biostatistical analysis. Third edition. Prentice Hall, Upper Saddle River, New Jersey.

Received 15 February 2012

Accepted 28 June 2012

## Urban White-tailed Jackrabbits (*Lepus townsendii*) Eat Spike Plants (*Cordyline australis*) in Winter

ALWYNNE B. BEAUDOIN<sup>1</sup> and YVES BEAUDOIN<sup>2</sup>

<sup>1</sup>Royal Alberta Museum, 12845-102nd Avenue, Edmonton, Alberta T5N 0M6 Canada

<sup>2</sup>Webpraxis Consulting, Edmonton, Alberta T5R 5S5 Canada

Beaudoin, Alwynne B., and Yves Beaudoin. 2012. Urban White-tailed Jackrabbits (*Lepus townsendii*) eat spike plants (*Cordyline australis*) in winter. *Canadian Field-Naturalist* 126(2): 157–159.

We observed White-tailed Jackrabbits (*Lepus townsendii*) eating spike plants (*Cordyline australis*), a non-native ornamental garden plant, in our front yard within the city of Edmonton, Alberta. We have noted this persistent behaviour every winter between 2006-2007 and 2011-2012. By late January, the plants were usually eaten right down to the stem base. We suggest that the White-tailed Jackrabbits turn to this food source in winter when more preferred foods are lacking, are in short supply, or are not as readily accessible. Our observations add another plant species to the list of non-native plants consumed by White-tailed Jackrabbits.

Key Words: *Lepus townsendii*, White-tailed Jackrabbit, diet, ecology, animal behaviour, urban wildlife, Edmonton, garden plants, *Cordyline australis*.

Each winter between 2006-2007 and 2011-2012, we have observed White-tailed Jackrabbits (*Lepus townsendii*) eating spike plants (*Cordyline australis*), a non-native ornamental garden plant, in our front yard within the city of Edmonton, Alberta. The White-tailed Jackrabbit is native to interior North American (Banfield 1974), and the Edmonton area is near the northwestern limit of its range (Smith 1993). The preferred habitat of the White-tailed Jackrabbit is open grasslands, including native prairie, pastures, and cultivated grain fields (Banfield 1974). The White-tailed Jackrabbit expanded its range during the previous century as more suitable habitat became available, primarily as a result of human activities (Wood et al. 2006). At its northern limit, the White-tailed Jackrabbit has taken advantage of cleared and more open landscapes in the Parkland ecoregion (Natural Regions Committee 2006), which includes the Edmonton area (Wood et al. 2006).

White-tailed Jackrabbits were observed in our urban neighbourhood in the west end of Edmonton (53°31.3'N, 113°33.6'W). The neighbourhood, Valleyview, is bordered to the east by the North Saskatchewan River valley, which forms part of an extensive urban parkland and greenspace within the city. It is an older residential neighbourhood that was mostly developed in the 1960s. Most older homes are set well back from the lot lines and have mature landscaping, providing plenty of open space, with cover provided by horticultural perennials, shrubs, large conifers, and deciduous trees. Neighbourhood roads are usually quiet and carry little traffic, mostly vehicles travelling at low speed.

We have three large wooden barrels (diameter of approximately 65 cm) in the front yard of our house, and we plant them with annuals in late spring each year (Figure 1). The centrepiece of each arrangement is a spike plant. Immature forms of *Cordyline australis* (Cabbage Tree), which is native to New Zealand, have

become popular annuals under the common name "spikes" or spike plant (also known as a dracaena or cane plant). We also plant one spike plant in a raised brick-edged flowerbed immediately adjacent to the front steps of the house. The local garden centre sells these plants as *Dracaena indivisa*. However, the *Dracaena* genus was synonymized with *Cordyline* (Dunlop 2009; NZ Plant Conservation Network 2012\*) and, based on vegetative characters, these container plants are most likely cultivars of *Cordyline australis* (Figure 1a) (Armitage and Clarkson 2008). Spike plants often remain green after frost kills the other annuals. In their native New Zealand habitat, *Cordyline* species are perennials but are susceptible to cold damage when temperatures fall below about -10°C (Harris et al. 2001). In Edmonton, with average winter temperatures around -11.8°C (National Climate Data and Information Archive 2012\*), spike plants do not survive over the winter outdoors.

White-tailed Jackrabbits usually start consuming spike leaves after the first snowfall. The White-tailed Jackrabbits start with the plant in the container furthest from the house (Figure 1d). As that plant is consumed and winter conditions become more severe, the plants in the containers closer to the house are gradually consumed. The plant in the flowerbed has never been eaten. By late January, all the container plants are eaten right down to the stem base. On 13 January 2007, we watched one White-tailed Jackrabbit for about 30 minutes in the early evening, just after dark. It hopped up onto one of the barrels by the driveway and browsed the remaining leaf bases on the spike plant (by this date, there was little foliage left). Tracks and droppings left on and around the barrel and the adjacent barrels provide evidence of the White-tailed Jackrabbits' feeding behaviour (Figure 1b). We have seen this feeding behaviour repeated on several occasions (Figure 1c).



FIGURE 1. Barrels (diameter ca. 65 cm, height ca. 44 cm) containing *Cordyline australis* plants eaten by White-tailed Jackrabbits, 2006-2007 to 2011-2012. 1a) Spike foliage next to the solar light has fallen over after frosts but is still green, 23 December 2011. 1b) Plant eaten to the stem base, 14 January 2007. Note tracks and droppings. 1c) Clear outline of White-tailed Jackrabbit's body in the snow, 24 December 2008. 1d) Following heavy snowfall in late December and early January, foliage in the barrel farthest from the house (upper part of photograph) has been consumed, 9 January 2011. Image credits: A. B. Beaudoin and Y. Beaudoin.

We have not seen White-tailed Jackrabbits eating spike plants during the summer and have only rarely noticed any browsing damage to the plants before winter. Our supposition is that White-tailed Jackrabbits use this food source in winter, when more preferred foods are lacking, are in short supply, or are not as readily accessible. Far from specializing on a few native plants, White-tailed Jackrabbits are generalists in their food consumption, taking advantage of a variety of different food sources, including woody shrubs and non-native forage crops such as Alfalfa (*Medicago sativa*) (Bear and Hansen 1966; Brunton 1981; Swihart and Yahner 1983; Lim 1987). Presumably, this accounts in part for their broad geographic range and success in disturbed open habitats. The winter consumption of spike plants

is thus consistent with White-tailed Jackrabbits' broad dietary habits.

Cambie and Ferguson (2003) report nutritive values for *Cordyline australis* roots, stems, and tops (that is, foliage) derived from a study by Fankhauser (1986). No toxins are reported. The data indicate that the tops are lower in carbohydrate than the roots (8.8% compared to 23.6%) but contain more protein (1.4% compared to 0.4%) and have a modest caloric yield (283 kJ/100g). In comparison, alfalfa hay has a caloric yield of 922.4 kJ/100g (Stanton and LeValley 2010\*). The White-tailed Jackrabbits are therefore getting some nutritional benefit by consuming the spike plant material.

Our observations of White-tailed Jackrabbits' behaviour and winter feeding habits, though admittedly lim-

ited, suggest several intriguing avenues for further research. An analysis of faecal pellets would provide more insights into the relative contribution of non-native horticultural plants to their overall diet, would identify any other horticultural plants being consumed, and would indicate whether spike plants are preferentially consumed. Investigation of the nutritional composition of native and non-native plants consumed by White-tailed Jackrabbits could help in the assessment of the long-term viability of these urban populations and the persistence of this species near the limit of its range.

### Acknowledgements

We thank the following people for assistance with this research: Warwick D. Harris (Landcare Research, Lincoln, New Zealand) for information on *Cordylina*, including help with descriptions and taxonomy; James Armitage (Royal Horticultural Society, Wisley, England) for assistance with identification of *Cordylina australis*, including a useful diagram, and information on *Cordylina* taxonomy; and Mark A. Edwards (Curator of Mammalogy, Royal Alberta Museum) for thoughtful and constructive comments on an earlier draft.

### Documents Cited (marked \* in text)

- National Climate Data and Information Archive.** 2012. Canadian Climate Normals 1971-2000. [http://www.climate.weatheroffice.gc.ca/climate\\_normals/index\\_e.html](http://www.climate.weatheroffice.gc.ca/climate_normals/index_e.html). (Accessed 14 October 2012).
- NZ Plant Conservation Network.** 2012. *Cordylina australis* information page. [http://www.nzpcn.org.nz/flora\\_details.asp?ID=1744](http://www.nzpcn.org.nz/flora_details.asp?ID=1744). (Accessed 14 October 2012).
- Stanton, T. L., and S. LeValley.** 2010. Feed Composition for Cattle and Sheep. Fact Sheet No. 1.615. Colorado State University Extension. 6 pages. <http://www.ext.colostate.edu/pubs/livestk/01615.pdf>. (Accessed 14 October 2012).

### Literature Cited

- Armitage, J. D., and J. J. Clarkson.** 2008. A morphological and molecular investigation of *Cordylina* hybrids and cultivars. *Acta Horticulturae* 799: 89–95.

- Banfield, A. W. F.** 1974. The Mammals of Canada. Published for the National Museum of Natural Sciences, National Museums of Canada, by the University of Toronto Press. Toronto, Ontario. 438 pages.
- Bear, G. D., and R. M. Hansen.** 1966. Food habits, growth and reproduction of White-tailed Jackrabbits in southern Colorado. Technical Bulletin, Agricultural Experiment Station, Colorado State University, No. 90. Colorado State University, Fort Collins, Colo. 59 pages.
- Brunton, D. F.** 1981. Nocturnal aggregations of white-tailed jack-rabbits at Rimbey, Alberta. *Blue Jay* 39: 120–121.
- Cambie, R. C., and L. R. Ferguson.** 2003. Potential functional foods in the traditional Maori diet. *Mutation Research* 523-524: 109–117.
- Dunlop, G.** 2009. *Cordylina indivisa* in the British Isles. *New Zealand Garden Journal* 12(1): 20–24.
- Fankhauser, B. L.** 1986. Archaeometric studies of *Cordylina* (Ti) based on ethnobotanical and archaeological research. Ph.D. thesis, University of Otago, Dunedin, New Zealand. 502 pages.
- Harris, W., R. E. Beever, and B. Smallfield.** 2001. Variation in response to cold damage by populations of *Cordylina australis* and of some other species of *Cordylina* (Lomandraceae). *New Zealand Journal of Botany* 39(1): 147–159.
- Lim, B. K.** 1987. *Lepus townsendii*. *Mammalian Species*. No. 288. 6 pages.
- Natural Regions Committee.** 2006. Natural Regions and Subregions of Alberta. Compiled by D. J. Downing and W. W. Pettapiece. Government of Alberta. Pub. No. T/852. 254 pages.
- Smith, H. C.** 1993. Alberta Mammals: An Atlas and Guide. Provincial Museum of Alberta. Edmonton, Alberta. 239 pages.
- Swihart, R. K., and R. H. Yahner.** 1983. Browse preferences of jackrabbits and cottontails for species used in shelter-belt plantings. *Journal of Forestry* 81(2): 92–94.
- Wood, J. R., J. Krenz, and T. Boyd-Zhang.** 2006. Urban White-Tailed Jackrabbits of the Edmonton region (1992–2002). Pages 119–133 in *Coyotes Still Sing in My Valley: Conserving Biodiversity in a Northern City*. Edited by R. W. Wein. Spotted Cow Press, Edmonton, Alberta.

Received 21 February 2012

Accepted 4 July 2012

## Resistance of Canada Yew (*Taxus canadensis*) Branch Wood to Two Wood Decay Fungi

DANA L. RICHTER<sup>1</sup>, AMY M. BERNS, and CLARE F. FREDERICK

School of Forest Resources and Environmental Science, Michigan Technological University, 1400 Townsend Drive, Houghton, Michigan 49931 USA

<sup>1</sup>Corresponding author email: dlrichte@mtu.edu

Richter, Dana L., Amy M. Berns, and Clare F. Frederick. 2012. Resistance of Canada Yew (*Taxus canadensis*) branch wood to two wood decay fungi. *Canadian Field-Naturalist* 126(2): 160–163.

Wood of the larger yews (*Taxus* spp.) is reported to be decay-resistant, but little is known about the decay resistance of Canada Yew (*Taxus canadensis* Marsh.) wood. Branch wood from Canada Yew was compared to branch wood from Northern Red Oak (*Quercus rubra* L.) and Eastern White Cedar (*Thuja occidentalis* L.) in a standard laboratory decay test to evaluate its resistance to decay by two decay fungi. Canada Yew was shown to be significantly more resistant to decay by *Gloeophyllum trabeum* (Pers.) Murr. (a brown rot fungus) and *Trametes versicolor* (L.: Fr.) Quél. (a white rot fungus) than Northern Red Oak ( $P \leq 0.05$ ). Canada Yew was shown to be equal to Eastern White Cedar in resistance to decay by *G. trabeum* and more than twice as resistant to decay by *Trametes versicolor* ( $P \leq 0.05$ ). These results may have relevance for survival of Canada Yew, which is under pressure from browsing by White-tailed Deer (*Odocoileus virginianus*).

Key Words: Canada Yew, *Taxus canadensis*, *Gloeophyllum trabeum*, brown rot fungi, *Trametes versicolor*, white rot fungi, White-tailed Deer, *Odocoileus virginianus*, decay resistance, decay fungi, browse.

Canada Yew (*Taxus canadensis* Marsh.) is an ever-green woody shrub native to northeastern North America. It has gained attention in recent years, partly because of the presence of the anti-cancer chemical paclitaxel (Cameron and Smith 2002) and partly because of the apparent decline of the shrub due to over-browsing by White-tailed Deer (*Odocoileus virginianus*) (Holmes et al. 2009; Windels and Flaspohler 2011).

The genus *Taxus* contains seven species of trees and shrubs, principally of temperate regions (Harlow and Harrar 1969). Although wood of the larger yews is reported to be decay-resistant, little is known about the decay resistance of Canada Yew wood because of its small size. The related species, English Yew (*Taxus baccata*) and Pacific Yew (*T. brevifolia*), attain the size of small trees and their wood is of modest commercial importance (Harlow and Harrar 1969; Thomas and Polwart 2003). The wood of both of these species is considered strongly decay-resistant (U.S. Forest Products Laboratory 1974; Rayner and Boddy 1988), although this is based on field observations, and actual laboratory decay tests of the woods of these species are not known (see Thomas and Polwart (2003) for *T. baccata* and U.S. Forest Products Laboratory (1967) for *T. brevifolia*).

Decay fungi associated with *Taxus baccata* and *T. brevifolia* include many common and non-specific brown rot and white rot species found on conifer species worldwide. de Vries and Kuyper (1990, cited in Thomas and Polwart 2003) list 73 Basidiomycotina decay fungi associated with *T. baccata*. Farr et al. (1989) cite references that include 12 species of Basidiomycotina decay fungi associated with *T. brevifolia*. Although nothing is cited with respect to the decay organisms of Canada Yew (Farr et al. 1989), it is likely that a similar range of fungi are responsible for the decay of its

wood, since the fungi associated with the larger yews are found on many woody species (Rayner and Boddy 1988; Schmidt 2006).

Wood decay takes place principally by the action of brown rot and white rot fungi (Rayner and Boddy 1988; Schmidt 2006). The fungi responsible for wood decay are commonly Basidiomycotina, although a few Ascomycotina white rot fungi are important decay organisms in forest ecosystems (Rayner and Boddy 1988; Schmidt 2006). Brown rot fungi act on the cellulose component of wood, leaving a brown residue consisting mostly of lignin (Rayner and Boddy 1988; Schmidt 2006). White rot fungi act on both the lignin and the cellulose components of wood (sometimes called simultaneous rot), leaving a white residue (Rayner and Boddy 1988; Schmidt 2006). There are far more white rot fungi than brown rot fungi (Schmidt 2006); however, both decay types are commonly used in wood decay resistance tests (ASTM 2005).

Canada Yew remains a shrub throughout its life, and its wood is rarely if ever used for structural or other purposes (Harlow and Harrar 1969). General botanical characteristics of Canada Yew are given in a U.S. Department of Agriculture technical report on the species (Martell 1974). However, apparently because it is not used as a woody species, there is no mention of its decay properties. Likewise, in the extensive list of fungi of plants of the United States, Farr et al. (1989) cite no wood decay fungi associated with Canada Yew.

To provide information about the decay resistance of Canada Yew, we exposed mature branch wood to a brown rot fungus and a white rot fungus in a standard laboratory decay test. The decay of Canada Yew was compared with the decay of branch wood of Northern Red Oak (*Quercus rubra* L.), a species susceptible to decay, and branch wood of Eastern White Cedar (*Thuja*

*occidentalis* L.), a decay-resistant species (Rayner and Boddy 1988).

## Methods

All plant material was collected in Houghton County, Michigan (47.10248°N, 88.51702°W), from live, healthy plants growing in the wild, free from decay or other defects. Branches of Canada Yew were collected from a putative clone approximately 10 m in diameter and 1 m in height. Lateral lower branches of Eastern White Cedar and Northern Red Oak were collected from four small trees of each species less than 5 m in height. Two to three branches 30 to 60 cm long and 1.0 to 1.5 cm in diameter were cut from each tree species.

Pieces 2.5 cm long with the bark left intact were cut from the branches for the decay test. Pieces were combined within species, and 20 pieces from each species were selected for uniformity (roundness, free from knots, etc.) for the decay test (10 for each of the two fungi tested). Branch pieces were labeled and dried to a constant weight at 40°C for 24 h, and individual weights were recorded. Pieces were sterilized in an autoclave for 15 min prior to being inserted in jars and inoculated with decay fungi, as described below.

Branch pieces were exposed individually to pure cultures of fungi following a standard decay testing protocol (ASTM 2005). The brown rot fungus *Gloeophyllum trabeum* (Pers.) Murr. (Gloeophyllaceae), American Type Culture Collection isolate no. 11539, and the white rot fungus *Trametes versicolor* (L.) Lloyd (Polyporaceae), American Type Culture Collection isolate no. 12679, were used. Fungi were grown on 2% malt agar (Difco) in 100 mm Petri plates for approximately one week at 22°C–24°C prior to use. A square jar (5 × 5 × 13.5 cm) containing 100 g (range 99–101) of dried (50°C) forest topsoil was wetted with 30 mL (range 29–31) of distilled water to obtain a soil moisture holding capacity of 90%–100%. The pH of the soil was 5.8–6.0 (1:1 soil to water). A plastic lid with a hole 5 mm in diameter covered by a strip of adhesive cloth tape was placed tightly on the jar to allow respiration, and jars were autoclaved for 30 min. After the jars had cooled, a piece of agar inoculum approximately 1 × 2 × 0.5 cm colonized by the fungus from the actively growing culture was placed on the soil surface in the jar, and a branch piece was pressed firmly into the inoculum. Jars were incubated at 27°C (range 26–28) and a relative humidity of 80% (range 80–84). Ten replicate branch pieces were used for each woody species/fungus test.

After 16 weeks, the branch pieces were removed from the jars, were re-dried to a constant weight at 40°C for 24 h, and were weighed to determine weight loss due to decay. Mean percentage weight loss of replicate sets by woody species/fungus exposure within decay type were compared by one-way ANOVA, followed by Tukey's test to identify significant differences between means ( $P \leq 0.05$ ) (Sigma Plot 12, 2010\*).

## Results

At the end of the incubation period, branch pieces were examined for colonization by fungi to note amount and type of coverage by mycelium. All branch pieces were colonized, and no contamination by mold fungi was present. Canada Yew branch pieces had light colonization overall by both *Gloeophyllum trabeum* and *Trametes versicolor*. Eastern White Cedar was colonized least by *G. trabeum*, and Eastern White Cedar and Northern Red Oak were moderately to heavily colonized by *Trametes versicolor*.

For both *G. trabeum* (brown rot) and *Trametes versicolor* (white rot), mean percentage weight loss due to decay was least for Canada Yew. The woody species most susceptible to decay by *G. trabeum* was Northern Red Oak (mean percentage weight loss of 12.8%), which differed significantly from Canada Yew. (mean percentage weight loss of 6.2%), and from Eastern White Cedar. (mean percentage weight loss of 7.7%) (Figure 1). The woody species most susceptible to decay by *Trametes versicolor* was Northern Red Oak (mean percentage weight loss of 62.2%), which differed significantly from Eastern White Cedar. (mean percentage weight loss of 37.4%), and from Canada Yew (mean percentage weight loss of 16.5%) (Figure 2). These data confirm that Northern Red Oak is susceptible to decay and that Eastern White Cedar is decay-resistant. Canada Yew is also shown to be a decay-resistant species.

## Discussion

Although other species of fungi are likely to attack Canada Yew branches in the wild, *Gloeophyllum trabeum* and *Trametes versicolor* are considered "typical" decay fungi commonly used to represent a range of brown rot and white rot fungi in standard decay testing (ASTM 2005). Both fungi occur within the geographical ranges of the woody species tested (Gilbertson and Ryvarden 1986). The results indicate that Canada Yew branches are more resistant to decay than Northern Red Oak when exposed to *G. trabeum* (brown rot) and *Trametes versicolor* (white rot). Compared to Eastern White Cedar, Canada Yew branches are equal in resistance to decay by *G. trabeum* and more than twice as resistant to decay by *T. versicolor*.

Canada Yew is a native shrub species that is considered to be in decline across its natural range due to several factors (Holmes et al. 2009; Windels and Flaspohler 2011). One factor proposed for the decline of Canada Yew is over-browsing by White-tailed Deer. For example, in their comprehensive review of the ecology of Canada Yew, Windels and Flaspohler (2011) state that larger patches (>1 ha) are browsed mainly on the outer portions of the clone, and they suggested this pattern was due to the fact that White-tailed Deer have difficulty penetrating the inner portions due to the stiffness and density of its branches. Results of our study of the decay resistance of Canada Yew support the obser-

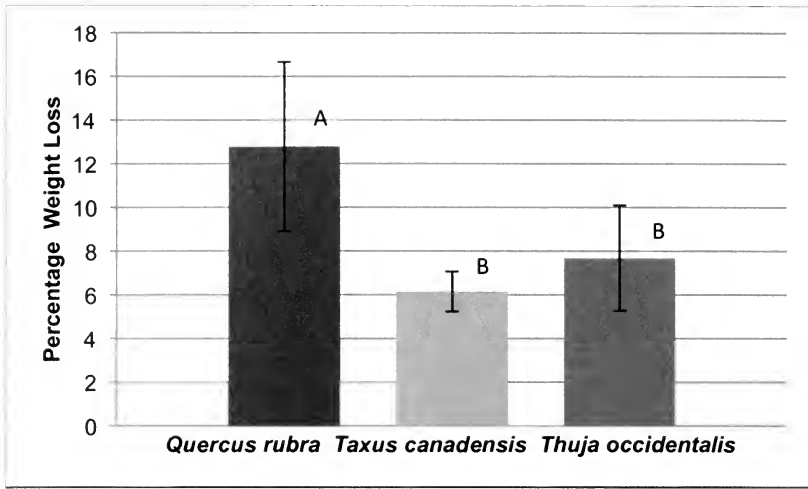


FIGURE 1. Mean percentage weight loss of branch pieces of the woody species Canada Yew (*Taxus canadensis*), Northern Red Oak (*Quercus rubra*), and Eastern White Cedar (*Thuja occidentalis*) by the brown rot fungus, *Gloeophyllum trabeum* ATCC 11539 ( $n = 10$  for each woody species). Bars with different capital letters are significantly different (ANOVA  $P \leq 0.05$ ); lines within bars represent the standard deviation.

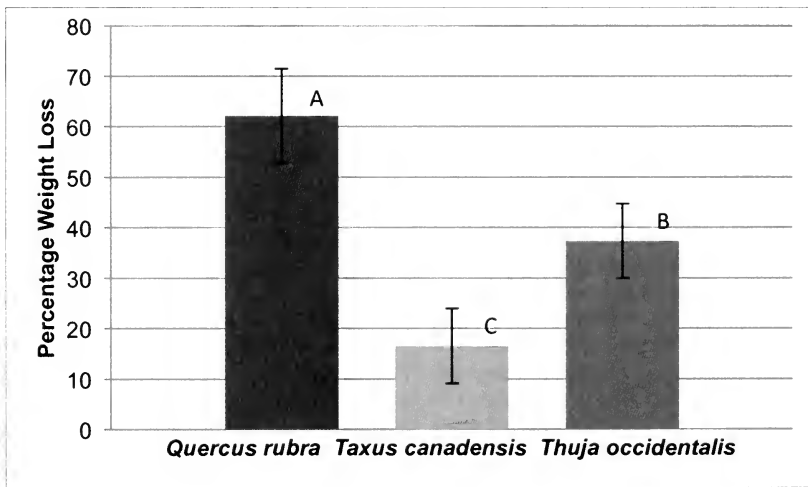


FIGURE 2. Mean percentage weight loss of branch pieces of the woody species Canada Yew (*Taxus canadensis*), Northern Red Oak (*Quercus rubra*), and Eastern White Cedar (*Thuja occidentalis*) by the white rot fungus, *Trametes versicolor* ATCC 12679 ( $n = 10$  for each woody species). Bars with different capital letters are significantly different (ANOVA  $P \leq 0.05$ ); lines within bars represent standard deviation.

vation that dead branches remain stiff and intact for long periods in nature (i.e., they are resistant to decay), thus deterring White-tailed Deer from browsing the interior portions of a clone or patch and providing “refugia” (Windels and Flaspohler 2011) for sexually reproducing branches on the interior of the clone or patch.

### Acknowledgements

The authors acknowledge financial support from GMO LLC, Boston, Massachusetts, and Dr. Andrew J. Storer, School of Forest Resources and Environmental Sciences, Michigan Technological University, Houghton, Michigan; additional appreciation is extended to Dr. Storer for reviewing the manuscript and to two anonymous reviewers.



**Documents Cited** (marked \* in text)

**Sigma Plot 12.** 2010. Systat Software, Inc., San Jose, California.

**Literature Cited**

- ASTM.** 2005. ASTM standard D2017-05: standard test method of accelerated laboratory test of natural decay resistance of woods. ASTM International, West Conshohocken, Pennsylvania USA.
- U.S. Forest Products Laboratory.** 1967. Comparative decay resistance of heartwood of native species. Forest Products Laboratory, Forest Service, U.S. Department of Agriculture. U.S. Forest Service Research Note FPL-0153. 2 pages.
- Cameron, S. L., and R. F. Smith.** 2002. Bringing "blue sky biology" down to earth: linking natural products research with commercialization. Pages 31–39 in Proceedings of the 29th Annual Meeting of the Plant Growth Regulation Society of America, 28 July to 1 August 2002, Halifax, Nova Scotia.
- de Vries, B. W. L., and T. W. Kuyper.** 1990. Lignicolous fungi on yew (*Taxus baccata*). *Zeitschrift für Mykologie* 56 (1): 87–94.
- Farr, D. E., G. F. Bills, G. P. Chamuris, and A. Y. Rossman.** 1989. Fungi on Plants and Plant Products in the United States. American Phytopathological Society, St. Paul, Minnesota. 1252 pages.
- Gilbertson R. L., and L. Ryvarden.** 1986. North American Polypores, Vol. 1 and 2. Edited by R. L. Gilbertson and L. Ryvarden. *Fungiflora A/S*, Oslo, Norway. 885 pages.
- Harlow, W. M., and E. S. Harrar.** 1969. Textbook of Dendrology. Fifth edition. McGraw-Hill, New York, New York. 512 pages.
- Holmes, S. A., C. R. Webster, D. J. Flaspohler, and R. E. Froese.** 2009. Death and *Taxus*: the high cost of palatability for a declining evergreen shrub, *Taxus canadensis*. *Canadian Journal of Forest Research* 39: 1366–1374.
- Martell, D. L.** 1974. Canada yew *Taxus canadensis* Marsh. Pages 158–160 in *Shrubs and Vines for Northeastern Wildlife. Compiled and revised by John D. Gill and William M. Healy.* Northeastern Forest Experiment Station, Forest Service, Upper Darby, Pennsylvania. U.S. Department of Agriculture Forest Service General Technical Report NE-9.
- Rayner, A. D. M., and L. Boddy.** 1988. Fungal Decomposition of Wood: Its Biology and Ecology. John Wiley and Sons, Bath, Avon. 587 pages.
- Thomas, P. A., and A. Polwart.** 2003. *Taxus baccata* L. No. 229 in the Biological flora of the British Isles. *Journal of Ecology* 91: 489–524.
- Schmidt, O.** 2006. Wood and Tree Fungi: Biology, Damage, Protection and Use. Springer Verlag, Berlin, Germany. 334 pages.
- U.S. Forest Products Laboratory.** 1974. Wood handbook: wood as an engineering material. Agriculture Handbook #72. Revised. U.S. Department of Agriculture.
- Windels, S. K., and D. J. Flaspohler.** 2011. The ecology of Canada yew (*Taxus canadensis* Marsh.): a review. *Canadian Journal of Botany* 89: 1–17.

Received 22 June 2012

Accepted 8 August 2012

# A Tribute to Charles Hogg Douglas, 1923–2004

EDWARD L. BOUSFIELD and FRANCIS R. COOK

Canadian Museum of Nature, Postal Station D, Ottawa, Ontario K1P 6P4 Canada

Bousfield, Edward L., and Francis R. Cook. 2012. A tribute to Charles Hogg Douglas, 1923–2004. *Canadian Field-Naturalist* 126(2): 164–166.

Tributes to former staff of Canadian museums and their encouragement of the inventorying and study of the natural history of Canada tend to emphasize the contributions and personalities of directors, research scientists, and curators. Often inadequately recognized are the support staff, artists, and technicians who aided the research and publications produced. The death of Charles Douglas on 22 April 2004 at age 80 marked the passing of the last person to hold the position of permanent staff artist in zoology at the Canadian Museum of Nature (previously the Natural History Museum of the National Museum of Canada and subsequently the National Museum of Natural Sciences, National Museums of Canada) in Ottawa. Charles followed in the footsteps of staff artists Claude Johnson, John Crosby, and John Tottenham, and a number of contractors, including Alan Brooks and F. C. Hennessy early in the 20th century. Susan Laurie-Bourque and Aleta Karstad Schueler late in the 20th century subsequently fulfilled museum zoology artistic needs on contract.

Charles Hogg Douglas was born near Aberdeen, on the east coast of Scotland, 28 December 1923, and moved to Canada when he was five. (His middle name was a carryon from an ancestral maternal family surname.) His father was a golf professional at Trenton (1928 to 1932) and Cornwall (1932 to 1945), and Charles attended Cornwall Collegiate and Vocational School. He became an apprentice draftsman with Courtauld Canada Ltd. after quitting school in grade 10. At 19 he enlisted in the Royal Canadian Air Force. Mishaps with a Tiger Moth biplane redirected him from pilot training. He was discharged in 1945 with the rank of Sergeant Bombardier. On his return to civilian life, he tried a variety of jobs in finance, car sales, and real estate. But simultaneously he did as much freelance commercial art as possible, including humorous but tasteful cartoons published in *Oui* and *Playboy* and elsewhere.

In 1966, his artistic precision won him a competition for the position of staff artist (zoological illustrator) with the Natural History Museum in Ottawa. He remained in this position with the Museum for the remainder of his career, retiring in 1986 as Artist in the Zoology Division. During his 20-year career with the Museum, he illustrated numerous technical journal papers by staff research scientists and major Museum publications on the Canadian fauna: *A Guide to the*

*Freshwater Sport Fishes of Canada* (by D. E. McAllister and E. J. Crossman, National Museum of Natural Sciences, National Museums of Canada, Ottawa, 1973) and *An Introduction to the Amphibians and Reptiles of Canada* (F. R. Cook, National Museum of Natural Sciences, National Museums of Canada, Ottawa, 1984) as well as contributions to *The Mammals of Canada* (A. W. F. Banfield, University of Toronto Press for the National Museum of Natural Sciences, National Museums of Canada, Toronto, 1974) and *The Freshwater Molluscs of Canada* (A. H. Clarke, Jr., National Museum of Natural Sciences, National Museums of Canada, Ottawa, 1981). He also illustrated *Munoo: The Life of an Arctic Sled Dog* (C. F. Harington, Polar Bear Publishing, 1986).

Charles Douglas was arguably the most dynamic, and perhaps the most versatile, artist ever employed by the Museum. He got on well with the scientists who assigned and supervised his work, and his painstaking attention to creating a natural image of his subjects allowed him, despite the majority of his work being done in the museum from preserved material, to satisfy the most demanding supervision. His almost unique ability to take criticism with good humour and make revisions (but not always without mild exasperation, especially over the despised flatfishes, difficult due to their time-consuming, numerous small scales) was a strong asset. His most notable participation in a Museum field expedition was one down the estuary of the St. Lawrence River in 1969 with E. L. Bousfield. Some of the results of that expedition are being included in a current study on burrowing amphipods by E.L.B.

Besides success as an illustrator of research publications, Charles provided illustrations for the series of museum handouts that began with a seven-part series on reptiles and amphibians in 1979 to facilitate response to enquiries from students. The series, entitled *Neotoma*, is available on the Canadian Museum of Nature website at <http://www.nature.ca/en/about-us/productservices/shopping/publications/neotoma>. The name *Neotoma* comes from *Neotoma cinera*, the Pack Rat, in honour of its habit of collecting objects (the museum's *Neotoma* represents a collection of facts). Later, Charles' conception of the *Nature Notebook* series was a major contribution to bringing natural history to the attention of the general public, particularly younger readers, in an effective way. This started as a weekly series which



FIGURE 1. Charles H. Douglas at work creating an illustration from a museum specimen of an angler fish, possibly a Monkfish, *Lophius americanus*.

ran with great success in the *Ottawa Citizen* and a number of other newspapers across Canada in both English and French. The accounts covered both Canadian species and a selection worldwide. Initial ones were written by him, and he established the style and type of content for the series. Later, some researchers contributed additional accounts in their specialties. Subsequently, the series was published in book form in five volumes of 52 accounts each. Most recently, these have been posted on the Canadian Museum of Nature website (<http://nature.ca/notebooks/english/mon2.htm>), with updated text and some photographs added.

Even after he retired, Charles' unpublished illustrations on file at the museum continued to appear in major

publications, notably in *The Encyclopedia of Canadian Fishes* (B. W. Coad with H. Waszczuk and I. Labignan, Canadian Museum of Nature and Canadian Sportfishing Productions, 1995). His drawings of 46 arctic and 15 additional non-arctic species will be included in the forthcoming multi-authored *Marine Fish of Arctic Canada*, sponsored by the Museum and Fisheries and Oceans Canada, started before Charles joined the Museum staff and only now nearing completion.

Charles Douglas was much more than a cartoonist, zoological illustrator, and popularizer of natural history. Two major recreational activities occupied much of his time when he was not at the museum or at his home drafting table. He was an avid fan of local horse

racing and owned a set of harness racers that ran on regional racetracks. He was also a lifetime golfer of near-professional status who was dubbed as "sweet swinging" on courses from Aylmer (Gatineau), Quebec, to North Bay, Ontario, where he often led the field in tournaments.

Charles married Jeannine Morin of Timmins in 1951, and they had three children, Brian (born in 1952), James (born in 1953), and William (born in 1961).

### Acknowledgements

Our thanks to his wife, Jeannine, and son Brian for materials and background as well as the photograph of Charles Douglas at work. Jeannine also corrected an earlier draft, as did Charles Gruchy and Brian Coad. The latter provided the count of his contribution to the

arctic fish of Canada volume in preparation and read an earlier draft. Special thanks to Andy Marshall for material in his fine profile cited below.

### Literature Cited

**Cook, F. R.** 1984. Charles Douglas. Page 200 in Introduction to Canadian Amphibians and Reptiles. National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario.

**Marshall, A.** 2003. Charles Douglas: from fish to sex symbols, he's drawn them all. *Wildlands Advocate Alberta* [WLA] 11(6): 20. [Six of Charles' drawings—five mammals and one frog—are scattered throughout the issue].

Received 18 July 2012

Accepted 8 August 2012

# A Tribute to Phillip Merrill Youngman: 1927–2011

IRWIN M. BRODO<sup>1</sup> and FRANCIS R. COOK

Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, Ontario K1P 6P4 Canada

<sup>1</sup>Corresponding author email: [ibrodo@mus-nature.ca](mailto:ibrodo@mus-nature.ca)

Brodo, Irwin M., and Francis R. Cook. 2012. A tribute to Phillip Merrill Youngman: 1927–2011. *Canadian Field-Naturalist* 126(2): 167–171.

Phillip Merrill Youngman was a well-known mammalogist, an all-round naturalist, a gifted carpenter, a great storyteller, and a collector of close friends. He spent most of his career at the Canadian Museum of Nature, beginning when it was called the National Museum of Natural Sciences, where he served in various positions, including Curator of Mammals, Exhibits Planner, and finally Assistant Curator of Quaternary Zoology. After a long illness, he passed away on 22 November 2011 at the age of 84.

Phil was born 1 September 1927 in New York City. Although he had early memories of becoming fascinated with animals through visits to the Bronx Zoo, he spent most of his childhood in New England. He told his children about wonderful hunting trips he took with his uncle, who introduced him to wilderness experiences that he would always enjoy. As a teenager (Figure 1), he joined a falconry club and thus became interested in birds.

Phil joined the U.S. Navy in 1945, and his duties included serving as an aviation machinist. In 1948, his love of animal study brought him to Storrs, Connecticut, where he worked at the University of Connecticut Museum and the Connecticut Department of Wildlife Management while taking courses in zoology. During this period, he also worked in the U.S. National Park Service teaching nature study and preparing exhibits. In the summer of 1950, Phil held a job with the American Museum of Natural History, spending much of his time in the Bahamas collecting plankton samples and doing oceanographic studies above and below the water.

His studies were put on hold from September 1952 until September 1954, while he again served in the United States Armed Forces, this time in the Army. He was sent to Korea as a mammalogist to study suspected rodent reservoirs of hemorrhagic fever, and he took the opportunity of being in such a biologically understudied region to make a large collection of mammals, reptiles, and amphibians from that country. Among his earliest papers was a study of the ecology of Korean rodents. (Phil credited this paper with helping to launch his career, as it gained the attention of academics at the University of Kansas who invited him to do a master's degree there.)



FIGURE 1. Phillip Merrill Youngman as a teenager.

Phil earned his B.A. in Zoology at the University of Connecticut in 1955, but not before he had spent another summer of research, this time working with L. R. Penner on schistosoma dermatitis (swimmer's itch) in Florida and collecting animals of all kinds for the University of Connecticut Museum.

In 1956, Phil moved on to Lawrence, Kansas, to begin graduate work, assisting in a graduate course in embryology and in other subjects. During the summer, he worked with the Colorado Cooperative Gopher Survey studying the pocket gophers (*Thomomys bottae*) of Colorado, and they became the subject of his master's thesis. Working under E. R. Hall, Phil received his M.A. in Zoology from the University of Kansas in 1957.

After Phil had spent two years as an instructor at the University of Tampa (Florida) teaching a large variety of zoology courses, Frank Banfield, a mammalogist colleague who was then Director of the National Museum of Natural Sciences in Ottawa, invited Phil to apply for the position of Curator of Mammals there. With Phil's vast experience collecting and studying mammals in various parts of the world, he was well qualified for the job. So Phil packed up his things and, with his pregnant wife, headed north. On 8 September 1960, he began his long tenure at the Museum.

His first research projects took him to the Yukon Territory, where he collected 2277 specimens added to the Museum mammal collection and studied thousands more. Besides mammals, Phil collected vascular plants and other animals, all now deposited in the Museum's collections. About half a dozen catalogued Pleistocene specimens in the Museum were collected in the Ogilvie River area, Yukon Territory, by Phil and Terry Morgan (museum taxidermist at the time) in July of 1971 (a couple of these specimens are mentioned in Harington (1980)). The Yukon was always special to Phil, but he also made major contributions to our knowledge of the mammals of the entire northwest, including Alaska, Siberia, and the Northwest Territories, especially as they related to Beringia and patterns of deglaciation in that region. He did not ignore the eastern mammals, however, and some of his papers deal with eastern populations of hares, mice, and shrews, and he also did fieldwork in Newfoundland.

When Phil arrived at the Museum, Gaston Tessier was already there, working for Earl Godfrey, the Curator of Ornithology. Gaston then became Phil's assistant, accompanying him on numerous field trips. The two became lifelong friends and kept in contact even after Gaston left for the Canadian Wildlife Service in 1965 and after Phil retired in 1992. Over the years, Phil spoke often and very warmly about Gaston. On his part, Gaston writes that Phil "became a mentor that I will always remember and be so thankful to have known."

While Phil was appointed to the Exhibits Section as an Exhibits Planner (October 1971–August 1978), he worked on a number of travelling and long-term exhibits, directing the activities of designers, thematic researchers, taxidermists, writers, artists, sculptors, and model makers. He produced a film for the Museum entitled *I'm a Mammal and So Are You*, and he visited major galleries across the country to assemble an important exhibition on what Canadian artists were saying about nature at that time. A trip to the Comoros Archipelago, off the east coast of Africa, from 20 March to May 1973 yielded local fishing gear (hand-line with hook for catching coelacanth plus a volcanic rock used for weighing the line) for an exhibit of the Museum's model of the "living fossil" coelacanths and the purchase of a variety of specimens, including mammals, reptiles, and molluscs. On his return, Phil

created a small coelacanth exhibit that travelled across Canada for a number of years, as well as a paper sculpture of a coelacanth with R. J. Sliwa.

From August 1978 until June 1982, Phil took special educational leave to pursue doctoral studies at the University of Helsinki, where he worked with Professor Björn Kurtén. He received his Ph.D. in Zoology in April 1983, with a thesis on the European Mink, *Mustela lutreola*. He also did phenetic (morphological) studies of European and American mink dealing with inter-specific relationships, hybridization, geographic variation, and distribution.

Upon his return from Finland, Phil again served in the mammal unit beginning in September 1983 and then transferred to the Paleobiology Division as Assistant Curator of Quaternary Zoology, working with C. Richard Harington. Harington recalls, "I asked him to pursue the study of ice age cave faunas in Canada, which I thought would be very important to the study of Quaternary Zoology here." To gain experience with cave studies, Phil spent part of a summer working with the U.S. cave expert, Jim I. Mead, then in Flagstaff, Arizona. Phil began his Canadian research at Bluefish Caves, northern Yukon, under the supervision of J. Cinq-Mars of the Canadian Museum of Civilization. Harington comments that these were "perhaps the most important Canadian caves yielding ice age mammal bones (including evidence of early humans dating to about 25 000 BP!)" At Bluefish Cave III (Figure 2), Phil found and excavated a rare specimen of the Saiga Antelope (*Saiga tatarica*), which was radiocarbon dated as 13 390 BP. A Beringian polecat (*Mustela eversmanni*) identified by Phil from the same site yielded a date of 33 500 BP, the oldest date recorded from bones from the Bluefish Caves (Harington 2012, page 173). He also collected a "mummified" shrew (*Sorex hoyi*) specimen from Bear Cave Mountain, Yukon, in 1986.

Closer to home, Phil continued his work on cave mammals with colleagues at the Université du Québec at Montreal. He provided stratigraphic information on Quaternary vertebrates from Laffèche Cave, a Late Pleistocene–Early Holocene site about 27 km north of Gatineau, Quebec. Among his discoveries were several species adapted to the Arctic, such as the Snowy Owl, Arctic Hare, and Ungava Collared Lemming, as well as an Arctic Fox dentary (jaw) that was illustrated in Milner and Ryan (2006: figure 18-C). This work is summarized in Harington (2012). Phil's papers published while with the Paleobiology Division are referenced and summarized in Harington (2003, pages 325–326). One particularly valuable paper of this period dealt with the Pleistocene small carnivores of eastern Beringia. Phil's complete bibliography follows this tribute.

Phil was elected a Fellow of the American Association for the Advancement of Science in 1964. He was a long-time member of the American Society of Mammalogists, and he served as an Associate Editor of *The*



FIGURE 2. Phillip Merrill Youngman at Bluefish Cave III in 1986.

*Canadian Field-Naturalist* from 1961 until 1970. He was also proud that his Finnish entomological colleague, Pekka Vilkamaa, named a new species of fly in his honour, *Corynoptera philii* (Hippa et al. 2010).

Phil was at the Museum for 32 years, retiring in 1992, thus avoiding an unsettled time of major reorganization at the Museum. Two of his papers (Youngman 1993, 1994) appeared after his retirement, but he did not finish additional work in mammalogy after that. Although he may have worked on fossils of wild dogs such as *Cuon* for a while and the Holocene fauna of Lafèche Cave from which he had collected numerous specimens, he devoted his time to home schooling his youngest daughter, Katherine, and doing cabinetry and other home-based projects that he had put off for so long. He was a talented carpenter and had spent years assembling and building a log home near North Gower, south of Ottawa. Phil also enjoyed working on his family's genealogy, sailing, bicycling, and cross-country skiing, as well as fine art.

Phil loved children and was a devoted father to the four children from his marriage with Ana Maria Lamers, who had come to the United States from Argentina. The oldest is Edward, followed by Stephen, David, and Elizabeth, who still lives in Ottawa. They provided Phil with eight grandchildren. Several years after his divorce from Ana, Phil married Liisa Rissanen, whom he met in Helsinki. She is an artist now living in Maberly, Ontario. They had two children, Anina and Katherine, both based in Ottawa, and Phil was equally devoted to them.

Although a youthful and fit man, Phil became ill not long after retiring, first with a melanoma, and then leukemia and other ailments, including a returning melanoma, which required surgery. He remained fairly mobile, chatty, and friendly to the end, however, always enjoying visits with his friends, talking about his adventures, and hearing about theirs. Phil was a remarkable person who will be fondly remembered by his large family and his many friends and colleagues.

## Bibliography of Phillip M. Youngman

- Starrett, A., P. Starrett, and P. M. Youngman. 1952. Additional records for watershrews, *Sorex palustris*, in New England. *Journal of Mammalogy* 33: 398.
- Youngman, P. M. 1954. A preliminary report on a population of the Striped Field Mouse (*Apodemus agrarius manchuricus*) in central Korea. Commission on Hemorrhagic Fever, [United States] Armed Forces Epidemiological Board. 24 August.
- Youngman, P. M. 1956. A population of the striped field mouse, *Apodemus agrarius corea*, in central Korea. *Journal of Mammalogy* 37(1): 1–10.
- Youngman, P. M. 1958. Geographic variation in the pocket gopher, *Thomomys bottae*, in Colorado. University of Kansas Publications, Museum of Natural History 9(12): 363–384.

## Acknowledgements

Many helped in the compilation and checking of the stories, facts, and especially the bibliography presented here, including Phil's daughters, Katherine and Anina, Pekka Vilkamaa of the Finnish Museum of Natural History, and staff members of the Canadian Museum of Nature, past and present: Yvon Brisson, Lory Beaudoin, Margaret Currie, Steve Cumbaa, Richard Day, Chantal Dussault, Peter Frank, Susan Good, Michele Gosselin, Charles G. Gruchy, C. Richard Harrington, Sylvie Laframboise, Donna Naughton, Joanne Sparks, Frederick W. Schueler, Michèle Steigerwald, and Gaston Tessier. As well as contributing perspective on Phil's work with the paleobiology section, Dick Harrington twice read earlier drafts and provided many corrections which greatly improved the text. Arrington Katherine and Anina provided the photographs from their family albums.

## Literature Cited

- Harrington C. R. 1980. Pleistocene mammals from Lost Chicken Creek, Alaska. *Canadian Journal of Earth Science* 17: 168–198. [See table 15 on page 185].
- Harrington, C. R. *Editor*. 2003. Annotated bibliography of Quaternary vertebrates of northern North America—with radiocarbon dates. University of Toronto Press, Toronto, in collaboration with the Canadian Museum of Nature. 539 pages. [See pages 325–326].
- Harrington, C. R. 2012. Quaternary cave faunas of Canada: a review of the vertebrate remains. *Journal of Cave and Karst Studies* 73(3): 162–180.
- Hippa, H., P. Vilkamaa, and K. Heller. 2010. Review of the Holarctic *Corynoptera* Winnertz, 1867, s. str. (Diptera, Sciaridae). *Zootaxa* 2695: 1–197.
- Milner, A., and M. Ryan. 2006. Late Pleistocene vertebrates along the northwestern margin of the Champlain Sea. *Field Trip Guidebook for the 66th Annual Meeting of the Society of Vertebrate Paleontology*, October 18–21, 2006, Ottawa, Ontario.
- Youngman, P. M. 1993. The Pleistocene small carnivores of eastern Beringia. *Canadian Field-Naturalist* 107(2): 139–163.
- Youngman, P. M. 1994. Beringian ferrets: mummies, biography and systematics. *Journal of Mammalogy* 75(2): 454–461.
- Youngman, P. M. 1962. The spread of the European hare to the Ottawa region of Ontario. *Canadian Field-Naturalist* 76(4): 223.
- Youngman, P. M. 1962. Bibliography of Rudolph Martin Anderson. *Canadian Field-Naturalist* 76(3): 134–141.
- Youngman, P. M. 1962. Review of Charles Paul May, *A book of Canadian animals*. *Canadian Field-Naturalist* 76(3): 172–176.
- Youngman, P. M. 1963. Review of Introduction to mammalogy by E. Lendell Cockrum. *Canadian Field-Naturalist* 77(1): 54–55.
- Youngman, P. M. 1964. Range extensions of some mammals from northwestern Canada. *National Museum of Canada, Natural History Papers* 23: 1–6.



- Youngman, P. M.** 1965. Walrus on Prince Patrick Island, Northwest Territories, Canada. *Journal of Mammalogy* 46(1): 104.
- Youngman, P. M.** 1967. A new subspecies of varying lemming, *Dicrostonyx torquatus* (Pallas), from Yukon Territory (Mammalia, Rodentia). *Proceedings of the Biological Society of Washington* 80: 31–34.
- Youngman, P. M.** 1967. Insular populations of the meadow vole, *Microtus pennsylvanicus*, from northeastern North America with descriptions of two new subspecies. *Journal of Mammalogy* 48(4): 579–588.
- Youngman, P. M.** 1968. The mammals of Canada. Pages 4–5 in *Canada Yearbook 1968*. Dominion Bureau of Statistics, Ottawa. Ontario 1277 pages.
- Youngman, P. M.** 1968. Notes on the mammals of south-eastern Yukon Territory and adjacent Mackenzie District. *National Museum of Canada Bulletin* 223. Contributions to Zoology 4: 70–86.
- Youngman, P. M., and D. A. Gill.** 1968. First record of the Southern Flying Squirrel, *Glaucomys volans volans*, from Quebec. *Canadian Field-Naturalist* 82(3): 227–228.
- Nadler, C. F., and P. M. Youngman.** 1969. Transferrin polymorphism among populations of the arctic ground squirrel, *Spermophilus undulatus* (Pallas). *Canadian Journal of Zoology* 45(5): 1051–1057.
- Nadler, C. F., and P. M. Youngman.** 1970. Further studies on transferrins of the arctic ground squirrel *Spermophilus undulatus* (Rodentia: Sciuridae). *Comparative Biochemistry and Physiology* 36: 80–86.
- Youngman, P. M.** 1972. Ranges of selected mammals. Page 168 in *The National Atlas of Canada*.
- Youngman, P. M.** 1972. Type specimens of mammals in the National Museum of Natural Sciences. *National Museum of Natural Sciences Publications in Zoology* (7): 1–7.
- Youngman, P. M.** 1975. Mammals of the Yukon Territory. National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario. National Museum of Natural Sciences Publications in Zoology 10. 192 pages.
- Youngman, P. M., and J. R. Sliwa.** 1976. Old fourlegs, a living fossil. *Paper Sculptures* (1), National Museum of Natural Sciences, Ottawa. 8 pages.
- Youngman, P. M., J. R. Sliwa, and D. A. Russell.** 1977. *Triceratops*, a dinosaur. *Paper Sculptures* (2), National Museum of Natural Sciences, Ottawa. 8 pages.
- Youngman, P. M., J. R. Sliwa, and C. R. Harington.** 1977. The polar bear. *Paper Sculptures* (3), National Museum of Natural Sciences, Ottawa. 8 pages.
- Youngman, P. M.** 1967. Review of The mammals of eastern Canada. *Edited by Randolph L. Peterson*. *Canadian Field-Naturalist* 81(4): 291–292.
- Forsten, Ann, and P. M. Youngman.** 1982. *Hydromalis gigas*. *Mammalian Species* 165. American Society of Mammalogists. 3 pages.
- Youngman, P. M.** 1982. Distribution and systematics of the European mink *Mustela lutreola* Linnaeus 1761. *Acta Zoologica Fennica* 166: 1–48.
- Youngman, P. M.** 1986. The extinct short-faced skunk *Brachyprotoma obtusata* (Mammalia, Carnivora): first records for Canada and Beringia. *Canadian Journal of Earth Sciences* 23(3): 419–424.
- Youngman, P. M.** 1987. Freeze-dried mummies are hot items with palaeontologists. *Biome* 7(2): 4.
- Youngman, P. M.** 1989. Letter to the editor: The status of Sea Mink. *Canadian Field-Naturalist* 103(2): 299.
- Youngman, P. M.** 1990. *Mustela lutreola*. *Mammalian Species* 362. American Society of Mammalogists. 3 pages.
- Youngman, P. M.** 1991. A bibliography of mustelids. Part IX: European Mink. *Syllogeus* 66. Canadian Museum of Nature, Ottawa, Ontario.
- Youngman, P. M., and F. W. Schueler.** 1991. *Martes nobilis* is a synonym of *Martes americana*, not an extinct Pleistocene–Holocene species. *Journal of Mammalogy* 72(3): 567–577.
- Youngman, P. M.** 1991. Freeze-dried mummies are hot items with palaeontologists. *Klondike Sun* (13 June): 34.
- Youngman, P. M.** 1993. The Pleistocene small carnivores of eastern Beringia. *Canadian Field-Naturalist* 107(2): 139–163.
- Youngman, P. M.** 1994. Beringian ferrets: mummies, biography and systematics. *Journal of Mammalogy* 75(2): 454–461.

Received 9 May 2012

Accepted 11 September 2012

# Book Reviews

**Book Review Editor's Note:** We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD. Euros are EUR, China Yuan Remimbi are CNY, Australian dollars are AUD and so on.

**Editor's Note.** The address of the Birds of Northumberland County website has been changed to <http://www.willowbeach-fieldnaturalists.org/Northumberland-County>. This is part of the Willow Beach Field Naturalists' website, but the URL above will take you directly to the Birds of Northumberland County. Please note that the URL is case sensitive. From Clive Goodwin.

## ZOOLOGY

### All the Birds of Nova Scotia

By Ian McLaren. 2012. Gaspereau Press, 47 Church Avenue, Kentville, Nova Scotia B4N 2M7. 336 pages. 47.95 CAD. Cloth.

More years ago than I care to remember I needed help with a mammal problem. I was referred to an expert, Dr. Ian McLaren, who answered my questions expertly. I have run in to Ian many times since that time and realised that Ian is not just knowledgeable about mammals but is one of the finest birders I have met. He has now written a scholarly book on the birds of his adopted province.

Going birding with Ian McLaren you quickly realise that he is far more careful and discerning than most birders. Where I might be content to call a bird an immature Ring-billed Gull, McLaren will be looking at individual feathers to determine its subspecies, age or point of origin. This is an ideal trait for the author of this book.

The Nova Scotia bird list is unlike that of central Canada. Birds that are abundant here [American Goldfinch] occur commonly, but in much lower numbers and are more infrequent. Even the over-abundant Red-winged Blackbird is much scarcer. Nova Scotia lists many seabirds and shorebirds. A Razorbill in Ottawa pulled in many birders to see this vagrant, but it is fairly easy to find in offshore Nova Scotia. While we chase a Black-legged Kittiwake or feel elated to see some Ruddy Turnstones, these are common birds for McLaren. What really boosts the NS list though is the large number of rarities.

When tropical storms devastate the Caribbean, odd birds reach Upper Canada. This forced dispersal is filtered by the landmass of the USA. Not so for Nova Scotia – birds are swept along the seaboard to add boobies and frigate birds to the provincial total. A number of small land birds also are pushed north [vireos, warblers]. Birds from Europe are driven west [thrushes], although some may hitch rides on ships. McLaren argues that the Magpie seen in 2008 is a ship-assisted

European bird. Birds also drift from the west. It is annoying to think that many of these birds went through eastern Canada unnoticed until they were stopped at the coast to be found by an alert Nova Scotian.

For this book McLaren systematically reviewed the historical and contemporary records for all the sightings in Nova Scotia and summarised his findings for each species. For the common birds he gives the range and status by season. Sensibly he includes all the records of vagrants. This includes likely, but unproven birds. For example, for Bahama Swallow he notes a probable sighting, but adds "photographs would be needed for wide acceptance of such a record." This gives readers a chance to decide for themselves and alerts them to the possibility of seeing this species. It also alerts the observer for the need of proof, in such cases.

The book is well supplied with photographs, many by McLaren, and mostly of the vagrants. The professor uses these as a teaching opportunity to highlight the characteristics that confirm the identification. Insert photos of look-alike species help the author point out the critical plumage details. For example, the page on the Willet shows both eastern and western forms and McLaren discusses the finer minutiae. There is one analysis I have trouble with however – the magpie record. Taxonomists [or is it systematists?] have split the black-and-white magpies into three to five species depending on their criteria. I have trouble separating these supposed species. McLaren suggest the Clam bay, 2008, sighting is a Eurasian Magpie [not a Black-billed Magpie], based on plumage and calls. The 10 magpies I saw in Russia last month did not appear any different from those I saw in Calgary in January. I tried side-by-side comparison of photos on the net and the variability caused by the disparity in light swamped any dif-

ferences in plumage colour. Simultaneous playing of Xeno Canto recordings of both species showed that magpie calls are varied and similar.

The other photograph that caught my attention was of two American Crows. One is remarkably smaller than the other. Again McLaren uses subtle plumage characters and call to identify this bird as a runt American Crow. This time I was happy with the identification as the likely vagrant, Fish Crow, has a clearly different call and an observable divergence in appearance. We need to remember there can be small individuals.

Many years ago I visited a rising star birder and was surprised to see a bulletin board covered in weather maps. This person has repeatedly been in the right

place at the right time, due to this studious approach. McLaren too includes a substantial discussion of weather patterns in NS and how these link to bird movements. This is an area we could all benefit from, by paying more attention to the role weather plays.

I really enjoyed reading this book. I brought back good memories and I learnt a lot from the identification discussions. The text on Status and I.D. Issues is clear and informative without being repetitive or stuffy. It will make a fine present for your favourite birding friend.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5

## The ROM Field Guide to Freshwater Fishes of Ontario

By E. Nicholas, E. Mandrak, and M. Burrige. 2009. Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario M5S 2C6. 462 pages. 29.99 CAD. Paper.

This guide covers the 128 native fish species in Ontario along with 17 species of established exotics. The Introduction indicates that it will enable the reader to identify species in the field. To this end, the book is replete with over 500 colour photographs of all the species, often as many as five for each species.

The book has short introductory sections on factors influencing distribution, habitats, observing fishes, how to use the book, further information (books and internet sources), anatomical figures and, at the end, illustrations and short descriptions of fishes that may occur in Ontario, a short glossary, a checklist, an index to common and scientific names, a list of photographers and illustrators, acknowledgements, and short blurbs about the authors.

Fifty-one pages are devoted to keys and the rest of the book, 355 pages, to the species accounts.

The keys are innovative in that they group fishes by a single illustrated character (initially eel-like body, barbels, adipose fin, one dorsal fin without spines, dorsal fin with one or more spines) and then each of these five headings have up to 3 subheadings. Within the subheadings a single character may identify a species or family of fishes although some require up to 3 characters to separate them. Members of the Carp and Minnow family, Cyprinidae, appear in 4 places (barbels, spineless dorsal fin with forked tail and belly keel, spineless dorsal fin with no keel, and spiny dorsal fin), evidence of their diversity. This works well and narrows down the possibilities.

The next section comprises Comparative Photographs which are reached from the key by a page number. This can be confusing as several unrelated fishes are grouped together and the heading of each page does not repeat the key characters. Page 40, for example, is reached from two key groups under "adipose fin" and "spiny dorsal fin". The species are two ciscoes (Sal-

monidae), a smelt (Osmeridae) and a silverside (Atherinopsidae) – the heading for the page is "Silvery fishes with a soft dorsal fin, no overhanging snout, and no keel". The latter two species are quite distinctive but there are no characters separating the two ciscoes. Later, in the species accounts, the authors do point out that "To the untrained eye, it is virtually impossible to tell all ciscoes apart". In the key, the smelt and silverside are given a page number for their species account, but not here in Comparative Photographs. This requires some work to locate the descriptions and maps of the species from this point as the index lists the brook silverside under "silverside, brook", for example. Generally, this comparative section requires some skill to use and is not always successful, e.g., "Redhorses with red tails" has one species without a red tail, indicative of the variation that can be found in fishes but confusing for the reader. The difficult group "Carp and Minnows" has 9 sections, two of which are "Minnows with large scales (36-54 lateral scales)" and 5 pages later "Minnows with large scales (39-55 lateral scales)" which is confusing. Some characters used are correct but might require some thought by the neophyte reader, e.g., under eel-like fishes, two lamprey species are distinguished by >2 or <3 bicuspid lateral circumoral teeth. The teeth are illustrated, which helps, but >2 meaning 3 or more, and <3 meaning 1 or 2, could have been expressed in this more familiar fashion.

Generally, it is difficult to see how this Comparative Photograph section can work for the reader in families where there is a high diversity in species but close similarity in appearance. The fact that the senior author of the book has taught regular fish identification courses indicates how tricky some identifications can be. Ideally, the Comparative Photographs should have been a continuation or subsets of the initial keys, although this would have necessitated an extensive

nested arrangement in such a diverse group as Carps and Minnows.

The book could have had true anatomical identification keys to difficult and speciose families which would help bridge the gap between the angler and amateur naturalist looking at a fresh fish just caught and needing a quick identification, and the biologist with access to a microscope and preserved specimens needing an accurate and more reasoned identification. Nonetheless, with patience and practice, most Ontario fishes can be identified using this guide.

Each of the 24 family accounts is preceded by a section giving illustrations of key characters referred to in the species accounts, clarifying structures that are not always apparent in colour photographs or not easily understood when expressed in words. The family has a one-page general account. In some families more could be added here, e.g., under each of the two gar species, the same sentence about their adhesive snout disc when young is repeated and should have been on the family page, giving more space for information on individual species.

Each two-page species account is headed by the common name and the scientific name, an explanation of the meaning of the scientific name, a colour photo-

graph of the fish on the white page background, a short section with some informative note about the fish such as distribution, anatomy, behaviour, relationships, etc., a description of the fish (anatomy and colour), a comparative section on similar species, an Ontario shaded distribution map, short sections on feeding, reproduction and habitat, letter and number codes that explain conservation status, and a two-line table giving maximum age, Ontario average length, and Ontario record and world record lengths, and sometimes weights. Other colour photographs in the account show adults, juveniles, close-ups of heads, eggs, fish in a nest, etc, mostly in a natural (or aquarium) setting. Species descriptions are alphabetical by common name so unrelated fishes (in body form) occur next to each other, e.g., smallmouth and largemouth bass are related species that an observer would want to distinguish but are separated by 4 unrelated species accounts.

The book is an excellent introduction to the fishes of Ontario and is packed with information. The authors have carried out a difficult task in an exemplary manner and are to be congratulated for their efforts in presenting this fauna to a wide audience.

BRIAN W. COAD

Canadian Museum of Nature, Ottawa, Ontario K1P 6P4

## Population Demography of Northern Spotted Owls

By E. Forsman and 26 co-authors. *Studies in Avian Biology* No. 40, Cooper Ornithological Society. University of California Press, 1445 Lower Ferry Road, Ewing, New Jersey 08618 USA. 105 pages. 35 USD. Cloth.

This well-researched and informative monograph used data from 11 long-term studies, ranging from 17 to 24 years in duration. Three study areas were in Washington, five in Oregon and three in California. Owls were trapped most often with a noose pole or snare pole. The number of captures/resightings per study area varied from 583 to 3777, involving 24,408 recaptures and resightings of 5,224 marked Spotted Owls, nearly five per adult. This giant data set for a rare species demonstrates a biennial cycle, with unexplained higher fecundity in even-numbered years.

The study areas were large and covered 19,813 km<sup>2</sup>, ~9% of the range of the Northern Spotted Owl. There was strong support for declining adult owl survival on 10 of the 11 study areas, with these declines most evident in Washington and Oregon. Reproduction and recruitment were insufficient to balance losses due to mortality and emigration; the average rate of Northern Spotted Owl population decline in all study areas combined was a worrying 2.9% per year.

There was also evidence of climatic effects (Pacific Decadal Oscillation and Southern Oscillation/El Niño Index) and of weather effects (early nesting season precipitation and early nesting season temperature).

Since about 1970, government agencies in the Pacific Northwest have attempted to maintain viable popu-

lations of Northern Spotted Owls, Marbled Murrelets and red tree voles, resulting in controversial reductions in the harvest of valuable old forests on federal lands. The Northern Spotted Owl, "the poster child" for conservation of old-growth and mature forests on federal lands, was listed as a threatened subspecies in 1990.

The more recent invasion of Barred Owls into the range of the Spotted Owl has elevated the concern. Apparent survival of Spotted Owls was negatively correlated with the presence of Barred Owls on the study area on six of the study areas.

Three possible data biases were identified: 1) permanent emigration of adults is rare because adult site fidelity is high; 2) variation in recapture rates is low because survey effort is relatively constant; 3) band loss bias is absent because band loss is close to zero; from more than 6,000 owls banded with standard aluminum bands or with colored bands, only two colored bands and no aluminum bands were lost.

The statistical analysis of these combined studies is exemplary. The monograph demonstrates the basic importance of bird banding as a tool for monitoring bird populations, identifying the reasons for their fluctuations. The results consistently identified loss of habitat and competition from Barred Owls as important stressors, the need to preserve as much high quality

old growth forest as possible and the need for continued monitoring of Northern Spotted Owls throughout their range. Experimental removal of Barred Owls in at least one study area is recommended.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

## Venomous Reptiles of the United States, Canada, and Northern Mexico. Volume 1

By C. Ernst, and E. Ernst. 2011. Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363 USA. xviii + 352 pages. 75 USD. Cloth.

Gila Monsters. Cottonmouths. Seasnakes. Such exotic species don't have very much in common other than the fact that they are all venomous reptiles. This first volume in a two volume series provides detailed summaries of the known biology of the venomous reptiles of North America. Together these books are an update to Carl Ernst's 1992 book *The Venomous Reptiles of North America*. Volume 1 covers 13 species: the 2 lizards, 5 elapid snakes (4 coral snakes and 1 seasnake), and 6 viperid snakes. Volume 2 will cover the rattlesnakes of the genus *Crotalus*. Only 3 of the total species covered in both volumes occur (or did occur) in Canada: the Massasauga (Volume 1) and the Timber and Western Rattlesnakes (Volume 2).

The geographic focus of the book is all species found north of 25° Latitude, which corresponds to the tip of the Baja peninsula of Mexico. This makes the book of limited value to a Mexican audience as the many venomous species of southern Mexico are excluded. Possibly, the authors include species from northern Mexico because of their interest to American researchers.

The book opens with chapters on reptile venom, statistics on envenomation, treatment of envenomation, the conservation of venomous reptiles and a key to the families of venomous reptiles. The bulk of the book provides detailed life history accounts of the various venomous reptiles. The accounts all follow the same standardized format: recognition (detailed description of the species including colour patterns, scale counts and body lengths), geographic variation, confusing species, karyotype, fossil record, distribution, habitat, behaviour and ecology, reproduction, growth and longevity, diet and feeding behaviour, venom delivery system, venom and bites, predators and defense, parasites and pathogens, populations (available data on abundance), and remarks (miscellaneous information). Each account also includes black and white photos of the species as well as a distribution map. The species accounts vary in length depending upon how much information is available. The account for the woefully understudied West Mexican Coralsnake (*Micrurus distans*) is

less than 5 pages, (including photos and a distribution map) but most accounts are at least twice that length. The book also includes colour photos of all the species. These photos are generally fairly good, but some are dark and rather mediocre.

Overall, the quality of the text is quite high. The Ernsts have summarized a vast amount of scientific literature. The literature cited for the book is almost 100 pages in length. The book is not without errors, of course. Species protected by law in Canada or Mexico are listed in one table and the authors overlooked that the Western Rattlesnake has been officially designated Threatened in Canada since 2004.

The authors claim that between "2,000 and 3,000 rattlesnake bites are reported annually in Canada" (page 25). This statistic seemed wildly improbable and a little fact-checking confirmed this. The cited paper by Kasuriratne and collaborators actually states that there are an estimated 260-372 envenomations per year in Canada. The estimate appears to be simply scaled to the US figures as their low and high estimates are approximately 10% of the US numbers. There do not appear to be any comprehensive data on snakebites in Canada but even 260 per year may be an overestimate. Considering that this book will likely become a standard reference, the 2000-3000 bites per year in Canada will likely be widely cited. Such mis-information can hardly benefit rattlesnake conservation.

Despite some careless errors, this is still a first rate book. Those primarily interested in venomous reptiles in the USA or Canada will find it an important reference work. Those with a broader geographic interest need to compare it with *The Venomous Reptiles of the Western Hemisphere* by Campbell and Lamar, published in 2004. Campbell and Lamar's two-volume set is fairly recent and covers 192 species. After all, why settle for just North America when you can have the entire western hemisphere?

DAVID SEBURN

Seburn Ecological Services, 2710 Clarendon Street, Ottawa, Ontario K2B 7S5

## A Field Guide to the Wildlife of South Georgia

Robert Burton and John Croxall. 2012. Princeton University Press 41 William Street, Princeton, New Jersey 08540-5237 USA. 200 pages. 24.95 USD. Paper.

A short time ago we decided to return to Antarctica. This magical place has wildlife that is not tame, but ignores you. If you sit among the penguins they will walk past you or even over you if you are in their way. Humans are simply nonentities; a wonderful and unique experience. South Georgia is technically a sub-antarctic island, being north of 60°S, but it is an essential stop on an Antarctic trip. Being milder, the biology is different from the continent itself and the island is a key component of the region's history. This was the base for the whaling industry and, no matter your viewpoint on killing whales for profit, it is a fascinating story. South Georgia also plays a major role in the most exciting tale in exploration history: the open boat voyage by Shackleton and his crew.

So I was delighted to pick up my copy of this new book. I noted that "All profits from the sale of this book will support conservation work in South Georgia" – a good reason in itself to buy the book. The South Georgia Heritage Trust [SGHT] seeks "to redress the damage to its environment done in the past." The book has introductory chapters on Topography and Geology, Climate, The Fertile Sea, History of Exploitation, Habitat Restoration, Biosecurity, Protected Areas and Regulations, and Vegetation and Plant Communities. The main section is a field guide to wildlife and there is a Glossary and an Index of English and Scientific Names. The area covered is South Georgia, the South Sandwich Islands, Shag and Clerke Rocks. The field guide section describes 65 species of birds, 20 species of sea mammals, 60 species of insects, and over 40 species of flowering and non-flowering plants, using 368 computer-manipulated photographs. The book has ten contributing authors two of which are the editor and editorial consultant.

The first chapters cover geography, climate, ecology, and conservation. While they brief they contain a lot of information and set the scene for the visitor. It is particularly import to understand the high productivity of the surrounding sea. The impact we humans have made is very significant and I applaud the SGHT and others who are now taking steps to restore the island.

The wildlife guide starts with the birds. The authors have dealt with the taxonomic nightmares in a logical fashion so readers can enjoy their sightings and still be happy with their identifications. The 65 species of bird include both the nesting and vagrant species. The important species, like Wandering Albatross and King Penguin, have a page of text and several photographs depicting the various plumages leading to adulthood. The text covers the biology of the species, especially identification and behaviour. Each species has a box giving the status [e.g., endangered, breeding visiting species], number of breeding pairs on South Georgia,

number of breeding pairs worldwide, length, wingspan, threats and where to see the species. The content of these boxes varies widely, depending on the data available. Less important species to the ecology of South Georgia like vagrants are shown four to a page, with correspondingly less information.

After birds comes the section on land and sea mammals. A similar format gives the equivalent information on the 20 mammals – mostly seals and whales. Then to my surprise there are some pages on insects, arachnids and molluscs.

Prior to our earlier trip we were disappointed we could not find much information on the vegetation. When I went to see the nesting Light-mantled Albatross near Grytviken I was chagrined to see [and photograph] the Eurasian Common Dandelion. So I was delighted to see a guide to 40 of the 60 to 70 species of plants likely to exist on South Georgia. About 35 to 40 of these are introduced, like the Dandelion. The guide not only covers the flowering plants, but grasses, ferns, lichens and others.

The book ends with some taxonomic notes that any book user should read before consulting the main text. There is a very short glossary of 19 words. Unfortunately it did not include the word I did not understand – on page 12 – Föhn [Föhn or foehn wind is a rain shadow wind that occurs on the downwind side of a mountain.]

An important theme throughout the book is the degradation of South Georgia's native wildlife by introduced problems. The SGHT is working and plans to continue to correct these impacts. I applaud their decision to remove the Reindeer. One photograph shows the devastation caused by the grazers on the native vegetation [a fenced area allowed native plants to recover and show the dramatic difference of eliminating this introduced mammal].

The text is a good summary of the pertinent information. I particularly liked the statistics in the box giving the number of breeding pairs on South Georgia as well as pairs worldwide. The illustrations are computer-modified images arranged in the classic field guide format. This works really well.

The photographs of the birds are beautifully crisp and clear, making them ideal as identification guides. Getting such photos takes skill, knowledge and patience. This is also true for the seals, but it takes much more to get great pictures of cetaceans. I get annoyed at guides that show lovely photos of whales taken underwater. Most people arrive in the southern oceans by ship and see these beasts on the surface, and this is what this guide shows. They are some of the best illustrations I have seen to help identify a whale in the water. A few of the photos are exceptional. I love the Reindeer

confronting the pair of king Penguins. The boulder covered with *Xanthoria* lichens set in a moody landscape is one I have been trying to find for years.

So this is a book to drool over. Anyone planning to visit South Georgia must buy this book, whether you are an avid naturalist or not. Even if you are only going to the region, this book is really worthwhile. I wish I

had got my copy earlier this year when I was struggling with prions and petrels in the Cape Horn-South Atlantic Area. In fact any naturalist would enjoy this book, just for the fun it gives.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5

## Societies of Wolves and Free-ranging Dogs

By S. Spotte. 2012. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473 USA. 394 pages. 120 CAD. Cloth.

The wonderful world of wolves is revealed here together with detailed descriptions of the descendants, which have evolved from them: coyotes, coydogs, domestic dogs and dingoes. The greatest detail, however, illustrates that the predominant volume of scientific publications is centred on wolves. Wolves are charismatic emblems of wilderness. Dogs, which descended from them, are models of urbanity. The free ranging dogs do not revert to the pack living of wolves except as an association of convenience. Focusing on behavioral ecology, this book assesses societies of both gray wolves and domestic dogs living as urban strays and in the feral state. The author defines a free-ranging dog as any dog of domestic origin uncontrolled by humans, including truly feral animals like dingoes, rural and urban strays, and wandering pets.

The text provides a comprehensive review of wolf genetics, particularly of New World wolves, and their confusing admixture of wolf, coyote and dog genomes. The author draws on the latest scientific findings across the specialized fields of genetics, sensory biology, reproductive physiology, space use, foraging ecology and socialization. This interdisciplinary approach provides a solid foundation for a startling and original comparison of the social lives of wolves and free-ranging dogs. It is possible to extrapolate which wolf characteristics can be attributed to our domestic pets, but domestic dogs are not discussed at any length. Unlike wolves, our pets do not become "adults" and mostly remain "puppies" in their relationship with their owners. A significant difference is that, with few exceptions, wolves cannot be domesticated or tamed and, again with few exceptions, domestic dogs do not form the packs, which include hierarchical status. Many North American wolf packs have been studied and monitored for long periods and are therefore well documented. Scientific instruments of radio-collars, satellite tracking and telemetry, and DNA analysis reveal more and more information about the "private"

lives of wolves. The wolf literature, which is vast, is a honeycomb of specialties. Wolves gave rise to domestic dogs and yet few studies have placed the two side-by-side and compared social aspects of their behavioral ecology. Free-ranging dogs do not form packs, either, but will form temporary loose associations of group living with several other dogs for breeding or food-foraging purposes. They are not territorial. It is interesting that free-ranging dogs often adopt objects as play toys, which they cache, whereas wolves only cache food. The life span of free-ranging dogs is about 5 years. The progeny of free-ranging dogs live short lives, mainly because of inadequate and unsuitable food and poor living conditions.

The literature surveyed is extensive. The bibliography runs to 49 pages, and there are nearly 900 citations in the text, resulting in 73 pages of Notes. Some of the literature dates from the early 20<sup>th</sup> Century. However, wolves are the subject of the majority of the literature cited, with far fewer academic studies of free-ranging dogs. There are a few studies of dingoes and coyotes listed, with more on the former.

The first two chapters of the book lay out the basic descriptions of first, what defines a wolf, and second, what defines a dog. The following chapters cover visual and tactile communication; olfactory and vocal communication; foraging; courtship and conception; reproduction and parenting; and socialization. The chapter on space discusses territorial use, pack dynamics (of wolves) natural controls on wolf populations. This subject is where free-ranging and domestic dogs have diverged greatly from wolves. Genetic studies play a major role in defining wolf pack lives and movements.

This is a valuable book, which brings right up to date the current state of our knowledge about this feared and admired member of our animal kingdom.

JANE ATKINSON

400 Kensington Avenue, Apartment 201, Westmount, Quebec H3Y 3A2

## BOTANY

**The Ecology of Plant Secondary Metabolites: From Genes to Global Processes**

By G. Iason, M. Dicke, and S. Hartley [Editors]. 2012. Cambridge University Press, UPH, Shaftesbury Road, Cambridge. CB2 8BS United Kingdom. xiii + 335 pages. 60.00 USD. Cloth.

Plants produce a diverse array of chemical compounds, some of the major groups of which include flavonoids, tannins, terpenoids, alkaloids, glycosides, and sterols, to name only a few. These are collectively called plant secondary metabolites (hereafter, PSMs), and there has been much debate about their roles over the past half-century or so. From the early idea that this diverse array of chemicals was simply waste products of metabolism, functional roles for these compounds were proposed beginning in the late 1950s. Such roles include defense against herbivores and pathogens, mediation of interactions with competitors, facilitation of pollination, and protection from abiotic stresses such as ultraviolet radiation. This book further elaborates the functional roles of PSMs by reviewing the evidence for multi-trophic, multi-scale relationships between PSMs and the ecosystems (or ecosystem components) in which they occur. This book is the result of a British Ecological Society symposium entitled "The integrative roles of plant secondary metabolites in natural systems", which was held at the University of Sussex in 2010. Sixteen review articles cover the function, ecology, and evolution of PSMs, including suggestions on ways forward for various research topics.

There is a huge body of literature on the occurrence and characterization of PSMs, and a smaller but still extensive amount of research on the effects of particular compounds or families of compounds on individual herbivores, but the field of study delving into the modes of operation of these compounds within the ecosystems in which the plants live (with their diverse species assemblages, seasonality, and complex inter-specific relationships) is still relatively young. This book aims to review this latter state of knowledge. Since this is still a relatively new area of ecological research, several of the chapters focus on the conceptual framework within which experimental studies should be conducted. Other chapters focus on particular experimental systems, or particular classes of compounds, and summarize what is known and where new research should focus.

One of the ideas that arises frequently in the chapters of this book is that there is a large amount of variability in the production of PSMs, between individuals of the same species, or even within an individual plant, depending on developmental stage, ecological context (below- or above-ground tissues), or the stress being imposed on the plant (herbivores, drought, ultraviolet

radiation, cold, etc.). In order to control for numerous variables, laboratory experiments often have been conducted to determine efficacy and mode of operation of particular compounds. Another approach to determining the mode of operation is to use mutant strains of the PSM producer that may be limited in their production of the PSM or that may produce large amounts of that compound, and compare the effects of varying levels of the PSM on test herbivores. These kinds of experiments are helpful in pulling mechanisms apart, especially when accompanied by studies of the genetic basis of these mutations and the parts of the biosynthetic pathways that are affected, but several of the chapters in this book also make the point that the ultimate goal of ecological PSM research is to understand how these compounds function in real ecosystems, with all of their complexity, interconnections, and spatial and temporal variability.

The chapters in this book cover a broad spectrum of PSM-related topics. Some of these include: natural selection for anti-herbivore PSMs, temporal changes in PSM production, ecological benefits of mixtures of PSMs, PSMs and abiotic stresses, PSMs in freshwater macrophyte-herbivore interactions, links between the soil microbial community and plant foliar defenses (relationship between below-ground and above-ground effects), the effects of PSMs on vertebrate herbivores, polymorphisms in PSMs and the extended chemical phenotype, and dynamics of PSMs relative to food chains, ecosystem dynamics, and evolutionary dynamics.

This book provides a leading-edge review of the roles of PSMs in their broader ecological contexts. It is technical, but it provides fascinating insights into the roles of some of the vast array of compounds that plants produce, not only at the individual plant-herbivore level, but at broader ecosystem levels, including multiple trophic levels. Furthermore, and perhaps most importantly, it provides numerous suggestions for future research, including guidance on how some of the more important research questions should be framed. For anyone involved in the study of plant secondary metabolites, co-evolution, natural selection, and ecosystem function, this book is most worthwhile.

WILLIAM J. CRINS

Ontario Ministry of Natural Resources, Parks & Protected Areas Policy Section, 300 Water Street, Peterborough, Ontario K9J 8M5



## OTHER

**In the Memory of the Map: A Cartographic Memoir**

By C. Norment. 2012. University of Iowa Press, 119 W. Park Road, 100 Kuhl House, Iowa City Iowa 52242-1000 USA. 253 pages. 22.50 USD. Paper.

Anyone who does fieldwork uses maps for many purposes, including wayfinding, locating and recording sample sites, and archiving spatial data. Folded, crumpled, water-stained, and scribbled-on, maps are an eloquent statement from the field. They are one of the basic tools of the trade. But what do maps actually mean and how do they relate to our life experience? These are the questions that biologist and ecologist Christopher Norment explores in this fascinating and thought-provoking book. His examination takes the form of a memoir, focussing on major life-phases, beginning with his childhood in California, moving through his restless and rootless young adulthood, then to later life as a wilderness instructor, field ecologist, academic, parent, and avid back-country trekker. At each stage a specific map triggers recollection and contemplation.

Maps are an abstraction; they don't show everything. Maps are selective in what they present, as are memories. Just as with recollections of the past, some things are excluded, deliberately edited out or omitted from maps. Both are fallible. For Norment, maps are containers of memory, in a way that is different from a narrative or a photograph. His ten reflective essays examine different types of maps – sketch maps, topographic maps, road maps, and maps created from field data. Maps display relationships and linkages. Just as we move inexorably through time, so we also travel through place and space. Norment is “aiming for ... an examination of the role of maps in [his] life, and by extension, in the lives of others” (page 2). His purpose is “to draw readers more fully into their aesthetics, mystery, function, power, shortcomings, and into consideration of the role that maps play in their lives” (page 3). For the fulfilment of these objectives, perhaps the most telling chapters of his narrative are the first and last, dealing with his childhood experiences and a journey without maps.

In the opening chapter, Norment remembers Saratoga, California, which he left when he was 10 years old, after living there for about two formative years. He draws from memory a map of his boyhood home. He also asks his sister, who is four years younger, to do the same. Then he compares the sketches. This small example powerfully demonstrates the capacity of memory to edit. His map is filled with boundaries – roads, rail lines, fences, a bridge, irrigation ditches, a stream channel – and places where he had adventures and played with his friends. Hers is filled with landmarks and natural features, especially specific plants and trees near their house. The nearby fills the view; the more distant Santa Cruz Mountains, which must have dominated the

skyline, don't impinge on either map. Some things are common to both sketches: the family home at the centre of the terrain and the driveway leading out to the road and the world beyond. What astounds him is that his sister marked a water tower across the highway from their front gate that he remembered but omitted and a barn on the acreage that he doesn't remember at all. Perhaps this shouldn't surprise us. It's well known, for comparison, that eyewitness accounts of recent incidents differ.

Norment has taken us here into the terrain of mental maps, the way in which people organize and remember space, and the way in which children develop a sense of the world around them. Later, he watches his own children develop spatial awareness as they grow up in Lawrence, Kansas, and Brockport, New York. For Norment and his sister, their memories built on their childhood experiences in which they spent much time outdoors, in close touch with nature, even if it was the rather groomed nature of orchards, fence lines, and irrigation ditches. Different experiences by different siblings produce different pictures. He realizes that their experience of the terrain has stayed with them through almost five decades, forming “the contours and coordinates of our childhoods, engraved in memory, and binding us to this earth” (page 18). These experiences were actual, not virtual – real mud, real trees, and real injury when he fell off a bridge across a stream. His narrative emphasizes the importance of genuine contact with nature. Although he doesn't mention this term, Norment's analysis suggests that such real-world exploration may provide one counteraction to the newly identified condition of “nature deficit disorder”.

Hiking, purposeful travel across the land, is a pervasive theme in Norment's life. Some journeys are straightforward, such as a traverse through geological time he takes with his daughter as they hike out of the Grand Canyon or a road-trip across the northern states with his son. Learning to wayfind by reading a map is a complex skill that many people with no experience of the outdoors have to be taught. He watches participants in Outward Bound courses gain confidence as they match a two-dimensional representation to the three-dimensional landscape around them. To bookend his narrative, Norment goes on a 13-day backpacking trip with a friend into the Pasayten Wilderness of northern Montana, deliberately hiking with no map or finding aids. This was an intentional challenge. He wanted to discover how maps had both facilitated and constrained his previous journeys. Their travels were not purposeful; they didn't have a specific objective, other than to make their way back to their starting point

at the end of their trip. When they returned, they retraced their route on the map so that the account is laced with the names of the places – peaks and streams – that for the most part they didn't know at the time. This chapter raises interesting questions about route finding through unknown terrain, that relate back to narratives of exploration and travel. Very little terrain is truly unknown. The traveller undertaking exploration is usually moving through places that are well known to other people if not to him.

Maps are simplifications, and can be made for a specific purpose or project. Norment describes one such set of maps, derived from his study of range territories defined by movements of feral burros in the Panamint Mountains of the Death Valley region. The movements of individual tracked animals defined territories and a seasonal pattern related to water and forage availability. Norment's other essays are almost all presented as journeys, narrowly linear travels between destinations. Only here does he approach contemplation of another major purpose of maps, and that is to delineate area. Consider, for example, the range maps found in field guides to wildlife or plants, such as winter and summer ranges of different bird species. These are constructed from many records, built up over many years and are subject to change as new evidence comes in. In fact, such maps have an inherent fluidity, because ranges may shift over time. Perhaps it is no coincidence that much of Norment's work in field ecology focuses on birds, including community surveys along the Verde River in Arizona, pipits in the Snowy Mountains of Australia, Harris's sparrows in the Canadian arctic, and waterfowl in western Alaska. Maps, after all, give a bird's-eye view of the land.

Printed maps have edges. Everyone who has done fieldwork is familiar with that frustration when the place you want to visit is on the boundary between two, or worse four, map sheets. This problem is diminishing as map data become available in digital format. Norment's map journeys aren't perturbed by edges; his memories narrated here are held and contained by map sheets. But he recognizes that the area beyond the map sheet has meaning too. It is either *terra incognita*, filled with enticing landscapes waiting to be explored and "fiercely imagined places" (page 22), or a *tabula rasa*, a blank space waiting to be occupied, to be filled in and to have meaning assigned. His travels are mostly by foot or by vehicle; the former giving a more intimate view, the latter revealing large scale connections. Most of his walks are in mountains or uplands, places that obviously appeal to him as centres of freedom and adventure. For Norment, maps are also a means of escape. In his teenage years, they were a way of fleeing abuse, getting away from a place of pain, even if only for a short time. As a mature adult, maps provide a way of temporarily laying down day-to-day responsibilities to focus on more basic issues of navigation, locational awareness, and survival.

Norment is a graceful and engaging writer and his book is a great pleasure to read. It is unquestionably the product of deep thought and considerable scholarship. Maps are so commonplace that, I suspect, most users take them for granted. Norment's well-written and articulate examination of maps and their place in his life, has ensured that I will never look at a map sheet quite the same way again.

ALWYNNE B. BEAUDOIN

Royal Alberta Museum, 12845-102nd Avenue N.W., Edmonton, Alberta T5N 0M6 Canada

## NEW TITLES

Prepared by Roy John

† Available for review \* Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

## ZOOLOGY

**Amphibian Biology – Volume 10.** By H. Heatwole [Editor]. 2012. Surrey Beatty and Sons PTY Ltd., P.O. Box 8159, Baulkham Hills NSW 2153, Australia. 435 pages. 137.50 AUD. Paper.

**The Feathery Tribe: Robert Ridgway and the Modern Study of Birds.** By D. Lewis. 2012. Yale University Press, P.O. Box 209040, New Haven, Connecticut 06520 USA. 368 pages. 46.00 USD. Cloth.

\***All the Birds of Nova Scotia.** By Ian McLaren. 2012. Gaspereau Press Limited, 47 Church Avenue Kentville, Nova Scotia B4N 2M7. 336 pages. 47.95 CAD. Cloth.

\***Squirrels of the World.** By Richard W. Thorington, Jr., John L. Koprowski, Michael A. Steele, and James F. Whatton. 2012. The Johns Hopkins University Press, 2715 N. Charles

Street, Baltimore, Maryland 21218-4363 USA. 472 pages. 75.00 USD. Cloth.

## OTHER

**Waiting for Godwits. A Bird of a Different Color. A Bird to Die For.** Three detective books for birders by Digby Maclaughlin. 2012. Bantry Books, Priory Hill House, NR21 0DQ Binham, Norfolk. Download directly from Amazon at: [http://www.amazon.com/s/ref=nb\\_sb\\_noss?url=search-alias%3Ddigital-text&field-keywords=Digby%2Bmaclaughlin](http://www.amazon.com/s/ref=nb_sb_noss?url=search-alias%3Ddigital-text&field-keywords=Digby%2Bmaclaughlin). 4.99 USD.

**John Latham, Surgeon, Ornithologist and Antiquary, Romsey's First Historian.** By M. Howard. 2012. Matador Press, 9 Priory Business Park, Wistow Road, Kibworth Beauchamp, Leicester, LE8 0RX, UK. 150 pages. 6.99 GBP. Paper.

# News and Comment

## Emergency COSEWIC Assessment for Three Species of Bats

An emergency assessment for three species of bat, Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*M. septentrionalis*), and Tri-colored Bat (*Perimyotis subflavus*), was requested by the Province of Nova Scotia on October 3, 2011. The request was due to: concerns regarding the mortality levels of White-nose Syndrome (WNS) on various bat species in the northeastern United States since 2006; the apparent rate of spread of the disease; and its confirmation in Nova Scotia, New Brunswick, Quebec, and Ontario. In early February 2012, an Emergency Assessment Subcommittee of COSEWIC assessed the three species as Endangered and recommended to the Minister of the Environment on February 22, 2012 that an Emergency Order be issued placing all three on Schedule 1 of the *Species at Risk Act*. A decision from the Minister is pending.

The rationale for the recommendation was: 1) catastrophic population declines have occurred in all three species in northeastern United States and similar impacts have occurred in Canada, with inference that future impacts to Canada will be same as had occurred in the United States; 2) a population model for *M. lucifugus* (considered applicable to *M. septentrionalis* and *P. subflavus*), predicts functional extirpation (decrease to < 1% of population) within 16 years for the northeastern region; and 3) predicted rate of spread was fast enough to impact > 50% of the Canadian population within three generations.

As per COSEWIC policy, a full status report is required within one year of an emergency listing decision by the Minister. All three species were addressed in a single report that is being reviewed currently by jurisdictions and other COSEWIC members. It is expected that the status report will be discussed at the full committee of COSEWIC in 2013.

## The Canadian Herpetologist (TCH) 2(1), Spring 2012

The Canadian Herpetologist (TCH) is a publication produced twice each year by the Canadian Association of Herpetologists and the Canadian Amphibian and Reptile Conservation Network.

CONTENTS: Executive Members of Societies — Instructions for Authors — Editorial Notes — Meetings: Turtle Survival Alliance and Freshwater Turtle and Tortoise subcommittee of IUCN meeting; World Congress of Herpetology — Feature Articles: Desert Night Snake and Northwestern Garter Snake species accounts by *Linda Gregory*; Peepers and Creakers by *Fred Schueler and Aleta Karstad* — Field Notes: Swamp Thing: How I learned to stop worrying and love *Chelydra serpentina* by *Dan Reeves*; Massasaugas Succumb to Flesh-Eating Fungal Infections by *Jonathan Choquette* — Book Reviews — Thesis Abstracts in Canadian Herpetology: **Banger, N.** M.Sc. 2012. University of Ottawa, Ottawa, ON. (Co-supervisors: Gabriel Blouin-Demers and Steve Loughheed).

Consequences of multiple paternity for female fitness in an Ontario population of Northern Map Turtles, *Graptemys geographica*. — **Boenke, M.** M.Sc. 2011. Redpath Museum, McGill University, Montreal, Quebec. (Supervisor: David Green). Terrestrial Habitat and Ecology of Fowler's Toads (*Anaxyrus fowleri*). — **Krause-Danielsen, A.** M.Sc. 2012. University of Manitoba, Winnipeg, Manitoba. (Co-supervisors: Pamela Rutherford and Nicola Koper). Using landowner knowledge and field captures to determine habitat use by the Northern Prairie Skink (*Plestiodon septentrionalis*) on exurban residential land in southwestern Manitoba. — **Moldowan, P.** B.Sc. 2012. University of Guelph, Guelph, Ontario. (Co-supervisors: Ryan Gregory and Tom Nudds). Influence of genome size on call complexity of anurans. — Recent Publications in Canadian Herpetology — News and Announcements — Membership Forms: CARCNET and CAH — Appendices to Schueler and Karstad article.

## Global Wildlife Resources – Wildlife Handling Job Board

Global Wildlife Resources has created a wildlife handling job board. This job board compliments other existing job boards and specifically lists jobs involving wildlife capture and handling as part of the job duties and helps potential employers find qualified applicants.

There are also links to other job boards and suggestions on how to succeed at finding work. More information is available at <http://www.wildliferesources.org/job-board/>.

## Letter to the Editor

Dear Editor:

As an antidote to the poisonous review of G. Vernon Byrd's and my book, "Birds of the Aleutian Islands, Alaska" (Series in Ornithology No. 1, Nuttall Ornithological Club and American Ornithologists' Union, 2007), published in CFN 125 (2), I refer any interested person to earlier, positive reviews of that work published in the spectrum of journals exemplified by

Marine Ornithology 37:93-95 (2009), Wilson Journal of Ornithology 120:425-426 (2008), Journal of Field Ornithology 79:226-228 (2008), Western Birds 39:107-108 (2008), and Birding 40:82-83 (2008).

Daniel D. Gibson  
3705 Quartz Road, PO Box 155, Ester, Alaska 99725

## Editor's Report for Volume 125 (2011)

Mailing dates for issues in volume 125:

- (1) 27 September 2011
- (2) 2 March 2012
- (3) 27 April 2012
- (4) 14 August 2012

A summary of the distribution of memberships in the Ottawa Field-Naturalists' Club and subscribers to *The Canadian Field-Naturalist* for 2011 is provided in Table 1. The number of articles and notes in Volume 125 is summarized in Table 2 by topic; totals for book reviews and new titles is given in Table 3; and the distribution of content by page totals per issue is provided in Table 4. Manuscripts (excluding book reviews, notices and reports) submitted to *The Canadian Field-Naturalist* totalled 54 in 2011. Of these, 46 were accepted for publication, and 20 were published in volume 125, along with 24 manuscripts submitted in 2010 and revised in 2011, and 6 manuscripts submitted in 2012.

Elizabeth Morton proofed and edited manuscripts; Wendy Cotie typeset galleys and corrections for page proofs and created pdfs; Roy John, Book Review Editor, requested books for review, selected reviewers, edited submitted reviews, and prepared the new titles listings; Jay Fitzsimmons, Journal Manager, developed an on-line submission system, conducted journal promotion through Twitter and other means, provided digital content to subscribers, and handled subscriptions, author charges, and issue orders. Frank Pope served as Business Manager. Leslie Cody prepared the Index with proofreading by Frank Pope. Sandra Garland, webmaster of the Ottawa Field-Naturalists' Club, posted tables of contents, abstracts, and pdfs on the CFN section of the OFNC website. Our Associate Editors managed manuscripts, provided reviews and recommendations, and guided authors through the revisions process. The Publication Committee, chaired by Dan Brunton and consisting Paul Catling, Jay Fitzsimmons Sandra Garland, Tony Gaston, Karen McLachlan Hamilton, Elizabeth Morton, Frank Pope, and Jeff Saarela effectively guided the operation of the journal. I am indebted to our very dedicated and effective team.

The following referees reviewed manuscripts submitted to the CFN (number of manuscripts reviewed >1 in parentheses):

*Associate Editors:* R. Anderson, Canadian Museum of Nature, Ottawa, Ontario (2); W. B. Ballard, Texas Tech University, Lubbock, Texas (7); C. D. Bird, Erskine, Alberta (4); B. W. Coad, Canadian Museum of Nature, Ottawa, Ontario (1); P. M. Catling, Agriculture and Agri-Food Canada, Ottawa, Ontario (6); F. R. Cook, Research Associate, Canadian Museum of Nature, Ottawa, Ontario (3); A. J. Erskine, Sackville, New Brunswick (6); T. S. Jung, Yukon Government, Whitehorse, Yukon Territory (2); D. F. McAlpine, New Brunswick Museum, St. John, New Brunswick (4); D. W. Nagorsen, Mammalia Biological Consulting, Victoria, British Columbia (6).

*Additional Reviewers:* P. Achuff, Waterton, Alberta; R. Alvo, Ottawa, Ontario; L. Bateman, Memorial University, Cornerbrook, Newfoundland; R. Belland, University of Alberta, Edmonton, Alberta; B. Bennett, Yukon Government, Whitehorse, Yukon Territory; J. Bhattacharyya, University of Waterloo, Waterloo, Ontario; A. Bixler, Clarke University, Dubuque, Iowa; S. Blaney, Atlantic Canada Conservation Data Centre, Sackville, New Brunswick; M. Boeckner, University of Alberta, Edmonton, Alberta; L. Brouillet, Montreal Botanical Gardens Herbarium, Montreal, Quebec; L. Carbyn, Edmonton, Alberta (2); J. Cayouette, Agriculture and Agri-Food Canada, Ottawa, Ontario; T. E. Chubbs, Department of National Defence Happy Valley-Goose Bay, Newfoundland; M. Collins, Memorial University, St. John's, Newfoundland; H. Costa-Sanchez, University of Saskatchewan, Saskatoon Saskatchewan; P. Cryan, US Geological Survey, Fort Collins, Colorado; S. Darbyshire, Agriculture and Agri-Food Canada, Ottawa, Ontario; S. Davis, Canadian Wildlife Service, Regina, Saskatchewan; M. Dowsley, Lakehead University, Thunder Bay, Ontario; B. Fenton, University of Western Ontario, London, Ontario; G. Forbes, University of New Brunswick, Fredericton, New Brunswick; P. Frame, University of Alberta, Edmonton, Alberta;

TABLE 1. The 2011 circulation of *The Canadian Field-Naturalist* (2010 in parenthesis). Compiled by Jay Fitzsimmons from mailing list for 125(4).

	Canada		USA		Other		Total	
Memberships								
Family & Individual	101	(453)	8	(18)	1	(2)	110	(473)
Subscriptions								
Individual	93	(90)	34	(35)	4	(3)	131	(128)
Institutional	120	(135)	179	(194)	23	(26)	322	(355)
Total	314	678	221	247	28	31	563	956

TABLE 2. Number of research and observation articles and notes published in *The Canadian Field-Naturalist*, Volume 125, by major field of study.

Subject	Articles	Notes	Total
Mammals	9	10	19
Birds	4	2	6
Amphibians and Reptiles	1	4	5
Fish	1	1	2
Plants	10	3	13
Other	2	1	3
Total	27	21	48

TABLE 3. Number of reviews and new titles published in the Book Review section of *The Canadian Field-Naturalist*, Volume 125, by topic.

	Reviews	New Titles
Zoology	26	77
Botany	8	22
Environment	2	12
Miscellaneous	21	26
Children	0	17
Total	57	154

J. Gilhen, Nova Scotia Museum of Natural History, Halifax, Nova Scotia (2); L. Gillespie Canadian Museum of Nature, Ottawa, Ontario; J. Green, Memorial University St. John's, Newfoundland; P. Gregory, University of Victoria, Victoria, British Columbia; C. Guppy, Quesnel, British Columbia; A. Gutleb Institute for Environmental Studies, Amsterdam, The Netherlands; P. Hall, Ottawa, Ontario; E. Holm, Royal Ontario Museum, Toronto, Ontario; R. Hutto, University of Montana, Missoula, Montana; M. Humphries, McGill University, Montreal, Quebec; G. Hvenegaard, University of Alberta, Edmonton, Alberta; D. Johnson (retired), Canadian Forest Service, Northern Forest Research Centre, Edmonton, Alberta; G. Kollias, Jr., Cornell University, Ithaca New York; C. Krebs, University of British Columbia, Vancouver, British Columbia; M. Light, Ottawa, Ontario; F. Lomer, Vancouver, British Columbia; R. MacLennan, University of Regina, Regina, Saskatchewan; N. Mandrak, Fisheries and Oceans Canada, Burlington, Ontario; J. McRoberts, Texas Tech University, Lubbock, Texas; R. MacCulloch, Royal Ontario Museum, Toronto, Ontario (3); I. McDonald, Calgary, Alberta; R. Moen, Minnesota Department of Natural Resources, St. Paul, Minnesota; T. Mosquin, Lanark, Ontario; D. Mossop, Yukon College, Whitehorse, Yukon Territory; V. Nams, Nova Scotia Agricultural College, Truro, Nova Scotia; D. Naughton (retired), Canadian Museum of Nature, Ottawa, Ontario; M. Oldham, Natural Heritage Information Centre,

TABLE 4. Number of pages per section published in *The Canadian Field-Naturalist*, Volume 125 (2011), by issue.

	Issue				Total
	1	2	3	4	
Editorials	6	0	0	0	6
Articles	48	59	55	56	218
Notes	21	11	13	17	62
Book Reviews*	14	16	21	14	65
News and Comment, Reports**	0	9	12	2	23
Tributes	4	0	0	11	15
Index	—	—	—	17	17
Advice to Contributors	1	3	3	3	10
Total	94	98	104	120	416

\*Includes reviews and new titles listings

\*\* Includes CFN Editor's report, Minutes of the OFNC Annual Business Meeting, and OFNC Awards report.

Ontario Ministry of Natural Resources, Peterborough, Ontario; M. Panasci, Texas Tech University, Lubbock, Texas; B. Patterson, Ontario Ministry of Natural Resources, Peterborough, Ontario; H. Proctor, University of Alberta, Edmonton, Alberta; J. Ray, Wildlife Conservation Society, Toronto, Ontario; J. Reddoch, Ottawa, Ontario (2); K. Reese, University of Idaho, Moscow, Idaho; C. Renaud, Canadian Museum of Nature, Ottawa, Ontario; J. Riley, Nature Conservancy Canada, Toronto, Ontario; J. Saarela, Canadian Museum of Nature, Ottawa, Ontario (2); J. Sanderson, Conservation International, Arlington, Virginia; C. Sheviak, New York State Museum at Albany, New York (2); F. W. Schueler, Bishops Mills Natural History Centre, Ontario (7); N. Smith (retired) New Mexico Department of Game and Fish, Santa Fe, New Mexico; R. Thiel (retired), Department of Natural Resources, Wisconsin; R. Thorington Jr. National Museum of Natural History Smithsonian Institution Washington, DC; R. Weir, Artemis Wildlife, British Columbia; W. F. Weller, Niagara Falls, Ontario; J. Whitaker Jr., Indiana State University, Terre Haute, Indiana; J. Willis, University of Louisiana, Lafayette, Louisiana; J. Wilmshurst, Parks Canada, Jasper, Alberta; G. Yaki, Calgary, Alberta.

The journal was printed at Gilmore Printers, Ottawa. Thanks to Chuck Graham and Michael Datson of Gilmore for overseeing production and printing. I am grateful to President Ann McKenzie and Council of the Ottawa Field-Naturalists Club for their support of the journal. I am also grateful to all of the individual subscribers and authors who encouraged me as I took on the role as Editor. Finally, I thank my family for being patient and supportive throughout many evenings of working on the journal.

CAROLYN CALLAGHAN  
Editor

# The Canadian Field-Naturalist — Instructions for Authors

## Aim and Scope

The Canadian Field-Naturalist (CFN; ISSN: 0008-3550) publishes peer-reviewed scientific papers on natural history relevant to Canada. Relevance to Canada usually means the species studied must inhabit Canada, even if the research itself occurred outside Canada, e.g., U.S.-based research on a species whose range extends into Canada, or research in Asia on a species introduced into Canada. Natural history comprises organism-scale biological research in diverse fields including behaviour, ecology, conservation, and taxonomy, among others. We publish research on any taxa, from microbes to large-bodied mammals. We encourage manuscript submissions from professional and amateur naturalists. Our journal has been published continuously since 1879 by the non-profit group The Ottawa Field-Naturalists' Club, making it one of the longest-running ecological journals in North America.

## Manuscript Types

**Articles.** Articles report original research and are at least five pages long in printed form. There are no upper-boundary restrictions on the number of pages or references for articles (maximum abstract length: 250 words). Articles are peer-reviewed.

**Notes.** Like articles, Notes report original natural history research. Notes only differ in being shorter (maximum abstract length: 100 words; maximum page length in final printed form: 4 pages, or approximately 2000 words). Many Notes report novel observations of animal behaviour, diet choice, or range extensions of species. Notes are peer-reviewed.

**Book Reviews.** We publish many reviews of books of interest to naturalists, from all over the world (i.e., not necessarily related to Canadian species). Each issue includes a list of new book titles received by our Book Reviews Editor with notation on books available for review, although we are open to suggestions of reviews for other titles. All book reviews and inquiries related to book reviews should be sent to our Book Review Editor, Roy John (r.john@rogers.com). Book reviews are edited by Roy John, but are not considered peer-reviewed.

**Tributes.** Tributes are descriptions of recently-deceased exemplary naturalists who contributed to our understanding of Canadian nature. Please inquire with our Editor-in-Chief, Dr. Carolyn Callaghan, before writing a Tribute. Tributes are not peer-reviewed.

**News, Opinions and Reports.** Short news items, commentary, or reports of interest to naturalist readers. They are not peer-reviewed, and are normally contributed by our Editor-in-Chief. News item suggestions should be directed to our Editor-in-Chief, Dr. Carolyn Callaghan (editor@canadianfieldnaturalist.ca). Commentary may be similar to articles in format or it may be just a series of paragraphs.

**Editorials, Club Reports.** These items are contributed by our editors and Ottawa Field-Naturalists' Club personnel, and are not open to submission by others.

## Manuscript Guidelines

Manuscripts are to be submitted to the Editor-in-Chief by email (editor@canadianfieldnaturalist.ca) or post, written in the journal style. Authors should consult a recent issue of CFN to understand journal format. A sample issue is available for free online at [www.ofnc.ca/cfn/122-1/subscribers-index.php](http://www.ofnc.ca/cfn/122-1/subscribers-index.php).

## Legal issues, ethical conduct

The research reported must be original. Manuscripts cannot have been published, or be under consideration for publication, in part or in entirety in any other publication media including journal, newsletter, book, report, either online or in print. The author(s) is/are expected to confirm that a manuscript submitted for consideration for publication in the Canadian Field-Naturalist has not already been published elsewhere, and will not be published elsewhere unless rejected by the Canadian Field-Naturalist. Published means distributed or otherwise made available in print, either in hard copy or online and with or without peer review.

All co-authors must have read and approved the submitted version of the manuscript. If institutional or contract approval for the publication of data is required, authors should have obtained it prior to manuscript submission. Authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, or minerals. Animal care should comply with relevant institutions' guidelines and be considered ethical by peers. A cover letter, indicating compliance with the preceding points must accompany the manuscript submission when appropriate.

## Language

Manuscripts can be submitted in English or French. Manuscripts are permitted, but not required, to include abstracts and keywords in both languages. Canadian spelling of the English language is required on manuscripts submitted in English. A contemporary reference for formal Canadian spelling is the *Canadian Oxford Dictionary*.

## Font, page format, file type

Font should be 12-point Times New Roman. Manuscripts should be double-spaced throughout including references with margins 2.5 cm (1 inch) wide. Pages should be numbered sequentially, and lines should be numbered continuously. The file should be saved as .doc (Microsoft Word 2003) file format.

## Nomenclature and units of measurement

Species' common names (when available) and scientific names should both be used at least once in the manuscript. Initial letters of species common names should be capitalized. Authorities' names (e.g., "Kuhl" in *Castor canadensis* Kuhl) should be omitted from scientific names unless the manuscript has taxonomic relevance or in the first reference to a featured species. Units of measurement should follow standard metric SI units.

## Vouchers, location information, GenBank

All voucher material should include the name and location of the collection and the specimens' catalog numbers. All collections or observations of species should include latitude and longitude in decimal degrees at two decimal points or finer depending on the sensitivity of the information. All genetic sequences should be accompanied by GenBank accession numbers.

## Title page

Include the title, a running title (maximum of 35 characters), the list of authors, and the type of submission the manuscript should be considered. For each author provide their



affiliation with postal address (home address is fine for unaffiliated amateurs) and e-mail address. Indicate which author is the corresponding author, and provide their phone number in addition to postal and e-mail address.

#### Abstract page

The second page of the manuscript (for Articles and Notes) should include the abstract and a list of key words (4-10 key-words).

#### Manuscript sections

Articles should typically contain the following sections listed as bolded, 16-point font headings, initial caps only: Introduction, Methods, Results, and Discussion. Alternative headings are permitted. Second-level subheadings are permitted and should be italicized in 12-point font. Notes' headings, if any, are at the authors' discretion. Both Articles and Notes should also include Acknowledgements, Documents Cited, and Literature Cited. Acknowledgements should list authors' funding sources and thank people who contributed significantly to the study. Documents and Literature Cited are described below.

#### Citation format

Below are example citations in CFN style. When more than one document is cited in a citation, sort them chronologically, and alphabetically within the same year, separated by semicolons.

**Single author:** "... fishers in Maine (Coulter 1966)."

**Two authors:** "... been observed (MacKinnon and Kennedy 2009)"

**Three or more authors:** "... diet composition (Arthur *et al.* 1989)."

**Multiple documents cited:** "... birds and tardigrades are very different (Tufts 1961; Nelson *et al.* 2009)."

#### References (Documents Cited and Literature Cited)

Cited references should be listed under the headings of Documents Cited (for reports of limited circulation and web documents) and Literature Cited (for journal articles, books, book sections, and theses). All references should have hanging indents. Web documents' citations should include their website address and the date they were accessed. Journal names should be written in full. Below are example references in CFN format.

#### Documents Cited

**Environment Canada.** 2008. National Climate Data and Information Archive, Environment Canada. Accessed 5 November 2008. [www.climate.weatheroffice.gc.ca](http://www.climate.weatheroffice.gc.ca).

**Friends of Fish Creek Provincial Park Society.** 2009. Water quality monitoring report 2009. Accessed 20 March 2011. <http://wsow.brbc.ab.ca/reports/FishCreekStudy2.pdf>.

**Stevens, V.** 1995. Wildlife diversity in British Columbia: distribution and habitat use of amphibians, reptiles, birds, and mammals in Biogeoclimatic Zones. Working Paper 04, B.C. Ministry of Forest Research Program, and Ministry of Environment, Lands, and Parks' Habitat Protection Branch, Victoria, British Columbia, Canada. 288 pages.

#### Literature Cited

**Arthur, S. M., W. B. Krohn, and J. R. Gilbert.** 1989. Habitat use and diet of fishers. *Journal of Wildlife Management* 53: 680-688.

**Coulter, M. W.** 1966. Ecology and management of fishers in Maine. Ph.D. thesis, Syracuse University, Syracuse, New York, USA.

**MacKinnon, C. M., and A. C. Kennedy.** 2009. Canada Lynx, *Lynx canadensis*, use of the Chignecto Isthmus and the possibility of gene flow between populations in New Brunswick and Nova Scotia. *Canadian Field-Naturalist* 122: 166-168.

**Nelson, D. R., R. Guidetti, and L. Rebecchi.** 2009. Tardigrada. Pages 455-484 in *Ecology and Classification of North American Freshwater Invertebrates*. Edited by J. H. Thorp and A. P. Covich. Third edition. Academic Press, San Diego, California.

**Tufts, R. W.** 1961. The Birds of Nova Scotia. Nova Scotia Museum, Rolph-Clark-Stone, Maritimes Limited, Halifax, Nova Scotia. 481 pages.

#### Figures and maps

Figures should be pasted on separate pages below the Literature Cited section in the manuscript file. Upon acceptance for publication, the Editor may ask the authors to send figures as separate files with sufficiently high resolution for publication-quality images. Microscopic images should be accompanied by a scale bar. Photographic reproductions of line drawings should be no larger than a standard page. Colour figures can be included in the online version of final articles, but figures are printed in black in printed CFN issues unless authors agree to pay the costs of colour printing (approximately \$650 per figure – contact the Editor-in-Chief if you would like colour printing). Authors should remember that readers often print online articles with black ink printers, so even colour figures online should be interpretable if printed in grayscale.

Not every article requires a map. There is no need for a map that just illustrates the location of a study area. Ideally, a map should make clear the spatial relationship of the data. For example, a paper on a range extension should show how far the species' range has been extended from the previous known limit.

Every map should include a north indicator, using a north arrow or by labeling Longitude (°W) and Latitude (°N) on the map. Although most maps have north at the top, maps can be oriented differently if there is a valid reason. Every map should include a scale bar. A ratio scale (e.g. 1:50000) is not recommended as the scale will change depending upon the published size of the map. An inset map showing the region where the study area is located may be used, and a legend can be used if warranted.

Maps should make use of a strong contrast – a white background with black lines. Avoid using a uniform gray background, but shading is appropriate for certain areas (e.g. lakes) or to indicate affected areas. Maps should be submitted as a separate raster graphic or bitmap file of sufficient resolution to print sharply. The specific file size will depend upon the file format. Some common formats include Windows bitmaps (\*.bmp), graphics interchange format (\*.gif), and joint photographic experts group format (\*.jpg).

#### Figure captions

Figure captions should be listed in the Figure Captions section following Figures. Figure captions should be listed and numbered in the order cited in the document. In text the word "Figure" should appear in small-caps (e.g., Figure 1) and in figure captions large-caps (e.g., "FIGURE 2. A young adult, melanistic American Red Squirrel (*Tamiasciurus hnd-*

*sonicus*) observed foraging in Upper Nine Mile River, Nova Scotia)." For multi-part figures, each part should be labelled (in text: e.g., Figure 1A).

#### Tables

Tables should be listed on separate pages in the Tables section following Figure Captions, with the word "TABLE" in small-caps.

#### Supplementary Material

Tables, figures, audio files, video files, and data files that compliment Articles or Notes but are not essential to their message can be included as supplementary material at the authors' discretion. Supplementary material will be available online only for subscribers to download. Supplementary material should be submitted during initial manuscript submission. List all supplementary material under the final manuscript heading "Supplementary material." Supplementary material is a new feature for CFN so we do not yet know which file formats can and cannot be accepted; please consult our Journal Manager with any questions about specific formats.

#### Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor, who sends it to two qualified reviewers as well as provides an evaluation of the manuscript. Authors are encouraged to suggest at least three suitable referees that could provide unbiased expert reviews. Authors can also request that their manuscript not be sent to certain referees, if proper justification is given. The Editor-in-Chief makes the final decision on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of *The Canadian Field-Naturalist*. As with any scientific journal, extensive revisions may be requested by editors in an effort to improve the clarity, accuracy, style, and overall quality of manuscripts. Changes made by authors at the proof (galley) stage may result in extra charges to the author.

#### Author Charges, Reprints, pdf files

As a non-profit journal run largely by volunteers devoted to natural history, we make every effort to keep our costs as low as possible. To cover costs we require payment from authors of Articles and Notes: \$90 per printed page, plus \$30 per figure (any size up to one page), and \$90 per page of tables. Under special circumstances, these charges can be waived for authors without grants or institutional support (e.g., amateurs, students, independent researchers). These waivers are courtesy of a generous bequest left by naturalist Tom Manning (1911-1998) to The Ottawa Field-Naturalists' Club. To learn more about Tom Manning and his research, refer to CFN 118(4):618-625 ([www.canadianfieldnaturalist.ca/index.php/cfn/article/view/70/70](http://www.canadianfieldnaturalist.ca/index.php/cfn/article/view/70/70)). Authors requesting charge waivers must make their request when submitting their manuscript and again (as a reminder) when authors return their proofs and order form after manuscript acceptance. Manuscripts of authors requesting waivers will not be treated any differently than other manuscripts during the editorial process.

Reprints can be ordered after acceptance for publication, with authors covering the cost of printing and mailing. Pdf files of published Articles, Notes, and Tributes are e-mailed to authors at no charge. As per the copyright agreement between authors and CFN, authors are permitted to distribute

their pdf file to colleagues and to post it on their research website, but are not permitted to distribute their article commercially.

Although not a requirement, submitting authors are encouraged to maintain personal subscriptions to *The Canadian Field-Naturalist* or membership in The Ottawa Field-Naturalists' Club to further support the mandate and reach of the journal.

#### How to Submit a Manuscript

Please ensure your manuscript complies with the journal style described above, and has been appraised by a qualified expert (listed in the Acknowledgements) prior to submission.

Please e-mail book reviews to Book Review Editor Roy John, [r.john@rogers.com](mailto:r.john@rogers.com). Please e-mail all other manuscripts to Editor-in-Chief Dr. Carolyn Callaghan at [editor@canadianfieldnaturalist.ca](mailto:editor@canadianfieldnaturalist.ca). Please also attach a cover letter briefly explaining 1) the significance and novelty of your study in plain terms, 2) why it would be of interest to CFN's readers, 3) confirmation that the submitted manuscript has not been distributed in print, either in hard copy or online and with or without peer review, 4) confirmation that the research was conducted in adherence to all pertinent legislation and institutional guidelines regarding the study, disturbance, or collection of animals, plants, or minerals, 5) the names, affiliations, e-mail addresses, and relevant expertise of at least three experts you feel could evaluate your manuscript without bias or conflicts of interest as referees. You can also request that certain experts not act as referees, as long as you provide adequate justification. We are working to set up a manuscript submission portal on CFN's website in the future that will allow you to track your manuscript as it proceeds along the reviewing process, but until the portal is fully functional please continue to use the e-mail method.

We can also receive manuscripts by postal mail. Please send two copies (double-sided preferably to reduce environmental costs of printing and financial costs of mailing) of your manuscript to:

DR. CAROLYN CALLAGHAN  
Editor-in-Chief, CFN  
Box 35069, Westgate PO  
Ottawa, ON, K1Z 1A2  
Canada

#### Contact Information

CFN website:  
<http://www.canadianfieldnaturalist.ca/index.php/cfn/about>

Ottawa Field-Naturalists' Club (our publisher) website:  
[www.ofnc.ca](http://www.ofnc.ca)

Editor-in-Chief: Dr. Carolyn Callaghan  
[editor@canadianfieldnaturalist.ca](mailto:editor@canadianfieldnaturalist.ca)

Assistant Editor: Trina Rytwinski  
[canadianfieldnaturalistae@gmail.com](mailto:canadianfieldnaturalistae@gmail.com)

Book Review Editor: Roy John  
[r.john@rogers.com](mailto:r.john@rogers.com)

Journal Manager: Jay Fitzsimmons  
[subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca)

**Tributes**

- A Tribute to Charles Hogg Douglas, 1923–2004    EDWARD L. BOUSFIELD and FRANCIS R. COOK    164
- A Tribute to Phillip Merrill Youngman: 1927–2011    IRWIN M. BRODO and FRANCIS R. COOK    167

**Book Reviews**

- ZOOLOGY: All the Birds of Nova Scotia — The ROM Field Guide to Freshwater Fishes of Ontario — Population Demography of Northern Spotted Owls — Venomous Reptiles of the United States, Canada, and Northern Mexico. Volume 1 — A Field Guide to the Wildlife of South Georgia — Societies of Wolves and Free-ranging Dogs    172
- BOTANY: The Ecology of Plant Secondary Metabolites: From Genes to Global Processes    178
- OTHER: In the Memory of the Map: A Cartographic Memoir    179
- NEW TITLES    181

**News and Comment**

- Emergency COSEWIC Assessment for Three Species of Bats    182
- The Canadian Herpetologist (TCH) 2(1), Spring 2012    182
- Global Wildlife Resources – Wildlife Handling Job Board    182
- Letter to the Editor    183

**Editor's Report for Volume 125 (2011)**

CAROLYN CALLAGHAN    184

**Instructions to Authors**

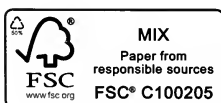
186

Mailing date of the previous issue 126(1): 3 October 2012

## Articles

- Ecology of a recently discovered population segment of Blanding's Turtles, *Emydoidea blandingii*, in Barren Meadow and Keddy Brooks, Nova Scotia  
JOSÉ LEFEBVRE, STEPHEN W. MOCKFORD, and TOM B. HERMAN 89
- An addition to the mammalian fauna of Saskatchewan: The Western Harvest Mouse, *Reithrodontomys megalotis*  
GILBERT PROULX and BENJAMIN P. PROULX 95
- Distribution and relative abundance of Richardson's Ground Squirrels, *Urocitellus richardsonii*, according to soil zones and vegetation height in Saskatchewan during a drought period  
GILBERT PROULX, KEITH MACKENZIE, and NEIL MACKENZIE 103
- Trends and fluctuations in bird populations on the tundra at Cambridge Bay, Nunavut  
C. MARTIN LOK and JAAP A. J. VINK 111
- Foods of Bats (Family Vespertilionidae) at five locations in New Hampshire and Massachusetts  
HOWARD H. THOMAS, PAUL R. MOOSMAN, JR., JACQUES PIERRE VEILLEUX, and JASON HOLT 117
- Bat populations and cave microclimate prior to and at the outbreak of White-Nose Syndrome in New Brunswick  
KAREN J. VANDERWOLF, DONALD F. MCALPINE, GRAHAM J. FORBES, and DAVID MALLOCH 125
- Site fidelity and annual survival of the Western Yellow-breasted Chat (*Icteria virens auricollis*) at the northern edge of its range  
RENÉ MCKIBBIN and CHRISTINE A. BISHOP 135
- Genetic evidence supports Boreal Chickadee (*Poecile hudsonicus*) × Black-capped Chickadee (*Poecile atricapillus*) hybridization in atlantic Canada  
LINDA A. LAIT, RANDY F. LAUFF, and THERESA M. BURG 143
- Notes**
- High spring mortality of adult Richardson's Ground Squirrels, *Urocitellus richardsonii*, associated with a severe rainstorm in southwestern Saskatchewan  
GILBERT PROULX 148
- Size of territories and home ranges of male Western Yellow-breasted Chats (*Icteria virens auricollis*) in British Columbia  
RENÉ MCKIBBIN and CHRISTINE A. BISHOP 152
- Urban White-tailed Jackrabbits (*Lepus townsendii*) eat Spike Plants (*Cordylone australis*) in winter  
ALWYNNE B. BEAUDOIN and YVES BEAUDOIN 157
- Resistance of Canada Yew (*Taxus canadensis*) branch wood to two wood decay fungi  
DANA L. RICHTER, AMY M. BERNIS, and CLARE F. FREDERICK 160

(continued on inside back cover)



CAN  
1824

# The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada



Volume 126, Number 3

July-September 2012

# The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

## Patron

His Excellency the Right Honourable David Johnston, C.C., C.M.M., C.O.M., C.M.  
Governor General of Canada

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

## Honorary Members

Ronald E. Bedford	Michael D. Cadman	John M. Gillett	Joyce Reddoch
Edward L. Bousfield	Paul M. Catling	Christine Hanrahan	Allan Reddoch
Charles D. Bird	Francis R. Cook	C. Stuart Houston	Dan Strickland
Fenja Brodo	Bruce Di Labio	Theodore Mosquin	John B. Theberge
Irwin M. Brodo	R. Yorke Edwards	Robert W. Nero	Sheila Thomson
Daniel F. Brunton	Anthony J. Erskine	E. Franklin Pope	

## 2012 Council

<b>President:</b> Ann MacKenzie	Daniel F. Brunton	David Hobden	Jeff Saarela
<b>1st Vice-President:</b> Fenja Brodo	Carolyn Callaghan	Diane Kitching	Henry Steger
<b>2nd Vice-President:</b> Jeff Skevington	Barbara Chouinard	Diane Lepage	Chris Traynor
<b>Recording Secretary:</b> Annie Bélair	Julia Cipriani	Karen McLachlan-Hamilton	Eleanor Zurbrigg
<b>Treasurer:</b> Ken Young	Sandra Garland	Rémy Poulin	

To communicate with the Club, address postal correspondence to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2, or e-mail: ofnc@ofnc.ca. For information on Club activities, go to [www.ofnc.ca](http://www.ofnc.ca)

## The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

**Website:** [www.canadianfieldnaturalist.ca/index.php/cfn](http://www.canadianfieldnaturalist.ca/index.php/cfn)

**Editor-in-Chief:** Dr. Carolyn Callaghan

**Assistant Editor:** Trina Rytwinski

**Copy Editor:** Elizabeth Morton

**Typographer:** Wendy Cotie

**Treasurer:** Ken Young, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2

**Journal Manager:** Jay Fitzsimmons: [subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca) or via postal address above.

**Book Review Editor:** Roy John

**Associate Editors:** Robert R. Anderson

Francis Cook

Donald F. McAlpine

Jeffery M. Saarela

Charles D. Bird

Anthony J. Erskine

David Nagorsen

David C. Seburn

Paul M. Catling

Thomas Jung

Claude Renaud

**Chair, Publications Committee:** Daniel F. Brunton

**All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by e-mail:** [editor@canadianfieldnaturalist.ca](mailto:editor@canadianfieldnaturalist.ca) or **postal mail (with disk):** 611 Chemin Cregheur, Luskville, QC J0X 2G0; (819) 455-1087;

**Book-review correspondence should be sent to the Book Review Editor by e-mail:** [r.john@rogers.ca](mailto:r.john@rogers.ca) or **postal mail:** 2193 Emard Crescent, Ottawa, Ontario K1J 6K5.

### Subscriptions and Membership:

Subscription rates for individuals are \$40 (online only), \$50 (print only), or \$60 (print + online) for volume 126. Libraries and other institutions may subscribe for \$60 (online only or print only) or \$90 (print + online) for volume 126. All foreign print subscribers and members (including USA) must add \$10 to cover postage. The Ottawa Field-Naturalists' Club annual membership fee of \$40 (individual), \$45 (family), or \$20 (student) includes an online subscription to *The Canadian Field-Naturalist*. Members can receive printed issues of CFN for an additional \$30 per volume (four issues). For further details, including discounts for members of the Canadian Museum of Nature, see <http://ofnc.ca/member.php>. The club's regional journal, *Trail & Landscape*, covers the Ottawa District and regional Club events and field trips. It is mailed to Ottawa area members, and is available to those outside Ottawa on request. It is available to libraries at \$33 per year. Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be sent to [subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca) or mailed to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O., Ottawa, ON, Canada, K1Z 1A2. Canada Post Publications Mail Agreement number 40012317. Return postage guaranteed.

COVER: American Badger (*Taxidea taxus*) in southwestern Saskatchewan. Photo by Gilbert Proulx. See notes by Proulx and MacKenzie, pages 221–225 and 226–230.

MCZ  
LIBRARY

MAY 15 2013

HARVARD  
UNIVERSITY

# The Canadian Field-Naturalist

Volume 126, Number 3

July–September 2012

## The Influence of Willow *Salix* sp. Rose Insect Galls on Moose *Alces alces* Winter Browsing

ROY V. REA

Natural Resources and Environmental Studies Institute, University of Northern British Columbia, 3333 University Way, Prince George, British Columbia V2N 4Z9 Canada

Rea, Roy V. 2012. The influence of Willow *Salix* sp. rose insect galls on Moose *Alces alces* winter browsing. Canadian Field-Naturalist 126(3): 189–193.

Feeding trials were conducted with Moose (*Alces alces*) habituated to people to determine whether Moose prefer winter shoots of Scouler's Willow (*Salix scouleriana*) with or without leafy willow rose insect galls created by rosette willow gall midges (*Rabdophaga* spp.). After sampling one or two shoots with galls, each Moose in the feeding trial showed a clear aversion to the galls and dropped or spit out parts of the willow shoot containing these structures in subsequent feeding bouts. Despite the reported importance of leafy materials in the fall and winter diets of Moose, these results suggest that morphological attributes of or chemical deterrents within galls may lead Moose to reject these structures in favour of gall-free shoots. Why galls are rejected is speculated upon, but remains untested.

Key Words: Moose, *Alces alces*, browse, feeding trial, gall, rosette gall, shoots, Scouler's Willow, *Salix scouleriana*, willow rose, *Rabdophaga* sp., Cecidomyiidae.

Moose are generalist herbivores and forage on a variety of seasonally available materials such as grasses, forbs, aquatic plants, lichens, and twigs of various shrubs and trees (Renecker and Schwartz 1998). In winter, Moose subsist predominantly on woody twigs and bark (Renecker and Schwartz 1998), but they are also known to consume leafy needles of coniferous plants (e.g., *Abies lasiocarpa*, Subalpine Fir, and *Pseudotsuga menziesii*, Douglas-fir) (Bergerud and Manuel 1968). Moose even select for and consume senescent and fallen leaves rather than twigs in winter as long as leaves are accessible (Renecker and Hudson 1985). Why Moose prefer autumn leaves to shoot materials is unknown, but it is likely related to leaves generally being more digestible (containing less fiber) than twigs (Renecker and Hudson 1988).

Several midge species of the genus *Rabdophaga* (Diptera: Cecidomyiidae) form stem or shoot tip galls on numerous species of willows (*Salix* spp.) (Darlington 1975; Samsone et al. 2011) that are eaten by Moose (personal observations). Unlike nodular galls, however, galls induced on the vegetative buds of willows by ovipositing insects, such as the European rosette willow gall midge (*Rabdophaga strobiloides* (occas. as *rosaria*)), form neoplastic structures called terminal rosette galls or willow roses (Darlington 1975; Samsone et al. 2011). These galls are composed of 30 to 60 leaves

shortened and crowded together on affected shoot tips (Stubbs 1986; Samsone et al. 2011). In most cases, the formation of the gall inhibits shoot elongation as resources from the shoot become incorporated into the gall (Nyman et al. 2011; Samsone et al. 2011).

Rosette galls begin to form with leaf expansion in early summer and provide shelter and nutrition around the developing midge larvae, which typically pupate within the gall (Nyman et al. 2011). When fully developed in late summer, galls appear red to green in colour and similar in shape to the solitary inflorescence of an ornamental rose (*Rosa* spp.), hence the name. Rosette galls turn brown in autumn and can persist in substantial numbers on willows over winter. As such, these structures represent a potential pool of accessible leafy materials for Moose and other herbivores to eat at a time of the year when leaves and other herbaceous resources are scarce.

Studies indicate that shoots with galls are highly attractive to some herbivorous insects (Nakamura et al. 2003) and that galling insects are found more commonly on the shoots of trees previously browsed by moose (Danell and Huss-Danell 1985); this has not been tested in British Columbia. Because Moose often select the shoots of previously browsed rather than unbrowsed plants (Danell et al. 1985), it follows that Moose will be faced with the choice of consuming or avoiding galls

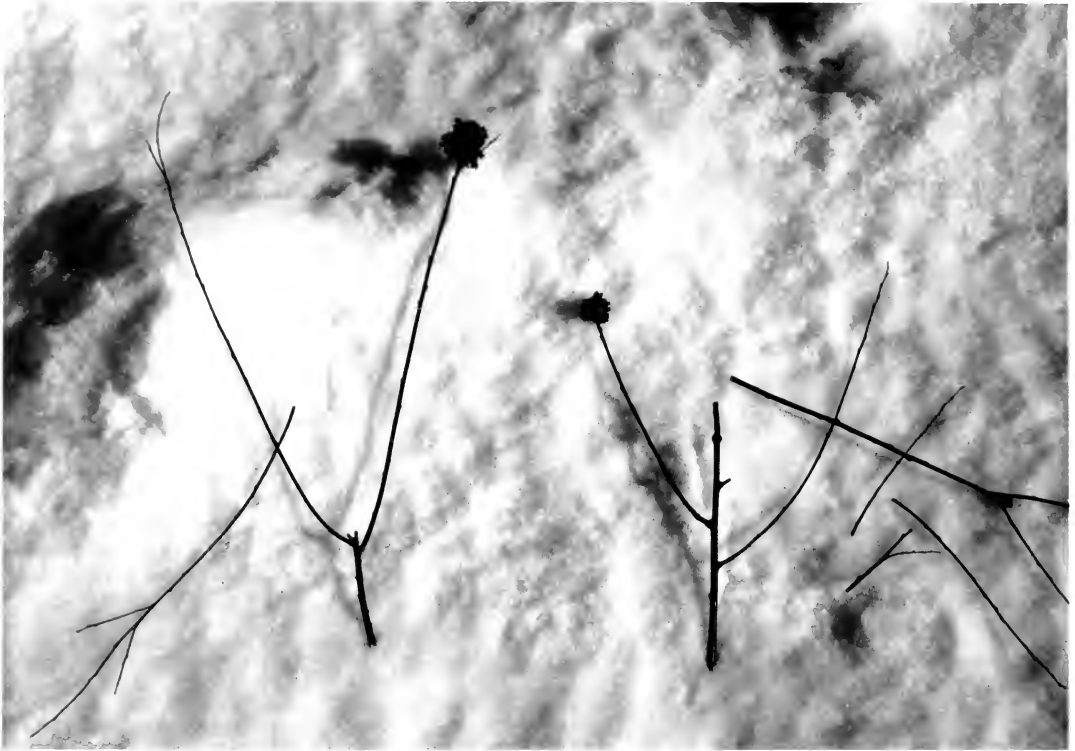


FIGURE 1. Photograph of a typical stem of Scouler's Willow (*Salix scouleriana*) with associated shoots (one with and one without a rosette gall) collected near Bednesti Lake for the feeding trial.

while feeding. However, this could depend in large part on both the morphological and chemical attributes of galls (Roininen et al. 1997).

Here, I tested whether, given a choice, Moose prefer shoots with willow roses or without willow roses (I assumed that willow roses constituted leafy material as defined by Renecker and Hudson (1985)) induced by *Rabdophaga* sp. near *salicisrhodoides* (Osten Sacken). My hypothesis was that, when offered plants with willow roses during winter, Moose would select shoots with willow roses rather than shoots without.

## Methods

### Shoot collections

On 16 February 2007, I collected shoots with and without willow roses from 28 Scouler's Willow (*Salix scouleriana*) plants which are commonly browsed by moose in northern BC in winter (Rea and Gillingham 2001). All collections were taken from plants growing along the verge of the Bednesti Lake South Road, Bednesti Lake, British Columbia (53°50'54"N, 123°21'32"W), 50 km west of Prince George. Stem collections were made at between 0°C and 4°C. From each plant, I harvested between 1 and 10 stems containing willow roses, for a total of 79 stems. I collected only stems that contained a shoot with a gall and a shoot

of similar length and basal diameter originating from the same stem without a gall; shorter or longer shoots on the same stem were removed (Figure 1). In this way, each stem that was presented to a Moose provided a choice of two shoots—one with a gall and one without a gall.

A small mark was placed at the base of each shoot that contained a gall so that each shoot containing a gall could be identified after the feeding trials. Stems were packaged in plastic bags and transported in an unheated car roof rack carrier at ambient outdoor temperatures (−10°C to 7°C) to the feeding site.

### Feeding trials

Feeding trials were conducted at the Northern Lights Wildlife Shelter run by the Northern Lights Wildlife Society in Smithers, B.C. (54°50'N, 127°04'W), approximately 4 hours west of the collection site by car. On 17 February 2007, stems containing shoots with and without willow roses were presented one at a time by six students from the University of Northern British Columbia to five Moose habituated to people. The Moose ranged in age from 9 to 33 months (Figure 2).

Moose were allowed to smell and test the stems before biting them. Once a bite was made, the stem was retracted from the reach of the Moose momentarily so





FIGURE 2. When Moose browsed shoots, they mouthed the shoot until they appeared to find the desired bite diameter, then they cropped the shoot from the stem. Shoots were then manipulated in their mouths until the tips were either consumed (tips without willow rose galls) or dropped (tips with willow rose galls).

that a determination could be made as to which shoot (the one with the gall or the one without the gall) had been selected first and at what diameter the shoot had been browsed. Stems were bagged following the offering and another set of shoots was presented to the Moose. The feeding trial took approximately 60 minutes.

#### Analysis

Analysis of variance (ANOVA) was used to test differences in attributes of shoots with and without willow roses, both before and after browsing by Moose. I used a Z-test to test the statistical significance in the order of consumption by Moose of galled and ungalled shoots (Zar 1984).

#### Results

The formation of galls on shoot tips presumably truncated the lengthwise extension of the shoots during summer growth. Selecting shoots of similar morphometry (i.e., basal shoot diameter and taper) for the experiment therefore resulted in the shoots that contained galls being significantly shorter than those without galls (ANOVA) (Table 1). Despite these initial differences in shoot length, Moose cropped shoots at similar diameters, leaving similar post-bite shoot lengths (Table 1). With the exception of three shoots that contained galls and seven shoots with normal tips, Moose cropped both shoots on all stem pairs (the shoot with and the shoot without a willow rose) presented in the feeding trials.

TABLE 1. Differences in the mean physical characteristics (with standard error) of gall-bearing and non-gall-bearing shoots of Scouler's Willow (*Salix scouleriana*) before and after being bitten by Moose (*Alces alces*). Note: Shoot tip first bitten does not equal 100% because some shoots remained unbitten, or both shoots in a pair were bitten at the same time.

Characteristics	Shoot tip type				P of ANOVA
	with willow rose galls		without willow rose galls		
	%	Mean	%	Mean	
Pre-Bite shoot length (mm)	–	31.49 ± 1.55	–	44.99 ± 1.54	<0.001
Post-Bite length (mm)	–	14.82 ± 1.26	–	15.32 ± 1.40	0.889
Bite diameter (mm)	–	3.79 ± 0.11	–	3.66 ± 0.12	0.796
Shoot tip first bitten	51.6	–	41.8	–	–

Twigs containing willow roses were selected first by Moose 51.6% of the time, and twigs without willow roses were selected first 41.8% of the time; the remainder remained unbitten or were bitten simultaneously (Table 1). Of the 79 stems that contained galls with which we experimented, 60 galls were not consumed by Moose and were recovered from the ground after the feeding trial. One or two galls appeared to have been sampled by each Moose, but most galls were rejected and dropped to the ground. Moose consumed significantly more ( $\hat{p} = 0.434$ ,  $Z = -8.738$ ,  $P \leq 0.001$ ) of the shoots with normal tips, with only 2 partial tips of the normal shoots being located on the ground after the feeding trials (compared to 60 shoot tips with galls). All shoot materials were easily detected atop the compacted, snow-covered feeding grounds. The average bite diameter on the shoot attached to the underside of the willow rose where the Moose had cropped off and spit out the willow rose while chewing the shoot, was 3.26 mm (SD 1.18). The average diameter of willow roses (measured at the widest part of the rose) was 34.106 mm (SD 11.054).

## Discussion

Browsing by Moose and Reindeer (*Rangifer tarandus*) is known to affect the activity of galling insects (Danell and Huss-Danell 1985; Olofsson and Strebom 2000; den Herder et al. 2004). Insect activity is generally greater on those plants that have previously been browsed by Moose (Roininen et al. 1997). Galling aphids respond similarly to browsing of some plant species by cattle (Martinez and Wool 2003). However, the way in which gall-forming insects influence Moose browsing directly through gall formation on browse plants appears, until now, to have gone unreported. Here, Moose clearly selected against shoots that contained galls during winter—a finding counter to my original hypothesis of Moose in winter seeking out larger, leafier bites while browsing.

My pre-feeding data indicate that winter shoots containing willow roses are shorter on average than those shoots without galls. This was expected and is an artifact of gall formation (Nyman et al. 2011; Samsone et al. 2011) which allows the shoot to continue to develop in girth and taper (those characters I sought to enable by pairing shoots on main stems), but not in length. Despite these initial differences, Moose cropped both types of shoots so that the remaining lengths of shoots and the associated bite diameters showed no significant differences between shoots with and without galls. This was accomplished by Moose cropping each bite well below the shoot tip at an average diameter of 3.7 mm, removing the shoot from the stem, and then consuming the shoot from the more proximal to the more distal portion of the shoot through oral manipulation. Upon reaching the end of the shoot, Moose would consume

(in the case of the ungalled tips) or spit out (in the case of shoots that contained galls) the shoot tip.

Unlike Iberian Wild Goats (*Capra pyrenaica*) of Spain's high Sierra Mountains that eat flower buds of the high Mediterranean shrub *Hormathophylla spinosa* with or without spheroid chalcid wasp galls (Zamora and J. M. Gómez 1993), Moose showed a clear and unexpected preference for willow shoots that did not contain rosette galls. During the trial, it appeared as if each Moose sampled one or two galls before systematically rejecting them in subsequent feeding bouts. This outcome suggests that leaves of willow roses are likely of a different quality than fallen leaves, which Renecker and Hudson (1985) reported comprised an important part of the early winter diet of Moose.

The differences in palatability of willow roses on the one hand and fall and winter leaves and leaf litter on the other, may be attributable to the differences in the morphology of normal willow leaves and willow roses. Chemical differences in shoots with and without galls may also explain differences in palatability. Galls produced by some insects contain 10 times the amount of tannins found in surrounding or gall-free tissues (Cornell 1983). An increase in oxidative enzyme activity was recently found to be present in rosette gall tissues, leading Samsone et al. (2011) to suggest such increases offer protection to larvae within the gall against generalist herbivores. The chemical constituents, if any, that may have led Moose to reject galls, however, remain undetermined.

In the years since the feeding trials, I have noticed freshly cropped willow roses on top of the snow twice in areas where Moose had been recently feeding, again suggesting that Moose have some aversion to these galls. Clearly, further research into whether rejection of such tissues by Moose is based on morphological or chemical characteristics of willow roses is required and may eventually help to explain that, for Moose, bigger mouthfuls are not always necessarily better.

## Acknowledgements

I thank my wife, Michelle, for sitting with me for hours at the kitchen table measuring twig morphometrics and students of the University of Northern British Columbia Fish and Wildlife Student Chapter of the Wildlife Society for helping present the twigs to Moose. I am indebted to Peter and Angelika Langen of the Northern Lights Wildlife Society in Smithers, B.C., for allowing me to work so closely with the Moose that they have bottle-raised and cared for over the years. I appreciate contributions from Jeff Joy and Raymond Gagné for help in classifying willow rose galls and the helpful comments of two anonymous reviewers, who helped make improvements to an earlier version of this manuscript.

## Literature Cited

- Bergerud, A. T., and F. Manuel.** 1968. Moose damage to balsam fir-white birch forests in central Newfoundland. *Journal of Wildlife Management* 32: 729–746.
- Cornell, H. V.** 1983. The secondary chemistry and complex morphology of galls formed by the Cynipinae (Hymenoptera): why and how? *American Midland Naturalist* 110: 225–234.
- Danell, K., and K. Huss-Danell.** 1985. Feeding by insects and hares on birches earlier affected by moose browsing. *Oikos* 44: 75–81.
- Darlington, A.** 1975. *The Pocket Encyclopaedia of Plant Galls*. Blandford Press, Dorset.
- Den Herder, M., R. Virtanen, and H. Roininen.** 2004. Effects of reindeer browsing on tundra willow and its associated insect herbivores. *Journal of Applied Ecology* 41: 870–879.
- Martinez, J.-J. Y., and D. Wool.** 2003. Differential response of trees and shrubs to browsing and pruning: the effects on pistacia growth and gall-inducing aphids. *Plant Ecology* 169: 285–294.
- Nakamura, M., Y. Miyamoto, and T. Ohgushi.** 2003. Gall initiation enhances the availability of food resources for herbivorous insects. *Functional Ecology* 17: 851–857.
- Nyman, T., R. Paajanen, S. Heiska, and R. Julkunen-Titto.** 2011. Preference–performance relationship in the gall midge *Rabdophaga rosaria*: insights from a common-garden experiment with nine willow clones. *Ecological Entomology* 36: 200–211.
- Olofsson, J., and J. Strengbom.** 2000. Response of galling invertebrates on *Salix lanata* to reindeer herbivory. *Oikos* 91: 493–498.
- Rea, R.V., and M.P. Gillingham.** 2001. The impact of the timing of brush management on the nutritional value of woody browse for moose *Alces alces*. *Journal of Applied Ecology* 38: 710–719.
- Reinecker, L. A., and R. J. Hudson.** 1985. Estimation of dry matter intake of free-ranging moose. *Journal of Wildlife Management* 49: 785–792.
- Reinecker, L. A., and R. J. Hudson.** 1988. Seasonal quality of forages used by moose in the aspen-dominated boreal forest, central Alberta. *Holarctic Ecology* 11: 111–118.
- Reinecker, L. A., and C. C. Schwartz.** 1998. Food habits and feeding behavior. Pages 403–440 *in Ecology and Management of the North American Moose*. Edited by A. W. Franzmann and C. S. Schwartz. Smithsonian Institution Press, Washington, D.C.
- Roininen, H., P. W. Price, and J. P. Bryant.** 1997. Response of galling insects to natural browsing by mammals in Alaska. *Oikos* 80: 481–486.
- Samsone, I., U. Andersone, and G. Ievinsh.** 2011. Gall midge *Rabdophaga rosaria*-induced rosette galls on *Salix*: morphology, photochemistry of photosynthesis and defense enzyme activity. *Environmental and Experimental Biology* 9: 29–36.
- Stubbs, F. B.** 1986. *Provisional Keys to British Plant Galls*. British Plant Gall Society. 96 pages.
- Zamora, R., and J. M. Gómez.** 1993. Vertebrate herbivores as predators of insect herbivores: an asymmetrical interaction mediated by size differences. *Oikos* 66: 223–228.
- Zar, J. H.** 1984. *Biostatistical analysis*. Second edition. Prentice Hall Inc., Englewood Cliffs, New Jersey.

Received 14 December 2011

Accepted 18 September 2012

# Proximity to Hibernacula and Road Type Influence Potential Road Mortality of Snakes in Southwestern Saskatchewan

ASHLEY N. FORTNEY<sup>1</sup>, RAY G. POULIN<sup>1,2</sup>, JESSICA A. MARTINO<sup>1</sup>, DENNILYN L. PARKER<sup>3</sup> and CHRISTOPHER M. SOMERS<sup>1,4</sup>

<sup>1</sup>Department of Biology, University of Regina, Regina, Saskatchewan S4S 0A2 Canada

<sup>2</sup>Royal Saskatchewan Museum, Regina, Saskatchewan S4P 2V7 Canada

<sup>3</sup>Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Saskatchewan S7N 5B4 Canada

<sup>4</sup>Corresponding author; email: chris.somers@uregina.ca

Fortney, Ashley N., Ray G. Poulin, Jessica A. Martino, Dennilyn L. Parker, and Christopher M. Somers. 2012. Proximity to hibernacula and road type influence potential road mortality of snakes in southwestern Saskatchewan. *Canadian Field-Naturalist* 126(3): 194–203.

The behaviour of snakes makes them vulnerable to road mortality, which may have conservation implications for some species. We examined factors affecting road mortality of snakes around Grasslands National Park of Canada (GNP), Saskatchewan, an area inhabited by a unique snake community within Canada, including the threatened Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*). Systematic surveys ( $n = 45$ ) of roads in the Grasslands National Park area in 2009 yielded 36 dead and 18 live snakes. Multivariate modelling revealed that proximity to hibernacula was positively correlated with presence of snakes on roads. Paved roads had disproportionately higher numbers of snake mortalities, suggesting that traffic patterns are a bigger risk factor than road use per se. Some radio-tracked Eastern Yellow-bellied Racers (2 of 17; 12%) and Bullsnares (*Pituophis catenifer sayi*) (4 of 5; 80%) captured at emergence from hibernacula had road areas in their home ranges. These individuals equipped with radio-transmitters used roads and immediately adjacent areas significantly more than expected, based on their availability, suggesting possible selection for roads. Strategies to reduce road mortality of snakes should focus on key stretches of roads, such as those near winter hibernacula or riparian zones. The placement of paved roads in sensitive areas like those in and around Grasslands National Park should be carefully considered to minimize snake mortality.

Key Words: Eastern Yellow-bellied Racer, *Coluber constrictor flaviventris*, Bullsnares, *Pituophis catenifer sayi*, Grasslands National Park of Canada, snake, road, mortality, habitat, Saskatchewan.

Roads can cause major changes to ecosystems and can have significant negative consequences for wildlife and biodiversity (Spellerberg 1998; Alexander and Waters 2000; Coffin 2007). Roads fragment habitat by presenting barriers to animal dispersal and cause spatial isolation of breeding groups (Ashley and Robinson 1996; Boarman et al. 1997; Epps et al. 2005; Row et al. 2007). In addition to landscape effects, roads can cause direct mortality of individuals via vehicle–animal collisions. For some taxa (e.g., deer, *Odocoileus* spp.), road mortality is fairly well understood and prevention measures are being tested and implemented (Foster and Humphrey 1995; Sullivan and Messmer 2003; Olsson and Widen 2008; Valitzski et al. 2009). However, for many taxa, broad knowledge of factors associated with road use and the consequences of road mortalities is lacking. Declines in reptile (class Reptilia) populations are occurring globally (Gibbons et al. 2000) and road mortality is a contributor for many species, yet our knowledge of the interactions of reptiles with roads lags behind that for other groups.

The ecology and behaviour of snakes (order Squamata) make them particularly vulnerable to road mortality (Andrews and Gibbons 2005). The heat-retaining properties of road surfaces may facilitate thermoregulation in snakes, causing them to bask in high-risk areas (Pienaar 1968; Ashley and Robinson 1996; Andrews

et al. 2008; Shepard et al. 2008). Snakes are slow-moving relative to other vertebrates (Rosen and Lowe 1994), and cold snakes that seek roads to facilitate warming may be slow to escape approaching vehicles. Compounding this problem, many snake species use crypsis rather than flight as a defence mechanism. This means that they remain motionless on the road rather than moving away from an approaching vehicle (Andrews and Gibbons 2005). Snakes also have very long bodies, which present a relatively large target to be hit by vehicle tires. Widespread dislike of snakes by humans also increases the risk of snake mortality on roads because some drivers deliberately run over snakes with vehicles (Langley et al. 1989; Seburn and Seburn 2000; Jochimsen 2006; Ashley et al. 2007).

Snakes have a record of being neglected in management and conservation programs. Historically, reptiles have been one of the most under-represented taxonomic groups in major ecological journals and have received the lowest amount of funding by granting agencies (Gibbons 1988). Currently, 90% of the reptilian species examined by COSEWIC have been classified as at risk, which is 20% higher than other vertebrate groups (COSEWIC 2012\*). Although research on snakes has more recently been on the rise (Shine and Bonnet 2000), information to aid in their management and conservation is still largely lacking.

Roads contribute significantly to mortality of snakes (Bonnet et al. 1999) and can greatly increase the probability of local extinction (Row et al. 2007). Populations of some snake species have declined or been extirpated in North America because of road mortality (Rosen and Lowe 1994; Rudolph et al. 1999; Row et al. 2007). For example, the abundance of larger snakes was reduced by more than 50% within 450 m of both a state highway (high traffic volume) and forest service system and county roads (lower traffic volume) in the Angelina National Forest in eastern Texas (Rudolph et al. 1999). Road mortality may be a significant threat to some Canadian snake populations, and data on road mortality are needed to facilitate conservation strategies.

The Grasslands National Park of Canada (GNP) area of southwestern Saskatchewan has a unique snake community within Canada. Six snake species occur there: Plains Gartersnake (*Thamnophis radix*), Wandering Gartersnake (*Thamnophis elegans vagrans*), Bullsnake (*Pituophis catenifer sayi*), Prairie Rattlesnake (*Crotalus viridis*), Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*), and Western Hog-nosed Snake (*Heterodon nasicus*).

At the time of this study, the Grasslands National Park area was one of only two locations in the country with a confirmed population of the Eastern Yellow-bellied Racer (Gardiner et al. 2011), which is designated threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC 2004\*) and under the federal Species at Risk Act. The Eastern Yellow-bellied Racer met the criteria to be considered for a designation of endangered, but was designated threatened because a large part of its habitat is in Grasslands National Park and there is rescue potential from Montana (COSEWIC 2004\*). The Bullsnake is listed as data deficient by COSEWIC (COSEWIC 2002\*), and the two gartersnake species, the Western Hog-nosed Snake, and the Prairie Rattlesnake have not been assessed by COSEWIC.

The development of a federal recovery strategy for the Eastern Yellow-bellied Racer requires the assessment of conservation threats, but no road mortality data for snakes in the Grasslands National Park area are currently available. Snakes, including Eastern Yellow-bellied Racers, have been found dead on the roads in and around Grasslands National Park in the past, but the environmental factors contributing to the risk of mortality on roads have not been determined. Accordingly, in this study we used road surveys and radiotelemetry to examine factors that could have an impact on potential road mortality of snakes in southwestern Saskatchewan.

## Study Area and Methods

### Study site

This study was conducted near the town of Val Marie, Saskatchewan (49°14'N, 107°43'W), and in the

west block of Grasslands National Park (Figure 1). The major landscape feature of the area is the Frenchman River valley, which contains most of the known communal snake hibernacula (also referred to as dens). Two paved highways (two-lane, speed limit 100 km/h) and several gravel roads (speed limit 80 km/h) and trails (vehicle speeds ~50 km/h) pass through the study area. The town of Val Marie has a population of less than 150, the nearest city (Swift Current, population ~15 000) is 120 km away, and Grasslands National Park receives only approximately 6000 visitors per year; thus, traffic volumes are relatively light. However, wildlife mortality on roads is still common in the area.

### Road surveys

We conducted 45 road surveys in the study area between 6 May and 21 August 2009. Roads were chosen to cover a large area inside and outside Grasslands National Park. We surveyed three road types: paved surface, gravel surface, and trails (tracks through the grass with no surface material added). Roads were surveyed between 0600 and 1800 every two or three days. The total length of the survey route was 132 km, consisting of 25 km of paved roads (19%), 91 km of gravel roads (69%), and 16 km of trails (12%) (Figure 1).

We drove the complete route at speeds that enabled the complete road surface ahead of the vehicle to be scanned easily (60–80 km/h on the paved highways, 50–70 km/h on gravel roads, and 30–50 km/h on the trails). For all surveys, we drove at the low end of the speed range indicated unless required to speed up because of traffic. The driver was always accompanied by a second observer to improve snake detection.

When a snake was encountered, we recorded the road type and the snake's condition (dead or alive), and we noted its location using a hand-held global positioning system (GPS) (model eTrex Legend, Garmin Ltd., Olathe, Kansas). All dead snakes were collected and donated to the Royal Saskatchewan Museum in Regina, Sask.

### Impact of habitat on presence of snakes

For road survey data, we employed a used versus available design to examine habitat variables that might influence snake presence/absence on roads. We designated the locations of snakes found on roads as used sites, and for comparison we generated an equal number of random available sites on the surveyed roads using a Geographical Information System (ArcGIS v. 9.2) (ESRI 2006\*).

We calculated the distance in ArcGIS from each site that was used by snakes and from each available site to the nearest known communal snake hibernaculum and to the Frenchman River. Using the Southern Digital Land Cover dataset of the Saskatchewan Research Council (Saskatchewan Research Council 1995\*), we also determined the proportion of water, exposed ground, urban area (including farm yards),

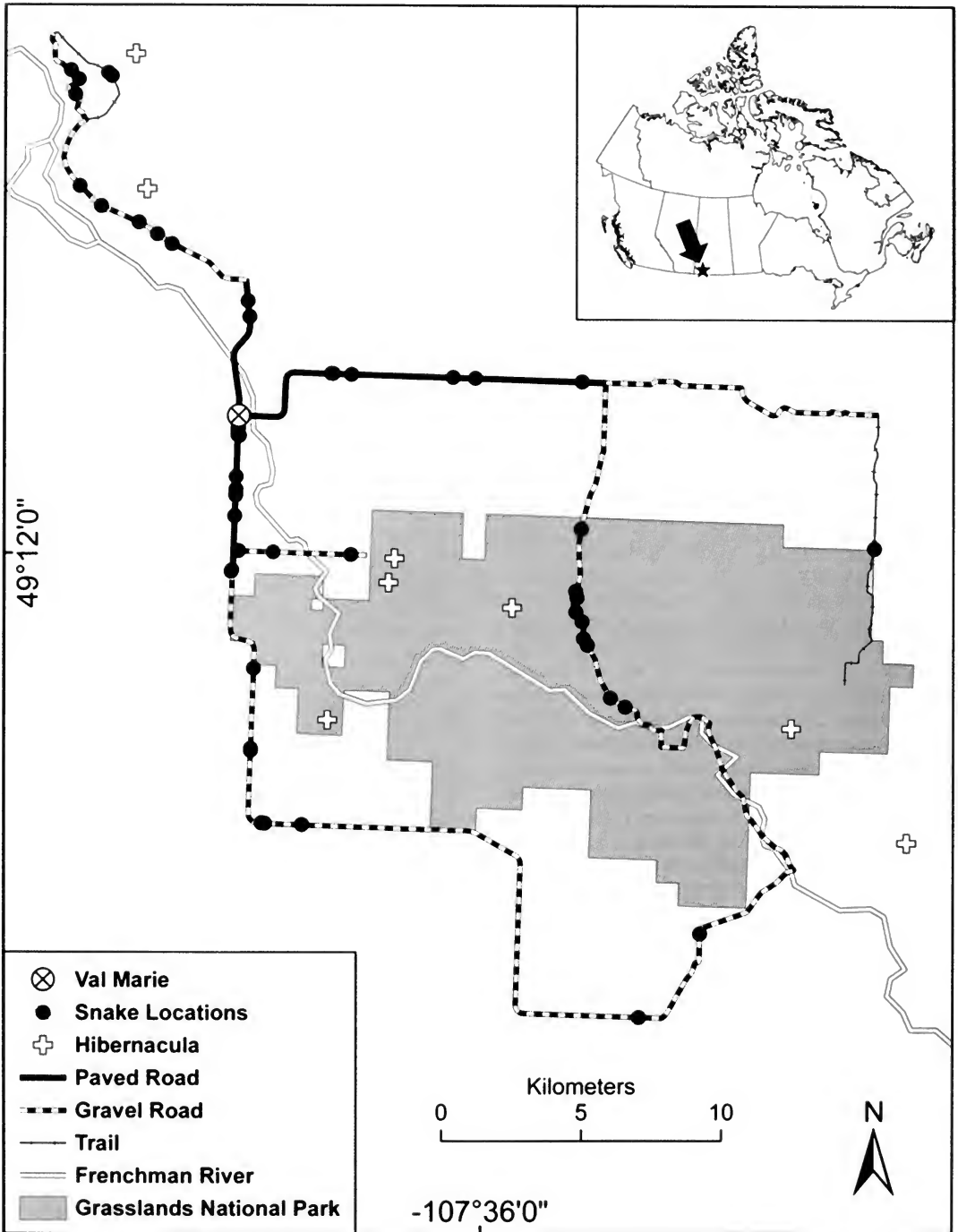


FIGURE 1. Study site surrounding Val Marie, Saskatchewan (49°14'N, 107°43'W).

shrubs, wetland, native grass, crop, hay, and woodland (i.e., habitat types) present within a 1-km radius of the sites that were used by snakes and the available sites. The 1-km radius, a common size in ecological studies, was chosen after initial univariate analyses of habitat variables indicated that a smaller radius (400 m) produced weaker relationships between snake use of roads and data variables (data not shown).

To determine the relationship between habitat and snake presence/absence, we analyzed road survey data using logistic regression to ascertain the  $-2$  log likelihood ( $-2LL$ ) for individual habitat variables. We also analyzed all possible variable combinations, with the exception of percentage cover of water, woodlands, and wetlands. The latter three variables were removed from analyses because in all cases the mean percentages for available locations and locations used by snakes were 0.0 (SD 0.0) and univariate analysis showed these variables were not good indicators of snake presence on roads. We also ascertained the  $-2LL$  for the intercept-only model, which represents no impact of habitat on sites used by snakes (i.e., random).

We converted the  $-2LL$ s to Akaike's Information Criterion with a second-order correction for small samples ( $AIC_c$ ) (Hurvich and Tsai 1989). We ranked models according to  $AIC_c$  values to determine which variables best explained differences between sites used by snakes and available sites.

#### *Road use versus mortality*

We tested for differences in snake use of roads and mortality between road types (paved, gravel, and trail) using a  $\chi^2$  contingency table analysis. We analyzed all snake locations, as well as locations of dead and live snakes separately, to determine whether snakes used road types proportionally based on availability and to determine whether there was a difference in mortality of snakes among road types. Specifically, of the total number of snakes found on roads, we expected to find 19% on paved, 69% on gravel, and 12% on trails, based on the proportion of each road type available. We also expected to find that dead and live snakes would be represented equally among road types if road type had no impact on snake mortality.

#### *Use of roads by individual snakes*

We used radio-telemetry to examine road use by Bullsnares and Eastern Yellow-bellied Racers in the Grasslands National Park area. We captured 17 Eastern Yellow-bellied Racers and 3 Bullsnares in the immediate vicinity of three known hibernacula, all of which are located at least 1 km from the nearest road. Two additional Bullsnares that were known to overwinter in a den well removed from roads were captured slightly later in the season in a pasture area <500 m from a gravel road.

All snakes were transported to the Western College of Veterinary Medicine at the University of Saskatchewan in Saskatoon, Saskatchewan, for surgical implan-

tation of radio-transmitters (model SB-2, 4–5 g, Holohil Systems Ltd., Carp, Ontario.). For both species, transmitters were implanted only when the transmitter was  $\leq 5\%$  of snake body mass. We followed the surgical procedures outlined by Reinert and Cundall (1982), with the following modifications: 10–15 minutes prior to inducing anaesthesia, snakes were given an intramuscular injection of buprenorphine at a dose of 0.01 mg/kg and snakes were also given an intramuscular injection of Meloxicam at a dose of 0.2 mg/kg as a post-operative analgesic.

We released snakes at their original point of capture and relocated them (receiver model R1000, Communication Specialists Inc., Orange, Calif.) approximately every two days between 17 May and 21 September 2009. When a snake was relocated, we recorded its location and the distance to the nearest road as greater than or less than 50 m. Snakes within 50 m of a road were considered to be using the road area, because this distance is less than the average daily movement for these snakes, as determined by Martino et al. (2012).

For radio-telemetry data, we also employed a used versus available design. We first identified snakes whose home ranges, determined based on 100% minimum convex polygons (MCP), contained roads. We then used ArcGIS to calculate the proportion of road area (road area = road + 50-m buffer) within the home range, and we compared the proportion of time (days) spent by snakes within road areas to the total time tracked. A radio-tracked snake was considered to be in one location for the day that it was radio-tracked plus half the number of days between its previous and subsequent locations.

The percentage of days each individual snake spent in a road area was compared with the percentage of road area in its home range using a Wilcoxon signed-rank test. If there was no correlation between roads and habitat use by snakes, the proportion of time spent in road areas would be equal to the proportion of the home range composed of road areas. We also performed this analysis on relocations directly by comparing the proportion of relocation points that were in road areas and the proportion of road in the home range.

## Results

### *Road surveys*

During 45 road surveys spanning the period 6 May to 21 August 2009 (a total distance surveyed of 5940 km of road surface), we found 54 snakes (36 dead and 18 live) (Table 1). The majority of snakes detected on roads were Prairie Rattlesnakes (43%) and Plains Gartersnakes (37%), followed by Bullsnares (13%) and Eastern Yellow-bellied Racers (7%).

### *Impact of habitat on presence of snakes*

The three top models that explained the difference between snake presence/absence on roads were (1) Distance to den + Road type + Percentage hay; (2) Distance to den + Road type; and (3) Distance to den +

Road type + Distance to river (Table 2). On average, sites used by snakes were 1.4 km (SD 4.1) closer to dens (Figure 2A) and 2.6 km (SD 5.0) closer to the Frenchman River (Figure 2B) than random available sites. The use of gravel roads and trails was lower than the availability of these road types, and the use of paved roads was higher than the availability of such roads (see below).

The habitat variables Distance to den and Road type appeared in all three top models. This finding suggests that proximity to a hibernaculum and the kind of road (paved, gravel, or trail) are good predictors of potential road mortality of snakes. The amount of hay surrounding sites where snakes were present also appeared in the top model. The 1-km buffer surrounding sites used by snakes had double the amount of hay of random available points (Figure 2C).

#### Road use versus mortality

Multivariate modelling revealed that the percentage availability was different from the percentage use for each road type. Specifically, the number of used sites on gravel roads ( $n = 29$ ) was 26% lower than the number of random available sites for such roads ( $n = 39$ ). As well, the number of used sites on trails ( $n = 3$ ) was 50% lower than the number of random available sites on trails ( $n = 6$ ). In contrast, the number of used sites on paved roads ( $n = 22$ ) was 244% higher than the number of random available sites on paved roads ( $n = 9$ ).

To better discern the importance of road type, we also performed a  $\chi^2$  analysis; this univariate analysis revealed that the locations of random available sites were not significantly different from expected, based on

the proportions of road types surveyed ( $\chi^2 = 0.287$ ,  $df = 2$ ,  $P = 0.9$ ). However, the total number of snakes found on paved roads, gravel roads, and trails was significantly different from expected, based on the proportions of road types surveyed (Table 1) ( $\chi^2 = 16.8$ ,  $df = 2$ ,  $P = 0.0002$ ), and more snakes were located on paved roads than expected.

The number of live snakes found on each road type was not different from expected (Figure 3A) ( $\chi^2 = 0.726$ ,  $df = 2$ ,  $P = 0.7$ ), but the number of dead snakes was significantly different from expected, based on available roads (Figure 3B) ( $\chi^2 = 22.2$ ,  $df = 2$ ,  $P < 0.0001$ ). More than twice as many dead snakes were found on paved roads than expected (50% of all detected), based on the proportion of this road type (19%) in the survey area.

#### Use of roads by individual snakes

Roads ran through the home ranges of 2 of 17 (12%) radio-tracked Eastern Yellow-bellied Racers and 4 of 5 (80%) radio-tracked Bullsnares. All snakes whose home ranges included road areas were found in road areas (on or within 50 m of the road) at least once during radio-tracking, with the exception of one Bullsnares. This individual had a road in its home range but was not located in the road area during radio-tracking.

In addition, all snakes whose home ranges included roads were located on both sides of the road during our study, with the exception of one Eastern Yellow-bellied Racer, confirming that they must have crossed the road. The Eastern Yellow-bellied Racer had a road in its home range and was located in the road area, but it was never located on the opposite side of the road during radio-

TABLE 1. Number of each snake species found dead or alive on the three road types near Val Marie, Saskatchewan.

Species	Number of snakes found dead on:				Number of snakes found alive on:				Total
	paved	gravel	trail	Subtotal	paved	gravel	trail	Subtotal	
<i>Crotalus viridis</i>	6	5	0	11	3	9	0	12	23
<i>Thamnophis radix</i>	6	8	2	16	1	2	1	4	20
<i>Pituophis catenifer sayi</i>	4	1	0	5	0	2	0	2	7
<i>Coluber constrictor flaviventris</i>	2	2	0	4	0	0	0	0	4
Total	18	16	2	36	4	13	1	18	54

TABLE 2. Top three models identifying variables that best explain the difference between all locations where snakes were found (both dead and alive) and available locations on roads near Val Marie, Saskatchewan. All models explained the data set better than random when tested against the intercept-only model.

Model	K <sup>†</sup>	-2LL	$\Delta AIC_c$	Weight <sup>‡</sup>	Evidence ratio <sup>§</sup>
*Distance to den + Road type + Percentage hay	5	127	0.00	0.45	1.00
Distance to den + Road type	4	130	0.91	0.29	1.58
Distance to den + Road type + Distance to river	5	128	1.12	0.26	1.75
Intercept-only	1	150	14.3	<0.01	1270.00

\*Top model

† Number of parameters in each model

‡ Indicates the level of support for each model when compared with the top model and its competitors.

§ Indicates the magnitude at which the top model is better at explaining the data than the model indicated.



tracking. The mean percentage of time that radio-tracked snakes spent in road areas (32%, SD 25; range 0–65%) was on average more than three times higher than expected, based on the proportion of home ranges made up of roads (9%, SD 5; range 4–16% of the home range area).

Snake use of road areas within home ranges was similar when the proportion of relocation points in road areas was used in the analysis instead of time (data not shown). On average, radio-tracked Eastern Yellow-bellied Racers spent 18% (SD 2) of the time in road areas even though roads made up only 5% (SD 1) of their home ranges, and radio-tracked Bullsnares spent 39% (SD 25) of the time near roads despite the fact that roads constituted only 12% (SD 4) of their home ranges. The use of roads by snakes whose home ranges included roads was significantly higher than the percentage of area made up by the road (Wilcoxon signed-rank test,  $W = 19$ ,  $n = 6$ ,  $P < 0.05$ ).

## Discussion

Our study indicates that proximity of roads to winter hibernacula is a key factor in the potential road mortality of snakes in the study area. Distance to den and Road type were the only habitat variables that were consistently present in top models, indicating that these variables best explain the difference between locations where snakes were present on roads and random available sites. This same result was found in a road mortality study of some ecologically similar snake species (*Crotalus oreganus*, *Pituophis catenifer*, *Thamnophis elegans*, and *Coluber taeniatus*) in Idaho (Jochimsen 2006).

Snakes often show high fidelity to hibernacula in temperate-zone areas (Brown and Parker 1976), so they are not likely to travel long distances from hibernaculum sites. Instead, most snakes will travel away from, or towards, the same den within the active season. Shepard et al. (2008) found that colubrid snakes experience higher numbers of road kills during seasonal periods that coincide with migration to and from hibernacula. The importance of winter hibernacula results in a higher concentration of snakes in the area surrounding a hibernaculum, and it explains the increased presence of snakes on roads closer to hibernacula than on roads farther away.

A second habitat variable that was potentially important was distance to the Frenchman River. The river valley contains all known snake hibernacula in the study area, so the Distance to river measurement may simply be a proxy for Distance to den. Alternatively, lowlands and riparian zones are important summer habitats for foraging and breeding Eastern Yellow-bellied Racers and Bullsnares in the study area (Martino et al. 2012), and this may result in higher snake numbers on roads near these habitats.

Conservation activities aimed at mitigating road mortality of snakes, such as road signs to alert drivers, could

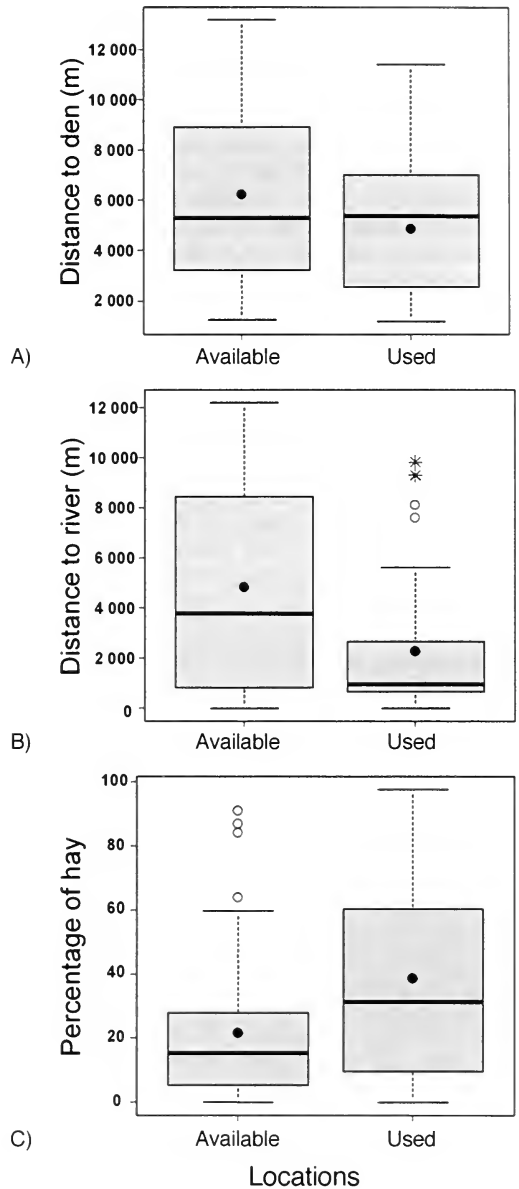


FIGURE 2. Box plots showing the distribution of values for habitat variables at all locations used by snakes (both dead and alive) and random available locations: A) Distance to den from random and all snake locations; B) Distance to river from random and all snake locations; C) Percentage of hay in a 1-km radius surrounding random and all snake locations. Horizontal lines on the box plots represent the minimum value; the 25th, 50th (median), and 75th percentiles; and the maximum value. Filled circles represent the mean. Open circles represent minor outliers, which are observations 1.5 times the interquartile range (IQR) outside the central box, and asterisks represent major outliers, which are observations 3 times the interquartile range.

be effectively focused on key stretches of roads near hibernacula and other important habitats (Shepard et al. 2008), such as riparian zones. Additionally, new roads in sensitive areas (e.g., for oil and gas development) (Walker et al. 2007) should be placed as far away as possible from riparian zones and known snake dens.

The composition of roadside habitats did not seem to have a major impact on snake presence on roads. With the exception of Percentage of hay, the variables related to vegetation that we measured were not useful predictors of potential snake mortality. The percentage of native grass did not explain differences between sites used by snakes and available sites. This finding was somewhat surprising, given that native prairie habitat is abundant close to den sites and in the Frenchman River valley (variables in the top models). Percentage of hay had a measurable influence only when it was included in a model with Distance to den and Road type.

We suggest three possible reasons for the inclusion of hay as a predictor variable in the top model only: (1) higher percentages of hay adjacent to roads may increase traffic volume associated with agricultural activities, thereby contributing to additional road mortality where snakes are already at elevated risk (on paved roads near hibernacula); (2) hay may have a biological value to snakes, such as increased availability of prey or access to refugia; or (3) Percentage of hay was not a truly informative predictor, but was included in the top model as a result of low penalties for additional variables that do not detract from the AIC model (Arnold 2010). We are unable to distinguish among these possibilities with our current data set, and suggest further inquiry into the potential ecological value of hay to snakes.

In our study, more road-killed snakes than expected were found on paved highways than on gravel roads or trails. Two potential explanations exist for this finding: (1) snakes are attracted to paved roads and use them more often than expected (e.g., for basking, as in Pienaar (1968) and Andrews et al. (2008)), thereby resulting in more vehicle encounters; or (2) snakes use paved roads in proportion to their availability but features of the road type make mortality events more likely.

Our analyses strongly favour the second explanation. We found no evidence that snakes were using any one road type disproportionately, i.e., the number of live snakes found on each type of road was as expected, based on availability of roads in our surveys. This suggests that snakes did not use paved roads more often than other road types; they were simply killed more often on paved surfaces. The most obvious differences between the paved roads and the other types in our study area are higher traffic volumes and higher vehicle speeds, both of which are likely major factors increasing the probability of snakes being killed (Roe et al. 2006).

Similar findings have been reported from road mortality studies in other areas (e.g., Rosen and Lowe

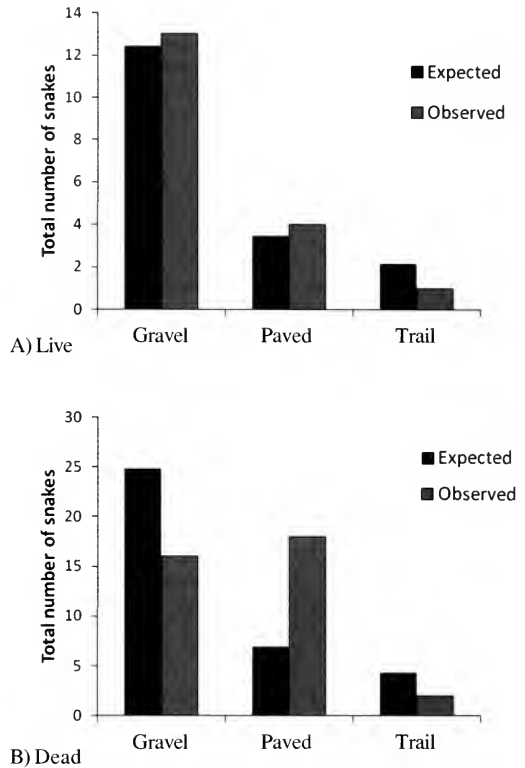


FIGURE 3. The number of snakes observed and expected, based on percentages of road type driven: A) live snakes and B) dead snakes. Dead snakes were found more than expected on paved roads.

1994; Clevenger et al. 2003), and they strongly suggest that paved roads deserve extra attention in conservation plans. For example, careful consideration should be given before gravel roads are upgraded to paved surfaces, and lower speed limits on existing and new paved roads may be required in sensitive areas. This would be beneficial to other taxa as well: a survey of road mortalities of species other than snakes in the study area also showed a greater than expected number of road kills taking place on paved roads than on other road types (Fortney 2010).

We encountered more dead and live Prairie Rattlesnakes than other species on roads. This implies that Prairie Rattlesnakes are more commonly found on roads, rather than that they are simply killed more often. This could be a reflection of a larger local population, or it could indicate that Prairie Rattlesnakes use or encounter roads more frequently than other species.

Differences in spatial use and movement patterns between species affect their risk of road mortality (Bonnet et al. 1999; Roe et al. 2006; Rouse et al. 2011). Venomous snakes may cross roads more slowly than other sympatric snake species because they have less

pressure to cross open spaces quickly (due to their defence mechanism of venom). Venomous snakes may also employ a more defensive stance as a vehicle approaches instead of fleeing (Andrews and Gibbons 2005). Rattlesnakes also use crypsis as a defence mechanism, and this may cause them to immobilize when they are approached by a vehicle.

Bullsnakes and Eastern Yellow-bellied Racers were found least often, despite the fact that our radio-tracking data suggest that both species have a propensity to use road areas. Eastern Yellow-bellied Racers may have been found less frequently because they use speed as a defence mechanism (they cross roads more quickly than other species and thus avoid vehicles) (Andrews and Gibbons 2005); alternatively, Bullsnakes and Eastern Yellow-bellied Racers may use roadside areas more than they use the road itself. The lower numbers found could also be a result of smaller regional populations. Absolute population sizes have not been estimated for snakes in the study area, but our observations suggest that gartersnakes and Prairie Rattlesnakes are much more abundant than the other species.

Although our radio-telemetry sample size is small, our study indicates that roads may have a disproportionately larger impact on snakes than on other wildlife because (at least some) snakes appear to select habitat in road areas. Radio-tracking revealed that, when roads were within the home ranges of Eastern Yellow-bellied Racers or Bullsnakes, the snakes spent a greater amount of time on or near the roads than expected by chance.

Our data do not allow us to examine why snakes select or do not select road areas. However, we offer the following potential explanations: (1) snakes are attracted to roads for use in thermoregulation (e.g., Klauber 1939; Pienaar 1968; Sullivan 1981; Andrews et al. 2008); (2) roadside ditches offer conditions that enhance prey resources (Bellamy et al. 2000; Rytwinski and Fahrig 2007); and (3) some snakes may be unwilling or unable to cross roads and are essentially isolated in adjacent habitats (e.g., Richardson et al. 2006; Rouse et al. 2011). Regardless of the underlying explanation, selection for road areas by snakes likely elevates their risk of road mortality well beyond what would be predicted based on the assumption that they encounter roads randomly based on availability.

Snakes that perceive roads as barriers and move alongside them instead of crossing them (e.g., Prairie Kingsnake, *Lampropeltis calligaster calligaster*) (Richardson et al. 2006) avoid the risk of encountering vehicles but may still be negatively affected by a number of other habitat fragmentation effects associated with roads (e.g., Kjos and Litvaitis 2001). Conservation planning for snakes should therefore include both potential habitat selection for roads as an elevated risk factor for road mortality and the indirect effects of roads (e.g., habitat fragmentation). To provide insight into how road mortality risks to snakes can potentially be

minimized, future studies should address why snakes select habitat near roads.

Our study has three main results of conservation and management relevance: (1) the probability of finding live or dead snakes on a road of any type is determined largely by the proximity of the road to a hibernaculum or to a river; (2) snakes do not show a preference for any one road type, but those that use paved roads are more likely to be killed by a vehicle; and (3) when a snake's home range includes roads, the road area is used more than expected by chance. We recommend further investigation to verify this third result using a larger sample size. We also suggest additional studies that examine long-term, seasonal, and sex-specific trends in road mortality.

The community of grassland snakes in the Grasslands National Park area is unique in Canada, and these results should be employed in conservation strategies to maintain this community. The information may also be useful to mitigate road mortality of snakes in other areas.

### Acknowledgements

We thank the Natural Sciences and Engineering Research Council of Canada, the Canada Research Chairs Program, Grasslands National Park, the Parks Canada Agency, the Royal Saskatchewan Museum, the Friends of the Royal Saskatchewan Museum, the Fish and Wildlife Development Fund of Saskatchewan Environment, the Interdepartmental Recovery Fund of Environment Canada, the Canadian Wildlife Federation, and the Canadian Museum of Nature for financial support. We also thank the University of Regina President's Committee on Animal Care, the Saskatchewan Ministry of the Environment, Environment Canada, the Parks Canada Agency, and Agriculture and Agri-Food Canada for issuing the required approval and permits to conduct this research. We also thank H. Sauder and J. Meaden for assistance with field work.

### Documents Cited (marked \* in text)

- COSEWIC. 2002. COSEWIC assessment and status report on the Gophersnake *Pituophis catenifer* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario. vii + 33 pages.
- COSEWIC. 2004. COSEWIC assessment and update status report on the Eastern and Western Yellow-bellied Racers, *Coluber constrictor flaviventris* and *Coluber constrictor mormon* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario. vii + 35 pages.
- COSEWIC. 2012. Canadian wildlife species at risk. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario. 98 pages.
- ESRI. 2006. ArcGIS 9.2. Environmental Systems Research Institute, Redlands, California.
- Saskatchewan Research Council. 1995. Southern Digital Land Cover (SDLC). Saskatchewan Research Council, Saskatoon, Saskatchewan.

## Literature Cited

- Alexander, S. M., and N. M. Waters. 2000. The effects of highway transportation corridors on wildlife: a case study of Banff National Park. *Transportation Research Part C: Emerging Technologies* 8: 307–320.
- Andrews, K. M., and J. W. Gibbons. 2005. How do highways influence snake movement? Behavioural responses to roads and vehicles. *Copeia* 2005: 772–782.
- Andrews, K. M., J. W. Gibbons, and D. M. Jochimsen. 2008. Ecological effects of roads on amphibians and reptiles: a literature review. Pages 121–143 in *Urban Herpetology*. Edited by J. C. Mitchell, R. E. Brown, and B. Bartohlemew. Herpetological Conservation No. 3. Society for the Study of Amphibians and Reptiles, Salt Lake City, Utah.
- Arnold, T. W. 2010. Uninformative parameters and model selection using Akaike's information criterion. *Journal of Wildlife Management* 74: 1175–1178.
- Ashley, P. E., and J. T. Robinson. 1996. Road mortality of amphibians, reptiles and other wildlife on the Long Point Causeway, Lake Erie, Ontario. *Canadian Field-Naturalist* 110: 403–412.
- Ashley, P. E., A. Kosloski, and S. A. Petrie. 2007. Incidence of intentional vehicle-reptile collisions. *Human Dimensions of Wildlife* 12: 137–143.
- Bellamy, P. E., R. F. Shore, D. Ardeshir, J. R. Treweek, and T. H. Sparks. 2000. Road verges as habitat for small mammals in Britain. *Mammal Review* 30: 131–139.
- Boarman, W. I., M. Sasaki, and W. B. Jennings. 1997. The effect of roads, barrier fences, and culverts on desert tortoise populations in California, USA. Pages 54–58 in *Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles—An International Conference*, 11–16 July 1993, State University of New York at Purchase, New York Turtle and Tortoise Society, New York, and the Wildlife Conservation Society, Bronx, New York.
- Bonnet, X., G. Naulleau, and R. Shine. 1999. The dangers of leaving home: dispersal and mortality in snakes. *Biological Conservation* 89: 39–50.
- Brown, W. S., and W. S. Parker. 1976. Movement ecology of *Coleuber constrictor* near communal hibernacula. *Copeia* 1976: 225–242.
- Clevenger, A. P., B. Chruszcz, and K. E. Gunson. 2003. Spatial patterns and factors influencing small vertebrate fauna road-kill aggregations. *Biological Conservation* 109: 15–26.
- Coffin, A. W. 2007. From roadkill to road ecology: a review of the ecological effects of roads. *Journal of Transport Geography* 15: 396–406.
- Epps, C. W., P. J. Palsboll, J. D. Wehausen, G. K. Roderick, R. R. Ramey II, and D. R. McCullough. 2005. Highways block gene flow and cause a rapid decline in genetic diversity of desert bighorn sheep. *Ecology Letters* 8: 1029–1038.
- Fortney, A. F. 2010. Road mortality survey in southwestern Saskatchewan. *Blue Jay* 68: 95–98.
- Foster, M. L., and S. R. Humphrey. 1995. Use of highway underpasses by Florida panthers and other wildlife. *Wildlife Society Bulletin* 23: 95–100.
- Gardiner L. E., J. A. Martino, R. G. Poulin, and C. M. Somers. 2011. Eastern yellow-bellied racer populations on the Canadian prairies. *Blue Jay* 69: 70–74.
- Gibbons, J. W. 1988. The management of amphibians, reptiles, and small mammals in North America: the need for an environmental attitude adjustment. Pages 4–10 in *Management of Amphibians, Reptiles, and Small Mammals in North America*. Edited by R. C. Szaro, K. E. Severson, and D. R. Patton. USDA Forest Service, Flagstaff, Arizona.
- Gibbons, J. W., D. E. Scott, T. J. Ryan, K. A. Buhlmann, T. D. Tuberville, B. S. Metts, J. L. Greene, T. Mills, Y. Leiden, S. Poppy, and C. T. Winne. 2000. The global decline of reptiles, déjà vu amphibians. *BioScience* 50: 653–666.
- Hurvich, C. M., and C-L. Tsai. 1989. Regression and time series model selection in small samples. *Biometrika* 76: 297–307.
- Jochimsen, D. M. 2006. Factors influencing the road mortality of snakes on the Upper Snake River Plain, Idaho. Pages 351–365 in *Proceedings of the 2005 International Conference on Ecology and Transportation*, August 29–September 2, 2005, San Diego, California. Edited by Leroy Irwin, Paul Garrett, and K. P. McDermott. Center for Transportation and the Environment, North Carolina State University, Raleigh, North Carolina.
- Kjoss, V. A., and J. A. Litvaitis. 2001. Community structure of snakes in a human-dominated landscape. *Biological Conservation* 98: 285–292.
- Klauber, L. M. 1939. Studies of reptile life in the arid Southwest. *Bulletin of the Zoological Society of San Diego* 14: 1–54.
- Langley, W. M., H. W. Lipps, and J. F. Theis. 1989. Responses of Kansas motorists to snake models on a rural highway. *Transactions of the Kansas Academy of Science* 92: 43–48.
- Martino, J. A., R. G. Poulin, D. L. Parker, and C. M. Somers. 2012. Habitat selection by grassland snakes at northern range limits: implications for conservation. *Journal of Wildlife Management* 76: 759–767.
- Olsson, M. P. O., and P. Widen. 2008. Effects of highway fencing and wildlife crossings on moose *Alces alces* movements and space use in southwestern Sweden. *Wildlife Biology* 14: 111–117.
- Pienaar, U. de V. 1968. The ecological significance of roads in a national park. *Koedoe: African Protected Area Conservation and Science* 11: 169–174.
- Reinert, H. K., and D. Cundall. 1982. An improved surgical implantation method for radio-tracking snakes. *Copeia* 1982: 702–705.
- Richardson, M. L., P. J. Weatherhead, and J. D. Brawn. 2006. Habitat use and activity of prairie kingsnakes (*Lampropeltis calligaster calligaster*) in Illinois. *Journal of Herpetology* 40: 423–428.
- Roe, J. H., J. Gibson, and B. A. Kingsbury. 2006. Beyond the wetland border: estimating the impact of roads for two species of water snakes. *Biological Conservation* 130: 161–168.
- Rosen, P. C., and C. H. Lowe. 1994. Highway mortality of snakes in the Sonoran Desert of southern Arizona. *Biological Conservation* 68: 143–148.
- Rouse, J. D., R. J. Willson, R. Black, and R. J. Brooks. 2011. Movement and spatial dispersion of *Sistrurus catenatus* and *Heterodon platirhinos*: implications for interactions with roads. *Copeia* 2011: 443–456.
- Row, J. R., G. Blouin-Demers, and P. J. Weatherhead. 2007. Demographic effects of road mortality in black rat-snakes (*Elaphe obsoleta*). *Biological Conservation* 137: 117–124.
- Rudolph, D. C., S. J. Burgdorf, R. N. Conner, and R. R. Schaefer. 1999. Preliminary evaluation of the impact of

- roads and associated vehicular traffic on snake populations in eastern Texas. Pages 128–135 in *Proceedings of the Third International Conference on Wildlife Ecology and Transportation*, September 13–16, 1999, Missoula, Montana. Edited by Gary L. Evink, Paul Garrett, and David Zeigler. Florida Department of Transportation, Tallahassee, Florida.
- Rytwinski, T., and L. Fahrig.** 2007. Effect of road density on abundance of white-footed mice. *Landscape Ecology* 22: 1501–1512.
- Seburn, D., and C. Seburn.** 2000. Conservation priorities for the amphibians and reptiles of Canada. World Wildlife Fund Canada and the Canadian Amphibian and Reptile Conservation Network. World Wildlife Fund Canada, Toronto, Ontario. 92 pages.
- Shepard, D. B., M. J. Dreslik, B. C. Jellen, and C. A. Phillips.** 2008. Reptile road mortality around an oasis in the Illinois corn desert with emphasis on the endangered eastern massasauga. *Copeia* 2008: 350–359.
- Shine, R., and X. Bonnet.** 2000. Snakes: a new 'model organism' in ecological research? *Trends in Ecology and Evolution* 15: 221–222.
- Spellerberg, I. F.** 1998. Ecological effects of roads and traffic: a literature review. *Global Ecology and Biogeography* 7: 317–333.
- Sullivan, B. K.** 1981. Observed differences in body temperature and associated behaviour of four snake species. *Journal of Herpetology* 15: 245–246.
- Sullivan, T. L., and T. A. Messmer.** 2003. Perceptions of deer-vehicle collision management by state wildlife agency and department of transportation administrators. *Wildlife Society Bulletin* 31: 163–173.
- Valitzki, S. A., G. J. D'Angelo, G. R. Gallagher, D. A. Osborn, K. V. Miller, and R. J. Warren.** 2009. Deer responses to sounds from a vehicle-mounted sound-production system. *Journal of Wildlife Management* 73: 1072–1077.
- Walker, B. L., D. E. Naugle, and K. E. Doherty.** 2007. Greater sage-grouse population response to energy development and habitat loss. *Journal of Wildlife Management* 71: 2644–2654.

Received 27 April 2012

Accepted 11 September 2012

# Early Spawning by the American Brook Lamprey (*Lethenteron appendix*) in Southeastern Minnesota

PHILIP A. COCHRAN<sup>1</sup>, MARK A. ROSS<sup>1</sup>, THOMAS S. WALKER<sup>1</sup>, and TREVOR BIEDERMAN<sup>2</sup>

<sup>1</sup>Biology Department, Saint Mary's University of Minnesota, 700 Terrace Heights, Winona, Minnesota 55987 United States; e-mail: pcochran@smumn.edu

<sup>2</sup>315 West Mills Street, Winona, Minnesota 55987 United States

Cochran, Philip A., Mark A. Ross, Thomas S. Walker, and Trevor Biederman. 2012. Early spawning by the American Brook Lamprey (*Lethenteron appendix*) in southeastern Minnesota. *Canadian Field-Naturalist* 126(3): 204–209.

Record-setting warm temperatures in the upper Midwest during early 2012 resulted in early spawning by the American Brook Lamprey (*Lethenteron appendix*) in southeastern Minnesota. American Brook Lampreys in a total of five streams in three drainages spawned up to one month earlier than typical. Mean day of year of spawning groups observed in 2012 was significantly different from the mean for groups observed during the period 2002–2010, but mean water temperature was not significantly different. Limited historical data are not sufficient to show an effect of climate change on spawning phenology because some data are confounded with the effects of latitude and year-to-year variability in thermal regime.

Key Words: American Brook Lamprey, *Lethenteron appendix*, *Lampetra appendix*, climate, Petromyzontidae, reproductive phenology, spawning, temperature, Minnesota, Wisconsin, Iowa.

Record-setting high temperatures were recorded in the upper Midwestern U.S. in early 2012. In Minnesota, the month of March 2012 was the warmest on record, based on data for a 118-year period (1895–2012), and January (the fifth warmest) and February (the tenth warmest) were also exceptional (U.S. National Oceanic and Atmospheric Administration 2012\*). At a local level, March was the warmest on record for Winona, Minnesota (data available back to 1893), Rochester, Minnesota (1896), and LaCrosse, Wisconsin (1873) (U.S. National Weather Service 2012\*). Temperatures in Rochester exceeded 27°C on 17 and 18 March (Minnesota Climatology Working Group 2012\*). The exceptionally warm spring in 2012 affected many phenological events (Zimmer 2012\*). For example, Lake Sturgeon (*Acipenser fulvescens*) began spawning in the Lake Winnebago system in Wisconsin on 20 March, the earliest start on record (Mentzer 2012\*).

The purpose of this note is to report exceptionally early spawning by the American Brook Lamprey (*Lethenteron appendix*) in southern Minnesota. Until recently this species was known as *Lampetra appendix* (Lang et al. 2009).

Like other lampreys, American Brook Lampreys spend most of their lives as filter-feeding larvae, or ammocoetes, which burrow into areas of fine sediment in streams. After undergoing metamorphosis to the adult phase, they spawn in areas of coarse bottom, usually just upstream from riffles. American Brook Lampreys do not feed as adults, and they die after spawning. Spawning periods within individual streams are typically brief (only a few days in duration) (Cochran et al. 1993), and spawning is localized within streams (Mundahl and Sagan 2005).

The American Brook Lamprey has been well studied in Minnesota and Wisconsin (Cochran 1984; Cochran et al. 1993; Mundahl and Sagan 2005; Mundahl et al. 2005; Mundahl et al. 2006; Cochran 2008; Cochran et al. 2008), and its spawning season in this region has been fairly well defined. In Wisconsin, Cochran (1984) observed spawning in Waukesha County on 25 April 1982, and Cochran et al. (1993) reported spawning in Rock County on 4 May 1984 and in Manitowoc County on 2 May 1988, 3 and 4 May 1989, and 6 May 1992. In Minnesota, Mundahl and Sagan (2005) observed spawning in southeastern Minnesota streams during the periods 25 April–11 May 1995, 28 April–9 May 1996, and 21–29 April 1997. Water temperatures during spawning were reviewed by Cochran et al. (1993); although spawning has been reported over a wide range of temperatures (6.7°C–20.6°C), its onset most often occurs at a temperature of 10°C–15°C.

## Methods

### 2012 surveys

After initial observations of early spawning in Rush Creek (Root River drainage basin) in Winona County, additional surveys for spawning were conducted in the Upper Iowa River drainage basin in Mower County and in the Whitewater River drainage basin in Winona County (locations are detailed in Table 1). Surveys were conducted by wading through typical spawning habitat, including locations where American Brook Lampreys had been observed spawning in the past. In some cases, video-recordings of spawning were obtained.

A distinction was made between spawning groups and “stragglers.” Stragglers, also referred to as “loners” (Mundahl and Sagan 2005), are solitary adults present

TABLE 1. Locations where American Brook Lampreys (*Lethenteron appendix*) were observed during the present study. Each drainage is a separate system tributary to the Mississippi River.

County	Drainage	Stream	Latitude	Longitude
Winona	Whitewater River	North Branch Whitewater	44.086	-92.034
Winona	Whitewater River	South Branch Whitewater	44.070	-91.979
Winona	Whitewater River	Beaver Creek	44.152	-92.028
Winona	Trout Creek	Trout Creek	43.996	-91.461
Winona	Trout Creek	Trout Creek	43.981	-91.496
Winona	Root River	Rush Creek	43.872	-91.813
Houston	Wildcat Creek	Wildcat Creek	43.689	-91.293
Mower	Upper Iowa River	Upper Iowa River	43.519	-92.500
Howard	Upper Iowa River	Upper Iowa River	43.494	-92.358
Howard	Upper Iowa River	Beaver Creek	43.460	-92.308
Howard	Upper Iowa River	Staff Creek	43.493	-92.391

in typical spawning habitat. Sometimes they are present early in the spawning season and may simply represent the first individuals to arrive in the spawning habitat. Sometimes they are present after spawning has peaked and may represent spent individuals that have not yet died. Thus, stragglers may introduce variability into data compiled for spawning groups.

#### 2002–2010 data

Data on spawning by the American Brook Lamprey in Winona County during the period 2002–2010 were compiled from field notes recorded by PAC. These include observations made during the study by Cochran et al. (2008) of spawning behavior, as well as incidental records obtained during the course of other projects.

Because the American Brook Lamprey dies after spawning, the collection of living adult specimens at a given location during a fish survey indicates that spawning has not yet been completed at that site. Therefore, data on occurrence of adults in spring fish collections conducted by PAC in southeastern Minnesota and adjacent Iowa were also compiled.

Statistical comparisons between spawning data for 2012 and 2002–2010 were conducted by using *t*-tests. Each comparison was conducted with data for stragglers included and with data for stragglers excluded.

#### Historical data

American Brook Lampreys are typically noticed by members of the general public only during the spawning season, when they are especially likely to be encountered by trout fishers. A search for historical records of American Brook Lampreys in southeastern Minnesota and adjacent Wisconsin was conducted by taking advantage of the Winona Newspaper Project, a website that permits electronic searches of Winona newspapers published during the 19th and early 20th centuries ([www.winona.edu/library/databases/winona\\_newspaperproject.htm](http://www.winona.edu/library/databases/winona_newspaperproject.htm)).

## Results

#### 2012 surveys

Over 20 groups of American Brook Lampreys were observed spawning on 22 March in Rush Creek up-

stream from the more southern County Road 25 crossing. Water temperature was 14°C. A captured female spontaneously released eggs when handled, and a video-recording of a spawning group revealed typical mating behavior as well as attachment by multiple males to single females (Cochran et al. 2008). No American Brook Lampreys were observed when the site was revisited on 27 March.

Spawning was in progress on 24 March when we surveyed the Upper Iowa River at the Mower County Road 12 crossing upstream from Leroy. Three spawning groups were observed, as well as four apparent nests with single spawners. Water temperature was 17°C.

In the Whitewater River drainage basin, observations were made in three streams: the North Branch Whitewater River, the South Branch Whitewater River, and Beaver Creek. In the North Branch Whitewater River upstream from Elba, no American Brook Lampreys were observed on 24 March (water temperature 12.5°C) or 27 March (water temperature 13.5°C), but one straggler was observed on a nest on 29 March (water temperature 13°C). No American Brook Lampreys were observed on 2 April (water temperature 10°C), but some apparent nests were present. In the South Branch Whitewater River near Crystal Springs, a straggler was observed in typical spawning habitat on 30 March (water temperature not available), but no American Brook Lampreys were observed on 2 April (water temperature 10°C). In Beaver Creek west of County Road 116, several spawning groups were present on 2 April (water temperature not available), and a video-recording revealed both typical mating and satellite male behavior (Cochran et al. 2008). A single straggler was observed on 4 April (water temperature 9.5°C).

#### 2002–2010 data

Spawning groups of American Brook Lampreys were observed on six occasions between 19 and 25 April, and stragglers were observed on three occasions between 10 and 27 April (Figure 1). Mean date of observed spawning was significantly different between 2002–2010 and 2012, regardless of whether stragglers were included ( $t = 8.857$ ,  $P = 0.000$ ) or excluded ( $t = 7.425$ ,  $P = 0.013$ ).

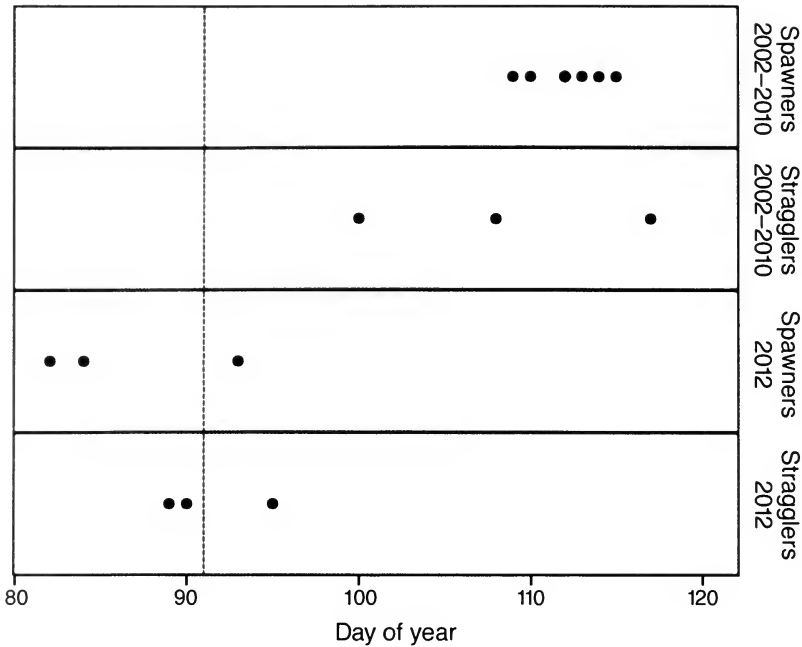


FIGURE 1. Dot plots of day of year (January 1 = day 1, December 31 = day 365) when spawning-phase American Brook Lampreys (*Lethenteron appendix*) were observed in southeastern Minnesota during the period 2002–2010 and during the exceptionally warm spring of 2012. Data are presented separately for spawning groups and stragglers. The vertical reference line indicates April 1.

Water temperatures were not always recorded when American Brook Lampreys were observed. However, during the period 2002–2010, spawning groups or stragglers were observed at water temperatures of 8°C–16°C (Figure 2). Mean water temperature was not significantly different between 2002–2010 and 2012, regardless of whether stragglers were included ( $t = 0.289$ ,  $P = 0.780$ ) or excluded ( $t = 1.576$ ,  $P = 0.176$ ).

We collected adult American Brook Lampreys on the following dates and locations in southeastern Minnesota: on 6 April and 8 April 2008 at two locations in Trout Creek (Winona County) and on 21 April 2008 in Wildcat Creek (Houston County). We also collected adults on 25 April 2011 in three streams in the Upper Iowa River drainage basin (Beaver Creek, Staff Creek, and Upper Iowa River) just south of the Minnesota border in Howard County, Iowa. Despite the relatively late date, water temperatures in the Iowa streams remained relatively cool (9°C–12°C). At none of the locations in Minnesota or Iowa did we observe any indications that spawning had yet occurred.

#### Historical data

Our search of Winona newspapers yielded two accounts of brook lampreys associated with spawning. Both occurred in the 1950s at a time when concern about the Sea Lamprey (*Petromyzon marinus*) in the Great Lakes led to heightened awareness of native lam-

preys in other systems. One article (Anonymous 1950\*) reported that trout fishers collected lamprey specimens averaging 17.5–20 cm in Beaver Creek (Trempealeau County, Wisconsin) and that lampreys had also been observed in Pigeon and Elk creeks. It was suggested that a “late spring” had resulted in lamprey spawning occurring after the onset of the trout fishing season. In a second article (Anonymous 1956\*), a photograph of a specimen collected on 6 May 1956 in Pine Creek (Root River drainage basin, Winona and Fillmore counties) appeared with commentary that other reports had been received during the previous two weeks. American Brook Lampreys have been documented from the streams mentioned in both articles (Fago 1983; Mundahl and Sagan 2005).

Eddy and Underhill (1974) reported that, prior to the disappearance of the American Brook Lamprey from the Credit River (Scott County, Minnesota) some time after the late 1940s, spawning occurred during the period 5–20 May. Finally, PAC was provided with American Brook Lampreys collected from spawning groups observed in the North Branch Whitewater River on 21 and 22 April 1988.

#### Discussion

Several factors must be considered when assessing the timing of phenological events. These include the effect of latitude and the contribution of year-to-year



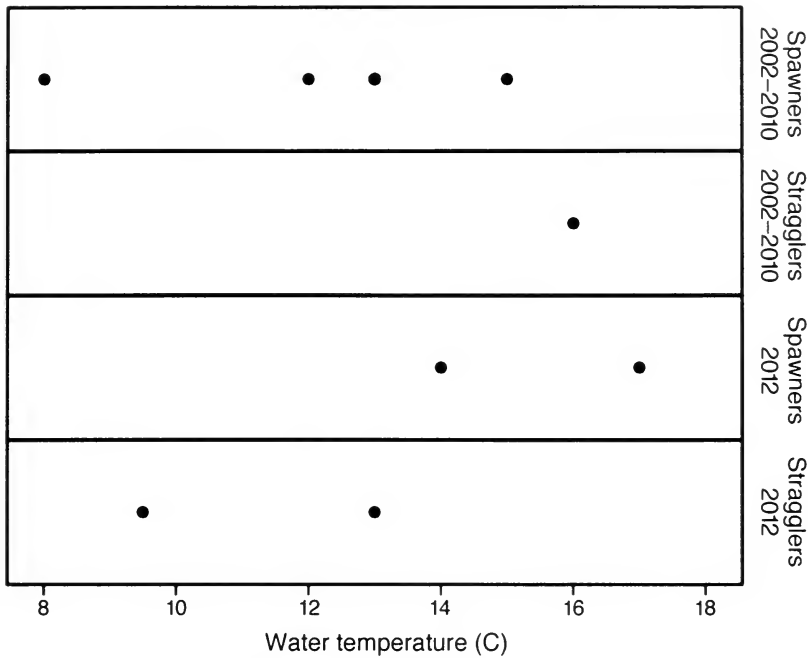


FIGURE 2. Dot plots of water temperature at which spawning-phase American Brook Lampreys (*Lethenteron appendix*) were observed in southeastern Minnesota during the period 2002–2010 and during the exceptionally warm spring of 2012. Data are presented separately for spawning groups and stragglers.

variability in climate. Finally, consideration of phenological phenomena in modern times must be placed in the context of climate change (e.g., Bradley et al. 1999).

Reproduction by fish species that spawn in the spring tends to occur later at higher latitudes. For example, the Slimy Sculpin (*Cottus cognatus*) spawns three to four weeks earlier in streams in Winona County (Majeski and Cochran 2009) than it does in a stream approximately 100 km to the north in Washington County (Petrosky and Waters 1975). Similarly, the American Brook Lamprey in Winona County spawns most often in late April (Mundahl and Sagan 2005; this study) but has been reported to spawn in early to mid-May approximately 85 km to the north in Scott County (Eddy and Underhill 1974).

The American Brook Lamprey has been reported to spawn in early March at the southern edge of its geographic distribution and as late as mid-June in the north (Table 2). However, our observations indicate that the range in spawning time among years within southeastern Minnesota encompasses over half the geographic range in spawning time.

Our limited data provide no evidence that climate change has resulted in the American Brook Lamprey spawning earlier in the spring in our region. Some early historical observations of spawning relatively late in the spring (May) are either confounded with the

effect of latitude (Eddy and Underhill 1974) or are explicitly associated with a year with a “late spring” (Anonymous 1950\*). Nevertheless, our observations that the American Brook Lamprey can spawn as much as a month early in a warm year suggest that this species has the capacity to respond to a climate shift.

Bradley et al. (1999) distinguished between species for which phenology is regulated by photoperiod and those that are regulated by temperature. Our data suggest that the timing of spawning by the American Brook Lamprey is responsive to water temperature. This is consistent with data for other lamprey species. For example, Cochran and Marks (1995) reported that the Silver Lamprey (*Ichthyomyzon unicuspis*) was captured during its upstream spawning migration earlier in warmer years. For both species, variability among years was greater with respect to day of year than with respect to temperature.

The American Brook Lamprey in southeastern Minnesota is found in streams that range from spring-fed, cold water streams (e.g., Beaver Creek in Winona County) to warm water streams fed to a greater extent by surface runoff (e.g., the Upper Iowa River). To the extent that streams fed primarily by groundwater are more resistant to the thermal effects of periods of extreme air temperature, there may be variability among streams in corresponding shifts in spawning time with years. In addition, Trautman (1981) suggested that

TABLE 2. Previously reported spawning periods for the American Brook Lamprey (*Lethenteron appendix*) at various locations throughout its range from south to north. In some cases, spawning periods were inferred from the timing of collections of adults.

Location	Spawning period	Source	Notes
Arkansas	2 March	Tumlison and Tumlison (1999)	
Tennessee	March	Seagle and Nagel (1982)	Inferred from collections
Tennessee	5 April	Etnier and Starnes (1993)	
Virginia	By mid-April	Jenkins and Burkhead (1994)	Latest adult seen on 16 April
Delaware	28 March–4 April	Rohde et al. (1976)	
Ohio	28 April	Trautman (1981)	
Michigan	18–20 April	Young and Cole (1900)	
Michigan	After 10 April	Okkelberg (1921)	
Michigan	20 April–16 June	Morman (1979)	Peaked in early May
New York	8–20 May	Gage (1893, 1928)	
New York	16 April	Dean and Sumner (1897)	
Massachusetts	22 April–1 May	Hoff (1988)	
New Hampshire	8 May	Sawyer (1960)	
Ontario	Late April–mid-May?	Kott (1971)	After spawning movements in mid-April–early May
Quebec	11 May–4 June	Vladykov (1949)	
Quebec	3–20 May	Comtois et al. (2004)	Captured adults freely released gametes

spawning occurred later in larger streams that took longer to warm in the spring. Variability in spawning times may contribute to variability among streams in length of growing season, and it may help explain why the American Brook Lamprey in some southeastern Minnesota streams achieves much greater total lengths (Mundahl and Sagan 2005).

### Acknowledgements

On 22 April 1988, when PAC was visiting Saint Mary's University of Minnesota to attend its Undergraduate Research Symposium, spawning American Brook Lampreys from the North Branch Whitewater River were obtained for him by Saint Mary's students Lenn Strapp and Scott Walker, the father of TSW. We are thankful for this data point, and we are grateful to more recent students who assisted us in the field, including Cassandra Hulett, Melissa Markert, Michael Mockler, Stephen Schmitt, and Jacob Zanon. Finally, we thank Saint Mary's University of Minnesota for its support of undergraduate research.

### Documents Cited (marked \* in text)

- Anonymous.** 1950. Not Sea Lamprey. Winona Republican-Herald (May 18): 18.
- Anonymous.** 1956. Brook lamprey. Winona Republican-Herald (May 9): 4.
- Mentzer, M.** 2012. Sturgeon, magnolia linked to same force. Green Bay Press-Gazette (May 25): C6.
- Minnesota Climatology Working Group.** 2012. Mild March 2012. Minnesota Climatology Working Group Climate Journal. [http://climate.umn.edu/doc/journal/mild\\_march\\_2012.htm](http://climate.umn.edu/doc/journal/mild_march_2012.htm). (Accessed 16 July 2012).
- U.S. National Oceanic and Atmospheric Administration.** 2012. State of the climate: national overview for March 2012. U.S. National Oceanic and Atmospheric Administration (NOAA), National Climate Data Center. <http://www.ncdc.noaa.gov/sotc/national/2012/3>. (Accessed 16 July 2012).

- U.S. National Weather Service.** 2012. The record warmth of March 2012. U.S. National Weather Service Weather Forecast Office, Lacrosse, Wisconsin. <http://www.crh.noaa.gov/arx/?n=2012Marchwarmth>. (Accessed 16 July 2012).
- Zimmer, R.** 2012. Record warmth brings out wildlife. Green Bay Press-Gazette (May 25): C5.

### Literature Cited

- Bradley, N. L., A. C. Leopold, J. Ross, and W. Huffaker.** 1999. Phenological changes reflect climate change in Wisconsin. Proceedings of the National Academy of Sciences of the United States of America 96: 9701–9704.
- Cochran, P. A.** 1984. Brook lampreys (*Ichthyomyzon fessor* and *Lampetra appendix*) in the Wisconsin portion of the Illinois River drainage. Transactions of the Wisconsin Academy of Sciences, Arts and Letters 72: 183–184.
- Cochran, P. A.** 2008. Observations on giant American Brook Lampreys (*Lampetra appendix*). Journal of Freshwater Ecology 23: 161–164.
- Cochran, P. A., D. D. Bloom, and R. J. Wagner.** 2008. Alternative reproductive behaviors in lampreys and their significance. Journal of Freshwater Ecology 23: 437–444.
- Cochran, P. A., and J. E. Marks.** 1995. Biology of the Silver Lamprey, *Ichthyomyzon unicuspis*, in Green Bay and the lower Fox River, with a comparison to the Sea Lamprey, *Petromyzon marinus*. Copeia 1995: 409–421.
- Cochran, P. A., M. E. Sneen, and A. P. Gripenotrog.** 1993. Notes on the biology of the American Brook Lamprey (*Lampetra appendix*) in Wisconsin. Transactions of the Wisconsin Academy of Sciences, Arts and Letters 81: 39–46.
- Comtois, A., F. Chapeau, C. B. Renaud, H. Fournier, B. Campbell, and R. Pariseau.** 2004. Inventaire printanier d'une frayère multispécifique: l'ichthyofaune des rapides de la rivière Gatineau, Québec. Canadian Field-Naturalist 118: 521–529.
- Dean, B., and F. B. Sumner.** 1897. Notes on the spawning habits of the brook lamprey (*Petromyzon willderi*). Transactions of the New York Academy of Science 16: 321–324.
- Eddy, S., and J. C. Underhill.** 1974. Northern Fishes. Third edition. University of Minnesota Press, Minneapolis, Minnesota. 414 pages.

- Etnier, D. A., and W. B. Starnes. 1993. The Fishes of Tennessee. University of Tennessee Press, Knoxville, Tennessee. 681 pages.
- Fago, D. 1983. Distribution and relative abundance of fishes in Wisconsin. II. Black, Trempealeau, and Buffalo river basins. Wisconsin Department of Natural Resources Technical Bulletin No. 140. 120 pages.
- Gage, S. H. 1893. The lake and brook lampreys of New York, especially those of Cayuga and Seneca lakes. Pages 421-493 in *The Wilder Quarter-Century Book: A Collection of Original Papers Dedicated to Professor Burt Green Wilder at the Close of His Twenty-fifth Year of Service in Cornell University, 1868-1893*. Comstock, Ithaca, New York.
- Gage, S. H. 1928. The lampreys of New York State—life history and economics. Pages 158-191 in *A Biological Survey of the Oswego River System. Supplemental to the 17th Annual Report, 1927*, New York Conservation Department. J. B. Lyon Company. Printers, Albany, New York.
- Jenkins, R. E., and N. M. Burkhead. 1994. Freshwater Fishes of Virginia. American Fisheries Society, Bethesda, Maryland. 1079 pages.
- Hoff, J. G. 1988. Some aspects of the ecology of the American Brook Lamprey, *Lampetra appendix*, in the Mashpee River, Cape Cod, Massachusetts. *Canadian Field-Naturalist* 102: 735-v737.
- Kott, E. 1971. Characteristics of pre-spawning American Brook Lampreys from Big Creek, Ontario. *Canadian Field-Naturalist* 85: 235-240.
- Lang, N. A., K. Roe, C. Renaud, H. Gill, I. Potter, J. Freyhof, A. Naseka, P. Cochran, H. Espinosa-Pérez, E. Habit, B. Kuhajda, D. Neely, Y. Reshetnikov, V. Salnikov, M. Stoumboudi, and R. Mayden. 2009. Novel relationships among lampreys (Petromyzontiformes) revealed by a taxonomically comprehensive molecular dataset. Pages 41-55 in L. R. Brown, S. D. Chase, M. G. Mesa, R. J. Beamish, and P. B. Moyle (editors). *Biology, Management and Conservation of Lampreys in North America*. American Fisheries Society, Symposium 72, Bethesda, Maryland.
- Majeski, M. J., and P. A. Cochran. 2009. Spawning season and habitat use of Slimy Sculpin (*Cottus cognatus*) in southeastern Minnesota. *Journal of Freshwater Ecology* 24: 301-307.
- Morman, R. H. 1979. Distribution and ecology of lampreys in the Lower Peninsula of Michigan, 1957-75. Great Lakes Fishery Commission Technical Report No. 33. 59 pages.
- Mundahl, N. D., C. Erickson, M. R. Johnston, G. A. Sayeed, and S. Taubel. 2005. Diet, feeding rate, and assimilation efficiency of American Brook Lamprey. *Environmental Biology of Fishes* 72: 67-72.
- Mundahl, N. D., and R. A. Sagan. 2005. Spawning ecology of the American Brook Lamprey, *Lampetra appendix*. *Environmental Biology of Fishes* 73: 283-292.
- Mundahl, N. D., G. A. Sayeed, S. Taubel, C. Erickson, A. Zalatel, and J. Cousins. 2006. Densities and habitat of American Brook Lamprey (*Lampetra appendix*) larvae in Minnesota. *American Midland Naturalist* 156: 11-22.
- Okkelberg, P. 1921. The early history of the germ cell in the brook lamprey, *Entosphenus wilderi* (Gage), up to and including the period of sex differentiation. *Journal of Morphology* 35: 1-151.
- Petrosky, C. E., and T. F. Waters. 1975. Annual production by the Slimy Sculpin population in a small Minnesota trout stream. *Transactions of the American Fisheries Society* 104: 237-244.
- Rohde, F. C., R. G. Arndt, and J. C. S. Wang. 1976. Life history of the freshwater lampreys, *Okkelbergia aepyptera* and *Lampetra lamottenii* (Pisces: Petromyzonidae) on the Delmarva Peninsula (East Coast, United States). *Bulletin of the Southern California Academy of Science* 75: 99-111.
- Sawyer, P. J. 1960. A new geographic record for the American Brook Lamprey, *Lampetra lamottei*. *Copeia* 1960: 136-137.
- Seagle, H. H., and J. W. Nagel. 1982. Life cycle and fecundity of the American Brook Lamprey, *Lampetra appendix*, in Tennessee. *Copeia* 1982: 362-366.
- Trautman, M. B. 1981. *The Fishes of Ohio*. Second edition. Ohio State University Press, Columbus, Ohio. 782 pages.
- Tumlison, R., and C. Tumlison. 1999. An extralimital population of *Lampetra appendix* (Petromyzontidae) in southwestern Arkansas. *Southwestern Naturalist* 44: 106-108.
- Vladykov, V. D. 1949. Quebec lampreys (Petromyzonidae) I. List of species and their economical importance. Department of Fisheries, Province of Quebec, Contribution No. 26. 67 pages.
- Young, H. T., and L. J. Cole. 1900. On the nesting habits of the brook lamprey (*Lampetra wilderi*). *American Naturalist* 34: 617-620.

Received 26 July 2012

Accepted 12 October 2012

# First Specimens of the Marine Eels *Venefica ocella* and *V. tentaculata* (Nettastomatidae) from British Columbia

GAVIN F. HANKE<sup>1</sup> and STEVEN M. ROIAS<sup>2</sup>

<sup>1</sup>Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2 Canada; email: ghanke@royalbcmuseum.bc.ca

<sup>2</sup>Archipelago Marine Research, 525 Head Street, Esquimalt, British Columbia V9A 5S1 Canada

Hanke, Gavin F., and Steven M. Roias. 2012. First specimens of the marine eels *Venefica ocella* and *V. tentaculata* (Nettastomatidae) from British Columbia. *Canadian Field-Naturalist* 126(3): 210–216.

Until recently, only the following seven species of marine eels were known to exist in waters off British Columbia (based on literature sources and museum records): *Nemichthys scolopaceus*, and *Avocettina infans* (Nemichthyidae, snipe eels), *Xenomystax atrarius* (Congridae, conger eels), *Serrivomer jespersenii* (Serrivomeridae, sawtooth eels), *Cyema atrum* (Cyematidae, bobtail eels), *Synphobranchus affinis* (Synphobranchidae, cutthroat eels), and *Thalassenchelys coheni* (Colocongridae, worm eels). *Histiobranchus bathybius* (also in the Synphobranchidae) is expected to occur in British Columbia, since its range extends from Mexico to Alaska. Recent surveys to determine the viability of crab fisheries facilitated the collection of non-game fishes from by-catch in bottom-trawl samples. Several eels were collected between 2004 and 2006, and they were originally identified as *Serrivomer jespersenii* (Serrivomeridae). Re-examination of these specimens indicates that they all are duckbill eels (Nettastomatidae), the first records of this family north of 45°39'N along the North American Pacific coast. Both *Venefica ocella* and *V. tentaculata* are represented, with *V. ocella* found farther north than *V. tentaculata*. All British Columbia specimens are housed at the Royal British Columbia Museum. The collection of new deep-water species in British Columbia reinforces the value of survey sampling to improve our knowledge of biodiversity.

Key Words: Nettastomatidae, *Venefica ocella*, *Venefica tentaculata*, British Columbia.

There is little research on non-game fishes in Canadian coastal waters. Eels (orders Anguilliformes and Saccopharyngiformes) seem to be particularly under-represented in the literature, even though they appear in fishery by-catch. The first attempts to summarize coastal fish diversity by Clemens and Wilby (1949, 1961) listed only two nemichthyid eels, *Nemichthys avocetta* and *Avocettina gilli* (now *Nemichthys scolopaceus* and *Avocettina infans*, respectively). Peden (1972) detailed the distribution of *Xenomystax atrarius*, and Hart (1973) summarized what was known for *Serrivomer jespersenii*, *Nemichthys scolopaceus*, *Avocettina infans*, and *Xenomystax atrarius* from British Columbia waters. Peden (1974) listed records of rare fishes and first records of several species along the British Columbia coast, but no new eels were mentioned. Lamb and Edgell (1986, 2010) dealt only with fishes from shallow depths, and Peden et al. (1985) recorded only *Avocettina infans* from the region of Ocean Station Papa (50°N, 145°W). Peden and Hughes (1986) extended the range of *Serrivomer jespersenii* along the British Columbia coast, the only eel species mentioned in their paper. Coad (1995) also did not list any nettastomatid (duckbill) eels from the Pacific coast of Canada. In addition to the taxa listed in Hart (1973), Mecklenburg et al. (2002) list *Synphobranchus affinis* and *Histiobranchus bathybius* from Alaskan waters, and include *Cyema atrum* and *Nemichthys larseni* as probable additions to the north east Pacific fauna, but not duckbill eels.

*Thalassenchelys coheni* has been collected in British Columbia (Mecklenburg et al. 2002), with specimens

deposited at the Royal British Columbia Museum, as well as farther south along the United States coastline (Shimokawa et al. 1995, Figure 2). Until recently, the relationships of *Thalassenchelys coheni* were uncertain, but Lopez et al. (2007) used mitochondrial DNA to show that *T. coheni* is a colocongrid eel.

Jordan et al. (1930) listed three species of *Venefica* from North America, two of which, *V. procera* and *V. tentaculata*, were known from the Pacific offshore of California. Until now, the northern-most record of nettastomatid eels in the eastern Pacific, more specifically, *Venefica procera*, was offshore of Oregon at 45°39'N, 125°18'W, at a depth of 2112 m (Edwards and Peden 1976), southwest of the Columbia River mouth.

## Study Area and Methods

Fisheries and Oceans Canada performed deepwater sampling to determine the viability of a Tanner Crab (*Chionoecetes tanneri*) fishery using a Campelen 1800 shrimp trawl between 1999 and 2006, from the Canadian Coast Guard stern trawler W. E. Ricker. The systematic survey plans, locations surveyed, and methods are detailed by Gillespie et al. (2004) and Workman et al. (2000). All organisms in the catch were identified to species if possible. Damage to specimens prevented identification of some fishes, but representative specimens, rarely collected fishes, range extensions, and first records for British Columbia, were taken from the by-catch for preservation. Specimens were bagged, labelled and frozen, after tissue samples had been taken for DNA barcoding. Specimens later were thawed, and fixed for

TABLE 1. Northern occurrences of *Venefica* spp. along the west coast of North America, including new records from 2004–2006 off British Columbia. Data from the Royal British Columbia Museum and the University of Washington Fish Collection (Burke Museum).

Museum Catalogue #	Specimen Identification	Specimen Length (cm)	Latitude	Longitude	Sample Depth (m)	Vessel	Gear	Collection Date	DNA Barcode
University of Washington Fish Collection									
19092	<i>Venefica proera</i>	80.2	45°38'53"	125°17'59"	2112	R/V John N. Cobb	?	Jun 17, 1966	n/a
47220	<i>Venefica</i> sp.	71.0	36°42'46"	122°16'54"	1171	Miller Freeman	bottom trawl	Oct 23, 1999	n/a
Royal British Columbia Museum									
010-200-007	<i>Venefica tentaculata</i>	88.4	50°33'13"	129°14'39"	1869	W.E. Ricker (CG2965)	bottom trawl	Oct 9, 2006	TZFPB738-05
006-029-005	<i>Venefica tentaculata</i>	55.0	48°58'26"	127°6'17"	1757	Frosti (CFL3773)	bottom trawl	Oct 16, 2005	TZFPB313-05
006-029-006	<i>Venefica tentaculata</i>	63.6	48°58'26"	127°6'17"	1757	Frosti (CFL3773)	bottom trawl	Oct 16, 2005	TZFPB314-05
006-029-007	<i>Venefica tentaculata</i>	70.3	48°58'26"	127°6'17"	1757	Frosti (CFL3773)	bottom trawl	Oct 16, 2005	TZFPB315-05
012-180-001	<i>Venefica ocella</i>	69.3	52°0'40"	131°34'55"	1669	W.E. Ricker (CG2965)	bottom trawl	Sep 5, 2004	n/a

a week in a 10% solution of Formaldehyde in water. Once fixed, all specimens were rinsed in freshwater, and then transferred to 70% Ethanol for long-term storage at the Royal British Columbia Museum. All specimens are catalogued in the Royal British Columbia Museum ichthyology collection (Table 1). Specimen measurements were compared to those from historical literature and original species descriptions (e.g., Garman 1899; Gilbert 1915; Günther 1887; Goode and Bean 1883, 1895). In all cases, specimen damage limited the accuracy of measurements as noted in the following species accounts.

## Results

### *Venefica* spp.

The five Canadian *Venefica* specimens were caught in trawl samples between 5 September 2004 and 9 October 2006 in depths between 1669 and 1869 m (Table 1). Most were damaged after being hauled to the surface; however, the eel collected on 9 October 2006 (RBCM 010-200-007) is in remarkably good shape, having lost only the last few centimetres of the body.

While on the Canadian Coast Guard Ship (CCGS) *W. E. Ricker* in 2006, GH suggested that the eel collected during that trip was a nettastomatid, based only on outline drawings in Eschmeyer et al. (1983, page 67) (we lacked the literature aboard ship to make a more precise identification). Despite this suggestion, the 2006 specimen was labelled *Serrivomer jasperseni*. The other eels collected in 2004 and 2005 (listed in Table 1) show the same suite of characters as the well-preserved 2006 specimen, and none belong to the genus *Serrivomer*.

Features that distinguish all British Columbia specimens in this report from *Serrivomer* include pectoral fin absent; gill openings as small pores not connected ventrally; anterior nostrils tubular and at tip of snout; posterior nostril opening oval to elongate and immediately ahead of the eye; dorsal fin origin at or just behind level of gill opening and far forward of the position of the anus; lateral line complete, with distinct pores along mid-flank; teeth all small and villiform/cardiform; enlarged serrated rows of vomerine teeth lacking; snout with a distinct fleshy proboscis; and upper jaw longer than lower jaw in all specimens (Eschmeyer et al. 1983; Smith 1999a, 1999b; Nelson 2006).

*Serrivomer jasperseni* also occurs in British Columbia waters (Hart 1973; Peden and Hughes 1986; Mecklenburg et al. 2002). *Serrivomer* specimens in the Royal British Columbia Museum collection (RBCM 980-299-001 and RBCM 002-207-001) were examined to confirm the distinguishing features at the family level (e.g., Eschmeyer et al. 1983; Smith 1999b; Nelson 2006). Within the family Nettastomatidae, the British Columbia specimens correspond to the genus *Venefica* based on the following choices from Smith (1999a): posterior nostrils high on the head; posterior nostril level with top of eye; tip of snout with elongate proboscis.

TABLE 2. Measurements used to resolve species identity of *Venefica* spp. from British Columbia.

Characters	<i>V. procer</i>		<i>V. proboscidea</i>		<i>V. ocella</i>		<i>V. tentaculata</i>		RBCM 012-180-001 <i>V. ocella</i>		RBCM 006-029-005 <i>V. tentaculata</i>		RBCM 006-029-006 <i>V. tentaculata</i>		RBCM 006-029-007 <i>V. tentaculata</i>		RBCM 010-200-007 <i>V. tentaculata</i>		
Proboscis length / Eye diameter	2	5	6.3-7.4*	3-4.1*	7.63	3.18	3.13	2.78	2.80										
Proboscis length / Snout length		0.5	.55-.71*	.33-0.475*	0.92	0.60	0.39	0.36	0.35										
Eye diameter / Head length	0.025	0.05	.0476-0.048*	.0625-0.067*	0.05	0.07	0.05	0.06	0.06										
Head length / Total length			0.11	0.11	0.11	0.11	0.12	0.11	0.10										
Head length / Snout-vent length	0.27			0.27	0.27	0.26	0.26	0.27	0.26										
Proboscis length / Snout-vent length				0.06	0.11	0.05	0.04	0.04	0.04										
Snout length / Snout-vent length				0.125	0.12	0.09	0.11	0.12	0.12										
Snout to Angle of Mouth / Snout-vent length				0.15	0.15	0.13	0.14	0.16	0.14										
Snout length / Head length	.35-.55		0.6	0.463-.504*	0.43	0.35	0.44	0.44	0.46										
Eye diameter / Snout-vent length				0.02	0.01	0.02	0.01	0.02	0.02										
Distance Gape extends past Eye / Eye diameter	1	far	1-1.33*	0.33-0.75*	1.00	0.50	0.50	1.80	1.25										
Eye diameter / Gill Opening diameter			.8-1*	1-1.07*	1.60	1.60	1.33	0.42	0.37										
Snout-Vent length / Total length	0.33	.5-6	0.33	0.33	0.41	0.42	0.44	0.42	0.42										
Dorsal Fin Rays			417	397	298	255	283	265	372										
Anal Fin Rays			324		203	194	176	197	243										
Dorsal Fin Ray level with Anal Origin	73		99	113-115†	96	106	95	93	102										
Lateral Pores along Maxillary ahead of Eye	12			12	10	10	12	12	12										
Median Pores along Snout	4 pairs		7-8 pairs	7 pairs	7 pairs	?	7 pairs	7 pairs	9 pairs										
Pores behind Eye	3			4	3	3	3	3	3										
Mandibular Pores	17			12	10+	11+	10	12	14										
Lateral Line Pores ahead of Anus	60-64	59-60	52	53	60	60	56	61	60										
Lateral Line Pores ahead of Gill Opening		8-9	6*	7-9*	9	5+	6	7	6										

\* estimated measurements based on historic drawings (Garman 1899)

† 93-98 in other specimens Garman (1899) and Gilbert (1915) thought also were *V. tentaculata*

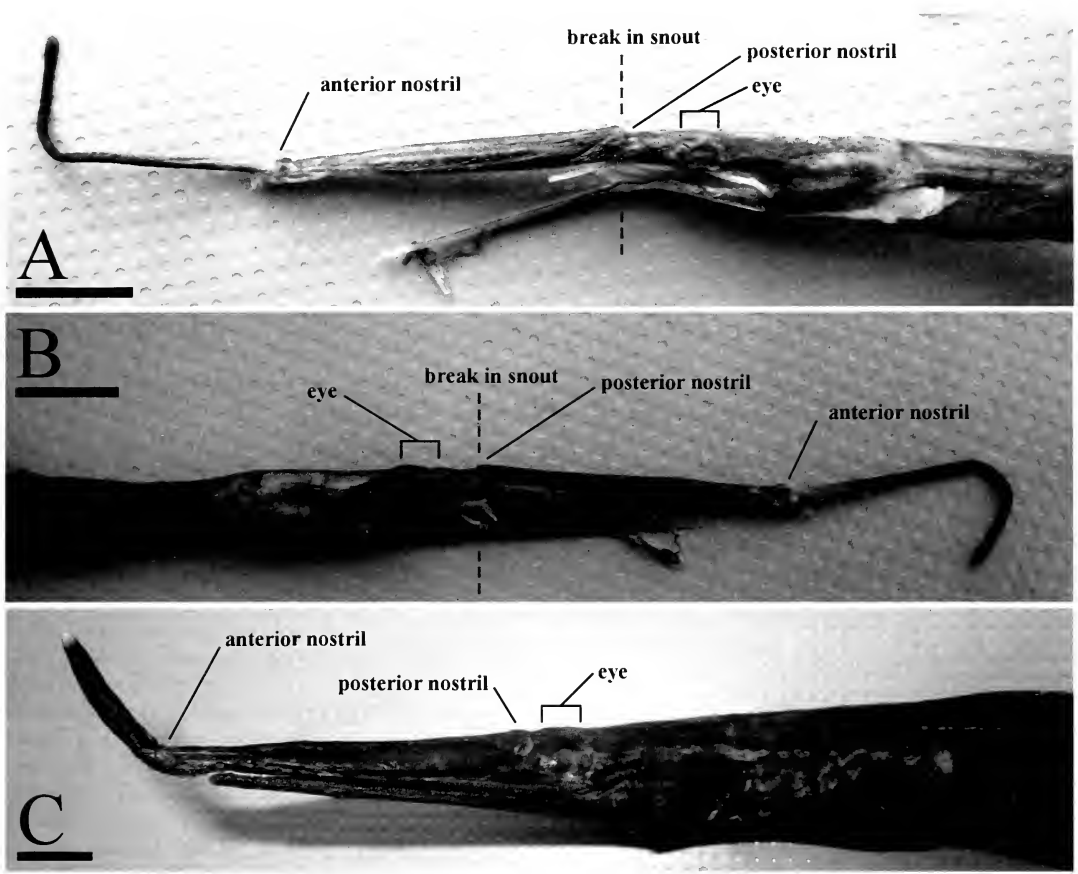


FIGURE 1. Photographs of the heads of each species found off British Columbia showing relative lengths of the proboscis: A) *Venefica ocella* (RBCM 012-180-001), left side; B) right side of the same specimen; and C) *V. tentaculata* (RBCM 010-200-007), left side. Scale bars = 1 cm.

All *Venefica* specimens in this report have damage incurred while in the trawl net, and snout measurements for some (Table 2) and dorsal/anal fin ray counts are therefore underestimates. Unfortunately, the bags containing the labels/collection data on several of the 2005 specimens were tied tightly round each fish's head or snout rather than farther back along the body, where there are fewer features needed for species identification. The identification of those fishes is tentative because several features (e.g., eye diameter, sensory pores on the head) now are obscured or damaged.

*Venefica* species descriptions, and descriptions of captured specimens from survey work, provide precious little information on each fish's anatomy and body proportions. Furthermore, features detailed in the original species descriptions vary among publications (compare: Garman 1899; Gilbert 1915; Günther 1887; Goode and Bean 1883, 1895). This variability creates problems when trying to identify species in new samples. Table 2 lists measurements and ratios of body proportions that were used to determine the identity of

the five new Canadian specimens. These species identifications must be considered tentative pending a complete re-evaluation of the anatomy and limits of variation in *Venefica* species.

#### *Venefica ocella*

One specimen (RBCM 012-180-001) (Figure 1A-B) stands out from all other *Venefica* collected in British Columbia. It possesses a longer proboscis relative to its snout length, eye diameter, and snout-vent length (all other specimens have a short proboscis, for example, Figure 1C) relative to the same features (Table 2). This one specimen with its long proboscis (RBCM 012-180-001) resembles historical drawings in Garman (1899, Plate 61, Figure 2) and proportions for specimen 28438 at the Museum of Comparative Zoology, Harvard University (MCZ), and we assign this fish to *Venefica ocella*. This species was originally found along the west coast of Central America (5°30'N, 86°45'W), and its range now extends north to Moresby Island (52°0'40"N, 131°34'55"W) (Figure 2).

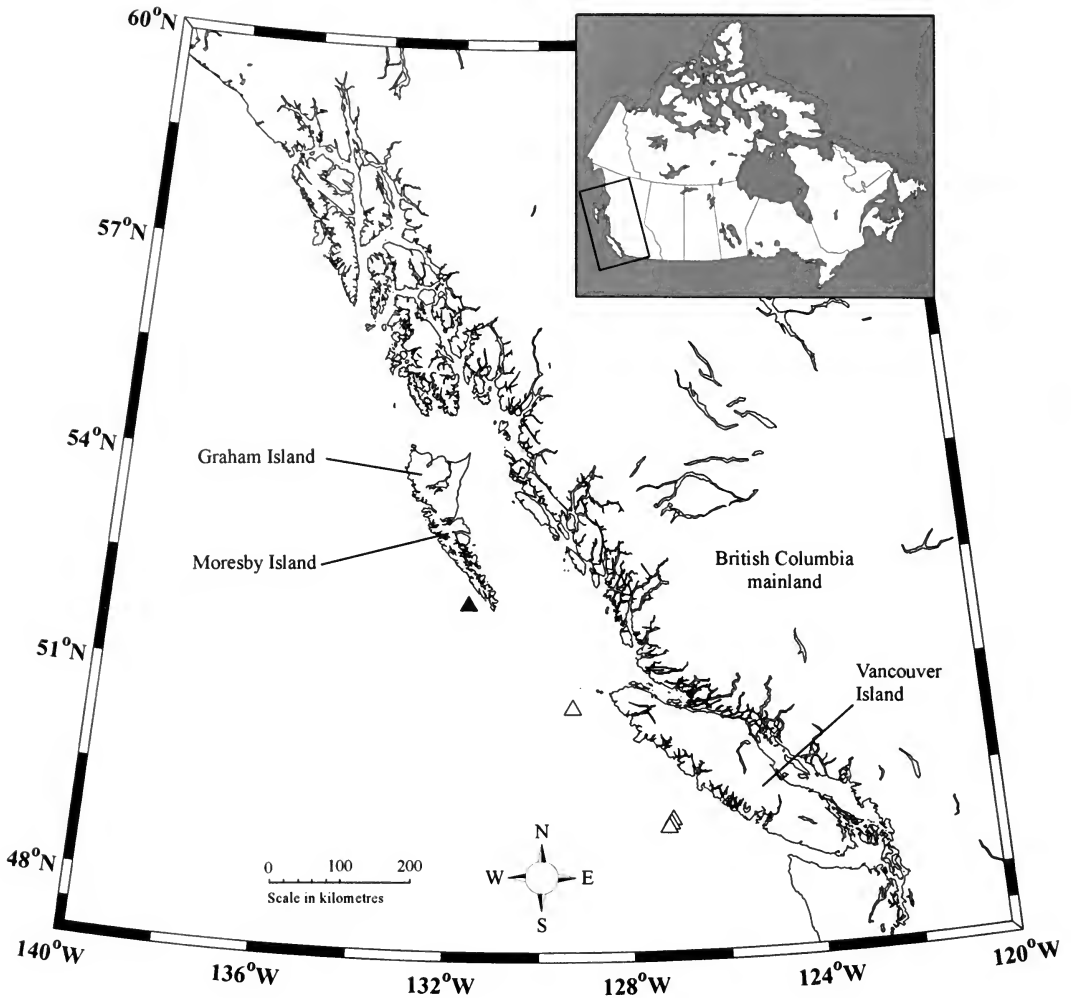


FIGURE 2. A simplified chart showing locations of trawl samples which returned specimens of *Venefica* spp. in British Columbia. Three specimens of *V. tentaculata* from 48°58'36"N, 127°6'17"W were from a single trawl sample and are played artificially to indicate three specimens were present ▲ = *Venefica ocella*, △ = *Venefica tentaculata*.

### *Venefica tentaculata*

The remaining four specimens from British Columbia show a far shorter proboscis relative to snout length and eye diameter (Table 2). Based on comparisons with known species, they show proportions similar to *Venefica tentaculata* (see Garman 1899, plate M, Figure 1a, and MCZ 28439). *Venefica tentaculata* originally was described from four specimens (Garman 1899, page 320) found between Cocos Island (Isla del Coco, off the west coast of Costa Rica) and Acapulco, Mexico. The species' range now extends from 5°26'N, 86°55'W to near the northern tip of Vancouver Island (50°33'13"N, 129°14'39"W) (Figure 2).

Two of the four specimens of *V. tentaculata* (RBCM 006-029-006 and RBCM 010-200-007) (Figure 1C) both have intact snouts, and their proboscis measure-

ments are reliable relative to the snout length. Unfortunately, RBCM 006-029-006 had a label tied tightly round the head level with the eyes, so proboscis to eye proportions are close but not precise, due to distortion of the head. Two specimens assigned to *V. tentaculata* (RBCM 006-029-005 and RBCM 006-029-007) also have broken snouts, and measurements are based on best estimates with the bones of the snout realigned for measurement.

### Discussion

New records reported in this paper extend the known range of the genus *Venefica* roughly 844 km north along the west coast of North America into Canadian waters to 52°00'N, near the south end of Moresby Island, with additional locations in Canadian waters along the coast



Anguilliformes (true eels)	
Congroidei	
Colocongridae (short-tail eels)	<i>Thalassenchelys coheni</i>
Congridae (conger eels)	<i>Xenomystax atrarius</i>
Serrivomeridae (sawtooth eels)	<i>Serrivomer jespersenii</i>
Synphobranchidae (cutthroat eels)	<i>Synphobranchus affinis</i> <i>Histiobranchus bathybius</i>
Nemichthyidae (snipe eels)	<i>Nemichthys scolopaceus</i> <i>Avocettina infans</i>
Nettastomatidae (duckbill eels)	<i>Venefica tentaculata</i> <i>Venefica ocella</i>

FIGURE 3. Eel diversity in British Columbia coastal waters.

of Vancouver Island at 48°58'N (Figure 2). With the addition of *Venefica tentaculata* and *V. ocella*, the diversity of eels in British Columbia now equals 9 species (Clemens and Wilby 1949, 1961; Hart 1973; Peden 1974; Peden et al. 1985; Peden and Hughes 1986; Coad 1995; Mecklenburg et al. 2002) (Figure 3).

The increased sampling along the British Columbia coast during bottom-trawl surveys between 2003 and 2006 revealed many new species living in deep water offshore of the Canadian Pacific coast. This recent increase in knowledge underscores the importance of survey collections. New species and range extensions of species already known to occur in both freshwater (Hanke et al. 2006; McPhail 2007; Cope 2011\*) and marine water (Peden 1972, 1973, 1974; Peden and Anderson 1978; Peden 1979a, 1979b; Stein and Peden 1979; Peden and Ostermann 1980; Peden and Anderson 1981; Peden and Hughes 1986; Anderson and Peden 1988) would be harder to detect without broad-scope survey sampling.

### Acknowledgements

Thanks to Jeannette Bedard for preparing the range map of British Columbia using Matlab software. Thanks to Graham Gillespie, Ken Fong, and Jim Boutillier (Fisheries and Oceans Canada, Nanaimo) for specimens collected in Canada and their associated data; Ken Fong transferred formalin-fixed specimens into alcohol prior to their arrival at the Royal British Columbia Museum and provided literature outlining the trawl survey methods. Thanks also to Ted Pietsch and Katherine Maslenikov from the University of Washington for photos of specimens and data on material held there. Thanks also to Claude Renaud and two others for their review of, comments on, and improvement to the original manuscript.

### Documents Cited (marked \* in text)

Cope, S. 2011. Alouette River salmonid smolt migration enumeration: 2010 data report. Alouette Dam Water Use Plan: Alouette River Smolt Enumeration. Westslope Fisheries Ltd., Cranbrook, British Columbia. 63 pages.

### Literature Cited

- Anderson, M. E., and A. E. Peden. (1988) The eelpout genus *Pachycara* (Teleostei: Zoarcidae) in the northeastern Pacific Ocean, with description of two new species. Proceedings of the California Academy of Sciences 46(3): 83–94.
- Clemens, W. A., and G. V. Wilby. 1949. Fishes of the Pacific coast of Canada. Fisheries Research Board of Canada Bulletin No. 68. 368 pages.
- Clemens, W. A., and G. V. Wilby. 1961. Fishes of the Pacific coast of Canada. Second Edition. Fisheries Research Board of Canada Bulletin No. 68. 443 pages.
- Coad, B. W. 1995. Encyclopedia of Canadian Fishes. Canadian Sportfishing Productions, Inc., Waterdown, Ontario, and Canadian Museum of Nature, Ottawa, Ont. 928 pages.
- Edwards, J. C., and A. E. Peden. 1976. Northernmost known record of the eel genus *Venefica* (Nettastomatidae) along the North American west coast. *Syesis* 9: 371–372.
- Eschmeyer, W. N., E. S. Herald, and H. Hammann. 1983. A Field Guide to the Pacific Coast Fishes of North America. Peterson Field Guide Series. Houghton Mifflin Company, Boston, Mass. 336 pages.
- Garman, S. 1899. Reports of an exploration off the west coasts of Mexico, Central and South America, and off the Galapagos Islands, in charge of Alexander Agassiz, by the U.S. Fish Commission steamer "Albatross," during 1891, Lieut.-Commander Z. L. Tanner, U.S.N., commanding. *Memoirs of the Museum of Comparative Zoology at Harvard College* 24: 1–431.
- Gilbert, C. H. 1915. Fishes collected by the United States Fisheries steamer "Albatross" in southern California in 1904. *Proceedings of the United States National Museum* 48: 305–380.
- Gillespie, G. E., K. H. Fong, A. C. Phillips, G. R. Meyer, and J. A. Boutillier. 2004. Development of a New Fishery for Tanner Crabs (*Chionoecetes tanneri* Rathbun, 1893) off British Columbia: 2003 Status Report. Canadian Science Advisory Secretariat (CSAS), Research Document 2004/132. Fisheries and Oceans Canada. 87 pages.
- Goode, G. B., and T. H. Bean. 1883. Reports on the results of dredging under the supervision of Alexander Agassiz, on the east coast of the United States, during the summer of 1880, by the U.S. Coast Survey steamer "Blake," Commander J. R. Bartlett, U.S.N., commanding. *Bulletin of the Museum of Comparative Zoology at Harvard College* 10(5): 183–226.

- Goode, G. B., and T. H. Bean. 1895. Oceanic ichthyology, a treatise on the deep-sea and pelagic fishes of the world, based chiefly upon the collections made by steamers "Blake", "Albatross", and "Fish Hawk" in the northwestern Atlantic. Special Bulletin No. 2, United States National Museum, Washington, D.C. 553 pages.
- Günther, A. 1887. Report on the deep-sea fishes collected by H.M.S. Challenger during the years 1873–76. Vol. 22 (Zoology) of Report of the Scientific Results of the Voyage of H.M.S. Challenger under the Command of Captain George S. Nares, R.N., F.R.S., and the Late Captain Frank Tourle Thomson, R.N. Eyre and Spottiswoode, London, for Her Majesty's Stationery Office. 268 pages.
- Hanke, G. F., M. C. E. McNall, and J. Roberts. 2006. First records of the Yellow Bullhead (*Ameiurus natalis*), a loricatoriid catfish (*Panaque suttonorum*), and a Silver Pacu (*Piaractus* cf. *P. brachyomus*) in British Columbia, Canada. *Canadian Field-Naturalist* 120(4): 421–427.
- Hart, J. L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada Bulletin No. 180. 740 pages.
- Jordan, D. S., B. W. Evermann, and H. W. Clark. 1930. A check-list of the fishes and fish-like vertebrates of North and Middle America north of the northern boundary of Venezuela and Colombia. Report of the United States Commissioner of Fisheries for the fiscal year 1928. Appendices, Part II. U.S. Department of Commerce, Washington, D.C. 670 pages.
- Lamb, A., and P. Edgell. 1986. Coastal Fishes of the Pacific Northwest. Harbour Publishing Company, Madeira Park, British Columbia. 224 pages.
- Lamb, A., and P. Edgell. 2010. Coastal Fishes of the Pacific Northwest. Revised and expanded second edition. Harbour Publishing Company, Madeira Park, British Columbia. 335 pages.
- López, J. A., M. W. Westneat, and R. Hanel. 2007. The Phylogenetic Affinities of the Mysterious Anguilliform Genera *Coloconger* and *Thalassenchelys* as supported by mtDNA Sequences. *Copeia* 2007(4): 959–966.
- McPhail, J. D. 2007. The Freshwater Fishes of British Columbia. University of Alberta Press, Edmonton, Alberta. 620 pages.
- Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society Publication, Bethesda, Maryland. 1116 pages.
- Nelson, J. S. 2006. Fishes of the World. Fourth edition. John Wiley and Sons, Inc., New York, New York. 601 pages.
- Peden, A. E. 1972. Redescription and distribution of the rare deep-sea eel *Xenomystax atrarius* in the eastern Pacific Ocean. *Journal of the Fisheries Research Board of Canada* 29: 1–12.
- Peden, A. E. 1973. Records of eelpouts of the genus *Lycenchelys* and *Embryx* from the northeastern Pacific Ocean. *Syesis* 6: 115–120.
- Peden, A. E. 1974. Rare fishes including first records of thirteen species from British Columbia. *Syesis* 7: 47–62.
- Peden, A. E. 1979a. Occurrence of the eelpout, *Bothrocara pusillum*. (Zoarcidae) off British Columbia. *Syesis* 12: 183–184.
- Peden, A. E. 1979b. Rare captures of two fishes, *Benthodesmus* and *Paralepis*, off British Columbia. *Syesis* 12: 179–180.
- Peden, A. E., and M. E. Anderson. 1978. A systematic review of the fish genus *Lycodapus* (Zoarcidae) with descriptions of two new species. *Canadian Journal of Zoology* 56(9): 1925–1961.
- Peden, A. E., and M. E. Anderson. 1981. *Lycodapus* (Pisces: Zoarcidae) of the eastern Bering Sea and nearby Pacific Ocean, with three new species and a revised key to the species. *Canadian Journal of Zoology* 59(4): 667–678.
- Peden, A. E., and G. W. Hughes. 1986. First records, confirmatory records, and range extensions of marine fishes off Canada's west coast. *Canadian Field-Naturalist* 100(1): 1–9.
- Peden, A. E., and W. Ostermann. 1980. Three fish species previously unknown from marine waters off British Columbia. *Syesis* 13: 215–217.
- Peden, A. E., W. Ostermann, and L. J. Pozar. 1985. Fishes observed at Canadian weather ship Ocean Station Papa (50°N, 145°W) with notes on the transpacific cruise of the CSS Endeavor. British Columbia Provincial Museum Heritage Record No. 18. 50 pages.
- Shimokawa, T., K. Amaoka, Y. Kajiwara, and S. Suyama. 1995. Occurrence of *Thalassenchelys coheni* (Anguilliformes: Chlopsidae) in the West Pacific Ocean. *Japanese Journal of Ichthyology* 42(1): 89–92.
- Smith, D. G. 1999a. Nettastomatidae, duckbill eels. Pages 1688–1690 in Batoid fishes, chimaeras and Bony fishes part 1 (Elopidae to Linophryniidae). Volume 3 of The Living Marine Resources of the Western Central Pacific. Edited by K. E. Carpenter and V. H. Niem. FAO Species Identification Guide for Fishery Purposes. Food and Agriculture Organization of the United Nations, Rome.
- Smith, D. G. 1999b. Serrivomeridae, sawtooth eels. Pages 1691–1692 in Batoid fishes, chimaeras and bony fishes part 1 (Elopidae to Linophryniidae). Volume 3 of The Living Marine Resources of the Western Central Pacific. Edited by K. E. Carpenter and V. H. Niem. FAO Species Identification Guide for Fishery Purposes. Food and Agriculture Organization of the United Nations, Rome.
- Stein, D. L., and A. E. Peden. 1979. First record of *Paraliparis paucidens* Stein (Pisces: Liparidae) from British Columbia waters. *Syesis* 12: 181.
- Workman, G. D., A. C. Phillips, F. E. Surrah, and J. A. Boutillier. 2000. Development of a Fishery for Tanner Crab (*Chionoecetes tanneri*) off the Coast of British Columbia. Canadian Stock Assessment Secretariat (CSAS), Research Document 2000/169. Fisheries and Oceans Canada. 71 pages.

Received 30 July 2012

Accepted 23 September 2012

# Notes

## Sea Ice Crossing by Migrating Caribou, *Rangifer tarandus*, in Northwestern Alaska

KYLE JOLY

National Park Service, Gates of the Arctic National Park and Preserve, Arctic Inventory and Monitoring Network, 4175 Geist Road, Fairbanks, Alaska 99709 United States

Joly, Kyle. 2012. Sea ice crossing by migrating Caribou. *Rangifer tarandus*, in northwestern Alaska. *Canadian Field-Naturalist* 126(3): 217–220.

Long movements across sea ice by Caribou (*Rangifer tarandus*) in Alaska are relatively uncommon and are not well documented. With rapidly diminishing sea ice cover in arctic waters, these movements may cease altogether. On 26 May 2012, a Caribou crossed a long span (57 km) of sea ice off the coast of Alaska. The cow successfully crossed after traveling 66 km on the sea ice and eventually reached the calving grounds. The highly dynamic nature of sea ice, which is driven by oceanic currents and wind during spring break-up, presents inherent hazards different from lake ice. Based on three years of Global Positioning System (GPS) radio-collar data, Caribou routinely crossed long expanses (30 km) of ice covering the brackish Selawik Lake and shorter stretches (<13 km) on Inland Lake during their spring migration north. There was also a single crossing on the ice covering Selawik Lake during the fall migration south to the wintering grounds that took place in early November 2010. Five GPS-collared Caribou crossed the short frozen span (14 km) of Kotzebue Sound between Cape Krusenstern National Monument and the Baldwin Peninsula in the fall of 2011.

**Key Words:** Caribou, *Rangifer tarandus*, climate change, migration, sea ice, Western Arctic Herd, Alaska.

In 2009, the Arctic Inventory and Monitoring Network of the U.S. National Park Service launched a program to monitor Caribou (*Rangifer tarandus*). One of the goals of this monitoring is to detect changes in the phenology and distribution of Caribou migrations. Although long-distance movements across sea ice are relatively common and are well documented in the Canadian Arctic Archipelago (e.g., Miller et al. 2005; Poole et al. 2010) and Eurasia (Klein and Kuzyakin 1982; Klein 1999), such movements are uncommon, but not unprecedented, and heretofore, to my knowledge, undocumented in Alaska.

### Study Area and Methods

My study area was along the northwestern coast of Alaska, where Western Arctic Herd Caribou have the potential to undertake relatively large ice crossings (Figure 1). The region is dominated by low tundra but shrublands and boreal forest habitats are common along the major waterways. The terrain is rugged in many places but elevations are generally <1100 m. In order to monitor Caribou, 68 cows of the Western Arctic Herd were fitted with satellite Global Positioning System (GPS) radio-collars (Telonics, TGW-4680, Mesa, Arizona, United States) from 2009 to 2011 that reported locations every 8 hours throughout the year. All animal handling followed Animal Welfare Policy guidelines and were approved by the Animal Care and Use Committee of the State of Alaska Division of Wildlife Conservation.

### Results

A GPS-collared Caribou left the shore of Cape Espenberg on 25 May 2012 and crossed the sea ice of Kotzebue Sound to reach Cape Krusenstern (Cow A) (Figure 1). The cow covered about 66 km of sea ice in approximately 28 hours. The straight-line distance between the two locations is about 57 km. The hills (elevation 500 m) in Cape Krusenstern National Monument were likely visible from high ground (elevation 20 m) near Cape Espenberg (see Miller et al. 2005).

The cow began her northbound migration on 15 May, after wintering within Bering Land Bridge National Preserve. Upon reaching the coast, where she found contiguous sea ice, she twice balked at crossing and worked her way east and reached land's end at Cape Espenberg before attempting the crossing of Kotzebue Sound (Figure 1). She traveled at an average speed of 0.54 km/hr (SD 0.25) until she reached the edge of the sea ice. The cow's average rate of travel during the crossing was about 2.33 km/hr (SD 0.88). Her pace slowed again, to 1.21 km/hr (SD 0.41), when she reached land at Cape Krusenstern National Monument. Although the ice pack was solid and covered nearly all of Kotzebue Sound (Figures 1 and 2), the cow's increased speed on it may have indicated a change in the urgency in her movement north. The Caribou continued north after reaching land and eventually made her way to the calving grounds on 9 June 2012 (Figure 3).

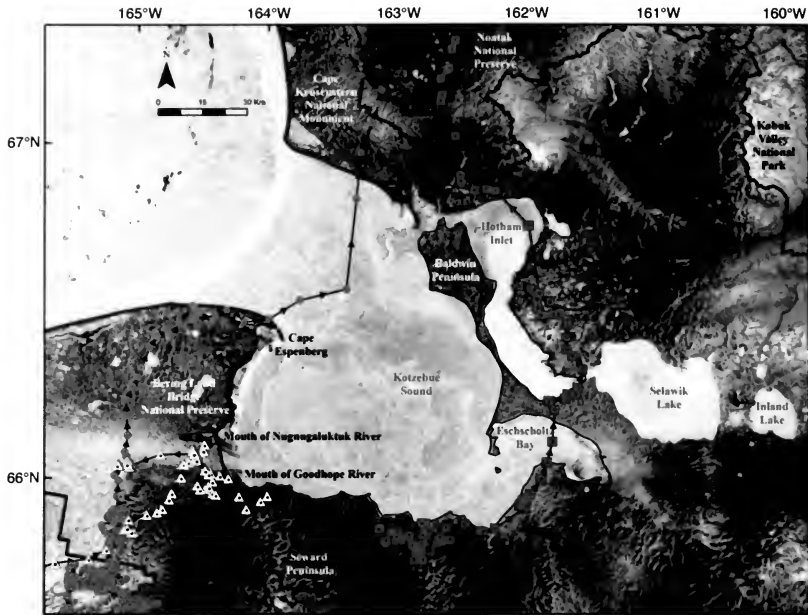


FIGURE 1. Northward spring migration of three radio-collared Caribou (*Rangifer tarandus*) of the Western Arctic Herd, May–June 2012. The background is a MODIS satellite image taken day 1 of the Caribou crossing of the Kotzebue Sound sea ice (26 May 2012). Markers represent GPS locations, collected every 8 hours, and lines show the route and direction of movement. Cow A (circles) headed north, crossed the frozen waters of Kotzebue Sound, and reached the calving grounds. Cow B (squares) migrated east round Kotzebue Sound and crossed its eastern reaches. Cow C (triangles) migrated northeast and reached Kotzebue Sound, where there were poor ice conditions (darker colors). She turned east to go around Kotzebue Sound but doubled back on 31 May 2012 and spent the calving and summer seasons in Bering Land Bridge National Preserve. MODIS satellite image: Geographic Information Network of Alaska. [www.gina.alaska.edu](http://www.gina.alaska.edu). (Accessed 25 June 2012).

Members of the Western Arctic Herd that overwinter on the central Seward Peninsula, which is on the western edge of the herd's winter range, typically migrate east around Kotzebue Sound before heading north (Figure 3). Eighteen other cows with GPS collars overwintered with Cow A on the Seward Peninsula, including 11 that were within 50 km of her. Seventeen of the 18 (94%) migrated east around Kotzebue Sound before heading north and making the >500 km journey to the calving grounds—adding >100 km on to their spring migration route versus the direct-line distance (Figure 3).

One of the cows that overwintered on the Seward Peninsula (Cow B) cut across 13.8 km of Eschscholtz Bay (which was ice covered) at the base of the Baldwin Peninsula (a straight-line distance of 13.3 km) as she migrated east around Kotzebue Sound in 2012 (Figure 1). Her rate of travel was 0.38 km/hr (SD 0.39) prior to the crossing, 1.12 km/hr (SD 0.22) during the crossing, and 0.25 km/hr (SD 0.21) after the crossing. Continuing north, she crossed 20 km of sea ice (straight-line distance of 19 km) on Hotham Inlet, northeast of Baldwin Peninsula (Figure 1). Again, her rate of travel across the ice (2.45 km/hr, SD 0.44) was greater than her rate prior to (0.43 km/hr, SD 0.30) or after (0.56 km/hr, SD 0.55) the crossing. She reached

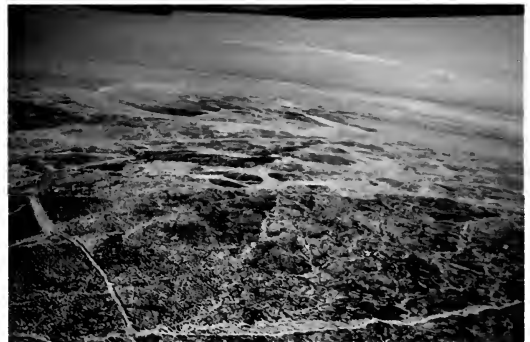


FIGURE 2. Photograph from a fixed-wing aircraft of Kotzebue Sound sea ice on 6 June 2012, 11 days after Cow A made the crossing. Photo: Marci Johnson, U.S. National Park Service.

the calving grounds by 30 May 2012. GPS-collared Caribou crossed the 30 km of brackish, frozen water of Selawik Lake, the state's third largest lake, during each spring migration of the project (2010–2012). At least 9 GPS-collared Caribou also traversed the approximately 12 km of ice in May on Inland Lake, which lies just east of Selawik Lake (Figure 1).

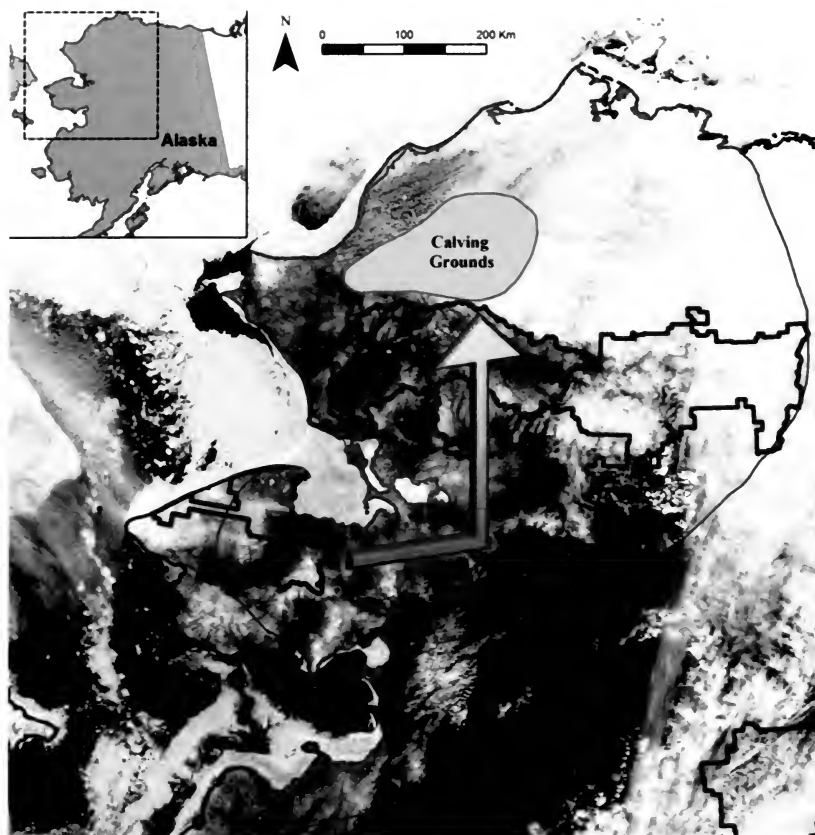


FIGURE 3. Range (red perimeter) and calving grounds of the Western Arctic Herd and the typical northbound spring migration route of Caribou (*Rangifer tarandus*) cows that overwinter on the Seward Peninsula (large arrow). The background is a MODIS satellite image (courtesy of Geographic Information Network of Alaska, [www.gina.alaska.edu](http://www.gina.alaska.edu), accessed 25 June 2012) taken 26 May 2012. Polygons are U.S. National Park units. Herd Range: Alaska Department of Fish and Game.

On the southbound fall migration, only one cow crossed the frozen Selawik Lake—on 1 November 2010. No GPS-collared cow definitely crossed Inland Lake on the fall migration. Five GPS-collared Caribou crossed the short frozen span (14 km) of Kotzebue Sound between the southern tip of Cape Krusenstern National Monument and the northern tip of the Baldwin Peninsula in November of 2011. Congruent with spring observations, fall travel rates were greater during the crossings of sea ice (2.72 km/hr, SD 0.61) than either before (1.20 km/hr, SD 1.09) or after (0.79 km/hr, SD 0.66) the crossings. The over-ice distance crossed by Caribou of the Western Arctic Herd falls within the range of distances traveled by Caribou in the Canadian Arctic Archipelago (e.g., Miller et al. 2005; Poole et al. 2010).

### Discussion

Given a warming Arctic and rapidly declining sea ice cover (Hinzman et al. 2005; Cosimo 2006), long-distance migrations over ice may become more infre-

quent and/or dangerous and could possibly cease altogether (Miller et al. 2005). Kotzebue Sound had extensive ice-free areas in May 2011 and has often (>33% of years) had open channels of water in May during the last decade (Geographic Information Network of Alaska 2012).

Pelagic water crossings are much more energetically demanding and are typically much shorter (<3 km) (Miller 1995; Ricca et al. 2012) than ice crossings. Unlike in the Canadian Arctic Archipelago, the loss of sea ice in Kotzebue Sound would not precipitate a functional loss of habitat because Caribou can and do migrate around Kotzebue Sound (Miller et al. 2005; this study). However, I posit that this potential change could have an impact on the number of Caribou that spend the summer on the Seward Peninsula in the future. Indeed, one GPS-collared cow that overwintered on the Seward Peninsula began to trek north in May 2012. She reached Kotzebue Sound near the mouth of the Nugnugaluktuk River on 23 May 2012 and approached Kotzebue Sound again on 27 May near

the mouth of the Goodhope River (Figure 1). Encountering ice conditions that were poor (dark areas in Figure 1), she started migrating east around Kotzebue Sound. After only a brief eastward movement, she doubled back the way she had come and was on the Seward Peninsula during the calving period and remained there for the duration of the summer. During a reconnaissance flight in July 2012, I was unable to determine whether she had a calf, as she was in a very tightly aggregated group of 300 that had about 30 calves. The ecological, nutritional and demographic impacts of summering on the Seward Peninsula on caribou are unclear at this time, however the region supported over 100,000 reindeer (*Rangifer tarandus*) less century ago (Stern et al. 1980).

### Acknowledgements

Funding for this work was provided by the U.S. National Park Service. This Caribou monitoring project is performed in collaboration with the Alaska Department of Fish and Game, the U.S. Bureau of Land Management, and the U.S. Fish and Wildlife Service. I thank Brad Shults, Jim Lawler, anonymous reviewers, and Canadian Field-Naturalist staff for providing recommendations for improving this manuscript.

### Literature Cited

- Comiso, J. C.** 2006. Abrupt decline in the arctic winter sea ice cover. *Geophysical Research Letters* 33: L18504. 5 pages. doi: 10.1029/2006GL027341.
- Geographic Information Network of Alaska.** 2012. www.gina.alaska.edu, accessed 25 June 2012.
- Hinzman, L. D., N. D. Bettez, W. R. Bolton, F. S. Chapin, M. B. Dyurgerov, C. L. Fastie, B. Griffith, R. D. Hollister, A. Hope, H. P. Huntington, A. M. Jensen, G. J. Jia, T. Jorgenson, D. L. Kane, D. R. Klein, G. Kofinas, A. H. Lynch, A. H. Lloyd, A. D. McGuire, F. E. Nelson, W. C. Oechel, T. E. Osterkamp, C. H. Racine, V. E. Romanovsky, R. S. Stone, D. A. Stow, M. Sturm, C. E. Tweedie, G. L. Vourlitis, M. D. Walker, D. A. Walker, P. J. Webber, J. M. Welker, K. S. Winker, and K. Yoshikawa.** 2005. Evidence and implications of recent climate change in northern Alaska and other arctic regions. *Climate Change* 72: 251–298.
- Klein, D. R.** 1999. The roles of climate and insularity in establishment and persistence of *Rangifer tarandus* populations in the High Arctic. *Ecological Bulletins* 47: 96–104.
- Klein, D. R., and V. Kuzyakin.** 1982. Distribution and status of wild reindeer in the Soviet Union. *Journal of Wildlife Management* 46: 728–733.
- Miller, F. L.** 1995. Inter-island water crossings by Peary Caribou, south-central Queen Elizabeth Islands. *Arctic* 48: 8–12.
- Miller, F. L., S. J. Barry, and W. A. Calvert.** 2005. Sea-ice crossings by caribou in the south-central Canadian Arctic Archipelago and their ecological importance. *Rangifer Special Issue* 16: 77–88.
- Poole, K. G., A. Gunn, B. R. Patterson, and M. Dumond.** 2010. Sea ice and migration of the Dolphin and Union Caribou Herd in the Canadian Arctic: an uncertain future. *Arctic* 63: 414–428.
- Ricca, M. A., F. W. Weckerly, A. Duarte, and J. C. Williams.** 2012. Range expansion of nonindigenous caribou in the Aleutian archipelago of Alaska. *Biological Invasions* 14: 1779–1784. DOI: 10.1007/s10530-012-0195-z.
- Stern, R. O., E. L. Arobio, L. L. Naylor, and W. C. Thomas.** 1980. Eskimos, reindeer, and land. University of Alaska, School of Agriculture and Land Management, Agricultural and Forestry Experiment Station Bulletin 59. 93 pages.

Received 3 July 2012

Accepted 9 October 2012

# Use of a Dorsal Radio-Transmitter Implant in American Badgers, *Taxidea taxus*

GILBERT PROULX and NEIL MACKENZIE

Alpha Wildlife Research & Management Ltd., 229 Lilac Terrace, Sherwood Park, Alberta T8H 1W3 Canada

Proulx, Gilbert, and Neil MacKenzie. 2012. Use of a dorsal radio-transmitter implant in American Badgers. *Taxidea taxus*. Canadian Field-Naturalist 126(3): 221–225.

We investigated the use of a dorsally implanted radio-transmitter in four American Badgers (*Taxidea taxus*) in southwestern Saskatchewan. The dorsal radio-transmitter did not appear to affect the health or behaviour of the animals. When the antenna was stretched out subcutaneously along the animal's back, the signal could be received from about 1 km away when the animal was above ground and from 750 m away when it was in the den. The dorsal implantation of radio-transmitters is a promising technique for the study of the movements of American Badgers.

Key Words: American Badger, *Taxidea taxus*, dorsal radio-transmitter implant, radio-telemetry, Saskatchewan.

Externally mounted radio-transmitters have commonly been used in the study of American Badgers (*Taxidea taxus*) but, because these animals have loose skin, a wide neck circumference relative to their head, and a burrowing lifestyle, the radio-transmitters have a tendency to get entangled and American Badgers shed the collars or harnesses (Messick and Hornocker 1981; Collins 2003). Abdominal (intraperitoneal) radio-transmitter implants may be used (Goodrich and Buskirk 1998; Apps et al. 2002), but health risks (e.g., omental adhesions, infections) have been reported in European Badgers (*Meles meles*) (Ågren et al. 2000), American Badgers (Quinn et al. 2010), and other mustelids (Eagle et al. 1984; Copeland 1996; Zschille et al. 2008).

## Study Area and Methods

We investigated the use of a dorsal radio-transmitter implant in American Badgers (*Taxidea taxus*) near Hazenmore (49°41'N, 107°08'W), in southwestern Saskatchewan. Our study area was located within the Brown soil zone characterized by warm temperatures, lack of moisture, and lack of organic matter. It encompassed mixed grasslands of Crested Wheatgrass (*Agropyron cristatum*), brome (*Bromus* spp.), Slender Wheatgrass (*Elymus trachycaulus*), alfalfa (*Medicago* spp.), and annual crops such as Wheat (*Triticum aestivum*) and Barley (*Hordeum vulgare*).

We used a snare pole to capture two orphaned male American Badgers approximately 10 weeks old (their mother had been road-killed) in June 2008 on a dirt road. Their maternal den was located in a nearby ditch bordering a pasture with various grasses. The den was approximately 1.5 km from the pasture where the young American Badgers with radio-transmitter implants would be released. We also captured with a snare pole one adult male in May 2010 on a dirt road adjacent to a Wheat field and a pasture dominated by Crested Wheatgrass where the American Badger hunted for Richardson's Ground Squirrels (*Urocyon richardsonii*). We

released the adult male with radio-transmitter implant at the capture site, at the edge of the Wheat field. We captured an adult female in a 36 × 36 × 92 cm wire mesh trap (model HD X-large, Duke Traps, West Point, Mississippi) in September 2008. The trap was set in a rock pile at the edge of a pasture with Crested Wheatgrass, brome, and buckbrush (*Ceanothus* spp.) where she hunted for Richardson's Ground Squirrels. We released the female American Badger with radio-transmitter implant beside the rock pile.

We transported the adult female in the wire mesh trap, and transferred the orphaned and the adult male American Badgers in a carrying cage, and anaesthetized them in a veterinary clinic with isoflurane. After an area 15 × 15 cm between the shoulder blades had been shaved and washed with antiseptic, the skin was peeled back from an incision 7 cm long (Figure 1).

With the young American Badgers and the adult female, we undermined the skin in an area sufficiently large to allow the introduction of a 25-g radio-transmitter with mortality mode, coiled whip antenna, and three-year battery life (model AI-2M, Holohil Systems Ltd., Carp, Ontario) (Figure 1). The 4.5 × 1.5 cm housing of the transmitter was a hermetically sealed brass cylinder. With the adult male, we lifted and freed the skin along the back to stretch out the 29-cm-long whip antenna subcutaneously to improve the distance of signal transmission. The incision was sutured, glued, and cleaned with hydrogen peroxide. The animals were injected with a non-steroidal anti-inflammatory drug and a dose of the antibiotic Tribissen 24% (Merck Animal Health, Kirkland, Quebec).

We monitored the American Badgers with a portable receiver (model TRX-2000S, Wildlife Materials Inc., Carbondale, Illinois) and a four-element Yagi antenna. We monitored the location of the young American Badgers daily, in the morning and at dusk, from 9 to 12 July 2008 at a distance of 300–500 m, which allowed us to observe the animals with binoculars. We

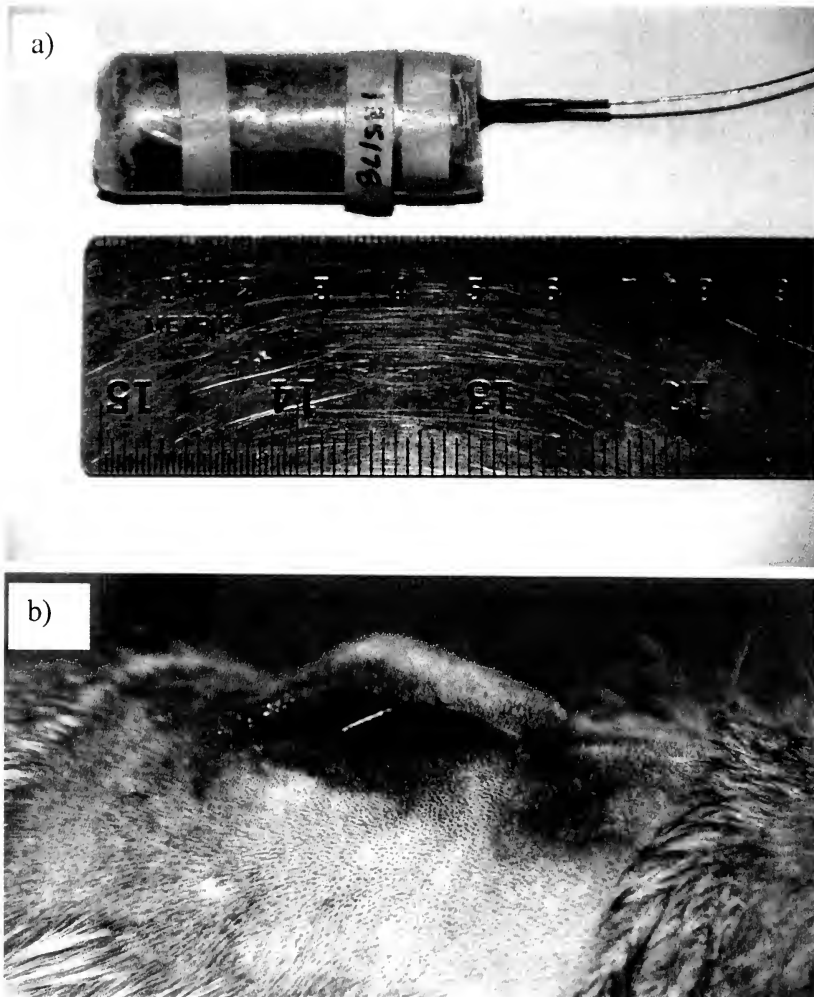


FIGURE 1. Radio-transmitter (a) implanted between the shoulder blades of an American Badger (*Taxus taxidea*) (b). Photo: G. Proulx

monitored the adult female's movements during 16 nights from September 29 to November 28 2008 (she was not active afterwards, when temperatures dropped to  $-20^{\circ}\text{C}$ ) and during irregular night visits from 2 May to 5 July 2009. Although she was present in her usual hunting grounds in 2010, we could not monitor her movements due to poor access caused by flooding. We monitored the adult male at night from 17 to 23 May and from 11 to 23 June 2010. We did not recapture the adult badgers to retrieve the radio-transmitters at the end of the study in July 2010.

In order to determine how far a radio signal could be received, we tried to locate the adult American Badgers at least 1 km away from the hunting grounds, where we observed them with a 400 000 candle power search light (Golight Inc., Culbertson, Nebraska). When we

did not find the animals, we drove slowly towards the hunting grounds until we received a radio signal. Sometimes, the animals were first detected with the search light, and we then confirmed their identity with the radio signal. When no radio signals were received, we drove near the edge of the hunting grounds or we walked through them to pinpoint the burrows where the animals were.

We considered that the American Badgers in their burrow system were close to the surface when we could hear them hissing or when the radio signal was very strong near the burrow entrance. We considered that the animals were deep below the surface when the radio signal was weak even when the antenna was placed near the burrow entrance. In a few instances, when the signal was weak, we used a push cable (snake type)





FIGURE 2. Young male American Badger (*Taxus taxidea*) at time of release, 9 July 2008. Photo: G. Proulx

video camera (model SWJ-3188D, Shenzhen FXT Technology Development Co., Shenzhen, China) to estimate how far below the surface the American Badgers were.

## Results

### *Young male American Badgers*

We captured the young American Badgers on 23 June 2008. The same day, one transmitter was implanted in one (1.7 kg) of the American Badgers. We kept both animals in a 4 × 4 m enclosure, and we observed their behavior with a remote video-camera until 6 July. During this observation period, the young male with the dorsally implanted radio-transmitter showed no sign of infection or discomfort. He never tried to scratch or rub the implant site, and his daily activities, movements, and feeding habits were identical to those of his sibling without an implant. Both animals were playful, fought over food, and dug holes within the enclosure.

Each young male American Badger ate approximately 300 g, i.e., 1.5 Richardson's Ground Squirrel carcasses, per day. In one instance, the young male with the implant gave chase to a Richardson's Ground Squirrel that had made its way inside the enclosure. He killed the Richardson's Ground Squirrel after capturing it by the upper thorax, as reported by Michener and Iwaniuk (2001), and proceeded to eat it.

Since the behaviour of the young male with the radio-transmitter implant appeared to be unaffected by the implant during the post-surgical recovery period, the second young male (3.1 kg) was equipped with a radio-transmitter implant on 6 July 2008 and was kept in the enclosure to recover for three days after the sur-

gery. At the time of release on 9 July 2008, both young American Badgers had doubled in size, the radio-transmitters were still at their implantation sites (i.e., they had not moved sideways), and both animals were of similar size.

We released the two young male American Badgers in a pasture approximately 300 m from an apparently abandoned American Badger burrow system. We chose this pasture because it was not subjected to Richardson's Ground Squirrel poisoning, which was common throughout southwestern Saskatchewan (Proulx and MacKenzie 2012). We also believed that no other American Badgers inhabited the pasture. However, on 29 September 2008, we captured an adult female 500 m from the apparently abandoned burrow. We surgically implanted a radio-transmitter in this female and found that she used a den less than 100 m from the abandoned burrow.

The young male American Badgers adopted the abandoned burrow system. They investigated their surroundings and fed on Richardson's Ground Squirrels. They were active all day, and at night they stayed in their burrow. We saw them for the last time on 12 July 2008, in the evening, prior to a thunderstorm with strong winds and heavy rain that saturated the grounds. We were not able to access the study area until 14 July, and we were not successful in finding the American Badgers. The following week, we searched for them daily, and thereafter on a weekly basis. On 25 September 2008, we found the remnants of a skin approximately 300 m from the young American Badgers' burrow. The skin was punctured in the thoracic region, and the site of the implant was obvious. However, the radio-transmitter was missing. We searched the pasture

and surrounding crops for signs of the other young American Badger but found no signs and received no radio-telemetry signal. On 30 September, we found a large regurgitation pellet with American Badger hairs approximately 500 m from the young American Badgers' burrow.

#### *Adult American Badgers*

We surgically implanted a radio-transmitter in the adult female American Badger on 29 September 2008 and released her approximately 6 hours after the surgery. We surgically implanted a radio-transmitter in the adult male on 17 May 2010 and released him a few hours later. They entered a nearby burrow system upon release, but we observed them digging out Richardson's Ground Squirrel burrow systems the same night. Thereafter, we located them in their usual hunting grounds.

#### *Radio signal*

Usually, the signal from the transmitters with the coiled antennas was received from  $\leq 250$  m away when the American Badgers were active above ground and from  $\leq 85$  m away when they were 1 m deep in their den. In one case, when the adult female was near the surface in a burrow system in a summer fallow, the signal was received from approximately 750 m away. Usually, the deeper the location of an animal in a burrow system, the weaker the signal. Also, when American Badgers were  $> 2$  m below the surface, the signal was received only when the antenna was nearby the occupied burrow.

The signal of the adult male's transmitter (with the antenna stretched out subcutaneously along the back) was received approximately 1 km away when he was above ground and from 750 m away when he was in the den ( $\leq 1.5$  m underground). When the American Badger was  $> 1.5$  m underground, if the tunnel went straight down, we had to aim the antenna directly over the den entrance in order to receive a signal.

#### **Discussion**

Biggins et al. (2006) reported using intraperitoneal and subcutaneous implants in American Badgers in 1984. They found that dorsally implanted subcutaneous units with implanted whip antennas 15.2 cm in length radiated more powerful signals than intraperitoneal units in the same animals, but abscesses that developed around the subcutaneous transmitters resulted in their premature loss. Echols et al. (2004) documented an overall implant surgery failure of 64% and a mean retention time of 101 days in American Black Bear (*Ursus americanus*) cubs with transmitters implanted between the base of the neck and the space between the shoulder blades. Although they could not explain all the circumstances under which implants came out of the cubs, it appears that body rejection and maternal and sibling intervention were important factors.

In the current study, on the basis of a very small sample size, we conclude that dorsal subcutaneous implants do not have an apparent effect on the health or behaviour of American Badgers. However, this study warrants further investigation with larger samples over long time periods to assess the transmitter housing, its wear or damage, and the long-term side effects on study animals that carry these implants throughout their lifespan (Thompson et al. 2012).

Subcutaneous and intraperitoneal implants have a relatively poor reception range compared with radio-collars (e.g., Green et al. 1985; Koehler et al. 2001) because the antennas are shorter (Korschgen et al. 1996) and the signal is absorbed by the body tissue (Kenward 1987; Biggins et al. 2006). The reduced signal is further attenuated by the animal's position in the burrow and terrain features nearby (Philo et al. 1981).

In this study, stretching the antenna subcutaneously along the animal's back allowed us to receive radio signals from a distance of 1 km when the animal was on the surface and from a distance of 750 m when it was underground. These distances are similar to or greater than those reported by other researchers for implants. The radio signal of subcutaneous transmitters implanted in the neck of Grizzly Bears (*Ursus arctos*) could be adequately received from an aircraft at a distance of 1.5 km, and the signal of subcutaneous abdominal transmitters implanted in Grizzly Bears could be received from 0.4–0.8 km away (Philo et al. 1981). Green et al. (1985) received signals transmitted from an abdominal implant 75–100 m away from Kit Foxes (*Vulpes macrotis*) in dens (1–2 m underground) and  $\geq 200$  m from Kit Foxes outside dens. In grasslands, Hunter (1998) received signals  $\leq 850$  m from a Lion (*Panthera leo*) with an abdominal transmitter implant.

While implants may not be suitable for locating far-ranging animals (Hunter 1998; Koehler et al. 2001), we found that the dorsally implanted radio-transmitters used in this study would be suitable for investigating questions related to American Badger habitat use (particularly at a fine scale), hunting grounds, and den utilization.

#### **Acknowledgements**

Advancing Canadian Agriculture & Agri-Food in Saskatchewan (as a Collective Outcome Project with Advancing Canadian Agriculture and Agri-Food in Alberta), Saskatchewan Agriculture Development Fund, and Saskatchewan Association of Rural Municipalities provided funding for this work. We thank Dr. Bonnie Brandt from the Animal Hospital of Assiniboia for implanting the transmitters and Keith MacKenzie for technical support. We are grateful to Pauline Feldstein, Thomas Jung, and Carolyn Callaghan for their comments on an earlier version of this manuscript.

### Literature Cited

- Ågren, E. O., L. Nordenberg, and T. Mörner.** 2000. Surgical implantation of radio-telemetry transmitters in European badgers (*Meles meles*). *Journal of Zoo and Wildlife Medicine* 31: 52–55.
- Apps, C. D., N. J. Newhouse, and T. A. Kinley.** 2002. Habitat associations of American badgers in southeastern British Columbia. *Canadian Journal of Zoology* 80: 1228–1239.
- Biggins, D. E., J. L. Godbey, B. J. Miller, and L. R. Hanebury.** 2006. Radio telemetry for black-footed ferret research and monitoring. Pages 175–190 in *Recovery of the Black-footed Ferret: Progress and Continuing Challenges — Proceedings of the Symposium on the Status of the Black-footed Ferret and its Habitat*. Fort Collins, Colorado, January 28–29, 2004. Edited by J. E. Rolle, B. J. Miller, J. L. Godbey, and D. E. Biggins. U.S. Geological Survey, Fort Collins, Colorado. Scientific Investigations Report 2005-5293.
- Collins, D. P.** 2003. Badger ecology on the Chapparral Wildlife Management Area, Texas. M.Sc. thesis, Stephen F. Austin State University, Nacogdoches, Texas.
- Copeland, J. P.** 1996. Biology of the wolverine in central Idaho. M.Sc. thesis, University of Idaho, Moscow, Idaho.
- Eagle, E. C., J. Choromanski-Norris, and V. B. Kuechle.** 1984. Implanting radio transmitters in mink and Franklin's ground squirrels. *Wildlife Society Bulletin* 12: 180–184.
- Echols, K. N., M. R. Vaughan, and H. D. Moll.** 2004. Evaluation of subcutaneous implants for monitoring American black bear cub survival. *Ursus* 15: 172–180.
- Goodrich, J. M., and S. W. Buskirk.** 1998. Spacing and ecology of North American badgers (*Taxidea taxus*) in a prairie-dog (*Cynomys leucurus*) complex. *Journal of Mammalogy* 79: 171–179.
- Green, J. S., R. T. Golightly, S. L. Lindsey, and B. R. Leamaster.** 1985. Use of radio transmitter implants in wild canids. *Great Basin Naturalist* 45: 567–570.
- Hunter, L. T. B.** 1998. The behavioural ecology of reintroduced lions and cheetahs in the Phinda Resource Reserve, Kwazulu-Natal, South Africa. Ph.D. thesis, University of Pretoria, Pretoria, South Africa.
- Kenward, R.** 1987. *Wildlife Radio Tagging: Equipment, Field Techniques and Data Analysis*. Academic Press, London, U.K.
- Koehler, G. M., P. Briggs Hall, M. H. Norton, and J. J. Pierce.** 2001. Implant- versus collar-transmitter use on black bears. *Wildlife Society Bulletin* 29: 600–605.
- Korschgen, C. E., K. P. Kenow, A. Gendron-Fitzpatrick, W. L. Green, and J. Dein.** 1996. Implanting intra-abdominal radiotransmitters with external whip antennas in ducks. *Journal of Wildlife Management* 60: 132–137.
- Messick, J. P., and M. G. Hornocker.** 1981. Ecology of the badger in southwestern Idaho. *Wildlife Monograph* 76: 1–53.
- Michener, G. R., and A. N. Iwaniuk.** 2001. Killing technique of North American badgers preying on Richardson's ground squirrels. *Canadian Journal of Zoology* 79: 2109–2113.
- Philo, L. M., E. H. Follmann, and H. V. Reynolds.** 1981. Field surgical techniques for implanting temperature-sensitive radio transmitters in grizzly bears. *Journal of Wildlife Management* 45: 772–775.
- Proulx, G., and N. MacKenzie.** 2012. Relative abundance of American badger (*Taxidea taxus*) and red fox (*Vulpes vulpes*) in two landscapes with high and low rodenticide poisoning levels. *Integrative Zoology* 7: 41–47.
- Quinn, J. H., P. M. Gaffney, M. Murray, D. A. Jessup, and C. K. Johnson.** 2010. Complication associated with abdominal surgical implantation of a radio transmitter in an American badger (*Taxidea taxus*). *Journal of Zoo and Wildlife Medicine* 41: 174–177.
- Thompson, C. M., R. A. Green, J. Sauder, K. L. Purcell, R. A. Sweitzer, and J. M. Arnemo.** 2012. The use of radiotelemetry in research on *Martes* species: techniques and technologies. Pages 284–319 in *Biology and Conservation of Martens, Sables, and Fishers: A New Synthesis*. Edited by K. Aubry, B. Zielinski, M. Raphael, G. Proulx, and S. Buskirk. Cornell University Press, Ithaca, New York.
- Zschille, J., N. Stier, and M. Roth.** 2008. Radio tagging American mink (*Mustela vison*)—experience with collar and intraperitoneal-implanted transmitters. *European Journal of Wildlife Research* 54: 263–268.

Received 8 November 2011

Accepted 3 October 2012

# Observations of Nocturnal Hunting Behaviour of American Badgers, *Taxidea taxus*, in Southwestern Saskatchewan

GILBERT PROULX and NEIL MACKENZIE

Alpha Wildlife Research & Management Ltd., 229 Lilac Terrace, Sherwood Park, Alberta T8H 1W3 Canada

Proulx, Gilbert, and Neil MacKenzie. 2012. Observations of nocturnal hunting behaviour of American Badgers, *Taxidea taxus*, in southwestern Saskatchewan. *Canadian Field-Naturalist* 126(3): 226–230.

This study describes the nocturnal hunting behaviour of American Badgers (*Taxidea taxus*) in areas inhabited by Richardson's Ground Squirrels (*Urocitellus richardsonii*) in southwestern Saskatchewan. Adult American Badgers searched for prey by zigzagging through clusters of Richardson's Ground Squirrel burrows or by going back and forth between one enlarged Richardson's Ground Squirrel burrow and other adjacent burrows. American Badgers' movements were not random and they were oriented to encounter prey.

Key Words: American Badger, *Taxidea taxus*, behaviour, hunting, movements, Richardson's Ground Squirrel, *Urocitellus richardsonii*, *Spermophilus richardsonii*, Saskatchewan.

American Badgers (*Taxidea taxus*) are known for their ability to capture subterranean rodents (Lampe 1976; Murie 1992; Michener 2004). Regardless of season, the most common technique used by American Badgers is excavation (Michener 2004). American Badgers may dig several holes at a site (Lampe 1976; Michener 2004), and they will even plug tunnel openings to confine potential prey (Knopf and Balph 1969; Michener 2004).

Although American Badgers are known to prey on ground squirrels (*Urocitellus* spp.) (Yensen and Sherman 2003), little is known about their hunting movements. Murie (1992) found no obvious spatial pattern to the sequence in which American Badgers dug into the nest burrows of Columbian Ground Squirrels (*Urocitellus columbianus*). On the other hand, Lampe (1976) suggested that American Badgers deliberately dig many holes to intersect the burrows of Plains Pocket Gophers (*Geomys bursarius*).

During a research and control program on Richardson's Ground Squirrels (*Urocitellus richardsonii*) in southwestern Saskatchewan between 2008 and 2010, we found a few American Badgers residing in our study areas. This study describes the nocturnal hunting behaviour of American Badgers in areas inhabited by Richardson's Ground Squirrels.

## Study Area and Methods

The study was carried out near Hazenmore (49°41'N, 107°08'W), in southwestern Saskatchewan (Figure 1). This is an agricultural region located within the Brown soil zone characterized by warm temperatures, lack of moisture, and lack of organic matter. It encompassed mixed grasslands of Crested Wheatgrass (*Agropyron cristatum*), brome (*Bromus* spp.), Slender Wheatgrass (*Elymus trachycaulus*), alfalfa (*Medicago* spp.), and annual crops such as Wheat (*Triticum aestivum*) and Barley (*Hordeum vulgare*). During the last decade, pop-

ulations of Richardson's Ground Squirrels reached high densities (often exceeding 40 adults/ha in spring) (Proulx et al. 2010) due to an extensive drought (Liu et al. 2004).

We identified three adult American Badgers that regularly used grasslands and pastures within our study area. We used 12 × 42 binoculars and a 400 000 candle power search light (Golight, Inc., Culbertson, Nebraska) with a reach of ≤800 m to study American Badger hunting activities. We avoided disturbing the animals with spotlighting by staying >100 m away from them and avoiding centering the light beam on their eyes. We stayed in contact with moving animals by eye shine, and we avoided making loud sounds, walking, or moving the vehicle when an animal was under observation. During some spotlighting sessions, although American Badgers were obviously hunting, we could not see them well enough to describe their hunting movements, and we occasionally lost track of them.

We equipped two of these adult American Badgers with radio-transmitters. We captured an adult female American Badger on 29 September 2008 in a 36 × 36 × 92 cm wire mesh trap (model HD X-large, Duke Traps, West Point, Miss.), and we dorsally implanted a 25-g radio-transmitter with mortality mode, coiled whip antenna, and three-year battery life (model AI-2M, Holo-hil Systems Ltd., Carp, Ont.) (Proulx and MacKenzie 2012). The adult female American badger inhabited a pasture (31.4 ha)-annual crop (16.2 ha) complex. The pasture encompassed Crested Wheatgrass, brome, and buckbrush (*Ceanothus* spp.). It was bordered by Wheat on one side, and Yellow Mustard (*Sinapis alba*) on the other side.

We also captured an adult male American Badger with a snare pole on 17 May 2010, and we dorsally implanted a radio-transmitter with an antenna stretched subcutaneously along his back (Proulx and MacKenzie 2012). He inhabited a Crested Wheatgrass pasture (24

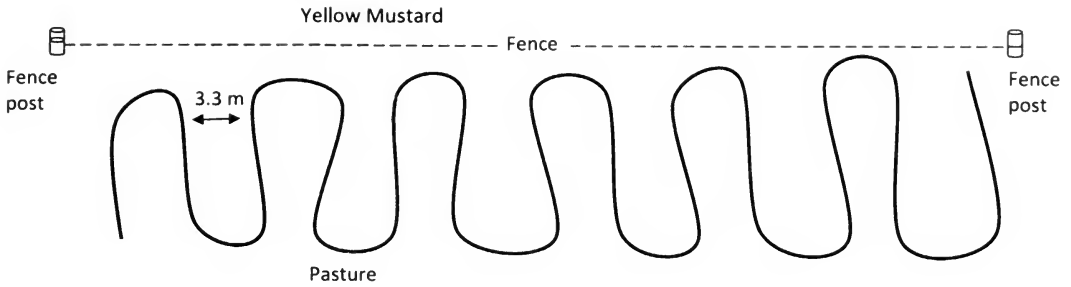


FIGURE 1. Zigzag hunting movements of the adult female American Badger (*Taxidea taxus*) equipped with the radio-transmitter.

ha)-annual crop (104 ha) complex. Crops consisted of Wheat (70%) and seeded alfalfa (30%).

The third adult American Badger was an adult female (she was seen with two kits in summer) without a radio-transmitter. We recognized her on the basis of its appearance, and recurring activities at specific locations within a 129 ha area consisting of summer fallow (12%), and annual crops of alfalfa (5%), Wheat (33%), and Crested Wheatgrass (50%).

We used spotlight observations and radio signals to identify hunting grounds (areas of intense hunting repeatedly used for several days) that we mapped on 1:5000 orthophotos (geometrically corrected aerial photographs; Geomatics Corp, Lethbridge, Alberta) using features such as fence posts, rock piles, and terrain characteristics. The day after each spotlighting session, we visited the areas where the animals had been observed in order to confirm specific locations where they had been active the night before and to record signs of digging. We marked the boundaries of the American Badgers' hunting grounds and determined the number of Richardson's Ground Squirrel burrow entrances/ha. Only entrances that were well opened and without collapsed dirt or vegetation growing in the entrance were counted (Schmutz and Hungle 1989; Finger et al. 2007\*).

## Results

### *Observation sessions and hunting grounds*

We observed the adult female American Badger inhabiting a pasture on 26 and 27 September 2008 with a spotlight, and we captured her and implanted the radio-transmitter on 29 September (Proulx and MacKenzie 2012). We monitored the movements of this adult female during 16 nights from 29 September to 28 November 2008 (she was not active afterwards, when temperatures dropped to  $-20^{\circ}\text{C}$ ), and during irregular night visits from 2 May to 5 July 2009. We collected 1953 minutes of spotlighting observations of this adult female over 18 nights: 2 spotlighting sessions of 60 minutes before the radio-transmitter was implanted and 16 sessions, ranging from 11 to 210 minutes (average 102.1 minutes, SD 54.8), after the radio-transmitter was implanted. The female was observed in four hunting grounds ranging in size from 0.10 to

0.38 ha that had, on average, 1308 (SD 608) Richardson's Ground Squirrel burrow entrances/ha, indicating that Richardson's Ground Squirrel populations were well established.

The second American Badger was an adult male that inhabited another pasture. We spotlighted the adult male eight times, from 25 July to 22 November 2009, but observations were <15 minutes in length because of the hilly topography and high vegetation in the meadow. In spring 2010, the animal was using the same sites as in fall 2009. We captured and equipped the male American Badger with the radio-transmitter in May 2010 (Proulx and MacKenzie 2012). We observed his hunting behaviour with the spotlight from 17 to 23 May and from 11 to 23 June 2010. Five observation sessions ranged from 15 to 70 minutes (average 39 minutes, SD 22.2). Observations occurred in five hunting grounds ranging in size from 0.11 to 0.80 ha and had, on average, 824 (SD 212) Richardson's Ground Squirrel burrow entrances/ha.

The third American Badger was an adult female without a radio-transmitter. We observed her hunting behaviour with the spotlight in an alfalfa field and a summer fallow during five sessions from 26 to 30 July 2009 and during two sessions on 19 May 2010. We spotted this adult female a total of seven times in three areas of a summer fallow. Observation periods ranged from 10 to 45 minutes (average 24.3 minutes, SD 12.1). Terrain features were scarce, and we subjectively established the borders of the hunting grounds on the basis of clusters of Richardson's Ground Squirrel burrows and American Badger diggings. These hunting grounds were 0.49 ha in size and they had, on average, 161 (SD 110) Richardson's Ground Squirrel burrow entrances/ha.

### *Sinuuous movements*

When hunting, the adult female with the radio-transmitter methodically zigzagged along the pasture side of a fence line that separated the pasture from an annual crop, for distances of up to 150 m, and investigated Richardson's Ground Squirrel burrow entrances (Figure 1). This behaviour was observed during 5 of 18 spotlighting sessions. The female walked with her head down, smelled entrances, and dug small, shallow holes

at or in between burrows (Figure 2). The amplitude of the zigzags and the distance between zigzags varied among sessions but could exceed 3 m (Figure 1). We also observed that this adult female walked in a more or less sinuous manner (i.e., low amplitude and irregular zigzags) among forbs growing along the fence in order to feed on grasshoppers.

We observed the adult male zigzagging between Richardson's Ground Squirrel burrow entrances. This behaviour was observed in 2 of 14 spotlighting sessions. On subsequent mornings, we found newly dug small holes among clusters of Richardson's Ground Squirrel burrow entrances.

We observed the adult female American Badger that did not have a radio-transmitter zigzagging slowly during 3 of 7 spotlighting sessions. She dug several small holes near fence lines and smelled the ground at or enlarged Richardson's Ground Squirrel burrow entrances. We also observed her with a Richardson's Ground Squirrel in her mouth while she was engaged in enlarging a burrow entrance.

#### *Back-and-forth movements*

During two sessions, the adult female with the radio-transmitter went back and forth between Richardson's Ground Squirrel burrow systems. First, we observed the adult female making repetitive, straight-line movements between two Richardson's Ground Squirrel entrances that could be as far as 6 m apart, all the time sniffing the ground. At each hole, the female went down and returned quickly above ground, always moving a significant amount of dirt and widening both entrances.

On another occasion, the adult female moved back and forth between one enlarged Richardson's Ground Squirrel burrow hole and several other burrow entrances. From the enlarged burrow entrance, the female moved straight to another Richardson's Ground Squirrel burrow entrance that was >10 m away, sniffed it, and returned to the enlarged entrance, where she went down and quickly returned above ground to initiate the same type of movement at a second burrow entrance (Figure 3). The adult female did not go back to previous burrow entrances, and she systematically investigated each Richardson's Ground Squirrel burrow entrance in a consecutive manner without missing any of them, always starting from the enlarged hole. During one of these hunting sessions, the adult female carried the head of a Richardson's Ground Squirrel in her mouth.

We observed the adult male display back-and-forth hunting movements in 2 of 14 sessions. The male American Badger had dug out one large hole, from which he investigated several Richardson's Ground Squirrel burrow entrances in a triangular formation, similar to the behaviour we observed with the adult female equipped with the radio-transmitter (Figure 3).

#### **Discussion**

Sinuous hunting movements have been reported in the past for the Ermine (*Mustela erminea*) (Powell



FIGURE 2. The adult female American Badger (*Taxidea taxus*) equipped with the radio-transmitter dug out a series of small, shallow holes while zigzagging along the fence line.

1978) and the Long-tailed Weasel (*Mustela frenata*) (Proulx 2005) as a strategy to increase their chances of encountering prey. In this study, American Badgers zigzagged through clusters of Richardson's Ground Squirrel burrows, i.e., in areas where there are numerous burrow entrances to access prey.

These were not random movements. They were spatially located to encounter prey. American Badgers are known to make a series of shallow "exploratory" excavations to detect the presence of Plains Pocket Gophers (Lampe 1976). This is exactly what American Badgers did in search of Richardson's Ground Squirrels, i.e., they dug small holes, and they sometimes enlarged burrows to capture the resident Richardson's Ground Squirrel(s).

The burrow systems of Richardson's Ground Squirrels may consist of many tunnels and chambers (Michener 2002, 2012\*), so American Badgers need to dig exploratory holes to find their prey. Olfactory or auditory clues, or both, are likely used to identify occupied nest burrows (Murie 1992). The systematic search for Richardson's Ground Squirrels from above ground would certainly be necessary when Richardson's Ground Squirrels enter hibernation and block their tunnels with soil plugs (see Michener 2012\*).

Back-and-forth movements have not been described in the past (e.g., Michener 2004), and it is unlikely that

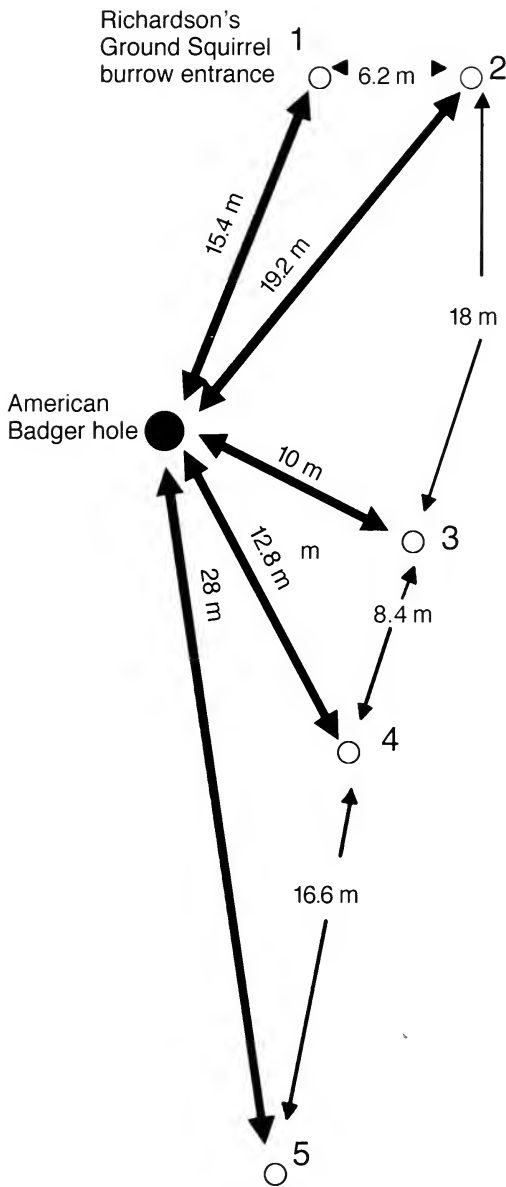


FIGURE 3. Back-and-forth hunting movements of the adult female American Badger (*Taxidea taxus*) equipped with the radio-transmitter. Arrows indicate the movement pattern of the American Badger between the hole she had enlarged (large filled circle) and the five Richardson's Ground Squirrel entrances (open circles).

someone could surmise their existence without witnessing American Badgers in action. However, because Richardson's Ground Squirrels may use a series of different underground chambers within the same area (Michener 2012\*) and yearlings may establish them-

selves near their natal home area (Michener and Michener 1973), the use of back-and-forth movements by American Badgers appears to be a suitable strategy to determine which chambers within a burrow system, or which adjacent burrow systems, are occupied by prey. Back-and-forth movements were not performed at random. They were carried out in areas where there were many Richardson's Ground Squirrel burrow entrances and therefore offered easy access to an underground tunnel network.

Favreau (2006) pointed out that animals with no knowledge of resource distributions may be most successful at finding resources by moving in a random walk (Bovet and Benhamou 1988). As cognitive ability increases, non-random movement patterns should develop if such movements will increase foraging success. The use of oriented movements such as zigzag and back-and-forth movements among clusters of Richardson's Ground Squirrel burrows indicates that American Badgers recognize these habitat patches as favourable for the detection of prey.

### Acknowledgements

Advancing Canadian Agriculture & Agri-Food in Saskatchewan (as a Collective Outcome Project with Advancing Canadian Agriculture and Agri-Food in Alberta), the Saskatchewan Agriculture Development Fund, and the Saskatchewan Association of Rural Municipalities provided funding for this work. We thank Pauline Feldstein from Alpha Wildlife for reviewing an earlier version of this manuscript.

### Documents Cited (marked \* in text)

- Finger, R., G. J. Wiles, J. Tabor, and E. Cummins.** 2007. Washington ground squirrel surveys in Adams, Douglas, and Grant counties, Washington, 2004. Washington Department of Fish and Wildlife, Olympia, Wash.
- Michener, G. R.** 2012. Burrow system of Richardson's Ground Squirrels (also known as gophers). *In* Richardson's Ground Squirrels (also known as gophers). By G. R. Michener. University of Lethbridge, Lethbridge, Alberta. <http://research.uleth.ca/rgs/burrow.cfm>.

### Literature Cited

- Bovet, P., and S. Benhamou.** 1988. Spatial analysis of animals' movements using a correlated random walk model. *Journal of Theoretical Biology* 131: 419–433.
- Favreau, J. M.** 2006. The effects of food abundance, foraging rules and cognitive abilities on local animal movements. Ph.D. thesis, North Carolina State University, Raleigh, North Carolina.
- Knopff, F. L., and D. F. Balph.** 1969. Badgers plug burrows to confine prey. *Journal of Mammalogy* 50: 635–636.
- Lampe, R. P.** 1976. Aspects of the predatory strategy of the North American badger, *Taxidea taxus*. Ph.D. thesis, University of Minnesota, Minneapolis, Minnesota.
- Liu, J., R. E. Stewart, and K. Szeto.** 2004. Moisture transport and other hydrometeorological features associated with the severe 2000/01 drought over the Western and Central Canadian Prairies. *American Meteorological Society* 17: 305–319.

- Michener, G. R.** 2002. Seasonal use of subterranean sleep and hibernation sites by adult female Richardson's ground squirrels. *Journal of Mammalogy* 83: 999–1012.
- Michener, G. R.** 2004. Hunting techniques and tool use by North American badgers preying on Richardson's ground squirrels. *Journal of Mammalogy* 85: 1019–1027.
- Michener, G. R., and D. R. Michener.** 1973. Spatial distribution of yearlings in a Richardson's ground squirrel population. *Ecology* 54: 1138–1142.
- Murie, J. O.** 1992. Predation by badgers on Columbian ground squirrels. *Journal of Mammalogy* 73: 385–394.
- Powell, R. A.** 1978. A comparison of fisher and weasel hunting behaviour. *Carnivore* 1: 28–34.
- Proulx, G.** 2005. Long-tailed weasel, *Mustela frenata*, movements and diggings in alfalfa fields inhabited by northern pocket gophers, *Thomomys talpoides*. *Canadian Field-Naturalist* 119: 175–180.
- Proulx, G., and N. MacKenzie.** 2012. Use of a dorsal radio-transmitter implant in American Badgers, *Taxidea taxus*. *Canadian Field-Naturalist*.
- Proulx, G., N. MacKenzie, K. MacKenzie, K. Walsh, B. Proulx, and K. Stang.** 2010. Strychnine for the control of Richardson's ground squirrels: efficiency and selectivity issues. Pages 125–128 in *Proceedings of the 24th Vertebrate Pest Conference*, Sacramento, California, February 22–25, 2010. Edited by R. M. Timm and K. A. Fagerstone. University of California, Davis, Davis, California.
- Schmutz, J. K., and D. J. Hungle.** 1989. Populations of ferruginous and Swainson's hawks increase in synchrony with ground squirrels. *Canadian Journal of Zoology* 67: 2596–2601.
- Yensen G. E., and P. W. Sherman.** 2003. Ground squirrels: *Spermophilus* and *Amnospermophilus* species. Pages 211–231 in *Wild mammals of North America: Biology, Management, and Conservation*. Edited by G. A. Feldhamer, B. C. Thompson, and J. A. Chapman. Johns Hopkins University Press, Baltimore, Maryland.

Received 8 November 2011

Accepted 14 September 2012



# A Significant Range Extension for the Eastern Ribbonsnake, *Thamnophis sauritus*, in Nova Scotia, Canada

JOHN GILHEN<sup>1</sup>, ALICE JONES<sup>2</sup>, JEFFIE MCNEIL<sup>3</sup>, and ARTHUR W. TANNER<sup>4</sup>

<sup>1</sup>Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6 Canada; email: gilhenja@gov.ns.ca

<sup>2</sup>586 Crouse Settlement Road, Italy Cross, Lunenburg County, Nova Scotia B4V 0P8 Canada

<sup>3</sup>Mersey Tobeatic Research Institute, 9 Mount Merrit Road, P.O. Box 215 Kempt, Queens County, Nova Scotia B0T 1B0 Canada

<sup>4</sup>91 Fitch Road, Conquerall Mills, Lunenburg County, Nova Scotia B4V 6E3 Canada

Gilhen, John, Alice Jones, Jeffie McNeil, and Arthur W. Tanner. 2012. A significant range extension for the Eastern Ribbonsnake, *Thamnophis sauritus*, in Nova Scotia, Canada. *Canadian Field-Naturalist* 126(3): 231–233.

In Nova Scotia the threatened Northern Ribbonsnake, *Thamnophis sauritus septentrionalis*, (the northern subspecies of the Eastern Ribbonsnake, *T. sauritus*) (Crother 2008) is known from localities in only Queens and Lunenburg counties, where it was first discovered in 1950. Many new localities, mostly in the headwaters of the Mersey River and the Medway River watersheds have been added since 2002, and Seven Mile Lake (in the West La Have River watershed) was added to the distribution in 2005. We add two localities to the distribution of the Northern Ribbonsnake in the previously unreported Petite Rivière watershed, Lunenburg County, Nova Scotia.

**Key Words:** Northern Ribbonsnake, *Thamnophis sauritus septentrionalis*, Eastern Ribbonsnake, *Thamnophis sauritus*, species at risk, new localities, Minamkeak Lake, Mud (Snake) Lake, Italy Cross, Petite Rivière watershed, Nova Scotia.

On 15 August 2011 one adult Eastern Ribbonsnake, *Thamnophis sauritus*, was observed and photographed by Arthur Tanner at Minamkeak Lake, Lunenburg County, Nova Scotia (approximately 44°17'19.82"N, 64°38'39.89"W) (Figure 1). On the 18 January 2012 another adult was discovered by Alice Jones near Mud (Snake) Lake, Italy Cross, Lunenburg County, Nova

Scotia (44°16.256'N, 64°33.299'W). A picture was taken by cell phone and is on file at the Nova Scotia Museum of Natural History. Both localities are within the Petite Rivière watershed, which has been added to the range of the Eastern Ribbonsnake in Nova Scotia (Figure 2). The Italy Cross record represents the only January sighting of the Eastern Ribbonsnake in Nova Scotia.



FIGURE 1. Northern Ribbonsnake, *Thamnophis sauritus septentrionalis*, from Minamkeak Lake, Lunenburg County, Nova Scotia, 15 August 2011. Photo Arthur Tanner.

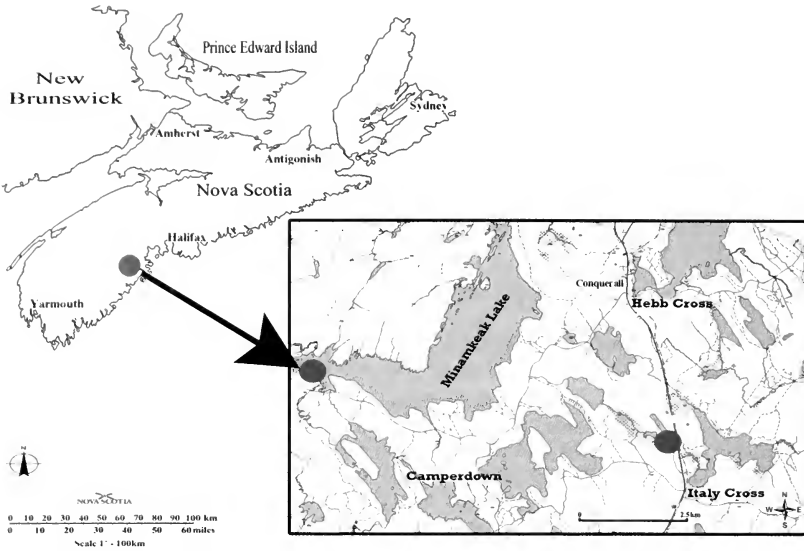


FIGURE 2. Distribution of the Northern Ribbonsnake, *Thamnophis sauritus septentrionalis*, in the Petite Rivière watershed, Lunenburg County, Nova Scotia.

This location is approximately 35 km south east of Seven Mile Lake, the nearest previously recorded Eastern Ribbonsnake location.

### Discussion

The Eastern Ribbonsnake, *Thamnophis sauritus*, is a complex of four subspecies widespread in eastern North America (Ernst and Ernst 2003). Canadian populations are represented by the Northern Ribbonsnake, *Thamnophis sauritus septentrionalis* (Cook 1984; Gilhen 1984). The Northern Ribbonsnake is a slender satiny black snake with yellow dorsal and lateral stripes. It has a caramel brown stripe below the yellow lateral stripes, and it always has yellowish white pre-ocular scales.

The *Thamnophis sauritus septentrionalis* was unknown in Nova Scotia until 12 July 1950 when an adult male and a female were discovered at a bog pond near Kempt, Queens County, in the Medway River watershed (Bleakney 1951). Later the same day another adult female was found at Caledonia, Queens County, and a third adult female was taken at Kempt on 20 July 1950 (Bleakney 1951). Over the next 50 years very few Northern Ribbonsnakes were recorded and almost all of those were within the headwaters of the Mersey River and the Medway River watersheds.

The Atlantic population of the Eastern Ribbonsnake was designated as threatened by the Committee on the Status of Wildlife in Canada in May 2002 (COSEWIC 2002), and subsequently was listed under the Nova Scotia Endangered Species Act. The Eastern Ribbonsnake Recovery Team was established in 2003.

Like the Blanding's Turtle, *Emdoidea blandingii*, the Northern Ribbonsnake is a climatic relict from the warm Hypsithermal period, of 3000 to 5000 years before present (Parks Canada Agency 2012) (see Bleakney 1958; Cook 1984; Gilhen 1984). During the Hypsithermal the range of the Eastern Ribbonsnake is thought to have been continuous throughout New Brunswick and the northeastern United States. Today in the Maritimes, the Northern Ribbonsnake is found in only southwestern Nova Scotia, the warmest region in the Maritimes (Bleakney 1958; Cook 1984; Gilhen 1984).

The principal objectives of the Eastern Ribbonsnake Recovery Team have been to determine the extent of the distribution in Nova Scotia and to estimate the population size (Parks Canada Agency 2012). Through the field efforts of volunteers and the recovery team (over a dozen individuals), new localities have been discovered, mostly in the headwaters of the Mersey River and the Medway River watersheds. On 13 July 1995 Seven Mile Lake, in the western LaHave River watershed, was included. Reports from East Lake, Annapolis River watershed, are currently being investigated (Eastern Ribbonsnake Recovery Team. 2012. Nova Scotia Ribbonsnake Database accessed 20 February 2012).

The earliest appearance in spring and latest observation in autumn of most species of amphibians and reptiles in Nova Scotia listed by Gilhen (1984) have been recorded by numerous individuals. Alice Jones' observation of an Eastern Ribbonsnake on 18 January 2012 is the only winter record for the Eastern Rib-

bonsnake and is probably linked to climate change. The snake was active on the woods road near Mud Lake and Edward Himmelman, owner of the property at Italy Cross, mentioned the air temperature was about 10°C, warm enough to work in the woods in short sleeves.

### Acknowledgements

The authors are grateful to Andrew Hebda, Curator of Zoology, Nova Scotia Museum of Natural History, for valuable comments and suggestions. The distribution map was prepared by Roger Lloyd, Collections Unit of the Nova Scotia Museum. We are grateful to Randall Himmelman for his assistance in the field and to his brother, Edward Himmelman for permission to investigate the observation site on his property at Italy Cross.

### Documents Cited (marked \* in text)

**Committee on the Status of Endangered Wildlife in Canada (COSEWIC)**, 2002. COSEWIC assessment and status report on the eastern ribbonsnake, *Thamnophis sauritus*. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario.

**Scientific and Standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding.** Com-

mittee on Standard English and Scientific Names. Sixth Edition. Edited by Brian I. Crother. 2008. Society for the study of amphibians and reptiles Herpetological Circular 37, 84 pages.

**Parks Canada Agency**, 2012. Recovery strategy for the Eastern Ribbonsnake (*Thamnophis sauritus*) Atlantic population in Canada. Species at Risk Act Recovery Strategy Series. Parks Canada Agency, Ottawa, Ontario. X + 46 pages.

### Literature Cited

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

**Bleakney, J. S.** 1958. A zoogeographical study of the amphibians and reptiles of eastern Canada. *National Museums of Canada, Bulletin* 155.

**Cook, F. R.** 1984. Introduction to Canadian Amphibians and Reptiles. National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario.

**Ernst, H., and E. M. Ernst.** 2003. Snakes of the United States and Canada. Smithsonian Books, Washington and London. 668 pages.

**Gilhen, J.** 1984. Amphibians and Reptiles of Nova Scotia. Nova Scotia Museum, Halifax, Nova Scotia.

Received 24 May 2012

Accepted 26 September, 2012

# *In situ* Caching of a Large Mammal Carcass by a Fisher, *Martes pennanti*

ETHAN A. HÜNER and JUSTIN F. B. PETER

Algonquin Park Visitor Centre, Algonquin Provincial Park, P.O. Box 219, Whitney, Ontario K0J 2M0 Canada

Hüner, Ethan A., and Justin F. B. Peter. 2012. *In situ* caching of a large mammal carcass by a Fisher, *Martes pennanti*. Canadian Field-Naturalist 126(3): 234–237.

We document what is apparently the first reported instance of *in situ* caching of a large mammal carcass by a Fisher (*Martes pennanti*).

Key Words: caching, Fisher, *Martes pennanti*, mustelid, scavenging, carcass, Algonquin Park, Ontario.

Caching is an animal behaviour widespread across taxa that involves the handling of food to conserve it for future use. Two key components of caching are that the consumption of the cached item is deferred and that the food item is handled in such a way as to deter competition for that item (Vander Wall 1990). For the purposes of this note, food caching is considered synonymous with hoarding and storing, as per Vander Wall (1990).

The Fisher (*Martes pennanti*) is one of several members of the family Mustelidae (order Carnivora), including the American Marten (*Martes americana*), the European Pine Marten (*Martes martes*), the Long-tailed Weasel (*Mustela frenata*), the Wolverine (*Gulo gulo*), and the American Badger (*Taxidea taxus*), that are known to cache food (Vander Wall 1990; Henry et al. 1990; Muths 1998; Michener 2000; Inman et al. 2012).

Caching by Fishers generally entails the carrying of prey or otherwise loose food items away from the kill or find site to a sheltered or concealed place such as a den, where the animal may store the item and later retrieve it (Pittaway 1978; Powell 1993). When they encounter an immovable food item such as a large mammal carcass, Fishers have been known to reside in close proximity to the carcass and return to the food item periodically to feed (Powell 1993). However, to our knowledge, there are no published accounts of Fishers or any other mustelids caching large, immovable items, and this note describes the first documented instance of this behaviour by a Fisher.

## Study Area and Methods

On 20 October 2008, we initiated a study of carrion feeders at a large mammal carcass depot in southwestern Algonquin Provincial Park, Ontario (45°29'51"N, 78°45'55"W). A digital motion-triggered trail camera (Moultrie Game Camera, Moultrie Feeders, Alabaster, Alabama) was installed on a tree 2.5 m behind the carcass of an adult male American Black Bear (*Ursus americanus*) that had been shot dead and deposited

there fresh on 18 October 2008. The carcass was placed on the ground, facing west in a prone position, and was intact except for three bullet holes in the area of the left shoulder.

The site was bounded to the north and northeast by a <0.5 acre stand of Eastern White Pine (*Pinus strobus*), White Spruce (*Picea glauca*), and Balsam Fir (*Abies balsamea*) with a sparse shrub layer of Beaked Hazelnut (*Corylus cornuta*), on the southeast by a gravel hillside opening of >2 acres, and to the west by an unpaved road running in a north–south axis. The roadside opposite the carcass was bounded by a narrow strip of forest cover similar to the above-mentioned; beyond it lay an open bog below the grade of the road.

The camera was aimed towards the road and was set so as to be triggered to take three photographs 30 seconds apart, followed by a one-minute latent period, during which the camera could not be triggered. The camera recorded the ambient temperature when each photograph was taken. EAH subsequently visited the site every two to five days (total seven visits) to monitor the camera batteries and adjust the camera position. The ambient temperature during the study ranged from –9°C to 14°C.

During his second visit (26 October 2008), EAH noticed scrapes in the gravel substrate forming a semi-circle round the rear end of the carcass. The distal edge of the scraped surface was approximately 0.9–1.2 m away from the carcass and the scraping patterns were directed towards it. The hind legs of the carcass were completely covered with dead and green grasses, dead Eastern White Pine needles, Moose (*Alces alces*) bones, and twigs, and this material was packed in between the legs, over the tail, onto the rump, and round the American Black Bear's perimeter. EAH viewed photos recorded by the camera and determined that a male Fisher was responsible for the placement of the materials, starting late in the afternoon on 22 October 2008.

The Fisher was recorded engaging in at least seven caching episodes<sup>1</sup>, during which it placed the above-

<sup>1</sup>We define an episode as an uninterrupted period during which the Fisher engaged in one activity without leaving the camera's field of view.

mentioned materials over the carcass, using his mouth and forelimbs to position the material. The Fisher was also recorded feeding on the carcass at least three times between 22 October and 26 October 2008, beginning through the American Black Bear's anus. Other than two brief episodes (documented <1 minute each) when he consumed uncovered flesh exposed at the bullet holes, the Fisher concentrated feeding round the anus. The Fisher was not recorded feeding on the American Black Bear prior to the first episode of caching. The last day of the study was 17 November 2008, and we did not monitor the carcass by any means beyond this date. We assume that a single male Fisher was the only individual recorded during the entire duration of the study.

### Observations

During the third visit by EAH, on 1 November 2008, EAH checked the photo log and confirmed that the Fisher had continued to eat and cache the American Black Bear's hindquarters *in situ*. Before departing, EAH placed a pile of dead Bracken Fern (*Pteridium aquilinum*) fronds and a pile of fresh White Spruce boughs, measuring approximately 60–100 cm in length, at the side of the carcass in order to determine whether the Fisher would incorporate these materials into the cache materials.

At EAH's next visit, on the afternoon of 5 November 2008, the photo record indicated that the Fisher had utilized all of the Bracken Fern for the cache on 1 November 2008 by taking mouthfuls from the pile and translocating them onto the top of the carcass (Figure 1), in addition to dragging up a White Spruce bough onto the American Black Bear's left shoulder area (the area with the bullet holes). During this visit, EAH removed debris off the American Black Bear's rump and partially from the upper hind limbs. The purpose of this type of intervention was to get an anecdotal sense as to whether the Fisher's caching represented a real tendency. The Fisher subsequently completely re-covered areas of the American Black Bear's rear upon his next visit, on the night of 5 November 2008. On 7 November 2008, EAH once again removed all of the caching material for the same purpose as stated above. On 9 November 2008, the Fisher re-covered the American Black Bear's hindquarters. At a certain point, American Black Bear entrails were left exposed through the material even though the caching material was otherwise intact.

Up until 17 November 2008, our camera documented 36 feeding episodes by the Fisher with a mean duration of 14.9 minutes (range <1 minute to 65 minutes) and 21 caching episodes with a mean duration of 7 minutes (range <1 minute to 13 minutes). The Fisher fed on the American Black Bear under the covered area either by completely exposing an area from which to feed or by penetrating the cache material with its muzzle. Visits to the carcass were almost exclusively noc-

turnal or crepuscular. The Fisher engaged in apparent scent-marking activity on at least one occasion. The Fisher covered as much as approximately one third of the carcass's surface.

Other vertebrates were also recorded at the site during the study. Twelve episodes of Red Fox (*Vulpes vulpes*) activity were recorded at the carcass (always crepuscular or nocturnal) between 29 October and 11 November 2008. During two of these episodes, two Red Foxes were recorded in the field of view simultaneously. Six episodes of a Red Fox feeding on the carcass, on two consecutive nights (29 and 30 October 2008), were recorded; a Red Fox initially displaced the caching material at the carcass's rear on the first night to feed, and the area was left uncovered until after a Red Fox fed a second time, at which point the Fisher returned. There were no recorded direct interactions between a Red Fox and the Fisher. However, during episodes just prior to, or following, the Fisher's recorded visits, the attending Red Fox appeared preoccupied by something in the environment.

A single Eastern Wolf (*Canis lupus lycaon*) was recorded investigating the carcass on the night of 23 October 2008 but it did not feed. One American Marten (*Martes americana*) was recorded briefly feeding on the rear of the carcass during the evening of 31 October 2008 (exact point of entry not visible). Common Raven (*Corvus corax*) activity was recorded during the day over the entire duration of the study, with up to seven birds recorded at one time. A Common Raven was first recorded feeding on 23 October 2008 at the bullet holes. Common Ravens scrutinized the rest of the carcass but were recorded feeding exclusively at the bullet holes from 23 to 28 October 2008.

The first recorded instance of a Common Raven feeding on the rear of the carcass was on 29 October 2008, following disturbance of the cache materials by the Red Fox. Ravens subsequently fed here throughout the remainder of the study by accessing the area directly where the Red Fox had left it exposed, by pilfering through caching material, or by feeding on the exposed edge of the feeding entry point once the opening in the carcass had become larger. On 1 November 2008, a Common Raven may also have removed a White Spruce bough that the Fisher had placed over the area of the bullet holes. There was one instance in which several Common Ravens were recorded at the carcass simultaneously with the Fisher; one Common Raven landed on the carcass as the Fisher fed, and moved in small increments towards the Fisher.

### Discussion

Partial concealment of the American Black Bear carcass by the Fisher did not deter competition for the carcass from other vertebrates, since Red Foxes, Common Ravens, and an American Marten all fed from it, including the area where the concealment activity by the Fisher was concentrated. However, the concealment did



FIGURE 1. Fisher placing a mouthful of dead Bracken Fern fronds on the hindquarters of the American Black Bear carcass in Algonquin Provincial Park on 1 November 2008 at 1027 h. Note previously placed cache material surrounding Fisher and piled along the right flank of the American Black Bear.

delay the consumption of the carcass's rear by Common Ravens. The caching may therefore have prolonged the availability of the food source to the Fisher, although our data do not allow us to confirm this.

Common Ravens can be significant competitors, not only because they consume carrion at the source, sometimes in large numbers, but because they can also carry away significant quantities of carrion in excess of their immediate energetic requirements in order to cache it (Kaczensky et al. 2005). Common Ravens are, however, unable to break through hide to access the flesh and must rely on other organisms to open the carcass (Boorman and Heinrich 1999). Concealment activity could be particularly important, given that Common Ravens are diurnal and the Fisher is mainly nocturnal and crepuscular. This means that the Fisher would presumably have no other means to dissuade them.

Concealment of a food source can deter Common Ravens if they have not seen the food source previously (B. Heinrich, personal communication). This might explain why the concealment activity ceased to be effective against the Common Ravens when it did. It is not known whether a greater thickness or area of caching material might have increased the caching

effectiveness against any of the observed vertebrate scavengers.

Although it did not extend to the entire carcass, the concealment activity may have been effective in increasing the persistence of the food source in other ways. Experiments involving Cougar (*Puma concolor*) caching of ungulate carcasses showed that caching can reduce the temperature of a carcass and reduce the discernible odour emanating from the carcass, suggesting that carrion may be useable for longer (due to a reduction in scavenging microbe and arthropod populations) and that competing scavengers may not be able to detect the carrion by olfactory means from as far away as without caching (Bischoff-Mattson and Mattson 2009). We did not measure carcass temperatures or odour, and we did not have an unconcealed carcass with which to experimentally compare the concealed one. As well, were the placement of caching materials by the Fisher serving to reduce decomposition or detection, the removal of said materials twice during the course of this study by us might have offset some of the positive effects of caching.

It is unlikely that the caching activity we observed would have been effective in preventing larger scav-

engers, such as wolves (*Canis* spp.), from utilizing a carcass. At least one Eastern Wolf was obviously aware of the carcass. Also, Eastern Wolves in Algonquin Park will feed on American Black Bear carcasses (EAH, personal observation) and will dig through barriers such as deep snow in order to access a carcass (JFBP, personal observation).

The food source in this study may not have been what is typically available to a Fisher. Fishers are opportunistic carnivores that subsist mainly by hunting any mammal or bird they can overpower (Powell 1993). They will search for prey throughout a relatively fixed home range that largely excludes conspecifics of the same sex (Arthur et al. 1989). Where it occurs, Snowshoe Hare (*Lepus americanus*) is a staple of the Fisher's diet (Raine 1987; Weir et al. 2005). Fishers will also scavenge carrion from a variety of organisms when encountered (Pittaway 1978; Powell 1993). Carrion can form an important component of the diet: carrion from deer (*Odocoileus* spp.) harvested by hunters can supplant the Snowshoe Hare as a primary food source when Snowshoe Hare populations decline, and carrion may even buffer Fishers against the cyclical nature of Snowshoe Hare numbers (Kuehn 1989).

In the study area—where there is no deer harvest—a Fisher may have periodic access to the remains of White-tailed Deer (*Odocoileus virginianus*) or Moose killed by Eastern Wolves. More rarely, they may use the carcass of a large mammal that has died by some other means; however, Eastern Wolves would be expected to scavenge such a carcass and would readily interfere with a Fisher's access to it (EAH and JFBP, personal observations). Therefore, access to an intact large mammal carcass such as the one in this study would provide an unusually large supplement to the Fisher's diet. The importance of such a supplement could be especially great in the study setting because the Snowshoe Hare population in Algonquin Park was experiencing a cyclic decline at the time, according to pellet counts in monitoring plots (Ontario Ministry of Natural Resources, staff communication). A Fisher's ability to prolong the availability of this food source by concealing it could provide it with a significant fitness advantage.

### Acknowledgements

This work was supported by Ontario Parks (Ontario Ministry of Natural Resources). We thank Rick Stronks for encouraging the preparation of this note. We also

thank him and Cavalcade Color Lab Foto Source (Huntsville, Ontario) for technical assistance and Dan Strickland and two anonymous reviewers for helpful comments on the manuscript.

### Literature Cited

- Arthur, S. M., W. B. Krohn, and J. R. Gilbert. 1989. Home range characteristics of adult fishers. *Journal of Wildlife Management* 53: 674–679.
- Bischoff-Mattson, Z., and D. Mattson. 2009. Effects of simulated mountain lion caching on decomposition of ungulate carcasses. *Western North American Naturalist* 69: 343–350.
- Boarman, W. I., and B. Heinrich. 1999. Common Raven (*Corvus corax*). No. 476 in *The Birds of North America*. Edited by A. Poole and F. Gill. *Birds of North America*. Inc., Philadelphia, Pennsylvania.
- Henry, S. E., M. G. Raphael, and L. F. Ruggiero. 1990. Food caching and handling by marten. *Great Basin Naturalist* 50: 381–383.
- Inman, R. M., A. J. Magoun, J. Persson, and J. Mattison. 2012. The wolverine's niche: linking reproductive chronology, caching, competition, and climate. *Journal of Mammalogy* 93: 634–644.
- Kaczynsky, P., R. D. Hayes, and C. Promberger. 2005. Effect of raven *Corvus corax* scavenging on the kill rates of wolf *Canis lupus* packs. *Wildlife Biology* 11: 101–108.
- Kuehn, D. W. 1989. Winter foods of Fishers during a Snowshoe Hare decline. *Journal of Wildlife Management* 53: 688–692.
- Michener, G. R. 2000. Caching of Richardson's ground squirrels by North American badgers. *Journal of Mammalogy* 81: 1106–1117.
- Muths, E. 1998. An observation on caching of prey by a long-tailed weasel (*Mustela frenata*). *Southwestern Naturalist* 43: 106.
- Pittaway, R. J. 1978. Observations on the behaviour of the fisher (*Martes pennanti*) in Algonquin Park, Ontario. *Naturaliste canadien* 105: 487–489.
- Powell, R. A. 1993. *The Fisher: Life History, Ecology, and Behaviour*. Second edition. University of Minnesota Press, Minneapolis, Minn. 237 pages.
- Raine, R. M. 1987. Winter food habits and foraging behaviour of fishers (*Martes pennanti*) and martens (*Martes americana*) in southeastern Manitoba. *Canadian Journal of Zoology* 65: 745–747.
- Vander Wall, S. B. 1990. *Food Hoarding in Animals*. University of Chicago Press, Chicago, Illinois. 445 pages.
- Weir, R. D., A. S. Harestad, and R. C. Wright. 2005. Winter diet of fishers in British Columbia. *Northwestern Naturalist* 86: 12–19.

Received 15 July 2012

Accepted 1 October 2012

# Severe Maxillary Osteomyelitis in a Gray Wolf (*Canis lupus*)

SHANNON BARBER-MEYER

U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711–37th Street, SE, Jamestown, North Dakota 58401-7317 United States; email: sbarber-meyer@usgs.gov

Barber-Meyer, Shannon. 2012. Severe maxillary osteomyelitis in a Gray Wolf (*Canis lupus*). *Canadian Field-Naturalist* 126(3): 238–241.

Whereas dental injuries and abnormalities have been documented in Gray Wolves (*Canis lupus*), severe maxillary necrosis has not previously been implicated in a Gray Wolf fatality. Here I report maxillary osteomyelitis in a wild Gray Wolf from northeastern Minnesota of such severity that I hypothesize it ultimately led to death by starvation.

Key Words: *Canis lupus*, carnassials, Gray Wolf, maxillary osteomyelitis, pressure necrosis, Minnesota.

Dental injuries to or abnormalities in functionally important teeth and associated bones in predators may significantly reduce the ability to kill and consume prey (Lazar et al. 2009). This impairment is likely exacerbated in coursing predators, such as Gray Wolves, that bite and hold onto fleeing and kicking prey with their teeth. Damage to carnassials (upper fourth premolar, P<sup>4</sup>, and lower first molar, M<sub>1</sub>) and associated bones in Gray Wolves may especially inhibit the consumption of prey because these teeth slice meat and crush bone. Here I report maxillary osteomyelitis involving the carnassials in a wild Gray Wolf from northeastern Minnesota of such severity that I hypothesize it ultimately caused the Gray Wolf to starve to death.

## Study Area and Methods

As part of a long-term research project on wolves in the Superior National Forest of northeastern Minnesota (48°N, 92°W), Female Gray Wolf 7188 was captured with a rubber-padded-jaw, foot-hold trap on 4 November 2011 and was fitted with a VHF mortality-sensing radio-collar (Mech 2009). She was estimated by tooth wear to be one and a half years old (Gipson et al. 2000), and her teeth condition was noted as “good with minimal wear”. No teeth were recorded as chipped or broken, and no foreign object was wedged across the upper palate. No facial or oral infection was apparent at capture. She weighed 20 kg (typical for a female of her age in northeastern Minnesota) (Mech 2006), and technicians described her as in “generally good condition.”

## Results

Following her release, I located her approximately weekly via aerial radio-telemetry. Except for one location, she was either alone or her locations (no visual observation) did not correspond to those of any of our other radio-collared Gray Wolves. She was located on 20 March 2012 with a radio-collared three-year-old female, Wolf 7117, but by the next location (4 April 2012) the two Gray Wolves had separated.

On 22 May 2012, I detected the signal of Gray Wolf 7188 on mortality mode. I had last detected her signal on active mode on 16 May 2012 (although she may have already been dead by that date, because her location was aerially indistinguishable on 16 and 22 May and the state of carcass decay suggested more than six days had passed since death). The collar may have been tripped back onto active mode as it collapsed through the decaying carcass or it may have been nudged by a small animal potentially inspecting the carcass.

Gray Wolf 7188 had travelled at least 4.8 km since 24 April 2012. Her skeleton (largely articulated) was almost entirely denuded of flesh. The Gray Wolf was somewhat curled up with her legs generally tucked under her torso. There was no evidence of a struggle and no evidence of other mammal activity at the site.

I necropsied Wolf 7188 on 22 May 2012 at the apparent location of death. Severe maxillary osteomyelitis 3.4 cm wide by 1.7 cm high extended 0.8 cm into the dorsal portion of the zygomatic bone on the left side of the maxilla near the left P<sup>4</sup> (part of the left carnassial pair) and upper first molar, M<sup>1</sup> (Figures 1A and 1B; collection of USGS Wolf and Deer project, Ely, MN). Minimal chipping on the left P<sup>4</sup> and M<sup>1</sup> cusps was noted in contrast to the right P<sup>4</sup> (part of the right carnassial pair), which was substantially chipped (enamel loss on the lingual aspect) and pink. Beginning stages of maxillary lysis were apparent on the right side corresponding to the severely necrotic location on the left side. Except for chipped cusps on the M<sub>1</sub> teeth and pink discoloration of some teeth, no other mandibular abnormality was noted. No broken bone or other abnormality was detected on the rest of the skeleton. Two femurs and one radius/ulna were devoid of marrow.

## Discussion

Because of the symmetrical location of the necrosis across the upper palate, it is likely that a foreign body such as a stick or bone was “lodged transversely between the carnassial teeth, resulting in pressure necrosis” and “ulceration of the adjacent palatine mucosa”



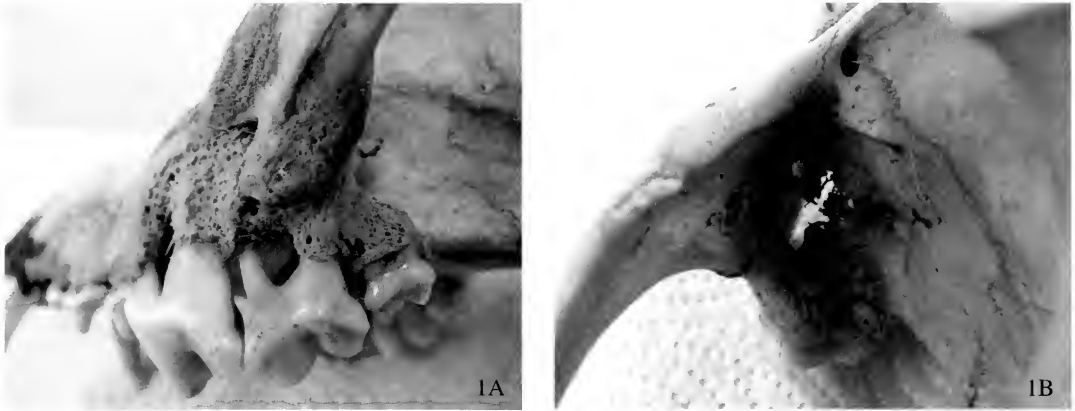


FIGURE 1. Severe maxillary osteomyelitis 3.4 cm wide by 1.7 cm high extended 0.8 cm into the dorsal portion of the zygomatic bone on the left side of the maxilla of Wolf 7188 near the upper left fourth premolar ( $P^4$ , part of the left carnassial pair) and upper first molar ( $M_1$ ); lateral/posterior view (A) and dorsal/posterior view (B). Photo: Shannon Barber-Meyer, U.S. Geological Survey.

sis" and "ulceration of the adjacent palatine mucosa" (Wobeser 1992, page 272) followed by maxillary osteomyelitis (Henderson et al. 1984) and "denudation of the root of the carnassials" of the right maxilla (Bradclaw 1935, page 46) associated with a secondary bacterial infection.

The maxillary necrosis on Wolf 7188's skull somewhat resembled another skull from our study, Wolf 6747 (Figure 2; collection of USGS Wolf and Deer project, Ely, MN). Adult female Wolf 6747 was captured on 10 June 1985 and had a stick (5.5 cm in length) wedged between the carnassials across the upper palate (we removed the stick). She was necropsied on 7 February 1986 (although she may have died by 17 January 1986) and another stick was found lodged between the carnassials. The necrosis was much less severe around the carnassials and on the buccal aspect of the maxilla than I observed in Wolf 7188, but it displayed greater palatine lysis extending into the nasal passages (Figure 3). Similar to Wolf 7188, the mandible of Wolf 6747 had chipped cusps on both of the  $M_1$  teeth. The chipped cusps likely resulted from occlusion with the stick because, upon articulation of Wolf 6747's mandible with her maxilla, both  $M_1$  contacted the stick and elevated it dorsally into the palatine cavity that connects to the nasal passages. Wolf 6747 apparently did not die as a direct result of this, but was possibly killed and eaten by other Wolves, as only her chewed head was found with several attached neck vertebrae. Fur and blood were found at the scene and another radio-collared Wolf 6749 was located in the area.

Another skull in our research collection (identity unknown) also had a stick wedged between the carnassials at death with similar maxillary necrosis, but was again much less severe than in Wolf 7188. Like Wolf 7188, this wolf's skull did not display palatine lysis. The mandible of the unidentified wolf was not available for comparison.

Numerous reports of dental injury and anomaly exist in wolves (e.g., Dolgov and Rossolimo 1964; Van Valkenburgh 1988; Hell 1990; Vilà et al. 1993; Andersone and Ozoliņš 2000; Miles and Grigson 2003; Pavlović et al. 2007; Lazar et al. 2009). Other researchers have described dead wolves with sticks wedged across their palate (Wobeser 1992; Theberge et al. 1994) but did not report maxillary osteomyelitis and did not implicate the lodged stick and subsequent pathology in the cause of death. Wobeser (1992) necropsied 241 wolves and noted that the one wolf with a stick lodged between the carnassials and resulting "ulceration of the adjacent palatine mucosa" was in "good body condition" (Wobeser 1992, page 272).

Biologists often collect wolf skulls (e.g., Mech et al. 2011). I suspect that the severity of maxillary osteomyelitis observed in Wolf 7188 is not common, because I was able to find no similar published records. Because I found only the skeleton and fur (no foreign body inside the mouth), I could not definitively determine the cause of the necrosis or death. Nevertheless, based on other wolf skulls, I hypothesize that Wolf 7188 had a foreign object (i.e., stick or bone) wedged between the carnassials that led to severe osteomyelitis and a secondary infection that ultimately resulted in starvation.

I suspect starvation was the proximate cause of death because the severity of the maxillary osteomyelitis made it probable that Wolf 7188 had a draining facial lesion and infection that would have compromised her ability to secure and consume prey (Richard Hanson, DVM, personal communication). The starvation hypothesis is supported by the lack of marrow in the femurs and radius/ulna. I excluded intraspecific aggression as the cause of death because the carcass was largely articulated and no sign of struggle was apparent (no broken vegetation or bloodied area).



FIGURE 2. Maxillary necrosis of the skull of Wolf 6747 (left). The necrosis is similar to but less severe than the necrosis of Wolf 7188 (right). Photo: Shannon Barber-Meyer, U.S. Geological Survey.

### Acknowledgements

This study was part of a long-term study supported by the U.S. Geological Survey (USGS) and directed by L. D. Mech, Bob Peterson and Hans Martin live-trapped Wolf 7188. I thank Richard Hanson (veterinarian consultant, International Wolf Center, and owner/practitioner, Ely Veterinary Clinic, Minnesota) for examining the skull of Wolf 7188. Reviews by L. David Mech (USGS), Diane K. Boyd (Montana Fish, Wildlife and Parks) and two anonymous referees greatly improved the manuscript.

### Literature Cited

- Anderson, Ž., and J. Ozoliņš. 2000. Craniometrical characteristics and dental anomalies in wolves *Canis lupus* from Latvia. *Acta Theriologica* 45: 549-558.
- Bradclaw, R. 1935. Pathological changes in the jaws of animals. *Proceedings of the Royal Society of Medicine* 28: 1672-1676.
- Dolgov, V. A., and O. L. Rossolimo. 1964. Dental abnormalities in *Canis lupus*. *Acta Theriologica* 8: 237-244.
- Gipson, P. S., W. B. Ballard, R. M. Nowak, and L. D. Mech. 2000. Accuracy and precision of estimating age of Gray Wolves by tooth wear. *Journal of Wildlife Management* 64: 752-758.
- Hell, P. 1990. Gebißanomalien des Westkarpatischen Wolfes und ihre Bedeutung für die Hundezucht (Dental anomalies among West Carpathian wolves and their significance in dog breeding). *Zeitschrift für Jagdwissenschaft* 36: 266-269 (English summary included).
- Henderson, G. M., R. Borthwick, and M. A. Camburn. 1984. Maxillary dento-alveolar abscess in a spotted hyaena *Crocuta crocuta*. *Journal of Zoo and Wildlife Medicine* 32: 127-129.
- Lazar, P., D. Konjević, U. Kierdorf, V. Njemirovskij, J. Curlik, and Marijan Grubešić. 2009. Traumatic injury to the incisive bones and maxillary dentition in a male gray wolf (*Canis lupus* L.) from Slovakia. *European Journal of Wildlife Research* 55: 85-89.
- Mech, L. D. 2006. Age-related body mass and reproductive measurements of gray wolves in Minnesota. *Journal of Mammalogy* 87(1): 80-84.
- Mech, L. D. 2009. Long-term research on wolves in the Superior National Forest. Pages 15-34 in *Recovery of Gray Wolf in the Great Lakes Region of the United States: an Endangered Species Success Story*. Edited by A. P. Wydeven, T. R. VanDeelen, and E. J. Heske. Springer, New York, New York. 355 pages.



FIGURE 3. Palatine lysis extending into the nasal passages of Wolf 6747. Both lower first molars ( $M_1$ ) contact the lodged stick (5.5 cm in length) and elevate it dorsally into the palate. Photo: Shannon Barber-Meyer, U.S. Geological Survey.

- Mech, L. D., R. M. Nowak, and S. Weisberg.** 2011. Use of cranial characters in taxonomy of the Minnesota wolf (*Canis* sp.). *Canadian Journal of Zoology* 89: 1188-1194.
- Miles, A. E. W., and C. Grigson.** 2003. Colyer's variations and diseases of the teeth of animals. Revised edition. Cambridge University Press, Cambridge, U.K. 692 pages.
- Pavlović, D., T. Gomerčić, G. Gužvica, J. Kusak, and D. Huber.** 2007. Prevalence of dental pathology in wolves (*Canis lupus* L.) in Croatia—a case report. *Veterinarski Arhiv* 77: 291-297.
- Theberge, J., G. J. Forbes, I. K. Barker, and T. Bollinger.** 1994. Rabies in wolves of the Great Lakes region. *Journal of Wildlife Diseases* 30: 563-566.
- Van Valkenburgh, B.** 1988. Incidence of tooth breakage among large, predatory mammals. *American Naturalist* 131: 291-302.
- Vilà, C., V. Urios, and J. Castroviejo.** 1993. Tooth losses and anomalies in the wolf (*Canis lupus*). *Canadian Journal of Zoology* 71: 968-971.
- Wobeser, G.** 1992. Traumatic, degenerative, and developmental lesions in wolves and coyotes from Saskatchewan. *Journal of Wildlife Diseases* 28: 268-275.

Received 7 August 2012

Accepted 17 October 2012

# The Impact of Deer Herbivory and Drought on Population Growth of *Goodyera pubescens* (Orchidaceae) in Southwestern Quebec

JOYCE M. REDDOCH and ALLAN H. REDDOCH

548 Rivershore Crescent, Gloucester, Ontario K1J 7Y7 Canada; email: reddoch@magma.ca

Reddoch, Joyce M., and Allan H. Reddoch. 2012. The impact of deer herbivory and drought on population growth of *Goodyera pubescens* (Orchidaceae) in southwestern Quebec. *Canadian Field-Naturalist* 126(3): 242–244.

During the last decade of a 37-year study of Downy Rattlesnake-plantain (*Goodyera pubescens* (Willdenow) R. Brown) major herbivory by White-tailed Deer (*Odocoileus virginianus*) caused marked decreases in the sizes of two previously expanding populations. The 2012 drought resulted in an additional decline of one population. Because population growth depends on large flowerings, which occur only every four to eight years, recovery to 2002 levels would take several decades under favourable conditions.

Key Words: Downy Rattlesnake-plantain, *Goodyera pubescens*, long-term studies, population growth, climate, herbivory, White-tailed Deer, *Odocoileus virginianus*, 2012 drought, Gatineau Park, Quebec.

In 2007 we published the results of our 31-year (1976–2006) study of two populations of *Goodyera pubescens* (Willdenow) R. Brown in Gatineau Park in southwestern Quebec (Reddoch and Reddoch 2007). Here we provide a six-year update on the impact and implications of deer herbivory and drought on these two populations.

In Gatineau Park, near the northern edge of its distribution (Kallunki 2002), *Goodyera pubescens* is an orchid of mature woodlands. It is a clonal species that consists of unbranched, leafy rhizomes that extend along the soil surface, anchored by occasional shallow roots. The leaves along the rhizome and around the growing tip give the appearance of an elongated rosette.

At the Gatineau Park study sites, each rosette (ramet) flowers only once, after developing for four to eight years. After flowering, one to three offshoots emerge near the base of the flowering stem, and the parent rhizome slowly dies. These offshoots, which are the next generation of rosettes, repeat the same cycle of growth as the parent (Reddoch and Reddoch 2007).

Seedlings also contribute to population growth but on a much longer time scale than vegetative reproduction. Few seedlings survive to flower and they require many years to do so (Reddoch and Reddoch 2007). The longest surviving seedling of eight that we have followed, which appeared in 1998, still has not flowered after 15 years. The other two surviving seedlings, which appeared in 2004, also have not yet flowered. It has been observed in Massachusetts (Ames 1921, 1922) and Quebec (Reddoch and Reddoch 2007) that seedlings often originate close to rhizomes. When young, seedlings can readily be distinguished from offshoots by their small, delicate appearance, but as they develop, they come to resemble offshoots. Thus, anyone looking at a patch for the first time will not be able to distinguish maturing seedlings from offshoots and

might mistakenly conclude that there are branched rhizomes.

Flowering of mature rosettes is usually initiated by a dry period in the May of the year preceding flowering, perhaps combined with other conditions. Such dry periods of below average precipitation and above average temperature last at least 19 days. These dry periods, which occur only every several years, are followed the next year by synchronous large-flowering of *Goodyera pubescens* populations (8% to 30% of the rosettes; Reddoch and Reddoch 2007). In the last decade there have been large flowerings in 2002 and 2006.

White-tailed Deer (*Odocoileus virginianus*) eat rosettes and inflorescences, killing rosettes and eliminating seed sources. From the mid-1970s until 2002, both study populations increased exponentially (Figures 1 and 2). We deduced that the Champlain Lookout population increased faster than the Moorside population because the former population had experienced no deer herbivory during that period while some deer herbivory had been evident since the mid-1980s in the latter population (Reddoch and Reddoch 2007).

Our recent observations show that in the Champlain Lookout population, which was a single patch 165 cm × 100 cm, major deer browsing reduced the number of rosettes from a high of 191 in 2002 to less than a quarter of that number by 2009 (Figure 1). Because we saw at least one deer close to the patch on almost every visit, we placed a large tree branch across the remaining rosettes in 2009. Since then, rosette numbers have remained constant. The Moorside population consisted of 10 patches scattered over a half kilometre. It numbered 867 rosettes in 2002, dropped to 65% of that number by 2004 and remained relatively stable until 2011 (Figure 2).

Between about 1995 and 2005, the herbaceous and shrub layers in the study areas essentially disappeared

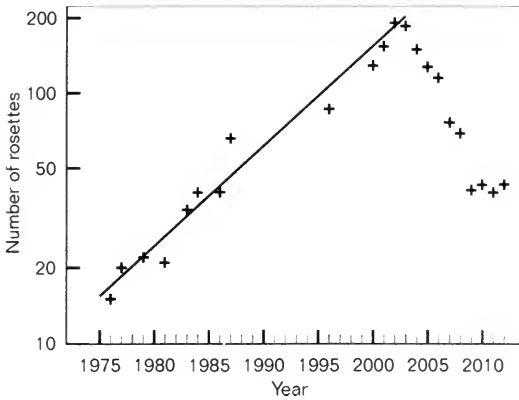


FIGURE 1. Growth curve of the Champlain Lookout population (1976–2002), subsequent decline (2003–2008), and levelling off (2009–2012); semi-log plot with fitted line for period of exponential growth.

leaving wide-open vistas through the forest. This observation is consistent with the changing densities of White-tailed Deer over the study period. Between 1980 and 1989, deer density in Gatineau Park increased to 5.5 deer/km<sup>2</sup> (Dryade 1991\*). Five deer per km<sup>2</sup> is considered the upper limit before deer herbivory causes serious and perhaps irreversible damage to the forest herbaceous layer (Anderson 1994, Whigham 2004, McGraw and Furedi 2005). After 2002 both orchid populations declined as deer densities increased. In 2004/2005 deer density had reached 15.6 deer/km<sup>2</sup> (Tecsult Inc. 2005\*). After the exceptionally severe winter in 2007/2008, deer density dropped to 5 deer per km<sup>2</sup> by 2011 (personal communication, Quebec Ministry of Natural Resources and Wildlife). The tree branch further protected the Champlain Lookout population from deer access.

The severe summer drought in 2012 (Environment Canada 2012\*) affected the Moorside population markedly (Figure 2), causing the leaves and rhizomes of many rosettes in areas of thin soil to die. No rosettes died in the Champlain Lookout population. That population was apparently more protected from drought, likely because it was situated on deeper soil near the base of a north-facing slope of a small, moist valley.

The growth of a *Goodyera pubescens* population depends on flowering, both to initiate vegetative reproduction by offshoots and for seed production. Flowering in relatively large numbers can take place only every several years following extensive warm, dry periods in the previous May and only by mature rosettes. Further, for population growth to occur, flowering rosettes must produce at least two offshoots, one to replace the parent rosette, which dies after flowering and reproduction, and at least one additional offshoot to contribute to the expansion of the population. When deer herbivory

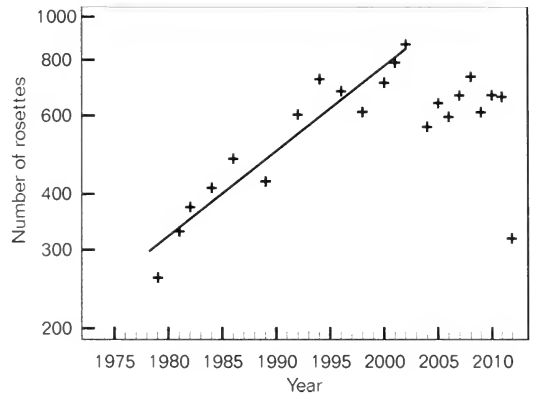


FIGURE 2. Growth curve of the Moorside population (1978–2002), subsequent decline and stabilization (2003–2011); further decline in 2012 in response to the extreme summer drought; semi-log plot with fitted line for period of exponential growth.

removes rosettes from the populations, significant population recovery begins only after the above conditions are fulfilled.

Recovery of these populations to 2002 levels, in the absence of further herbivory and drought, would take several decades. The mechanism of recovery depends on sporadic climate-dependent initiation of flowering, as well as continued production of more than one offshoot per flowering rosette, in addition to on-going seed production, and other factors such as the continued health of the associated mycorrhizal fungi.

### Acknowledgements

We thank the reviewers for their useful comments and the National Capital Commission for granting research permits to conduct this long-term study.

### Documents Cited (marked \* in text)

- Dryade.** 1991. Cerf de Virginie dans le parc de la Gatineau / Évaluation de la population et capacité de support du milieu. Commission de la capitale nationale, Ottawa, Ontario. 30 pages + appendices.
- Environment Canada.** 2012. National Climate Data and Information Archive, Environment Canada. Accessed 31 August 2012. [www.climate.weatheroffice.gc.ca](http://www.climate.weatheroffice.gc.ca).
- Tecsult Inc.** 2005. Évaluation de la capacité de support du parc de la Gatineau pour le cerf de Virginie. Commission de la capitale nationale, Ottawa Ontario. 64 pages + appendices.

### Literature Cited

- Ames, O.** 1921. Seed dispersal in relation to colony formation in *Goodyera pubescens*. *Orchid Review* 29: 105–107.
- Ames, O.** 1922. Notes on New England orchids.—II. The mycorrhiza of *Goodyera pubescens*. *Rhodora* 24: 37–46.
- Anderson, R. C.** 1994. Height of white-flowered trillium (*Trillium grandiflorum*) as an index of deer browsing intensity. *Ecological Applications* 4: 104–109.

- Kallunki, J. A.** 2002. *Goodyera pubescens* in Flora of North America North of Mexico. Volume 26. *Edited by* Flora of North America Editorial Committee. Oxford University Press, New York, New York.
- McGraw, J. B., and M. A. Furedi.** 2005. Deer browsing and population viability of a forest understory plant. *Science* 307: 920–922.
- Reddoch, J. M., and A. H. Reddoch.** 2007. Population dynamics and flowering synchrony of *Goodyera pubescens* (Orchidaceae) in southwestern Quebec, Canada. *Journal of the Torrey Botanical Society* 134: 379–388.
- Whigham, D. F.** 2004. Ecology of woodland herbs in temperate deciduous forests. *Annual Review of Ecology, Evolution, and Systematics* 35: 583–621.

Received 12 October 2012

Accepted 8 November 2012

# A Tribute to Stewart Dixon MacDonald, 1927–2010

DAVID R. GRAY and SALLY E. GRAY

Grayhound Information Services, 3107 8th Line Road, Metcalfe, Ontario K0A 2P0 Canada; e-mail: grayhound@xplornet.com

Gray, David R., and Sally E. Gray. 2012. A tribute to Stewart Dixon MacDonald, 1927–2010. *Canadian Field-Naturalist* 125(3): 245–251.

Stewart Dixon MacDonald wanted to be known as “Stu,” specifically to be pronounced “Stoo.” Not “Stew.” “I don’t want to share my name with a dish of meat,” he said.

And there we have Stu MacDonald’s easy sense of informality and gentle sense of humour, for which he was known throughout his 83 years. These endearing aspects of the arctic scientist’s character were carried in a body characterized first and foremost by smiling eyes and gentle, slow speech. One might be tempted to guess the wavy-haired, bearded gentleman was simply a teddy bear, but if he was, he was of the polar variety—alert, focused, and formidable.

Born in Bayhead, Nova Scotia, in 1927, Stu became interested in the nature of the world round him at a young age. As a teen, he encountered others with shared passions and developed skills that would influence his life. After finishing high school he was hired as a technician in the Zoology section of the National Museum of Canada (now the Canadian Museum of Nature) in

Ottawa in 1947. He began his long career in the Museum cleaning bird and mammal skulls, and ended it as Curator of Vertebrate Ethology, a section he established in the early 1970s.

Public education as a museum curator was a natural outlet for Stu’s love of and delight in the natural world, particularly birds, and he was a natural teacher. He was a popular speaker, an artist, and a gifted writer, to which his bibliography attests. He also gave much heed to encouraging and training young, upcoming naturalists and scientists.

A major part of Stu’s early career was the almost annual field trip to various parts of Canada. Here he utilized his skill in the preparation of bird and mammal study skins, a skill that he practised throughout his career, resulting in thousands of specimens in the Museum collections.

Stu’s developing skills in collecting, preserving, and mounting birds and mammals also led to important contributions to many of the well-loved dioramas in



FIGURE 1. National Museum of Canada ornithological expedition to Saskatchewan, 1948. Rodger O. Standfield (*left*) and Stewart D. MacDonald with field vehicle, a Department of Mines and Resources truck (the Museum was part of this department at the time). Canadian Museum of Nature archives.

the Museum's mammal and bird halls, some of which are still at the Canadian Museum of Nature today. He worked with many well-known artists at the Museum, including Clarence Tillenius and Terry Shortt. The different Museum collecting and display projects took Stu across Canada, from the Yukon mountains in the west to the Labrador Sea in the east, and from Alert on the northern tip of Ellesmere Island to Point Pelee, Canada's southernmost tip of land. However, it was the Canadian Arctic that became the dominant focus of Stu's career.

Stu's first arctic ventures were made possible by the opening of the string of weather stations in the High Arctic jointly established and staffed by the Canadian and U.S. governments just after World War II. His first expedition into the High Arctic was in 1949, when he travelled to Mould Bay on Prince Patrick Island for the National Museum of Canada in conjunction with the Smithsonian Institution. As on all of his subsequent research trips, he collected a wide range of specimens, including plants, invertebrates, fish, birds, and mammals. This introduction began a love affair with the Arctic that ended only with his death.

On his next trip to the High Arctic, in 1951, Stu spent five and a half months in the vicinity of Alert, on northern Ellesmere Island. He observed Arctic Wolves and Peary Caribou and made a series of colour photographs of all aspects of life in the Arctic. He returned to Mould Bay for the summer of 1952, again spending five months in the field. Highlights of that trip include the successful collecting of 50 lots of marine and freshwater invertebrates and a medical evacuation to Montreal for treatment of an infected seal bite! Stu's great interest in the behaviour of arctic birds continued to develop, and he made sketches of the courtship behaviours and postures of several bird species.

The third in the series of biological investigations at the weather stations in the High Arctic was conducted in the summer of 1954 at Isachsen, on Ellef Ringnes Island. Stu's notes on Rock Ptarmigan behaviour that summer were undoubtedly the springboard for the more intensive studies on Rock Ptarmigan he carried out in the late 1960s and 1970s.

In the summer of 1955, Stu headed north again, this time to the west side of Ellesmere Island, working in the vicinity of the weather station at Eureka on the Fosheim Peninsula. On this trip, he was accompanied by David F. Parmelee, who became a long-standing field partner, collaborator, and friend. This trip also saw the beginnings of an important collaboration with Fred Roots, then of the Geological Survey of Canada. With the logistical support of Fred and the Geological Survey, Stu was able to fly to and survey many points on Axel Heiberg Island and western Ellesmere Island.

Stu's published reports on those early trips to the Arctic are still a valuable source of information on many aspects of arctic biology, and they are essential reading for newcomers to arctic science and fieldwork.

Some of the northern localities Stu worked in have seldom been visited by biologists since then. The early collections of arctic flora and fauna, too, are an invaluable resource for current comparative or baseline studies. The detailed notes that Stu made on many aspects of bird and mammal behaviour during his early trips to the Arctic foreshadow the ethological studies that became the focus of his later career.

Stu resigned from his position at the National Museum in 1956 to attend the State University of Iowa. On his return to Ottawa in 1959, he became Assistant Curator of Birds under the Curator, W. Earl Godfrey. A major result of that collaboration was the publication of *The Birds of Canada*, first published in 1966. The information that Stu had personally gathered in the Arctic greatly improved the distribution maps of many birds whose ranges extend into the arctic regions. He also prepared many fine black-and-white illustrations for this first edition, most of which were retained in the revised edition, issued in 1986.

To Stu, with his vast experience in field studies, particularly in studying birds, it was clear that complex patterns of behaviour, such as the breeding behaviours of birds, are characteristic of a species as any structural or morphological features. He realized that species can often be recognized as easily by their behaviour as by their structure, and he recognized the study of ethology (animal behaviour) as an important tool for taxonomists.

It was this passion for the study of ethology that led Stu to push for the establishment of a Museum section dedicated to the study of animal behaviour. This dream came into existence in 1972 with the formation of the Vertebrate Ethology section in the Vertebrate Zoology Division at the National Museum of Natural Sciences, National Museums of Canada. Stu then became the Curator of the Vertebrate Ethology section, a position he held until his retirement in 1988.

This unique section of the Museum survived for 22 years. It ended in 1994, due to reorganization and budget cuts that also eliminated scientists from some traditional museum disciplines. What has survived at the Museum is an impressive collection of still photos, moving images, and sound recordings, captured as part of the program of ethological research. Many of the sounds Stu recorded have also been archived at the Cornell Laboratory of Ornithology.

### **The High Arctic Research Station**

While assembling data on geographic distribution for *The Birds of Canada*, Stu recognized a major gap in our geographical knowledge of arctic wildlife—a vast area in the Queen Elizabeth Islands known as the “barren wedge.” Here the influence of the cold Arctic Ocean penetrates far to the south.

Based on his knowledge of the fauna of the arctic islands, Stu realized that Bathurst Island, which was virtually unknown biologically, would be an important



and fascinating place to study in the “barren wedge.” Bathurst Island was potentially between the ranges of eastern and western bird populations, and the number of breeding species, their migration patterns, and their taxonomic relationships would be of great interest.

Stu decided to organize an expedition to Bathurst Island, and he chose the wet lowland bisecting the island, named Polar Bear Pass, as an area that was likely to support abundant vegetation and wildlife. It was also close enough to Resolute Bay for efficient logistic support.

The first expedition to Polar Bear Pass was in the summer of 1968. Supported wholeheartedly by Fred Roots, then Director of the Polar Continental Shelf Project, Stu and two fellow scientists, with two young field assistants (one was DRG), set up a temporary research base and began a series of studies of the behaviour and ecology of arctic birds and mammals.

With several successful seasons completed, including DRG’s 11-month overwinter stay at Polar Bear Pass, Stu set out to campaign for a more permanent presence there. In 1972, with the continued support of the Polar Continental Shelf Project and a grant from the Anglo-American Oil Company, the High Arctic Research Station gained a permanent building to support the growing number of researchers who worked there each season. Designed by Stu and his colleagues, the lab building featured an observation tower as well as working and sleeping space. With this new “permanent” status, Stu was appointed Director of the High Arctic Research Station.

That his choice of place and timing was an astute one is demonstrated by the 25 successive years that scientists returned to investigate all aspects of this remarkable place. As well as zoologists, botanists, climatologists, ecologists, and archeologists. Stu also encouraged artists, musicians, writers, and even politicians to visit the research station.

The list of publications—books, scientific papers, popular articles, graduate theses, and documentary films—based on research in Polar Bear Pass runs to an impressive 150 items. Among the books about the studies at Polar Bear Pass are *High Arctic* (1971), an account of artist George Miksch Sutton’s time at the Station, Peter Buerschaper’s *Arctic Journey: Paintings, Sketches, and Reminiscences of a Vanishing World* (1977), and *The Muskoxen of Polar Bear Pass* by DRG (1987), an illustrated account of the longest running project at the Station.

Although the Canadian Museum of Nature gave up the High Arctic Research Station when the Vertebrate Ethology section was closed in 1994, the lab building is still used, both by researchers and occasionally by Inuit from Resolute Bay.

### Stewart as Conservationist

During the early 1970s, when oil companies proposed to build a pipeline across Polar Bear Pass, they



FIGURE 2. Stu MacDonald holding an Arctic Hare, 30 July 1968, at Polar Bear Pass, Bathurst Island. Photo: David R. Gray.

met formidable opposition, led by Stu. The gentle bear opened the windows of the world to the Pass with his tour of beautifully illustrated lectures, his 1976 photographic exhibit, “An Arctic Oasis,” and many public media talks. It was a long 18-year battle led by Stu, but victory was attained in 1986. Public pressure encouraged the Canadian government to create a national wildlife reserve of 2624 km<sup>2</sup> around and including Polar Bear Pass. The Polar Bear Pass National Wildlife Area was the first of five such national wildlife areas set aside to preserve wildlife and habitat in what is now Nunavut.

It is interesting to recall that during meetings between government representatives and the oil companies, Stu’s efforts to preserve the Pass were described as “jeopardizing the economic future of Canada.”

A research cruise to the Antarctic in 1972, with David Parmelee, allowed Stu to expand his horizons to include the conservation of birds of the south polar regions as well.

As opportunities arose, Stu continued his surveys of breeding birds throughout the High Arctic. His discovery in 1973 of the only known colony of Ivory Gulls in Canada, on Seymour Island, off the northwest coast

of Bathurst Island, led to a unique three-year study of this rare and endangered gull. Several years later, in 1976, he discovered what was then the only known breeding location for Ross's Gull in Canada, on the Cheyne Islands in the channel east of Bathurst Island. Again several seasons of dedicated, intensive study under incredibly difficult conditions resulted in new knowledge of another rare gull species. In the research camps on both Seymour Island and the Cheyne Islands, prowling Polar Bears challenged the observers, and at times both the bears and Arctic Foxes destroyed the breeding colony. Stu's discovery led to the establishment of the Seymour Island Migratory Bird Sanctuary in 1975.

Based on his work to preserve the wildlife and their habitats in Polar Bear Pass and on Seymour Island, Stu was awarded the Massey Medal by the Royal Canadian Geographical Society in 1992 in recognition of his great contributions to increasing Canadians' knowledge of Canada's northern geography.

### Stewart as an Interpreter

Stu preferred to write popular articles rather than scientific papers, but his contributions to arctic science are widely acknowledged in spite of this. Stu struggled over the "right" way to say things in scientific papers, and scientific analysis was not his pleasure. He was much happier as an interpreter of science. Hence many of the items in his bibliography were published in more popular nature magazines, leading to a greater readership but fewer points in the museum and science world.

Stu was always focused on the important parts of life: beauty, people, and relationships. He exemplified kindness and compassion to everyone he encountered. His experiences and contacts with Inuit—at Resolute Bay in the 1950s, at Eskimo Point (now Arviat) in the 1960s, and at Grise Fiord in the 1970s—were great examples of cultural humility and positive sharing of similar interests. Stu's colour photographs of the people of those places are an important record of the changing lifestyles in the North.

Stu's arctic research and his work on preserving Polar Bear Pass and the various research projects carried out there were the inspiration for several documentary films. Working as a scientific consultant for the CBC, especially with David Suzuki and *The Nature of Things*, Stu effectively transferred his knowledge of and concern for arctic wildlife and habitat to a very wide audience. The CBC documentary productions *The Arctic Islands: A Matter of Time*, *Ellesmere-land*, *The Living Arctic*, and *Grouse Country* were very much a product of his inspiration, and his talents.

As well as the notable line drawings and distribution maps in *The Birds of Canada*, Stu illustrated his own papers on bird behaviour, for example, the beautiful drawings of Rock Ptarmigan in his 1970 papers on their breeding behaviour and life history. As an artist, Stu had plans and dreams of paintings he wanted to

create. He left behind few finished paintings, but there were several interesting started canvasses.

It was Stu's photography that became his enduring artistic legacy. Hundreds of his photographs have been published as posters and magazine covers, have been used in exhibits, and illustrate many books and magazines. Some 10 000 of his images are held in the Canadian Museum of Nature's photo collection. His still and motion photography show the results of his artistic eye for composition and his naturalist's eye for capturing significant behaviours of the animals he studied and encountered. This acute eye for detail, both as an artist and as an observer of behaviour, made him a valued and excellent judge for various wildlife art competitions, and he was a willing consultant for many wildlife artists.

### Stewart the Man

For DRG, working with Stu as his "boss" for over 20 years was a wonderful experience. He was always more of a colleague and a friend than a boss, providing advice and guidance in a spirit of freedom and encouragement.

When DRG began planning for an overwinter stay at Bathurst Island as a student, there were many who focused on the difficulties and challenges, but Stu and Fred Roots, both friends of all arctic research, took the road of encouragement and followed through with the practical support and advice that typify these two arctic colleagues and veterans. During that wonderful winter, Stu insisted on a radio message once a week and faithfully communicated the contents to our families.

The many years of shared experiences in the field with Stu were a rare privilege. Camp life was full of entertaining stories of past exploits and encounters. Stu was a talented camp cook, working wonders with limited resources and always setting a high standard for service to others. Each day in any camp with Stu featured a wrap-up with reports from each person's day, highlighted by the daily "Guess what I saw today!"

One can't think about Stu without thinking about his family. He and his wife, Isobel, brought up three active sons, Iain, Bruce, and Alexander, in Ottawa and later in Dunrobin (west of Ottawa), where the couple brought new life to an enchanting old farm called *Windwhistle*. Many friends enjoyed their hospitality and shared Stu's love of gardening over the years.

In the mid-1970s Stu was overjoyed to be able to take two of his boys to the Arctic to assist him with his research projects. This was an important time for the family, since Stu had missed so many summers with them when they were young. The three sons all show aspects of their dad in their appearance, natures, and chosen occupations.

### Stewart in Retirement

When Stu retired in 1988, we collected photos and memories of his life from hundreds of people he had

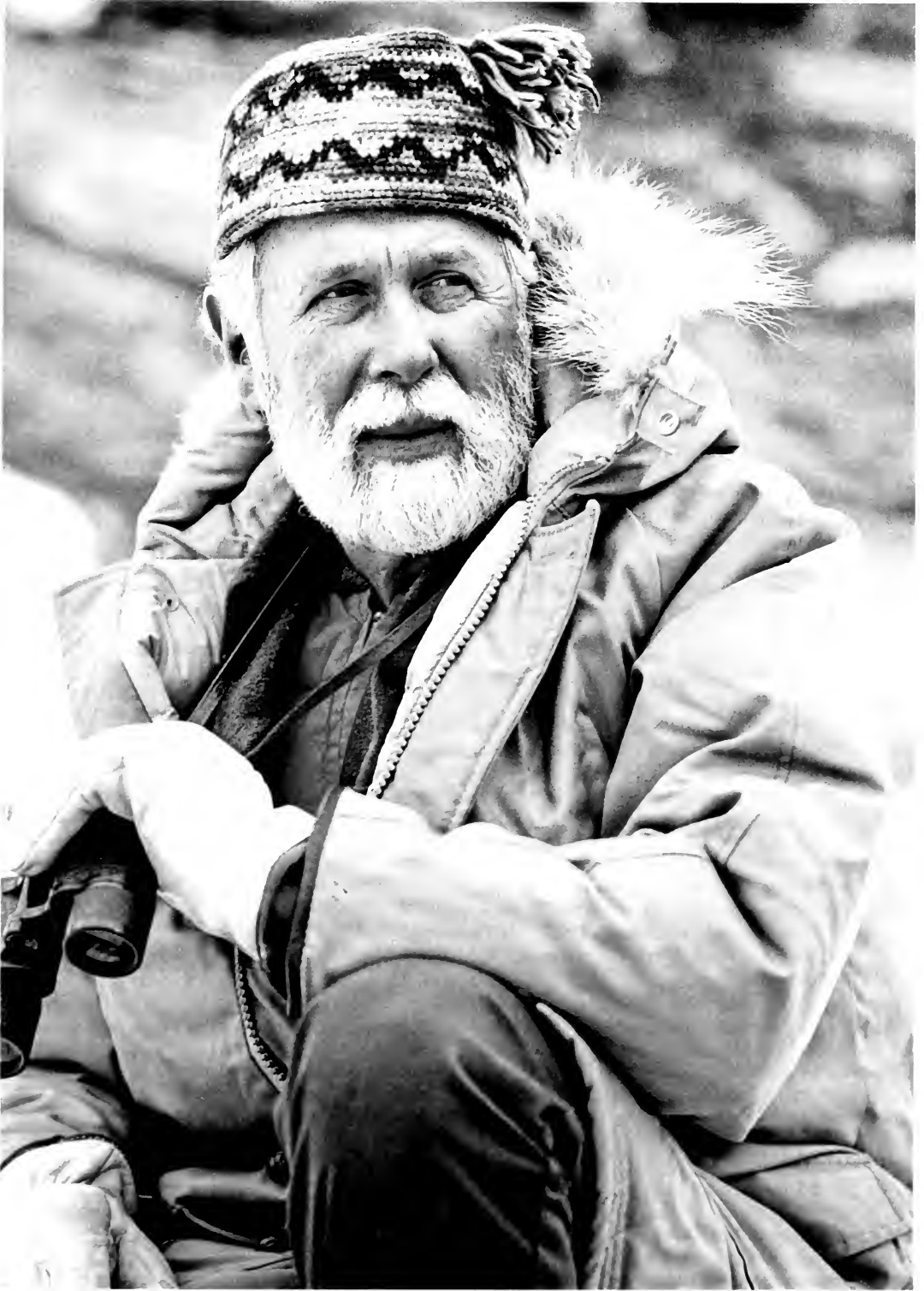


FIGURE 3. Stu MacDonald photographed near his home in Dunrobin, Ontario, March 1987. Photo: Alexander MacDonald.

influenced in one way or another over his 40 years in the Arctic and with the Museum. The incoming mail was filled with admiring notes sent from appreciative scientists and others in many fields whose careers had been launched, or at least encouraged, by Stu.

In retirement, Stu worked with others to publish important aspects of his work on arctic gulls that he had not managed to prepare for publication while at the Museum.

In his later life, Stu also connected with a group preserving the history of the U.S.–Canada joint weather stations. Because he had worked at many of the stations in their early years, his knowledge of Alert, Mould Bay, Eureka, and Resolute Bay was unique. His contributions to the history of the early days at the weather stations were greatly valued.

Stu was predeceased by Isobel, his wonderful wife of 50 years, to whom he devoted all of his life and energy during her long illness. He delighted in his grandchildren in his retirement years. He never ran out of dreams, projects, or his love of the North, family, and friends.

When we interviewed Stu for the documentary film, *Arctic Shadows*, in the summer of 2009, he recalled for us, as requested, his unique memories of R. M. Anderson, former Chief Biologist at the National Museum. This was an unusual opportunity to look into the distant past of the old Museum through the eyes of one who had been there. But Stu also shared with us a review of his long and happy involvement with the Arctic, specifically the work at Bathurst Island, which obviously meant so much to him. The wonderful times shared with kindred spirits at Polar Bear Pass were clearly the high point of his arctic career.

In August 2010, when Stu had gone into the hospital for his last stay, his daughter-in-law sent an email to inform us of his situation. From an arctic expedition ship off the east coast of Baffin Island, DRG was able to tell Stu how just that week DRG had been sharing with the 75 students on the *Students on Ice Expedition* how much he had influenced not only DRG's own career in arctic research but also the careers of so many other young students.

Stu's impact on many young people, on the preservation of significant arctic places, and on our record of arctic wildlife, environments, and history, will continue far into the future. All of his contributions form a lasting tribute to the man described as "a scientist with the soul of an artist."

### Acknowledgements

We extend our appreciation to Charles Gruchy (North Gower, Ontario), Donna Naughton (Canadian Museum of Nature), and Phillip S. Taylor (Saskatoon, Saskatchewan) for reading the manuscript and to Chantal Dussault, Andr e Bisson, Richard Martin and Susan Goods of the Canadian Museum of Nature for

researching photographs, and Bruce and Alexander MacDonald for additional information on these.

### Bibliography of Stewart D. MacDonald

- MacDonald, S. D.** 1951. Biological investigations on Prince Patrick Island. National Museum of Canada Bulletin 123: 131–132.
- MacDonald, S. D.** 1953. Report on biological investigations at Alert, N.W.T. National Museum of Canada Bulletin 128: 241–256.
- MacDonald, S. D.** 1954. Report on biological investigations at Mould Bay, Prince Patrick Island, N.W.T., in 1952. National Museum of Canada Bulletin 132: 214–238.
- Parmelee, D. F., and S. D. MacDonald.** 1960. The birds of west-central Ellesmere Island and adjacent areas. National Museum of Canada Bulletin 169: 1–103. 10 plates.
- MacDonald, S. D.** 1961. Biological investigations at Isachsen, Ellef Ringnes Island, N.W.T. National Museum of Canada Bulletin 172: 90–97.
- MacDonald, S. D., and D. F. Parmelee.** 1962. Feeding behaviour of the Turnstone in Arctic Canada. *British Birds* 55: 241–244.
- MacDonald, S. D., and A. H. Macpherson.** 1962. Breeding places of the Ivory Gull in Arctic Canada. National Museum of Canada Bulletin 183: 111–117.
- Godfrey, W. Earl.** 1966. The Birds of Canada. National Museum of Canada Bulletin 203: 1–428. Illustrations by J. A. Crosby, line drawings by S. D. MacDonald. [Issued also in French as *Les oiseaux du Canada*.]
- MacDonald, S. D.** 1968. The courtship and territorial behavior of Franklin's race of the Spruce Grouse. *Living Bird* 7: 5–25.
- MacDonald, S. D.** 1969. Preliminary report on a zoological expedition to Bathurst Island, May 18 to August 12. *Arctic Circular* 19: 18–20.
- MacDonald, S. D.** 1970. The breeding behaviour of the Rock Ptarmigan. *Living Bird* 9: 195–238.
- MacDonald, S. D.** 1970. Life history of Rock Ptarmigan on Bathurst Island, NWT. *Arctic Circular* 20: 44–48.
- MacDonald, S. D.** 1972. The Arctic: land of fragile beauty. *Ontario Naturalist* 11(2): 24–29.
- MacDonald, S. D.** 1972. Rites of spring. *Audubon Magazine* 74(3): 68–75.
- MacDonald, S. D.** 1972. Look at a marsh with straight eyes. *Nature Canada* 1(2): 17–19.
- MacDonald, S. D.** 1974. Sanctuaries of the woods. *Nature Canada* 3(2): 14–17.
- MacDonald, S. D.** 1975. Review of Paul A. Johnsgard, *Grouse and Quails of North America*. *Canadian Field-Naturalist* 89: 473–474.
- MacDonald, S. D.** 1975. Review of George Miksch Sutton, *High Arctic—An Expedition to the Unspoiled North*. *Canadian Field-Naturalist* 89: 485–486.
- Parmelee D. F., and S. D. MacDonald.** 1975. Recent observations on the birds of Isla Contramaestre and Isla Magdalena, Straits of Magellan. *Condor* 77: 218–220.
- MacDonald, S. D.** 1976. Phantoms of the polar pack ice. *Audubon Magazine* 78(3): 2–19.
- MacDonald, S. D.** 1976. Gyr! *Audubon Magazine* 78(4): 76–79.
- MacDonald, S. D.** 1977. An arctic oasis. *Nature Canada* 6(3): 4–6.

- MacDonald, S. D.** 1977. An Arctic oasis / Une oasis arctique [exhibit]. Photography by S. D. MacDonald. National Museum of Natural Sciences, Ottawa. 12 pages. Brochure to accompany the exhibit.
- MacDonald, S. D.** 1979. First breeding record of Ross's Gull in Canada [abstract]. Page 16 in *Proceedings: 1979 Conference of the Colonial Waterbird Group*.
- MacDonald, S. D.** [1979?] Status report on the Ivory Gull, *Pagophila eburnea*, in Canada, 1978. Committee on the Status of Endangered Wildlife in Canada, Ottawa.
- MacDonald, S. D.** 1980. Scientific progress: terrestrial biology, an overview. Pages 171–186 in *A Century of Canada's Arctic Islands 1880–1980*. Royal Society of Canada.
- Hollett, K. G., V. G. Thomas, and S. D. MacDonald.** 1984. Structural and functional aspects of supraorbital combs of grouse. Pages 193–211 in *Third International Grouse Symposium*, York, England, 1984. *Edited by* P. Hudson and T. W. I. Lovel. International Council for Game and Wildlife Conservation and World Pheasant Association.
- Godfrey, W. E.** 1986. *The Birds of Canada*. Revised edition. National Museum of Natural Sciences, National Museums of Canada, Ottawa. Illustrations by J. A. Crosby; line drawings by J. A. Crosby and S. D. MacDonald. 595 pages. [Issued also in French as *Les oiseaux du Canada, édition révisée*].
- Thomas, V. G., and S. D. MacDonald.** 1987. The significance of terrestrial and marine oases in the High Arctic. Pages 147–153 in *Arctic Heritage: Proceedings of a Symposium, August 24–28, 1985*. Banff, Alberta, Canada. *Edited by* G. Nelson, R. Needham, and L. Norton. Association of Canadian Universities for Northern Studies, Ottawa. 653 pages.
- Thomas, V. G., and S. D. MacDonald.** 1987. The breeding distribution and current population status of the Ivory Gull in Canada. *Arctic* 40: 211–218.
- MacDonald, S. D.** 1990. The whelping patch: adrift on pack ice in the Labrador Sea, hooded seals give birth to their young. *Nature Canada* 19(3): 23–27.
- MacDonald, S. D.** [1990?]. Status report on the Ivory Gull, *Pagophila eburnea*, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa.
- Haney, J. C., and S. D. MacDonald.** 1995. Ivory Gull (*Pagophila eburnea*). No. 175 in *The Birds of North America*. *Edited by* A. Poole and F. Gill. Academy of Natural Sciences, Philadelphia, and the American Ornithologists' Union, Washington, D.C. 24 pages.
- Alvo, Robert, and S. D. MacDonald.** 1996. Updated status report on the Ivory Gull, *Pagophila eburnea*, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa.
- O'Briain, Michéal, Austin Reed, and S. D. Macdonald.** 1998. Breeding, moulting, and site fidelity of Brant (*Branta bernicla*) on Bathurst and Seymour islands in the Canadian Arctic. *Arctic* 51: 350–360.
- Mallory, Mark L., Iain J. Stenhouse, Grant Gilchrist, Gregory Robertson, J. Christopher Haney, and S. D. MacDonald.** 2008. Ivory Gull (*Pagophila eburnea*). No. 175 in *The Birds of North America*. *Edited by* A. Poole. *The Birds of North America Online*. Cornell Lab of Ornithology, Ithaca, New York <http://bna.birds.cornell.edu/bna/species/175doi:10.2173/bna.175>.

Received 9 March 2012

Accepted 18 September 2012

# A Tribute to Donald M. Britton (1923–2012), Canada’s Premier Pteridologist

DANIEL F. BRUNTON

216 Lincoln Heights Road, Ottawa, Ontario K2B 8A8 Canada

Brunton, Daniel F. 2012. A tribute to Donald M. Britton (1923–2012), Canada’s premier pteridologist. *Canadian Field-Naturalist* 126(3): 252–259.

“Do you know what you have here, man?” When Donald Britton, one of the world’s foremost pteridologists, got that excited about a specimen, you knew that an adventure was about to begin.

Don (Figure 1) enjoyed a long, exceptionally productive career at the University of Guelph specializing in the cytogenetics and systematics of ferns and fern allies. In addition to building the pteridophyte collection in the University of Guelph herbarium (OAC) (Thiers 2012) to world-class status and conducting a large body of scientific research that generated an impressive bibliography (appended), he inspired a whole community of academic and applied researchers. Subsequent investigations of fern distribution, taxonomy, genetics, and ecology were taken to heights never before seen in Canada.

Don benefited from an early exposure to the natural world at a beloved family cottage on an island in Portage Lake (Gordon Bay) in the District of Parry Sound about 125 km north of his Toronto, Ontario, home. He spent entire summers there as a child. Whether hiking with his cousin under the supervision of his uncle Jock (Charles) Stewart, who informed the lads about the identification of the flora, or exploring the “wilderness” of the family island on his own, Don learned instinctively to be comfortable in the natural world (John Beverly Clark, personal communication, 28 July 2012). Until the end of his life, Don retained a close relationship with the natural world and spoke affectionately of Portage Lake, almost as if it were a lifelong friend.

Donald MacPhail Britton was born in Toronto on 6 March 1923, the youngest son of Arthur Britton and Marjorie Spence. He endured a bout of tuberculosis as a child and wiled away many hours during his recovery examining seed catalogues. His cousin, John Beverly Clark (personal communication, 28 July 2012), suggests this greatly encouraged his already budding interest in horticulture and plants. Don maintained a magnificent garden throughout his adult life.

He was schooled locally, completing an undergraduate degree in biology and science in 1946 at the University of Toronto. He did graduate work at the University of Virginia, achieving his Ph.D. in 1950 with a thesis entitled “Cytogenetic studies on the Boragina-

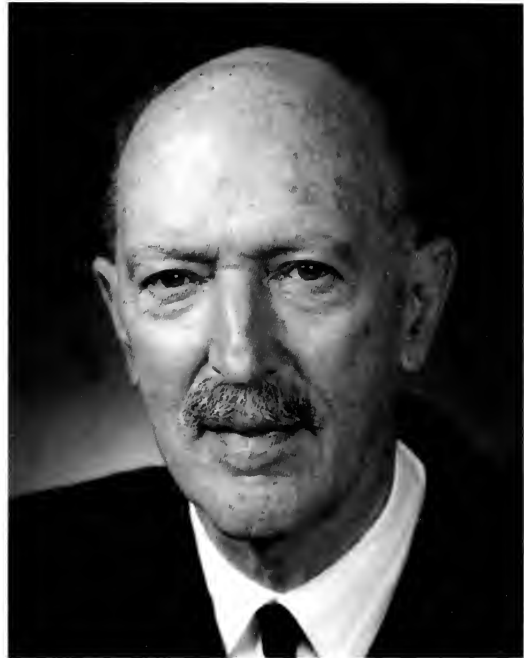


FIGURE 1. Donald M. Britton (1997). Photo courtesy of Robert Britton.

ceae” (Catling 2003). Thereafter, he was a post-doctoral fellow in the Department of Plant Sciences at the University of Alberta for a year (Britton 1953) and spent five more years as an Assistant Professor of Horticulture at the University of Maryland, working on *Rubus* (Catling 2003). Even in those early days, he had established a reputation for working on “impossible groups” of plants (Mainguy 2007), a research challenge that remained with him throughout his career.

Precisely when his interest in pteridophytes developed is unclear, but it was evident early in his academic career. He published his first paper on ferns in 1953. He was inspired to undertake a cytological study of southern Ontario ferns by British scientist Irene Manton (1904–1988), who pioneered the use of staining and squash techniques and later employed the new electron microscopy technology to produce greatly enhanced

images of fern chromosomes (Preston 1990). In documenting her findings, she included cytological data on European populations of species also present in southern Ontario (Manton 1950). Don refined her techniques for his Canadian studies, producing cytological images with previously unknown efficiency and clarity. Not surprisingly, Portage Lake was the source of some of the plant material (e.g., Fragile Fern (*Cystopteris fragilis*)) for his initial pteridophyte publication.

Don joined the Department of Botany (later, Department of Botany and Genetics) at the University of Guelph in 1958, becoming a full Professor in 1971 and Professor Emeritus upon his retirement in 1988. In her eloquent address at Don's memorial service, former student Kathleen Pryer of Duke University described him as a teacher and supervisor, noting that he:

was extremely generous with his time and very patient with students, and he showed us through his example how you need to put in the long hours to get those perfect chromosome squashes, and to locate those hard-to-find ferns when doing field work. It was a natural talent for him—it was as though he had special radar in the field for finding the ferns that we were after. One does not learn how to do that from books, but by watching and observing, if you are fortunate to be with someone who has the “know how”... I [am] reminded not only of his very special sense of humour, but also how he was always gently encouraging me to move beyond my comfort zone—to get my work published and to move on, to not “stew about things” or be so “fearful”.

Don was proud of his students and followed their progress closely, likely none more than Kathleen Pryer, who appropriately enough at the time of his death was President of the American Fern Society.

In his professional undertakings, he took a biosystematic approach, combining his various laboratory tools with direct and typically first-hand field experience. His use of this combination of investigative methods led frequently to valuable insights into the systematics of some of the most complex and seemingly inscrutable of fern groups. He became a world authority on the taxonomy of genera such as *Dryopteris*, *Polypodium*, *Woodsia*, *Pellaea*, *Polystichum*, and *Isoetes*. Unravelling the complexities of such groups typically followed the same path: first ferret out the taxonomic basics (find the diploids), then work towards the complexities (the polyploids), and let the exceptions (hybrids) help to establish the boundaries between species.

His work with hybrids in several fern genera was ground-breaking and led to two particularly notable “Do you know what you have here, man?” moments. The first was in the early 1970s, when he immediately identified the strange woodfern (*Dryopteris*) that Paul Keddy and I found in Algonquin Provincial Park,

Ontario, as a hybrid involving Fragrant Wood Fern (*Dryopteris fragrans*) as one of the parents. By then, Don was a well-established authority on the complex genus *Dryopteris*, which was also being studied extensively by the prominent U.S. botanist Warren (Herb) Wagner Jr. and others. Hybrids that involved all other widespread species of *Dryopteris* in North America had been found and described. Don and Herb were in a (mostly!) friendly competition to find the missing link and now Don had it. As we developed and refined our investigation, Don admonished us to keep news of this under our hats in case “others” got wind of it and might be tempted to rush similar findings into publication. The idea that botanical taxonomists could think like Yukon prospectors staking gold claims in the dead of night was a revelation to us, but we kept quiet.

Soon enough, a letter arrived from Herb Wagner speaking of rumours of a *Dryopteris fragrans* hybrid found in our neck of the woods. There followed an exchange of uninformative “weather's fine: wish you were here” responses to Herb's bundles of reprints, specimens, and information that arrived as incentives to loosen our tongues. We managed to keep the confidence, however, until the description of the Algonquin Woodfern (*Dryopteris* × *algonquinensis* D. M. Britton) was in press (Britton et al. 1975) (Figure 2). Such intrigue!

The second “Do you know what you have here, man?” moment occurred years later and with considerably fewer cloak and dagger elements. It began in 1988, with an Ottawa River *Isoetes* specimen I sent Don to be deposited in the OAC herbarium and for his verification. He immediately recognized it as a hybrid—the existence of such entities in *Isoetes* only having just been discovered. We eventually described it as Dodge's Quillwort (*Isoetes* × *dodgei* Eat.) (Britton and Brunton 1989)... and the floodgates opened. When you started a project with Don, you had to be ready to be inundated with letters, papers, photos, specimens, and thoughts of all kinds, and to be prepared for the project to veer off into other directions, most undertaken simultaneously. In the preceding years, Don had begun to unravel the cytological and morphological mysteries of the exasperatingly difficult aquatic lycoplyte genus *Isoetes* with graduate student Laina Kott (e.g., Kott and Britton 1983). Work on the *I.* × *dodgei* hybrid opened many leads, and from the late 1980s, as our journey led us in new and unexpected directions, Don and I became increasingly fascinated (obsessed?) with the genus.

He was deliberate and thorough in his leadership of these investigations. Following our comprehensive reviews of thousands of herbarium specimens to identify populations of possibly undescribed taxa from various parts of North America, I would then conduct field searches for living plants. These field explorations were almost always conducted in concert with skilled field botanist Karen L. McIntosh and were focussed in

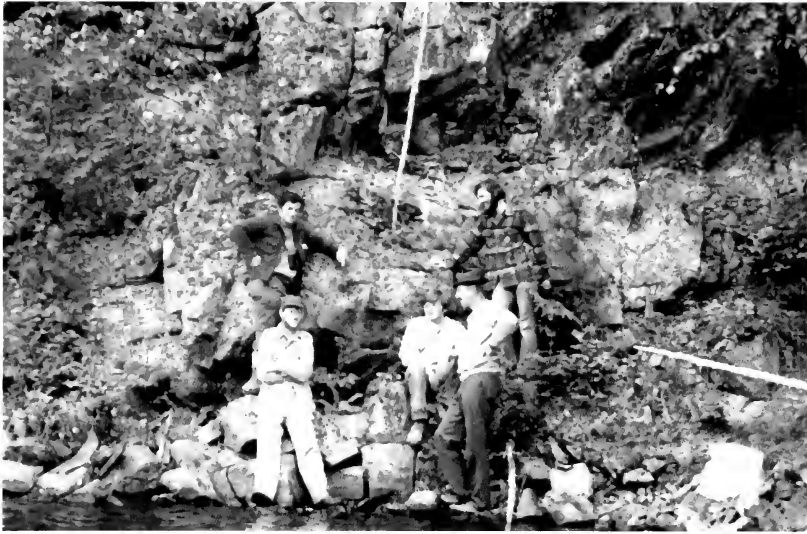


FIGURE 2. At the site of the Algonquin Woodfern, 15 June 1975 (left to right: Daniel Strickland, Paul Keddy, Daniel Brunton, Don Britton, Tony Reznicek). Photo: D. F. Brunton.

areas particularly rich in species of *Isoetes* in western Canada, the Maritimes, and the southeastern United States. When searches were successful and target plants had been secured, we would pass the living material to Don, who then applied his cytological expertise, real-world experience, and scholarly insight to unravelling or confirming what we had brought back.

Over a period of two decades of such investigation, “the book” on quillworts was practically rewritten. Within a few years, he had us studying and writing about *Isoetes* taxa from across North America and from Europe, Asia, and even New Zealand. At one point, I flippantly noted that we were studying 34 of the 30 known species of *Isoetes* in North America. Over 30 scientific papers and 17 new taxonomic descriptions resulted. Remarkably, all of these papers were published after Don had officially retired. A detailed listing of his many taxonomic innovations and redefinitions is provided in Pryer (*in press*).

Don never questioned that these investigations would be anything but joint efforts, even when his partner lacked an institutional affiliation or formal training. As with all his cooperative initiatives, he was completely unimpressed by one’s title or position. If you shared his passion and had a measure of skill and determination, you were part of the team (Brunton and Catling 2012). This democratic attitude to research and to research associates encouraged the development of a large network of contacts within Canada and beyond. While he never became comfortable with the Internet, Don maintained an internet network scale of correspondents with whom he exchanged a steady flow of information, specimens, and insights. This not only contributed significantly to the growth of the OAC

herbarium but also positioned him uniquely to address the ecological and distributional aspects of the Canadian pteridophyte flora in the definitive *Ferns and Fern Allies of Canada*, which he co-authored with Bill Cody in 1989 (Cody and Britton 1989).

It has to be said, however, that despite successfully managing such a large international communications network, Don was not always the clearest of communicators. His writing style was cryptic at times (most times!), often taking the form of a stream of botanical consciousness (Figure 3). I only half-jokingly observed that I developed a fuller understanding of the scope of particular projects we were working on when Don copied me on a letter he had sent to someone else explaining what we were doing! I think he assumed that his thoughts must also be occurring to you when you were working on the same project. He did not seem to realize that his insight and grasp of the subject might be several times deeper and quicker than yours. Flattering and intimidating all at the same time!

Don was known by everyone in the fern world. This was vividly demonstrated when I attended fern conferences with him in Toronto in 1989 and Montreal in 1997. He was a quiet-spoken and unassuming gentleman and moved very much in the quieter areas of those halls, leaving the more brightly illuminated, crowded areas to the more flamboyant participants, such as the aforementioned, always delightful Herb Wagner. We would be sitting quietly off to the side with Don occasionally punctuating the conversation with “Oh joy” in ironic reference to some new challenge that a speaker had just shared with the rest of us. But our conversations were constantly interrupted by a stream of botanists who just had to come over and express their



This is a crazy genus!  
 Engel. almost sets up a variety  
 (canadensis) > cites only two  
 collections. Pfeiffer (1922) holds onto  
 the variety ~~canadensis~~ > yet puts  
 Crow R. (Macoun) in I. riparia s. str.  
 > all of Ottawa in canadensis.  
 "Just add water > stir"

FIGURE 3. Britton marginal note: "This is a crazy genus! [George] Engel[mann] almost sets up a variety (*Isoetes riparia*) *canadensis*) and cites only two collections. [Norma] Pfeiffer (1922) holds on to the variety... and yet puts [one of the two collections, the] Crow River [Ontario collection by] ([John] Macoun) in *I. riparia* s. str. and all of [the] Ottawa [River] collections in *canadensis*. "Just add water and stir".

delight in seeing him and thanking him for the various things he had done for them. He took this all in stride, just matter-of-factly mentioning some of the ways that he had assisted particular researchers with certain of their undertakings.

Appropriately, Don received many scientific accolades and honours in his lifetime. He was awarded the Lawson Medal by the Canadian Botanical Association in 1991. The citation for this prestigious award highlighted his work as a pioneering pteridophyte cytogeneticist and his effective direction of productive graduate students (Catling 2003). He was made an honorary member of the American Fern Society in 2001 for his extensive contributions to North American and global pteridophyte research in general and to *Isoetes* systematics in particular (Anonymous 2002). He also received the inaugural John Goldie Award for Field Botany from the Field Botanists of Ontario in 2007 in acknowledgement of his outstanding work as a field botanist, for contributing over 13 000 vascular plant specimens (the vast majority of these being pteridophytes) to the OAC herbarium, for his mentorship of both professional and non-professional botanical associates, and his service as an important resource person for many conservation initiatives across Ontario (Mainguy 2007). Similar achievements and contributions on a national scale were noted when he was made an honorary member of the Ottawa Field-Naturalists' Club in 2001 (Brodo et al. 2001). Don was a long-term member of the OFNC, joining in 1972.

He was a co-recipient of the Windler Prize in 1997 for the best paper published in the 1996 volume of *Castanea* (Tyndall 1997), on the clarification and re-description of *Isoetes virginica* Pfeiffer (Brunton et al. 1996). On the occasion of his 80th birthday in 2003, two issues of BEN (*Botanical Electronic Newsletter*) were dedicated to his achievements (Brunton 2003; Catling 2003; Ceska and Ceska 2003; Pryer 2003; Reznicek 2003), and an upcoming paper concerning *Cystopteris* and *Gymnocarpium*, genera of which Don was a keen student, is dedicated to his memory (Pryer, *in press*).

Don was humble about awards and tributes. He was, however, delighted to have several fern taxa named in his honour. In each case, his pleasure was heightened by having enjoyed a lengthy personal relationship and extensive research activity with one or more of the authors. Taxa named in his honour (all still recognized as originally described) are as follows:

Britton's Oak Fern (*Gymnocarpium* × *brittonianum* Sarvela) K. M. Pryer & C. Haufler),

Britton's Quillwort (*Isoetes* × *brittonii*) D. F. Brunton & W. C. Taylor, and

Britton's Male Fern (*Dryopteris filix-mas* spp. *Brittonii*) C. Fraser-Jenkins & C.-J. Widen.

I think he was particularly pleased that the endemic North American subspecies of the Male Fern (Figure 4) was named in his honour; he maintained several fine specimens of this handsome fern in his garden.



FIGURE 4. Britton's Male Fern (*Dryopteris filix-mas* spp. *brittonii*). Cape Breton Highlands National Park, Nova Scotia. Photo: D. F. Brunton.

Even as Don was winding down his research activities, he remained generous with both his time and his botanical resources. He donated the majority of his rich fern library and thousands of scanning electron microscope images of *Isoetes* for my use, for example.

Unfortunately, Don was diagnosed with Alzheimer's disease in 2008. Despite this debilitating challenge, he retained his love of nature virtually to the end of his life. He was well and gently cared for by his family,

particularly by his delightful wife of 60 years, Mary Ann (née Cronyn), until her death in 2010, and thereafter by his children. His son Robert moved into the family home in 2010 to allow Don to remain with his prized fern garden and comfortable, familiar surroundings. Don died of pneumonia on 18 May 2012 and his remains were subsequently interred in the cemetery of St. John's York Mills Anglican Church (Toronto). In addition to his son, Robert, he is survived by two daughters, Barbara and Anne (Terry Greenlay), and two grandsons, Ben and Scott Greenlay.

A Celebration of Life Memorial Service was held in Guelph on 28 July 2012 at St. George's Anglican Church, where he and Mary had been long-time members. Kathleen Pryer, Hugh Dale, and I were honoured to speak there of his scientific achievements and the esteem in which he was held in the botanical world. It is a measure of Don's humble nature that the significance of his scientific reputation was unknown to most of his long-time church associates in attendance that day.

In final reflection upon a great life and a great career, I am reminded once again of Don's question, "Do you know what you have here, man?" I sure do; in Donald Britton we had an internationally renowned botanist, the greatest fern authority Canada has known, an extraordinarily creative and inspiring researcher, and a loyal and generous friend. Of all those wonderful attributes, the last of these was perhaps the greatest.

### Acknowledgements

My thanks to Kathleen Pryer of Duke University, Durham, North Carolina, and Adolf Ceska of the Royal British Columbia Museum, Victoria, British Columbia, who shared some of their personal experience of Don Britton and also provided valuable information on his professional activities and achievements. Ernest Small of Agriculture and Agri-Food Canada, Ottawa, Ontario, contributed additional information for the bibliography. Robert Britton was helpful in many ways throughout the production of this tribute and provided invaluable personal insights concerning his father and their family history. The constructive comments of Karen L. McIntosh of Ottawa, Robert Britton, and Kathleen Pryer significantly improved the manuscript.

### Literature Cited

**Anonymous.** 2002. Election results [honorary members]. Fiddlehead Forum 28: 8.

**Britton, D. M.** 1953. Chromosome studies on ferns. American Journal of Botany 40: 575-583.

**Britton, D. M., and D. F. Brunton.** 1989. A new *Isoetes* hybrid (*I. echinospora* × *riparia*) for Canada. Canadian Journal of Botany 67: 2995-3002.

**Britton, D. M., C. J. Widen, D. F. Brunton, and P. A. Keddy.** 1975. A new hybrid woodfern, *Dryopteris* × *algonquinensis* D. M. Britton, from Algonquin Park, Ontario. Canadian Field Naturalist 89: 163-171.

**Brodo, I. M., C. Hanrahan, S. Darbyshire, and S. Thomson.** 2001. The Ottawa Field-Naturalists' Club Awards April 2001, Honorary Membership: Donald M. Britton. Canadian Field-Naturalist 115: 728.

**Brunton, D. F.** 2003. Don Britton at 80. Botanical Electronic News (BEN) 305: 1-2.

**Brunton, D. F., D. M. Britton, and T. F. Wieboldt.** 1996. Taxonomy, identity and status of *Isoetes virginica* (Isoetaceae). Castanea 61: 145-160.

**Brunton, D. F., and P. M. Catling.** 2012. A tribute for Donald M. Britton (1923-2012), a wonderful botanist! Canadian Botanical Association Bulletin 45: 104-105.

**Catling, P. M.** 2003. Donald M. Britton—1991 recipient of the Lawson Medal. Botanical Electronic News (BEN) 304: 1-2.

**Ceska, O., and A. Ceska.** 2003. *Isoetes minima*—guess who identified it! Botanical Electronic News (BEN) 304: 8.

**Cody, W. J., and D. M. Britton.** 1989. Ferns and Fern Allies of Canada. Research Branch, Agriculture Canada, Ottawa, Ontario. 430 pages.

**Kott, L. S., and D. M. Britton.** 1983. Spore morphology and taxonomy of *Isoetes* in northeastern North America. Canadian Journal of Botany 61: 3140-3163.

**Mainguy, S.** 2007. Some facts about the 2007 Goldie Award Recipient: Dr. Donald M. Britton. Field Botanists of Ontario Newsletter 19.

**Manton, I.** 1950. Problems of cytology and evolution in the Pteridophyta. Cambridge University Press, Cambridge.

**Preston, R. D.** 1990. Irene Manton 17 April 1904-13 May 1988. Biographical Memoirs of Fellows of the Royal Society 35: 248-261.

**Pryer, K. M.** 2003. Don Britton (DMB) Turns 80? Botanical Electronic News (BEN) 304: 3-4.

**Pryer, K. M.** *In press.* The distinguished legacy of DMB: Donald MacPhail Britton (1923-2012). American Fern Journal.

**Reznicek, A. A.** 2003. Don Britton—appreciation. Botanical Electronic News (BEN) 304: 2-3.

**Thiers, B.** 2012. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden Virtual Herbarium. <http://sweetgum.nybg.org/ih/>. (Accessed 15 December 2012).

**Tyndall, R. W.** 1997. 1997 Richard and Minnie Windler Award Recipients—Daniel F. Brunton, Donald M. Britton and Thomas F. Wieboldt. Castanea 62: 136.

### Bibliography of Donald M. Britton

(compiled by D. F. Brunton and K. M. Pryer)

#### Research publications

**Britton, D. M.** 1951. Cytogenetic studies on the Boraginaceae. Brittonia 7: 233-266.

**Britton, D. M.** 1953. Chromosome studies on ferns. American Journal of Botany 40: 575-583.

**Britton, D. M., and J. W. Hull.** 1956. Mitotic instability in blackberry seedlings from progenies of Boysen and of Young. Journal of Heredity 47: 205-210.

**Hull, J. W., and D. M. Britton.** 1956. Early detection of induced internal polyploidy in *Rubus*. Proceedings of the American Society for Horticultural Science 68: 171-177.

**Britton, D. M., and J. W. Hull.** 1957. Chromosome numbers of *Rubus*. Fruit, Varieties and Horticultural Digest 11: 58-60.

- Britton, D. M., and J. W. Hull.** 1957. Mitotic instability of *Rubus*. *Journal of Heredity* 48: 11–20.
- Tryon, A. F., and D. M. Britton.** 1958. Cytotaxonomic studies on the fern genus *Pellaea*. *Evolution* 12: 137–145.
- Britton, D. M., and J. W. Hull.** 1959. A black raspberry-blackberry hybrid. *Proceedings of the American Society for Horticultural Science* 72: 156–157.
- Britton, D. M., J. W. Lawrence, and I. C. Haut.** 1959. The inheritance of apricot fruit-color in raspberries. *Canadian Journal of Genetics and Cytology* 1: 89–93.
- Britton, D. M.** 1960. Recent fern literature—ferns of Alberta. *American Fern Journal* 50: 156–157.
- Britton, D. M.** 1960. Report on the Rougemont field trip. *American Fern Journal* 50: 216–218.
- Hull, J. W., and D. M. Britton.** 1960. New colchipsoid and natural polyploid breeding lines in *Rubus*. *Bulletin of the Maryland Agricultural Experiment Station A-91*.
- Britton, D. M.** 1961. The problems of variation in North America *Dryopteris*. *American Fern Journal* 51: 23–30.
- Britton, D. M.** 1962. *Dryopteris dilatata* (Hoffm.) A. Gray in North America. *Rhodora* 64: 207–212.
- Knobloch, I. W., and D. M. Britton.** 1963. The chromosome number and possible ancestry of *Pellaea wrightiana*. *American Journal of Botany* 50: 52–55.
- Britton, D. M.** 1964. Chromosome number of ferns in Ontario. *Canadian Journal of Botany* 42: 1349–1354.
- Britton, D. M.** 1965. Hybrid wood ferns in Ontario. *Michigan Botanist* 4: 3–9.
- Britton, D. M., and J. H. Soper.** 1966. The cytology and distribution of *Dryopteris* species in Ontario. *Canadian Journal of Botany* 44: 63–78.
- Tryon, R. M., and D. M. Britton.** 1966. A study of variation in the cytotypes of *Dryopteris spinulosa*. *Rhodora* 68: 69–92.
- Britton, D. M.** 1967. Diploid *Dryopteris dilatata* from Quebec. *Rhodora* 69: 1–4.
- Britton, D. M., A. Legault, and S. J. Rigby.** 1967. *Pellaea atropurpurea* (L.) Link and *Pellaea glabella* Mett. in Quebec. *Naturaliste canadien* 94: 761–763.
- Britton, D. M.** 1968. The spores of four species of spinulose wood ferns (*Dryopteris*) in eastern North America. *Rhodora* 70: 340–347.
- Britton, D. M., and S. J. Rigby.** 1969. In search of the Purple Cliff Brake. *Ontario Nature* 8: 5–7; 12.
- Widen, C.-J., and D. M. Britton.** 1969. A chromatographic and cytological study of *Dryopteris dilatata* in eastern North America. *Canadian Journal of Botany* 47: 1337–1344.
- Rigby, S. J., and D. M. Britton.** 1970. The distribution of *Pellaea* in Canada. *Canadian Field-Naturalist* 84: 137–144.
- Reznicek, T. [A. A.], and D. M. Britton.** 1971. Chromosome studies on the spring beauties, *Claytonia*, in Ontario. *Michigan Botanist* 10: 61–62.
- Widen, C.-J., and D. M. Britton.** 1971. Chemotaxonomic investigations on *Dryopteris fragrans*. *Canadian Journal of Botany* 49: 989–992.
- Widen, C.-J., and D. M. Britton.** 1971. Chemotaxonomic investigations on the *Dryopteris cristata* complex in North America. *Canadian Journal of Botany* 49: 1141–1154.
- Widen, C.-J., and D. M. Britton.** 1971. A chromatographic and cytological study of *Dryopteris dilatata* in North America and eastern Asia. *Canadian Journal of Botany* 49: 247–258.
- Widen, C.-J., and D. M. Britton.** 1971. A chromatographic and cytological study of *Dryopteris filix-mas* and related taxa in North America. *Canadian Journal of Botany* 49: 1589–1600.
- Britton, D. M.** 1972. Spinulose woodferns (*Dryopteris*) in western North America. *Canadian Field-Naturalist* 86: 241–247.
- Britton, D. M.** 1972. Spore ornamentation in the *Dryopteris spinulosa* complex. *Canadian Journal of Botany* 50: 1617–1621.
- Britton, D. M.** 1972. The spores of *Dryopteris clintoniana* and its relatives. *Canadian Journal of Botany* 50: 2027–2029.
- Britton, D. M.** 1974. The significance of chromosome numbers in ferns. *Annals of the Missouri Botanical Garden* 61: 310–317.
- Britton, D. M., and A. C. Jermy.** 1974. The spores of *Dryopteris filix-mas* and related taxa in North America. *Canadian Journal of Botany* 52: 1923–1926.
- Britton, D. M., and C.-J. Widen.** 1974. Chemotaxonomic studies on *Dryopteris* from Quebec and eastern North America. *Canadian Journal of Botany* 52: 627–638.
- Britton, D. M.** 1975. Orchids of Wellington County I. *Newsletter of the Guelph Naturalists' Club [now Guelph Field-Naturalists]* 5(4): 5–6.
- Britton, D. M.** 1975. Orchids of Wellington County II. *Newsletter of the Guelph Naturalists' Club* 5(5): 5–7.
- Britton, D. M.** 1975. Orchids of Wellington County III. *Newsletter of the Guelph Naturalists' Club* 5(6): 4–5.
- Britton, D. M.** 1975. Orchids of Wellington County IV. *Newsletter of the Guelph Naturalists' Club* 5(7): 5–7.
- Britton, D. M., C.-J. Widen, D. F. Brunton, and P. A. Keddy.** 1975. A new hybrid woodfern. *Dryopteris* × *algonquinensis* D. M. Britton, from Algonquin Park, Ontario. *Canadian Field-Naturalist* 89: 163–171.
- Widen, C.-J., D. M. Britton, W. H. Wagner Jr., and F. S. Wagner.** 1975. Chemotaxonomic studies on hybrids of *Dryopteris* in North America. *Canadian Journal of Botany* 53: 1554–1567.
- Britton, D. M.** 1976. The distribution of *Dryopteris spinulosa* and its relatives in eastern Canada. *American Fern Journal* 66: 69–74.
- Britton, D. M.** 1976. Two decades of cytotaxonomic research on Canadian ferns. Pages 116–126 in *Recent Advances in Botany: Prof. P. N. Mehra Commemorative Volume*. Edited by P. Kachroo. Bishan Singh Mahendra Pal Singh, Dehra Dun: Periodical Experts Book Agency, Delhi. 407 pages.
- Britton, D. M.** 1977. The fern *Woodsia obtusa* (Spreng) Torrey in Ontario. *Canadian Field-Naturalist* 91: 84–85.
- Britton, D. M.** 1977. A note: solicited review of “The Origin of *Dryopteris campyloptera* by M. Gibby. *Canadian Journal of Botany* 55: 1419–1428”. *American Fern Journal* 67: 121–122.
- Campbell, C. A., and D. M. Britton.** 1977. Pteridophytes of the Regional Municipality of Waterloo, Ontario. *Canadian Field-Naturalist* 91: 262–268.
- Kott, L. S., and D. M. Britton.** 1980. Chromosome numbers for *Isoetes* in northeastern North America. *Canadian Journal of Botany* 58: 980–984.
- Hersey, R. E., and D. M. Britton.** 1981. A cytological study of three species and a hybrid taxon of *Lycopodium* (section *Complanata*) in Ontario. *Canadian Journal of Genetics and Cytology* 23: 497–504.
- Sarvela, J., D. M. Britton, and K. M. Pryer.** 1981. Studies on the *Gymnocarpium robertianum* complex in North America. *Rhodora* 83: 421–431.

- Kott, L. S., and D. M. Britton.** 1982. A comparative study of spore germination of some *Isoetes* species of northeastern North America. *Canadian Journal of Botany* 60: 1679–1687.
- Kott, L. S., and D. M. Britton.** 1982. A comparative study of sporophyte morphology of the three cytotypes of *Polypodium* in Ontario. *Canadian Journal of Botany* 60: 1360–1370.
- Kott, L. S., and D. M. Britton.** 1982. Comparison of chromatographic spot patterns of some North American *Isoetes* species. *American Fern Journal* 72: 15–18.
- Britton, D. M., H. L. Dickson, and D. J. White.** 1983. Rare species of Ophioglossaceae. Two looseleaf pages in *Atlas of the Rare Vascular Plants of Ontario, Part 2*. Edited by G. W. Argus and D. J. White. National Museums of Canada, Ottawa, Ontario. [looseleaf].
- Cranfill, R., and D. M. Britton.** 1983. Typification within the *Polypodium virginianum* complex (Polypodiaceae). *Taxon* 32: 557–560.
- Kott, L. S., and D. M. Britton.** 1983. Spore morphology and taxonomy of *Isoetes* L. in northeastern North America. *Canadian Journal of Botany* 61: 3140–3163.
- Pryer, K. M., and D. M. Britton.** 1983. Spore studies in the genus *Gymnocarpium*. *Canadian Journal of Botany* 61: 377–388.
- Pryer, K. M., D. M. Britton, and J. McNeill.** 1983. A numerical analysis of chromatographic profiles in North American taxa of the fern genus *Gymnocarpium*. *Canadian Journal of Botany* 61: 2592–2602.
- Pryer, K. M., D. M. Britton, and J. McNeill.** 1983. Systematics studies in the genus *Gymnocarpium* Newm. (Aspleniaceae) in North America. *American Journal of Botany* 70: 60 (Abstract).
- Widen, C.-J., J. Sarvela, and D. M. Britton.** 1983. On the location and distribution of phloroglucinols (filicin) in ferns: new results and review of the literature. *Annales Botanici Fennici* 20: 407–417.
- Britton, D. M.** 1984. Biosystematic studies on pteridophytes in Canada: progress and problems. Pages 543–560 in *Plant Biosystematics*. Edited by W. F. Grant. Academic Press, Toronto, Ontario. 674 pages.
- Britton, D. M.** 1984. Checklist of Ontario pteridophytes. Part one: fern allies. *Plant Press (Mississauga)* 2: 95–99.
- Cody, W. J., and D. M. Britton.** 1984. *Polystichum lemmontii*, a Rock Shield-fern new to British Columbia and Canada. *Canadian Field-Naturalist* 98: 375.
- Goltz, J. P., D. M. Britton, and R. E. Whiting.** 1984. *Phegopteris hexagonoptera* (Michx.) Fee (southern or broad beech fern) discovered in the District of Muskoka. *Plant Press (Mississauga)* 2: 39–40.
- Pryer, K. M., D. M. Britton, and J. McNeill.** 1984. Hybridization in the fern genus *Gymnocarpium* Newm. (Aspleniaceae) in North America. *American Journal of Botany* 71: 42 (Abstract).
- Britton, D. M.** 1985. Checklist of Ontario pteridophytes. Part two: ferns. *Plant Press (Mississauga)* 3: 14–23.
- Britton, D. M., W. G. Stewart, and W. J. Cody.** 1985. *Cystopteris protrusa* (creeping fragile fern), an addition to the flora of Canada. *Canadian Field-Naturalist* 99: 380–382.
- Cody, W. J., and D. M. Britton.** 1985. *Dryopteris filix-mas* (male fern), a phytogeographically important discovery in northern Saskatchewan. *Canadian Field-Naturalist* 99: 101–102.
- Hauffer, C. H., M. D. Windham, D. M. Britton, and S. J. Robinson.** 1985. Triploidy and its evolutionary significance in *Cystopteris protrusa*. *Canadian Journal of Botany* 63: 1855–1864.
- Kott, L. S., and D. M. Britton.** 1985. Role of morphological characteristics of leaves and the sporangial region in the taxonomy of *Isoetes* in northeastern North America. *American Fern Journal* 75: 44–55.
- Widen, C.-J., and D. M. Britton.** 1985. Phloroglucinol derivatives of *Dryopteris tokyoensis* and the missing genome in *D. cristata* and *D. carthusiana*. *Annales Botanici Fennici* 22: 213–218.
- Anderson, A. B., and D. M. Britton.** 1986. *Isotria verticillata* (Muhl. ex. Willd.) Raf. (whorled pogonia) in Ontario. *Plant Press (Mississauga)* 4: 18–19.
- Britton, D. M., and A. B. Anderson.** 1986. The ferns of Manitoulin Island: notes and a new record. *Plant Press (Mississauga)* 4: 60–61.
- Britton, D. M., and D. F. Brunton.** 1987. Rare species of Selaginellaceae. One looseleaf page in *Atlas of the Rare Vascular Plants of Ontario*. Edited by K. M. Pryer and G. W. Argus. National Museums of Canada, Ottawa, Ontario. [looseleaf].
- Britton, D. M., P. M. Catling, H. L. Dickson, K. M. Pryer, and D. J. White.** 1987. Rare species of Aspleniaceae. Two looseleaf pages in *Atlas of the Rare Vascular Plants of Ontario*. Edited by K. M. Pryer and G. W. Argus. National Museums of Canada, Ottawa, Ontario. [looseleaf].
- Britton, D. M., H. L. Dickson, K. M. Pryer, and D. J. White.** 1987. Rare species of Ophioglossaceae. Six looseleaf pages in *Atlas of the Rare Vascular Plants of Ontario*. Edited by K. M. Pryer and G. W. Argus. National Museums of Canada, Ottawa, Ontario. [looseleaf].
- Britton, D. M., and D. F. Brunton.** 1989. A new *Isoetes* hybrid (*Isoetes echinospora* × *riparia*) for Canada. *Canadian Journal of Botany* 67: 2995–3002.
- Cody, W. J., and D. M. Britton.** 1989. Ferns and Fern Allies of Canada. Research Branch, Agriculture Canada, Ottawa, Ontario. 430 pages. Issued also in French as *Les fougères et les plantes alliées du Canada*. Agriculture Canada, Direction générale de la recherche, Ottawa, Ontario. 452 pages.
- Britton, D. M.** 1991. A hybrid *Isoetes*, *I. × harveyi* in northeastern North America. *Canadian Journal of Botany* 69: 634–640.
- Britton, D. M., and D. F. Brunton.** 1991. The spores and affinities of *Isoetes taiwanensis* (Isoetaceae). *Fern Gazette* 14: 73–81.
- Britton, D. M., and J. P. Goltz.** 1991. *Isoetes prototypus*, a new diploid species from eastern Canada. *Canadian Journal of Botany* 69: 277–281.
- Britton, D. M., P. M. Catling, T. Norris, and S. Varga.** 1991. Engelmann's quillwort, *Isoetes engelmannii*, an addition to the aquatic flora of Canada. *Canadian Field-Naturalist* 105: 67–70.
- Brunton, D. F., and D. M. Britton.** 1991. *Isoetes × hickeyi* (*Isoetes echinospora* × *macrospora*) in Canada. *Fern Gazette* 14: 17–23.
- Sharp, M. J., and D. M. Britton.** 1991. *Isoetes tuckermanii*, an addition to the flora of Ontario, Canada. *Canadian Field-Naturalist* 105: 283–285.
- Britton, D. M., and D. F. Brunton.** 1992. *Isoetes × jeffreyi*, hyb. nov. a new *Isoetes* (*Isoetes macrospora* × *Isoetes riparia*) from Quebec, Canada. *Canadian Journal of Botany* 70: 447–452.
- Britton, D. M.** 1993. *Isoetes reticulata* RS. Hill 1987 (Alcheringa 12: 158) is an illegitimate name. *American Fern Journal* 83: 128.
- Britton, D. M., and D. F. Brunton.** 1993. *Isoetes × truncata*: a newly considered pentaploid hybrid from western North America. *Canadian Journal of Botany* 71: 1016–1025.

- Brunton, D. F., and D. M. Britton.** 1993. *Isoetes prototypus* (Isoetaceae) in the United States. *Rhodora* 95: 122–128.
- Taylor, W. C., N. T. Luebke, D. M. Britton, R. J. Hickey, and D. F. Brunton.** 1993. Isoëtaceae Reichenbach, quillwort family. No. 4 in *Pteridophytes and Gymnosperms*. Vol. 2 of the Flora of North America North of Mexico. Edited by the Flora of North America Editorial Committee. Oxford University Press, New York, New York.
- Brunton, D. F., D. M. Britton, and W. C. Taylor.** 1994. *Isoetes hyemalis* sp. nov. (Isoetaceae): a new quillwort from the southern United States. *Castanea* 59(1): 12–21.
- Britton, D. M., and D. F. Brunton.** 1995. *Isoetes × marensis*, a new interspecific hybrid from western Canada. *Canadian Journal of Botany* 73: 1345–1353.
- Whittier, D. P., and D. M. Britton.** 1995. Gametophytes of *Diphasiastrum × habereri*. *American Fern Journal* 85: 89–94.
- Britton, D. M., and D. F. Brunton.** 1996. *Isoetes × pseudo-truncata*, a new triploid hybrid from western Canada and Alaska. *Canadian Journal of Botany* 74: 51–59.
- Brunton, D. F., and D. M. Britton.** 1996. Noteworthy collections: Alabama and Georgia; *Isoetes hyemalis* D. F. Brunton (Isoetaceae). *Castanea* 61: 398–399.
- Brunton, D. F., and D. M. Britton.** 1996. The status, distribution and identification of Georgia Quillwort (*Isoetes georgiana*; Isoetaceae). *American Fern Journal* 86: 105–113.
- Brunton, D. F., and D. M. Britton.** 1996. Taxonomy and distribution of *Isoetes valida* (Isoetaceae). *American Fern Journal* 86: 16–25.
- Brunton, D. F., D. M. Britton, and T. F. Wieboldt.** 1996. Taxonomy, identity and status of *Isoetes virginica* (Isoetaceae). *Castanea* 61: 145–160.
- Britton, D. M., D. F. Brunton, and S. S. Talbot.** 1997. *Isoetes* in Alaska, the Yukon and the Aleutians—a classical biosystematic study and its limitations. *American Journal of Botany* 84(6) (Abstracts): 161.
- Brunton, D. F., and D. M. Britton.** 1997. Appalachian Quillwort (*Isoetes appalachiana*, sp. nov.; Isoetaceae), a new pteridophyte from the eastern United States. *Rhodora* 99: 118–133.
- Brunton, D. F., and D. M. Britton.** 1997. A new Appalachian *Isoetes* species in the eastern United States. *American Journal of Botany* 84(6) (Abstracts): 161.
- Brunton, D. F., and D. M. Britton.** 1998. *Isoetes microvela* (Isoetaceae), a new quillwort from the coastal plain of the southeastern United States. *Rhodora* 100: 261–275.
- Brunton, D. F., and D. M. Britton.** 1999. Maritime Quillwort, *Isoetes maritima* (Isoetaceae), in the Yukon Territory, Canada. *Canadian Field-Naturalist* 113: 641–645.
- Brunton, D. F., and D. M. Britton.** 1999. Quillworts (*Isoetes*) of the Ottawa District. *Trail & Landscape* 33: 131–146.
- Brunton, D. F., and D. M. Britton.** 1999. Rush Quillwort (*Isoetes junceiformis*, sp. nov.), a new pteridophyte from southern Georgia. *American Fern Journal* 79: 187–197.
- Britton, D. M., D. F. Brunton, and S. S. Talbot.** 1999. *Isoetes* in Alaska and the Aleutians. *American Fern Journal* 79: 133–141.
- Brunton, D. F., and D. M. Britton.** 2000. *Isoetes × echtuckerii*, hyb. nov., a new triploid quillwort from northeastern North America. *Canadian Journal of Botany* 77: 1662–1668.
- Brunton, D. F., and D. M. Britton.** 2000. *Isoetes melanopoda* spp. *silvatica* (subsp. nov.), a new quillwort (Isoetaceae) from eastern North America. *Castanea* 71: 15–30.
- Britton, D. M.** 2002. In his element. A reminiscence within. *Obituary: Warren H. Wagner, Jr. (1920–2000)*. *American Fern Journal* 92: 46.
- Des Marais, D. L., A. R. Smith, D. M. Britton, and K. M. Pryer.** 2003. Phylogenetic relationships and evolution of extant horsetails, *Equisetum*, based on chloroplast DNA sequence data (rbcL and trnL-F). *International Journal of Plant Sciences* 164: 737–751.
- Brunton, D. F., and D. M. Britton.** 2006. *Isoetes × novae-angliae*, a new quillwort (Isoetaceae) from northeastern North America. *Rhodora* 108: 228–241.

#### Reviews

- Britton, D. M.** 1966. Review of Frère Marie-Victorin. *Flore Laurentienne*. *American Fern Journal* 56: 84–86.
- Britton, D. M.** 1978. Review of A. Löve, D. Löve and R. E. G. Pichi. *Cytotaxonomical Atlas of the Pteridophyta. Cytotaxonomical Atlases, Volume III*. *Quarterly Review of Biology* 53: 64–65.
- Britton, D. M.** 1978. Review of J. D. Lovis. *Evolutionary Patterns and Process in Ferns in Advances in Botanical Research, Volume 4*. *Bulletin of the Torrey Botanical Club* 105: 245–246.
- Britton, D. M.** 1979. Review of W. J. Cody. *Ferns of the Ottawa District*. *Canadian Field Naturalist* 93: 345.
- Britton, D. M.** 1981. Review of K. Dhir. *Ferns of North-western Himalayas*. *Canadian Field-Naturalist* 95: 119–120.
- Britton, D. M.** 1982. Review of A. E. Porsild and W. J. Cody. *Vascular Plants of the Continental Northwest Territories, Canada*. *American Fern Journal* 71: 68.
- Britton, D. M.** 1983. Review of R. M. Tryon and A. F. Tryon. *Ferns and Allied Plants with Special Reference to Tropical America*. *Canadian Field-Naturalist* 97: 361.
- Britton, D. M.** 1986. Review of *A Field Manual of the Ferns and Fern-Allies of the United States and Canada*. Plant Press (Mississauga) 4: 34–35.

Received 13 December 2012

Accepted 19 December 2012

# Book Reviews

**Book Review Editor's Note:** We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars are AUD and so on.

**Editor's Note.** The address of the Birds of Northumberland County website has been changed to <http://www.willowbeach-fieldnaturalists.org/Northumberland-County>. This is part of the Willow Beach Field Naturalists' website, but the URL above will take you directly to the Birds of Northumberland County. Please note that the URL is case sensitive. From Clive Goodwin.

## ZOOLOGY

### **Birds of Central Asia: Kazakhstan, Turkmenistan, Uzbekistan, Kyrgyzstan, Tajikistan, Afghanistan**

By Raffael Ayé, Manuel Schweizer and Tobias Roth. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 336 pages. 39.50 USD. Paper.

For many years I said I had a field guide that covered the birds everywhere in the world, but Afghanistan. Over time I replaced many of these books with better, more modern versions. Yet I never added a volume on Afghanistan. Now there is a guide to this tumultuous area. Actually it covers six "stans": Kazakhstan, Turkmenistan, Uzbekistan, Kyrgyzstan, Tajikistan and Afghanistan.

It follows the pattern of the string of recent excellent field guides from Princeton University Press. There are 25 modern bird guides and about 20 guides to other wildlife. This latest book is written by three (very brave?) expert ornithologists from Switzerland, and it is the first-ever field guide I have seen to this mystical area of steppe, semi-desert, and mountains. It covers 618 species, including all residents, migrants, races and vagrants, with most having a range map. (The promotional material says every species, but this is not so).

This book starts with a political map of the region followed by a geographical map and a biome map. Text and photographs give examples of the various habitats. While most of the region is rolling, dry plains and rugged, rocky mountains there is a tiny zone of subtropical forest. This allows some southern species, like drongos, White-throated Kingfisher, Oriental White-eye and Purple Sunbird to gain a toe hold in the region. There is also a small patch of boreal forest in northern Kyrgyzstan. In fact, a lot of the species listed just make it into the fringes of the area, bolstering the length of the list, but leave you wondering as to their true range. Many bird accounts end with status in the region unknown. These two points surely reflect the lower birding effort in this area. As a measure of this effort I could find six to ten times more trip reports on the Internet for popular destinations like Kenya or Peru than for Kyrgyzstan.

The book is organised in classical fashion with plates on the right pages and text with a range map on the left, with five species per page the book is not crowded and is well organized. The author's have paid particular attention in describing the key field marks. The descriptions of the difficult to separate species, like warblers, is very well done and will be useful in the field. The author's have made sure that they selected the appropriate sub-species for the region.

The range maps are well organised and useful. It is not clear to me why some species do not qualify for a range map. Red-necked Phalarope is "common and often numerous" does not have a map, yet many scarce birds (Marsh Tit, several flycatchers for example) do, with minuscule arrow pointing to one locality.

There are 13 artists and 11 of these illustrated Birds of India (Richard Grimmett and Carol and Tim Inskipp, Princeton University Press) and seven were used for Birds of East Asia (Mark Brazil, Princeton University Press). Not surprisingly some of the artwork of shared species is repeated in this book. The quality of this artwork is high and is quite consistent given the number of artists.

I have one serious issue with this guide. I cannot tell how abundant the bird is, and therefore how likely am I to see it. Selecting the Carrion Crow, surely a common bird, I see from the range map that it is widespread in the east of the region. Yet there is no mention of its abundance. At the other end of the scale the Siberian Crane is listed as very rare and does not have a range map or a note of where it is found. As the western population of this species is a few to none, I would have liked a lot more information on this bird's status. On a more practical level, if I make a summer visit to Lake Balkhash in Kazakhstan, how likely am I to see an Eastern Imperial Eagle or both Greater and Asian Short-

toed Larks. Similarly the Little (Small) Pratincole is a summer breeding bird in Afghanistan, but there is no map and no text to enlighten me.

The authors should be congratulated for an inspiring effort. They have obviously scoured the references to make the text as accurate as possible. It is clear that the region is ripe for an invasion of borders who could bol-

ster the often limited records. This book will make it easier to improve these needed inputs. So would anyone like to go on a search for an Afghan Snowfinch – in Zabul Province (next to Kandahar)?

ROY JOHN

2193 Emaral Crescent, Ottawa, Ontario K1J 6K5

## Birds of the Masai Mara

By Adam Kennedy. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 176 pages. 27.95 USD. Paper.

## Animals of the Masai Mara

By Adam and Vicki Kennedy. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 152 pages. 27.95 USD. Paper.

The Masai Mara is a legendary place with an abundance of remarkable wildlife. It is home to the ferocious Masai tribe, who, fortunately, are charming hosts to visiting naturalists. The Masai Mara National Reserve covers 1,510 sq km – reduced from its maximum size when land was returned to the Masai and is a part of the Greater Mara Ecosystem. This game reserve in south-western Kenya borders the Serengeti National Park in Tanzania. Something under 300,000 tourists enjoy the park's grassland and riverine forest with its signature acacia trees every year. The park is renowned for its more than one million Blue Wildebeest that move north each year from the Serengeti plains. They are joined in this migration by half a million Thomson's gazelles, a quarter of a million Burchell's Zebras and tens of thousands of Topi and Elands.

The Kennedys have produced two volumes aimed at visitors. The first covers 65 species of mammals and also includes 17 reptile species (six snakes). This is about 70 percent of the total list of species of mammals (missing primarily bats and rodents). Each species has a page or two of photographs and a summary of the biology. The book is 15 cm by 20 cm by 1 cm, so is small and light. If it were much larger it would be a coffee-table book, because the photographs are excellent. I really liked the Cape Buffalo (page 81), covered in mud and looking so delightfully grumpy. The text discusses the life of each species, taking the reader through something of their daily lives. These are written with wit and understanding, showing the author's comfortable understanding of the animals he loves. I was gratified by his write-up of the Spotted Hyena that began with "...that suffers from seriously bad public relations.... (his) obligation to put the record straight." This correction the author does in fine fashion. Hyenas are competent, capable opportunists and why we judge them so harshly is beyond me.

The book also covers a few reptiles which, apart from the Nile crocodile, can be very hard to find. I have actively searched likely places for reptiles, even after

dark, and I have yet to see a snake and only saw four other reptile species (one not in this book).

The second book covers 200 species representing 35 to 40 per cent listed for the park (the species listed depends on which authority you choose). It is easy to see 50 species in a day even if you spend your time looking at mammals. What is missing are species like weavers (6 of 19), sandpipers (3 of 17) and cisticolas (2 of 9). These are the less colourful birds that take a lot more effort to find and identify. What are left are the big, bright and obvious birds that are most likely to be seen. Foremost is the stunning Lilac-breasted Roller, Kenya's national bird.

The book is arranged, not in taxonomic order, but by habitat; plains, marsh, woodland, acacia scrub, villages and nighttime. So plovers are in the plains and marsh sections. Eagles are in the plains, marsh and woodland sections.

Neither book typically gives more than a scant idea of how likely you are to see an animal. In all of the Masai Mara and Serengeti combined I could only find one Side-striped Jackal (described as scarce) but saw 11 of its cousin, the Black-backed Jackal. Similarly the bird book does not prime you for the frequently seen Pied Crow compared to the harder to find Village Indigobird.

The authors use some lesser-known names for some species. A good example is Egyptian mongoose (*Herpestes ichneumon*) is called Ichneumon Mongoose. Similarly, Blue Wildebeest are White-bearded Wildebeest and Burchell's Zebras are Plains Zebra. This is not a big issue and the author does give the Swahili and Masai names. (The one word of Swahili most of us know is Simba, the Lion). The bird book does not give scientific names in the main text, but has an extra index by scientific name. Unfortunately this index is in alphabetical order by scientific name so you cannot look a species up by the common name.

These books will appeal to the naturalist and non-naturalist alike because of their delightful style and

inspiring photos. If you read these books you will surely want to visit this park. The text and photos give you a good feel for the wildlife and their lives, but there is no substitute for being there. We had some of our most memorable experiences in the Masai Mara; being charged by a male Elephant, seeing a young Lion trying to attack a baby Elephant and being instantly stopped by an irate mother and watching several Lioness stalk and kill a Wildebeest.

After decades of using classical field guides I am more comfortable using books that follow taxonomic

order. However, I can see the value to new visitors to sequence the bird book by habitat. Both books are more of an introduction to the wildlife rather than an identification guide, but both books do give some identification help. My recommendation is for new visitors to read these books at home and then take classic field guides to the mammals and birds on safari. You can take these books too as they are small and lightweight and will add to your experience.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5

## Squirrels of the World

By R. W. Thorington, J. L. Koprowski, M. A. Steele and J. F. Wharton. 2012. The John Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363 USA. 472 pages. 75.00 USD. Cloth.

Squirrels have been characterized as heroes (as in *Rocky and Bullwinkle*) but are more frequently seen as villains, pilfering a disproportionate share of seed from our bird feeders and making homes in our attics. Across most of Canada, *the squirrel* is the Red Squirrel, though many of our urban areas host the Eastern Gray (either as a native or introduced) as well. However, there are almost 300 species worldwide, from ground squirrels to marmots. And *Squirrels of the World* does a wonderful job at surveying this charismatic group of mammals. The book is well-written and I think largely consumable by most readers.

The photographs in this book are worth the cost of the book by themselves. Some, like the flight sequence of the Red Giant Flying Squirrel, are stunning; others represent photographic captures arising from great skill (or perhaps luck). The few pictures which are not striking are there, I suspect, because no suitable pictures of the species exist; sadly, a few species are without photos.

This book is organized similar to many "...of the world" books, with several introductory chapters followed by the species accounts. The taxonomy is brief, and could have benefited from the addition of the actual characteristics which split or lump different groups of squirrels with or from each other. Sadly, as is *de rigueur* for the times, the only phylogenetic tree presented is that representing molecular data...not that DNA isn't important, just that it's too frequently taken as the last or (gasp!) only word on phylogeny. There are brief chapters on palaeontology and anatomy, and an appendix showing three views of squirrel skulls from each

genus. Had there been text associated with the appendix, especially a key, I would have said the anatomy was represented well. As it is, the anatomical material is adequate, and will be likely enough for most readers.

The accounts, as expected, are more information-packed for well-known squirrels, and deficient for remote species of limited distribution. Where possible, descriptions (with subspecific variation), habitat, natural history and conservation status are given ample space. Each squirrel's distribution is given by a section in the text, and a distribution map. It is the latter which holds the annoying technical flaw in the book. For species with a small distribution, a locator map is appended in the bottom left corner of the main map. Since there is no border surrounding the locator map, and since waters are both the same shade of blue in both, and lands the same shade of yellow in both, the main map and locator map sometimes appear as one confusing map. Annoying to interpret at times, but not enough (by far) to be a detriment in acquiring the book.

As an indicator of the thoroughness with which this book was researched, the reference section contains an amazing 1400-odd papers; I almost hate to quibble here, but including the references to the original species descriptions would have made this section fantastic, not just the unparalleled literature resource that it is.

Overall, this is an enjoyable read worthwhile to nature enthusiast and biologist alike.

RANDY LAUFF

St. Francis of Xavier University, Antigonish, Nova Scotia  
B2G 2W5



## OTHER

**Okanagan Geology South: Geologic Highlights of the South Okanagan Valley, British Columbia**

By Murray A. Roed and Robert J. Fulton, (editors). 2011. Okanagan Geology Committee, Kelowna, British Columbia. 237 pages. 24.95 USD. Paper.

The Okanagan area is a popular tourist and retirement destination, not least because of its pleasant climate, attractive scenery and abundant wineries. This colourful and informative geology guidebook will be useful to the many visitors who travel along the valley as well as residents who are more familiar with the landscape and want to know more about the place where they live. It covers the area from Osoyoos to Summerland. With the assistance of ten other contributors, Roed and Fulton have compiled an account of the basic geology of the region and geologic highlights at specific places, accompanied by more detailed discussion of mining, geologic hazards, surface and groundwater resources, and the relationship between geology and wine.

The heart of the book, and probably the section that will be of most interest to travellers, is Chapter 4 (Highlights of Residential Centres) compiled by Roed (pages 68–135). The Okanagan Valley is not particularly urbanized, but there are several small communities and service centres strung out along the valley, and this account takes the form of a journey from south to north, visiting each in turn. The discussion covers Osoyoos, Oliver, Okanagan Falls, Kaleden, Penticton, and Summerland, with side trips to Naramata, east of Okanagan Lake, and the White Lake area, southwest of Okanagan Falls. Specific locations of interest, usually about six or so, are shown on geologic maps for each of the eight areas of focus. These are usually places that the reader can visit and, book in hand, relate the description to what they can see in the landscape. However, the inclusion of co-ordinates (decimal lat/long) for these places would have been helpful.

The floor of the Okanagan Valley is largely mantled in recent surficial deposits (glacial, fluvio-glacial, aeolian, fluvial, and lacustrine materials), whereas the steep mountain slopes constraining the valley are mostly bedrock. The accompanying maps show both surficial (in colour) and bedrock (in black and white) geology, as well as major structural features, such as faults. They are based in part on recent (2011) bedrock geology maps by Andrew Okulitch. The bedrock units are amalgamated into six main categories, five based on temporal groupings (e.g., Jurassic to Cretaceous), whereas the sixth is based on lithology and comprises mostly plutonic and intrusive metamorphic rocks spanning ages from probable Devonian to Cretaceous. These broad categories probably mask some geological complexity, but they do make the maps clear and understandable.

This region offers abundant opportunities for the hard-rock enthusiast as well as the geomorphologist and

landscape specialist. There is plenty of variety in features to be visited and explored. I especially liked the mix of late Quaternary and older geologic features highlighted in this section. Roed has spent much of his career in surficial mapping and clearly knows this area well. The focus on the modern landscape is welcome and refreshing and distinguishes this volume from most traditional roadside geology guides.

Other sections of the book are equally interesting. I enjoyed Roed's discussion of Geologic Pioneers (Chapter 1), including G. M. Dawson from the nineteenth century, Hugh Bostock and Hugh Nasmith from the mid-20th century, and more recent workers, especially a notable contingent from the Geological Survey of Canada, including Fulton. This section illustrates how recent work and new interpretations have built on the solid groundwork of earlier survey and mapping efforts. The historical theme is taken up again in Chapter 6 on Mining and Exploration by Brian Hughes, Roed and Jennifer Clarke, which concentrates mainly on gold production. Chapter 9 on Geology and Wine by Fulton zooms out the spatial focus and places the area in a wider regional context by inclusion of a soil landscape map that extends to the northern Okanagan Valley. He discusses the terroir of several specific vineyards and notes the geological and climate factors that may influence wine characteristics.

Mountain valleys are especially prone to abrupt geologic dangers, and the Okanagan Valley is often in the news because of rock-falls, landslides or debris flows. In Chapter 5 (Geologic Hazards), Roed, with Norman Williams, Jennifer Clarke, and Nigel Skermer, provides a survey of some particularly well-known events, including the debris flow at Testalinden Creek in 2010. This flow received widespread media coverage and raised awareness of the suddenness and destructiveness of such events. Intense and heavy rainfall is often implicated in these episodes, and yet the Okanagan Valley is characterized as a dryland area. Hence surface water (Chapter 8 by Don Dobson) and groundwater (Chapter 7 by Laurie A. Neilsen-Welch, Diana M. Allen, and Roed) resources are very important and good water management is essential to support the burgeoning human population of the region. A chapter dealing explicitly with climate and related factors, such as storms, avalanches, and forest fires, would be a worthwhile enhancement to a future edition.

The book is abundantly illustrated, with many colour photographs and some black-and-white historic photographs. Sidebars amplify selected topics and provide historical and cultural insights; these include contri-

butions by Ken Murray and David Gregory. Several cross-sections and block diagrams help to explain concepts and relate structures and landscape elements to each other. A particularly attractive and unusual feature is the inclusion of six acrylic paintings by Murray Road, five showing scenes in the Okanagan area and one of Mount St Helens. His painting of McIntyre Bluff and Vaseux Lake forms the cover image. Roed joins the small but eminent group of Canadian geologists, such as A. P. Coleman, who have also been talented and perceptive artists.

The book is well designed, with a two-column format that makes it easy to read, despite various typos. It is printed on glossy heavy stock paper which unfortunately over-strains the binding; my copy was starting to split after a couple of readings. I have some doubts of its physical durability. However, I have no doubts about the book's educational durability as a travel and geology guide. Any visitor or resident of the south Okanagan area will find it a valuable resource and a stimulus to exploration of their surroundings.

ALWYNNE B. BEAUDOIN

Royal Alberta Museum, Edmonton, Alberta

## NEW TITLES

Prepared by Roy John

† Available for review \* Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

### ZOOLOGY

\* **Odd Couples: Extraordinary Differences Between the Sexes in the Animal Kingdom.** By Daphne J. Fairbairn. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 312 pages. 27.95 USD. Cloth.

\* **Animals of the Masai Mara.** By Adam and Vicki Kennedy. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 152 pages. 27.95 USD. Paper.

**Wildlife of Australia.** By Iain Campbell and Sam Woods. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 288 pages. 19.95 USD. Paper.

\* **Birds of the Masai Mara.** By Adam Kennedy. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 176 pages. 27.95 USD. Paper.

**Britain's Freshwater Fishes.** By Mark Everard. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 144 pages. 27.95 USD. Paper.

\* **The Natural History of Canadian Mammals.** By Donna Naughton. 2012. Canadian Museum of Nature (with UOT Press), 240 McLeod Street, Ottawa, Ontario K2P 2R1 Canada. 784 pages. 69.85 CAD. Cloth.

\* **The Mammals of the World – Volume 3 (Primates).** By Russell A. Mittermeier and Don E. Wilson (Editors). 2012. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 160.00 EUR. Cloth.

**Britain's Day-flying Moths – A Field guide to the day-flying Moths of Britain and Ireland.** By David Newland, Robert Still and Andy Swash. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 160 pages. 29.95 USD. Paper.

\* **The Boreal Owl: ecology, behaviour and conservation of a forest-dwelling predator.** By Erkki Kormipaki and Harri Hakkarainen. Cambridge University Press UPH, Shaftesbury Road, Cambridge, CB2 8BS United Kingdom. 354 pages. 76.00 USD. Cloth.

\* **Pterosaurs – Natural History, Evolution, Anatomy.** By Mark P. Witton. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 336 pages. 35.00 USD. Cloth.

\* **The Crossley ID Guide: Raptors.** By Richard Crossley, Jerry Liguori, and Brian L. Sullivan. 2013. Princeton Univer-

sity Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 288 pages. 29.95 USD. Flexibound.

\* **The Warbler Guide.** By Tom Stephenson and Scott Whittle. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 560 pages. 29.95 USD. Flexibound.

### BOTANY

**The Kingdom of Fungi.** By Jens H. Petersen. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 256 pages. 29.95 USD. Cloth.

\* **The Illustrated Encyclopedia of Trees, Second Edition.** By David More and John White. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 832 pages. 49.95 USD. Cloth.

\* **Common Mosses of the Northeast and Appalachians.** By Karl B McKnight and Joseph R. Rohrer. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 392 pages. 24.95 USD. Paper.

**Aldrovanda the Waterwheel Plant.** By Adam Cross. Redfern Natural History Productions, 61 Lake Drive, Hamworthy, Poole, Dorset BH15 4LR United Kingdom. 249 pages. Unsigned 19.99 GBP. Signed 21.99 GBP. Cloth.

### OTHER

**Climate Change (Second Edition) – A Multidisciplinary Approach.** By William J. Burroughs. 2012. Cambridge University Press, 100 Brook Hill Drive, New York, New York 10884-2133 USA. 390 pages. 50.00 USD. Cloth.

**Ian McTaggart-Cowan – The Legacy of a Pioneering Biologist, Educator and Conservationist.** By Ronald D. Jakimchuk, R. Wayne Campbell and Dennis A. Demarchi. 2012. Biodiversity Centre for Wildlife Studies, 3825 Cadboro Bay Road, P.O. Box 55053, Victoria, British Columbia V8N 6L8 Canada.

\* **Protection of the Three Poles.** By Falk Heutmann (Editor). 2012. Springer Publishing Company, Shin-Osaka Copper Building, 4-11-21 Nishinakajima, Yodogawa-ku, Osaka 532-0011 Japan. 337 pages. 39.95 EUR. Cloth.

**The Reindeer Botanist: Alf Erling Porsild, 1901–1977.** By Wendy Dathan. 2012. University of Calgary Press, 2500 University Drive N.W., Calgary, Alberta T2N 1N4 Canada. 600 pages. 44.95 CAD. Paper.

# News and Comment

## Northeast Natural History Conference 2013

The 13<sup>th</sup> Northeast Natural History Conference (NENHC) hosted by The Association of Northeastern Biologists to be held 13-15 April 2013 at the Sheraton Springfield Hotel in Springfield, Massachusetts. This is a 3 day conference which promises to be the largest forum for researchers, natural resource managers, students, and naturalists to present current infor-

mation on the varied aspects of applied field biology (freshwater, marine, and terrestrial) and natural history for the Northeastern United States and adjacent Canada. Registration is currently open. Deadline for abstract submissions is March 1, 2013 and early registration deadline is March 8, 2013. More information is available at [http://www.eaglehill.us/NENHC\\_2013/NENHC2013.shtml](http://www.eaglehill.us/NENHC_2013/NENHC2013.shtml).

## American Society of Mammalogists Annual Meeting 2013

The 93<sup>rd</sup> annual meeting of the American Society of Mammalogists to be held 14-18 June 2013 at the Philadelphia Marriott Downtown in Philadelphia, Pennsylvania. Planned symposia include White-nose Syndrome in Bats, Ecological Niche Modeling, and

Advances in Ungulate Biology. Registration is currently open. Deadline for abstract submissions is April 1<sup>st</sup>, 2013. More information is available at [www.mammal-society.org](http://www.mammal-society.org).

## Erratum The Canadian Field-Naturalist 119(3): 359

Le titre de l'article devrait se lire : Caractéristiques d'une population introduite du Grand brochet, *Esox lucius*, dans le lac Ramsay, Parc de la Gatineau, Québec, et impact sur l'ichtyofaune. La bande citation de l'article devrait se lire: Vachon, Josiane, Brigitte F. Lavallée, et François Chapleau. 2005. Caractéristiques d'une population introduite du Grand brochet, *Esox lucius*, dans le lac Ramsay, Parc de la Gatineau, Québec, et impact sur l'ichtyofaune. Canadian Field-Naturalist 119(3): 359-366.

The title of the article should be : Caractéristiques d'une population introduite du Grand brochet, *Esox lucius*, dans le lac Ramsay, Parc de la Gatineau, Québec, et impact sur l'ichtyofaune. The citation strip should be: Vachon, Josiane, Brigitte F. Lavallée, et François Chapleau. 2005. Caractéristiques d'une population introduite du Grand brochet, *Esox lucius*, dans le lac Ramsay, Parc de la Gatineau, Québec, et impact sur l'ichtyofaune. Canadian Field-Naturalist 119(3): 359-366.

# Minutes of the 133<sup>rd</sup> Annual Business Meeting of The Ottawa Field-Naturalists' Club January 10, 2012

Place and time: Fletcher Wildlife Garden, Ottawa, Ontario, 7:00 pm  
Chairperson: Ann MacKenzie, President

Attendees spent the first half-hour reviewing the minutes of the previous ABM, the Treasurer's report and the OFNC committees' annual reports for 2011. The meeting was called to order at 7:30 pm with some opening remarks from the President.

## 1. Minutes of the Previous Meeting

It was moved by Annie Bélair and seconded by David Hobden that the minutes of the 132<sup>nd</sup> Annual Business Meeting be accepted with the following corrections:

- a. Item #6. "Nomination of the Auditor", should read "Nomination of the Financial Reviewer".
- b. The year stated in the motion to accept the slate of nominees as members of the Council for 2010 should be replaced by 2011.

Carried

## 2. Business Arising from the Minutes

- a. It was suggested that a way of allowing club members to express their opinion to Council should be found. During the year, Council tried out social media BigTent, but didn't feel that it would appeal to members. Therefore, there is no mechanism at the moment for members and Council to have an on-line discussion.
- b. In October 2011, Council agreed to offer a student membership for \$20 to full-time, post-secondary students. This new membership category was included in the membership renewal forms at the end of the year.

## 3. Communications Relating to the Annual Business Meeting

There were no communications relating to the Annual Business Meeting.

## 4. Treasurer's Report – Frank Pope

Frank began by saying that printed copies of the financial statements were available at the meeting and an electronic copy was also available upon request.

He then thanked Wendi Mosher of Mosher Book-keeping for compiling the data necessary for the financial report, Ann MacKenzie for reviewing the draft financial statements, Mark Patry of Welch LLP for doing the financial review and Alan German for preparing the charts in his presentation. He also thanked the volunteers at the Fletcher Wildlife Garden, who, through an agreement with the Central Experimental Farm, pay

the rent for this property and these facilities by sweat labour. He said that this was but one example of the many volunteer hours that go into running the club.

Frank then announced that the club was in a good financial position in spite of heavy expenditures on the Canadian Field-Naturalist. He presented the salient points of the financial statements in 5 charts. The first showed net assets, the next two revenues and expenditures for the club and the last two, revenues and expenditures for the Canadian Field-Naturalist. He said that the current deficit in publishing the Canadian field-Naturalist was due to the publication of 6 issues in 2011 and the introduction of an electronic edition.

Frank then leafed through the financial statements, briefly explaining each page.

It was moved by Frank Pope that this financial statement be accepted as a fair representation of the financial position of the Club as of September 30, 2011.

Seconded by Diane Lepage.

Discussion:

- a. Henry Steger, chair of the Membership Committee, pointed out that it was odd that the revenue from memberships was \$5000 lower in 2011 than in 2010, despite the rise in fees. **ACTION:** Frank to investigate and report back.
- b. Ian Whyte commented that it would be better to use the OFNC's money for conservation instead of putting it into bonds; that the club's mandate is to conserve and protect nature. Ann pointed out that on top of having a large deficit to manage in the last many years, there are many unknowns related to the CFN; the Finance Committee still feels the need to be cautious. Frank added that the OFNC still has donated \$128 000 over the last two years towards the purchase of land for conservation. Ken Young, outgoing chair of the Conservation Committee, pointed out that in some cases, the relatively small amounts of funding the OFNC could provide to help fight urban development, for example, would not be sufficient; political action is required in these situations. However, the OFNC does support education and information sharing, the Canadian Field-Naturalist being an outstanding example.

- c. There was mention of the fact that the club operated on a calendar year except for the financial records which are on a fiscal year of October 1<sup>st</sup> to September 31<sup>st</sup>. It was suggested that we might revisit this situation to assess the implications of using the same year end for both.

**Motion carried with 1 opposed.**

**5. Committee Reports**

Ann MacKenzie asked for questions and comments on the 2011 committee reports which had been distributed to the attendees.

Moved by Diane Lepage and seconded by Diane Kitching that the reports be accepted as distributed.

**Carried**

**6. Nomination of the Financial Reviewer**

Moved by Frank Pope and seconded by Diane Lepage that the accounting firm of Welch LLP be nominated to conduct a review of the OFNC's accounts for the 2010-11 fiscal year.

**Carried**

**7. Report of the Nominating Committee – E. Zurbrigg**

SLATE PROPOSED BY THE NOMINATING COMMITTEE

First motion: Moved by Eleanor Zurbrigg and seconded by Karen McLachlan Hamilton that the first format of the slate be accepted as members of the Council of the OFNC for 2012.

The format of the slate was modified during the meeting: the name of committee chairs not on Council, duplicate names and the name of the committees were removed. The revised slate is presented below.

NOMINATIONS FOR OFNC COUNCIL 2012  
(\* indicates a change from 2011)

- Officers*  
 President  
 1st Vice President  
 2nd Vice President  
 Recording Secretary  
 Treasurer

- Ann MacKenzie  
 Fenja Brodo  
 Jeff Skevington  
 Annie Bélair  
 Ken Young\*

*Council members*

- Dan Brunton  
 Barbara Chouinard  
 David Hobden  
 Diane Lepage  
 Remy Poulin  
 Henry Steger  
 Yi Zhang\*
- Carolyn Callaghan  
 Don Hackett\*  
 Diane Kitching  
 Karen McLachlan Hamilton  
 Jeff Saarela  
 Chris Traynor  
 Eleanor Zurbrigg

Second motion: Moved by Eleanor Zurbrigg and seconded by Ian Whyte that the revised slate (as presented here) be accepted as members of the Council of the OFNC for 2012.

**Carried**

**8. New Business**

Frank Pope is retiring from Council, after 32 years! Ann thanked him deeply and said that a tribute will appear in the Trail & Landscape and in the CFN. She gave him the 6<sup>th</sup> edition of the *National Geographic Field Guide to the Birds of North America* as a thank you gift.

Frank thanked everyone for their support over the years. He said that we have a great club, good people; he enjoyed the experience and was proud to be a member of the club.

**9. Adjournment**

Moved by Diane Kitching and seconded by David Hobden that the meeting be adjourned at 8:45 pm.

**Carried**

ANNIE BÉLAIR  
Recording Secretary

ADDENDUM

During the Treasurer's Report at the ABM, Henry Steger noticed that the revenue from memberships was about \$5,000 higher in 2010 than in 2011, and said that that was very unlikely since the fees had increased. The fiscal year 2010-2011 Financial Statements show revenues from Membership fees of \$32,412 and \$37,414 for 2011 and 2010 respectively, a decrease of \$5,002.

For the fiscal year 2009-10 an allocation of \$13,264 was made for accounting purposes for life members who had paid a lump sum for their perpetual membership. This had not been done in previous years so it was a catch up of several years and greatly increased the amount shown for membership. In 2010-11 the allocation was only a one year allocation of \$2,120. Without these allocations past membership revenue was \$23,547(2009), \$24,150(2010) and \$30,292(2011). The club is no longer offering life memberships.

## The Ottawa Field-Naturalists' Club 2010-2011 Annual Reports

### Awards Committee

The Awards Committee met once in 2011 to select recipients for the Club's seven awards. Committee members prepared the citations for each recipient, which outline the many ways in which the person had distinguished herself or himself by accomplishments in the field of natural history and conservation, or by extraordinary activity within the Club. The awards were presented at the Club's annual Soiree in April.

ELEANOR ZURBRIGG  
Chair, Awards Committee

### Birds Committee

The Birds Committee organized the Fall Bird Count and along with the Club des Ornithologues de l'Outaouais participated in the 2010 Christmas Bird Count. The annual Peregrine Falcon Watch did not go ahead for the second straight year due to egg failure. The seed-a-thon was successful in raising money to operate the club's bird feeders. The committee continues to operate a rare bird alert and the Ottawa bird status line, a recorded telephone message of current bird sightings. Several committee members handle the large number of bird identification requests that come in to the club via its website. The Bird Record Subcommittee met during the year to review rare bird reports and continues to work on an extensive database of Ottawa bird records.

CHRIS TRAYNOR  
Chair, Birds Committee

### Conservation Committee

#### 1. NCC Greenbelt Master Plan Review

The Greenbelt Master Plan Review being conducted by the National Capital Commission will shape the future of the Greenbelt in the decades to come. The Conservation Committee participates in the Greenbelt Coalition in order to monitor the progress of the review and attempt to influence it.

In April, 2011, the NCC and the City of Ottawa announced a "Joint Study to Assess Cumulative Effects of Transportation Infrastructure on the National Capital Greenbelt". The purpose of this study is for the City to lobby the NCC to permit additional roads and/or the widening of existing roads through the Greenbelt. Stony Swamp is one of the threatened areas, with either a widening of Richmond Road or a new road across the south end in the cards.

In May, 2011, the NCC released "strategic statements and preliminary land use concepts that will guide the future of the Greenbelt until 2060". Greenbelt Coalition members were disappointed with the limited nature of the proposed concepts. None involve more than marginal changes to the Greenbelt. During the public consultation on these proposals, the Greenbelt Coalition urged that a larger-scale expansion of the Greenbelt be undertaken. We proposed that significant natural spaces be added to the Greenbelt system, such as the Carp Hills/South March Highlands. The current review of the Master Plan is the time to establish that strategy.

#### 2. Development of the South March Highlands

Attempts to stop further development in the South March Highlands were unsuccessful, and KNL Developments began land clearing over the winter. However, there was good news in September, with the announcement by the Ministry of Natural Resources that the Kizell Drain Wetland Complex is a provincially significant wetland (psw). KNL was planning to use the Kizell Drain, which feeds into Beaver Pond, to drain its development. That cannot be done to a psw.

#### 3. Other Activities

##### Rideau Corridor Landscape Strategy

Parks Canada is conducting a project called the "Rideau Corridor Landscape Strategy". The project stems from the designation of the canal system as a World Heritage Site, and concerns the "visual character" of the canal system. An organization called the Rideau Roundtable is coordinating the response from environmental organizations, in order to make our input effective. An exploratory meeting was held on April 5, 2011, which Ken Young attended. Kingston Field Naturalists also sent a representative.

##### Use of Wild Raptors in Falconry

The Conservation Committee drafted letters for the President's signature opposing the use of wild raptors in falconry in Ontario.

##### Carp Hills-South March Highlands BioBlitz

On May 28, a bioblitz was held in the Carp Hills and South March Highlands. The OFNC provided some support with publicity, and some members participated in the fieldwork. The Education & Publicity Committee presented a display at the Carp Farmers' Market, from which the bioblitz was conducted.

##### University of Ottawa Student Request

Advice was provided to a University of Ottawa student interested in doing a project involving recreation and the environment.

KEN YOUNG  
Chair, Conservation Committee

### Education & Publicity Committee

This committee met six times this year, mostly to prepare for exhibits for various venues. We staff a sales table at all of our monthly meetings.

#### Wildlife Festival, Billings Bridge, Saturday, March 26<sup>th</sup>, 2011

Three meetings were devoted to creating our exhibit on the theme "The Boreal Forest." Six volunteers staffed our table. The amount of foot traffic and interest in our display made this event worthwhile.

#### OFNC Soirée April 16, 2011

Our Boreal Forest Exhibit was on display.

#### Carp Farmers' Market & Carp Bioblitz Saturday May 28<sup>th</sup>

Three volunteers staffed our table that featured our "Boreal Forest" display and other OFNC material.

#### EcoFair, Saturday September 17<sup>th</sup> at Carleton University Fieldhouse

Six volunteers staffed our booth that featured our Boreal Forest display as well as information on all our club activities. A new venue and new time slot (previously in the spring) resulted in a lower attendance, however, those that came were very interested in our and the other exhibits. We used the Club computer to run a continuous slide show.

#### "Meet the Experts", Canadian Museum of Nature, November 26<sup>th</sup> & 27<sup>th</sup>

We shall be show-casing our Club and its many activities to complement the Museum's show casing the expertise and knowledge of their staff. Twelve volunteers sought to staff our tables.

### Ottawa Regional Science Fair, Saturday 2 April

Our judges found worthy recipients for our prizes and wrote this event up for *T&L*.

We field many requests, usually coming from our webpage, for trip leaders or speakers. This year we supplied people for the following events:

- Jane Jacob's Walk, May 7 & 8.
- Kiwanis Club, birding talk, May 25
- Environment week, Federal Government, June 6th.
- Royal Visit: July 2, Macoun Field-Club and Fletcher Wildlife Garden members honoured.
- Organized 2 nature walks for AJA 50+
- Amica at Westboro Park, presentation on local birds.
- Pinhey's Point, afternoon birding walk, April 16<sup>th</sup>.
- Earth Day, OFNC exhibit, NCC Lobby, 8-2:00 p.m.
- Ottawa Riverkeeper event, Victoria Island, Sept. 25<sup>th</sup>.

FENJA BRODO

Chair, Education & Publicity Committee

### Excursions and Lectures Committee

We would like to take this opportunity to thank the many volunteers who provided the excellent slate of activities in 2011. Over the course of the year, club members coordinated and/or led 59 events: 44 outings, nine monthly meetings, four workshops, a business meeting, and our annual party (Soirée). This is an impressive number and diversity of events. If you enjoyed a talk or outing, we encourage you to let your leader know! Our events explored a diverse range of natural history: birds (25), general natural history (13), botany (4), insects (4), mycology (3), natural history by canoe (2), geology (2), amphibians (1), fish (1), lichens (1), mammals (1), photography (1) and club business (1). Planning such a large number of events requires a constant supply of both leaders and ideas. If you would like to lead or co-lead an event in 2012, please contact one of us and let us know what you propose. Even if you don't have any specific ideas, or have not led an event before but would like to get involved, just let us know. Although in Ottawa we are fortunate to have many experts as leaders, you do not have to be an expert to lead an outing! Participants are also often knowledgeable and many great outings are a collective effort. We are similarly interested in hearing about ideas for monthly speakers, or workshops of interest to members. Please speak to us at an upcoming event, or respond to the following email address(es): Jeff Skevington (jhskevington@gmail.com), Holly Bickerton (hbickerton@hotmail.com), Fenja Brodo, Julia Cipriani and Hume Douglas (Excursions and Lectures committee members).

JEFF SKEVINGTON

Chair, Excursions and Lectures Committee

### Finance Committee

In addition to the other changes within OFNC this year, OFNC's accounting/financial systems also underwent major restructuring. The Finance Committee met several times during the year to consider the logistics and systems in respect of the changes. The year ended with online membership registration, a new bookkeeper and new auditor. In addition, systems were set up for the new online revenue process, the deposit process, the payables processing and financial reporting. These initiatives took the work of many individuals not just from the Finance Committee but across the committees

to plan, program and work out the details. A very complicated year for the club's accounting and financial information systems and the process is not yet done.

The last Finance Committee meeting concentrated on fiscal responsibility and the 2011/12 budget. It is anticipated the initiatives/changes started in the 2010/11 year will continue into the 2011/12 fiscal period.

The club is continuing to run a deficit. However the long-term goal for the club is a balanced budget. This hopefully will be realized in the 2012/13 fiscal period when the changes within the club will have stabilized.

Fiscal Responsibility for the OFNC is the Finance Committee's objective. Once there is a consistent balanced budget then the club can make better use of the surplus/legacy funds and can start looking at new areas/projects beyond the club's normal operations that it could undertake as per the OFNC objectives to promote, conserve and appreciate Canada's natural heritage

BARBARA CHOUINARD  
Chair, Finance Committee

### Fletcher Wildlife Garden

The committee met monthly during the past year, with the December meeting a gathering for all the volunteers who do most of the work at the FWG. We also thank Agriculture and Agri-Food Canada (AAFC) for their continuing support in some projects.

The proposal for a Monarch Waystation that we submitted to the Evergreen Foundation last year resulted in a grant of \$2500 in fall 2010 and second place in a contest co-sponsored by Fido this summer. We thank all those who voted for our project. The additional \$15,000 prize will allow us to register the entire FWG as a monarch waystation, establish a smaller-scale waystation in the Butterfly Meadow, and provide information to visitors about butterfly conservation. Future plans include a workshop to gather other stakeholders and coordinate local conservation efforts and provide information via our web site.

Some of the prize money was used to rebuild and improve our nursery to grow larger plants for our own purposes and for our annual plant sale.

The volunteers working on Wednesday evenings continued to expand the Butterfly Meadow, gradually replacing the invasive dog-strangling vine (DSV = *Cynanchum rossicum*) with a variety of nectar and pollen sources. Two weeding bees attracted 20 volunteers each to remove DSV, and AAFC rot-tilled three new areas for planting in 2012.

A new group of volunteers formed this year to work on invasive species, principally DSV. An additional scythe was purchased as cutting DSV before it produces seeds has proven to be the best way to keep it in check, pending the discovery of a biological control system. Weeding bees were also organized to remove DSV from among "good" species.

On Friday mornings, a large group of volunteers, most of whom have been with us for many years, continued to maintain the Backyard Garden. No major changes were made. In addition to many casual visitors, a botanical art class made good use of this area this year. Invasive species work is also being done by some of the Friday morning group, working on buckthorn and Amur maple.

Our usual activities continued. We grew many plants for our annual native plant sale and raised about \$2800. Two bird feeders were maintained throughout the winter. We were involved in the Wildlife Festival and the Great Backyard Bird

Count. Volunteers opened the Interpretation Centre on Sunday afternoons through the summer.

Work on the bridge at the east end of our Amphibian Pond, begun in summer 2010, was completed late in the year and is much enjoyed by visitors and volunteers alike.

DAVID HOBDEN  
Fletcher Wildlife Garden Committee  
Representative on Council

SANDRA GARLAND  
Chair, Fletcher Wildlife Garden

**Macoun Field Club Committee**

The Committee met once and thereafter carried out the month-to-month planning by telephone and e-mail. Committee members supervised or gave presentations at 19 indoor meetings and led 15 field trips during the school year. Indoor sessions were held in the Fletcher Wildlife Garden building; the field trips took place either at the Club's nature-study area in Ottawa's Greenbelt or on private properties in Lanark County. Additionally, several of the indoor meetings incorporated short field trips within the Fletcher Wildlife Garden. Members of the Committee and representatives of the OFNC met with the family of the late Martha Camfield, a long-time leader, leading to the establishment of an endowment fund in her name for specified Macoun Club activities, to be managed

by the OFNC. The family also directed memorial donations to the Macoun Club.

ROBERT E. LEE  
Chair, Macoun Field Club Committee

**Membership Committee**

The distribution of the membership for 2011 on September 30, 2011 is shown in the table below, with the corresponding numbers for 2010 shown in brackets. "Others" represent, for the greatest part, affiliate organizations that receive complimentary copies of the Club's publications. Local membership (within 50 km of Parliament Hill) was 621 and 650 in 2011 and 2010, respectively. The decrease in total membership of 53 continues an ongoing trend that was interrupted only in 2010. The continued decrease in members located more than 50 km from Ottawa accounted for slightly less than one half of the overall decrease in membership.

The decrease in membership can be partially attributed to the increase in Club fees and the introduction of a fee for receiving the Canadian Field Naturalist (CFN) in hard copy. Only 56 members, excluding Honorary Members, opted for hard-copy CFN.

HENRY STEGER  
Chair, Membership Committee

	CANADIAN		USA		OTHER		TOTAL	
	2011	2010	2011	2010	2011	2010	2011	2010
Individual	361	(386)	13	(15)	0	(0)	374	(401)
Family	282	(293)	1	(1)	1	(1)	284	(295)
Sustaining*	-	(14)	-	(0)	-	(0)	-	(14)
T&L	2	(4)	0	(0)	0	(0)	2	(4)
Honorary	24	(21)	0	(0)	0	(0)	24	(21)
Life	48	(52)	4	(3)	1	(1)	53	(56)
Other	23	(22)	0	(0)	1	(1)	24	(23)
<b>TOTAL</b>	<b>740</b>	<b>(792)</b>	<b>18</b>	<b>(19)</b>	<b>3</b>	<b>(3)</b>	<b>761</b>	<b>(814)</b>

\*Sustaining membership was discontinued in 2011. Renewing members assumed either Individual or Family membership.

**Publications Committee**

To suggest that 2011 has been an exceptional year would be a considerable understatement. Not since 1918 when Percy Taverner, James Macoun and their associates reformed the local *Ottawa Naturalist* to become the national *Canadian Field-Naturalist* have we witnessed such a seismic shift in the OFNC publications program. In those post-WWI times such a substantial restructuring was deemed essential to re-engage and enlarge the journal's constituency, to reflect how best to deliver its content in a dramatically changed landscape and to ensure its continued existence into the foreseeable future. The issues are no less urgent for the CFN today and the stakes no less significant. The initial outcomes, we are happy to report, have been no less gratifying.

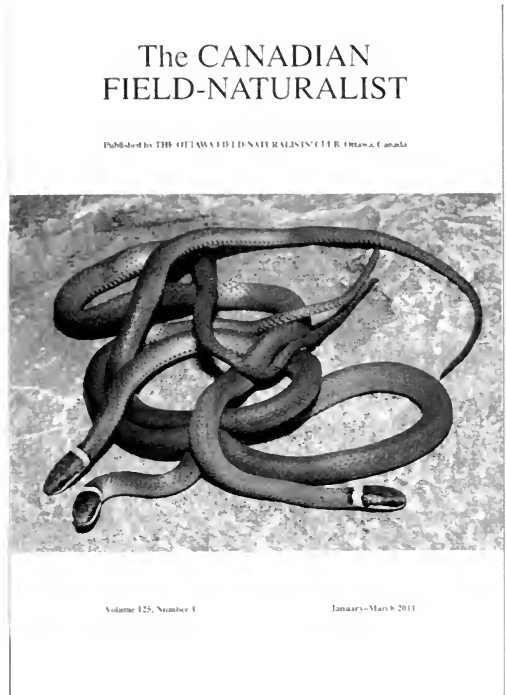
Retiring CFN editor Francis Cook and his remarkable production team oversaw the publication and distribution of six issues of the journal in 2011, those being two issues of volume 123 and all four issues of volume 124, 631 pages in all. In addition, in-coming Editor-in-Chief Carolyn Callaghan oversaw the publication of issues 125 (1) and (2), representing 188 pages (125 (2) actually be published in January 2012).

This total production of 819 pages in 12½ months represents an all-time productivity record. It easily exceeds that of several ca. 750 page volumes at the turn of this century and volume 112 (1998) which produced 794 pages over a 15-month period.

The breadth and scope of the original research covered in these six issues is classic CFN material, representing a rich combination of taxonomic, ecological, historical and conservation-oriented studies that will contribute to the investigation and protection of Canadian biodiversity for decades to come. The unprecedented use of colour images and maps greatly enhances the appearance and effectiveness of these contributions. Such publications are an enduring credit to both the researchers who produce significant, original work and to the CFN production team who review, process and publish them.

Volume 125 saw the production of the first electronic issues of CFN. The installation and application of the Open Journal Systems (OJS) electronic publication process has fallen largely upon the shoulders of incoming Journal Manager Jay Fitzsimmons. Jay worked diligently with indefatigable retiring CFN Business Manager Frank Pope to ensure that the





transition from our traditional hard copy process was as efficient and painless as possible. They have succeeded magnificently, a few inevitable glitches notwithstanding. Much work remains to be done in 2012 to fully integrate all of the OJS elements, but substantial progress has been made.

So many individuals have contributed to the success of CFN in 2011. I've spoken of the production team – and retiring Business Manager Frank Pope deserves special credit here for the million and one issues he has quietly and efficiently resolved – but we must also note the considerable patience and forbearance of the OFNC Council who facilitated both the effort and budget required as we entered this brave new world. Their support was essential and is gratefully acknowledged. First and foremost, however, we acknowledge the continued support of the contributors of important, original material for consideration in CFN.

The OFNC and the Ottawa Valley naturalist community is also blessed by the production of our remarkably successful second periodical, *Trail & Landscape*. Editor Karen McLachlan Hamilton and her team quietly and efficiently went about their business in 2011 as they have for a full decade of T&L's more than 40 years of existence. Another 188 pages of information and data that contributes significantly to both our knowledge of the local landscape and to the enjoyment of it by the naturalist community was published in T&L this year.

The Publication Committee's challenge for 2012 is to sustain the remarkable, historic achievements of 2011 and to continue our support for those dedicated folks on the front lines. We ask all members and subscribers to assist by considering the submission of manuscripts to the CFN and T&L. And we also ask you to encourage your associates to do likewise. That, ultimately, is what this is all about.

DANIEL F. BRUNTON  
Chair, Publications Committee

# Review Engagement Report

To The Members of THE OTTAWA FIELD NATURALISTS' CLUB

We have reviewed the statement of financial position of the The Ottawa Field-Naturalists' Club as at September 30, 2011, the statement of operations and changes in net assets and the statement of cash flows for the year then ended. Our review was made in accordance with Canadian generally accepted standards for review engagements and accordingly consisted primarily of enquiry, analytical procedures and discussion related to information supplied to us by the club.

A review does not constitute an audit and consequently we do not express an audit opinion on these financial statements.

Based on our review, nothing has come to our attention that causes us to believe that these financial statements are not, in all material respects, in accordance with Canadian generally accepted accounting principles.

**CHARTERED ACCOUNTANTS**  
**Licensed Public Accountants**



Ottawa, Ontario  
 December 22, 2011

## The Ottawa Field-Naturalists' Club Statement of Financial Position September 30, 2011

	2011	2010
<b>ASSETS</b>		
<b>CURRENT ASSETS</b>		
Cash	\$136,624	\$78,103
Short-term investments (note 5)	65,494	98,954
Accounts receivable	33,482	2,388
Prepaid Expenses	290	1,935
	<u>235,890</u>	<u>181,380</u>
Long-term Investments (Note 5)	<u>362,304</u>	<u>363,126</u>
Land	-	3,348
	<u>\$598,194</u>	<u>\$547,854</u>
<b>LIABILITIES AND NET ASSETS</b>		
<b>CURRENT LIABILITIES</b>		
Accounts payable and accrued liabilities	13,610	4,478
Unearned revenue	13,721	10,438
	<u>27,331</u>	<u>14,916</u>
LIFE MEMBERSHIPS (Note 8)	<u>3,360</u>	<u>5,480</u>
<b>NET ASSETS</b>		
Unrestricted fund	289,356	280,770
Restricted fund for endowment purposes	36,989	-
Internally restricted	241,158	246,688
	<u>567,503</u>	<u>527,458</u>
	<u>\$598,194</u>	<u>\$547,854</u>

Approved by Council:

..... President

..... Treasurer

(See accompanying notes)

PREPARED WITHOUT AUDIT

**The Ottawa Field-Naturalists' Club**  
**Statement of Operations and Changes in Net Assets –**  
**Unrestricted Fund**  
**For the year ended September 30, 2011**

	2011	2010
<b>REVENUES</b>		
Membership Fees	\$32,412	\$37,414
Donations – bequests	11,462	–
– other	6,728	7,572
Interest	8,572	11,280
Sales	1,228	626
Other	142	187
	<u>60,544</u>	<u>57,079</u>
<b>OPERATING EXPENSES</b>		
Administrator	2,000	2,000
Affiliation fees	225	225
Computer expense	2,451	2,751
Membership committee	1,286	866
Donations	3,538	2,000
Bookkeeping	7,542	6,300
Telephone	2,495	2,768
Insurance	580	785
Office and miscellaneous	3,486	4,986
Postage	1,083	906
Professional fees	2,000	2,500
	<u>26,686</u>	<u>26,087</u>
<b>CLUB ACTIVITY EXPENSES</b>		
Awards	858	-146
Birds	739	628
Publication – Canadian Field-Naturalist – net (note 6)	23,537	1,284
Education and publicity	328	912
Excursions and lectures	115	-3,897
Macoun Field Club	–	145
Trail and Landscape	7,230	7,099
Fletcher Wildlife Garden – net (note 7)	4,890	3,638
	<u>37,697</u>	<u>9,663</u>
Total Expenses	<u>64,383</u>	<u>35,750</u>
<b>EXCESS (DEFICIENCY) OF REVENUES OVER EXPENSES</b>	-3,839	21,329
<b>FUND BALANCE, BEGINNING OF YEAR</b>	<u>280,770</u>	<u>256,843</u>
	<u>276,931</u>	<u>278,172</u>
Cumulative gains reported directly, end of year	16,898	4,473
Cumulative gains reported directly, beginning of year	4,473	1,875
Changes in unrealized gains of investments in the year	12,425	2,598
<b>FUND BALANCE, END OF YEAR</b>	<u>\$289,356</u>	<u>\$280,770</u>

**The Ottawa Field-Naturalists' Club**  
**Statement of Operations and Changes in Net Assets –**  
**Endowment Fund**  
**For the year Ended September 30, 2011**

	2011	2010
<b>Revenue</b>		
Interest	\$ 535	\$ –
<b>Fund Balance, Beginning of Year</b>	–	–
	535	–
Endowment contribution	35,000	–
Inter-fund transfer	-267	–
Changes in unrealized gains of investments in the year – allocation	1,721	–
<b>Fund Balance, End of Year</b>	<u>\$ 36,989</u>	<u>\$ –</u>
<b>The Ottawa Field-Naturalists' Club</b> <b>Statement of Cash Flows</b> <b>For the year ended September 30, 2011</b>		
	2011	2010
<b>Cash Flows from Operating Activities</b>		
Net revenue (expenses) – all funds	\$ -5,824	\$ 20,688
Adjustments for:		
Accounts receivable	-31,094	-1597
Prepaid expenses	1,645	1,500
Accounts payable and accrued liabilities	9,133	1,978
Deferred revenue	3,283	451
Life Memberships	-2,120	-13,264
	<u>-24,977</u>	<u>9,756</u>
<b>Cash Flows from Investing Activities</b>		
Purchase of investments	-25,000	-16,554
Proceeds from maturity of investments	73,498	–
	<u>48,498</u>	<u>-16,554</u>
<b>Cash Flows from Financing Activities</b>		
Endowment contribution	35,000	–
<b>Increase (Decrease) in Cash</b>	58,521	-6,798
<b>Cash at Beginning of Year</b>	<u>78,103</u>	<u>84,901</u>
<b>Cash at End of Year</b>	<u>\$136,624</u>	<u>\$ 78,103</u>

(See accompanying notes)

PREPARED WITHOUT AUDIT

**The Ottawa Field-Naturalists' Club**

**Statement of Operations and Changes in Net Assets – Internally Restricted Funds**

Year ended September 30, 2011

	General Reserve for Contingencies	Manning Fund	Seedathon Fund	Anne Hanes Memorial Fund	De Kiriline Lawrence Fund	Macoun Fund	2011 Total	2010 Total
<b>Revenue</b>								
Donations	–	–	932	–	320	–	1,252	2,859
Interest	–	2,166	–	–	–	–	2,166	4,199
	–	2,166	932	–	320	–	3,418	7,058
<b>Expenses</b>								
CFN Author (Expenses)	–	4,147	–	–	–	–	4,147	2,840
Donations	–	–	–	–	–	1,035	1,035	3,977
Seed	–	–	722	–	–	–	722	882
Other	–	–	–	34	–	–	34	–
	–	4,147	722	34	320	1,035	5,938	7,699
<b>Net Revenues (Expenses)</b>	–	-1,981	210	-34	320	-1,035	-2,520	-641
<b>Fund Balances, Beginning of Year</b>	100,000	120,944	409	630	13,064	1,204	3,977	240,228
	100,000	122,303	22	630	13,064	3,568	–	239,587
<b>Other</b>								
Inter-fund transfer	–	–	–	–	–	267	267	–
Cumulative gains reported directly, end of year	–	3,824	–	–	–	–	3,824	7,101
Cumulative gains reported directly, beginning of year	–	7,101	–	–	–	–	7,101	1,219
Changes in unrealized gains of investments in the year	–	-3,277	–	–	–	–	-3,277	5,882
<b>Fund Balances, End of Year</b>	\$100,000	\$124,146*	\$232	\$596	\$13,384	\$2,800	\$241,158	\$246,688

\* includes principal of \$100,000 plus undistributed income of \$24,146

(See accompanying notes)

PREPARED WITHOUT AUDIT

**The Ottawa Field-Naturalists' Club**  
**Notes to the Financial Statements Year Ended September 30, 2011**

---

**1. Purpose of the Organization and Tax Status**

The Canadian Field-Naturalists' Club (the "Club") is a registered charitable organization incorporated under the Corporations Act of the Province of Ontario. The Club promotes the appreciation, preservation, and conservation of Canada's natural heritage, encourages the investigation, publishes the results of research in all fields of natural history, and diffuses the information to the public and supports and cooperates with other organizations engaged in preserving, maintaining and restoring environments of high quality for living things.

The Club is a registered charity, and is exempt from income taxes by virtue of section 149(1)(f) of the Income Tax Act (Canada).

**2. Significant Accounting Policies**

*Revenue recognition*

General donations and fundraising proceeds are recorded as revenue in accordance with the deferral method of accounting. Restricted contributions are recognized as revenue of the appropriate restricted fund when the organization becomes entitled to them.

Membership fees and subscriptions are recorded as revenue over the term of the membership agreement once receipt is assured.

*Fund accounting*

The Club maintains its accounts in accordance with the principles of fund accounting. Resources are classified for accounting and reporting purposes into funds according to the activity or object specified.

- The Unrestricted Fund accounts for the Club's program delivery and administration activities.
- The Endowment Fund was established by the family and friends of Martha Camfield to help continue her efforts to have children study, understand, respect and preserve their natural environment. Half of the interest generated is re-invested in the capital of the fund, while the other half of the interest generated is made available only for the use by the Macoun Field Club (the Macoun Fund).
- The General Reserve was established by the Club to fund outstanding operating expenses should the Club discontinue its operations.
- The Manning fund was established by a bequest, and the interest generated is used to assist authors to publish articles in the Canadian Field Naturalist (80%) and to assist the Club's special projects (20%).
- The Seedathon fund collects donations from the annual bird sighting event and purchases seed for the Club's bird feeders.
- The Anne Hanes Memorial fund was raised in memory of Anne Hanes, the founding editor of *Trail and Landscape*, and is used to finance the annual winners of the Anne Hanes Natural History Award.

- The de Kiriline-Lawrence fund was funded by a bequest from the popular author of nature books, and is supplemented by annual donations and used to support conservation efforts.
- The Macoun Baille Birdathon fund recognizes the donations and pledges based upon the number of bird sightings in the one day birdathon sponsored by Bird Studies Canada, and is used to support the Macoun Field Club, a youth club.

*Investments*

The Club designates all of its investments as available-for-sale and records them at their fair value. Changes in fair value are recognized in the statement of changes in net assets until the investment is disposed or maturity. Upon disposition or maturity, the investment's accumulated unrecognized gain or loss is recognized in the statement of operations.

Fair values of securities are determined by reference to published price quotations in an active market at year-end. Guaranteed investment certificates (GICs) are stated at cost plus accrued interest income, which approximates fair value given the short-term nature of these investments.

The purchase and sale of investments are accounted for using settlement date accounting. Investment management fees are expensed as incurred.

*Capital assets*

Capital assets are expensed in the year of acquisition.

*Contributed services*

The Club relies on contributed human resources in order to carry out its activities. As there is difficulty in determining the fair value of contributed services, they are not recognized in the financial statements.

*Use of estimates*

The preparation of financial statements in conformity with Canadian generally accepted accounting principles requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities and disclosure of contingent assets and liabilities at the date of the financial statements and the reported amounts of revenues and expenses during the reporting period. Actual results could differ from these estimates.

**3. Future Accounting Standards**

The Accounting and Standards Board of the Canadian Institute of Chartered Accountants recently approved a financial reporting framework designed specifically to meet the needs of the users of financial statements prepared by not for profit organizations. Not-for-profit organizations are also given the option to adopt International Financial Reporting Standards (IFRS) instead of the new not-for-profit accounting standards if that is the organization's preferred course of action. One of these new frameworks must be applied for the Club's

September 30, 2013 fiscal year-end and the Club is permitted to adopt these standards next year if they wish to do so. Council is currently evaluating the impact of these new reporting frameworks on their financial statements.

#### 4. Financial Instruments

The Club's financial instruments consist of cash, investments, accounts receivable, accounts payable and accrued liabilities, unearned revenue and deferred life memberships. Unless otherwise noted, it is management's opinion that the Club is not exposed to significant interest, currency or credit risks arising from these instruments.

The Club's cash, accounts receivable, accounts payable and accrued liabilities and unearned revenue are measured at their amortized cost in the financial statements. Due to their nature and capacity for prompt liquidation, the fair values of

these financial instruments approximate their carrying values. The Club's investments are presented at their fair value as described in Note 2. The fair value of the deferred life memberships is not readily determinable.

#### *Credit risk*

The Club is exposed to credit risk resulting from the possibility that parties may default on their financial obligations. The Club's maximum exposure to credit risk represents the carrying value of its accounts receivable. The Club manages its credit risk by reviewing accounts receivable on a regular basis and following up on outstanding amounts. Management believes that all accounts receivable at year-end will be collected and has not deemed it necessary to establish an allowance for doubtful accounts.

#### 5. Investments

Short-term investments are comprised of:

	2011	2010
CIBC GIC –		
0.65% due October 1, 2010	\$ –	\$ 20,734
CIBC GIC –		
0.80% due September 29, 2011	–	78,220
CIBC GIC –		
0.50% due October 3, 2011	20,734	–
Province of Newfoundland –		
4.58% due October 17, 2011	44,760	–
	<u>\$ 65,494</u>	<u>\$ 98,954</u>

Long-term investments are comprised of:

	2011	2010
Newfoundland –		
4.58% due October 17, 2011	\$ –	\$ 44,015
Canadian Western Bank –		
4.41% due October 9, 2012	29,562	28,313
Ontario –		
4.64% due December 2, 2012	15,166	14,769
Manitoba –		
4.75% due September 2, 2013	44,556	43,092
CIBC –		
4.19% due October 31, 2014	65,046	62,246
New Brunswick –		
4.30% due December 3, 2015	65,894	65,437
Ontario Hydro –		
4.01% due November 26, 2016	25,235	23,495
Ontario –		
4.07% due December 2, 2017	49,102	45,239
British Columbia –		
3.74% due March 5, 2019	27,257	–
Newfoundland –		
4.36% due January 7, 2020	40,486	36,520
	<u>\$ 362,304</u>	<u>\$ 363,126</u>

#### *Interest rate risk*

The Club manages the interest rate risk of its fixed income securities by using a laddered portfolio with varying terms to maturity. The laddered structure of maturities helps to enhance the average portfolio yield while reducing the sensitivity of the portfolio to the impact of interest rate fluctuations.

#### *Market risk*

The Club's investments are comprised of fixed income securities thus mitigating the risk and volatility of investment returns.

## 6. Canadian Field-Naturalist Publication

	2011	2010
<b>Revenues</b>		
Subscriptions	\$ 23,541	\$ 17,208
Reprints and electronic copies	4,181	4,400
Publication charges	<u>41,609</u>	<u>34,206</u>
	<u>69,331</u>	<u>55,814</u>
<b>Expenses</b>		
Publishing	57,951	33,282
Reprinting	607	996
Circulation	15,542	13,449
Editing	13,433	9,371
Open Journal System set-up (electronic publishing)	<u>5,335</u>	<u>—</u>
	<u>92,868</u>	<u>57,098</u>
	<u>\$ -23,537</u>	<u>\$ -1,284</u>

## 7. Fletcher Wildlife Garden Activities

	2011	2010
<b>Revenues</b>		
Donations and other income	<u>\$ 5,055</u>	<u>\$ 4,408</u>
<b>Expenses</b>		
Program	1,033	94
Backyard	464	575
Habitats	7,733	6,112
Interpretation centre	5	100
Administration	196	469
Fund raising	209	563
Publications	201	74
Library	<u>104</u>	<u>59</u>
	<u>9,945</u>	<u>8,046</u>
	<u>\$ (4,890)</u>	<u>\$ (3,638)</u>

## 8. Commitments

*Life memberships*

The Club is committed to provide for regular membership benefits to lifetime members. Since it is not practicable to determine the total liability associated with providing these benefits for the rest of the lives of these individuals, the annual costs are being charged against the existing liability and will be expensed as incurred after the liability is extinguished. Lifetime membership are no longer being offered by the Club. As of September 30, 2011, there were 53 active lifetime members.

*Fletcher Wildlife Garden*

The Club is also committed to maintaining a 13-acre property known as the Fletcher Wildlife Garden until March 31, 2014. The costs associated with maintaining the property are approximately 2,000 hours of contributed human resources per year. As the fair value of contributed human resources are not recognized in the financial statements, the corresponding

costs are also not recognized as part of the Fletcher Wildlife Gardens expenses described in Note 8. The expenses described in Note 8 are made over and above the Club's service requirements under the agreement.

## 9. Capital Disclosures

The Club defines its capital as its fund balances. The Club's objective when managing its capital is to hold sufficient unrestricted fund balances to maintain the stability of its financial structure enabling it to focus its efforts on serving its members. The Club's council is responsible for overseeing the effective management of capital.

## 10. Comparative Figures

Certain comparative figures have been reclassified where necessary to conform to the presentation adopted in the current year and are based upon financial statements reviewed by another accountant.

# The Canadian Field-Naturalist — Instructions for Authors

## Aim and Scope

The Canadian Field-Naturalist (CFN; ISSN: 0008-3550) publishes peer-reviewed scientific papers on natural history relevant to Canada. Relevance to Canada usually means the species studied must inhabit Canada, even if the research itself occurred outside Canada. e.g., U.S.-based research on a species whose range extends into Canada, or research in Asia on a species introduced into Canada. Natural history comprises organism-scale biological research in diverse fields including behaviour, ecology, conservation, and taxonomy, among others. We publish research on any taxa, from microbes to large-bodied mammals. We encourage manuscript submissions from professional and amateur naturalists. Our journal has been published continuously since 1879 by the non-profit group The Ottawa Field-Naturalists' Club, making it one of the longest-running ecological journals in North America.

## Manuscript Types

**Articles.** Articles report original research and are at least five pages long in printed form. There are no upper-boundary restrictions on the number of pages or references for articles (maximum abstract length: 250 words). Articles are peer-reviewed.

**Notes.** Like articles, Notes report original natural history research. Notes only differ in being shorter (maximum abstract length: 100 words; maximum page length in final printed form: 4 pages, or approximately 2000 words). Many Notes report novel observations of animal behaviour, diet choice, or range extensions of species. Notes are peer-reviewed.

**Book Reviews.** We publish many reviews of books of interest to naturalists, from all over the world (i.e., not necessarily related to Canadian species). Each issue includes a list of new book titles received by our Book Reviews Editor with notation on books available for review, although we are open to suggestions of reviews for other titles. All book reviews and inquiries related to book reviews should be sent to our Book Review Editor, Roy John (r.john@rogers.com). Book reviews are edited by Roy John, but are not considered peer-reviewed.

**Tributes.** Tributes are descriptions of recently-deceased exemplary naturalists who contributed to our understanding of Canadian nature. Please inquire with our Editor-in-Chief, Dr. Carolyn Callaghan, before writing a Tribute. Tributes are not peer-reviewed.

**News, Opinions and Reports.** Short news items, commentary, or reports of interest to naturalist readers. They are not peer-reviewed, and are normally contributed by our Editor-in-Chief. News item suggestions should be directed to our Editor-in-Chief, Dr. Carolyn Callaghan (editor@canadianfieldnaturalist.ca). Commentary may be similar to articles in format or it may be just a series of paragraphs.

**Editorials, Club Reports.** These items are contributed by our editors and Ottawa Field-Naturalists' Club personnel, and are not open to submission by others.

## Manuscript Guidelines

Manuscripts are to be submitted to the Editor-in-Chief by email (editor@canadianfieldnaturalist.ca) or post, written in the journal style. Authors should consult a recent issue of CFN to understand journal format. A sample issue is available for free online at [www.ofnc.ca/cfn/I22-1/subscribers-index.php](http://www.ofnc.ca/cfn/I22-1/subscribers-index.php).

## Legal issues, ethical conduct

The research reported must be original. Manuscripts cannot have been published, or be under consideration for publication, in part or in entirety in any other publication media including journal, newsletter, book, report, either online or in print. The author(s) is/are expected to confirm that a manuscript submitted for consideration for publication in the Canadian Field-Naturalist has not already been published elsewhere, and will not be published elsewhere unless rejected by the Canadian Field-Naturalist. Published means distributed or otherwise made available in print, either in hard copy or online and with or without peer review.

All co-authors must have read and approved the submitted version of the manuscript. If institutional or contract approval for the publication of data is required, authors should have obtained it prior to manuscript submission. Authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, or minerals. Animal care should comply with relevant institutions' guidelines and be considered ethical by peers. A cover letter, indicating compliance with the preceding points must accompany the manuscript submission when appropriate.

## Language

Manuscripts can be submitted in English or French. Manuscripts are permitted, but not required, to include abstracts and keywords in both languages. Canadian spelling of the English language is required on manuscripts submitted in English. A contemporary reference for formal Canadian spelling is the *Canadian Oxford Dictionary*.

## Font, page format, file type

Font should be 12-point Times New Roman. Manuscripts should be double-spaced throughout including references with margins 2.5 cm (1 inch) wide. Pages should be numbered sequentially, and lines should be numbered continuously. The file should be saved as .doc (Microsoft Word 2003) file format.

## Nomenclature and units of measurement

Species' common names (when available) and scientific names should both be used at least once in the manuscript. Initial letters of species common names should be capitalized. Authorities' names (e.g., "Kuhl" in *Castor canadensis* Kuhl) should be omitted from scientific names unless the manuscript has taxonomic relevance or in the first reference to a featured species. Units of measurement should follow standard metric SI units.

## Vouchers, location information, GenBank

All voucher material should include the name and location of the collection and the specimens' catalog numbers. All collections or observations of species should include latitude and longitude in decimal degrees at two decimal points or finer depending on the sensitivity of the information. All genetic sequences should be accompanied by GenBank accession numbers.

## Title page

Include the title, a running title (maximum of 35 characters), the list of authors, and the type of submission the manuscript should be considered. For each author provide their



affiliation with postal address (home address is fine for unaffiliated amateurs) and e-mail address. Indicate which author is the corresponding author, and provide their phone number in addition to postal and e-mail address.

#### Abstract page

The second page of the manuscript (for Articles and Notes) should include the abstract and a list of key words (4-10 keywords).

#### Manuscript sections

Articles should typically contain the following sections listed as bolded, 16-point font headings, initial caps only: Introduction, Methods, Results, and Discussion. Alternative headings are permitted. Second-level subheadings are permitted and should be italicized in 12-point font. Notes' headings, if any, are at the authors' discretion. Both Articles and Notes should also include Acknowledgements, Documents Cited, and Literature Cited. Acknowledgements should list authors' funding sources and thank people who contributed significantly to the study. Documents and Literature Cited are described below.

#### Citation format

Below are example citations in CFN style. When more than one document is cited in a citation, sort them chronologically, and alphabetically within the same year, separated by semicolons.

**Single author:** "... fishers in Maine (Coulter 1966)."

**Two authors:** "... been observed (MacKinnon and Kennedy 2009)"

**Three or more authors:** "... diet composition (Arthur *et al.* 1989)."

**Multiple documents cited:** "... birds and tardigrades are very different (Tufts 1961; Nelson *et al.* 2009)."

#### References (Documents Cited and Literature Cited)

Cited references should be listed chronologically under the headings of Documents Cited (for reports of limited circulation and web documents) and Literature Cited (for journal articles, books, book sections, and theses). All references should have hanging indents. Web documents' citations should include their website address and the date they were accessed. Journal names should be written in full. Below are example references in CFN format.

#### Documents Cited

**Environment Canada.** 2008. National Climate Data and Information Archive. Environment Canada. Accessed 5 November 2008. [www.climate.weatheroffice.gc.ca](http://www.climate.weatheroffice.gc.ca).

**Friends of Fish Creek Provincial Park Society.** 2009. Water quality monitoring report 2009. Accessed 20 March 2011. <http://wsow.brbc.ab.ca/reports/FishCreekStudy2.pdf>.

**Stevens, V.** 1995. Wildlife diversity in British Columbia: distribution and habitat use of amphibians, reptiles, birds, and mammals in Biogeoclimatic Zones. Working Paper 04. B.C. Ministry of Forest Research Program, and Ministry of Environment, Lands, and Parks' Habitat Protection Branch, Victoria, British Columbia, Canada. 288 pages.

#### Literature Cited

**Arthur, S. M., W. B. Krohn, and J. R. Gilbert.** 1989. Habitat use and diet of fishers. *Journal of Wildlife Management* 53: 680-688.

**Coulter, M. W.** 1966. Ecology and management of fishers in Maine. Ph.D. thesis, Syracuse University, Syracuse, New York, USA.

**MacKinnon, C. M., and A. C. Kennedy.** 2009. Canada Lynx, *Lynx canadensis*, use of the Chignecto Isthmus and the possibility of gene flow between populations in New Brunswick and Nova Scotia. *Canadian Field-Naturalist* 122: 166-168.

**Nelson, D. R., R. Guidetti, and L. Rebecchi.** 2009. Tardigrada. Pages 455-484 in *Ecology and Classification of North American Freshwater Invertebrates*. Edited by J. H. Thorp and A. P. Covich. Third edition. Academic Press, San Diego, California.

**Tufts, R. W.** 1961. The Birds of Nova Scotia. Nova Scotia Museum, Rolph-Clark-Stone, Maritimes Limited, Halifax, Nova Scotia. 481 pages.

#### Figures and maps

Figures should be pasted on separate pages below the Literature Cited section in the manuscript file. Upon acceptance for publication, the Editor may ask the authors to send figures as separate files with sufficiently high resolution for publication-quality images. Microscopic images should be accompanied by a scale bar. Photographic reproductions of line drawings should be no larger than a standard page. Colour figures can be included in the online version of final articles, but figures are printed in black in printed CFN issues unless authors agree to pay the costs of colour printing (approximately \$650 per figure – contact the Editor-in-Chief if you would like colour printing). Authors should remember that readers often print online articles with black ink printers, so even colour figures online should be interpretable if printed in grayscale.

Not every article requires a map. There is no need for a map that just illustrates the location of a study area. Ideally, a map should make clear the spatial relationship of the data. For example, a paper on a range extension should show how far the species' range has been extended from the previous known limit.

Every map should include a north indicator, using a north arrow or by labeling Longitude (°W) and Latitude (°N) on the map. Although most maps have north at the top, maps can be oriented differently if there is a valid reason. Every map should include a scale bar. A ratio scale (e.g. 1:50000) is not recommended as the scale will change depending upon the published size of the map. An inset map showing the region where the study area is located may be used, and a legend can be used if warranted.

Maps should make use of a strong contrast – a white background with black lines. Avoid using a uniform gray background, but shading is appropriate for certain areas (e.g. lakes) or to indicate affected areas. Maps should be submitted as a separate raster graphic or bitmap file of sufficient resolution to print sharply. The specific file size will depend upon the file format. Some common formats include Windows bitmaps (\*.bmp), graphics interchange format (\*.gif), and joint photographic experts group format (\*.jpg).

#### Figure captions

Figure captions should be listed in the Figure Captions section following Figures. Figure captions should be listed and numbered in the order cited in the document. In text the word "Figure" should appear in small-caps (e.g., Figure 1) and in figure captions large-caps (e.g., "FIGURE 2. A young adult, melanistic American Red Squirrel (*Tamiasciurus hudsonicus*)").

*sonicus*) observed foraging in Upper Nine Mile River, Nova Scotia)." For multi-part figures, each part should be labelled (in text: e.g., Figure 1A).

### Tables

Tables should be listed on separate pages in the Tables section following Figure Captions, with the word "TABLE" in small-caps.

### Supplementary Material

Tables, figures, audio files, video files, and data files that compliment Articles or Notes but are not essential to their message can be included as supplementary material at the authors' discretion. Supplementary material will be available online only for subscribers to download. Supplementary material should be submitted during initial manuscript submission. List all supplementary material under the final manuscript heading "Supplementary material." Supplementary material is a new feature for CFN so we do not yet know which file formats can and cannot be accepted; please consult our Journal Manager with any questions about specific formats.

### Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor, who sends it to two qualified reviewers as well as provides an evaluation of the manuscript. Authors are encouraged to suggest at least three suitable referees that could provide unbiased expert reviews. Authors can also request that their manuscript not be sent to certain referees, if proper justification is given. The Editor-in-Chief makes the final decision on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of *The Canadian Field-Naturalist*. As with any scientific journal, extensive revisions may be requested by editors in an effort to improve the clarity, accuracy, style, and overall quality of manuscripts. Changes made by authors at the proof (galley) stage may result in extra charges to the author.

### Author Charges, Reprints, pdf files

As a non-profit journal run largely by volunteers devoted to natural history, we make every effort to keep our costs as low as possible. To cover costs we require payment from authors of Articles and Notes: \$90 per printed page, plus \$30 per figure (any size up to one page), and \$90 per page of tables. Under special circumstances, these charges can be waived for authors without grants or institutional support (e.g., amateurs, students, independent researchers). These waivers are courtesy of a generous bequest left by naturalist Tom Manning (1911-1998) to The Ottawa Field-Naturalists' Club. To learn more about Tom Manning and his research, refer to CFN 118(4):618-625 ([www.canadianfieldnaturalist.ca/index.php/cfn/article/view/70/70](http://www.canadianfieldnaturalist.ca/index.php/cfn/article/view/70/70)). Authors requesting charge waivers must make their request when submitting their manuscript and again (as a reminder) when authors return their proofs and order form after manuscript acceptance. Manuscripts of authors requesting waivers will not be treated any differently than other manuscripts during the editorial process.

Reprints can be ordered after acceptance for publication, with authors covering the cost of printing and mailing. Pdf files of published Articles, Notes, and Tributes are e-mailed to authors at no charge. As per the copyright agreement between authors and CFN, authors are permitted to distribute

their pdf file to colleagues and to post it on their research website, but are not permitted to distribute their article commercially.

Although not a requirement, submitting authors are encouraged to maintain personal subscriptions to The Canadian Field-Naturalist or membership in The Ottawa Field-Naturalists' Club to further support the mandate and reach of the journal.

### How to Submit a Manuscript

Please ensure your manuscript complies with the journal style described above, and has been appraised by a qualified expert (listed in the Acknowledgements) prior to submission.

Please e-mail book reviews to Book Review Editor Roy John, [r.john@rogers.com](mailto:r.john@rogers.com). Please e-mail all other manuscripts to Editor-in-Chief Dr. Carolyn Callaghan at [editor@canadianfieldnaturalist.ca](mailto:editor@canadianfieldnaturalist.ca). Please also attach a cover letter briefly explaining 1) the significance and novelty of your study in plain terms, 2) why it would be of interest to CFN's readers, 3) confirmation that the submitted manuscript has not been distributed in print, either in hard copy or online and with or without peer review, 4) confirmation that the research was conducted in adherence to all pertinent legislation and institutional guidelines regarding the study, disturbance, or collection of animals, plants, or minerals, 5) the names, affiliations, e-mail addresses, and relevant expertise of at least three experts you feel could evaluate your manuscript without bias or conflicts of interest as referees. You can also request that certain experts not act as referees, as long as you provide adequate justification. We are working to set up a manuscript submission portal on CFN's website in the future that will allow you to track your manuscript as it proceeds along the reviewing process, but until the portal is fully functional please continue to use the e-mail method.

We can also receive manuscripts by postal mail. Please send two copies (double-sided preferably to reduce environmental costs of printing and financial costs of mailing) of your manuscript to:

DR. CAROLYN CALLAGHAN  
Editor-in-Chief, CFN  
Box 35069, Westgate PO  
Ottawa, ON, K1Z 1A2  
Canada

### Contact Information

CFN website:  
<http://www.canadianfieldnaturalist.ca/index.php/cfn/about>

Ottawa Field-Naturalists' Club (our publisher) website:  
[www.ofnc.ca](http://www.ofnc.ca)

Editor-in-Chief: Dr. Carolyn Callaghan  
[editor@canadianfieldnaturalist.ca](mailto:editor@canadianfieldnaturalist.ca)

Assistant Editor: Trina Rytwinski  
[canadianfieldnaturalistae@gmail.com](mailto:canadianfieldnaturalistae@gmail.com)

Book Review Editor: Roy John  
[r.john@rogers.com](mailto:r.john@rogers.com)

Journal Manager: Jay Fitzsimmons  
[subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca)

**Book Reviews**

ZOOLOGY: Birds of Central Asia: Kazakhstan, Turkmenistan, Uzbekistan, Kyrgyzstan, Tajikistan, Afghanistan — Birds of the Masai Mara — Animals of the Masai Mara — Squirrels of the World 260

OTHER: Okanagan Geology South: Geologic Highlights of the South Okanagan Valley, British Columbia 263

NEW TITLES 264

**News and Comment**

Northeast Natural History Conference 2013 — American Society of Mammalogists Annual Meeting 2013 265

*Erratum* The Canadian Field-Naturalist 119(3): 359 265

**Minutes of the 133<sup>rd</sup> Annual Business Meeting of The Ottawa Field-Naturalists' Club  
January 10, 2012** 266

**Instructions to Authors** 278

Mailing date of the previous issue 126(2): 4 December 2012

## Articles

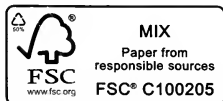
- The influence of Willow *Salix* sp. rose insect galls on Moose *Alces alces* winter browsing  
ROY V. REA 189
- Proximity to hibernacula and road type influence potential road mortality of snakes in southwestern Saskatchewan  
ASHLEY N. FORTNEY, RAY G. POULIN, JESSICA A. MARTINO,  
DENNILYN L. PARKER AND CHRISTOPHER M. SOMERS 194
- Early spawning by the American Brook Lamprey (*Lethenteron appendix*) in southeastern Minnesota  
PHILIP A. COCHRAN, MARK A. ROSS, THOMAS S. WALKER, and TREVOR BIEDERMAN 204
- First specimens of the marine eels *Venefica ocella* and *V. tentaculata* (Nettastomatidae) from British Columbia  
GAVIN F. HANKE and STEVEN M. ROIAS 210

## Notes

- Sea ice crossing by migrating Caribou, *Rangifer tarandus*, in northwestern Alaska  
KYLE JOLY 217
- Use of a dorsal radio-transmitter implant in American Badgers, *Taxidea taxus*  
GILBERT PROULX and NEIL MACKENZIE 221
- Observations of nocturnal hunting behaviour of American Badgers, *Taxidea taxus*, in southwestern Saskatchewan  
GILBERT PROULX and NEIL MACKENZIE 226
- A significant range extension for the Eastern Ribbonsnake, *Thamnophis sauritus*, in Nova Scotia, Canada  
JOHN GILHEN, ALICE JONES, JEFFIE MCNEIL, and ARTHUR W. TANNER 231
- In situ* caching of a large mammal carcass by a Fisher, *Martes pennanti*  
ETHAN A. HÜNER and JUSTIN F. B. PETER 234
- Severe maxillary osteomyelitis in a Gray Wolf (*Canis lupus*)  
SHANNON BARBER-MEYER 238
- The impact of deer herbivory and drought on population growth of *Goodyera pubescens* (Orchidaceae) in southwestern Quebec  
JOYCE M. REDDOCH and ALLAN H. REDDOCH 242

## Tributes

- A tribute to Stewart Dixon MacDonald, 1927–2010  
DAVID R. GRAY and SALLY E. GRAY 245
- A tribute to Donald M. Britton (1923–2012), Canada's premier pteridologist  
DANIEL F. BRUNTON 252



CAN  
1824

# The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada



Volume 126, Number 4

October–December 2012

# The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

## Patron

His Excellency the Right Honourable David Johnston, C.C., C.M.M., C.O.M., C.M.  
Governor General of Canada

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

## Honorary Members

Ronald E. Bedford	Michael D. Cadman	Christine Hanrahan	Joyce Reddoch
Edward L. Bousfield	Paul M. Catling	C. Stuart Houston	Allan Reddoch
Charles D. Bird	Francis R. Cook	Theodore Mosquin	Dan Strickland
Fenja Brodo	Bruce Di Labio	Robert W. Nero	John B. Theberge
Irwin M. Brodo	Anthony J. Erskine	E. Franklin Pope	Sheila Thomson
Daniel F. Brunton	John M. Gillett		

## 2012 Council

<b>President:</b> Ann MacKenzie	Daniel F. Brunton	David Hobden	Jeff Saarela
<b>1<sup>st</sup> Vice-President:</b> Fenja Brodo	Carolyn Callaghan	Diane Kitching	Henry Steger
<b>2<sup>nd</sup> Vice-President:</b> Jeff Skevington	Barbara Chouinard	Diane Lepage	Chris Traynor
<b>Recording Secretary:</b> Annie Bélair	Julia Cipriani	Karen McLachlan-Hamilton	Eleanor Zurbrigg
<b>Treasurer:</b> Ken Young	Sandra Garland	Rémy Poulin	

To communicate with the Club, address postal correspondence to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2, or e-mail: [ofnc@ofnc.ca](mailto:ofnc@ofnc.ca). For information on Club activities, go to [www.ofnc.ca](http://www.ofnc.ca)

## The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

**Website:** [www.canadianfieldnaturalist.ca/index.php/cfn](http://www.canadianfieldnaturalist.ca/index.php/cfn)

**Editor-in-Chief:** Dr. Carolyn Callaghan

**Assistant Editor:** Trina Rytwinski

**Copy Editor:** Elizabeth Morton

**Typographer:** Wendy Cotie

**Treasurer:** Ken Young, P.O. Box 35069, Westgate P.O. Ottawa, K1Z 1A2 Canada

**Journal Manager:** Jay Fitzsimmons: [subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca) or via postal address above.

**Book Review Editor:** Roy John

**Associate Editors:** Robert R. Anderson

Francis Cook

Donald F. McAlpine

Jeffery M. Saarela

Charles D. Bird

Anthony J. Erskine

David Nagorsen

David C. Seburn

Paul M. Catling

Thomas Jung

Claude Renaud

**Chair, Publications Committee:** Daniel F. Brunton

**All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by e-mail:**

**editor@canadianfieldnaturalist.ca or postal mail (with disk):** 611 Chemin Cregheur, Luskville, QC J0X 2G0; (819) 455-1087;

**Book-review correspondence should be sent to the Book Review Editor by e-mail:** [r.john@rogers.ca](mailto:r.john@rogers.ca) or postal mail: 2193 Emard Crescent, Ottawa, Ontario K1J 6K5.

## Subscriptions and Membership:

Subscription rates for individuals are \$40 (online only), \$50 (print only), or \$60 (print + online) for volume 126. Libraries and other institutions may subscribe for \$60 (online only or print only) or \$90 (print + online) for volume 126. All foreign print subscribers and members (including USA) must add \$10 to cover postage. The Ottawa Field-Naturalists' Club annual membership fee of \$40 (individual), \$45 (family), or \$20 (student) includes an online subscription to *The Canadian Field-Naturalist*. Members can receive printed issues of CFN for an additional \$30 per volume (four issues). For further details, including discounts for members of the Canadian Museum of Nature, see <http://ofnc.ca/member.php>. The club's regional journal, *Trail & Landscape*, covers the Ottawa District and regional Club events and field trips. It is mailed to Ottawa area members, and is available to those outside Ottawa on request. It is available to libraries at \$33 per year. Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be sent to [subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca) or mailed to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O., Ottawa, ON, Canada, K1Z 1A2. Canada Post Publications Mail Agreement number 40012317. Return postage guaranteed.

COVER: A partial albino Northern Ring-necked Snake (*Diadophis punctatus edwardsii*), hatching on 22 August 2012 from egg laid by female captured at Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia, Canada. Photo by Roger Lloyd. See pages 336-339 in this issue.

## A Direct Comparison of Enclosed Track Plates and Remote Cameras in Detecting Fishers, *Martes pennanti*, in North Dakota

STEVEN C. LOUGHRY<sup>1</sup>, MAGGIE D. TRISKA<sup>1,2</sup>, DOROTHY M. FECSKE<sup>1,3</sup>, and THOMAS L. SERFASS<sup>1,4</sup>

<sup>1</sup>Department of Biology and Natural Resources, Frostburg State University, Frostburg, Maryland 21532 United States

<sup>2</sup>Current address: School of Plant Biology, University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009 Australia

<sup>3</sup>Current address: United States Fish and Wildlife Service, Great Swamp National Wildlife Refuge, 241 Pleasant Plains Road, Basking Ridge, New Jersey 07920 United States

<sup>4</sup>Corresponding author email: tserfass@frostburg.edu

Loughry, Steven C., Maggie D. Triska, Dorothy M. Fecske, and Thomas L. Serfass. 2012. A direct comparison of enclosed track plates and remote cameras in detecting Fishers, *Martes pennanti*, in North Dakota. *Canadian Field-Naturalist* 126(4): 281–287.

Fishers (*Martes pennanti*) historically were reported to occupy forested areas of northeastern North Dakota, but the population was presumed extirpated during the 1900s as a result of overtrapping. Recently ( $\leq 15$  years), Fishers have been recolonizing the state, and there is increasing interest in developing approaches for monitoring the population. During the period June–August 2008, we compared the efficacy of remote cameras and enclosed track plates in detecting Fishers in riparian forest along portions of the drainage basin of the Red River of the North in eastern North Dakota. We monitored 122 scent stations, each composed of both detection devices, with the remote camera positioned to monitor the entrance of the enclosed track plate. Fishers were detected at 40 of the 122 scent stations (32.8%) distributed along approximately 790 km of riparian forest. Among those 40 stations, Fishers were detected by both camera and track plate at 28 stations (70.0%), by camera only at 9 stations (22.5%), and on track plates only at 3 stations (7.5%). Overall, Fishers were detected 37 times by camera (92.5%) and 31 times on a track plate (77.5%). From photographic evidence at the 37 stations where Fishers were detected by camera, we determined that the average latency to initial detection was 4.8 days (SE 0.3, range 1–8). Among the 37 stations where Fishers were detected by camera, detections most frequently occurred on one (27 sites) (73.0%) or two days (7 sites) (19.0%) of a detection period.

**Key Words:** Fisher, *Martes pennanti*, enclosed track plate, remote camera, Red River of the North, North Dakota.

Fishers (*Martes pennanti*) were historically reported to occupy forested portions of northeastern North Dakota, but overtrapping apparently caused the population to become extirpated during the 1900s (Bailey 1926; Adams 1961). Road kills and accidental captures of Fishers by trappers pursuing legal furbearers demonstrate that Fishers have been recolonizing portions of the Red River of the North and its tributaries in North Dakota since at least 1999 (Triska et al. 2011), presumably from expansion of a well-established population in Minnesota (Berg and Kuehn 1994; Erb 2010\*, Seabloom 2011).

In 2008, we initiated a project using remote cameras and enclosed track plates to document the distribution of the newly recolonizing Fisher population in North Dakota (Loughry 2010; Triska 2010; Triska et al. 2011). These devices are known to be generally useful for presence/absence sampling of Fishers (Zielinski and Kucera 1995; Foresman and Pearson 1998; Gompper et al. 2006), and they remain popular meth-

ods for determining the presence of Fishers and other mesocarnivores (Long et al. 2008).

Foresman and Pearson (1998) and Gompper et al. (2006) conducted projects that compared the efficacy of remote cameras and track plates in detecting various mesocarnivores, including Fishers. These works provide a comprehensive review of the advantages and disadvantages of the respective devices relative to cost, efficiency, and the questions being addressed. Foresman and Pearson (1998) and Gompper et al. (2006) concluded that both methods have general utility for presence/absence sampling of Fishers. However, differences in habitat, distribution and placement of sampling devices, season, and sample sizes (Foresman and Pearson (1998) detected few Fishers) limit meaningful comparisons between the studies.

Neither Foresman and Pearson (1998) nor Gompper et al. (2006) placed cameras and track plates at the same station. Gompper et al. (2006) detected Fishers at a higher percentage of sites with remote cameras than

with enclosed track plates when both devices were simultaneously distributed at different locations along the same 5-km transects. In contrast, Foresman and Pearson (1998) compared the data gathered by cameras and track plates placed at the same general locations during different seasons—winter and spring, respectively. Consequently, spatial and temporal differences in the respective studies in the placement of cameras and track plates do not allow the two to be compared directly.

The objective of our project was to compare detection rates for Fishers for remote cameras and track plates placed simultaneously at the same scent station, with the respective sampling devices thus serving to cross-validate the efficacy of the other at each sampling station. This approach provided certainty that a Fisher attracted to a station encountered and had an opportunity to be detected by both devices. We were particularly interested in determining whether Fishers attracted to a station were generally willing to enter the enclosed track plate.

### Study Area

The study was conducted in riparian forests in portions of the Red River of the North and five of its tributaries (the Pembina River, the Tongue River, the Park River, the Forest River, and the Turtle River) in northeastern North Dakota. The Red River of the North (which forms the boundary between North Dakota and Minnesota) originates at the confluence of the Bois de Sioux River and the Otter Tail River at Wahpeton, North Dakota, and Breckenridge, Minnesota, from there flowing northward into Manitoba, Canada (Renard et al. 1986; Koel and Peterka 1998; Hagen et al. 2005\*). Sampling locations for our study encompassed river reaches (maximum river distance, i.e., the actual length of the river, including meanders, from the upstream and downstream sampling locations) for a total of approximately 790 km (550 km of the Red River of the North, 60 km of the Pembina River, 50 km of the Tongue River, 15 km of the Park River, 20 km of the Forest River, and 95 km of the Turtle River) (Figure 1).

Previous to European settlement, portions of North Dakota drained by the Red River of the North consisted mainly of tallgrass prairie, much of which now has been replaced by agricultural fields and other development (Renard et al. 1986; Hagen et al. 2005\*). The forested portions of the drainage basin were primarily limited to riparian areas, a condition that persists today (Renard et al. 1986; Hagen et al. 2005\*; Triska 2010; Triska et al. 2011). Details of forest conditions in eastern North Dakota immediately prior to agricultural development (ca. 1860) are relatively scant. Pre-agricultural forests along tributaries of the Red River of the North generally were described as patches interrupted by extensive segments of prairie, with forests becoming more continuous as tributaries neared the Red River of the North (Severson and Sieg 2006). In

contrast, the forest along the Red River of the North was described as relatively continuous, a condition that would differ substantially from the present riparian forest, which is highly fragmented by agricultural and other development (see Triska (2010) for a review of the size and distribution of forest patches in the study area).

Forested patches in the study area during the study were composed almost entirely of deciduous trees, with dominant species consisting of American Elm (*Ulmus americana*), Quaking Aspen (*Populus tremuloides*), Balsam Poplar (*Populus basamifera*), Manitoba Maple (*Acer negundo*), Burr Oak (*Quercus macrocarpa*), Eastern Cottonwood (*Populus deltoides*), Green Ash (*Fraxinus pennsylvanica*), Paper Birch (*Betula papyrifera*), and members of the willow family (Salicaceae). The structure and composition of the understory vegetation varied among sampling locations, but common species included hawthorns (*Crataegus* spp.), Grey Dogwood (*Cornus racemosa*), Chokecherry (*Prunus virginiana*), Missouri Gooseberry (*Ribes missouriense*), raspberries (*Rubus* spp.), and Downy Serviceberry (*Amelanchier arborea*).

### Methods

Sampling was conducted during June, July, and August 2008. Sampling involved placing scent stations in forested riparian areas distributed throughout the study area (Figure 1). Each station consisted of an enclosed track plate and a motion-sensitive infrared-triggered remote camera. Our intent was to systematically place stations at intervals of approximately 3000 m along riparian corridors. However, the uneven distribution and size of forested patches contributed to substantial variation in the spacing of stations, with an average distance between adjacent stations of 3015 m (SD 2615, range 213–15,742). We limited sampling to forest patches >2 ha, with the average size of patches sampled being 60.5 ha (SE 11.0).

Five sampling sessions were completed during the study. Each session consisted of the placement and removal of a suite of detection devices (typically, 25 stations were monitored during a session); 127 stations were established. Our goal was to have each station operational for a period of 8 days. However, logistics (e.g., travel distance and differences in time required to access various stations) contributed to variation in the number of days a site was monitored. Our primary interest was the comparison of detection devices, and we therefore omitted stations from the study if cameras or track plates were not functional for a period of  $\geq 4$  consecutive days.

We used three models of Cuddeback cameras with motion and heat sensors (Non Typical Inc., Green Bay, Wisconsin): the Excite, Expert, and infrared Noflash. The cameras were positioned to monitor the entrance to and the area surrounding the track plate. Each camera was mounted on a tree at a height of 0.5–1.5 m, 2–2.5 m from the track plate facing the opening. The



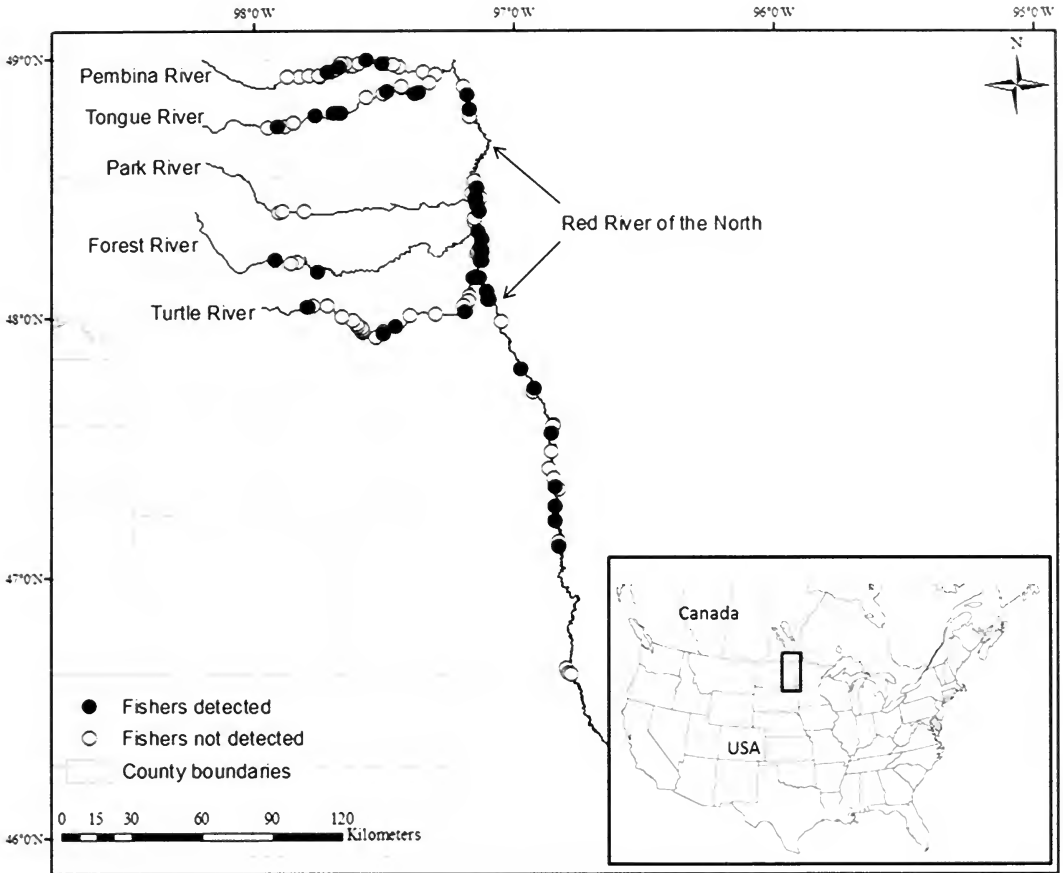


FIGURE 1. Location of the 122 scent stations (dots) along portions of the Red River of the North and five of its tributaries (the Pembina River, the Tongue River, the Park River, the Forest River, and the Turtle River) in eastern North Dakota used to compare Fisher detection rates of enclosed track plates and remote cameras during the period June–August 2008.

camera delay (minimum time between pictures) was set at 1 minute.

Track plates consisted of an aluminum plate  $0.1 \times 20.3 \times 76.2$  cm. The front 40 cm of the track plate was blackened with a portable welding torch (only acetylene gas is burnt while blackening the plate [i.e., the oxygen supply required for welding is turned off], which maximizes soot production; see Zielinski and Kucera 1995) and the other 25 cm was covered with contact paper (adhesive side up) to record tracks. Each track plate was mounted on a plywood base  $1.9 \times 30.4 \times 76.2$  cm and enclosed by a roof constructed of two pieces of flexible black PVC stock  $0.32 \times 40.6 \times 71.1$  cm inserted in grooves 0.9 cm deep cut lengthwise about 1.5 cm from both edges of the plywood base (Figure 2). See Zielinski and Kucera (1995), Foresman and Pearson (1998), Gompper et al. (2006), and Long et al. (2008) for details of configuring various versions of enclosed track plates. A single entrance was established by placing the back of the enclosed track plate against a tree and filling gaps between the tree and the

plastic sheeting with branches gathered at the site. Fisher tracks were identified from illustrations, photos, and descriptions provided in Zielinski and Kucera (1995).

For bait, we placed about 85 g of American Beaver (*Castor canadensis*) meat and about 2 g of beaver castor mixed with glycerol at the rear of each track plate (the end against the tree). To serve as a general attractant, we hung a perforated camera film canister containing a cotton swab soaked in Striped Skunk (*Mephitis mephitis*) essence from monofilament fishing line attached to a branch  $\leq 3$  m from the entrance of the track plate (usually between the camera and the track plate) at a height of about 2 m. Beaver castor and Striped Skunk essence were purchased from Murray's Lures and Trapping Supplies, Walker, West Virginia, USA.

We typically checked stations midway (Day 4) through a detection period (i.e., the number of days a station was maintained) to perform any needed maintenance (e.g., replenish bait, replace track plates if tracks were present, download pictures from cameras,



FIGURE 2. Fisher (*Martes pennanti*) photographed by a remote camera while leaving an enclosed track plate at a scent station in the Red River of the North drainage basin in eastern North Dakota on 27 June 2008.

and remedy any equipment malfunctions or other problems at the station). The actual number of the day varied, and at some stations there was no midway evaluation because of logistical constraints (e.g., cases where establishing all stations for a session took too much time to facilitate opportunities for a midway evaluation of each station). Consequently, a station had either one or two monitoring periods.

#### Detection of Fishers

We calculated the percentage of scent stations at which Fishers were detected (i.e., positive stations) and the percentage of monitoring periods during which Fishers were detected. For stations at which Fishers were detected, we compared the percentage of occasions on which Fishers were detected that were common to both the cameras and the track plates with the percentage of occasions on which Fishers were detected only by the camera or on the track plate.

#### Cameras

Uniquely for cameras, we assessed 1) the number of camera-days per detection, 2) the average number of days on which Fishers were detected at the scent stations where Fishers were detected, 3) the latency to initial detection, and 4) the average number of unique

occasions on which a Fisher was detected on each day that a Fisher was detected. We defined camera-days as the sum of 24-hour periods monitored by all cameras functioning for an entire detection cycle, and we defined latency to initial detection as the number of days between when a camera was operational at a positive site and when the first detection was made (Foresman and Pearson 1998). To calculate the number of visits by a Fisher to a station during a monitoring period, we assumed photographs occurring >30 minutes apart represented unique events, from criteria established by Stevens and Serfass (2008).

We could not determine the number of times a Fisher entered an enclosed track plate during a monitoring period—only that a detection had occurred. Even in cases where cameras indicated multiple visits to a scent station, photographs typically showed a Fisher in the vicinity of an enclosed track plate rather than inside it. We used photographic evidence, however, to determine whether Fishers that visited on more than one day during a monitoring period were more likely to be detected at track plates than those that visited on a single day only. To determine whether visits to a station increased the likelihood of a detection by track

plates, we compared stations where Fishers were detected by a camera on only one day with stations where Fishers were detected by a camera on more than one day. We used  $\chi^2$  analyses to test for independence between stations visited on one day and stations visited on more than one day to compare stations where bait was replenished and stations where the bait was not replenished (i.e., one versus two monitoring periods, respectively). For track plates checked twice, we calculated the percentage of occasions when a Fisher was detected during only the first or second monitoring period with the percentage of occasions when a Fisher was detected during both check periods.

## Results

### *Station monitoring*

Of the 127 scent stations we established, 5 were not included in the analysis because either the track plate or the camera was not operational during  $\geq 4$  consecutive days of the monitoring period. Of the 122 stations 19 were checked once and 103 were checked twice, resulting in a total of 225 monitoring periods. The average number of days that a station was deployed was 7.8 (SE 0.3, range 4–9), and average deployment days were similar between stations monitored once (7.5 days, SE 0.2) and twice (7.8 days, SE 0.1).

### *Detection of Fishers*

Fishers were detected at 40 of the 122 scent stations (32.8%) (Figure 1). Among those 40 stations, Fishers were detected by both cameras and track plates at 28 stations (70.0%) (Figure 2), by camera only at 9 stations (22.5%), and on track plates only at 3 stations (7.5%) (i.e., overall, a Fisher was detected 37 times by camera (92.5%) and 31 times on a track plate (77.5%)). Fishers were detected during 47 of 225 monitoring periods (20.9%): a Fisher was detected 32 times by camera and on track plates (68.1%), 11 times by camera only (23.4%), and 4 times on track plates (8.5%) only.

### *Cameras*

Fishers were recorded by camera during 48 of 954 camera-days (5.0%) (1 detection: 19.9 camera-days). The average latency to initial detection for the 37 scent stations where Fishers were recorded by camera was 4.8 days (SE 0.3, range 1–8), and the average number of days a camera was deployed at these stations was 7.7 (SE 0.2, range 6–9). Among the 37 stations where Fishers were detected, Fishers most frequently were detected on one (27 sites) (73.0%) or two days (7 sites) (19.0%) (maximum 4 days) of a detection period. Fishers typically did not make multiple visits to a station during a day on which a detection occurred, with the average number of unique occasions when a Fisher was detected on days on which Fishers were detected being 1.2 (SE 0.1, range 1–7).

### *Track plates*

The number of times a Fisher was detected at track plates appeared to be influenced by the number of days

a Fisher visited a scent station (as determined by cameras). Among the 37 stations where Fishers were detected by camera, those with detections on 1 day had detections at 19 of 27 (70.4%) of corresponding track plates, whereas those with detections on  $>1$  day had detections at 9 of 10 (90%) of corresponding track plates ( $\chi^2_1 = 4.05$ ,  $P = 0.04$ ). The number of times a Fisher was detected did not differ between stations that were checked once (a Fisher was detected 6 times at 19 sites (31.6%)) or twice (a Fisher was detected 25 times at 103 sites (24.3%)) ( $\chi^2_1 = 0.27$ ,  $P = 0.61$ ). Among the 25 stations at which Fishers were detected that were checked twice, Fishers were detected at 8 stations (32.0%) during the first monitoring period only, at 12 stations (48.0%) during the second monitoring period only, and at 5 stations (20.0%) during both periods. For these 25 sites, the average time of the mid-period check was after 4.2 days (SE 0.1, range 6–9).

## Discussion

Both cameras and track plates have been proven to be relatively effective at verifying the presence of Fishers and a variety of other mesocarnivores (Zielinski and Kucera 1995; Foresman and Pearson 1998; Gompert et al. 2006; Long et al. 2008). In this study, cameras were considerably more effective in detecting Fishers, contributing 92.5% of the occasions when Fishers were detected at the 40 stations where the presence of Fishers was recorded, in comparison to 77.5% recorded on track plates.

We encountered relatively few failures with either cameras or track plates during this study. Among the 127 scent stations, only 5 were not operational during a full monitoring period (the batteries failed in cameras at 3 stations and the track plates were trampled by cattle at 2 stations). Other studies also have reported battery failure in remote cameras (e.g., Foresman and Pearson 1998—using film cameras). In our case, this problem was encountered during the first monitoring cycle and was remedied by more diligently monitoring the charge of batteries (i.e., replacing them before charges dropped to  $<50\%$ ). There were 4 occasions when Fishers were detected by track plates but were not recorded by the corresponding camera, all apparently caused by improper mounting of the camera (in each case, the camera had been mounted so that the detection zone (field of view) was above the preferred detection area).

The 11 occasions when Fishers were detected by camera but were not recorded by the corresponding track plates could plausibly be attributed to a variety of factors, including avoidance of the enclosed track plates by some Fishers, dissipation of the scent of lures and bait over time, and the frequency with which Fishers visited a scent station. Fishers are active foragers and will readily explore earthen dens, crevices, and cavities in search of food, as well as for refuge (Powell 1993). Consequently, we generally would not expect

Fishers to be hesitant about entering an enclosed track plate, but such avoidance could be attributed to a disturbance during a visit to a station or negative experiences associated with similar devices (e.g., an Fisher that had previously been trapped in a cage trap and released might avoid entering an enclosed track plate). The number of days a Fisher visited a scent station appeared to influence the likelihood of tracks being left on track plates, with visits on more than one day being more likely to result in tracks than visits during only a single day. Therefore, the likelihood of detecting Fishers using track plates could be enhanced by maintaining stations for longer periods, thereby increasing opportunities for Fishers to make visits to a station on multiple days.

Removal of bait by Raccoons (*Procyon lotor*), feral cats (*Felis catus*), or other wildlife before Fishers visited a scent station is another factor that may have contributed to Fishers not being detected, but, in such instances, lingering scent from the bait presumably served as an adequate olfactory stimulus to entice a Fisher into an enclosed track plate. Our results provide support for this presumption, since there was no substantial difference between the number of times a Fisher was detected by track plates in those stations that were checked once and those that were checked twice (i.e., baits not replenished or replenished, respectively). However, our project was not designed specifically to determine whether persisting smell of bait has the same value as the presence of bait itself in attracting a Fisher into an enclosed track plate, and our results could have been confounded by various factors (e.g., bait plausibly could have been equally present when Fishers arrived at a station, something that would need to be controlled to address the issue beyond inference).

As with most carnivores, monitoring Fishers is particularly challenging because they are elusive, maintain low population densities, and occupy relatively large home ranges (Powell 1993). Consequently, assessing the influence of different factors on the efficacy of detection devices, including regions, seasons, and habitat conditions, is fundamental to enhancing monitoring protocols (Zielinski and Kucera 1995; Long et al. 2008). Various studies have evaluated the relative merit of remote cameras and track plates in monitoring carnivores (Bull et al. 1992; Zielinski and Kucera 1995; Foresman and Pearson 1998; Mowat et al. 2000). Advantages of using cameras instead of track plates include less frequent baiting and monitoring, generally smaller and lighter equipment and materials required for deployment, ease of species identification, and ability to determine the number of individuals visiting a site and visitation patterns (e.g., latency to initial detection and the time, duration, and frequency of visits) (Foresman and Pearson 1998; Hilty and Merenlender 2000; Gompper et al. 2006). These advantages were evident during our project, as cameras allowed us to

acquire detailed information on latency to initial detection and diurnal activity patterns, and we were able to identify the general period when cubs began actively moving about the study area (Loughry 2010)—information that could not have been effectively obtained with track plates. Ongoing advances in remote camera technology have made them particularly appropriate for wildlife studies (Long et al. 2008). The cameras used in our study were reliable, easy to use, and outperformed track plates in detecting Fishers.

### Acknowledgements

Funding for this study was provided through the Wildlife and Sport Fish Restoration funds under the State Wildlife Grants program (CFDA 15.634) administered by the North Dakota Game and Fish Department. We particularly appreciate the help and guidance provided by Sandra Johnson, Patrick Isakson, and Steve Dyke, Conservation Section, North Dakota Game and Fish Department. We appreciate the helpful comments provided by two reviewers.

### Documents Cited (marked \* in text)

- Erb, J.** 2010. Registered furbearer harvest statistics: 2009-10 report. Forest Wildlife and Populations Research Group, Minnesota Department of Natural Resources, Grand Rapids, Minnesota.
- Hagen, S. K., P. T. Isakson, and S. R. Dyke.** 2005. North Dakota Comprehensive Wildlife Conservation Strategy. North Dakota Game and Fish Department, Bismarck, North Dakota.

### Literature Cited

- Adams, A. W.** 1961. Furbearers of North Dakota. North Dakota Game and Fish Department, Bismarck, North Dakota.
- Bailey, V.** 1926. A biological survey of North Dakota. North American Fauna No. 49. U.S. Department of Agriculture Bureau of Biological Survey. U.S. Government Printing Office, Washington, D.C.
- Berg, W. E., and D. W. Kuehn.** 1994. Demography and range of fishers and American martens in a changing Minnesota landscape. Pages 262–271 in Martens, Sables and Fishers: Biology and Conservation. Edited by S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell. Cornell University Press, Ithaca, New York.
- Bull, E. L., R. S. Holthausen, and L. R. Bright.** 1992. Comparison of 3 techniques to monitor marten. Wildlife Society Bulletin 20: 406–410.
- Foresman, K. R., and D. E. Pearson.** 1998. Comparison of proposed survey procedures for detection of forest carnivores. Journal of Wildlife Management 62: 1217–1226.
- Gompper, M. E., R. W. Kays, J. C. Ray, S. D. Lappoint, D. A. Bogan, and J. R. Cryan.** 2006. A comparison of non-invasive techniques to survey carnivore communities in northeastern North America. Wildlife Society Bulletin 34: 1142–1150.
- Hilty, J. A., and A. Merenlender.** 2000. A comparison of covered track-plates and remotely-triggered cameras. Transactions of the Western Section of the Wildlife Society 36: 27–31.

- Koel, T. M., and J. J. Peterka.** 1998. Stream fishes of the Red River of the North basin, United States: a comprehensive review. *Canadian Field-Naturalist* 112: 631–646.
- Long, R. A., P. Mackay, W. J. Zielinski, and J. C. Ray.** 2008. Noninvasive survey methods for carnivores. Island Press, Washington, D.C.
- Loughry, S. C.** 2010. Assessing the natural history and habitat use of the fisher in eastern North Dakota. M.Sc. thesis, Frostburg State University, Frostburg, Maryland.
- Mowat G., C. Shurgot, and K. G. Poole.** 2000. Using track-plates and remote cameras to detect marten and short-tailed weasels in coastal cedar hemlock forest. *Northwestern Naturalist* 81: 113–121.
- Powell, R. A.** 1993. *The Fisher: Life History, Ecology, and Behavior*. University of Minnesota, Minneapolis, Minnesota.
- Renard, P. A., S. R. Hanson, and J. W. Enblom.** 1986. Biological survey of the Red River of the North. Special Publication No. 142. Minnesota Department of Natural Resources, St. Paul, Minnesota.
- Seabloom, R. W.** 2011. *Mammals of North Dakota*. North Dakota Institute of Regional Studies, North Dakota State University, Fargo, North Dakota.
- Severson, K. E., and C. H. Sieg.** 2006. The nature of eastern North Dakota: pre-1880 historical ecology. North Dakota Institute of Regional Studies, North Dakota State University, Fargo, North Dakota.
- Stevens, S. S., and T. Serfass.** 2008. Visitation patterns and behavior of nearctic river otters (*Lontra canadensis*) at their latrines. *Northeastern Naturalist* 15: 1–12.
- Triska, M. D.** 2010. Assessing the current and projected distribution of a recently reestablishing fisher (*Martes pennanti*) population in eastern North Dakota. M.Sc. thesis, Frostburg State University, Frostburg, Maryland.
- Triska, M. D., S. C. Loughry, and T. L. Serfass.** 2011. Persistence of fishers in riparian forests in North Dakota, USA following a severe flood event. *Acta Theriologica* 56: 367–374.
- Zielinski, W. J., and T. E. Kucera.** 1995. American marten, fisher, lynx, and wolverine: survey methods for their detection. United States Forest Service, United States Department of Agriculture. General Technical Report PSW GTR-157.

Received 1 June 2012

Accepted 25 September 2012

# Population Structure of Harvested Red Foxes (*Vulpes vulpes*) and Coyotes (*Canis latrans*) on Prince Edward Island, Canada

WENDELA WAPENAAR<sup>1</sup>, FIEP DE BIE<sup>2</sup>, DAVID JOHNSTON<sup>3</sup>, RYAN M. O'HANDLEY<sup>4</sup>, and HERMAN W. BARKEMA<sup>5</sup>

<sup>1</sup>Department of Population Health, School of Veterinary Medicine and Science, University of Nottingham, Sutton Bonington Campus, Leicestershire, LE12 5RD, U.K. Corresponding author email: wendela.wapenaar@nottingham.ac.uk

<sup>2</sup>Atlantic Veterinary College, University of Prince Edward Island, 550 University Avenue, Charlottetown, Prince Edward Island C1A 4P3 Canada

<sup>3</sup>Johnston Biotech, 1080 Braemar Lane, Sarnia, Ontario N7V 3B5 Canada

<sup>4</sup>Department of Parasitology, Faculty of Veterinary Medicine, University of Adelaide, Adelaide, Australia

<sup>5</sup>Department of Production Animal Health, Faculty of Veterinary Medicine, University of Calgary, 3330 Hospital Drive N.W., Calgary, Alberta T2N 4N1 Canada

Wapenaar, Wendela, Fiep de Bie, David Johnston, Ryan M. O'Handley, and Herman W. Barkema. 2012. Population structure of harvested Red Foxes (*Vulpes vulpes*) and Coyotes (*Canis latrans*) on Prince Edward Island, Canada. *Canadian Field-Naturalist* 126(4): 288–294.

An understanding of the population dynamics and habitat of wild Red Foxes (*Vulpes vulpes*) and Coyotes (*Canis latrans*) is a prerequisite to wildlife management. This information is also important in assessing the risk these wild canids pose to the public and domestic animals. On Prince Edward Island, information on age, sex, reproductive activity, and habitat use of 271 Red Foxes and 201 Coyotes was collected in the hunting and trapping season of 2004–2005. The estimated age of Red Foxes and Coyotes ranged from 0.5 to 13.5 years. A large proportion of harvested Red Foxes and Coyotes (58% and 48%, respectively) consisted of juveniles. The sex ratio was not significantly different from 1:1 for either species. Average litter size was 5.0 and 5.2 for Red Foxes and Coyotes, respectively. Number of placental scars ranged from 0 to 7 in Red Foxes and from 0 to 11 in Coyotes. Agricultural areas were the main habitat type (52%) of harvested Red Foxes. For harvested Coyotes, forest was the main habitat (44%), followed closely by agricultural areas (43%). Urban areas were a significant part (13%) of the habitat of Red Foxes. These data can be used to monitor population dynamics over time, provide information for wildlife management, and provide information on potential risk areas for disease transmission by wild canids.

Key Words: Coyote, *Canis latrans*, Red Fox, *Vulpes vulpes*, age, reproductive activity, habitat, Prince Edward Island.

The abundance of Coyotes (*Canis latrans*) on Prince Edward Island has increased rapidly since they were first observed in 1983, and Coyotes now occur throughout the island. Coyotes have been observed scavenging carcasses close to cattle, poultry, and hog farms (Field 2003). The role of Coyotes as a predator of domestic livestock is frequently cited as a justification for control of this species (Chambers 1992; Parker 1995; Mitchell et al. 2004). There is no published report regarding the population density of Coyotes in the province, but it has been estimated at 0.4 animals/km<sup>2</sup> (R. Dibblee, Prince Edward Island Department of Environment, Energy and Forestry, personal communication). In eastern Canada, several studies have documented specific aspects of Coyote demography. These studies, carried out in Quebec, Nova Scotia, and New Brunswick, focused on body condition (Poulle et al. 1995; Dumond and Villard 2000), productivity (Jean and Bergeron 1984), and social organization and space use (Patterson and Messier 2001). Two studies were previously carried out on Prince Edward Island (Field 2003; Gautreau 2004) to investigate the population ecology of Coyotes; however, the sample size in both studies was limited.

The Red Fox (*Vulpes vulpes*) is common on Prince Edward Island (Government of PEI, 2012). Many Red Foxes on Prince Edward Island have lost their fear of

people, as they are often fed in campgrounds and urban areas. This proximity to people may pose a risk to human health. Red Foxes and Coyotes can be carriers of pathogens, such as the rabies virus (Constantine 1966) and the zoonotic parasites *Toxocara canis* (Smith et al. 2003; Wapenaar et al. 2013) and *Echinococcus* spp. (Eckert et al. 2000). Furthermore, Red Foxes and Coyotes can play a role in transmitting diseases, such as *Sarcocystis* spp. (Farmer et al. 1978) and *Neospora caninum* (Wapenaar et al. 2006), to livestock.

The density of Red Foxes in the province is estimated at 1 animal/km<sup>2</sup> (R. Dibblee, Prince Edward Island Department of Environment, Energy and Forestry, personal communication), comparable to densities of Red Foxes reported in metropolitan Toronto, Ontario (Voigt 1987; Rosatte et al., 1991). There are limited published studies of Red Foxes in eastern Canada. One report from Prince Edward Island described the Red Fox population from 1972 to 1980 (Curley 1983). Long-distance movement (170 km) of one Red Fox (Rosatte 2002) and the ecology and disease management implications of Red Foxes in Toronto (Adkins and Stott 1998; Rosatte and Allan 2009) have also been described. Voigt and Macdonald (1984) described significant variation in spatial behaviour of Red Foxes in rural Ontario and in Oxfordshire in the U.K. However,

the demography of Red Foxes on Prince Edward Island may have changed since 1980, and their behaviour there is expected to be different from that in an urban environment, such as Toronto.

Descriptive baseline studies are required to better understand the population dynamics of Red Foxes and Coyotes to help monitor and provide evidence for appropriate wildlife management. Better understanding of wild canid populations makes managing the risk of disease transmission to humans and domestic animals more feasible. The objective of this study was to describe the population structure and habitat of harvested Red Foxes and Coyotes on Prince Edward Island.

## Methods and Materials

### *Field sample collection*

Red Fox and Coyote carcasses were obtained from 32 hunters and trappers on Prince Edward Island, Canada, between 19 October 2004 and 24 March 2005. All carcasses were sampled as soon as possible after death, varying from a few hours to five days. Sex, date of death, and the location where the animal was killed were recorded. Location was based on written or verbal information collected from hunters and trappers, who used names of villages or other landmarks nearby the place of harvest to identify the location.

A canine tooth was extracted from the lower jaw of each carcass for age analysis. Radiographs were made of the individual canine teeth to assess width of the pulp cavity to differentiate between a juvenile (<1 year old) and an adult animal (>1 year old) (Johnston et al. 1999). The age of adult animals was determined by counts of the annual growth zones in the canine tooth cementum (Grue and Jensen 1976). Most Red Foxes and Coyotes give birth in spring. Because sample collection was performed in fall and winter, the minimum estimated age recorded was 0.5 year and increased in 1-year increments.

Reproductive tracts were removed from female Red Fox and Coyote carcasses. Reproductive status was assessed based on the presence of placental scars in females older than 1 year of age. Only dark placental scars were considered in the estimation of litter size of the most recent breeding season; pale scars may have originated from a previous reproductive season (Martorell Juan and Gortazar Schmidt 1993).

### *Habitat characteristics*

Foxes and coyotes were collected throughout Prince Edward Island, Canada. The present land surface of PEI ranges from nearly level in the west to hilly in the central region and to rolling hills in the east. The shoreline of PEI generally alternates between headlands of sandstone bluffs and sandy beaches. Close to 50% of the land on PEI has been identified as being highly productive farm land and the remaining habitat consists mainly of forest and a small proportion of wetland. Latitude and longitude of the locations where the animals were killed were recorded and entered into GIS

software (ArcGIS 9.0) (ESRI Corp., Redlands, California).

Firstly, the habitat characteristics were defined by drawing a circle round the recorded location to represent the estimated home range (9 km<sup>2</sup> for Red Foxes and 50 km<sup>2</sup> for Coyotes). These estimates of home range size were based on previous studies (Harris 1977; Lloyd 1980; Voigt and Tinline 1980; Trehwella et al. 1988; Atkinson and Shackleton 1991; Field 2003; Gautreau 2004; Rosatte and Allan 2009).

The size of the home range of Coyotes reported previously varies considerably, ranging from 3 km<sup>2</sup> to 100 km<sup>2</sup>, depending on the region, availability of food, human activities, reproductive season, and the technique used to calculate the home range. For example, home ranges are smaller in urban habitats than in rural habitats (Atwood et al. 2004). Because this study was performed in a rural area in winter, a large home range estimate of 50 km<sup>2</sup> was used.

Secondly, to determine the predominant land use type within the habitat of harvested Red Foxes and Coyotes, we derived land use data from field-validated aerial photographs of Prince Edward Island taken in 2000 (Government of PEI, 2013). These data were redefined into four general land use categories: forest, agriculture, wetland, and urban areas. Clear-cuts, abandoned land, and tree plantations were included in the forest category. Agriculture consisted of farmsteads, feedlots, fur ranches, orchards, pastures, and cropland. Swamps and marshes were considered wetland. Urban land types consisted of commercial, recreational, park, institutional, residential, greenbelt, and transportation land use. The percentage of each of these land types within the estimated habitat of individual Red Foxes and Coyotes was calculated using ArcGIS 9.0.

### *Statistical analyses*

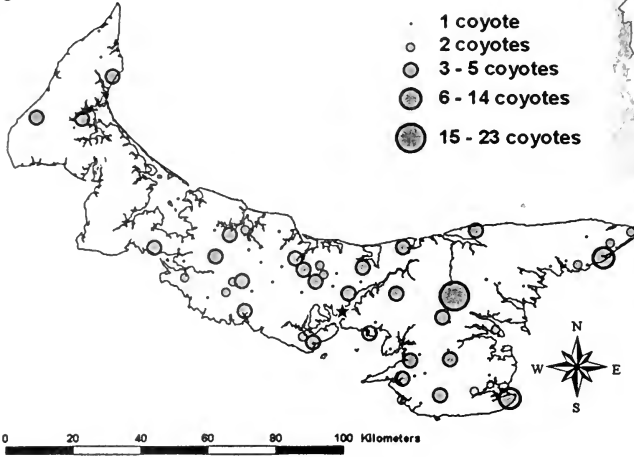
A one-sample proportion test was used to compare habitat proportions with the overall cover type distribution on Prince Edward Island.  $\chi^2$  analysis was used to investigate distribution of age, sex, and reproductive status. A Student's *t*-test was used to analyze the distribution of litter size between primiparae and multiparae Red Foxes and Coyotes. EpiTools epidemiological calculator (Sergeant 2009\*) was used for the statistical analyses of the data.

## Results

### *Descriptive data*

We collected data on 271 Red Foxes and 201 Coyotes in Prince Edward Island during the period from October 2004 to March 2005. This sample size represented 34% of the Red Foxes (Government of PEI, unpublished data) and 59% of the Coyotes (Government of PEI, 2012) that were harvested during the 2004-2005 trapping and hunting season on Prince Edward Island. The method of kill for most Red Foxes (96%) ( $n = 261$ ) and Coyotes (55%) ( $n = 111$ ) was trapping. Five Red Foxes and 2 Coyotes collected for

## A. Coyotes



## B. Red foxes

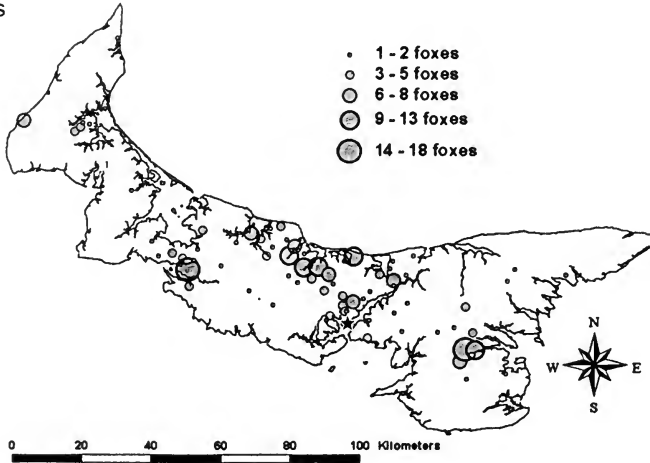


FIGURE 1. Graduated points of locations on Prince Edward Island, Canada ( $46^{\circ}$  degrees latitude,  $-63^{\circ}$  degrees longitude), where Coyotes (*Canis latrans*, Map A) and Red Foxes (*Vulpes vulpes*, Map B) were trapped or hunted in 2004–2005 (ArcGIS 9.0, ESRI Corp., Redlands, California). The capital Charlottetown is indicated by a black star.

this study were killed by motor vehicles and the remaining Red Foxes ( $n = 5$ ) and Coyotes ( $n = 88$ ) were killed by hunters.

Red Foxes were mainly collected in December; Coyotes were collected more consistently throughout the hunting and trapping season (approximately 30–40 Coyotes per month from November until March). Coyote harvesting was evenly distributed across Prince Edward Island, whereas Red Fox harvesting was mainly clustered in central Prince Edward Island (Figure 1). A high number of Red Foxes (35%) collected by

one trapper contributed to this clustering. Sex was recorded for 246 Red Foxes (115 females and 131 males) and for 180 Coyotes (92 females and 88 male). The sex ratio was not significantly different from parity in Red Foxes ( $P = 0.21$ ) or Coyotes ( $P = 0.79$ ).

#### Age distribution and litter size

Canine teeth were collected from 271 Red Foxes and 184 Coyotes. The proportion of juvenile Red Foxes (58%) ( $n = 158$ ) was significantly higher than the proportion of juvenile Coyotes (48%) ( $n = 89$ ,  $P = 0.04$ ). The age distribution ranged from 0.5 to 13.5



TABLE 1. Distribution of age and sex recorded for 246 Red Foxes (*Vulpes vulpes*) and 163<sup>b</sup> Coyotes (*Canis latrans*) collected in 2004-2005 on Prince Edward Island, Canada.

Age (years)	Red Fox				Coyote			
	Male		Female		Male		Female	
	N	%	N	%	N	%	N	%
0.5	84	64	57	50 <sup>a</sup>	35	45	40	47
1.5	19	15	21	18	14	18	15	17
2.5	17	13	18	16	10	13	11	13
3.5	3	2	10	8	6	8	7	8
4.5	4	3	3	3	4	5	5	6
5.5-10.5	4	3	4	3	6	8	7	8
11.5-13.5	0	0	2	2	2	3	1	1
Total	131	100	115	100	77	100	86	100

<sup>a</sup> Significant ( $P = 0.03$ ) difference between male and female juvenile Red Foxes.

<sup>b</sup> This is a subset of the total harvested number of coyotes, as both age and sex data were only available from 163 carcasses.

TABLE 2. Age-related reproductive status, average litter size (extrapolated from placental scars), and number of placental scars observed in 51 female Red Foxes (*Vulpes vulpes*) and 32 female Coyotes (*Canis latrans*) collected in 2004-2005 on Prince Edward Island, Canada.

	n	Reproductively active (%)	Average litter size (n)	Number of placental scars/female				
				0	1 or 2	3 or 4	5 or 6	7 to 11
Red Fox	16	50	4.9	8	0	4	3	1
	17	76	5.4	4	0	3	8	2
	10	70	4.7	3	1	2	3	1
	8	75	4.8	2	0	3	2	1
	51	66	5.0	17	1	12	16	5
Coyote	11	55	2.5 <sup>a</sup>	5	3	3	0	0
	11	55	5.7	5	0	1	4	1
	3	100	7.0	0	0	1	1	1
	7	100	6.3	0	0	0	5	2
	32	68	5.2	10	3	5	10	4

<sup>a</sup> Significant ( $P < 0.05$ ) difference between the extrapolated average litter size in primiparae and multiparae Coyotes.

years for both Red Foxes and Coyotes (Table 1). The median age was 0.5 years (mean 1.5) and 1.5 years (mean 2.1) for Red Foxes and Coyotes, respectively. Juvenile Red Foxes were more often male than female ( $P = 0.03$ ) (Table 1); this skew was not present in Coyotes ( $P = 0.60$ ). The oldest Red Fox was a 13.5-year-old female, and she had no dark or pale placental scars. Two Coyotes of 13.5 years of age were collected, a female with 5 placental scars and a male.

Uteri were not available from all female Red Foxes and Coyotes, due to autolysis of carcasses that made placental scar counts unreliable. Placental scar counts were performed on the uteri of 51 adult female Red Foxes and 32 adult female Coyotes. Thirty-four of 51 (66%) adult female Red Foxes and 22 of 32 (68%) adult female Coyotes were reproductively active (Table 2). Fifty percent of Red Foxes and 55% of Coyotes of 1.5 years of age were reproductively active.

The average litter size for Red Foxes and Coyotes, extrapolated from placental scar counts, was 5.0 (95% CI, 4.5-5.5) and 5.2 (95% CI, 3.9-6.4), respectively. Number of placental scars ranged from 0 to 7 in Red Foxes and from 0 to 11 in Coyotes (Table 2). In Coy-

otes, the litter size of primiparae was smaller than for multiparae ( $P = 0.001$ ). This significant increase in litter size in multiparae was not observed in Red Foxes ( $P = 0.36$ ).

#### Habitat characteristics

Habitat characteristics were estimated for 266 harvested Red Foxes and 185 harvested Coyotes for which the location of kill was recorded. For both canids, agricultural areas were important habitat types, comprising 52% of the habitat of Red Foxes and 43% of the habitat of Coyotes. Forest was the largest habitat type for Coyotes, comprising of 44% of their habitat (Table 3). The estimated habitat of harvested Red Foxes contained a higher percentage of urban (13%) and agricultural (52%) land types than the distribution of these land types on Prince Edward Island as a whole (Table 3).

#### Discussion

To our knowledge, this is the first descriptive report on age, sex, litter size, and habitat of harvested Red Foxes and Coyotes on Prince Edward Island. A small proportion consisted of remarkably old animals, with

TABLE 3. Distribution of land types on Prince Edward Island compared to the distribution of land types in the estimated habitat of harvested Red Foxes (*Vulpes vulpes*) ( $n = 266$ ) and Coyotes (*Canis latrans*) ( $n = 185$ ) collected in 2004-2005 on Prince Edward Island, Canada.

	On Prince Edward Island	Habitat type	
		Of Red Foxes	Of Coyotes
Forest (%)	47	29 <sup>a</sup>	44
Agriculture (%)	39	52 <sup>a</sup>	43
Wetland (%)	8	6	7
Urban (%)	6	13 <sup>a</sup>	6

<sup>a</sup> Significant difference ( $P < 0.01$ ) between the percentage of land type in the habitat of harvested Red Foxes and the distribution of the same land type on Prince Edward Island.

one Red Fox and two Coyotes of 13.5 years of age. A Coyote of 16.5 years of age has previously been reported in New Brunswick (Dumond and Villard 2000). This is the first published report of a wild Red Fox of 13.5 years of age in eastern Canada.

A high proportion of harvested Red Foxes (58%) were juveniles. This may represent the actual age ratio, but it could also be explained by less experienced juvenile Red Foxes being easier to trap. High juvenile counts are common when trapping Red Foxes and Coyotes: a previous study reported that juveniles comprised 64% of a mainly trapped Red Fox population studied on Prince Edward Island between 1972 and 1980 (Curley 1983). The high proportion of juvenile Red Foxes could also be attributed to the abundance of food, as an increase in food supply would support better body condition and survival rates for young individuals (Voigt 1987; Dumond and Villard 2000).

The average and median ages of Red Foxes were lower than for Coyotes. Eighty-five percent of Coyotes in 14 North American studies were under 3 years of age (Parker 1995), which is similar to 76% of the harvested Coyote population in this study. However, age estimates vary greatly among studies: in nearby northeastern New Brunswick, an unusually high average age of 5.6 years has been observed in Coyotes (Dumond and Villard 2000).

The extrapolated average litter size of Red Foxes corroborates the findings from a previous study performed on Prince Edward Island, where a litter size of 5.2 was observed (Curley 1983). A mean litter size of 4.7, 3.3, and 8.0 was observed in studies of Red Foxes around Bristol, U.K. (Harris and Trehwella 1988), in northeastern Spain (Martorell Juan and Gortazar Schmidt 1993), and in Ontario (Voigt and Macdonald 1984), respectively. The differences in climate and habitat between Europe and Prince Edward Island are significant and may have influenced the difference in litter size.

The percentage of reproductively active female Coyotes (68%) is higher than previous findings of 54% on Prince Edward Island (Field 2003). In a study in New Brunswick, only 41% of adult female Coyotes were reproductively active, and on average 6.6 placental scars were present in females older than 5 years (Dumond and Villard 2000).

Litter sizes of Coyotes generally vary between 3 and 4 per litter in established populations, whereas litter sizes in harvested populations of Coyotes vary between 5 and 8 pups per litter (Field 2003). In this study, an increasing litter size for multiparae Coyotes was observed (Table 2). Data from only one hunting season were available, so it was not possible to compare our findings to pre-harvest data and it is therefore not feasible to assess the effect of harvesting on the population. Continued annual data collection would provide valuable information on changes in litter size.

It is important to note that the presence of placental scars is most commonly used in wildlife to indicate the number of young born in the most recent litter. However, counting placental scars is a crude measure of reproductive success, because it fails to account for resorption of embryos, aborted fetuses, or pup or kit mortality. Therefore, our findings may be an overestimate of actual litter size derived from counting pups at a den site. A study of fetal viability in captive wild-caught Coyotes found that 75–85% of the placental scars represented live pups in most years, although lower percentages were observed among younger and older females (Green et al. 2002).

A previous study indicated that the relative abundance of Red Foxes and Coyotes on Prince Edward Island was uniform throughout the island (Field 2003). Coyotes were collected in an even distribution over the island in the current study, and the findings from the harvested Coyotes may therefore be representative of the general Coyote population. However, there are the limitations associated with using harvesting records to infer population demography. A previous study investigating harvesting records of Red Grouse (*Lagopus lagopus scoticus*) determined that the sample population poorly reflected the true age and sex ratio of the wild population (Bunnfeld et al. 2009).

The habitat of harvested Red Foxes and Coyotes was estimated by placing a buffer of 9 km<sup>2</sup> and 50 km<sup>2</sup>, respectively, round the point of capture. These zones may not have accurately represented the true habitat of the Red Foxes and Coyotes, as some of these animals may have been tracked for some time before they were killed. In addition, the method of kill for 96% of the collected Red Foxes was trapping, in contrast to 55% for the Coyotes. Trapped animals were expected to be

trapped in their natural habitat; however, one trapper was responsible for 35% of harvested Red Foxes, and this may have biased the results and therefore limits application of the findings of the harvested population to the wild Red Fox population on Prince Edward Island. On the other hand, it is common for trappers to trap in areas where they expect many Red Foxes, and the current sample of Red Foxes may therefore be representative of their distribution. Similarly, a study investigating Red Grouse demonstrated that the number of Red Grouse shot did reflect the actual density (Bunnfeld et al. 2009). Comparative research with radio-telemetry or multiple recapture data was not feasible within this study but is required to determine whether the estimated distribution and habitat preferences are truly representative of the natural habitats of these wild canids.

This study described the characteristics of harvested Red Fox and Coyote populations on Prince Edward Island with a high proportion of reproductively active females and a high litter size, particularly in multiparae Coyotes. Agricultural areas for both Red Foxes and Coyotes and urban areas for Red Foxes were an important part of the habitat, indicating that there is ample opportunity for these animals to transmit disease to humans and domestic animals. Gathering additional data on population dynamics over time would be valuable to inform appropriate wildlife management and provide information on potential risk areas for disease transmission by wild canids.

### Acknowledgements

We thank the participating hunters and trappers of Prince Edward Island for their vital contribution to this study and Leonard Doucette, Lonke Zeijlemaker, and Barbara Poorter for their technical assistance.

### Documents Cited (marked \* in text)

- Government of Prince Edward Island.** 2013. GIS data layers. <http://www.gov.pe.ca/gis>. Accessed January 27, 2013.
- Government of Prince Edward Island.** 2012. <http://www.gov.pe.ca/forestry/index.php3?number=1010073&lang=E>. Accessed 22 February, 2013.
- Government of Prince Edward Island.** 2012. [http://www.gov.pe.ca/photos/original/AF\\_HuntSum12.pdf](http://www.gov.pe.ca/photos/original/AF_HuntSum12.pdf). Accessed February 22, 2013.
- Sergeant, E. S. G.** 2009. EpiTools epidemiological calculators. AusVet Animal Health Services and Australian Biosecurity Cooperative Research Centre for Emerging Infectious Disease. Available at: <http://epitools.ausvet.com.au>.

### Literature Cited

- Adkins, C. A., and P. Stott.** 1998. Home ranges, movements and habitat associations of red foxes *Vulpes vulpes* in suburban Toronto, Ontario, Canada. *Journal of Zoology* 244: 335–346.
- Atkinson, K. T., and D. M. Shackleton.** 1991. Coyote, *Canis latrans*, ecology in a rural-urban environment. *Canadian Field-Naturalist* 105: 49–54.
- Atwood, T. C., H. P. Weeks, and T. M. Gehring.** 2004. Spatial ecology of coyotes along a suburban-to-rural gradient. *Journal of Wildlife Management* 68: 1000–1009.
- Bunnfeld, N., D. Baines, D. Newborn, and E. J. Milner-Gulland.** 2009. Factors affecting unintentional harvesting selectivity in a monomorphic species. *Journal of Animal Ecology* 78: 485–92.
- Chambers, R. E.** 1992. Reproduction of coyotes in their northeastern range. Pages 39–52 in *Ecology and Management of the Eastern Coyote*. Edited by A. H. Boer. Wildlife Research Unit, Fredericton, New Brunswick.
- Constantine, D. G.** 1966. Transmission experiments with bat rabies isolates: bite transmission of rabies to foxes and coyote by free-tailed bats. *American Journal of Veterinary Research* 116: 20–23.
- Curley, F. R.** 1983. Population dynamics and morphological variation of the red fox (*Vulpes vulpes rubricosa* Bangs) on Prince Edward Island. M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.
- Dumond, M., and M. A. Villard.** 2000. Demography and body condition of coyotes (*Canis latrans*) in eastern New Brunswick. *Canadian Journal of Zoology* 78: 399–406.
- Eckert, J., F. J. Conraths, and K. Tackmann.** 2000. Echinococcosis: an emerging or re-emerging zoonosis? *International Journal of Parasitology* 30: 1283–1294.
- Farmer, J. N., I. V. Herbert, M. Partridge, and G. T. Edwards.** 1978. The prevalence of *Sarcocystis* spp. in dogs and red foxes. *Veterinary Record* 102: 78–80.
- Field, S. A.** 2003. Population ecology of eastern coyotes (*Canis latrans*) on Prince Edward Island. M.Sc. thesis, University of Prince Edward Island, Charlottetown, Prince Edward Island.
- Gautreau, N.** 2004. A study of Eastern Coyotes (*Canis latrans*) on Prince Edward Island. M.Sc. thesis, University of Prince Edward Island, Charlottetown, Prince Edward Island.
- Green, J. S., F. F. Knowlton, and W. C. Pitt.** 2002. Reproduction in captive wild-caught coyotes (*Canis latrans*). *Journal of Mammalogy* 83: 501–506.
- Grue, H., and B. Jensen.** 1976. Annual cementum structures in canine teeth in arctic foxes (*Alopex lagopus* (L.)) from Greenland and Denmark. *Danish Review of Game Biology* 10: 1–12.
- Harris, S.** 1977. Distribution, habitat utilization and age structure of a suburban fox (*Vulpes vulpes*) population. *Mammal Review* 7: 25–39.
- Harris, S., and W. J. Trehwella.** 1988. An analysis of some of the factors affecting dispersal in an urban fox (*Vulpes vulpes*) population. *Journal of Applied Ecology* 25: 409–422.
- Jean, Y., and J. M. Bergeron.** 1984. Productivity of coyotes (*Canis latrans*) from southern Quebec. *Canadian Journal of Zoology* 62: 2240–2243.
- Johnston, D. H., D. G. Joachim, P. Bachmann, K. V. Kardong, R. E. A. Stewart, L. M. Dix, M. A. Strickland, and I. D. Watt.** 1999. Aging furbearers using tooth structure and biomarkers. Pages 228–43 in *Wild Furbearer Management and Conservation in North America*. Edited by M. Novak, J. A. Baker, and M. E. Obbard. Ontario Fur Managers Federation, Sault Sainte Marie, Ontario.
- Lloyd, H. G.** 1980. *The Red Fox*. B. T. Batsford Ltd., London, U.K. 320 pages.

- Martorell Juan, I., and C. Gortazar Schmidt. 1993. Reproduction of red foxes (*Vulpes vulpes* Linnaeus, 1758) in north-eastern Spain: a preliminary report. *Revue scientifique et technique* [Scientific and Technical Review]. Office International des Epizooties [World Organisation for Animal Health, Paris] 12: 19–22.
- Mitchell, B. R., M. M. Jaeger, and R. H. Barrett. 2004. Coyote depredation management: current methods and research needs. *Wildlife Society Bulletin* 32: 1209–1218.
- Parker, G. R. 1995. Eastern Coyote: The Story of its Success. Nimbus Publishing Ltd., Halifax, Nova Scotia. 254 pages.
- Patterson, B. R., and F. Messier. 2001. Social organization and space use of coyotes in eastern Canada relative to prey distribution and abundance. *Journal of Mammalogy* 82: 463–477.
- Poulle, M. L., M. Crete, and J. Huot. 1995. Seasonal variation in body mass and composition of eastern coyotes. *Canadian Journal of Zoology* 73: 1625–1633.
- Rosatte, R. C. 2002. Long distance movement by a coyote, *Canis latrans*, and red fox, *Vulpes vulpes*, in Ontario: implications for disease spread. *Canadian Field-Naturalist* 116: 129–131.
- Rosatte, R., and M. Allan. 2009. The ecology of red foxes, *Vulpes vulpes*, in metropolitan Toronto, Ontario: disease management implications. *Canadian Field-Naturalist* 123: 215–220.
- Rosatte, R., M. Power, and C. MacInnes. 1991. Ecology of urban skunks, raccoons and foxes in metropolitan Toronto. Pages 31–38 in *Wildlife Conservation in Metropolitan Environments*. Edited by L. W. Adams and D. L. Leedy. National Institute for Urban Wildlife, Columbus, Maryland.
- Smith, G. C., B. Gangadharan, Z. Taylor, M. K. Laursen, H. Bradshaw, G. Hide, J. M. Hughes, A. Dinkel, T. Romig, and P. S. Craig. 2003. Prevalence of zoonotic important parasites in the red fox (*Vulpes vulpes*) in Great Britain. *Veterinary Parasitology* 118: 133–142.
- Trewhella, W. J., S. Harris, and F. E. McAllister. 1988. Dispersal distance, home-range size and population density in the red fox (*Vulpes vulpes*): a quantitative-analysis. *Journal of Applied Ecology* 25: 423–434.
- Voigt, D. 1987. Red fox. Pages 379–393 in *Wild Furbearer Management and Conservation in North America*. Edited by M. Novak, J. Baker, M. Obbard, and B. Malloch. Ontario Ministry of Natural Resources and Ontario Trappers Association, North Bay, Ontario.
- Voigt, D., and D. Macdonald. 1984. Variation in the spatial and social behaviour of the red fox, *Vulpes vulpes*. *Acta Zoologica Fennica* 171: 261–265.
- Voigt, D., and R. Tinline. 1980. Strategies for analyzing radiotracking data. Pages 387–404 in *A Handbook on Biotelemetry and Radio-Tracking*. Edited by C. Amlaner and D. MacDonald. Pergamon Press, Oxford, U.K.
- Wapenaar, W., M. C. Jenkins, R. M. O'Handley, and H. W. Barkema. 2006. *Neospora caninum*-like oocysts observed in feces of free-ranging red foxes (*Vulpes vulpes*) and coyotes (*Canis latrans*). *Journal of Parasitology* 92: 1270–1274.
- Wapenaar, W., H. W. Barkema, and R. M. O'Handley. 2013. Fecal shedding of *Toxocara canis* and other parasites in foxes and coyotes on Prince Edward Island, Canada. *Journal of Wildlife Diseases*. *In press*.

Received 28 April 2012

Accepted 25 September 2012

# Stand-level Attributes of Snowshoe Hare (*Lepus americanus*) Habitat in a Post-Fire Trembling Aspen (*Populus tremuloides*) Chronosequence in Central Yukon

WAYNE L. STRONG<sup>1,3,4</sup> and THOMAS S. JUNG<sup>2</sup>

<sup>1</sup>Arctic Institute of North America, 2500 University Drive NW, Calgary, Alberta T2N 1N4 Canada

<sup>2</sup>Yukon Department of Environment, P.O. Box 2703, Whitehorse, Yukon Y1A 2C6 Canada

<sup>3</sup>Corresponding author (email: strong@ucalgary.ca)

<sup>4</sup>Present address: P.O. Box 40186 Station Main, Whitehorse, Yukon Y1A 6M9 Canada

Strong, Wayne L. and Thomas S. Jung. 2012. Stand-level attributes of Snowshoe Hare (*Lepus americanus*) habitat in a post-fire Trembling Aspen (*Populus tremuloides*) chronosequence in central Yukon. *Canadian Field-Naturalist* 126(4): 295–305.

Large-scale fires are anticipated to increase in frequency in the boreal forest under global climate warming scenarios. To understand concomitant responses by wildlife to fire-induced habitat changes, fecal pellet counts were used to assess Snowshoe Hare (*Lepus americanus*) use of four age-classes of boreal forest after fire in central Yukon, Canada. Use of stands across a chronosequence of 8–177 years was bimodal. Post-fire Trembling Aspen (*Populus tremuloides*) stands  $\leq 20$  years old had greater densities of Snowshoe Hare pellets (median 156 pellets/dam<sup>2</sup>) than Trembling Aspen stands 21–70 years old, mixedwood stands 71–120 years old ( $< 17$  pellets/dam<sup>2</sup>), or Western White Spruce (*Picea albertiana*)-dominated stands 121–170 years old (71 pellets/dam<sup>2</sup>). Forty stand-level compositional and structural variables were assessed as possible predictors of Snowshoe Hare pellet densities. Multidimensional scaling was used to identify variables ( $n = 10$ ) that were most strongly related to pellet densities and was followed by multiple regression. Canopy cover of Trembling Aspen  $< 50$  cm tall and Western White Spruce  $\leq 1$  m tall, and deadfall depth, in combination, were the best estimators of Snowshoe Hare pellet densities among stands in the chronosequence ( $P < 0.001$ , 64.5% variance explained). Although Trembling Aspen  $< 50$  cm tall explained the most variance, its canopy cover did not exceed 10%. More Trembling Aspen cover  $< 50$  cm tall and greater deadfall depths within the chronosequence were associated with stands  $\leq 20$  years old. Peak Snowshoe Hare use occurred in early ( $\leq 20$  years old) rather than mid-successional (21–120 years old) stands, contrary to use patterns reported elsewhere. The lack of tall understory shrubs likely limited the use of mid-successional stands.

**Key Words:** Trembling Aspen, *Populus tremuloides*, Western White Spruce, *Picea albertiana*, Snowshoe Hare, *Lepus americanus*, chronosequence, coarse woody debris, deadfall, forest fire, post-fire succession.

Large-scale fires are anticipated to increase in frequency in the boreal forest under global climate warming scenarios (McCoy and Burn 2005). If increasingly larger portions of the landscape are affected by fire, then it is important to understand concomitant responses by wildlife to those changes. The focus of studies that aim to explore how landscape-level disturbances, such as climate change, may affect wildlife should initially be on keystone species, because changes in their abundance and distribution may result in major shifts in ecosystem dynamics (*sensu* Krebs et al. 2001a).

The Snowshoe Hare (*Lepus americanus*) is a keystone species in Nearctic boreal forests (Boutin et al. 1995). Snowshoe Hare are important as prey of commercially-valued furbearers such as the Canada Lynx (*Lynx canadensis*) and as a harvested food (Jacqmain et al. 2007; Nelson et al. 2008). Various studies have been conducted to identify important habitat attributes of the Snowshoe Hare. From these studies, it is clear that Snowshoe Hare prefer tall dense shrubby vegetation, with or without a tree overstory (e.g., Litvatis et al. 1985; St-Georges et al. 1995; Hodges 2000). Greater site use occurs when the shrub stratum is 1–4 m tall with  $> 4000$  stems/ha (Wolfe et al. 1982; Pietz and

Tester 1983; de Bellefeuille et al. 2001; Jacqmain et al. 2007) and forage is within 3 m of the ground surface, when overhead and lateral vegetation cover  $\leq 2.5$  m tall exceeds 60–70% in summer (Litvatis et al. 1985; Ferron and Ouellet 1992; de Bellefeuille et al. 2001), and when overhead cover is  $> 40\%$  in winter (Wolfe et al. 1982). Stand structure and adequate cover are often more important than either the species composition or an immediately available food supply (Litvatis et al. 1985; Ferron and Ouellet 1992).

When habitats that are favoured by Snowshoe Hare (i.e., greater relative use) develop and how long they persist in a forest landscape can vary with the type of vegetation and the associated rate of ecological succession. For example, de Bellefeuille et al. (2001) suggested that peak use of clearcuts in southern Quebec forest was expected when Balsam Fir (*Abies balsamea*) and Black Spruce (*Picea mariana*) regeneration was 15–22 and 18–30 years old, respectively. Forest stands  $> 15$  years old were more intensively used than younger post-disturbance areas in Quebec (Jacqmain et al. 2007; Hodson et al. 2011), Labrador (Newbury and Simon 2005), Ontario (Thompson et al. 1989), Maine (Monthey 1986), and central Alaska (Paragi et al.

1997). Nevertheless, Keith and Surrendi (1971) reported Snowshoe Hare use of 1-year-old burns in central Alberta.

Few studies have investigated the longer term (>50 years) response by the Snowshoe Hare to botanical and structural changes that occur within stands during secondary succession (Fisher and Wilkinson 2005), particularly in high-latitude boreal forests. Most comparative habitat studies have evaluated stand re-establishment during the first 20–30 years after disturbance (e.g., Jacqmain et al. 2007), focused on concurrent differences in composition and structure among vegetation types that were not necessarily part of the same chronosequence (e.g., Poole et al. 1996), or assessed only selected segments of a chronosequence (e.g., Parigi et al. 1997). Unfortunately, changes in Snowshoe Hare abundance in northwestern Canada successional sequences can probably not be extrapolated from studies conducted in southern or eastern boreal forests, except at a very general level, because of regional variability in successional patterns and differences in understory vegetation composition and stand structure (e.g., Chen and Popadiouk 2002; Redburn and Strong 2008; Strong 2009).

The objective of this study was to examine Snowshoe Hare use of forest vegetation after stand-devastating fires in the boreal forest of northwestern Canada. Using fecal pellet counts, we compare Snowshoe Hare use of different age classes of forest after fire, within a 169-year Trembling Aspen (*Populus tremuloides*) chronosequence. To better understand Snowshoe Hare response to forest succession, we identified stand-level botanical and structural variables that were associated with Snowshoe Hare habitat use. These data may be useful in better understanding the response of the Snowshoe Hare (a keystone species) to an increased frequency in forest fires (a predicted result of climate change) and an associated increase in juvenile vegetation.

## Methods

### Study area

The study was conducted along a 223 km north-south transect running from Little Fox Lake (61.368°N, 135.675°W) to north of Pelly Crossing (63.024°N, 136.448°W) in central Yukon, Canada (see Figure 1 in Strong 2009). The area occurs in the Northern Cordilleran Boreal (NCb) ecoclimatic region, which is characterized by early seral Trembling Aspen and successional more mature Trembling Aspen and Trembling Aspen–Western White Spruce (*Picea albertiana* ssp. *albertiana*, Strong and Hills 2006) forests on zonal sites, as opposed to spruce (*Picea* spp.) or Lodgepole Pine (*Pinus contorta* var. *latifolia*) forests that predominate in the surrounding regions (Strong 2013). Western White Spruce is the predominant late-successional species on upland sites in the Northern Cordilleran Boreal ecoclimatic region, which occurs below ~1200 m elevation; open Spruce/Willow-Birch (*Piceal*

*Salix-Betula*) vegetation occurs above. Sampled sites are between 470 and 875 m in elevation.

The median May–September temperature is 10.8°C, and in the November–March period it is –18.8°C, based on 1984–2007 monthly data from three meteorological stations within the region (Strong 2013). Most precipitation (177 of 279 mm) occurs in summer, but ~72 cm of snow falls on average during November–March. Wildfires have been a common disturbance agent in the study area, with extensive burns in 1958, 1995, and 1998 (Englefield 2003). The location and distribution of sampled sites as well as the extent of more recent wildfires in the study area were reported by Strong (2009). Hunting, gathering, furbearer trapping, firewood harvesting, and a small amount of agriculture are the principal land uses in the area.

### Field sampling

Vegetation sampling included post-fire Trembling Aspen, mixedwood, and late-successional Western White Spruce stands. Late-successional stands were sampled if they contained live, standing dead, or remnant downed Trembling Aspen trees. Only sites with ≤3% slope gradients and well to moderately well drained soils, without atypical levels of disease or insect infestation and without notable recent or historical tree cutting were sampled. Sites (mostly <15 years old) were excluded if post-fire snags and deadfall had been harvested. Stands were arbitrarily selected for sampling, and an attempt was made to distribute sites across as broad an age range as possible.

Vegetation composition and species abundance sampling of individual stands was based on a 20 m × 30 m plot that included a centrally located transect 30-m in length with five 2.5 m × 2.5 m quadrats for assessing the canopy cover of plants 1–2.5 m tall. Each quadrat included a 1 m × 1 m nested quadrat for sampling vascular plants ≤1 m tall, bryophytes, and terrestrial lichens. The lower left-hand corner of each quadrat was placed at 5-m intervals along the transect beginning at the 5-m mark. The 20 m × 30 m plot was used to assess the canopy cover of trees and shrubs >2.5 m tall. Ocular percent canopy cover estimates were used to gauge plant species abundance. Plant nomenclature follows ITIS Partners (2013\*), unless otherwise indicated.

Point-centered quarter sampling (Mueller-Dombois and Ellenberg 1974) was used to estimate tree (>1 m tall) stem densities, with sampling points located at 10-m intervals (at the –5-, 5-, 15-, and 25-m marks) along the vegetation composition sampling transect. Tree ages were determined for the two tallest Trembling Aspen (or Western White Spruce if Aspen were absent); remnant pre-fire trees were excluded. Stand aging was based on annual growth-ring counts that were obtained from immediately above the tree root collar. The older of the two cored trees, regardless of species, was considered to represent the stand age.

The length, median diameter, and maximum depth of woody stems  $\geq 5$  cm in diameter were measured in each 2.5 m  $\times$  2.5 m vegetation sampling quadrat to determine coarse woody debris or deadfall volume and the number of stems. All stems within 2.5 m of the forest floor and at an incline of  $<45^\circ$  were included. The latter criterion was used to differentiate between downed and standing dead trees. Any substantial portion of a woody stem that was in contact with the ground surface was excluded from assessment.

Snowshoe Hare fecal pellets were counted along a transect 1.5 m in width and 30 m in length (90 m<sup>2</sup>) located on each side of, and 5 m from, the vegetation sampling transect. This sampling design allowed 15% of the study plot to be efficiently sampled, and the large proportion of sampled area increased the likelihood of encountering pellets on sites where few occurred (Hodges and Mills 2008) while potentially avoiding some of the technical issues related to the use of small plots (e.g.,  $\leq 1$  m<sup>2</sup>) with higher edge-to-area ratios (McKelvey et al. 2002). All observed intact pellets were counted regardless of age due to the difficulty of reliable aging (Prugh and Krebs 2004).

In the absence of a specific equation to determine Snowshoe Hare density through the use of pellet counts for the study area, densities were estimated using an algorithm developed by Krebs et al. (2001b). However, these estimates may be inflated because pellets were not cleared from each site a year prior to sampling (Hodges and Mills 2008). Pellet and tree stem densities, and deadfall volumes were summarized by decameter<sup>2</sup> (dam<sup>2</sup>, i.e., 100 m<sup>2</sup>). Field sampling was limited to late June and July 2008. This was a period when the Snowshoe Hare population was in decline (Sheriff et al. 2011).

#### Data analysis

In addition to analyzing individual forest stand variables and plant taxa by stratum, composite variables (e.g., total herb, forb, species cover) and selected botanical diversity measures (e.g., richness and dominance concentration – Strong 2002) were also assessed. Composite variables were created by summing species percent cover values within individual relevés. The cover values of bryum moss (*Bryum caespiticium*) and Fire Moss (*Ceratodon purpureus*) were combined to represent early seral or pioneer mosses.

A total of 40 stand variables were considered in the analysis. Forest stands ( $n = 96$ ) were segregated into four age classes:  $\leq 20$  ( $n = 24$ ), 21–70 ( $n = 29$ ), 71–120 ( $n = 33$ ), and 121–177 ( $n = 10$ ) years old. These age classes generally corresponded to major physiognomy and overstory composition differences within the chronosequence: juvenile post-fire (early seral); Trembling Aspen- (mid-seral); Trembling Aspen-Western White Spruce (late seral); and Western White Spruce (late-successional) vegetation, respectively. Kruskal-Wallis tests were used to determine whether there

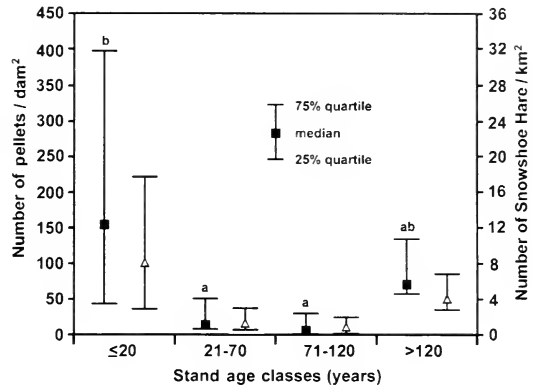


FIGURE 1. Snowshoe Hare (*Lepus americanus*) fecal pellet densities (■) and corresponding population densities (△) by age class within a Trembling Aspen (*Populus tremuloides*) chronosequence from central Yukon. Comparison of pellet densities among stand age classes was based on a Kruskal-Wallis test ( $P < 0.001$ ). Age classes with the same letter above the quartile range bars do not differ at the  $\alpha$  0.05 level based on Scheffé rank test results. Snowshoe Hare population densities were estimated using an algorithm developed by Krebs et al. (2001b), but may be overestimated because vegetation stands were not cleared of pellets the year prior to sampling.

were differences in stand variables among age classes. Post-hoc nonparametric Scheffé rank tests (Miller 1966) were used to identify pair-wise differences at the  $\alpha$  0.05 level.

Multidimensional scaling (an ordination technique) was used to determine the relative numerical relationship among stand variables and Snowshoe Hare pellet densities, based on a two-dimensional solution using the standard Guttman-Lingoes procedure (Statsoft 1995). The purpose of the ordination was to identify candidate variables that had the best potential for estimating pellet densities. Variables that occurred in closer proximity to the pellet density loci were most strongly associated, but it was unknown which combination of variables could be used to optimize the estimation of Snowshoe Hare pellet densities. As an objective criterion, only stand variables with the shortest Euclidean distances to the pellet density loci ( $<25\%$  of longest distance) were included in the regression analyses (see below). This criterion approximated the first quartile value among Euclidean distance measurements and a natural break in the distribution of variables within the ordination. The percentage of variance explained by the ordination was equal to  $100 - \text{coefficient of alienation}^2 \times 100$  (Schiffman et al. 1981, page 92).

Multiple regression analysis was used to simultaneously compare the relative importance of candidate variables (independent variables) selected from the mul-

TABLE 1. Median (1st–3rd quartile in parentheses) botanical characteristics of different age classes in a Trembling Aspen (*Populus tremuloides*) chronosequence from central Yukon.

Variable	Stand age classes (years)				P value <sup>1</sup>
	≤20 (n = 24)	21–70 (n = 29)	71–120 (n = 33)	121–177 (n = 10)	
Tree stratum (>2.5 m tall, percent cover)					
Trembling Aspen (POTR5)	10(2–28)ab <sup>1</sup>	60(40–65)c	45(15–60)bc	+ (0–2)a <sup>†</sup>	<0.001
Western White Spruce (PIAL3)	0a	10(4–30)b	25(15–35)bc	40(35–40)c	<0.001
Willow (SX3)	0(0–1)a	+ (0–1)a	0(0–+)a	0a	0.143
Tall shrub stratum (1–2.5 m tall, percent cover)					
Trembling Aspen (POTR4)	9(6–13)b	0(0–1)a	0(0–+)a	0a	<0.001
Western White Spruce (PIAL2)	0a	0(0–2)a	0a	+ (0–1)a	0.005
Willow (SX2)	3(1–8)b	0(0–+)a	0(0–1)a	0a	<0.001
Low shrub stratum (≤1 m tall, percent cover)					
Trembling Arctic Lupine (LUAR)	0a	0(0–2)a	0(0–2)a	0a	0.208
Trembling Aspen ≤1 m tall (POTR3)	5(2–9)b	+ (0–1)a	0(0–1)a	0a	<0.001
Trembling Aspen 50–100 cm tall (POTR2)	2(1–8)b	0a	0(0–+)a	0a	<0.001
Trembling Aspen <50 cm tall (POTR1)	1(0–1)a	+ (0–1)a	0a	0a	0.006
Common Bearberry (ARUV)	0(0–+)a	10(2–22)b	0(0–7)a	0a	<0.001
Bog Cranberry (SAVI)	0a	0(0–2)a	0(0–2)a	+ (0–+)a	0.118
Buffaloberry (SHCA)	0(0–1)a	0(0–1)ab	3(0–16)b	0(0–1)ab	0.004
Fireweed (CHAN)	6(2–11)c	3(1–5)bc	1(+–3)ab	0a	<0.001
Purple Reedgrass (CAPU)	3(0–14)b	17(6–21)c	8(2–12)bc	+ (0–+)a	<0.001
Twinflower (LIBO)	0(0–1)a	0(0–1)a	+ (0–3)a	+ (0–+)a	0.225
Western White Spruce (PIAL1)	+ (0–2)a	0(0–1)a	+ (0–1)a	0a	0.106
Wild Rose (ROAC)	0a	0(0–+)ab	0(0–5)a	0ab	0.001
Willow (SX1)	3(2–9)b	0(0–1)a	0a	0a	<0.001
Ground stratum (percent cover)					
Dog tongue lichens (PELT)	1(+–3)ab	+ (0–1)a	+ (0–3)a	4(3–6)b	<0.001
Mature stand mosses (Mm)	+ (0–3)a	+ (0–1)a	3(1–31)b	71(55–87)b	<0.001
Pioneer mosses (Mp)	44(24–60)b	0a	0a	0a	<0.001

<sup>1</sup> Comparisons based on Kruskal-Wallis tests. Values in rows with the same letter(s) do not differ at the  $\alpha$  0.05 level according to post-hoc Scheffé rank tests.

<sup>†</sup> “+” indicates a cover value  $\leq 0.55\%$ .

tidimensional scaling ordination. Variables that substantially overlapped in botanical composition with better estimators were excluded from the analysis. The stepwise backwards procedure was used to identify the combination of independent variables that best explained the variation in Snowshoe Hare pellet densities (dependent variable). Both composite and stepwise regression analyses were based on a correlation matrix. Variable normalization and standardization were not done because both procedures substantially reduced the degree of dependent variables explanation. Neither procedure is a necessity when multiple regression analysis is based on a correlation matrix, although they can sometimes improve the degree of explanation (Tabachnick and Fidell 1989).

The fit of sample distributions to a normal curve was assessed using Kolmogorov-Smirnov one-sample tests. Statistical comparisons were performed using STATISTICA software (Statsoft 1995); except for Scheffé rank tests, which were manually determined.

## Results

### Vegetation

Stands ranged from 8 to 177 years old. Post-fire stands  $\leq 20$  years old had an open canopy tree stratum

of Trembling Aspen that ranged up to 4–5 m in height (Tables 1 and 2). The tree and tall shrub strata had a similar amount of Trembling Aspen cover, but willows (*Salix* spp.) were more abundant in the tall shrub stratum. Stands typically contained 42–168 live tree stems/dam<sup>2</sup>, but ranged up to 677 stems/dam<sup>2</sup>. The low shrub stratum included willows, Fireweed (*Chamerion angustifolium*), Purple Reedgrass (*Calamagrostis purpurascens*), and small amounts of Trembling Aspen in the <50 and 50–100 cm height ranges, with a discontinuous ground layer of post-fire pioneer mosses on mineral soil (Table 1). Western White Spruce often occurred in the low shrub stratum. Half of the stands (1st–3rd quartiles, Table 2) in this age class contained 0.1–0.9 m<sup>3</sup>/dam<sup>2</sup> of downed and criss-crossed deadfall, mostly coniferous trees from the pre-fire forest. Deadfall reached a depth of 1 m, with an upper quartile value of 46 cm. Typically, 8–23 downed trees  $\geq 5$  cm in diameter occurred in each 2.5 m  $\times$  2.5 m quadrat.

Stands 21–70 years old were dominated by Trembling Aspen 7–10 m tall with some Western White Spruce in the tree stratum. Stands typically contained 29 to 52 live tree stems/dam<sup>2</sup> (Table 2). Purple Reedgrass and Common Bearberry (*Arctostaphylos uva-ursi*) with Fireweed dominated the low shrub stratum



TABLE 2. Median (1st–3rd quartile in parentheses) stand and structural characteristics of different age classes in a Trembling Aspen (*Populus tremuloides*) chronosequence from central Yukon.

Variable	Stand age classes (years)				P value <sup>1</sup>
	≤20 (n = 24)	21–70 (n = 29)	71–120 (n = 33)	121–177 (n = 10)	
Growth form (percent cover)					
Trees (STt)	10(3–30)a	74(67–81)b	70(56–80)b	41(37–51)a	<0.001
Shrubs (SH2)	13(5–19)b <sup>†</sup>	21(8–30)ab	13(1–35)b	+ (0–2)a <sup>†</sup>	0.002
Shrubs ≤1 m tall (SH1)	8(3–13)b	1(0–3)a	6(+–22)ab	0(0–2)a	0.001
Forbs (FORBS)	11(5–15)ab	11(5–21)b	8(3–14)ab	2(1–7)a	0.033
Trees <2.5 m tall (TRun)	18(10–25)b	2(1–3)a	1(+–2)a	+ (0–1)a	<0.001
Tall shrub stratum (STs)	13(10–22)b	1(+–3)a	+ (0–1)a	+ (0–1)a	<0.001
Low shrub stratum (STIs)	36(23–45)b	58(40–67)b	44(18–52)b	82(58–96)a	<0.001
Ground stratum (STg)	52(38–69)c	1(+–2)a	55(45–74)b	82(58–96)c	<0.001
Understory plants (UNDER)	88(79–100)c	60(40–69)bc	55(45–74)ab	92(65–98)a	<0.001
Total species (TOTc)	125(111–131)	133(115–144)	123(113–142)	127(122–136)	0.411
Stand characteristics					
Age (years, AGE)	10(10–14)	55(47–59)	99(87–110)	142(136–156)	–
Tree stems >1 m tall/dam <sup>2</sup> (STEMS)	87(42–168)b	41(29–52)b	16(12–26)a	19(11–21)a	<0.001
Deadfall depth (cm; DFd)	0(0–46)a	8(0–15)a	0(0–1)a	<1(0–30)a	0.658
Deadfall stems (per 6.25m <sup>2</sup> , DFn)	14(8–23)c	2(1–4)ab	3(1–7)b	4(0–6)a	<0.001
Deadfall volume (m <sup>3</sup> /dam <sup>2</sup> , DFv)	0.4(0.1–0.9)b	0.1(+–0.1)a	0.1(+–0.2)a	0.1(0–0.3)ab	0.002
Richness of vascular taxa (Rv)	9(8–11)ab	12(10–14)b	10(8–13)ab	5(3–8)a	<0.001
Richness of nonvascular taxa (Rn)	4(3–4)a	3(2–5)a	4(2–9)a	12(9–13)b	<0.001
Dominance concentration (× 100, Dw)	53(50–59)a	63(58–67)b	64(56–67)b	71(65–74)b	<0.001

<sup>1</sup>Comparisons based on Kruskal-Wallis tests. Age-classes by variable with the same letters do not differ at the  $\alpha$  0.05 level according to post-hoc Scheffé rank tests.

<sup>†</sup>“+” indicates a cover value ≤0.55%.

(Table 1). Bryophytes and lichens were essentially absent. The abundance of deadfall was less than in stands ≤20 years old stands, but depths between the age classes were statistically the same (Table 2). Two downed trees typically occurred in each 2.5 m × 2.5 m quadrat. Trembling Aspen >2.5 m tall, Purple Reedgrass, and Common Bearberry canopy cover peaked in this age class (Table 1).

Trembling Aspen <15 m tall dominated the tree stratum of stands 71–120 years old, but Western White Spruce composed one-third of the overstory cover. Purple Reedgrass was the dominant understory species, with a median cover of 8%. Buffaloberry (*Shepherdia canadensis*), Wild Rose (*Rosa acicularis*), and Common Bearberry (all ≤3% cover), with various herbaceous species (e.g., Twinflower, *Linnaea borealis*, Arctic Lupine, *Lupinus arcticus*, and Bog Cranberry – *Vaccinium vitis-idaea*) had low cover and constancy in the low shrub stratum (Table 1). The abundance of most understory plants was less than in stands 21–70 years old, except for Stairstep Moss (*Hylacomium splendens*), which increased (Table 1). Deadfall was typically less than 0.2 m<sup>3</sup>/dam<sup>2</sup> in stands of this age class, with three downed trees per 2.5 m × 2.5 m quadrat (Table 2).

Stands 121–177 years old were dominated by Western White Spruce. Stands typically contained 11–21 stems/dam<sup>2</sup> (Table 1 and 2) and maximum heights were 19–22 m. Tall and low shrub strata were absent,

but a relatively continuous Stairstep Moss carpet occurred that included dog tongue lichens (*Peltigera aphthosa* and *P. malacea*).

The median abundance of deadfall decreased with increasing stand age, although a slight increase occurred in the 121–177 year age class based on the upper quartile value (Table 2). The abundance of Trembling Aspen declined as Western White Spruce cover increased. Total tree stratum cover peaked when stands were 21–120 years old (Table 2). In contrast, nonvascular species richness and dominance concentration showed a pattern of increase with stand age, but total species cover was similar among age classes (Table 2).

#### Pellet densities

A median density of 31 (quartile range 5–119) Snowshoe Hare fecal pellets/dam<sup>2</sup> was found among sampled stands, with significant differences among age classes (Figure 1). The quartile limits for stands ≤20 years old were 48 to 399 pellets/dam<sup>2</sup>, with a median of 156 pellets/dam<sup>2</sup>. Peak densities occurred in stands 8–15 years old (Figure 2a). Few pellets were found in the 21–70 and 71–120 year age classes (median 16 and 8 pellets/dam<sup>2</sup>, respectively), whereas the oldest age class had slightly less than half as many pellets as ≤20 year-old stands. Stands ≤20 years old had Snowshoe Hare densities above the dataset median, whereas older age classes were below the median, especially the stands 21–120 years old, with the equivalent of <1 Snowshoe Hare/km<sup>2</sup> (Figure 1).

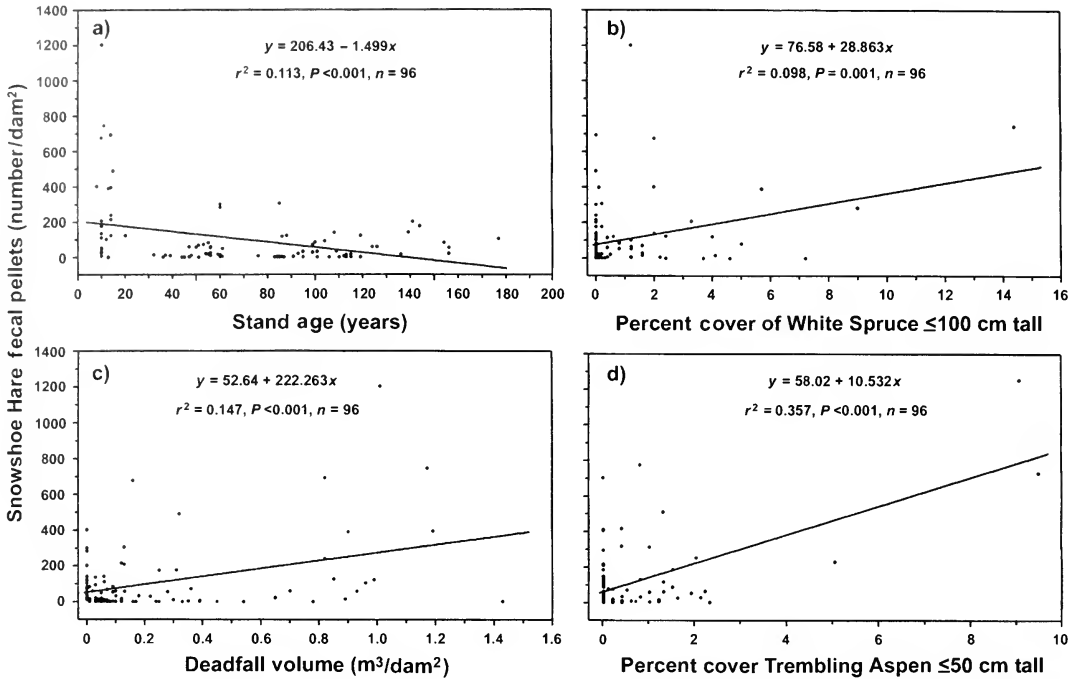


FIGURE 2. Scatter diagrams and associated linear regression models of independent variables that formed model 2b (Table 3), with Snowshoe Hare (*Lepus americanus*) pellet densities as the dependent variable.

#### Ordination and regression

Ordination produced a distinct cluster of variables, which included Snowshoe Hare pellet densities (PD), with other variables generally at a similar distance from and to the right of the pellet density loci in a crescent-shaped pattern (Figure 3). Most understory taxa; overstory tree, forb, shrub, pioneer moss, and sometimes tall shrub cover variables; species richness; dominance concentration; and stand age occurred outside the 25% Euclidean distance limit. Dog tongue lichens (PELT) and ground stratum cover (STg) occurred halfway between the two groupings. The clustered variables were related to understory vegetation composition, stem densities, deadfall, pioneer mosses, and trees and shrub cover in the low and tall shrub strata. The ordination explained ~96% of the variance among variables.

Eleven stand variables occurred within the established distance limit from the pellet density loci (Figure 3). However, Trembling Aspen cover  $\leq 1$  m tall (POTR3) was removed from consideration, because its composition overlapped with Trembling Aspen  $< 50$  cm tall (POTR1) and 50–100 cm tall (POTR2). Subsequent testing by regression analyses also showed that Trembling Aspen cover  $\leq 1$  tall was a less useful variable for explaining pellet density variation than the two other variables.

Regression analysis of the remaining 10 variables, as a group, explained 53.8% of the variance in Snowshoe Hare pellet densities (Model 1a in Table 3). Among these variables, however, only two had a significant  $P$  values ( $P < 0.05$ ): Trembling Aspen cover  $< 50$  cm tall and Western White Spruce cover  $\leq 1$  m tall (PIAL1). Based on the standardized beta coefficient, the cover of Trembling Aspen  $< 50$  cm tall explained most of the variance (Table 3). Stepwise regression analysis (model 1b in Table 3) identified the two former variables and deadfall depth (DFd) as the most useful for predicting Snowshoe hare pellet densities. In combination, these variables explained 53.9% of the variance. All three variables were positively correlated with pellet densities. None of the other stand variables had significant  $P$  values (i.e.,  $P < 0.05$ ) in the stepwise regression analysis. In addition, the  $y$ -intercept did not contribute significantly to the estimation of pellet densities in either model 1a or model 1b (Table 3), i.e., the  $y$ -intercept was not significantly different from zero.

Re-analysis of the data with the  $y$ -intercept set to zero yielded similar regression results between models 1a and 2a based on a comparison of standardized beta coefficients (Table 3). The exceptions were the additional recognition of pioneer moss cover (Mp) as

a significant variable in model 2a and a greater proportion of explained variance (i.e., 64% versus 54%). The same independent variables were identified as significant in models 1b and 2b. Stepwise regression model 2b explained more variance than model 1b (Table 3). Model 2b explained almost twice the variance of any of the individual independent variables in the model (Figure 2b, 2c, and 2d).

Model 2b was the most efficient of the four models for predicting Snowshoe Hare pellet densities in the chronosequence. It had the highest proportion of explained variance and included of the fewest independent variables. Differences between observed and model 2b predicted pellet densities (residuals) did not conform to a normal distribution ( $P > 0.05$ ). However, the standard deviation of the residuals was 42 pellets for two-thirds of the stands that did fit a normal distribution. All stands not conforming to a normal distribution had under-predicted pellet densities, and most of these stands were <20 years old. No particular trend was identified among the independent variables that could be used to explain the under-predictions.

In the absence of Trembling Aspen canopy cover variables in the understory vegetation, stepwise regression identified the density of tree stems >1 m tall as the strongest variable for estimating pellet densities. However, the associated regression model explained only 50% of the variation in the data.

## Discussion

Among chronosequence stands, the greatest cover of Trembling Aspen  $\leq 50$  cm tall and greatest deadfall depths were associated with post-fire stands  $\leq 20$  years old. Low-growing Trembling Aspen might be ecologically-important because of the cover and food that it can provide Snowshoe Hares (Wolff 1978) during the snow-free season. The 50–100 cm height class might be more important in winter, when snow buries the shorter plants (Bider 1961). Successionally, both height classes diminish in abundance as stands age because of height growth, overstory suppression, and tree stem exclusion.

Stand characteristics, such as shrub cover and tree stem density, have been traditionally recognized as important habitat variables for the Snowshoe Hare (e.g., Wolfe et al. 1982; Pietz and Tester 1983; Litvatis et al. 1985; Ferron and Ouellet 1992; de Bellefeuille et al. 2001; Jacqmain et al. 2007), but the depth of deadfall less so. Deadfall above the forest floor likely serves as hiding cover (Hodges 1998; Andruskiw 2003; Berg et al. 2012), possibly as thermal cover in winter (Conroy et al. 1979; Roy et al. 1995), and likely facilitates safer movement by Snowshoe Hares through the local vegetation. Not all young forest stands contained deadfall, possibly due to the pre-fire characteristics of a stand or the intensity of local burning, nor were older stands devoid of the material. The greater availability of elevated deadfall in the stands 121–177

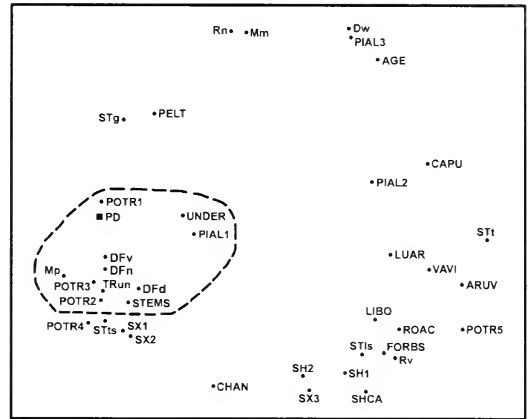


FIGURE 3. Relative numerical relationships among stand variables and Snowshoe Hare (*Lepus americanus*) fecal pellet densities within a Trembling Aspen (*Populus tremuloides*) chronosequence from central Yukon based on ordination by multidimensional scaling ( $n = 96$  stands). Variables in the delineated group occurred nearest the Snowshoe Hare pellet density loci (i.e.,  $\leq 25\%$  of the distance to the most distal stand variable). DFD – Deadfall depth, DFn – Deadfall stems, DFv – Deadfall volume, Mp – pioneer moss cover, PD – Snowshoe Hare pellet densities, PIAL1 – Western White Spruce  $\leq 1$  m tall cover, POTR1 – Trembling Aspen  $\leq 50$  cm tall cover, POTR2 – Trembling Aspen 50–100 cm tall cover, POTR3 – Trembling Aspen  $\leq 1$  m tall, POTR4 – Trembling Aspen 1–2.5 m tall, STEMS – Tree stems >1 m tall, TRun – Trees <2.5 m tall cover, and UNDER – understory plant cover. See Table 1 or 2 for additional acronyms.

years old and dominated by Western White Spruce may explain the associated greater pellet densities (as opposed to the prolonged persistence or greater visibility of pellets on feathermoss carpets in these stands) than in the Trembling Aspen or mixedwood forest stands 21–120 years old.

The small sample size for stands in the oldest age class ( $n = 10$ ) may have limited our ability to detect a statistically significant difference in pellet densities and deadfall levels between stands 121–177 years old and 21–120 years old. However, a similar bimodal pattern of pellet densities was reported in eastern Quebec by Hodson et al. (2011). Although Hodson et al. (2011) did not measure deadfall, its association with more intensively used canopy gaps in older growth stands seems likely (J. Hodson, personal communication, 2011; cf. Lowe et al. 2011). Greater pellet densities in Western White Spruce stands dominated by a ground cover of feathermosses indicates possible use in winter as cover, when young Trembling Aspen stands lack foliar cover and deep snow has buried other cover (Wolff 1980; Keith and Bloomer 1993; Hodges and Sinclair 2005). The occurrence of deadfall in conjunc-

TABLE 3. Results of standard and stepwise backward multiple regression analyses of selected stand variables based on an estimated  $y$ -intercept (models 1a and 1b) and  $y$ -intercept set to zero (model 2a and 2b) models for predicting Snowshoe Hare (*Lepus americanus*) fecal pellet densities in an Trembling Aspen (*Populus tremuloides*) chronosequence from central Yukon, Canada.

Variable	Beta coefficients	Standardized beta coefficients	P value	Beta coefficients	Standardized beta coefficients	P value
<b>Composite multiple regression models</b>						
$y$ -intercept	-57.201	-	0.184	0	-	-
Trembling Aspen cover $\leq 50$ cm tall (POTR1)	66.930	0.523	<0.001	66.799	0.493	<0.001
Trembling Aspen cover 50–100 cm tall (POTR2)	-0.069	-0.001	0.993	1.481	0.115	0.840
Western White Spruce cover $\leq 1$ m tall (PIAL1)	24.899	0.283	0.003	24.901	0.271	0.003
Tree cover $< 2.5$ m tall (TRun)	-2.841	-0.143	0.339	-3.268	-0.173	0.272
Tree stems $> 1$ m tall (STEMS)	0.356	0.161	0.174	0.342	0.161	0.193
Understorey cover $\leq 1$ m tall (UNDER)	0.625	0.082	0.314	-0.096	-0.032	0.752
Pioneer moss cover (Mp)	1.332	0.155	0.143	1.722	0.196	0.048
Deadfall depth (DFd)	2.119	0.210	0.116	1.925	0.251	0.152
Deadfall volume (DFv)	-7.304	-0.013	0.931	3.486	0.007	0.967
Number of deadfall stems (DFn)	-0.531	-0.023	0.892	-1.125	-0.057	0.774
Adjusted coefficient of determination ( $R^2 \times 100$ )		53.8%	<0.001		64.1%	<0.001
<b>Best stepwise multiple regression model</b>						
$y$ -intercept	-18.714	-	0.354	0	-	-
Trembling Aspen cover $< 50$ cm tall (POTR1)	70.714	0.552	<0.001	9.301	0.516	<0.001
Western White Spruce cover $\leq 1$ m tall (PIAL1)	27.937	0.317	<0.001	6.159	0.293	<0.001
Deadfall depth (DFd)	2.553	0.252	<0.001	0.576	0.275	<0.001
Adjusted coefficient of determination ( $R^2 \times 100$ )		53.9%	<0.001		64.5%	<0.001

tion with low-growing Trembling Aspen may enhance Snowshoe Hare use of young stands compared with only one or the other habitat characteristics being present (Hodges and Sinclair 2005; de Chantal and Granström 2007).

The statistically significant relationship between pellet density and Western White Spruce  $\leq 1$  m tall (Table 3) might be due to the hiding cover that small, dense-canopied trees might provide. The low abundance of such stems in stands 21–120 years of age might explain the lower relative abundance of Snowshoe Hare within this age range. The potential importance of Trembling Aspen  $< 50$  cm tall and Western White Spruce  $\leq 1$  m tall to Snowshoe Hare in this chronosequence must be great, based on their limited abundance in these stands (Table 1). The occurrence of pioneer mosses as an important attribute in the composite regression analyses likely represents a proxy variable for post-fire ecological conditions, because these mosses provide no cover and have little if any known forage value for the Snowshoe Hare.

The finding that tree stem density was not an important Snowshoe Hare habitat variable in the studied vegetation chronosequence is contrary to other studies (Wolfe et al. 1982; Pietz and Tester 1983; de Bellefeuille et al. 2001; Jacqmain et al. 2007). This result occurred with or without regression variables normalized and/or standardized. Therefore, Trembling Aspen cover in summer might be more critical than the number of tree stems needed to form the canopy, although the two factors are not unrelated.

The stands 21–120 year-old in the chronosequence had essentially no deadfall and little shrubbery to provide hiding cover or browse for Snowshoe Hares. The lack of deadfall was probably due to the settling and decomposition of post-fire debris and the fact that healthy stands of this age range do not typically generate large quantities of deadfall. Minimal shrub content occurs because of forest overstory suppression as part of the ecological succession process, and the general lack of medium-height and tall shrubs such as Beaked Hazelnut (*Corylus cornuta*), Saskatoon (*Amenlanchier alnifolia*), or Low-bush Cranberry (*Viburnum edule*) in the vegetation of central Yukon. As a result, stands 21–120 years old were largely unused by Snowshoe Hares in the chronosequence, even though they are important habitats elsewhere (e.g., Monthey 1986; Thompson et al. 1989; Paragi et al. 1997; Newbury and Simon 2005; Jacqmain et al. 2007; Hodson et al. 2011).

Burns  $< 9$  years old were uncommon in the study area. Therefore, it cannot be directly determined when relatively intense or peak post-fire use of young Trembling Aspen stands began by Snowshoe Hare. Data compiled by Oswald and Brown (1990) suggest that sufficient stem densities (148 stems/dam<sup>2</sup> with 89% cover) and heights of  $< 1$  m develop within 5 years after a wildfire in southwestern Yukon. The presence

of deadfall, however, might encourage early use of post-fire stands if vegetation does not provide sufficient cover (Conroy et al. 1979). The fact that a high pellet density occurred in the youngest stand in the chronosequence (402 pellets/dam<sup>2</sup>, stand 8 years old) suggests that peak Snowshoe Hare abundance may occur within a few years after a fire; this is earlier than reported in other studies ( $> 15$  years – e.g., Monthey 1986; Thompson et al. 1989; Paragi et al. 1997; Newbury and Simon 2005; Jacqmain et al. 2007; Hodson et al. 2011). In cutblocks with only spruce and Balsam Fir tree regeneration, the delay in Snowshoe Hare recolonization may be related to the conical physiognomy of the trees, which provide limited horizontal and lateral cover until the trees reach a sufficient height and density (i.e., 15–30 years – Paragi et al. 1997; de Bellefeuille et al. 2001; Jacqmain et al. 2007). In contrast, regenerating Trembling Aspen tend to increase in height quicker and have bushy stems that often establish at higher densities than planted or naturally regenerating conifer stands and, as a result, produce greater canopy cover at a much lower height in less time.

The habitat most intensively used by Snowshoe Hares within the studied chronosequence conformed to vegetation characteristics generally recognized as important in other studies, i.e., shrubby vegetation. Among the studied forest stands, the strongest predictors of Snowshoe Hare habitat use were common attributes of young post-fire stands. Forest stands  $> 20$  years old that have been documented as being important habitat elsewhere were largely unused in central Yukon. Therefore, the general abundance of Snowshoe Hares in central Yukon is in part dependent upon the extent and frequency of wildfires (cf. Fox 1978), which may increase with future global warming (McCoy and Burn 2005). A shortening of the fire-return interval in the study area might initially increase the abundance of juvenile forest stands because of the mature nature of most of the current vegetation and thereby increase the availability of better quality Snowshoe Hare habitat. In the long-term, however, more frequent fires will reduce the average age of stands at the landscape-level. A warmer climate might also cause a shift towards forest understories with a greater shrub content and possibly cause a reduction in the availability of trees that form persistent coarse-woody debris, such as Western White Spruce. Such changes could alter the current Snowshoe Hare habitat use relationship. Unfortunately, the potential effects of future climatic warming on vegetation in this high-latitude environment are not fully known.

### Acknowledgements

Field data collection was in part funded by the Yukon Department of Environment. Karen Clyde provided comments on an initial project design and Val Loewen provided an unpublished manuscript (Yukon Department of Environment), and Yukon Energy, Mines and

Resources Library staff provided helpful assistance. Dr. James Hodson (formerly at Université Laval) provided background commentary on a related paper that he published. Comments that improved the clarity of the manuscript were provided by an associate journal editor and two anonymous reviewers.

### Documents Cited (marked \* in text)

ITIS Partners. 2013\*. Integrated taxonomic information system. <http://www.itis.gov/index.html> (accessed 8 February 2013).

### Literature Cited

- Andruskiw, M. 2003. Prey abundance, availability, and anxiety in structured environments. M.Sc. thesis, University of Guelph, Guelph, Ontario. 46 pages.
- Berg, N. D., E. M. Gese, J. R. Squires, and L. A. Aubry. 2012. Influence of forest structure on the abundance of snowshoe hares in western Wyoming. *Journal of Wildlife Management* 76: 1480–1488.
- Bider, J. R. 1961. An ecological study of the hare *Lepus americanus*. *Canadian Journal of Zoology* 39: 81–103.
- Boutin, S., C. J. Krebs, R. Boonstra, M. R. T. Dale, S. J. Hannon, K. Martin, A. R. E. Sinclair, J. N. M. Smith, R. Turkington, M. Blower, A. Byrom, F. I. Doyle, C. Doyle, D. Hik, L. Hofer, A. Hubbs, T. Karels, D. L. Murray, V. Nams, M. O'Donoghue, C. Rohner, and S. Schweiger. 1995. Population changes of the vertebrate community during a snowshoe hare cycle in Canada's boreal forest. *Oikos* 74: 69–80.
- Chen, H. Y. H., and R. V. Popadiouk. 2002. Dynamics of North American boreal mixedwoods. *Environmental Review* 10: 137–166.
- Conroy, M. J., L. W. Gysel, and G. R. Dudderar. 1979. Habitat components of clear-cut areas for snowshoe hares in Michigan. *Journal of Wildlife Management* 43: 680–690.
- de Bellefeuille, S., L. Bélanger, J. Huot, and A. Cimon. 2001. Clear-cutting and regeneration practices in Quebec boreal balsam fir forest: effects on snowshoe hare. *Canadian Journal of Forest Research* 31: 41–51.
- de Chantal, M., and A. Granström. 2007. Aggregations of dead wood after wildfire act as browsing refugia for seedlings of *Populus tremula* and *Salix caprea*. *Forest Ecology and Management* 250: 3–8.
- Englefield, A. (compiler). 2003. Yukon fire history atlas: 1946–2001 (CD-ROM). Yukon Fire Centre, Whitehorse, Yukon, and Northern Forestry Research Centre, Edmonton, Alberta.
- Ferron, J., and J-P. Ouellet. 1992. Daily partitioning of summer habitat and use of space by the snowshoe hare in southern boreal forests. *Canadian Journal of Zoology* 70: 2179–2183.
- Fisher, J. T., and L. Wilkinson. 2005. The response of mammals to forest fire and timber harvest in the North American boreal forest. *Mammal Review* 35: 51–81.
- Fox, J. F. 1978. Forest fires and the snowshoe hare—Canada lynx cycle. *Oecologia* 31: 349–374.
- Hodges, K. E. 1998. Snowshoe hare demography and behaviour during a cyclic population low phase. Ph.D. thesis, University of British Columbia, Vancouver, British Columbia. 230 pages.
- Hodges, K. E. 2000. The ecology of snowshoe hares in northern boreal forests. Pages 163–206 in *Ecology and Conservation of Lynx in the United States*. Edited by L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, G. M. Koehler, C. J. Krebs, K. S. McKelvey, and J. R. Squires. University of Colorado Press, Boulder, Colorado.
- Hodges, K. E., and L. S. Mills. 2008. Designing fecal pellet surveys for snowshoe hares. *Forest Ecology and Management* 256: 1918–1926.
- Hodges, K. E., and A. R. E. Sinclair. 2005. Browse site selection by snowshoe hares: effects of food supply and predation risk. *Canadian Journal of Zoology* 83: 280–292.
- Hodson, J., D. Fortin, and L. Bélanger. 2011. Changes in relative abundance of snowshoe hare (*Lepus americanus*) across a 265-year gradient of boreal forest succession. *Canadian Journal of Zoology* 89: 908–920.
- Jacqmain, H., L. Bélanger, S. Hilton, and L. Bouthillier. 2007. Bridging native and scientific observations of snowshoe hare habitat restoration after clearcutting to set wildlife habitat management guidelines on Waswanipi Cree land. *Canadian Journal of Forest Research* 37: 530–539.
- Keith, L. B., and S. E. M. Bloomer. 1993. Differential mortality of sympatric snowshoe hares and cottontail rabbits in central Wisconsin. *Canadian Journal of Zoology* 71: 1694–1697.
- Keith, L. B., and D. C. Surrendi. 1971. Effects of fire on a snowshoe hare population. *Journal of Wildlife Management* 35: 16–26.
- Krebs, C. J., R. Boonstra, S. Boutin, and A. R. E. Sinclair. 2001a. Conclusions and future directions. Pages 491–502 in *Ecosystem Dynamics of the Boreal Forest: the Kluge Project*. Edited by C. J. Krebs, S. Boutin, and R. Boonstra. University of Oxford Press, New York City, New York.
- Krebs, C. J., R. Boonstra, V. Nams, M. O'Donoghue, K. E. Hodges, and S. Boutin. 2001b. Estimating snowshoe hare population density from pellet plots: a further evaluation. *Canadian Journal of Zoology* 79: 1–4.
- Litvatis, J. A., J. A. Sherburne, and J. A. Bissonette. 1985. Influence of understory characteristics on snowshoe hare habitat use and density. *Journal of Wildlife Management* 49: 866–873.
- Lowe, J., D. Pothier, J-P. L. Savard, G. Rompré, and M. Bouchard. 2011. Snag characteristics and cavity-nesting birds in the unmanaged post-fire northeastern Canadian boreal forest. *Silva Fennica* 45: 55–67.
- McCoy, V. M., and C. R. Burn. 2005. Potential alteration by climate change of the forest-fire regime in the boreal forest of central Yukon Territory. *Arctic* 58: 276–285.
- McKelvey, K. S., G. W. McDaniel, L. S. Mills, and P. C. Griffin. 2002. Effects of plot size and shape on pellet density estimates for snowshoe hares. *Wildlife Society Bulletin* 30: 751–755.
- Miller Jr., R. G. 1966. *Simultaneous Statistical Inferences*. McGraw-Hill Book Company, New York, New York. 299 pages.
- Monthey, R. W. 1986. Responses of snowshoe hare, *Lepus americanus*, to timber harvesting in northern Maine. *Canadian Field-Naturalist* 100: 568–570.
- Mueller-Dombois, D., and H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. John Wiley & Sons, New York, New York. 547 pages.
- Nelson, J. L., E. S. Zavaleta, and F. S. Chapin III. 2008. Boreal fire effects on subsistence resources in Alaska and adjacent Canada. *Ecosystems* 11: 156–171.
- Newbury, T. L., and N. P. P. Simon. 2005. The effects of clearcutting on snowshoe hare (*Lepus americanus*) relative

- abundance in central Labrador. *Forest Ecology and Management* 210: 131–142.
- Oswald, E. T., and B. N. Brown.** 1990. Vegetation establishment during 5 years following wildfire in northern British Columbia and southern Yukon Territory. Information Report BC-X-320. Forestry Canada, Victoria, British Columbia. 46 pages.
- Paragi, T. F., W. N. Johnson, D. D. Katnik, and A. J. Magoun.** 1997. Selection of post-fire seres by lynx and snowshoe hares in the Alaskan Taiga. *Northwestern Naturalist* 78: 77–86.
- Pietz, P. J., and J. R. Tester.** 1983. Habitat selection by snowshoe hares in north central Minnesota. *Journal of Wildlife Management* 47: 686–696.
- Poole, K. G., L. A. Wakelyn, and P. N. Nicklen.** 1996. Habitat selection by lynx in the Northwest Territories. *Canadian Journal of Zoology* 74: 845–850.
- Prugh, L. R., and C. J. Krebs.** 2004. Snowshoe hare pellet-decay rates and aging in different habitats. *Wildlife Society Bulletin* 32: 386–393.
- Redburn, M. J., and W. L. Strong.** 2008. Successional development of silviculturally treated and untreated high-latitude *Populus tremuloides* clearcuts in northern Alberta, Canada. *Forest Ecology and Management* 255: 2937–2949.
- Roy, L. D., J. B. Stelfox, and J. W. Nolan.** 1995. Relationship between mammal biodiversity and stand age and structure in aspen mixedwood forests in Alberta. Pages 159–189 in *Relationships Between Stand Age, Stand Structure, and Biodiversity in Aspen Mixedwood Forests in Alberta*. Edited by J. B. Stelfox. Alberta Environmental Centre, Vegreville, and Canadian Forest Service, Edmonton, Alberta.
- Schiffman, S. S., M. L. Reynolds, and F. W. Young.** 1981. Introduction to multidimensional scaling: theory, methods, and application. Academic Press, New York, New York. 413 pages.
- Sheriff, M. J., C. J. Krebs, and R. Boonstra.** 2011. From process to pattern: how fluctuating predation risk impacts the stress of snowshoe hares during the 10-year cycle. *Oecologia* 166: 593–605.
- Statsoft.** 1995. STATISTICA for Windows. Statsoft Inc., Tulsa, Oklahoma.
- St-Georges, M., S. Nadeau, D. Lambert, and R. Décarie.** 1995. Winter habitat use by ptarmigan, snowshoe hares, red foxes, and river otters in the boreal forest–tundra transition zone of western Quebec. *Canadian Journal of Zoology* 73: 755–764.
- Strong, W. L.** 2002. Assessing species abundance unevenness within and between plant communities. *Community Ecology* 3: 237–246.
- Strong, W. L.** 2009. *Populus tremuloides* Michx. postfire stand dynamics in the northern boreal-cordilleran ecoclimatic region of central Yukon Territory, Canada. *Forest Ecology and Management* 258: 1110–1120.
- Strong W. L.** 2013. Ecoclimatic zonation of Yukon (Canada) and ecoclimatic variation of vegetation. *Arctic* 66: 52–67.
- Strong, W. L., and L. V. Hills.** 2006. Taxonomy and origin of present-day morphometric variation in *Picea glauca* (*xengelmannii*) seed-cone scales in North America. *Canadian Journal of Botany* 84: 1129–1141.
- Tabachnick, B. G., and L. S. Fidell.** 1989. Use of multivariate statistics. Harper & Row Publishers, New York, New York. 746 pages.
- Thompson, I. D., I. J. Davidson, S. O'Donnell, and F. Brazeau.** 1989. Use of track transects to measure the relative occurrence of some boreal mammals in uncut forest and regenerating stands. *Canadian Journal of Zoology* 67: 1816–1823.
- Wolfe, M. L., N. V. Debyle, C. S. Winchell, and T. M. McCabe.** 1982. Snowshoe hare cover relationships in northern Utah. *Journal of Wildlife Management* 46: 662–670.
- Wolff, J. O.** 1978. Food habits of snowshoe hare in interior Alaska. *Journal of Wildlife Management* 42: 148–153.
- Wolff, J. O.** 1980. The role of habitat patchiness in population dynamics of snowshoe hares. *Ecological Monographs* 50: 111–130.

Received 13 May 2012

Accepted 26 September 2012

# Predicting the Spread of Purple Loosestrife (*Lythrum salicaria*) in the Prairies

CORY J. LINDGREN<sup>1</sup> and DAVID WALKER<sup>2</sup>

<sup>1</sup>Department of Environment and Geography, University of Manitoba, Winnipeg, Manitoba R3T 2N2 Canada; email: cjllind@mymts.net

<sup>2</sup>Department of Environment and Geography, University of Manitoba, Winnipeg, Manitoba R3T 2N2 Canada

Lindgren, Cory J., and David Walker. 2012. Predicting the spread of Purple Loosestrife (*Lythrum salicaria*) in the Prairies. *Canadian Field-Naturalist* 126(4): 306–319.

Purple Loosestrife (*Lythrum salicaria*) is an invasive plant introduced into North America in the early 1800s. It has since spread into the prairie provinces of Canada (Manitoba, Saskatchewan, and Alberta). It invades wetland habitats, marshes, riparian areas, and natural areas, and it outcompetes native wetland vegetation. In this study we modelled the potential distribution of Purple Loosestrife in the Prairies, explored which suites of predictive variables produced the best ecological niche models, and explored two different approaches to the partitioning of data in evaluating models. We used a number of performance measures and expert evaluation to select our best models. The best model was developed using a suite of climate variables and growing degree-days as the predictive variables and by partitioning testing and training data using stratified random sampling. The model indicated that Purple Loosestrife has not yet reached its full potential distribution in the Prairies. The modelling techniques presented in this paper may be used to predict the potential distribution of other emerging invasive plants, and the results can be used to optimize early detection and surveillance strategies for Purple Loosestrife in areas of the Prairies.

Key Words: Purple Loosestrife, *Lythrum salicaria*, invasive weed, ecological niche modelling, genetic algorithm for rule-set prediction, GARP, Manitoba, Saskatchewan, Alberta.

Invasive plants threaten the economy, environment, and health, as well as managed and unmanaged systems worldwide (Bradley et al. 2009). Purple Loosestrife (*Lythrum salicaria*; Lythraceae) is an invasive plant that was introduced into North America in the early 1800s and has since spread across Canada (Thompson et al. 1987; Mal et al. 1992; Lindgren 2003; Welk 2004). It invades wetland habitats, marshes, riparian areas, and other natural areas (White et al. 1993\*; Mal et al. 1997; Mullin 1998; Anderson et al. 2006), and it outcompetes native wetland vegetation (Gaudet and Keddy 1988; Johansson and Keddy 1991; Gaudet and Keddy 1995; Mal et al. 1997). It is found in all three Canadian prairie provinces (Manitoba, Saskatchewan, and Alberta), and once established it is difficult and costly to eradicate (Ottenbreit 1991; Ottenbriet and Staniforth 1994; Ali and Verbeek 1999\*; Lindgren et al. 2001; Lindgren 2003).

Studies have modelled the potential distribution of Purple Loosestrife at continental and regional scales in North America (Welk 2004; Soberon and Peterson 2005; Anderson et al. 2006; Bella 2009\*), but there have been no studies that model the potential distribution of Purple Loosestrife specifically in the Prairies. Although Purple Loosestrife has become established in parts of the Prairies (Lindgren 2003), it would be of significant value to know if it has reached the full extent of its geographic distribution within this region, to help determine, for example, which management strategies could be effective. Hence, the first objective of this study was to model the potential distribution

of Purple Loosestrife in order to determine whether it has reached its full range potential in the Prairies.

## *Ecological niche modelling*

Increases in international trade have resulted in an increasing number of new invasive weeds being introduced globally. Hence there is a need to explore the use of tools that may support preventive strategies by predicting the potential distribution of a pest in a new area (Pheloung et al. 1999; Zalba et al. 2000; Brasier 2008; Dehnen-Schmutz et al. 2010; Lindgren 2012).

Predicting pest distributions is a topic of interest dating back many years (Cook 1925; Messenger 1959). Modelling geographic distributions has been referred to as ecological niche modelling (Peterson and Cohoon 1999). Ecological niche modelling generally characterizes the abiotic conditions (e.g., climatic conditions) associated with a known location of a species in one area and attempts to predict the potential distribution of that species in a new area based upon those conditions. Ecological niche modelling attempts to approximate Hutchinson's (1957) fundamental niche (Soberon and Peterson 2005).

There are a variety of modelling approaches that have been used to estimate the ecological niche, including BIOCLIM (Busby 1986), Maxent (Phillips et al. 2006), CLIMEX (Sutherst and Maywald 1985; Sutherst et al. 2000), and the Genetic Algorithm for Rule-set Prediction (GARP) (Stockwell and Noble 1992; Stockwell 1997; Stockwell and Peters 1999); see Guisan and Thuiller (2005) for a review of these modelling approaches.



In this study we explored the use of the GARP algorithm, as it has been used successfully across a wide range of disciplines. It has been used to predict the potential distribution of invasive plants (Madsen 1999; Daehler and Carino 2000; Peterson 2001; Welk et al. 2002; Peterson et al. 2003; Sanchez-Flores 2007), mice (Anderson et al. 2002), aphids (Ganeshaiah et al. 2003), owls (Peterson and Robins 2003), butterflies (Oberhauser and Peterson 2003), and diseases (Levine et al. 2004; Adjemian et al. 2006) and to explore how climate change influences potential distributions (Kerns et al. 2009). Specific to invasive plants, it has been successfully used to predict the potential distribution of Garlic Mustard (*Alliaria petiolata*), Russian Olive (*Elaeagnus angustifolia*), Hydrilla (*Hydrilla verticillata*), and Sericea Lespedeza (*Lespedeza cuneata*) (Welk et al. 2002; Peterson et al. 2003).

The GARP algorithm is a machine learning approach that uses algorithms to enable the computer to learn from experience and improve its prediction over time. The GARP algorithm uses decision rules to summarize the ecological niche of a species, as defined by a set of known presence points in one area, and then predicts the potential distribution in a new area based on the summarized ecological niche (Peterson et al. 2003). The rule types used by GARP are atomic, envelope (i.e., based on BIOCLIM rules), and logit. It resamples known occurrence points and pseudo-absence points (e.g., sites at which the species is not known to occur) randomly with replacement to create training and test data sets of up to 1250 points each. It works in an iterative process to develop rules that identify key niche parameters, evaluates their importance and predictivity, and either incorporates them into the model or rejects them (Oberhauser and Peterson 2003). GARP is a superset of individual algorithms that has greater predictive ability than any one of them (Peterson 2001).

When compared to other ecological niche modelling approaches, GARP has several advantages in that (1) it is an algorithm that iteratively evaluates and improves on prediction rules used to generate a predictive risk map (Stockwell and Peters 1999); (2) it is data-driven, producing informative models that allow parameters to be optimized using expert knowledge and errors of omission and commission (Peterson and Cohoon 1999; Stockwell and Peterson 2002); (3) it has been used by a wide variety of practitioners across a number of disciplines (see examples above); (4) it is predictive in that it anticipates a pest's distribution in geographic areas where distribution information is lacking (Peterson 2001); (5) it is a superset of other modelling approaches, providing greater predictive ability than any one individual approach (Peterson 2001); and (6) it is freely available. Free access to a spatial modelling tool allows others to critically scrutinize and replicate risk maps (Kriticos and Randall 2001). Open access is particularly important for countries, for example, that are signatories to the International Plant Pest Convention

(see [www.ipcc.int](http://www.ipcc.int)) and hence have obligations to conduct science-based risk assessments but may not have the resources to purchase expensive modelling applications.

#### *Selecting predictive variables*

In developing an ecological niche model, the choice of predictive variables affects the final risk model and how robust it will be. When models perform well, it is generally because predictor variables that are associated with habitat suitability have been selected. When models do not perform well, it suggests that meaningful predictor variables were not selected (Evangelista et al. 2008). It would be of value to know which predictor variables determine a species' distribution; however, such knowledge is generally lacking (Jimenez-Valverde et al. 2011). The second objective of this study was therefore to determine which of two suites of predictive variables and growing degree-days, or combinations of them, produced the most realistic ecological niche models for Purple Loosestrife.

There are many abiotic variables that may determine a species' geographic distribution, but it is likely that climate, topography, and growing degree-days are the primary variables constraining the distribution of Purple Loosestrife in the Prairies. In this study, we explored the influence of climate variables, as these are known to be principal predictive variables in determining species' distributions (Andrewartha and Birch 1954; Peterson and Cohoon 1999; Welk et al. 2002; Pearson and Dawson 2003; Welk 2004; Helouet and Beaugrand 2009; Kearney and Porter 2009). Specifically, we explored temperature and precipitation as predictive variables, as they have been found to be determining factors in the distribution of invasive plants, including Kudzu (*Pueraria lobata*) (Follak 2011) and Purple Loosestrife (Bella 2009\*).

We selected growing degree-days, a thermal measure associated with air temperature, as a predictive variable, as it is considered a spatially dynamic variable (Hassan et al. 2000; Jodoin et al. 2008; Hassan and Bourque 2009) that is known to constrain the distribution of Purple Loosestrife (Lindgren and Walker 2012) and is a driver of species' distributions (Austin et al. 2006). We also explored the influence of topographic variables, as they also have been reported to be determining variables in species' distributions (Kearney and Porter 2009) and are correlated with wetland plants (Welk 2004). Climate, topography, and growing degree-days are also landscape-scale variables which are meaningful in assessing distributions at large spatial scales (Peterson et al. 2011), such as the Prairies.

#### *Geographic partitioning of data*

The third objective of this study was to explore two different approaches to data partitioning. Occurrence point data are commonly partitioned into training and testing datasets to evaluate the resulting model. Hence, the way in which the data are partitioned needs to be

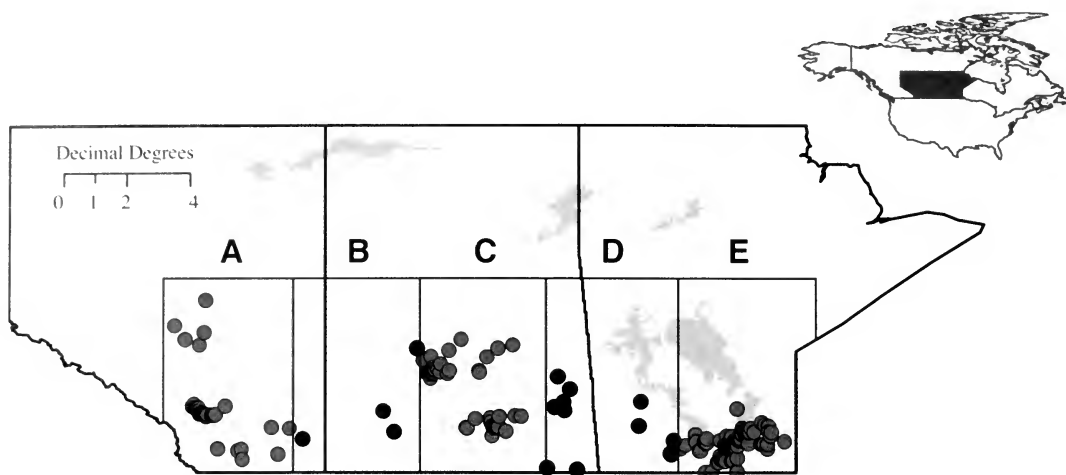


FIGURE 1. Illustration of the quintile data partitioning approach used to evaluate model predictivity for the spread of Purple Loosestrife (*Lythrum salicaria*) in the Prairies. Occurrences in areas B and D were used to train models using occurrence points ( $N = 22$ ) (black dots); areas A, C, and E were used to test the models using occurrence points ( $N = 609$ ) (grey dots). Study area consists of Alberta, Saskatchewan, and Manitoba (from left to right). Major lakes are shown for context.

carefully considered (Fielding and Bell 1997; Peterson and Shaw 2003). Occurrence data are generally partitioned so that one subset is used to train the model and another subset is used to independently test the model (Fielding and Bell 1997; Osborne and Suárez-Seoane 2002; Peterson and Shaw 2003; Heikkinen et al. 2007; Syartinilia and Tsuyuki 2008). To calculate measures of model accuracy, an independent testing dataset is generally withheld from model training (Fielding and Bell 1997; Osborne and Suárez-Seoane 2002; Peterson and Shaw 2003; Peterson et al. 2011). Examples of data partitioning approaches include random sampling (Osborne and Suárez-Seoane 2002), stratified random sampling (Hirzel and Guisan 2002), and partitioning by administrative boundaries (Kapetsky et al. 1988; Anderson et al. 2006).

In this study, we explored the use of two approaches to data partitioning in testing the predictive power of our GARP models: (1) stratified random sampling, in which the data were partitioned by province; and (2) a quintile approach, in which the data were partitioned into five regions of equal size. Partitioning data using these approaches forces the model to predict into broad, unsampled areas from which no input occurrence points are available (Peterson and Shaw 2003; Peterson et al. 2007). Partitioning the testing and training data using a stratified random sampling approach simulated a scenario whereby sampling effort might be planned through provincial survey efforts, with specific administrative boundaries. Both partitioning methods allowed for realistic model evaluation, as the majority of the evaluation area is limited to areas into which Purple Loosestrife might disperse and hence should reduce

overall errors of commission in the model (Peterson et al. 2011).

## Methods

### Study area

The study area covers an area of 360 000 km<sup>2</sup> and includes the provinces of Manitoba, Saskatchewan, and Alberta (Figure 1). The spatial extent of the study area represents accessible area, an important consideration often overlooked in modelling studies (Anderson and Raza 2010; Barve et al. 2011; Peterson 2011). The study area constitutes a geographic space in which Purple Loosestrife has become established and into which it may extend its range, based upon abiotic and dispersal factors. Because of the large scale of the study area, biotic factors should not significantly influence the models.

### Occurrence data

One of the challenges of spatial predictive modelling is obtaining accurate occurrence data, as the quality and quantity of these data directly influence modelling results (Welk 2004; Elith et al. 2006; Yemshanov et al. 2010). We obtained 631 geo-referenced occurrence points for the study area. Manitoba occurrence data (i.e., site records) were collected between 1992 and 2004 by CJL (e.g., Lindgren 2003), and the remaining validated data were collected by the Saskatchewan Purple Loosestrife Eradication Project (Summers 2005) and the Alberta Purple Loosestrife program (Ali and Verbeek 1999\*; Cole et al. 2007) (this dataset can be obtained by contacting CJL). Models were developed using presence only data (GARP generates

pseudo-absence points in model development), and no occurrence data from garden plantings, herbaria, or museums were included in the dataset.

#### *Predictive variables*

We used (1) growing degree-days, (2) a suite of climate variables (mean daily temperature, mean annual diurnal temperature, mean annual precipitation, and mean annual number of wet days), and (3) a suite of topography variables (elevation, slope, and aspect) as the predictive variables. To explore the influence of the predictive variables on predictive accuracy, we ran GARP models with each variable alone (i.e., first order models) as well as with all possible combinations of the variables (i.e., second and third order models).

We were unable to find growing degree-days data that were specific to Purple Loosestrife, so we created a new predictive layer using a  $T_{\text{base}}$  of 8°C, which is a threshold temperature specific to Purple Loosestrife growth (Shamsi and Whitehead 1974). To calculate growing degree-days (GDD), the following equations were used:  $\text{GDD}_{\text{daily}} = (T_{\text{max}} + T_{\text{min}}) / 2 - T_{\text{base}}$ , and cumulative  $\text{GDD} = \sum \text{GDD}_{\text{daily}}$ , where  $T_{\text{max}}$  is the maximum daily temperature,  $T_{\text{min}}$  is the minimum daily temperature, and  $T_{\text{base}}$  is the base temperature where growth and development are not deemed to occur (McMaster and Wilhelm 1997; Miller et al. 2001; Laswon et al. 2006; Shrestha et al. 2010). Cumulative growing degree-days were calculated by summing those daily growing degree-days that were above 0°C. Temperature data from 48 weather stations that covered the geographic extent of the Prairies were used to interpolate a growing degree-days surface. Data were imported into an Excel spreadsheet to process cumulative growing degree-days.

We used ArcGIS 9.3's (Environmental Systems Research Institute, Redlands, California) Geostatistical Analyst tool to krigé (i.e., spatial correlation modeling) (Cousens et al. 2002; Kleijnen 2009) a surface using latitude, longitude, and the growing degree-days value, and we converted this into a digital raster layer. Digital raster GIS datasets for climate and topography predictor variables were obtained from the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change 2001). Data were sampled at a pixel resolution of  $0.2^{\circ} \times 0.2^{\circ}$  or about  $20 \times 20$  km grid. We created a study area mask of the Prairies to prevent GARP from selecting pseudo-absence data from areas where Purple Loosestrife was absent for possible abiotic or dispersal reasons, and the mask forced models to be trained in the geographic area of interest (Barve et al. 2011; Peterson et al. 2011).

#### *Model building*

We used GARP to model the potential distribution of Purple Loosestrife across the Prairies (Stockwell and Peters 1999). In producing each GARP model, we set optimization parameters to 100 runs (i.e., each

run produced a unique model) or a convergence limit of 0.01 with the number of maximum iterations set to 1000. Occurrence points were divided randomly by GARP: 50% into training data and 50% into testing datasets.

For each task, atomic, range, negated range, and logistic regression rule sets were selected. GARP selects a rule set method and applies it to the training data, and a rule is developed. Rules then evolve through an iterative process to maximize predictivity, where the change in predictive accuracy from one iteration to the next is used to determine whether a specific rule should be incorporated and each rule set represents a different method of characterizing the ecological niche (Peterson and Shaw 2003; Peterson et al. 2007). Predictive accuracy is evaluated based upon 1250 points resampled from the test data and 1250 pseudo-absence points from the Prairies (Peterson and Shaw 2003). For all GARP models, a subset of data was withheld to allow for independent testing of the model.

As each of the 100 models produced was unique and varied in quality, we selected a best subset of 10 models and summed these together to create one composite model (see Anderson et al. 2003 for discussion on best subset approach). The best subset approach minimizes overfitting by prioritizing errors of omission over errors of commission (Peterson et al. 2008). In optimizing our modelling parameters, we selected an extrinsic omission threshold of 10% so that models with greater than 10% of testing points omitted would be excluded from the final composite model; we set the commission threshold at 50%. Using extrinsic training data, we calculated the median commission index across models with the lowest number of errors of omission, and the models with indices closest to the commission median were chosen as the best subset.

#### *Evaluating model performance*

Model evaluation is used to identify models that predict into either excessively small or excessively large areas (Raxworthy et al. 2007). As there is no accepted single way to measure model performance (Fielding and Bell 1997; Peterson et al. 2011; Tarkesh and Jetschke 2012), we employed a number of measures, as well as expert evaluation (Table 1). The GARP algorithm produces binary models that allow performance measures to be calculated from elements of a  $2 \times 2$  confusion matrix (Fielding and Bell 1997; Welk 2004). In the confusion matrix, element *a* represents pixels where the species is known to occur and the model correctly identifies as present, element *b* represents pixels where the species is not known to occur but are incorrectly identified as present (i.e., errors of commission) (false positives), element *c* represents pixels of known distribution incorrectly identified as absent by the model (i.e., errors of omission) (false negatives), and element *d* represents pixels where the species has not been found and the model correctly identifies as absent.

TABLE 1. Measures used to evaluate performance and accuracy of best subset composite models used to predict the spread of Purple Loosestrife (*Lythrum salicaria*) in the Prairies. Letters *a* to *d* represent elements of the  $2 \times 2$  confusion matrix (see Methods).

Measure	Calculation
Intrinsic errors of omission (performance)	$c / (a + c)$
Intrinsic commission index (performance)	$b / (b + d)$
Sensitivity (performance)	$a / (a + c)$
Specificity (performance)	$d / (d + b)$
Kappa (accuracy)	$\frac{(a + d) - ((a + c)(a + b) + (b + d)(c + d)) / N}{N - ((a + c)(a + b) + (b + d)(c + d)) / N}$
Testing accuracy	$(a + b) / (a + b + c + d)$
Extrinsic accuracy	$\frac{\text{outside model}}{N_{\text{test points}}} / \frac{N}{N_{\text{test points}}}$

We used extrinsic accuracy, testing accuracy, sensitivity, specificity, omission error rate, and commission index to measure the accuracy of our models. Sensitivity is the proportion of observed true positives, correctly indicating how good the model is at detecting a pest or an occurrence point (Fielding and Bell 1997). Specificity is the proportion of observed true negatives or absences that are predicted as absent, indicating how good the model is at detecting absences or predicting no presence (Fielding and Bell 1997). The intrinsic omission error is the proportion of known localities that fall outside the predicted area (i.e., the false negative rate), and the intrinsic commission index (i.e., the false positive rate) is the proportion of pixels predicted as present by the model (Anderson et al. 2003). In general, models with zero or low errors of omission that are sensitive are desired (Peterson et al. 2011).

We also used the kappa statistic ( $\kappa$ ), as it corrects the overall accuracy of model predictions by the accuracy expected to occur by chance, and it also accounts for both errors of commission and omission in one parameter (Landis and Koch 1977; Fielding and Bell 1997; Liu et al. 2005; Allouche et al. 2006; Zhu et al. 2007; Tarkesh and Jetschke 2012). However, the kappa statistic should be used with caution, as it weights errors of omission and commission equally and hence may not be a good measure of performance for invasive species models, where errors of omission are considered more serious than errors of commission (Guisan and Thuiller 2005; Peterson et al. 2011).

We also measured model accuracy by using independently withheld testing data to calculate the percentage of the number of known occurrence points predicted correctly.

While it is important that practitioners quantitatively evaluate models, the importance of expert evaluation in evaluating models cannot be overlooked (Anderson et al. 2003), and expert evaluation should be incorporated into final model selection methodology (Thuiller 2003). Expert evaluation is required to determine whether the ecological niche model is geospatially realistic and make senses both intuitively and biolog-

ically. Expert evaluation has been found to be very informative, for example, in risk analysis frameworks (Pheloung et al. 1999; Therriault and Herborg 2008).

In this study, we defined an expert as someone who has both extensive biological knowledge of Purple Loosestrife (i.e., the species) and knowledge of the biogeography of the Prairies (i.e., the study area). Our definition of an expert is similar to that of Anderson et al. (2003). We, the authors of this study, served as the expert evaluators. We interpreted the composite models and evaluated them as either good or poor. We defined a good model (in this paper we refer to a good model also as a realistic model) as one which excluded unsuitable areas where Purple Loosestrife could not exist (i.e., high elevations of the Rocky Mountains in Alberta or areas of the Boreal Plains ecozone (Ecological Stratification Working Group 1996) where Purple Loosestrife cannot become established) or disperse (i.e., areas where there would be no known pathways for possible introduction). A poor model was one that included large unsuitable areas (i.e., areas where Purple Loosestrife could not disperse or become established due to biotic or abiotic events). For example, a good model accurately delimited the current distribution as well as predicting potential distribution into novel areas where expert opinion determined there were suitable abiotic conditions as well as a potential to disperse into these areas.

We employed an error cost criterion, where errors of omission (i.e., false negatives) were considered to be more costly than errors of commission (i.e., false positives); an error of omission is more serious than an error of commission, as it indicates a model has failed to predict known occurrence points (Raxworthy et al. 2003; Chen et al. 2007; Peterson et al. 2008).

#### *Geographic partitioning of data*

To test the predictive power of the ecological niche models, we partitioned the occurrence data geographically using a quintile approach and a stratified random sampling approach (i.e., by province). Both approaches tested the models' ability to predict into unknown geographic space. In the quintile approach, data were partitioned for model testing and training into five re-

gions (i.e., quintiles) of about four degrees longitude each (Figure 1). To test the accuracy of the model in predicting across unsampled areas of the study area, we used quintiles A, C, and E to independently test models (number of occurrence points) ( $N = 609$ ) and we used quintiles B and D to train ( $N = 22$ ) GARP models. In the stratified random sampling approach, occurrence data were first partitioned among the three provincial boundaries, and then about 30% of the data from each province were randomly selected for model testing ( $N = 441$  for model training and  $N = 190$  for model testing).

*Geographic information processing*

ArcGIS 9.3 was used to process and project the GARP models. The 10 best models were imported into ArcGIS, converted from ASCII files to raster grid files, and projected onto a map of the three prairie provinces. For each model, GARP predicts Purple Loosestrife as either present or absent within a pixel. The ArcGIS Spatial Analyst tool (i.e., local cell statistics) was used to sum all 10 best subset models together to create a final composite model. Using ArcGIS 9.3, we reclassified the modelling results into one of six categories representing probable risk: 0 (i.e., no models predicted presence), <25%, 26–50%, 51–75%, 76–99%, and 100% (i.e., all 10 models agreed). Projection of the composite model onto a map of the Prairies provided a final invasive risk map.

**Results and Discussion**

*Geographic partitioning of data*

We found that the way in which we partitioned the data (i.e., into training and testing subsets) influenced the modelling results. Evaluation data for the composite models developed using the quintile data partitioning approach are found in Table 2. Using the performance measures and expert evaluation to assess the quintile models, we determined that the single variable climate model (Figure 2A) was the best model.

The next best model was the three variable model (Figure 2G), which had good performance and accuracy measures but suffered from errors of omission (i.e., the model failed to predict as suitable areas of central Alberta where there are known established populations). Using our adopted error cost criterion, where an error of omission is considered to be the most serious error (Wiley et al. 2003), we evaluated the three variable model as poor.

The remaining models also had errors of omission (Figures 2C, 2D, and 2E), errors of commission (Figures 2B and 2F), and in some cases both (Figures 2B, 2C, 2D, 2F), and were hence evaluated as poor. While errors of commission, or overprediction, may be desirable in invasive species models (Stockman et al. 2006), the topography model and the topography and climate model (Figures 2B and 2F) predicted potential distributions into areas of northern Alberta that were beyond what we expected.

TABLE 2. Performance data for ecological niche models for Purple Loosestrife (*Lythrum salicaria*) in the Prairies developed using the quintile data partitioning approach. Measures represent mean values for the best subset composite model. Predictive variables used to develop GARP models were climate, topography (Topo), and growing degree-days (GDD). Models were evaluated using specificity, sensitivity, testing accuracy, and expert evaluation, the kappa statistic, and expert evaluation, number of occurrence points found outside the model, independent test accuracy using points found outside the model, and errors of commission and omission.

Predictor dataset	Model evaluation					Error rate			
	Specificity (%)	Sensitivity (%)	Testing accuracy (%)	Kappa	Expert evaluation	Occurrence points outside the model	Independent test accuracy (%)	Commission (%)	Omission (%)
Three variable model									
Climate + Topo + GDD	69	97	59	0.98	poor	114	82	35	0
Two variable models									
Climate + GDD	25	90	73	0.98	poor	185	70	25	0
Topo + GDD	34	78	71	0.99	poor	183	70	34	0
Topo + Climate	65	95	61	0.98	poor	0	100	54	0
Single variable models									
Climate	33	75	70	0.85	good	0	100	34	0
Topography	35	70	67	0.99	poor	188	70	34	2
GDD	44	100	77	0.98	poor	189	69	43	0

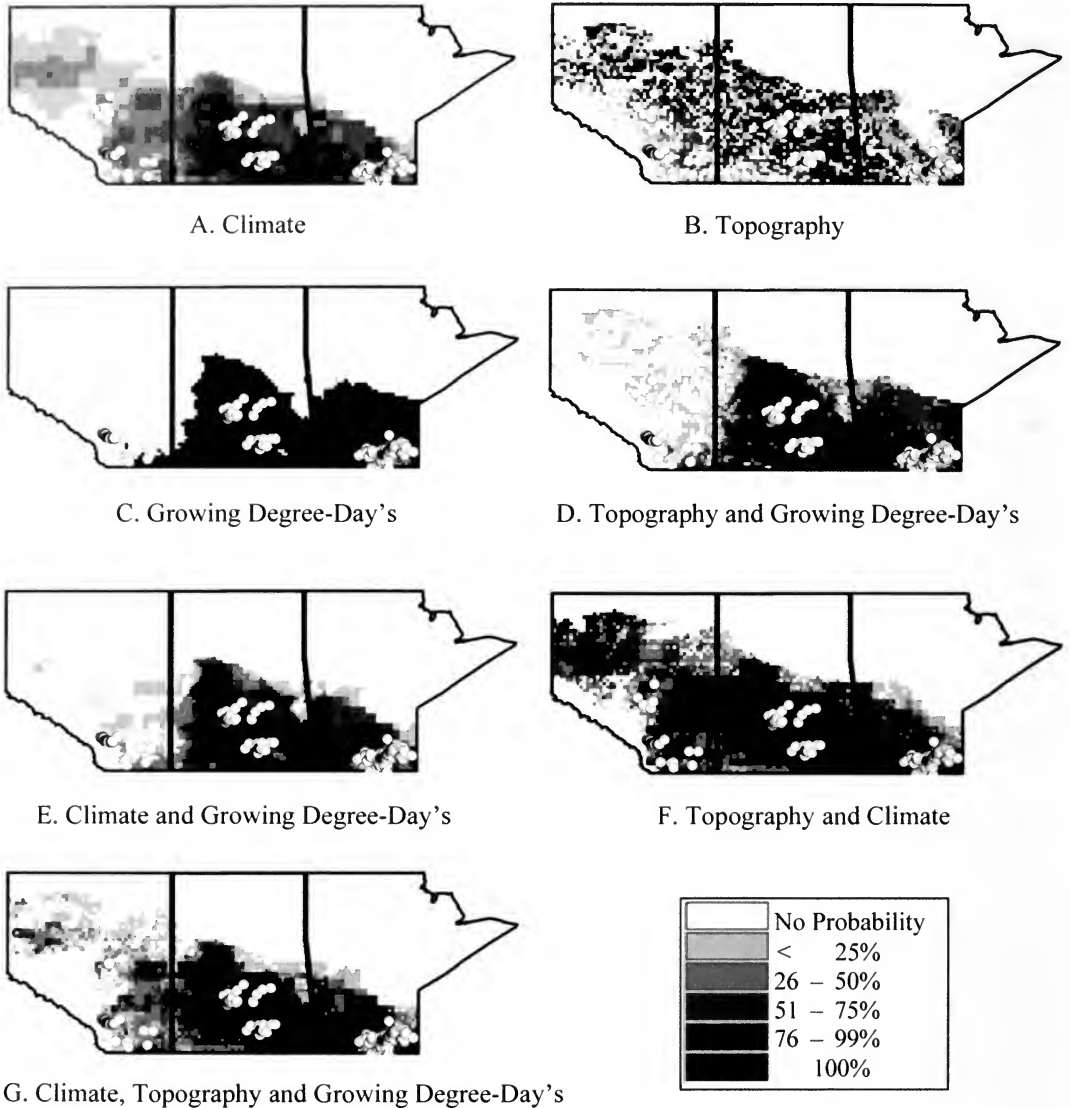


FIGURE 2. Ecological niche models for Purple Loosestrife (*Lythrum salicaria*) in the Prairies produced using the quintile data partitioning approach. White circles represent occurrence points use to test the model.

Evaluation data for composite models developed using the stratified random sampling partitioning approach are found in Table 3. Using the performance measures and expert evaluation, we selected the climate and growing degree-days model (the two variable model) as the best model developed when data were partitioned using a stratified random sampling approach (Figure 3E). The model had a low intrinsic commission index as well as high values for testing accuracy and sensitivity. Expert evaluation determined it appeared to be the most realistic in predicting the potential distribution of Purple Loosestrife in the study area.

The next best model was determined to be the single variable climate model (Figure 3A), which had a low commission index and high values for sensitivity and testing accuracy. Expert evaluation determined it to be a good model, but, when it was compared with the climate and growing degree-days model, it over-predicted into areas of northwestern Alberta where climate conditions as well land use (i.e., boreal forest) would most likely prevent Purple Loosestrife from becoming established.

The remaining models were evaluated as poor, as they suffered from errors of omission (3B, 3C, 3D),

TABLE 3. Performance data for ecological niche models for Purple Loosestrife (*Lythrum salicaria*) in the Prairies using the stratified random sampling approach to partition the data. Measures represent mean values for the best subset composite model. Predictive variables used to develop GARP models were climate, topography (Topo), and growing degree-days (GDD). Models were evaluated using specificity, sensitivity, testing accuracy, the kappa statistic, and expert evaluation, number of occurrence points found outside the model, independent test accuracy using points found outside the model, and errors of commission and omission.

Predictor dataset	Model evaluation					Error rate			
	Specificity (%)	Sensitivity (%)	Testing accuracy (%)	Kappa	Expert evaluation	Number of occurrence points outside the model	Independent test accuracy (%)	Commission (%)	Omission (%)
Three variable model									
Climate + Topo + GDD	56	96	69	0.77	poor	0	100	50	2
Two variable models									
Climate + GDD	31	94	82	0.83	good	0	100	32	2
Topo + GDD	42	92	74	0.82	poor	1	99	42	9
Topo + Climate	32	92	73	0.83	poor	0	100	32	3
Single variable models									
Climate	25	89	79	0.76	good	0	100	25	7
Topography	59	84	63	0.79	poor	7	97	58	10
GDD	58	99	70	0.77	poor	1	99	59	1

errors of commission (Figure 3B, 3C, 3D, 3F, 3G), or both (Figure 3B, 3C, and 3D).

Overall, we concluded that the most realistic models were produced when data were partitioned using a stratified random sampling approach (see expert evaluation discussion below).

*Selecting predictive variables*

As we expected, the selection of predictive variables used to build our models significantly influenced the final results. The single variable models produced using topography and growing degree-days as a single predictive variable were evaluated to be of poor quality. Using either of the data partitioning approaches, we found that the topographic models (Figures 2B and 3B) overpredicted suitable area across the majority of the study area except areas of high elevation in the Rocky Mountains of western Alberta and areas of low elevation in northern Manitoba and Saskatchewan. The growing degree-days models (Figures 2C and 3C) developed using either of the data partitioning methods also suffered from errors of omission, as they failed to predict as suitable areas in central Alberta where known occurrence point data existed. In addition, each pixel in the potential distribution was determined to be 100% at risk. In other words, all ten models forming the composite model agreed that the pixel was suitable, illustrating the limitations of using only one predictive variable in developing a model.

Based on performance measures and expert evaluation, the GARP models using the suite of climate variables (Figure 2A and 3A) were found to be of good quality, as they correctly captured the current distribution and predicted a realistic potential distribution, where the northern extent of the potential distribution of Purple Loosestrife would be constrained by the physiographic features of the Boreal Plains ecozone (Ecological Stratification Working Group 1996).

The two variable topography and growing degree-days models (Figures 2D and 3D) both suffered from errors of omission, as they did not predict potential areas in central Alberta as suitable habitat when in fact there were known occurrence points. We judged these models to be poor. These models also suffered from errors of commission, as they predicted potential distribution into northern areas of Saskatchewan and Alberta where expert opinion determined Purple Loosestrife could not become established or disperse.

The climate and growing degree-days models (Figure 3E) were judged to be good when stratified random sampling was used to partition the data, but there were errors of omission when the quintile approach was used (i.e., did not predict suitable areas through Alberta). The ecological niche model produced with topography and climate variables using stratified random sampling to partition the data (Figure 3F) was of good quality; the model produced using the quintile partitioning (Figure 2F) approach unrealistically overpredicted suitable area into northwestern Alberta. This

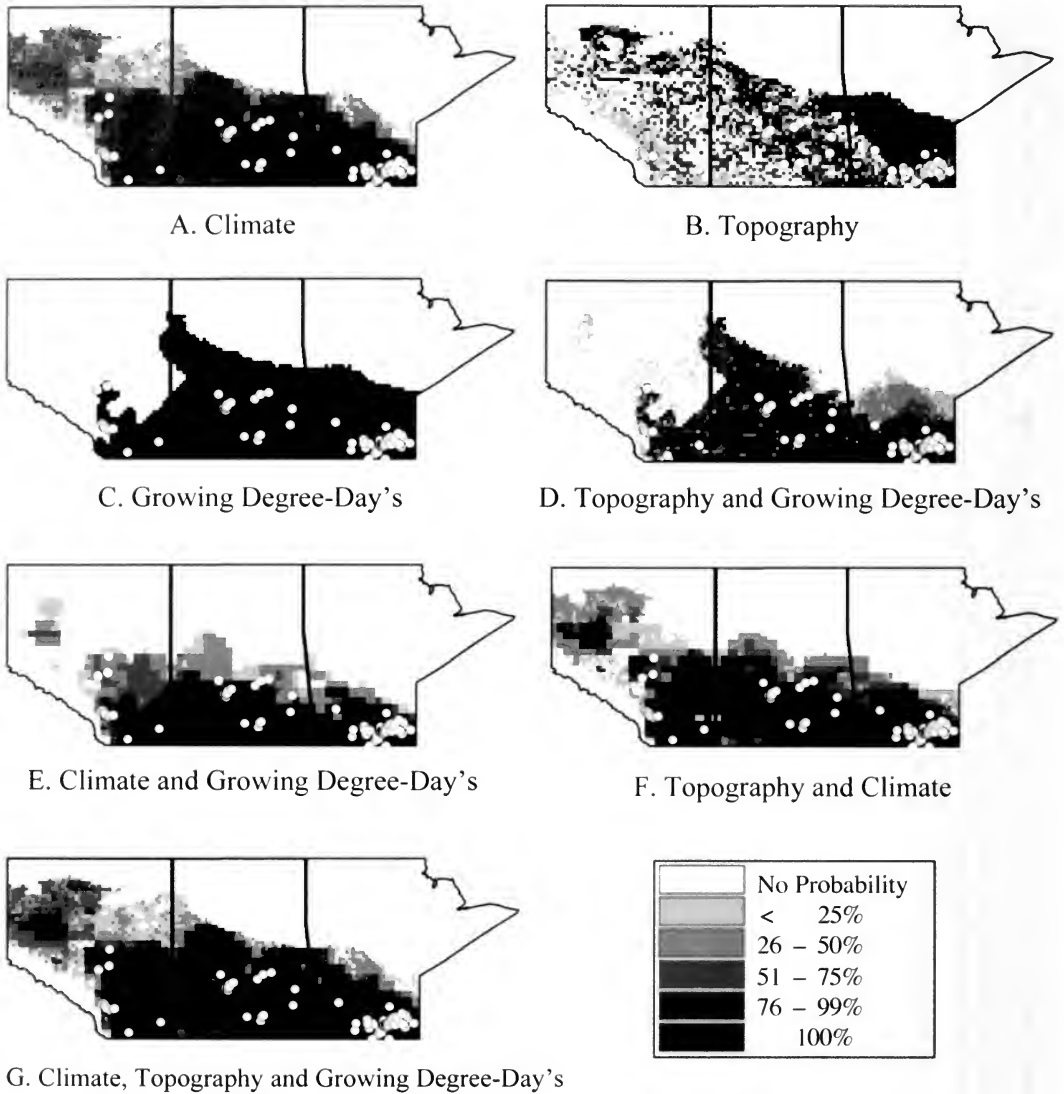


FIGURE 3. Ecological niche models for Purple Loosestrife (*Lythrum salicaria*) in the Prairies produced using stratified random sampling to partition the data. White circles represent occurrence points use to test the model.

is a good example of how different data partitioning methods produce different potential distributions.

In this study, more variables did not produce better models, as the models using all three predictive variables overpredicted into areas of northwestern Alberta and were evaluated as poor. When stratified random sampling was used to partition the data (Figure 3G), the amount of area predicted as suitable by all 10 models in the composite model seemed unrealistic. When the quintile data partitioning approach was used, the three variable model suffered from errors of omission (it failed to predict areas of central Alberta as suitable

where there are known occurrence points) and was evaluated as poor (Figure 2G). It also overpredicted into northern areas of Alberta where expert opinion determined Purple Loosestrife could not become established or disperse.

#### Expert evaluation

We found that expert evaluation was a useful discriminatory measure in selecting the best or most realistic models. Overall, expert evaluation determined that 78% of the models were poor and 22% were good. Selecting the best models using performance measures



alone would have resulted in different results. It was evident that a model could have high values for performance measures but could conversely be evaluated by an expert as poor or unrealistic, for example, the models in Figures 2F and 3A. Based on the results of this study, a triage approach is recommended to select the best ecological niche model using (1) measures of predictive accuracy, (2) performance measures, and (3) expert evaluation as the final discriminatory measure.

Expert evaluation was also found to be important in evaluating data partitioning approaches. Expert evaluation determined that both approaches had errors of commission in that they overpredicted into areas of northwestern Alberta or northern Saskatchewan where Purple Loosestrife would not be expected to become established or disperse. The GARP algorithm has been reported to overpredict (Peterson et al. 2007); however, the choice of predictive variables and data partitioning methods influences the degree of overprediction.

In this study, expert evaluation concluded that using stratified random sampling to partition the testing and training data produced more realistic models than the quintile data partitioning approach. This conclusion is also supported by performance measures using the independently withheld dataset (Tables 2 and 3), where the overall mean independent tests of accuracy for the quintile and stratified random sampling approach were 80% and 99%, respectively.

#### *Selecting the best overall model*

Using expert evaluation as the final discriminatory measure, we determined that the best overall model used the suite of climate variables and growing degree-days as the predictive variables and stratified random sampling to partition the data (Figure 3E). The model had good performance measures, including low errors of omission and commission (Table 3). The potential distribution of Purple Loosestrife generally follows the extent of the Prairies ecozone (Ecological Stratification Working Group 1996) in Canada. For example, the potential distribution of Purple Loosestrife is constrained by the Rocky Mountains in western Alberta and by the Boreal Plains ecozone in all three provinces. Areas predicted as 100% probable for invasion (e.g., all 10 models agree) follow the 49<sup>th</sup> parallel across the prairie provinces and a semicircular pattern north to Strathmore (Alberta), Prince Albert (Saskatchewan), and Yorkton (Saskatchewan), and then east to the southeastern part of Manitoba. The model indicated that there is suitable habitat in the Prairies for Purple Loosestrife to continue to expand its distribution northward.

#### *Practical applications of the model*

Spatial and temporal characterizations of risk or models of potential distribution are required in order to develop strategies to respond to an invasive plant (Venette et al. 2010). Models of potential distribution are very useful in preparing response strategies for invasive plants, as limited resources can then be pri-

oritized for prevention, eradication, or control strategies (Waage and Mumford 2008). Prevention is the preferred strategy, and predictive models provide the spatial information required to develop response strategies. Therefore, based on the predictive map developed in this study, we make the following recommendations: (1) to prevent Purple Loosestrife from becoming established in areas of the Prairies predicted by the model, authorities should develop regulations to prohibit horticultural sales of Purple Loosestrife (to prevent human-mediated dispersal); (2) provinces should develop regional programs that target either the eradication or the containment of localized populations; and (3) provinces should focus early detection programs on areas predicted as suitable by the model into which Purple Loosestrife has not yet dispersed or where Purple Loosestrife has not yet become established.

The spatial predictive model can be used to optimize early detection programs by identifying high-risk areas for surveillance, leading to efficient allocation of survey resources. For example, the model suggests that early detection efforts should be directed to areas near Grande Prairie, Alberta (i.e., an area predicted by the model as having suitable habitat for Purple Loosestrife but where Purple Loosestrife has not yet become established). A city about 460 km northwest of Edmonton, Grande Prairie has a population of over 50 000, and garden centres there may retail ornamental plants that could provide dispersal pathways. The area also has wetlands, reservoirs, and rivers that would provide suitable aquatic habitat if an ornamental planting of Purple Loosestrife escaped. Early detection strategies should also consider using field naturalists in their survey efforts.

#### **Conclusions**

Based on the results of this study, we conclude that GARP is a useful tool that can be successfully used to model the potential distribution of invasive plants, in this case, Purple Loosestrife. Our model indicates that although Purple Loosestrife has been established in the Prairies for some time, there is considerable potential for further invasion. It will be interesting to observe how the distribution of Purple Loosestrife changes over the coming years. Changes in the distribution may support the GARP models that we determined overpredicted the potential distribution or they may support the models that we selected as good models. It could be argued, for example, that the overpredicted areas represent areas where Purple Loosestrife will become established and spread. In predicting the potential distribution of an invasive plant, it may be wise to err on the side of caution and accept a reasonable amount of error of commission, which may represent geographic space into which a species simply has not yet dispersed (Jimenez-Valverde et al. 2011).

**Documents Cited** (marked \* in text)

- Ali, S., and C. Verbeek. 1999. The Alberta Purple Loosetrife Eradication Program 1999 Status Report. Alberta Agriculture, Food and Rural Development, Edmonton, Alberta.
- Bella, E. M. 2009. Invasive plant species response to climate change in Alaska: bioclimatic models of current and predicted future ranges. Report prepared for the U.S. Fish and Wildlife Service, Anchorage, Alaska. 33 pages.
- White, D. J., E. Haber, and C. Keddy. 1993. Invasive Plants of Natural Habitats in Canada: An Integrated Review of Wetland and Upland Species and Legislation Governing Their Control. Report prepared for the Canadian Wildlife Service, Environment Canada, Ottawa, Ontario.

**Literature Cited**

- Adjemian, J. C. Z., E. H. Girvetz, L. Beckett, and J. E. Foley. 2006. Analysis of genetic algorithm for rule-set production (GARP) modeling approach for predicting distributions of fleas implicated as vectors of plague, *Yersinia pestis*, in California. *Journal of Medical Entomology* 43: 93–103.
- Allouche, O., A. Tsor, and R. Kadmon. 2006. Assessing the accuracy of species distribution models: prevalence, kappa and the true skill statistic (TSS). *Journal of Applied Ecology* 43: 1223–1232.
- Anderson, R. P., and A. Raza. 2010. The effect of the extent of the study region on GIS models of species geographic distributions and estimates of niche evolution: preliminary tests with montane rodents (genus *Nephelomys*) in Venezuela. *Journal of Biogeography* 37: 1378–1393.
- Anderson, R. P., M. Gomez-Laverde, and A. T. Peterson. 2002. Geographical distributions of spiny pocket mice in South America: insights from predictive models. *Global Ecology and Biogeography* 11: 131–141.
- Anderson, R. P., D. Lew, and A. T. Peterson. 2003. Evaluating predictive models of species' distributions: criteria for selecting optimal models. *Ecological Modelling* 162: 211–232.
- Anderson, R. P., A. T. Peterson, and S. L. Egbert. 2006. Vegetation-index models predict areas vulnerable to purple loosetrife (*Lythrum salicaria*) invasion in Kansas. *Southwestern Naturalist* 51: 471–480.
- Andrewartha, H. G., and L. E. Birch. 1954. *The Distribution and Abundance of Animals*. University of Chicago Press, Chicago, Ill. 782 pages.
- Austin, M. P., L. Belbin, J. A. Meyers, M. D. Doherty, and M. Luoto. 2006. Evaluation of statistical models for predicting plant species distributions: role of artificial data and theory. *Ecological Modelling* 199: 197–216.
- Barve, N., V. Barve, A. Jimenez-Valverde, A. Lira-Noriega, S. P. Maher, A. T. Peterson, J. Soberon, and F. Villalobos. 2011. The crucial role of the accessible area in ecological niche modeling and species distribution modeling. *Ecological Modelling* 222: 1810–1819.
- Bradley, B. A., M. Oppenheimer, and S. A. Wilcove. 2009. Climate change and plant invasions: restoration opportunities ahead? *Global Change Biology* 15: 1511–1521.
- Brasier, C. M. 2008. The biosecurity threat to the UK and global environment from international trade in plants. *Plant Pathology* 57: 792–808.
- Busby, J. R. 1986. A biogeographical analysis of *Nothofagus cunninghamii* (Hook.) Oerst. in southeastern Australia. *Australian Journal of Ecology* 11: 1–7.
- Chen, P., E. O. Wiley, and K. M. McNyset. 2007. Ecological niche modeling as a predictive tool: silver and bighead carps in North America. *Biological Invasions* 9: 43–51.
- Cole, D. E., J. R. King, D. A. Oyarzun, T. H. Dietzler, and A. McClay. 2007. Experiences with invasive plant management and ecology in Alberta. *Canadian Journal of Plant Science* 87: 1013–1022.
- Cook, W. C. 1925. The distribution of the alfalfa weevil (*Phytonomus pesticus* Gyll.): a study in physical ecology. *Journal of Agricultural Research* 30: 479–491.
- Cousens, R. D., R. W. Brown, A. B. McBratney, B. Whelan, and M. Moerkerk. 2002. Sampling strategy is important for producing weeds maps: a case study using kriging. *Weed Science* 50: 542–546.
- Daehler, C. C., and D. A. Carino. 2000. Predicting invasive plants: prospects for a general screening system based on current regional models. *Biological Invasions* 2: 93–102.
- Dehnen-Schmutz, K., O. Holdenrieder, M. J. Jegar, and M. Pautasso. 2010. Structural change in the international horticultural industry: some implications for plant health. *Scientia Horticulturae* 125: 1–15.
- Ecological Stratification Working Group. 1996. A national ecological framework for Canada. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research, and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa.
- Elith, J., C. Graham, R. Anderson, M. Dudik, S. Ferrier, A. Guisan, R. Hijmans, F. Huettmann, R. Leathwick, A. Lehmann, J. Lucia, G. Lohman, B. Loiselle, G. Manion, C. Moritz, M. Nakamura, Y. Nakazawa, J. Overton, A. Townsend Peterson, S. Phillips, K. Richardson, R. Scachetti-Pereira, E. Schapire, J. Soberon, S. Williams, M. Wisz, and N. E. Zimmerman. 2006. Novel methods improve prediction of species distributions from occurrence data. *Ecography* 29: 129–151.
- Evangelista, P. H., S. Kumar, T. J. Stohlgren, C. S. Jarvovich, A. W. Crall, J. B. Norman III, and D. T. Barnett. 2008. Modelling invasion for a habitat generalist and a specialist plant species. *Diversity and Distributions* 14: 808–817.
- Fielding, A. H., and J. F. Bell. 1997. A review of methods for the assessment of prediction errors in conservation presence/absence models. *Environmental Conservation* 24: 38–49.
- Follak, S. 2011. Potential distribution and environmental threat of *Pueraria lobata*. *Central European Journal of Biology* 6: 457–469.
- Ganeshaiyah, K. N., N. Barve, N. Nath, K. Chandrashekara, M. Swamy, and R. Shaanker. 2003. Predicting the potential geographic distribution of the sugarcane woolly aphid using GARP and DIVA-GIS. *Current Science* 85: 1526–1528.
- Gaudet, C. L., and P. A. Keddy. 1988. A comparative approach to predicting competitive ability from plant traits. *Nature* 334: 242–243.
- Gaudet, C. L., and P. A. Keddy. 1995. Competitive performance and species distribution in shoreline plant communities: a comparative approach. *Ecology* 76: 280–291.
- Guisan, A., and W. Thuiller. 2005. Predicting species distributions: offering more than simple habitat models. *Ecological Letters* 8: 993–1009.
- Hassan, Q., and C. Bourque. 2009. Potential species distribution of Balsam Fir based on the integration of biophys-

- ical variables derived with remote sensing and process-based methods. *Remote Sensing* 1: 393–407.
- Hassan, Q., C. Bourque, F. Meng, and W. Richards.** 2007. Spatial mapping of growing degree days: an application of MODIS-based surface temperatures and enhanced vegetation index. *Journal of Applied Remote Sensing* 1: 1–12.
- Heikkinen, R. K., M. Luoto, R. Virkkala, R. G. Pearson, and J. H. Korber.** 2007. Biotic interactions improve prediction of boreal bird distributions at macro-scales. *Global Ecology and Biogeography* 16: 754–763.
- Helaouet, P., and G. Beaugrand.** 2009. Physiology, ecological niches and species distributions. *Ecosystems* 8: 1235–1245.
- Hernandez, P. A., C. H. Graham, L. L. Master, and D. L. Albert.** 2006. The effect of sample size and species characteristics on performance of different species distribution modeling methods. *Ecography* 29: 773–785.
- Hirzel, A., and A. Guisan.** 2002. Which is the optimal sampling strategy for habitat suitability modelling? *Ecological Modelling* 157: 331–341.
- Hutchinson, G. E.** 1957. Concluding remarks. *Population Studies: Animal Ecology and Demography*, Cold Spring Harbour Symposium on Quantitative Biology 22: 415–457.
- Intergovernmental Panel on Climate Change.** 2001. Climate data archive. Geneva, Switzerland. <http://www.ipcc.ch>. (Accessed May 2010).
- Jimenez-Valverde, A. T. Peterson, J. Soberon, J. M. Overton, P. Aragon, and J. M. Lobo.** 2011. Use of niche models in invasive species risk assessments. *Biological Invasions* 13: 2785–2797.
- Jodoin, Y., C. Lavoie, P. Villeneuve, M. Theriault, J. Beaulieu, and F. Belzile.** 2008. Highways as corridors and habitat for the invasive common reed *Phragmites australis* in Quebec, Canada. *Journal of Applied Ecology* 45: 459–466.
- Johansson, M. E., and P. A. Keddy.** 1991. Intensity and asymmetry of competition between plant pairs of different degrees of similarity: an experimental study on two guilds of wetland plants. *Oikos* 60: 27–34.
- Kapetsky, J. M., J. M. Hill, and L. D. Worthy.** 1988. A geographic information system for catfish farming development. *Aquaculture* 68: 311–320.
- Kearney, M., and W. Porter.** 2009. Mechanistic niche modeling: combining physiological and spatial data to predict species' ranges. *Ecology Letters* 12: 334–350.
- Kerns, B. K., B. J. Naylor, M. Buonopane, C. G. Parks, and B. Rogers.** 2009. Modeling *Tamarix* (*Tamarix spp.*) habitat and climate change effects in the northwestern United States. *Invasive Plant Science and Management* 2: 200–215.
- Kleijnen, J. P.** 2009. Kriging metamodeling in simulation: a review. *European Journal of Operational Research* 192: 707–716.
- Kriticos, D. J., and R. P. Randal.** 2001. A comparison of systems to analyze potential weed distributions. Pages 61–79 in *Weed Risk Assessment*. Edited by R. H. Groves, F. D. Panetta, and J. G. Virtue. CSIRO Publishing, Collingwood, Victoria, Australia.
- Landis, J. R., and G. C. Koch.** 1977. The measure of observer agreement for categorical data. *Biometrics* 33: 159–174.
- Lawson, A. N., R. C. Van Acker, and L. F. Friesen.** 2006. Emergence timing of volunteer canola in spring wheat fields in Manitoba. *Weed Science* 54: 873–882.
- Levine, R. S., A. T. Peterson, and M. Q. Benedict.** 2004. Geographic and ecological distributions of the *Anopheles gambiae* complex predicted using a genetic algorithm. *American Journal of Tropical Medicine and Hygiene* 70: 105–109.
- Lindgren, C. J.** 2003. A brief history of Purple Loosestrife, *Lythrum salicaria*, in Manitoba and its status in 2001. *Canadian Field-Naturalist* 117: 100–109.
- Lindgren, C. J.** 2012. Biosecurity policy and the use of geo-spatial predictive tools to address invasive plants: updating the risk analysis toolbox. *Risk Analysis* 32: 9–15.
- Lindgren, C. J., and D. Walker.** 2012. Growth rate, seed production, and assessing the spatial risk of *Lythrum salicaria* using growing degree-days. *Wetlands* 32: 885–893.
- Lindgren, C. J., J. Corrigan, and R. A. DeClerk-Floate.** 2001. *Lythrum salicaria* L., Purple Loosestrife (Lythraceae). Pages 383–390 in *Biological Control Programmes in Canada, 1981–2000*. Edited by G. Mason and J. T. Huber. CABI Publishing, Wallingford, U.K.
- Liu, C., P. M. Berry, T. P. Dawson, and R. G. Pearson.** 2005. Selecting thresholds of occurrence in the prediction of species distributions. *Ecography* 28: 385–393.
- Madsen, J. D.** 1999. Predicting the invasion of Eurasian watermilfoil into northern lakes. U.S. Army Corps of Engineers Waterways Experiment Station. Technical Report A-99-2, February 1999.
- Mal, T. K., J. Lovett-Doust, L. Lovett-Doust, and G. A. Mulligan.** 1992. The biology of Canadian weeds. 100. *Lythrum salicaria*. *Canadian Journal of Plant Science* 72: 1305–1330.
- Mal, T. K., J. Lovett-Doust, and L. Lovett-Doust.** 1997. Time-dependent competitive displacement of *Typha angustifolia* by *Lythrum salicaria*. *Oikos* 79: 26–33.
- McMaster, G. S., and W. W. Wilhelm.** 1997. Growing degree-days: one equation, two interpretations. *Agricultural and Forest Meteorology* 8: 291–300.
- Messenger, P. S.** 1959. Bioclimatic studies with insects. *Annual Review of Entomology* 4: 183–206.
- Miller, P., W. Lanier, and S. Brandt.** 2001. Using growing degree days to predict plant stages. Montana State University Extension Service, Bozeman, Montana.
- Mullin, B. H.** 1998. The biology and management of Purple Loosestrife (*Lythrum salicaria*). *Weed Technology* 12: 397–401.
- Oberhauser, K., and A. T. Peterson.** 2003. Modeling current and future potential wintering distributions of eastern North American monarch butterflies. *Proceedings of the National Academy of Sciences of the United States of America* 100: 14063–14068.
- Osborne, P. E., and S. Suárez-Seoane.** 2002. Should data be partitioned spatially before building large scale distribution models? *Ecological Modelling* 157: 249–259.
- Ottenbreit, K.** 1991. The distribution, reproductive biology, and morphology of *Lythrum* species, hybrids and cultivars in Manitoba. M.S. thesis, University of Manitoba, Winnipeg, Manitoba.
- Ottenbreit, K., and R. J. Staniforth.** 1994. Crossability of naturalized and cultivated *Lythrum* taxa. *Canadian Journal of Botany* 72: 337–341.

- Pearson, R. G., and T. P. Dawson. 2003. Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? *Global Ecology and Biogeography* 12: 361–371.
- Peterson, A. T. 2001. Predicting species' geographic distributions based on ecological niche modeling. *Condor* 103: 599–605.
- Peterson, A. T. 2011. Ecological niche conservatism: a time-structured review of evidence. *Journal of Biogeography* 38: 817–827.
- Peterson, A. T., and K. P. Cohoon. 1999. Sensitivity of distributional prediction algorithms to geographic data completeness. *Ecological Modelling* 117: 159–164.
- Peterson, A. T., and C. R. Robins. 2003. Using ecological-niche modeling to predict barred owl invasions with implications for spotted owl conservation. *Conservation Biology* 17: 1161–1165.
- Peterson, A. T., and J. Shaw. 2003. *Lutzomyia* vectors for *Cutaneous leishmaniasis* in southern Brazil: ecological niche models, predicted geographic distributions, and climate change effects. *International Journal for Parasitology* 33: 919–931.
- Peterson, A. T., M. Papes, and D. A. Kluza. 2003. Predicting the potential invasive distributions of four alien plant species in North America. *Weed Science* 51: 863–868.
- Peterson, A. T., R. Williams, and G. Chen. 2007. Modeled global invasive potential of Asian gypsy moths, *Lymantria dispar*. *Entomologia Experimentalis et Applicata* 125: 39–44.
- Peterson, A. T., M. Papes, and J. Soberon. 2008. Rethinking receiver operating characteristic analysis applications in ecological niche modeling. *Ecological Modelling* 213: 63–72.
- Peterson, A. T., J. Soberon, R. G. Pearson, P. Anderson, E. Martinez-Meyer, M. Nakamura, and M. Bastos Araujo. 2011. *Ecological Niches and Geographic Distributions*. Princeton University Press, Princeton, New Jersey. 316 pages.
- Pheloung, P. C., P. A. Williams, and S. R. Halloy. 1999. A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. *Journal of Environmental Management* 57: 239–251.
- Phillips, S. J., R. P. Anderson, and R. E. Schapire. 2006. Maximum entropy modeling of species geographic distributions. *Ecological Modelling* 190: 231–259.
- Raxworthy, C. J. C. M. Ingram, N. Rabibisoa, and R. G. Pearson. 2007. Applications of ecological niche modeling for species delimitation: a review and empirical evaluation using day geckos (*Phelsuma*) from Madagascar. *Systematic Biology* 56: 907–923.
- Sanchez-Flores, E. 2007. GARP modeling of natural and human factors affecting the potential distribution of the invasives *Schismus arabicus* and *Brassica tournefortii* in "El Pinacate y Gran Desierto de Alter" Biosphere Reserve. *Ecological Modelling* 204: 457–474.
- Shamsi, S. R. A., and F. H. Whitehead. 1974. Comparative eco-physiology of *Epilobium hirsutum* L. and *Lythrum salicaria* L. I. General biology, distribution and germination. *Journal of Ecology* 62: 279–290.
- Shrestha, A., B. D. Hanson, W. Fidelibus, and M. Alcorta. 2010. Growth, phenology, and intraspecific competition between glyphosate-resistant and glyphosate-susceptible horseweeds (*Conyza canadensis*) in the San Joaquin Valley of California. *Weed Science* 58: 147–153.
- Soberon, J., and A. T. Peterson. 2005. Interpretation of models of fundamental ecological niches and species' distributional areas. *Biodiversity Informatics* 2: 1–10.
- Stockwell, D. R. B. 1997. Generic predictive systems: an empirical evaluation using the learning base system (LBS). *Expert Systems with Applications* 12: 301–310.
- Stockwell, D. R. B. 2000. The GARP modelling system: problems, solutions and automated spatial prediction. *International Journal of Geographic Information Science* 13: 143–158.
- Stockwell, D. R. B., and I. R. Noble. 1992. Induction of sets of rules from animal distribution data: a robust and informative method of data analysis. *Mathematics and Computers in Simulation* 33: 385–390.
- Stockwell, D. R. B., and D. Peters. 1999. The GARP modeling system: problems and solutions to automated spatial prediction. *International Journal of Geographical Information Science* 13: 143–158.
- Stockwell, D. R. B., and A. T. Peterson. 2002. Effects of sample size on accuracy of species distribution models. *Ecological Modelling* 148: 1–13.
- Summers, W. H. 2005. Exotic plant species in the mixed-wood section of the southern boreal forest of Saskatchewan. M.Sc. thesis, University of Saskatchewan, Saskatoon, Saskatchewan. 138 pages.
- Sutherst, R. G. F. Mayward, and B. L. Russell. 2000. Estimating vulnerability under global change: modular modelling of pests. *Agriculture, Ecosystems and Environment* 82: 303–319.
- Sutherst, R. W. 2003. Prediction of species geographical ranges. *Journal of Biogeography* 30: 805–816.
- Sutherst, R. W., and G. F. Maywald. 1985. A computerised system for matching climates in ecology. *Agriculture, Ecosystems and Environment* 13: 281–299.
- Syartinilia, S., and S. Tsuyuki. 2008. GIS-based modeling of the Javan Hawk-Eagle distribution using logistic and autologistic regression models. *Biological Conservation* 141: 756–769.
- Tarkesh, M., and G. Jetschke. 2012. Comparison of six correlative models in predictive vegetation mapping on a local scale. *Environmental and Ecological Statistics* 19: 437–457.
- Therriault, T. W., and L. Herborg. 2008. A qualitative biological risk assessment for vase tunicate *Ciona intestinalis* in Canadian waters: using expert knowledge. *ICES Journal of Marine Science* 65: 781–787.
- Thompson, D. Q., R. L. Stuckey, and E. Thompson. 1987. Spread, Impact and Control of Purple Loosestrife (*Lythrum salicaria*) in North American Wetlands. U.S. Fish and Wildlife Service, Fish and Wildlife Research 2. 55 pages.
- Thuiller, W. 2003. BIOMOD—optimizing predictions of species distributions and projecting potential future shifts under global change. *Global Change Biology* 9: 1353–1362.
- Venette, R., D. Kriticos, D. Magarey, F. Koch, R. Baker, S. Worner, N. Raboteau, D. McKenny, E. Dobesberger, D. Yemshanov, P. De Barro, W. Hutchison, G. Fowler, T. Kalaris, and J. Pedlar. 2010. Pest risk maps for invasive alien species: a roadmap for improvement. *BioScience* 60: 349–362.
- Waage, J. K., and J. D. Mumford. 2008. Agricultural biosecurity. *Philosophical Transactions of the Royal Society B: Biological Sciences* 363: 863–876.
- Welk, E. 2004. Constraints in range predictions of invasive plant species due to non-equilibrium distribution patterns:

- purple loosestrife (*Lythrum salicaria*) in North America. *Ecological Modelling* 19: 551–567.
- Welk, E., K. Schubert, and M. H. Hoffmann.** 2002. Present and potential distribution of invasive garlic mustard (*Aliaria petiolata*) in North America. *Diversity and Distributions* 8: 219–233.
- Wiley, E. O., K. M. McNyset, A. T. Peterson, C. R. Robins, and A. M. Stewart.** 2003. Niche modeling and geographic range predictions in the marine environment using a machine-learning algorithm. *Oceanography* 16: 120–127.
- Yemshanov, D., F. H. Koch, Y. Ben-Haim, and W. D. Smith.** 2010. Robustness of risk maps and survey networks to knowledge gaps about a new invasive pest. *Risk Analysis* 30: 261–276.
- Zalba, S. M., M. I. Sonaglioni, C. A. Compagnoni, and C. J. Belenguer.** 2000. Using a habitat model to assess the risk of invasion by an exotic plant. *Biological Conservation* 93: 203–208.
- Zhu, L., O. Sun, W. Sang, L. Zhenyu, and K. Ma.** 2007. Predicting the spatial distribution of an invasive plant species (*Eupatorium adenophorum*) in China. *Landscape Ecology* 22: 1143–1154.

Received 27 June 2012

Accepted 4 December 2012

## Notes

### Cougars, *Puma concolor*, in Ontario: Additional Evidence

FRANK F. MALLORY<sup>1</sup>, REBECCA A. CARTER<sup>1</sup>, JENNY L. FORTIER<sup>1</sup>, I. STUART KENN<sup>2</sup>, LINSAY WEIS<sup>3</sup>, and B. N. WHITE<sup>3</sup>

<sup>1</sup>Department of Biology, Laurentian University, Sudbury, Ontario P3E 2C6 Canada

<sup>2</sup>Ontario Puma Foundation, P.O. Box 580, 46 Tecumseth Street, Beeton, Ontario L0G 1A0 Canada

<sup>3</sup>Natural Resources DNA Profiling and Forensic Centre, Peterborough, Ontario K9J 7B8 Canada

Mallory, Frank F., Rebecca A. Carter, Jenny L. Fortier, I. Stuart Kenn, Lindsay Weis, and B. N. White. 2012. Cougars, *Puma concolor*, in Ontario: additional evidence. *Canadian Field-Naturalist* 126(4): 320–323.

Recent evidence suggests that the Cougar (*Puma concolor*) has returned to New Brunswick, Quebec, Manitoba, and Ontario. An abundance of sightings have been reported for many decades throughout south-central Ontario, but genetic confirmation has been confounded by a lack of carcasses or DNA. In this paper, we identify (1) genetic evidence of a single Cougar in the wild of Ontario, (2) a gene (cytochrome b) and methodology to distinguish the Cougar from other mammals in Ontario using scats, hair follicles, and soft and hard tissue, and (3) a gene that can distinguish individual Cougars from each other and would distinguish populations of subspecies if they exist in Ontario. Potential Cougar scats and other tissue samples were collected from across Ontario, and hair snares baited with catnip and carnivore lure were placed in locations where Cougar sightings were frequent, near Sudbury, Ontario. We analyzed samples for mtDNA, and one scat sample from the Wainfleet Bog Conservation Area, Port Colborne, Ontario, was positive for Cougar. Evidence from archeological data and Cougar sightings suggests that the historical range of Cougars extended in Ontario from the Great Lakes–St. Lawrence Ecotone south, primarily associated with the Eastern Deciduous Forest Biome and the primary prey of the Cougar, the White-tailed Deer (*Odocoileus virginianus*) and the North American Elk (*Cervus elaphus*). The data suggest that Cougar distribution has moved north in recent times due to clear-cutting, along with their primary prey. Further studies of Cougar presence in the province are warranted.

Key Words: Cougar, Puma, Mountain Lion, *Puma concolor*, scats, hair, mtDNA analysis, hair-snares, Ontario.

The present distribution of the Cougar (*Puma concolor*) in North America is restricted mainly to the western mountain ranges and the southeastern United States, primarily Florida. Cougars were extirpated from most of eastern and central North America and still are persecuted in some jurisdictions (Ross et al. 1995; Anderson et al. 2010; Garcia Alaniz et al. 2010a). In 1978, the eastern subspecies of the Cougar was declared endangered by the Committee on the Status of Endangered Wildlife in Canada; however, the status was re-examined in 1998 and the animal was designated data deficient, because there was not enough data to evaluate the status of the animal or its classification as a subspecies. Recent evidence suggests that the Cougar has returned to New Brunswick, Quebec, Manitoba, and Ontario (Nero and Wrigley 1977; Rosatte 2011). Our study provides genetic data confirming the presence of cougar in Ontario.

White-tailed Deer (*Odocoileus virginianus*) and North American Elk (*Cervus elaphus*) have been identified as the primary prey of Cougar in the U.S. and Canada, with Mule Deer (*O. hemionus*) replacing White-tailed Deer in the west (Hornocker 1970; Seidensticker et al. 1973; Dixon 1982; Belden and Maehr 1986). Historically, White-tailed Deer and North American Elk were found in the Eastern Deciduous Forest

Biome in southern Ontario and to a lesser extent in the Great Lakes–St. Lawrence Ecotone (Seton 1909, 1927; Gleason and Cronquist 1964; Rowe 1972; Bryant and Maser 1982; Baker 1984).

The primary objectives of this study were; (1) to identify Cougar in the wild of Ontario; (2) to identify a gene (cytochrome b) and methodology to distinguish Cougar from other mammals in Ontario using scats, hair follicles, and soft and hard tissue; (3) to identify a gene that could distinguish individual Cougars from each other and would distinguish populations of subspecies if they exist in Ontario; and (4) to discuss possible changes in Cougar distribution across the province.

#### Study Area

Two transects 2 km in length were located in two sites (one north of Sudbury, Ontario, and one south of Sudbury) (80°W, 45°N), where Cougar sightings were frequent. The location north of Sudbury was primarily abandoned agricultural land composed of old fields and drainage ditches with secondary deciduous forest, such as birch (*Betula*) and poplar (*Populus*) along the edges. The location south of Sudbury was in the French River region and consisted of rock outcrops with relatively mature mixed deciduous and conifer-dominated forest cover.

## Methods and Materials

### Hair morphology

Hair snares baited with catnip and carnivore lure (Wildcat Lure #2, Hawbaker's Wildcat Lures, Hawbaker and Sons, Fort Loudon, Penn.) were placed along each transect (Weaver et al. 2005; Garcia Alaniz et al. 2010b). Hair snares were made from pieces of carpet 12 × 17 cm with two strips of hook and loop fasteners 7 cm in length and five roofing nails that projected through the carpet (Garcia Alaniz et al. 2010b). We placed these snares along game trails at both sites. At the northern site, 23 hair snares were nailed approximately 0.5 m from the ground every 30 m on tree trunks and stumps. Hair snares were put out on 10 September 2006 and retrieved on 14 October 2006. At the southern site, 28 hair snares were similarly put out, on 22 September 2006 and retrieved on 24 October 2006. On retrieval, hair snares were placed in re-sealable plastic bags, labelled and the GPS coordinates were recorded using a Garmin hand-held GPS Unit (Model GPS 72HBUNDLE).

Hairs were subsequently removed from the hair snares using tweezers and a magnifying glass, and imprints were made by pressing each hair into a thin layer of clear nail polish (Lady Clairol) applied to a clean microscope slide (Garcia Alaniz et al. 2010b). After 2 to 3 minutes, the hair was slowly removed, leaving an imprint of the scale pattern. Hairs were analyzed using a compound microscope at 400× magnification and identified based on scale patterns described in guard hair keys by Adorjan and Kolenosky (1969) and Garcia Alaniz (2009).

### DNA analysis

Potential Cougar scats, hair, and bone were collected from volunteers across southern and central Ontario between 2003 and 2006. Eleven samples were collected. All 11 samples were placed in re-sealable plastic bags, maintained in a conventional freezer (approximately -20°C), and later analyzed for mtDNA. In addition, all hairs identified as Cougar from the Sudbury hair snare study were also sent for mtDNA analysis to the Natural Resources DNA Profiling and Forensic Centre in Peterborough, Ontario.

All samples were analyzed using the QIAamp (Qiagen) DNA extraction protocol. Extracted DNA from each sample was quantified using a fluorometer-based picogreen assay on the BMG Fluostar Galaxy 96-well plate system. A dilution series of DNA from each sample was analyzed using an amplified region of the cytochrome b gene on mitochondrial DNA to assess the quality of each sample. A sub-region of the cytochrome b gene on the mtDNA was subsequently amplified and run on a MegaBACE 1000 DNA analysis system.

The sequences from each hair sample were compared to control sequences from Gene Bank for Canada Lynx (*Lynx canadensis*), Bobcat (*L. rufus*), American Beaver (*Castor canadensis*), Cougar, Red Fox

(*Vulpes vulpes*), White-tailed Deer, and Humans (*Homo sapiens*).

### Historical data, recent Cougar sightings, and distribution of North American Elk and White-tailed Deer

Cougar trapping records from 1919 to 1984, as well as more recent sighting reports for Ontario (Rosette 2011) and adjacent provinces and states, were gleaned from the literature (Wright 1953; Nero and Wrigley 1977; Anonymous 1987; Gerson 1988; Cumberland and Dempsey 1994; Stocek 1995; Swanson and Rusz 2006) and compared to White-tailed Deer and North American Elk distribution across Ontario (Seton 1909, 1927; Bryant and Maser 1982; Baker 1984).

## Results

### Hair morphology

We collected a total of 298 hairs from 51 hair snares: 180 were analyzed. The other 118 hairs were either under-fur or fragments of guard hairs. A total of 8 Cougar hairs from 5 hair snares (3 from the mixed deciduous-conifer site and 2 from the old field site) were identified by their scale pattern. Seventy-six hairs from the old field site, which was associated with residential housing, were identified as Domestic Cat (*Felis catus*) and 21 as Domestic Dog (*Canis familiaris*). Thirty-one Deer Mouse (*Peromyscus maniculatus*), 8 American Black Bear (*Ursus americanus*), 4 Fisher (*Martes pennanti*), 3 Canada Lynx, and 2 Coyote (*C. latrans*) hairs were also identified. Deer Mouse and Fisher hairs were found at both sites. American Black Bear and Lynx hairs were found only at the mixed deciduous-conifer site, and Coyote hair was found only at the old field site. The 8 potential Cougar hairs were subsequently subjected to DNA testing to confirm identity.

### DNA analysis

Sequence comparison and phylogenetic analysis revealed that, of the 11 samples collected from across Ontario, scat sample no. 5 collected in 2004 from the Port Colborne/Wainfleet Bog area (79°W, 43°N) had low sequence divergence from and a statistically significant grouping with the control sequence for Cougar (Figure 1). A sequence comparison and phylogenetic analysis of the 10 other samples collected by volunteers did not reveal Cougar DNA. Scat samples 6, 8, and 10 from across Ontario indicated that the mtDNA originated from canids, the sample labelled no. 1 originated from American Beaver, and sample no. 3 originated from Lynx. Hair samples 2, 4, 7, 9, and 11 did not generate the quality or quantity of mtDNA to allow analysis. Due to a laboratory mix-up, none of the 8 hairs identified morphologically as Cougar from the Sudbury region hair snare study generated the quality of mtDNA required to identify them and unfortunately all were destroyed in the process.

Control Sample
GTGGCTATGACCGCAAATAGTAGTATGATTCCAATATTTTCATGTTTCCGAGAAG <b>GTATAGGAGCC</b> CATAATATATTC CTCGTCCCACGTGCATGTATAGGCAGATAAAGAATA
Wild Sample from Port Colborne/Wainfleet Bog
GTGGCTATGACCGCAAATAGTAGTATGATTCCAATATTTTCATGTTTCCGAGAAG <b>ATGTAGATGCC</b> CATAATATATTC CTCGTCCCACGTGCATGTATAGGCAGATAAAGAATA

FIGURE 1. Sequence comparison and phylogenetic analysis revealed that sample no. 5 collected in 2004 from the Port Colborne/Wainfleet Bog area (79°W, 43°N) had low sequence divergence from and a statistically significant grouping with the control sequence for Cougar (differences in the base sequence between the control and wild sample are in bold).

## Discussion

The mtDNA finding confirms that at least one Cougar was present in the wild in southern Ontario in association with the Niagara Escarpment, which may have been the epicentre of the original range of Cougar in Ontario. The potential Cougar hair samples identified by scale pattern further suggest that Cougar occur in the Sudbury region. Both these results from this study have been previously cited by Rosatte (2011) and further support his data on tracks, scats and photographs that Cougars reside in Ontario.

Although it was thought that an eastern and western subspecies of the Cougar existed (Seton 1909, 1927), recent genetic work by Culver et al. (2000) has determined that only a single subspecies, *P. concolor cougar*, existed north of Mexico. We do not know the origin (e.g., wild resident, disperser, or released captive) of the Cougar identified from sample no. 5 or if it is of this subspecies. However, if there is a breeding population of Cougars in Ontario from whatever genetic source, we need to understand their demographics and ecological impact.

Trapping records between 1919 and 1984 indicated that not a single Cougar pelt was sold in Ontario or the rest of eastern Canada, with the exception of Quebec, which recorded 8 animals sold in 1919–1920 (Anonymous 1987). Similarly, no Cougars were reported in the trapping records of Manitoba, Michigan, New York, Pennsylvania, Ohio, and Minnesota (all adjacent to Ontario) during this same period (Anonymous 1987). In contrast, in the west, 7 animals were recorded from the Northwest Territories, 61 animals were recorded from Alberta, and 3,690 Cougar skins were sold from British Columbia during the same period (Anonymous 1987).

Cougars were largely absent and likely extirpated from Ontario and eastern Canada by the early 1900s. The last Cougar shot in Ontario was in 1884 near Creemore (43°N, 79°W), approximately 20 km west of Barrie, Ontario, and just east of the Niagara Escarpment (Joe Belanger, personal communication).

Historically, the primary prey of the Cougar, White-tailed Deer and North American Elk, were confined to southern Ontario and did not occur north of the Great

Lakes–St. Lawrence Ecotone (Baker 1984). Numerous records and archeological sites in southern Ontario contained artifacts made from White-tailed Deer and North American Elk (Taber et al. 1982; Patrick Julig, personal communication). Evidence of North American Elk has not been found in any northern Ontario sites, and White-tailed Deer appeared only in recent historical times, according to Laurentian University anthropologists, Patrick Julig (personal communication) and biologists (Peterson 1966; Taber et al. 1982).

Prior to extirpation, North American Elk ranged throughout south-central Ontario and Quebec (Peterson 1966); however, by the late 1800s, agriculture and hunting had significantly reduced North American Elk populations (Smith 1901; Seton 1927; Ranta 1979). Between 1893 and 1910, only a few kills and sightings of North American Elk were recorded from North Bay, Ontario (Seton 1927); Elk Lake, Ontario (Bosveld 1996); and Grand Lac Victoria, Quebec (Seton 1927). Gerson (1988) recorded recent Cougar sightings as far north as the Hudson Bay lowlands, including most of the Precambrian Shield area.

Although North American Elk were extirpated from Ontario in the late 1800s, White-tailed Deer moved north in association with clear-cutting and homesteading, and the data suggest that Cougar have recently expanded their range in association with their primary prey, as has been suggested in Manitoba (Nero and Wrigley 1977).

A review of more recent data indicates that Cougars have been confirmed in New Brunswick (Wright 1953; Cumberland and Dempsey 1994; Anonymous 1987), Manitoba (Nero and Wrigley 1977), Ontario (Rosatte 2011) and adjacent eastern states (Wright 1953; Nero and Wrigley 1977; Cumberland and Dempsey 1994; Stoeck 1995; Swanson and Rusz 2006). These data indicate that Cougars may be returning to eastern Canada, although the sources of these animals remain unclear. Nevertheless, sightings of Cougars with kittens and reports of young animals suggest that a breeding population exists in Ontario and adjacent provinces (Wright 1953; Nero and Wrigley 1977; Gerson 1988; Rosette 2011).

The findings from this study (1) confirm the presence of a Cougar occurring in the wild in Ontario, (2)



provide circumstantial evidence from Cougar sightings (Gerson 1988; Rosatte 2011) and hair morphology that a breeding population of Cougar exists in Ontario, and (3) support the hypothesis that the distribution of the Cougar has moved northward in recent times, approximating the line of continuous clear-cut, as have their primary prey, the White-tailed Deer. Further studies of Cougar presence in the province are warranted.

### Acknowledgements

Funding was provided by Laurentian University and technical support was furnished by Michael N. Hall (Ontario Ministry of Natural Resources), Dr. Josef Hamr (Cambrian College), Jesse N. Popp (Laurentian University), Dr. Paul J. Wilson (Trent University), the Ontario Puma Foundation, and the Natural Resources DNA Profiling and Forensic Centre, Peterborough, Ontario.

### Literature Cited

- Adorjan, A. S., and G. B. Kolenosky.** 1969. A manual for the identification of hairs of selected Ontario mammals. Wildlife Research Report 90, Ontario Ministry of Natural Resources. 64 pages.
- Anderson, C. Jr., F. Lingzey, K. H. Knopf, M. G. Jalkotzy, and M. S. Boyce.** 2010. Cougar management in North America. Pages 41–56 in *Cougar: Ecology and Conservation*. Edited by M.G. Hornocker and S. Negri. University of Chicago Press, Chicago, Illinois.
- Anonymous.** 1987. Furbearer harvests in North America, 1600–1984. Edited by M. Novak, M. E. Obbard, J. G. Jones, R. Newman, A. Booth, A. J. Satterthwaite, and G. Linscombe. Wildlife Branch, Ontario Ministry of Natural Resources, Toronto, Ontario. 270 pages.
- Baker, R. H.** 1984. Origin, classification and distribution. Pages 1-72 in *White-tailed Deer Ecology and Management*. Edited by L. K. Halls. Stackpole Books, Harrisburg, Pennsylvania.
- Belden, R. C., and D. S. Maehr.** 1986. Florida panther food habits. Annual Performance Report, Florida Game and Fish Commission, Tallahassee, Florida.
- Bosveld, H. J.** 1996. A review of documented occurrences of native elk (*Cervus elaphus*) in Ontario. Parks Canada, Ontario Region, Cornwall, Ontario.
- Bryant, L. D., and C. Maser.** 1982. Classification and distribution. Pages 1–59 in *Elk of North America: Ecology and Management*. Edited by J. W. Thomas and D. E. Towell. Stackpole Books, Harrisburg, Pennsylvania.
- Culver, M., W. E. Johnson, J. Pecon-Slattery, and S. J. O'Brien.** 2000. Genomic ancestry of the American puma (*Puma concolor*). *Journal of Heredity* 91: 186–197.
- Cumberland, R. E., and J. A. Dempsey.** 1994. Recent confirmation of a cougar, *Felis concolor*, in New Brunswick. *Canadian Field-Naturalist* 108: 224–226.
- Dixon, K. R.** 1982. Mountain Lion. Pages 711–727 in *Wild Mammals of North America: Biology, Management, Economics*. Edited by J. A. Chapman and G. A. Feldhamer. Johns Hopkins University Press, Baltimore, Maryland.
- Garcia Alaniz, N.** 2009. Field and genetic methodologies for the study of felids in the Selva Lacandona, Chiapas, Mexico: a non-invasive approach. Ph.D. thesis, Laurentian University, Sudbury, Ontario.
- Garcia Alaniz, N., E. J. Naranjo, and F. F. Mallory.** 2010a. Human-felid interactions in three mestizo communities of the Selva Lacandona, Chiapas, Mexico: benefits, conflicts and traditional uses of species. *Human Ecology* 38: 451–457.
- Garcia Alaniz, N., E. J. Naranjo, and F. F. Mallory.** 2010b. Hair-snares: a non-invasive method for monitoring felid populations in the Selva Lacandona, Mexico. *Tropical Conservation Science* 3: 403–411.
- Gersen, H. B.** 1988. Cougar, *Felis concolor*, sightings in Ontario. *Canadian Field-Naturalist* 102: 419–424.
- Gleason, H.A., and A. Cronquist.** 1964. The natural geography of plants. Columbia University Press, New York. 420 pages.
- Hornocker, M. G.** 1970. An analysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. *Wildlife Monographs* 21: 1–39.
- Nero, R. W., and R. E. Wrigley.** 1977. Status and habits of the cougar in Manitoba. *Canadian Field-Naturalist* 91: 28–40.
- Peterson, R.L.** 1966. The mammals of eastern Canada. Oxford University Press, Toronto, Ontario. 465 pages.
- Ranta, B.** 1979. Range and habitat relationships of wapiti (*Cervus canadensis*) in the Burwash-French River area of Ontario. M.Sc. thesis, Carleton University, Ottawa, Ontario. 205 pages.
- Rosatte, R.** 2011. Evidence to support the presence of Cougars (*Puma concolor*) in Ontario, Canada. *Canadian Field-Naturalist* 125: 116–125.
- Ross, P. I., M. G. Jalkotzy, and P-Y. Daoust.** 1995. Fatal trauma sustained by cougars, *Felis concolor*, while attacking prey in southern Alberta. *Canadian Field-Naturalist* 109: 261–263.
- Rowe, J. S.** 1972. Forest regions of Canada. Canadian Forest Service Publication #1300.
- Seidensticker, J., M. G. Hornocker, W. V. Wiles, and J. P. Messick.** 1973. Mountain lion social organization in the Idaho Primitive Area. *Wildlife Monographs* 35: 1–60.
- Seton, E. T.** 1909. Life histories of northern mammals. Volume 1. Chas. Scribner and Sons. New York. New York. 673 pages.
- Seton, E. T.** 1927. Lives of game animals. Volume III, Part 1. Doubleday, Doran and Company Inc., Garden City, New Jersey. 409 pages.
- Smith, L. H.** 1901. The extinction of the elk in Ontario. *Ottawa Naturalist* 11(5): 95–97.
- Stocek, R. F.** 1995. *Felis concolor* in the Maritime provinces. *Canadian Field-Naturalist* 109: 19–22.
- Swanson, B. J., and P. J. Rusz.** 2006. Detection and classification of cougars in Michigan using low copy DNA sources. *American Midland Naturalist* 155: 363–372.
- Taber, R. D., K. Raedeke, and D. A. McCaughran.** 1982. Population characteristics. Pages 279–298 in *Elk of North America: Ecology and Management*. Edited by J. W. Thomas and D.E. Towell. Wildlife Management Institute, Stackpole Books, Harrisburg, Pennsylvania.
- Weaver, J. L., P. Wood, D. Peatkau, and L. L. Laack.** 2005. Use of scented hair snares to detect ocelots. *Wildlife Society Bulletin* 33: 1384–1391.
- Wright, B. S.** 1953. Further notes on the panther in the north-east. *Canadian Field-Naturalist* 67: 12–28.

Received 21 March 2011

Accepted 19 December 2012

## First Record of Parasites from Cougars (*Puma concolor*) in Manitoba, Canada

O. K. DARE<sup>1,3</sup> and W. G. WATKINS<sup>2</sup>

<sup>1</sup>Centre for Communicable Diseases and Infection Control, Public Health Agency of Canada, Ottawa, Ontario K1A 0K9 Canada

<sup>2</sup>Wildlife Branch, Manitoba Conservation and Water Stewardship, Box 24, 200 Saulteaux Crescent, Winnipeg, Manitoba R3J 3W3 Canada

<sup>3</sup>Corresponding author email: yemisi.dare@gmail.com

Dare, O. K., and W. G. Watkins. 2012. First record of parasites from Cougars (*Puma concolor*) in Manitoba, Canada. *Canadian Field-Naturalist* 126(4): 324–327.

Cougars (*Puma concolor*) are a rare sighting in Manitoba. This is the first report on Cougar parasites in Manitoba and the first record of *Taenia omissa* for the province. These data provide an important baseline that will inform future research on parasite profiles and predator–prey interactions between these large carnivores and other wildlife in the province.

**Key Words:** helminths, cestode, tapeworms, nematode, roundworms, Cougar, *Puma concolor*, *Taenia omissa*, *Toxocara cati*, Manitoba.

The Cougar (*Puma concolor*) is a rare species in Manitoba; only one confirmed sighting per year has been recorded since 2001. Historical accounts are few, but it seems likely that the range of the species extended to the north as far as southern Manitoba at the time of European settlement. Cougars were generally assumed to have been extirpated from the province until 1973, when an adult male Cougar was shot by a landowner. This event and a review of well-documented sightings established the Cougar as being resident (Nero and Wrigley 1977). However, 31 years passed before another dead Cougar was turned over to wildlife management authorities. In 2004, an adult female Cougar was also shot by a landowner. One month later and 97 km away, an adult male was caught by a licensed trapper in a power snare set for Coyotes (*Canis latrans*). The propensity to scavenge makes Cougars susceptible to baited traps set for Gray Wolves (*Canis lupus*) or Coyotes (Knopff et al. 2010), and a fourth Cougar (the third adult male), was discovered in a trap set for Coyotes close to the Canada–U.S. border south of Boissevain in January 2011.

The ratio of male to female Cougars that have been killed in Manitoba and the lack of any confirmed sightings of kittens over the last 10 years make it unclear whether the few animals found in recent years are members of a resident cryptic population or are dispersing into or through the province from populations elsewhere. The nearest known breeding population is found in North Dakota, and a recent evaluation of potential dispersal corridors in the U.S. Midwest noted several that potentially connect the Badlands of North Dakota to southern Manitoba (LaRue and Nielsen 2008). There is little evidence to suggest that Cougars in Manitoba may have come from the Cypress Hills

population on the Alberta–Saskatchewan border to the west.

Although the source of the few Cougars observed in Manitoba remains unknown, the identification of their associated parasites provides a basis for further investigation into where these Cougars have been, that is, host range dispersal and possible source of intermediate host species. We report our observations of parasites found in the Cougar caught in January 2011 and, within the limits of our single sample, discuss our findings.

### Methods

The young male trapped in 2011 weighed 65.9 kg, making it the heaviest Cougar reported from Manitoba in the modern era. Its age was based on dentition and coat, and was estimated to be 3–5 years. It was skinned and the carcass was kept frozen until necropsy. The hide was preserved for display at the Manitoba Museum. Weights of the male and female adult Cougars killed in 2004 were 52.2 kg and 41.3 kg, respectively; the weight of the male killed in 1973 was 41.3 kg (Nero and Wrigley 1977).

A gross pathological examination of the carcass of the young male caught in 2011 for body condition and tissue lesions was followed by a closer examination of organs, fat, and musculature for helminth (parasitic worm) infection by sectioning pieces and pressing between plates of glass. The lungs were cut open with scissors along air passages. The eyes and brain were not examined. The intestines were sliced open and gently rinsed into a basin with warm water. The wash was then passed through two sieves of different mesh sizes to collect the contents. Helminths were found in only the small intestine.

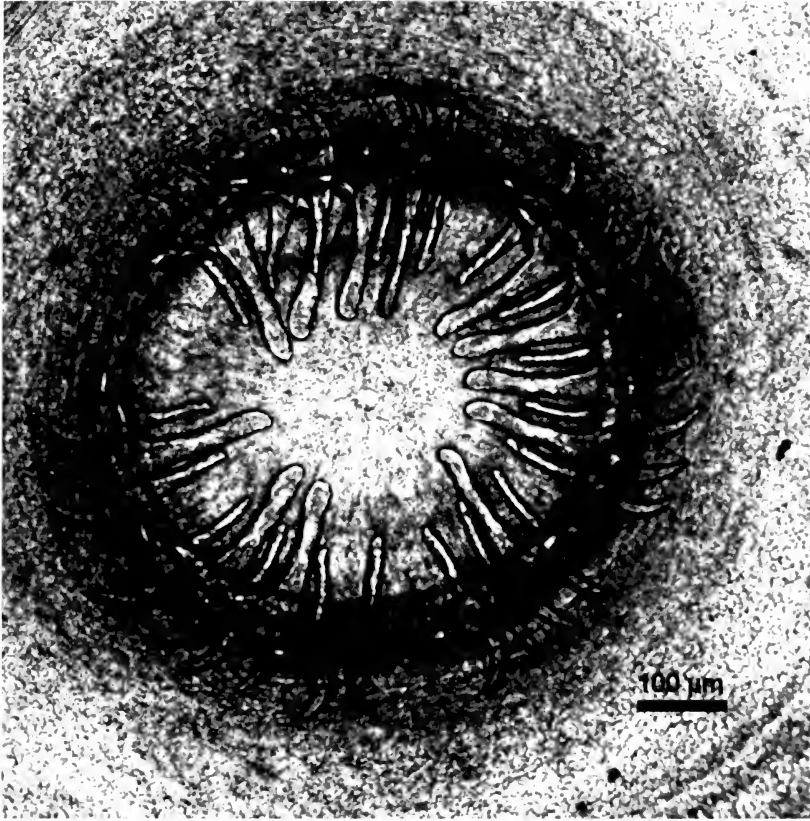


FIGURE 1. *En face* view of slide-mounted rostellar hooks of *Taenia omissa* recovered from the gastrointestinal tract of a Cougar (*Puma concolor*) from Manitoba, Canada (magnification 20 $\times$ ). Large hooks ranged in size from 246.5 to 276.0  $\mu\text{m}$ ; small hooks ranged from 177.5 to 221.8  $\mu\text{m}$ .

Cestodes (tapeworms) were relaxed in physiological saline for 6 hours during transportation to another wet lab for closer examination, and measurements of length and width for each worm were taken. The cestodes were then processed using standard methods of fixation in Bouin's fixative (picric acid, acetic acid, formaldehyde) and stored in 70% ethanol.

Nematodes (roundworms) were placed in 95% ethanol during transportation to the wet lab, then transferred to 70% glycerol solution (glycerol: 70% ethanol) to clear within 10 hours of collection.

## Results

Fifteen adult cestodes were found, ranging from 139 mm to 694 mm in length (mean 293.9 mm, SE 4.0). Strobila widths, measured at the widest (most mature) proglottids, ranged from 10 to 11 mm (mean 10.5 mm, SE 0.11). The rostellum of each cestode was sliced off, cleared with a few drops of xylene, placed *en face* onto a microscope slide, and mounted under a coverslip to observe the hooks (Figure 1). The hooks were measured with the use of a microscope eyepiece

graticule at 20 $\times$  magnification. Blade and handle lengths were also measured for each hook, as described by Riser (1956) (Table 1). The shape and size of the hooks and strobilar widths are consistent with those reported for *Taenia omissa* from North American felids (Riser 1956; Rausch 1981; Loos-Frank 2000; Jones and Pybus 2001). Four of the 15 worms had lost their rostellar hooks and thus the species could not be confirmed for these specimens; however, the characteristic width and shape of the strobila distinguished these worms from other similar species, such as *Taenia rileyi* (Rausch et al. 1983). Reference specimens were deposited in the Manitoba Museum (accession numbers TMM 54921 and 54922).

Seven nematodes were found and identified by their characteristically prominent cervical lateral alae as *Toxocara cati* (Fisher 2003). Five of these worms were identified as females and two as males possessing characteristic digitiform tails with spicules (Eberhard and Alfano 1998). Reference specimens have been deposited in the Manitoba Museum (accession numbers TMM 54923 and 54924).

TABLE 1. Rostellar hook length measurements for *Taenia omissa*. Measurements include whole hook, blade, and handle lengths for small and large hooks from 11 cestodes. Mean, standard error, and range of lengths are reported.

<i>Taenia omissa</i> hooks	Whole length ( $\mu\text{m}$ )	Blade ( $\mu\text{m}$ )	Handle ( $\mu\text{m}$ )
Large ( $n = 37$ )	259.7 $\pm$ 0.9 (246.5–276.1)	87.3 $\pm$ 1.0 (64.1–98.6)	172.4 $\pm$ 1.4 (162.7–197.2)
Small ( $n = 117$ )	193.7 $\pm$ 0.9 (177.5–221.8)	75.3 $\pm$ 0.4 (64.1–83.8)	118.5 $\pm$ 1.1 (93.7–152.8)

In comparison to the two dead Cougars examined in 2004, the 2011 specimen was relatively free of pathologies. Scarring consistent with past blunt trauma was evident on the internal organs of both animals killed in 2004. The male exhibited scar tissue on the right lung, the pancreas, and along the duodenum. The female's injuries were more severe. Scar tissue was evident on her spleen; her diaphragm, although healed, had been perforated. A fold of mesenteric membrane protruded through the perforation, held tightly in place by scar tissue. Breathing must have been compromised for some time following the injury, and the presence of old North American Porcupine (*Erethizon dorsatus*) quills in the front legs and throat area of the animal suggest that she may have compensated for an inability to run down larger prey by hunting small mammals. Specimens believed to be *Taenia omissa* and *Toxocara cati* were retrieved from both animals (January 22, 2005), but this information cannot be verified, as notes and voucher specimens have been lost in a fire (Lane Graham, personal communications, Jan–Mar 2005).

## Discussion

This first record of Cougar parasites for Manitoba is consistent with helminth species and burdens previously documented for other Cougars in North America (see Rausch et al. 1983). *Toxocara cati* is often found in wild felids and has been reported in Cougars in the U.S.A. (Rausch et al. 1983). Infection by this nematode occurs through the ingestion of eggs or second stage larvae (L2) in tissues of a number of small mammal prey species (Despommier 2003).

Cougars are believed to be exclusive definitive hosts of *Taenia omissa*, and this cestode has been recovered from Cougars across their full range, from British Columbia and Alberta, as well as from several states along the west coast of the U.S.A. and Colombia (Rausch 1981; Rausch et al. 1983; Waid and Pence 1988). White-tailed Deer (*Odocoileus virginianus*) and Mule Deer (*Odocoileus hemionus*) are the intermediate hosts for *Taenia omissa* (Forrester and Rausch 1990; Pybus 1990). Analysis of the intestinal contents of the necropsied Cougar revealed White-tailed Deer hair remains identified to species by experts from the Manitoba Museum. High densities of White-tailed Deer populate southwestern Manitoba (Manitoba Conservation 2007), and it is possible that the Cougar acquired infections from local White-tailed Deer populations; however, as discussed below, the presence of intermediate

hosts may be only one factor in acquisition of infection. Although Mule Deer are found in southwestern Manitoba, they are extremely rare and are listed as a threatened species under the Manitoba Endangered Species Act. The Wildlife Branch of Manitoba Conservation receives a handful of reports of sightings (4 or 5) per year, but exact numbers of Mule Deer are unknown.

Parasites can serve as a useful surrogate for determining ecological and trophic linkages among host species (Hoberg and Mcgee 1982; Hoberg 2010). The transmission of parasites is often intimately linked to trophic interactions among predator and prey species, and parasites with complex lifecycles are most often transmitted from one host to another along a food chain. For parasites that infect few host species, high densities and frequent interaction among hosts are required to ensure continued transmission (Torchin et al. 2003; Torres et al. 2006; Hoberg 2010). Studies have shown that high densities of hosts can relate to the accumulation of parasite species (Morand and Poulin 1998). Furthermore, hosts, including large carnivores that live in low densities within small geographical ranges, have been found to be depauperate in parasite species (Torres et al. 2006). Thus, particularly for host-specific species, parasite survival is intimately linked to the presence and density of unique host species, and the loss of a single host species in the chain of a parasite's lifecycle may lead to local extirpation.

This intimate association offers the opportunity to use parasite species as indicators of the presence of host species that comprise the lifecycle and also provides a coarse measure of the density of definitive and intermediate hosts. Such information is particularly valuable for species that are cryptic or otherwise difficult to study. Thus, one explanation for the observed low parasite species richness in this Cougar could be the presence of only a small resident population of Cougars with limited ranges of movement.

Loss of parasite species may also occur during extra-range host dispersal, in which host movement into new habitats presents conditions that may not be conducive for the continuation of host-specific lifecycles (see Torchin et al. 2003; Colautti et al. 2004). Thus, the low parasite richness observed in this Cougar may relate to "parasite release," whereby hosts lose parasites associated with enzootic ranges and fail to acquire new parasites in newly established ranges. Hosts may also lose parasites from home ranges and acquire new parasites from the newly established ranges (Hoberg and

Mcgee 1982; Torchin et al. 2003). These two latter mechanisms may or may not be dependent on the density of the host species.

We acknowledge that this is a single sample and we thus cannot draw any conclusions concerning the mechanisms that would explain our findings. Further research on any future Cougars in Manitoba and an examination of White-tailed Deer in the vicinity are needed to confirm the region as a potential source of infection.

This report provides an important foundation for parasite research on Cougars in Manitoba and intermediate hosts, and it contributes to the general body of knowledge on parasite infections in this cryptic felid species.

### Acknowledgements

We are grateful to Lane Graham for providing some historical context for previously examined Cougars in the province and for his directions on the technical aspects of parasite identification. We thank Mark Swendrowski for the initial pathological examination of the carcass and the Biology Department at Brandon University and Bernadette Ardelli for the use of laboratory space and a departmental microscope for the examination and preservation of helminth specimens. Four anonymous referees made helpful comments on earlier versions of this manuscript. Financial support for this study was provided by Manitoba Conservation, Manitoba Agriculture, Food and Rural Initiatives (MAFRI), and by the Natural Sciences and Engineering Research Council (NSERC) of Canada.

### Literature Cited

Colauti R. I., A. Ricciardi, I. A. Grigorovich, and H. J. MacIsaac. 2004. Is invasion success explained by the enemy release hypothesis? *Ecology Letters* 7: 721–733.

Despommier, D. 2003. Toxocarasis: clinical aspects, epidemiology, medical ecology, and molecular aspects. *Clinical Microbiology Reviews* 16: 265–272.

Eberhard, M. L., and E. Alfano. 1998. Adult *Toxocara cati* infections in U.S. children: report of four cases. *American Journal of Tropical Medicine and Hygiene* 59: 404–406.

Forrester, D. J., and R. L. Rausch. 1990. Cysticerci (Cestoda: Taeniidae) from White-tailed Deer, *Odocoileus virginianus*, in southern Florida. *Journal of Parasitology* 76: 583–585.

Fisher, M. 2003. *Toxocara cati*: an underestimated zoonotic agent. *Trends in Parasitology* 19: 167–170.

Hoberg, E. P. 2010. Invasive processes, mosaics and the structure of helminth parasite faunas. Review scientifique et technique [Scientific and Technical Review]. Office

International des Epizooties [World Organisation for Animal Health. Paris] 29 (2): 255–272.

- Hoberg, E. P., and S. G. Mcgee. 1982. Helminth parasitism in raccoons, *Procyon lotor hirtus* Nelson and Goldman, in Saskatchewan. *Canadian Journal of Zoology* 60: 53–57.
- Jones, A., and M. J. Pybus. 2001. Taeniasis and echinococcosis. In *Parasitic Diseases of Wild Mammals*. Edited by W. M. Samuel, M. J. Pybus, and A. A. Kocan. Second edition. Iowa State University Press, Ames, Iowa.
- Knopff, K. H., A. A. Knopff, and M. S. Boyce. 2010. Scavenging makes cougars susceptible to snaring at wolf bait stations. *Journal of Wildlife Management* 74(4): 644–653.
- LaRue, M. A., and C. K. Nielsen. 2008. Modelling potential dispersal corridors for cougars in midwestern North America using least-cost path methods. *Ecological Modelling* 212: 372–381.
- Loos-Frank, B. 2000. An up-date of Verster's (1969) 'Taxonomic revision of the genus *Taenia* Linnaeus' (Cestoda) in table format. *Systematic Parasitology* 45: 155–183.
- Manitoba Conservation. 2007. Five Year Report on the Status of Wildlife to the Legislature for the period ending March 31, 2007. Manitoba Conservation. Wildlife and Ecosystem Protection Branch. Winnipeg, Manitoba. 67 pages.
- Morand, S., and R. Poulin. 1998. Density, body mass and parasite species richness of terrestrial mammals. *Evolutionary Ecology* 12: 717–727.
- Nero, R. W., and R. E. Wrigley. 1977. Status and habits of the cougar in Manitoba. *Canadian Field-Naturalist* 91(1): 28–40.
- Pybus, M. J. 1990. Survey of hepatic and pulmonary helminths of wild cervids in Alberta, Canada. *Journal of Wildlife Diseases* 26: 453–459.
- Rausch, R. L. 1981. Morphological and biological characteristics of *Taenia rileyi* Loewen, 1929 (Cestoda: Taeniidae). *Canadian Journal of Zoology* 59: 653–666.
- Rausch, R. L., C. Maser, and E. P. Hoberg. 1983. Gastrointestinal helminths of the cougar, *Felis concolor* L., in north-eastern Oregon. *Journal of Wildlife Diseases* 19: 14–19.
- Riser, N. W. 1956. The hooks of taenioid cestodes from North American felids. *American Midland Naturalist* 56: 133–137.
- Torchin, M. E., K. D. Lafferty, A. P. Dobson, V. J. McKenzie, and A. M. Kuris. 2003. Introduced species and their missing parasites. *Nature* 421: 628–630.
- Torres, J., J. Miquel, J.-C. Casanova, A. Riba, C. Feliu, and S. Morand. 2006. Endoparasite species richness of Iberian carnivores: influences of host density and range distribution. *Biodiversity and Conservation* 15: 4619–4632.
- Waid, D. D., and D. B. Pence. 1988. Helminths of mountain lions (*Felis concolor*) from southwestern Texas, with a redescription of *Cylicospirura subaequalis* (Molin, 1860) Vevers, 1922. *Canadian Journal of Zoology* 66: 2110–2117.

Received 15 November 2011

Accepted 16 March 2012

## Evidence for the Collection of a Reddish Egret (*Egretta rufescens*) in Nova Scotia During the 19<sup>th</sup> Century and its Association with the McCulloch Collection of Birds

ERIC L. MILLS

Department of Oceanography, Dalhousie University, 1355 Oxford Street, P.O. Box 15000, Halifax, Nova Scotia B3H 4R2  
Canada; email: e.mills@dal.ca  
History of Science and Technology Programme, University of King's College, 6350 Cobourg Road, Halifax, Nova Scotia  
B3H 2A1 Canada

Mills, Eric L. 2012. Evidence for the collection of a Reddish Egret (*Egretta rufescens*) in Nova Scotia during the 19<sup>th</sup> century and its association with the McCulloch collection of birds. *Canadian Field-Naturalist* 126(4): 328–332.

Based on several lines of evidence, a specimen of an adult white-morph Reddish Egret (*Egretta rufescens*) now on display in the Macdonald Museum of the Annapolis Valley Historical Society in Middleton, Nova Scotia, probably originated from the 19<sup>th</sup>-century Nova Scotian bird collections of Thomas McCulloch senior (1776–1843) and his son Thomas (1809–1865), likely between 1838 and 1865. The only other records of this species in Canada are sightings in Nova Scotia in 1965 and 1966. This may therefore be the first specimen evidence of the species in Nova Scotia and Canada. Historical evidence links the specimen with the McCulloch collection of birds, part of which has survived at Dalhousie University.

Key Words: Reddish Egret, *Egretta rufescens*, Annapolis Valley Historical Society Macdonald Museum, Thomas McCulloch senior, Thomas McCulloch junior, McCulloch collection of birds, Nova Scotia.

The least abundant of North American herons, the Reddish Egret (*Egretta rufescens*) occurs mainly in saltwater habitats of southern Florida, the coast of the Gulf of Mexico, Baja California, other parts of Mexico, part of the West Indies, and parts of northern South America (Dunn and Alderfer 2011, page 116). It ranges north sparsely as a vagrant to southern New England, but it has not been recorded in Maine or New Brunswick (Lowther and Paul 2002; Maine Bird Checklist 2007\*; New Brunswick Rare Birds Committee 2011\*; Derek Lovitch, personal communication, 25 July 2012). There have been two sight records in Nova Scotia (the only ones in Canada) by competent observers, the first a dark-morph adult at Clam Bay, Halifax County, September 5 and 6, 1965, and the second a white-morph bird (typical of West Indian populations) at Canso, Guysborough County, in November 1966 (Tufts 1986, pages 63–64; McLaren 2012, pages 80–81). Neither was accepted by Godfrey, (1986), who carefully followed reports from Nova Scotia.

In June 2012, while visiting the Macdonald Museum of the Annapolis Valley Historical Society in Middleton, N.S., during a search for information on 19<sup>th</sup>-century bird collections in Nova Scotia, I found a specimen of a white-morph adult Reddish Egret on display (Figure 1) with common Nova Scotian species. Somewhat worn and dirty, and showing some signs that bill and legs had been retouched, it is an adult in breeding plumage.

According to a label in the cases, the bird specimens in the Macdonald Museum were transferred there from the Nova Scotia Museum (now the Nova Scotia Museum of Natural History) in Halifax. All are apparently

of 19<sup>th</sup>-century provenance, although the three cases and diorama views are of more recent vintage, dating from after the opening of the Macdonald Museum in 1982, probably from the 1990s, when the specimens came to Middleton (Andrew Hebda and Sherry Griffin, personal communications; Fred Scott, personal communication, 23 August 2012). The other specimens are of species found commonly in Nova Scotia, making the Reddish Egret unique and of unusual interest because of its rarity.

What is the evidence that it came from Nova Scotia and by whom and when might it have been collected?

### *History of collections*

Andrew Hebda, zoologist at the Nova Scotia Museum of Natural History, remembers seeing the specimens in the Macdonald Museum in 1996 in 19<sup>th</sup>-century cases. Moreover, Hebda recalls the original cases (which have not been located) being similar to cases still in the Nova Scotia Museum of Natural History that came from the collections of Thomas McCulloch (1776–1843) and his son Thomas (1809–1865).

The elder Thomas McCulloch came to the New World as a Free Church minister late in 1803. He settled in Pictou, Nova Scotia, taking on a role as one of the preeminent educators and religious controversialists in 19<sup>th</sup>-century Nova Scotia (W. McCulloch 1920; Bugey and Davies 1988; Whitelaw 1985). A school that he established in 1806 to train Free Church ministers had evolved by 1818 into Pictou Academy. McCulloch's educational philosophy has been called "liberal," indicating that he envisioned a broad education, including physical and natural sciences in addi-

tion to languages, humanities and religion, as a prerequisite to a moral and socially responsible life (Harvey 1943; Wood 1987). In this, birds played an important role.

By 1821, the educational program at Pictou Academy included natural history field trips, which provided specimens for a museum. McCulloch's first collections appear to have been of insects, some of which he sent to his Scottish alma mater, Glasgow University, and to British scientific societies. He maintained an active correspondence with collectors and naturalists in Scotland and northern England, exchanging specimens for collecting equipment and preserving materials (Whytock 1999), and about 1824 he began a collection of Nova Scotian birds that was housed in an expanded museum in the Academy.

By the early 1830s, the senior McCulloch, aided by his son Thomas, who had learned taxidermy, had become famous for his bird collection, which was regarded then as one of the best in private hands in the New World. Audubon, returning from a summer on the north shore of the Gulf of St. Lawrence ("Labrador") in 1833, made a point of visiting the McCullochs in Pictou and carried away some specimens with him (Audubon 1897, pages 435–444; W. McCulloch 1920, page 148; Lewis 1933, pages 164–165). The Audubon connection was maintained, especially by the younger Thomas, who corresponded with and sent specimens to Audubon until the latter's death in 1851. But the collection in Pictou was valuable, and McCulloch senior was straining to find funds to maintain his struggling school. Thomas junior took much of the collection to Britain and sold it there in 1835, mainly to Edward Stanley, 13th Earl of Derby, whose collections established the Derby Museum in Liverpool (now World Museum Liverpool). A few recognizable specimens from the first McCulloch collection still exist in Liverpool (Whytock 1999, pages 45–47).

#### *The surviving McCulloch collection*

When Thomas McCulloch senior was appointed first President of Dalhousie College (now University) in 1838, he began a new bird collection, aided again by his son Thomas. William McCulloch (1811–1895), another son, reported that in 1841 both Thomas McCullochs were hard at work collecting for a new museum (W. McCulloch 1920), and about 1842 the elder McCulloch went on a collecting expedition to Sable Island (no documentary evidence apart from a family letter has been found of this). When he died in early September 1843, he had just finished a collecting expedition to western Nova Scotia.

The development of the second McCulloch collection becomes unclear after 1843 because the younger Thomas McCulloch, who never married, seems to have left no papers. Nonetheless, he continued to collect, and at the time of his death in 1865 had an even more substantial bird collection, mainly of Nova Scotian ori-

gin but including some European specimens (primarily from Scotland) acquired by his father. It was probably housed in Dalhousie College, where from 1863 until his death Thomas junior was Professor of Natural Philosophy. According to the terms of his will, in 1865 it became the property of his brother William, a Presbyterian clergyman in Truro, Nova Scotia. In 1884, William McCulloch offered the McCulloch collection to Dalhousie College, to which it was formally transferred in 1887. There the collection remains, housed since 1971 in the McCulloch Museum of the Biology Department in the Dalhousie University Life Sciences Centre.

Thomas McCulloch senior had hoped to make his last collection the basis of a provincial museum in Halifax. When this did not happen and the collection came into the hands of the more reclusive Thomas junior, it was lost to public view and was probably unknown or unavailable to late 19-century Nova Scotian naturalists. Its quality was manifest after it returned to public view in 1887, especially in the 20th century, when it became clear that it contained treasures such as specimens of a Labrador Duck (*Camptorhynchus labradorius*) and Eskimo Curlews (*Numenius borealis*) (Lloyd 1920; Hahn 1963).

Archival sources reveal that the present-day McCulloch collection in Dalhousie University is only part of the original, supplemented by post-McCulloch specimens. For example, there are no passerine specimens whatsoever: they were probably lost before the collection was taken out of storage and rehabilitated in the 1920s and again in the 1950s. Some specimens from earlier collections apparently remained in Pictou Academy, a few are now housed in the McCulloch House Museum in Pictou, and some may have been acquired by Pictonians for their household collections. At some stage, likely before 1899, when Harry Piers became director and written accessioning began, McCulloch specimens made their way undocumented into the collections of the Provincial Museum of Nova Scotia (now the Nova Scotia Museum of Natural History), where a few remain, and where the specimens in the Macdonald Museum of the Annapolis Valley Historical Society originated.

There is a botanical clue that links the collection date of the specimen in Middleton with the second McCulloch collection. The bases on which the Reddish Egret and other specimens in Middleton are mounted are surrounded by carpets of the mosses *Hypnum imponens* and *Dicranum scoparium*. Bare spaces have been covered by the later addition (probably in the 1920s) of another species, *Rhytidiadelphus triquetrus*, not seen in any other collection. The oldest specimens in the Dalhousie McCulloch collection—the ones showing the least evidence of change during restoration in 1924—also have *Hypnum imponens*, with some *Dicranum*, surrounding their bases. The birds in



FIGURE 1. White-morph Reddish Egret (*Egretta rufescens*) (centre) in display case, Macdonald Museum of the Annapolis Valley Historical Society, Middleton, Nova Scotia, 23 June 2012. Photo: Eric Mills.

earlier cases from the McCullochs, dating from before 1838, originating in Pictou Academy and salvaged from the New Glasgow, Nova Scotia, high school for the Nova Scotia Museum of Natural History, have bases covered with different mosses, especially *Pleurozium schreberi* and *Thuidium delicatulum*, probably species easily available to the young Thomas McCulloch junior (who was the taxidermist of the collections) around his Pictou home (information on mosses from Anne Mills) (see also Morris 2010, pages 212-217 on the uses of mosses and other materials in case preparation by

taxidermists). Thus the moss cover links the Reddish Egret in Middleton with the McCulloch collection in Halifax.

### Discussion

This is a complex and circumstantial story, but it is consistent with the origin of the specimen of the Reddish Egret in Middleton being one of the McCulloch collections from a Nova Scotian location. Both McCullochs traded specimens, but the only obvious ones in the largest surviving fragment, the McCulloch



collection in Dalhousie University, are Old World game birds (Black Grouse (*Tetrao tetrix*), Red Grouse (*Lagopus lagopus scoticus*), Capercaillie (*Tetrao urogallus*), etc.). Thomas McCulloch junior may have traded specimens with Audubon, but there are no other specimens from the southeastern United States among those surviving today. It seems most likely that the specimen came from the large collection maintained and expanded by Thomas McCulloch junior before his death in 1865, in which case it dates from the period 1838 to 1865.

Although the Reddish Egret specimen might have come from portions of the original collection that remained in Pictou in 1835 (when most of the collection was sold in Britain), this is unlikely. A Reddish Egret specimen would have been very valuable, so it seems unlikely that the impecunious Thomas McCulloch senior would have held it back from the collection that was sold in 1835. Thus it was probably collected after that year, but certainly before 1865.

It is not known for certain why the McCulloch collections do not figure in 19th-century accounts of the birds of Nova Scotia, such as the list published by the British Army officers Blakiston and Bland (1857), in the more substantial catalogues published three decades later by Chamberlain (1887) and Downs (1888), in Macoun's turn-of-the-20th-century *Catalogue of Canadian Birds* (1900). In none of these is there any mention of Reddish Egret. Nor is there a specimen documented in the extensive collections of the Halifax taxidermist Thomas Egan (1842–1914), who was closely associated with Downs (Regan 1908, pages 126–130). Egan prepared a very large collection of mounted birds for the Paris International Exhibition of 1867; photographs of many of these cases, in the Nova Scotia Museum of Natural History, do not include a Reddish Egret.

The second McCulloch collection seems to have remained invisible, because it became a pawn in Halifax politics of the 1840s surrounding the founding of a provincial museum. Had the two Thomas McCullochs, disappointed then in their attempt to found a provincial museum based on their second bird collection, not kept their collection to themselves, there would be contemporary accounts of the Reddish Egret now housed in Middleton. Although it may be impossible to prove definitively that the Reddish Egret in Middleton was collected in Nova Scotia by a McCulloch, the weight of evidence suggests that it was, and associates it with the second McCulloch collection.

### Acknowledgements

I am grateful to Andrew Hebda of the Nova Scotia Museum of Natural History for a great amount of information on 19th-century collections in Nova Scotia and for his time and interest. Sherry Griffin of the Macdonald Museum of the Annapolis Valley Historical

Society kindly provided information on the collections there. Fred Scott, formerly of the Nova Scotia Museum of Natural History, provided information on the transfer of the cases from Halifax to Middleton. Karen E. M. Smith of the Dalhousie University Archives provided me with a road map into both the Dalhousie McCulloch archival material and the material in the Nova Scotia provincial archives (Nova Scotia Archives and Research Management), along with a great deal of other information. Derek Lovitch provided information on the status of Reddish Egret in Maine. Anne Mills first suggested the use of mosses to give clues to the origins of the collections. Ian McLaren read and commented on an earlier version of the manuscript. A. J. Erskine, Dan Brunton, and an anonymous reviewer provided very helpful reviews.

### Documents Cited (marked \* in text)

- Maine Bird Checklist.** 2007. Maine bird checklist. <http://www.mainebirding.net/checklist/state>. (Accessed 27 August 2012).
- New Brunswick Bird Records Committee.** 2011. New Brunswick Birds / Oiseaux du Nouveau Brunswick. <http://personal.nbnnet.nb.ca/BRC/NBBirdsTabular.html>. (Accessed 27 August 2012).

### Literature Cited

- Audubon, M. R.** 1897. Audubon and His Journals. With Zoological and Other Notes by Elliott Coues. Vol. I. Charles Scribner's Sons, New York. 532 pages.
- Blakiston, T., and R. E. Bland.** 1857. A list of the birds of Nova Scotia, as far as ascertained, compiled mostly from actual observations, in the years 1852-3-4 and 5. Waterbirds. *The Naturalist* (London) 7: 103–106.
- Buggey, S., and G. Davies.** 1988. McCulloch, Thomas. *Dictionary of Canadian Biography* 7: 529–541.
- Chamberlain, M.** 1887. A Catalogue of Canadian Birds with Notes on the Distribution of the Species. J. & A. MacMillan, St. John, New Brunswick. 543 pages.
- Downs, A.** 1888. A catalogue of the birds of Nova Scotia. *Proceedings of the Nova Scotian Institute of Science* 7: 142–178.
- Dunn, J. L., and J. Alderfer.** 2011. *National Geographic Field Guide to the Birds of North America*. Sixth edition. National Geographic Society, Washington, DC. 574 pages.
- Godfrey, W. E.** 1986. *The Birds of Canada*. Revised edition. National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario. 595 pages.
- Hahn, P.** 1963. Where is That Vanished Bird? An Index to the Known Specimens of the Extinct and Near Extinct North American Species. Royal Ontario Museum, Toronto, Ontario. 347 pages.
- Harvey, D. C.** 1943. Dr. Thomas McCulloch and liberal education. *Dalhousie Review* 23: 352–362.
- Lewis, H. F.** 1933. Some Canadian Audubonia. *Canadian Field-Naturalist* 47: 162–172.
- Lloyd, H.** 1920. The duck specimens recorded as Labrador Duck in Dalhousie College, Halifax, Nova Scotia. *Canadian Field-Naturalist* 34: 155–156.
- Lowther, P. E., and R. T. Paul.** 2002. Reddish Egret (*Egretta rufescens*). No. 633 in *The Birds of North America*. Edited by A. Poole. Cornell Lab of Ornithology, Ithaca,

- New York. Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu/bna/species/633>.doi:10.2173/bna633. (Accessed 27 August 2012).
- Macoun, J.** 1900. Catalogue of Canadian Birds. Part I. Water Birds, Gallinaceous Birds, and Pigeons. S. E. Dawson, Ottawa, Ontario. 218 pages.
- McLaren, I. A.** 2012. All the Birds of Nova Scotia: Status and Critical Identification. Gaspereau Press, Kentville, Nova Scotia. 247 pages.
- McCulloch, W.** 1920. Life of Thomas McCulloch, D. D. Pic-tou. Privately printed, Truro, Nova Scotia. 221 pages.
- Morris, P. A.** 2010. A History of Taxidermy: Art, Science and Bad Taste. MPM Publishing, Ascot, England. 396 pages.
- Regan, J. W.** 1908. Sketches and Traditions of the Northwest Arm. John W. Regan, Halifax, Nova Scotia. 181 pages.
- Tufts, R. W.** 1986. Birds of Nova Scotia. Third edition. Nimbus Publishing and Nova Scotia Museum, Halifax, Nova Scotia. 478 pages.
- Whitelaw, M.** 1985. Thomas McCulloch: His Life and Times. Nova Scotia Museum, Halifax, Nova Scotia. 42 pages.
- Whytock, J. C.** 1999. Thomas McCulloch's quest to educate: societies, collections and degrees. Papers of the Canadian Society of Presbyterian History 24: 28–48.
- Wood, B. A.** 1987. Thomas McCulloch's use of science in promoting a liberal education. *Acadiensis* 17: 56–73.

Received 17 September 2012

Accepted 18 December 2012

# Observations of Wild Cougar (*Puma concolor*) Kittens with Live Prey: Implications for Learning and Survival

L. MARK ELBROCH<sup>1</sup> and HOWARD QUIGLEY

Panthera, 8 West 40th Street, 18th Floor, New York, New York 10018 USA

<sup>1</sup>Corresponding author (email: melbroch@panthera.org)

Elbroch, L. Mark, and Howard Quigley. 2012. Observations of wild Cougar (*Puma concolor*) kittens with live prey: implications for learning and survival. *Canadian Field-Naturalist* 126(4): 333–335.

The Cougar (*Puma concolor*) is a cryptic species in which social learning or opportunity learning has yet to be documented in the wild. "Opportunity teaching" is teaching in which an animal creates opportunities for conspecifics to observe or participate in operant learning. We present video data on an observation of Cougar kittens exhibiting social learning and inefficiency and inexperience in attempting to kill a live Mule Deer (*Odocoileus hemionus*) fawn. Our observations provide evidence for the importance of maternal care and they help explain why Cougar kittens less than a year of age have low survival rates.

**Key Words:** Cougar, *Puma concolor*, Mule Deer, *Odocoileus hemionus*, hunting, opportunity teaching, predation, social learning, Wyoming.

Cougars (*Puma concolor*) are a cryptic, solitary species difficult to observe, and one in which social learning, including opportunity learning, has yet to be documented in the wild. "Opportunity teaching" is a type of teaching observed in carnivores, during which an individual creates opportunities for conspecifics to observe or participate in operant learning (Caro and Hauser 1992; Hoppitt et al. 2008). In domestic cats (*Felis catus*), for example, successful predation incorporates the diverse skills of identifying prey, stalking prey, and manipulating and dispatching prey (Caro 1980), and kittens learn predation skills by observing the hunting behaviors of their siblings and mothers (Kuo 1930; John et al. 1968). Domestic cats exposed to particular prey types when they are kittens are more efficient at dispatching the same prey when they are adults (Caro 1980).

Many felids, as well as Meerkat (*Suricata suricatta*) parents and helpers, have been observed creating learning opportunities for developing offspring by presenting wounded prey, upon which younger animals can practice predation sequences (Caro 1987; Caro and Hauser 1992; Kitchener 1999; Thornton and Raihani 2010). In felids, the strongest evidence for this type of social learning has been documented in domestic cats and Cheetahs (*Acinonyx jubatus*) (Kruuk and Turner 1967; Caro and Hauser 1992; Kitchener 1999). For example, when Cheetah cubs are 5–7 months old, adult females catch and release 33% of their prey for their cubs to dispatch (Caro 1987; Caro 1994). By 10.5 months of age, incompetent Cheetah cubs are inefficiently attacking and beginning to consume 50% of prey captured by their mother. Adult female Cheetahs continue to increase learning opportunities for their cubs as they mature, and by the time cubs are 12.5 months old, mothers are catching and releasing 70% of prey for their cubs to dispatch (Caro 1987; Caro

1994). The time needed for young felids to learn successful predation behaviors from their mothers is longest in the largest felids, which hunt large prey (Kitchener 1999).

Cougar kittens typically disperse between 12 and 24 months of age (Logan and Sweanor 2010), by which time they must be proficient hunters. Because hunting skills equate to survival, greater insights into when Cougar kittens develop efficient killing techniques might assist wildlife managers in predicting the survival of kittens orphaned at specific ages or in better understanding why kittens of particular ages are unable to survive on their own.

Orphaned or dispersing kittens are rarely monitored successfully enough to determine their fate. Nevertheless, it is assumed that orphaned or dispersed kittens less than 9 months old have a low chance of survival (Logan and Sweanor 2001). In a New Mexico study, 10 kittens  $\leq 5$  months old died when orphaned, whereas a kitten 7.5 months old and another kitten 9.8 months old survived (Logan and Sweanor 2001). In a Utah study of 11 orphaned kittens, 5 died between the ages of 4 and 6 months, a 9-month-old was killed on a depredation permit after being independent for 6 weeks, and 5 others disappeared without researchers determining their fate (Stoner et al. 2006). In more recent research in the northern Yellowstone ecosystem and the Garnet Mountain area of Montana, 13 of 22 orphaned or dispersed kittens that became independent at less than one year of age survived (J. R. Newby, L. S. Mills, T. K. Ruth, D. H. Pletscher, M. S. Mitchell, H. B. Quigley, and K. M. Murphy, unpublished data).

As part of our study of Cougar ecology in the southern Yellowstone ecosystem, including Grand Teton National Park and the Bridger-Teton National Forest north of Jackson, Wyoming, we radio-collared adult

Cougars (Vectronics, Berlin, Germany) and kittens (Telonics, Mesa, Ariz.) to study demographics and spatial and foraging ecology. Our work includes telemetry monitoring of individuals to document survivorship and cause-specific mortality, as well as field investigations of spatially aggregated GPS points (i.e., "GPS clusters") (see Anderson and Lindzey 2003), to search for and document prey remains. Here, we present data on a single observation of two 12-month-old Cougar kittens with a live Mule Deer (*Odocoileus hemionus*) fawn.

On 10 July 2012, at 1710, we opportunistically encountered a female Cougar (F61) and two female kittens (K1 with MOD-400 collar, K2 without collar) in thick brush at close range while we were conducting a routine site investigation of a GPS cluster. When the Cougars moved away, we discovered a live Mule Deer fawn at the site; the fawn had been attacked and its hind leg was broken. We set two remote cameras (Bushnell HD Max) at the site and departed the area at 1727. The cameras were set to capture 60-second videos when they were triggered by movement, with a 15-second delay between potential trigger events.

We returned to pick up the cameras on 13 July, after the GPS collar worn by F61 relayed location data indicating the family group had departed the area. The two kittens were detected by the cameras at the site of the fawn at 2003 on the same day the cameras were set up. GPS data indicated that the adult female Cougar also returned to the site with her kittens, but she was never documented by the cameras. Both kittens were recorded at the site for 20 minutes before they pulled the Mule Deer fawn beyond the area recorded by the cameras. We discovered the remains of the fawn (rumen, 4 legs) approximately 25 m from the camera site.

Videos recorded the kittens' initial nervousness with the fawn (Supplementary Video Material, Part 1), exploratory predation behaviors, and social learning as they observed each other (Supplementary Video Material, Parts 2 and 3). Kittens nipped or bit the fawn on 13 occasions and swatted it with a paw 8 times during the 20 minutes they were recorded at the site; each contact elicited distress calls from the fawn. Only one kitten engaged the fawn at any one time, and the other sibling observed. K1 observed K2 interact with the fawn for a total of 2 minutes, and K2 observed K1 interact with the fawn for a total of 4.5 minutes. On 8 occasions, the kitten engaged with the fawn walked away from it or allowed the fawn to move away without restraining it. In the 20 minutes recorded by the cameras, the kittens were unsuccessful in killing the fawn. In Supplementary Video Material, Part 2, K2 observed as K1 swatted and nipped the fawn ineffectively, and chewed through and removed both ears. In Supplementary Video Material, Part 3, K1 observed while K2 swatted and pawed at the fawn, and then more efficiently secured a hold on its neck and dragged it from the view of the camera.

The fact that the adult female Cougar was present at the site but allowed her kittens to explore the fawn on their own, leads us to speculate that, in parallel with Cheetahs, she had initially wounded the fawn and then provided it to her kittens as a form of opportunity teaching. The inefficiency exhibited by the kittens and their unsuccessful exploratory predation behaviors further support the notion that the kittens were not responsible for the fawn's broken leg.

Here, we documented two kittens 12 months of age still developing the repertoire of predation behaviors required to be successfully independent. These observations provide evidence of maternal care requirements and social learning among conspecifics, and they provide a clearer picture of wild Cougar behavioral development. Our recorded observations demonstrate why kittens orphaned at less than a year of age are less likely to survive than older kittens, and they suggest that the time needed for Cougar kittens to develop complex predation behaviors for ungulate prey is greater than one year. In fact, the mean age of dispersal for 11 kittens in our project was 17.5 months (SE 0.6) (Newby 2011). The fact that 12-month-old kittens were recorded still developing their hunting skills has implications for conservation management aimed at mitigating the number of orphaned kittens and for management actions required for orphaned kittens.

Inexperienced Cougar kittens and sub-adults, both orphaned and dispersing, are disproportionately involved in conflicts with humans, including depredation of livestock and pets. Linnell et al. (1999) suggested that younger animals with unrefined hunting skills were more likely to attack livestock. Sixty-seven percent of 9 cougars in a Montana study (Aune 1991) and 33% of 286 cougars in a California study (Torres et al. 1996) involved in depredation activity were less than two years old. Further, young Cougars are more likely to attack humans (Beier 1991).

Our observations provide evidence that Cougars up to 12 months of age are unlikely to have developed the full set of requisite skills needed to efficiently dispatch prey, and suggest that managers should consider both mitigating the potential for orphaned kittens as well as preparing to take action to mitigate potential problems caused by orphaned kittens.

### Acknowledgements

Funding for this work was generously provided by the Richard King Mellon Foundation, the Charles Engelhard Foundation, the Summerlee Foundation, the Thaw Charitable Trust, L. and K. Westbrook, and a variety of individual donors. We thank J. Newby and P. Alexander for comments on an earlier version of the manuscript. We also thank our collaborators at Craighead Beringia South, for their ongoing support and involvement.

### Literature Cited

- Anderson, C. R. Jr., and F. G. Lindzey.** 2003. Estimating cougar predation rates from GPS location clusters. *Journal of Wildlife Management* 67: 307–316.
- Aune, K. E.** 1991. Increasing mountain lion populations and human-mountain lion interactions in Montana. Pages 86–94 in *Mountain lion-human interaction symposium and workshop*. Edited by C. S. Braun. Colorado Division of Wildlife, Denver, Colorado.
- Beier, P.** 1991. Cougar attacks on humans in the United States and Canada. *Wildlife Society Bulletin* 19: 403–412.
- Caro, T. M.** 1980. The effects of experience on the predatory patterns of cats. *Behavioral and Neural Biology* 29: 1–28.
- Caro, T. M.** 1987. Indirect costs of play: cheetah cubs reduce maternal hunting success. *Animal Behavior* 35: 295–297.
- Caro, T. M.** 1994. *Cheetahs of the Serengeti Plains: Group Living in an Asocial Species*. University of Chicago Press, Chicago, Illinois. 500 pages.
- Caro, T. M., and M. D. Hauser.** 1992. Is there teaching in nonhuman animals? *Quarterly Review of Biology* 67: 151–174.
- Hoppitt, W. J. E., G. R. Brown, R. Kendal, L. Rendell, A. Thornton, M. M. Webster, and K. N. Laland.** 2008. Lessons from animal teaching. *Trends in Ecology and Evolution* 23: 486–493.
- John, R. E., P. Chesler, F. Bartlett, and I. Victor.** 1968. Observational learning in cats. *Science* 159: 1489–1490.
- Kitchener, A. C.** 1999. Watch with mother: a review of social learning in the Felidae. Pages 236–258 in *Mammalian Social Learning: Comparative and Ecological Perspectives*. Edited by H. O. Box and K. R. Gibson. Cambridge University Press, Cambridge.
- Kruuk, H., and M. Turner.** 1967. Comparative notes on predation by lion, leopard, cheetah and wild dog in the Serengeti area, East Africa. *Mammalia* 31: 1–27.
- Kuo, Z. Y.** 1930. The genesis of the cat's responses to the rat. *Journal of Comparative Psychology* 11: 1–35.
- Linnell, J. D. C., J. Odden, M. E. Smith, R. Aanes, and J. E. Swenson.** 1999. Large carnivores that kill livestock: do "problem individuals" really exist? *Wildlife Society Bulletin* 27: 698–705.
- Logan, K. A., and L. L. Sweanor.** 2001. *Desert Puma: Evolutionary Ecology and Conservation of an Enduring Carnivore*. Island Press, Washington, DC. 464 pages.
- Logan, K. A., and L. L. Sweanor.** 2010. Behavior and social organization of a solitary carnivore. Pages 105–117 in *Cougar: Ecology and Conservation*. Edited by M. Homocker and S. Negri. University of Chicago Press, Chicago, Illinois.
- Newby, J. R.** 2011. *Puma dispersal in the Central Rocky Mountains*. M.S. thesis. University of Montana, Missoula, Montana. 104 pages.
- Stoner, D. C., M. L. Wolfe, and D. M. Choate.** 2006. Cougar exploitation levels in Utah: implications for demographic structure, population recovery, and metapopulation dynamics. *Journal of Wildlife Management* 70: 1588–1600.
- Thornton, A., and N. J. Raihani.** 2010. Identifying teaching in wild animals. *Learning and Behavior* 38: 297–309.
- Torres, S. G., T. M. Mansfield, J. E. Foley, T. Lupo, and A. Brinkhaus.** 1996. Mountain lion and human activity in California: testing speculations. *Wildlife Society Bulletin* 24: 451–460.

Supplementary video available at:  
<http://www.canadianfieldnaturalist.ca>

Received 2 October 2012

Accepted 27 November 2012

## A Partial Albino Hatchling Northern Ring-necked Snake, *Diadophis punctatus edwardsii*, from Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia, Canada

JOHN GILHEN<sup>1</sup>, GRAHAM CASWELL, CARRIE DRAKE, MARY MACDONALD, and HEATHER MCKINNON-RAMSHAW

Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6 Canada.

<sup>1</sup>Corresponding author (email: gilhenja@gov.ns.ca)

Gilhen, John, Graham Caswell, Carrie Drake, Mary MacDonald, and Heather McKinnon-Ramshaw. 2012. A partial albino hatchling Northern Ring-necked Snake, *Diadophis punctatus edwardsii*, from Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia, Canada. *Canadian Field-Naturalist* 126(4): 336–339.

On 10 June 2012 a sample of seven gravid female Northern Ring-necked Snakes (*Diadophis punctatus edwardsii*), from Big Tancook Island, Lunenburg County, Nova Scotia, was selected for a seasonal live display at the Nova Scotia Museum of Natural History in Halifax. A total of 13 eggs was removed from the display in late June 2012 and incubated for public viewing. The eggs began hatching on 22 August 2012. One of the hatchlings was partial albino (with zanthophores or amelanistic). This is the first record of an albinistic Northern Ring-necked Snake in Nova Scotia.

Key Words: partial albino, zanthophore, amelanistic, hatchling, Northern Ring-necked Snake, *Diadophis punctatus edwardsii*, Big Tancook Island, Nova Scotia.

We collected seven gravid female Northern Ring-necked Snakes (*Diadophis punctatus edwardsii*) from among approximately 40 adults observed on Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia (44°27'00"N, 64°10'00"W) (Figure 1) on 10 June 2012 for a live display in the Netukulimk Gallery

of the Nova Scotia Museum of Natural History in Halifax over the summer. The females (three slate grey and four brown morphs) were found under loose slate, boards, and other debris in tall grass in a clear-cut area about 100 m from the sea shore. Big Tancook Island is a drumlin 4 kilometers long and 1.6 km wide.

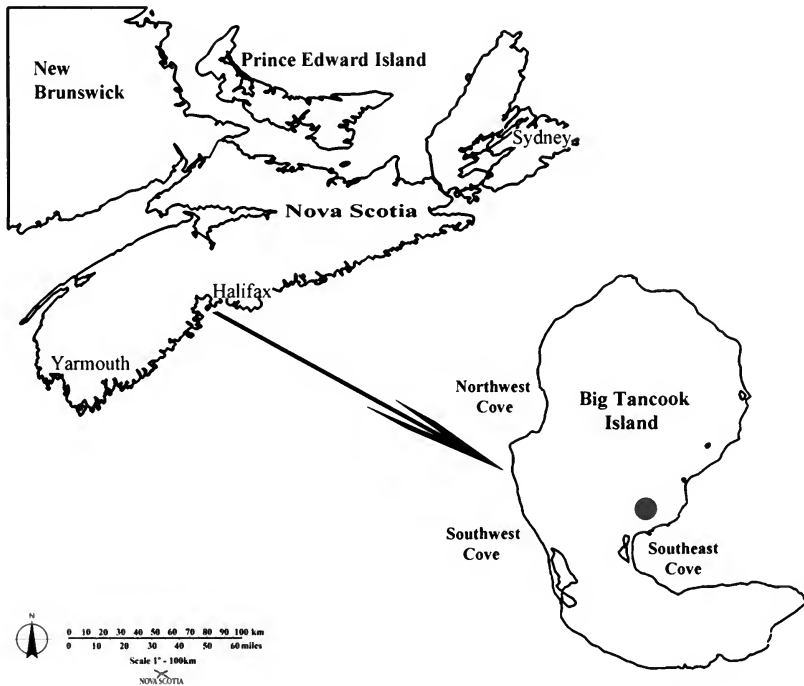


FIGURE 1. Map of Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia. Photo by Roger Lloyd.



FIGURE 2. Dorsal view of an albinistic and a normal Northern Ring-necked Snake, *Diadophis punctatus edwardsii*, both hatched on 22 August 2012 from eggs laid by gravid females that were collected on 10 June 2012 from Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia. Photo by Roger Lloyd.

A total of 13 eggs were laid by the females in late June 2012. The eggs were removed from the display and incubated so that the public could observe them hatching. One of the hatchlings (see cover illustration) was comparable to the partial albino (with zanthophores or yellow pigment) described by Drykacz (1981). It was also amelanistic in that it completely lacked black pigment, which is characteristic of the ground colour of this subspecies in Nova Scotia (Gilhen, 1970).

This hatchling, approximately 12 cm total length and 1.2 grams in weight, had pink eyes and a white tongue. The dorsal colour was pinkish-white with a pale yellow neck band. The neck band was bordered anterior and posteriorly by a narrow grey translucent band (Figure 2). The underside was yellowish-orange (Figure 3), paler than that of normal hatchlings.

A partial leucistic adult male Northern Ring-necked Snake (leucistic with erythrophores) approximately 30 cm in total length was found under a large piece of quartzite in a boulder field at Geizer Hill, west of peninsular Halifax City, Nova Scotia (44°39'03"N, 63°39'28"W), on 28 June 1997 (Gilhen 1999) (Figure 4). This snake lacked black pigment except for the eyes, which were black. Above, the snake was greyish-white on the trunk and pinkish-white on the tail. The skin between the scales was dull white. The major dif-

ferences between that specimen and the albino hatchling described above is that the albino hatchling had pink eyes and a white tongue (see cover illustration) and the leucistic individual had black pigmented eyes and red tongue (Figure 4). The head of the hatchling was pinkish-white and the head of the adult male was orange brown. Both had a pale yellow band round the neck with a greyish translucent border above and below. The underside of the hatchling was yellowish-orange while the adult male was darker orange. Based on these differences, we propose that this hatchling is the first record in Nova Scotia of a partial albino Northern Ring-necked Snake with zanthophores.

### Discussion

In Nova Scotia, reports of albino, leucistic, and amelanistic amphibians and reptiles have increased in recent decades. Such anomalies happen rarely in nature. However, in Nova Scotia these phenomena are believed to be the result of inbreeding in isolated, disturbed and fragmented habitats (Russell et al 2012).

Nova Scotia is a narrow and elongate province which juts out into the Atlantic Ocean. With the exception of sea turtles and species introduced onto Newfoundland, it represents the northeastern limit for amphibians and reptiles. The entire landscape is almost completely sur-



FIGURE 3. Ventral view of an albinistic and a normal Northern Ring-necked Snake, *Diadophis punctatus edwardsii*, both hatched on 22 August 2012 from eggs laid by gravid females that were collected on 10 June 2012 from Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia. Photo by Roger Lloyd.



FIGURE 4. Dorsal view of an adult male leucistic Northern Ring-necked Snake, *Diadophis punctatus edwardsii*, from Geizer Hill, west of peninsular Halifax, Halifax County, Nova Scotia, on 28 June 1997. Photo by Roger Lloyd and Richard Plander.



rounded by the sea, and the present native herpetofauna has been isolated here for thousands of years (Bleakney 1958, Cook 1967 and Gilhen 1984). The province is also characterized by a varied geology, topography, and climate, which can limit the distributional gene flow for some species, such as the Northern Ring-necked Snake (Gilhen, 1984).

The Atlantic coast of Nova Scotia in many areas is clustered with islands inhabited by amphibians and reptiles, particularly salamanders and snakes, separated from the mainland for centuries and in some cases thousands of years. Major highways follow the coast and often separate the amphibians and reptiles inhabiting the numerous coastal peninsulas and further inhibit gene flow. In recent years, urbanization of these peninsulas has created an "island" effect, which further divides amphibian and reptile populations.

This carving up of the landscape makes it more likely that individuals carrying a recessive gene for the albino, leucistic and amelanistic conditions will encounter and mate with individuals of similar genotype in these small, isolated habitats. Consequently, in the future, we expect more frequent reports of amphibians and reptiles in Nova Scotia that manifest these aberrant conditions.

#### Acknowledgements

The authors are grateful to Roger Lloyd for producing the cover image, and, also Figures 1, 2, and 3. Roger Lloyd and Richard Plander worked together on Figure 4. The continued professional care of seasonal live displays at the Nova Scotia Museum of Natural History, Halifax, in particular, professional help main-

taining and feeding the partial albino hatchling Northern Ring-necked Snake (which is eating and growing at this time in the Nature Lab) is done by the naturalist/interpreters, Andrew Hebda, Curator of Zoology, made useful comments on the draft manuscript. Katherine Ogden, Assistant Curator, was very helpful during the preparation of the manuscript.

#### Literature Cited

- Bleakney, J. S.** 1958. A zoogeographical study of the amphibians and reptiles of eastern Canada. National Museums of Canada, Bulletin 155: 1-119.
- Cook, F. R.** 1967. An analysis of the herpetofauna of Prince Edward Island. National Museums of Canada Bulletin 212. 60 pages.
- Dyrkacz, S.** 1981. Recent instances of albinism in North American amphibians and reptiles. Society for the study of amphibians and reptiles. Herpetological Circular Number 11.
- Gilhen, J.** 1970. An unusual Nova Scotian population of the Northern Ringneck Snake, *Diadophis punctatus edwardsi*. Occasional Paper No. 9. Science Series No. 6. Nova Scotia Museum, Halifax, Nova Scotia. 21 pages.
- Gilhen, J.** 1984. Amphibians and Reptiles of Nova Scotia. Nova Scotia Museum, Halifax, Nova Scotia.
- Gilhen, J.** 1999. First record of a partial leucistic Northern Ring-necked Snake, *Diadophis punctatus edwardsi*, in Nova Scotia. Canadian Field-Naturalist 113: 282-284.
- Russell, R. W., W. Beslin, M. Hudak, A. Ogunbiyi, A. Withrow, and J. Gilhen.** 2011. A second amelanistic Eastern Red-backed Salamander, *Plethodon cinereus*, from Nova Scotia, Canada. Canadian Field-Naturalist 125: 359-362.

Received 27 November 2012

Accepted 3 December 2012

## Book Reviews

**Book Review Editor's Note:** We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars are AUD and so on.

**Editor's Note.** The address of the Birds of Northumberland County website has been changed to <http://www.willowbeachfieldnaturalists.org/Northumberland-County>. This is part of the Willow Beach Field Naturalists' website, but the URL above will take you directly to the Birds of Northumberland County. Please note that the URL is case sensitive. From Clive Goodwin.

### ZOOLOGY

#### **Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding – Seventh Edition.**

By Brian I. Crother, (committee chair). 2012. Society for the Study of Amphibians and Reptiles. Herpetological Circular 39. 92 + 5 pages. [Single copies of this circular are available from the Publications Secretary, Breck Bartholomew. P.O. Box 58517, Salt Lake City, Utah 84158-0517 USA. E-mail: [ssar@herplit.com](mailto:ssar@herplit.com). 14.00 USD].

This checklist was prepared for the Society for the Study of Amphibians and Reptiles and issued for the World Congress of Herpetology in Vancouver, British Columbia, in August 2012. It is a revision of the 2008 SSAR Sixth Edition (reviewed by Cook 2008). Its key feature is the inclusion of "Comments Regarding Confidence in Our Understanding". These comments give useful background for taxa where the names on this list are still subjects of continuing disagreement and debate among contemporary herpetologists. Although one choice is preferred for the list, references and short discussions are included for most dissenting alternate views. As well, comments on studies yet unpublished, in progress, or needing to be undertaken to clarify certain outstanding problems in relationships, are also included.

The origin of North American checklists for amphibians and reptiles with "common" [English] names is traced to Yarrow (1882) in the introduction to the current list. In 1956, the American Society of Ichthyologists and Herpetologists (ASIH) formed a committee of herpetologists and published a checklist. It provided standardized common names for use in zoos and popular publications for amphibians and reptiles comparable what had been accomplished long before for birds by The American Ornithologists Union (AOU). In 1977, a SSAR Common and Scientific Names Committee was formed to update the previous ASIH list. It was chaired by Joseph T. Collins with decisions made by committee. It produced editions in 1978 and 1982, however, in 1990, for the third edition, Collins unilaterally changed from committee chairman to author. Subsequently (Collins 1991) he published, in advance of the next edition of the checklist, a recommendation for mass changes by elevating 55 allopatric (geographically not in contact) distinctive subspecies to species

rank in line with the developing evolutionary species concept. This stimulated widespread controversy and debate among herpetologists (Adler 2012: 331–333).

Although Collins was removed as chair of the SSAR after he produced a fourth edition in 1997, (Adler 2012) he followed with a fifth in 2000 and a sixth in 2009. The fifth was re-titled *Standard Common and Current Scientific Names for North American Amphibians, Turtles, Reptiles, and Crocodylians* to reflect group concepts that added birds to traditional "reptiles". It restricted the term reptile to lizards and snakes and listed 53 reviewers but no committee. It was published by the Center for North American Herpetology (CNAH) [originally Center for North American Amphibians and Reptiles] which had been founded by Collins. Meanwhile, the SSAR formed a new committee and also issued a fifth (2000), and sixth edition (2008) under the traditional title and classification.

The seventh edition by the SSAR begins with the historical background of amphibian and reptile checklists and useful tabular comparison including the number of species covered in checklists in 1882, 1978, 2012 with the total species 465, 454, to 632 reflecting largely the recent emphasis on the evolutionary species concept, data from DNA, and increased access to little known corners of the world. A guide to proper citation is followed by very useful instructions on forming Standard English Names. Next, a section covers rules on capitalization, formation of descriptive or modifying word, formation and use of group names, formation of English species and subspecies names; literature cited, and acknowledgements. Finally, 71 pages cover and annotate recognized species and subspecies by portions of the committee: Anura (Frogs): Darrel R. Frost, Roy W. McDiarmid, Joseph R. Mendelson III, David M. Green; Caudata (Salamanders): Stephen G.

Tilley (Chair), Richard Highton, David B. Wake; Squamata (Lizards) Kevin D. Quieroz, Tod W. Reeder; Squamata (Snakes): Brian I. Crother (Chair), Jeff Boundy, Frank T. Burbrink, Jonathan A. Campbell, R. Alexander Pyron; Crocodylia (Crocodylians): Brian I. Crother; Testudines (Turtles), John B. Iverson (Chair), Peter A. Meylan, Michael E. Seidel; Alien Species: Fred Kraus. It concludes with a 5-page listing of available SSAR publications.

There is a conspicuous omission of direct reference to the existence of parallel fifth and sixth checklists produced by the CNAH. There are a number of differences in recognition of taxa, the most notable [and rejected] in the SSAR list is Collins and Taggart (2008) resurrection of generic names for Fox Snakes (*Mintoniinus*) [see Crother et al. 2011] and “Woodland Rat Snakes” (*Scotophis*) [see Pyron et al. 2009] which were accepted in Collins and Taggart (2009) but remain included in *Pantherophis* in the SSAR list.

This list has been adopted as their official list by Society for the Study of Amphibians and Reptiles (SSAR), the Herpetologists League (HL), the American Society of Ichthyologists and Herpetologists (ASIH), Canadian Association of Herpetologists (CAH), Canadian Amphibian and Reptile Conservation Network (CARCNet), and Partners in Amphibian and Reptile Conservation (PARC). As well, more informally, Canadian federal and provincial reports on amphibians and reptiles generally follow the SSAR list. However, having two standard English lists has been confusing for many and thus weakened their effectiveness to promote public utilization.

A companion volume to the 2012 SSAR checklist in English is a list of French names is covered in a separate publication (Green 2012).

FRANCIS R. COOK

Curator Emeritus and Research Associate, Canadian Museum of Nature, Ottawa, Ontario K1P 6P4

## **Amphibian Biology Volume 10. Conservation and Decline of Amphibians: Ecological Aspects. Effect of Humans, and Management**

By Harold Heatwole and John W. Wilkinson (editors). 2012. Surrey Beatty & Sons, Baulkham Hills, New South Wales, Australia. xii + pages 3291–3727. 295.00 USD.

Amphibians were often lightly regarded by naturalists long before the father of systematics, Carolus Linnaeus, Latinized his own name and those of every animal and plant known at the time. In his 10<sup>th</sup> edition of *Systema Naturae* in 1758 he dismissed amphibians which he lumped together with reptiles, lampreys and some fish, as so foul and disgusting that their Creator had not made many of them. Over the subsequent years wider exploration of the continents and the modern advances in distinguishing species though DNA, there are now over 6300 named species of amphibians, now restricted to include only the frogs, salamanders, and

## **References**

- Adler, K. Editor. Contributions to the History of Herpetology. Volume 3. Issued to commemorate the 7<sup>th</sup> World Congress of Herpetology Vancouver, British Columbia 2012. Society for the Study of Amphibians and Reptiles. 564 pages.
- Collins, J. T. 1991. Viewpoint: A new taxonomic arrangement for some North American amphibians and reptiles. *Herpetological Review* 22(3): 41–42.
- Collins, J. T., and T. W. Taggart. 2008. An alternative classification of the New World rat snakes (genus *Pantherophis* [Reptilia: Squamata: Colubridae]). *Journal of Kansas Herpetology* 26: 16–18.
- Collins, J. T., and T. W. Taggart. 2009. Standard Common and Current Scientific Names for North American Amphibians, Turtles, Reptiles, and Crocodylians. Sixth Edition. Publication of The Center for North American Herpetology, Lawrence, Kansas. iv + 44 pages.
- Cook, F. R. 2008 [2009]. [Book review]. Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding. Sixth Edition. *Canadian Field-Naturalist* 122(4): 357–358.
- Crother, B. I., M. E. White, J. M. Savage, M. E. Eckstut, M. R. Graham, and D. W. Gardner. 2011. A Reevaluation of the Status of the Fox Snakes, *Pantherophis gloydi* Conant and *P. vulpinus* Baird and Girard (Lepidosauria). *ISRN Zoology* 2011(436049): 1–15.
- Green, D. M. 2012. Noms Francais des Amphibiens et des Reptiles d'amerique au Nord du Mexique/Standard French Names of Amphibians and Reptiles of North America North of Mexico. *Herpetological Circulars*, Society for the Study of Amphibiens and Reptiles, number 40. 63 pages.
- Gibbs, H. Lisle, S. J. Corey, G. Blouin-Demers, K. A. Prior, and P. J. Weatherhead. 2006. Hybridization between mtDNA-defined phylogeographic lineages of black rat-snakes (*Pantherophis* sp.). *Molecular Ecology* 15: 3755–3767.
- Pyron, R. A., and F. T. Burbrink. 2009. Neogene diversification and taxonomic stability in the snake tribe Lamproleptini (Serpentes: Colubridae). *Molecular Phylogenetics and Evolution* 52(2): 524–529.

caecilians. And there is general agreement that many more exist that are yet to be discovered and described.

*Amphibian Biology* is a multi-volume series began in 1994, projected to provide detailed reviews of research on all aspects of the group, complimentary to those that the late Carl Gans and co-editors had provided for reptiles in *The Biology of the Reptilia*. The latter ran for 22 volumes between 1969 and 2010. This volume, the tenth in the amphibian series, like previous ones, contains compilations of a staggering amount of information from an impressive number of studies around the world.

Reviews of three previous volumes in the *Amphibian Biology* series, have appeared in *The Canadian Field-Naturalist*: Volumes 1: The Integument and 2: Social Behaviour in 111(4): 687–689, and Volume 8: Decline: Diseases, Parasites, Maladies and Pollution in 123(4): 378. Other volumes in the series (not reviewed in this journal) have been 3: Sensory Perception; 4: Paleontology; 5: Otolaryngology; 6: Endocrinology; 7: Systematics; 9, Part 1: Status of Decline, Western Hemisphere – Paraguay, Chile, and Argentina; 9, Part 2: Status of Decline, Western Hemisphere – Uruguay, Brazil, Columbia, and Ecuador. Volume 11 will cover Status of Decline in the Eastern Hemisphere.

In the present volume (10) on conservation and decline of amphibians the emphasis is on the impact of human attitudes and the activities which have reduced or destroyed amphibian habitats, including of modifications of the landscapes, expansion of human constructs: buildings, roads, and drainage and other agriculture or industrial projects. Also covered are the negative consequences of introductions. Emphasis is placed on extensive compilations on human reaction to amphibians, and their study and management. Its world-wide scope is attested to by the contributions being from 22 authors from 13 countries: Australia (2), Brazil, Canada, Fiji, Hungary, Malaysia, Indonesia, Romania, Russia, Sweden, United Arab Emirates (2), United Kingdom (3), and USA(6). Stephen J. Hecnar, Lakehead University, Thunder Bay, Ontario, is the sole Canadian contributor, despite the growing activity here in assessing the local status and conservation of Canadian populations.

The book opens with a preface to the series followed by one to the volume, a dedication to Trevor Beebee (one of the pioneers in the United Kingdom in herpetological conservation efforts), contents, and a list of contributors. Fifteen chapters follow:

1. Destruction, loss and modification of habit.
2. Ecological impacts and non-native species.
3. Man meets frog: perceptions, use and conservation of amphibians by indigenous people.
4. Harvesting of amphibians for food.
5. International trade in amphibians.
6. Road kills.
7. Declines and extinction in amphibians. An evolutionary and ecological perspective.

8. Phylogenetic correlates of population decline and extinction risk in amphibians.

9. Geographic correlates of extinction risk in amphibians.

10. Life history correlates of extinction risk in amphibians.

11. Monitoring amphibian populations.

12. Habitat protection: refuges and reserves.

13. Guidelines of the International Union for the Conservation of Nature for re-introductions and their application to amphibians.

14. Captive breeding of amphibians for conservation.

15. Integrated procedures: where do we go from here?

A cautious approach has been taken to the lack of consensus among contributing authors on recent wholesale changes in amphibian nomenclature and subsequent continuing revisions. The editors have left the use of names up to the choice of individual authors, leading to an inconsistent mixture of usages of past and present scientific names.

An example of the improvement in public attitudes toward amphibians is demonstrated by the revision of the well-known fable of the princes and the frog where, in the current version, a kiss leads to the breaking of a spell and the conversion of the amphibian into a handsome prince. In its original German version by the brothers Grimm in 1812 the spell was broken when the disgusted princess throws the frog against a wall.

That there is also a growing public interest and appreciation of the variety of amphibians is reflected in the growth of ecotourism particularly in Central America specifically to see the colourful forms in their natural habitats.

Any concerned naturalist, and all amphibian researchers, will find this volume a treasury of reference literature and of guidance for further studies. Even this attention may not halt, in the view of some conservationists, the seeming inevitable coming of silent nights bereft of frog choruses while the mute salamanders vanish unnoted by the public. A sobering point stresses that many of the factors in amphibian declines are not remedied by simply changing our attitudes but those that are should be addressed while there is still time.

FRANCIS R. COOK

Curator Emeritus and Research Associate, Canadian Museum of Nature, Ottawa, Ontario K1P 6P4

## The Amphibians and Reptiles of Michigan: A Quaternary and Recent Faunal Adventure

By J. Alan Holman. 2012. Wayne State University Press, The Leonard N. Simons Building, 4809 Woodward Avenue, Detroit, Michigan 48201-1309 USA. 291 pages. 49.60 CAD. Cloth.

Modern herpetology in Michigan was given an early start by Alexander Ruthven who's 1908 Ph.D. thesis was a comprehensive analysis of garter snakes (*Thamnophis*). This model monograph on the most abundant and widespread snakes in North America is still re-

ferred to the present day. It was followed by *The Herpetology of Michigan* by Ruthven C. Thompson, and H. Thompson in 1912 and by a revision by Ruthven C. Thompson, and H. Gaige in 1928. Ruthven became director of the Museum of Zoology, University of

Michigan and, eventually, president of the University. Remarkably, these guides were the last comprehensive account of all the amphibians and reptiles of Michigan until the present volume by J. Alan Holman. The glaring hiatus is astonishing as the state has long been one of the leading training grounds in North America for herpetologists, primarily at The University of Michigan, Ann Arbor, but also at Michigan State University, and Wayne State University. Neighbouring states have been covered by individual guides since the second World War (Illinois 1961, Wisconsin 1981, Indiana 2001; and for adjacent Canada, Ontario in 2002).

J. Alan Holman (1931–2006) had a distinguished teaching and research career which largely emphasized Quaternary fossils but included studies of present forms as well. He died of a heart attack just a few days after turning the manuscript for this volume in to the publisher. It was (according to an introductory publisher's note page *ix*) "finished but not perfected" but colleagues, James Harding, James Gillingham, and David Mifsud provided additional photographs, updated references, and other information to complete the book.

It opens with a preface [pages *xv–xvi*], which, after commenting on the number of studies presented on Michigan amphibians and reptiles at meetings of the Michigan Academy of Science, Arts, and Letters, follows with this disturbing observation: "All is not happy banter when Michigan herpetologists get together, as we all fidget and fret about the diminishing populations of amphibians and reptiles in the state. The most frightening thing is that not only are the officially threatened and endangered species of concern but also the many species that were very common throughout the large portions as recently as the early 1980s. They too are becoming rare and exist only as fragmented populations".

Brief acknowledgments [pages *xv–xvi*] and a note on the species range maps follow [page *xix*]. The maps plot county occurrences rather than exact localities. This gives an adequate depiction of overall state distribution because of the subdivision of the state into relatively small counties. This approach was used in some earlier state field guides to give an overall impression of range when records, even for common species, were still sparse in many areas. Now that ranges are vastly better documented not using this detailed information is justified here because the state's herpetofauna "has already been targeted by illegal collectors in the pet trade (J. H. Harding personal communication) and such dots on state maps can be used by these individuals to find local herpetological "hot spots" "[However, overlooked and not discussed here is that the omission of exact locations also denies easy access to this knowledge to people who might attempt to block developers planned destruction if they only knew locations critical in their area for a rare a species. Most data bases allow access to such detailed data only for proven conservation use and approval is dependent on the arbitrary

judgment of the inquirer's intent by those maintaining the database. The application process is daunting to many who may consequently not bother to apply for relevant data for their area].

Part 1 [pages 1–26] opens the book with an introduction to Michigan as herpetological habitat, covering topography and vegetation with text, photographs, and maps.

Part 2 contains the dominant content in 223 pages (27 to 249) of comprehensive species accounts covering 54 species, an increase of 10 recorded for the state since 1928. Although nomenclature changes since the days of Ruthven are numerous, modern combinations are followed except in the long traditional *Bufo* and *Rana*, where recent change to *Anaxyrus* and *Lithobates* (except for the Wood Frogs), respectively, has been adopted because of disagreement raised by certain herpetologists. However, these changes are increasingly being used by most other current researchers.

Headings within each account are scientific and common names, identification, general distribution, Michigan distribution, geographic variation, habitats and habits, reproduction and growth, diet, predation and defence, interaction with humans, behavioural characteristics, population health, and general remarks. All are well-referenced and many Canadian studies are included along with the impressive number of Michigan ones. As well, the accounts contain many gems of author experience which make even long-standard information fresh.

"The call of *Bufo americanus americanus* is an extended – up to 30 seconds – musical trill [page 68] .... The call of *Bufo fowleri* is an eerie, mournful 'waaaaaaaaa' that lasts from two to seven seconds and sounds as if it was emanating from a misty swamp in Transylvania. Most people I know subjectively consider the Eastern American Toad sweet and the Fowler's Toad call annoying. But I prefer the call of *Bufo fowleri* as it brings back nostalgic memories of warm, sweet-smelling, early summer evenings in the country, gazing at a yard lighted only by glowworms and fireflies" [page 72].

"I have only been bitten once by an Eastern Snapping Turtle, and the bite happened completely by surprise. Years ago while in the service near Memphis, Tennessee, I was fishing in a farm pond. Sitting happily on top of a galvanized minnow bucket hoping to catch a catfish, I felt a sharp pain in my rear and discovered an eight-inch snapper hanging from my blue jeans and a 'pinch' of skin just beneath. As I stood, the snapper dropped off and continued straight to the water amidst a hail of four-letter words that I had acquired in the Navy. It was late May and the attacker must have been a female returning from her nesting site. My only guess for the reason of the attack was that I was blocking her straight-line route back to the water" [page 109].

"Painted Turtles need tussocks, logs, lily pads, mats of vegetation, or even junk to bask upon" [page 113].

"Milksnakes get their common name from the belief that they suck milk from the udders of cows, perhaps because they are frequently found in or around barns. This is false folklore. A Milksnake's teeth and jaws are not constructed to do such sucking, and besides, any cow that I have ever met would not stand for such toothy abuse." [page 171].

"When confronted this snake [Eastern Hognose] inflates its body with air. This behaviour causes its pattern to stand out boldly. Its head and neck then spread out in a 'cobra-like' fashion, and it expels the air in its body, causing a very loud and long hiss. For this reason it is often known as 'puff-adder' or 'spreading adder'. Its mouth then gapes widely, and the snake may or may not make fake strikes at the would-be predator or other tormentor. If these behaviours do not work, the snake puts on the most exaggerated death-feigning act in the animal kingdom. All of a sudden its movements become uncoordinated as it writhes and rubs its open mouth on the ground and often expels the contents of its stomach and cloaca. Also, it sometimes bleeds from the mouth. The last and final act occurs when the snake rolls over on its back, belly up, often with its tongue lolling out. If one backs off from the dead-looking snake and stays still a few minutes, the snake's head turns up and the air is tested slowly with the tongue. If the information the snake receives from this registers favourably, the reptile will right itself and crawl away as fast as its chubby body allows. If the snake is caught again and placed upright, it will go belly up again giving away the stereotyped nature of the performance" [page 167].

Part 3 discusses Quaternary remains of Michigan's amphibians and reptiles. This is most remarkable for a state field guide in its detail on sites and specimens. It expands consideration of the herpetofauna back

beyond the present. It is amply illustrated covering, in three separate sections, Michigan's Pleistocene Herpetofauna, Herpetofauna of Michigan Archaeological Sites and the Pleistocene. The last discusses this epoch in general and the adjustments made to its changing conditions by the North American herpetofauna. Here it is pointed out that "In spite of all the Pleistocene stresses undergone by amphibians and reptiles in North America, no amphibians or reptiles became extinct during this epoch except for some large tortoises". This is contrasted to the extinction of 8 families, 46 genera, and about 191 species of mammals over the same epoch and area. Humans, in contrast to their impact on other vertebrate groups, have had little effect on amphibians and reptiles during Pleistocene with the only documented disappearance being the easily obtained giant tortoises of the genus *Hesperotestudo* which were eaten in Florida. In addition "Many Michigan archaeological sites have yielded large turtles but very few have yielded small amphibians and reptiles. Apparently, sometimes it is important to be small and slimy" [page 238].

There is a 23-page section (253–275) of references that emphasizes Michigan studies and is dominated by 18 references by Holman as sole author and an additional 9 as senior author.

This may be the best state herpetology yet, and will be widely used as a reference by naturalists and professional herpetologists in Michigan and beyond. Both discussions of present occurrence and of past remains are well-illustrated with colour photographs of the first and sharply executed line drawings of the second. It is very relevant for eastern Canada as only 8 species (2 salamanders, 2 turtles, 1 lizard, and 3 snakes) which occur in Michigan do not also reach Canada naturally and the two turtles have been recorded (from escaped or abandoned individuals) in a number of localities here where they might eventually become established.

FRANCIS R. COOK

Canadian Museum of Nature, Ottawa, Ontario K1P 6P4

### Contributions to the History of Herpetology. Volume 3

By Kraig Adler (editor). Issued to commemorate the 7<sup>th</sup> World Congress of Herpetology Vancouver, British Columbia 2012. Society for the Study of Amphibians and Reptiles. 564 pages. 75.00 USD. Cloth.

This is volume 29 of the Society for the Study of Reptiles and Amphibians series *Contributions to Herpetology* and the third to feature biographies of herpetologists of the past. These have been compiled by the indefatigable herpetological historian Kraig Adler. Also included are the third editions of contributed sections by John S. Applegarth (Index of authors in taxonomic herpetology) and Ronald Altig (Academic lineages of doctoral degrees in herpetology).

The volume was prepared for the Seventh World Congress of Herpetology held 8 to 14 August 2012 at

the University of British Columbia, Vancouver. Each of the two earlier volumes were also issued to mark notable gatherings of herpetologists. The first was for the initial World Congress of herpetology held in Canterbury, England, in 1989, and the second to mark the 50<sup>th</sup> Anniversary of the Society for the Study of Amphibians and Reptiles held at St. Louis, Missouri, in 2007 (see Cook, F. R. 2007 [2009]. [Book review] *Contributions to the History of Herpetology Volume 2. Edited by K. Adler. Canadian Field-Naturalist* 121(4): 448).

The bulk of Volume 3 consists of the Bibliographies which occupy pages 13 to 353. They are followed by Literature Cited (pages 354–360) which includes publications with biographical information about herpetologists. Next (pages 361–386) there is a comprehensive index to bibliographies in all three volumes. (Volume 1 is out-of-print but available online and copies of Volume 2 are still available in print). The table of contents for volume 3 lists all the biographies included in this volume by time period in which each researcher made their most significant contribution, rather than date of birth. Volume 3 has the most bibliographies with 349; volume 2 had 285, and volume 1 contained 152, for a total of 786. A Canadian qualified for each of the first two volumes, Stanley W. Gorham (1917–1984) and E. B. Shelly Logier (1893–1979). One more is added to the latest, Clyde Louis Patch (1887–1952). Throughout there is fascinating detail on the careers and major accomplishments of those discussed in each entry. Despite all the stress that a research career can put on a marriage, only one herpetologist is recorded as fatally shot by his wife (Bernard Martof).

The Index to Taxonomists compiled by Applegarth follows (pages 387–469) and covers authors who have participated in the naming of taxa of living amphibians and reptiles at the genus level or below. Also included are those with one or more taxa within these groups named in their honour of those who have authored at least one contribution in herpetology.

Academic lineages compiled by Altig (pages 471–564) includes only doctoral degrees. The total is 5562 names (1752 new) covering 1745–2012 (267 years) from 58 countries (about 25% of those recognized by the United Nations).

This project began 30 years ago in 1982 with a slide presentation prepared for the 25<sup>th</sup> anniversary of the Society for the Study of Amphibians and Reptiles. Adler comments in the introduction to the latest volume that it is the final one in the series. Likely an alternative for additional contemporary biographies will be found when needed, perhaps one is already in progress as Applegarth states for his section that he is planning a fourth edition.

FRANCIS R. COOK

Curator Emeritus and Research Associate, Canadian Museum of Nature, Ottawa, Ontario K1P 6P4

## A Pocket Guide to Lizards and Turtles of Pennsylvania

By Walter E. Meshaka, Jr., and Joseph T. Collins. 2012. The Pennsylvania Heritage Foundation, 225 State Street, Suite 302, Harrisburg, Pennsylvania 17101 USA. 40 pages. 4.71 USD.

This 15.2 by 9.5 by 0.3 cm guide is ideal for field use. It will easily fit into most pockets/ in pants, jackets or backpacks. It is printed on heavy glossy stock which should stand up well to field use in a multitude of weather conditions.

Its authors have excellent credentials. Walter Meshaka is a senior curator of zoology and botany at the State Museum of Pennsylvania and the late Joe Collins, who died in January 2012, was founder of the Center of North American Herpetology and junior co-author of the third edition of the Peterson Series *Field Guide to the Reptiles and Amphibians of Eastern and Central North America* as well as author or coauthor of numerous herpetological papers. The *Pocket Guide* is illustrated by colour photographs by Suzanne L. Collins. An initial statement also credits an impressive multi-sponsorship list: The State Museum of Pennsylvania, Pennsylvania Historical & Museum Commission; Wild Resource Conservation Program, Pennsylvania Department of Conservation & Natural Resources; Dickinson College Biology Department; Forgotten Friend Reptile Sanctuary; Friends of Wildwood Lake Nature Center, Inc.; Liberty Environmental, Inc.; Powdermill Nature Reserve; Shippensburg University; and The Center for North American Herpetology.

On the inside of the front cover there is a dedication to Carl H. Ernst for his studies of turtles. An initial table of contents page is followed by an introduction

and acknowledgements and 17 pairs of facing pages which cover each native species. One has a brief text and the other two (three for one lizard) photographs in colour. Text covers English name, scientific name, brief selected representative details of body size, range (in Pennsylvania), habitat, habits, breeding, diet, and conservation considerations. One instance insufficiently edited for clarification occurs on page 12 which concludes "Common Snapping Turtles are harvested for human consumption, and the harvesting practices of these turtles should be approached cautiously in light of their delayed maturity".

The state range maps presented for each species are based on information from the *Pennsylvania Herpetological Atlas* web site and *Amphibians and Reptiles of Pennsylvania and the northeast* by Arthur C. Hulse, C. J. McCoy, and Ellen J. Censky. The maps are minute but by depicting counties present in green makes the distribution patterns stand out. The photographs generally show typical animals sufficient to identify each species but many are perhaps too dark and their value would be enhanced if the locality was included for each particularly for the Painted Turtle whose morphology varies across the state between two hybridizing subspecies.

The guide concludes with four pages covering a checklist, notice of three additional pocket guides in the series which cover snakes, frogs and toads, and

salamanders of Pennsylvania, sources of further information on herpetology on websites, and publications relevant to Pennsylvania, comments on herpetoculture including addresses for information on current state regulations. The inside back cover has capsule biographies of the authors and artist and a quote from Archie Carr's *Handbook of Turtles*. The outside back cover gives information on the sponsors of the guide.

The English and scientific names understandably follow Collins and McTagert 2009 *Standard Common and Current Scientific Names for North American Amphibians, Turtles, Reptiles, and Crocodylians* published by the Center for North American Herpetology rather than that edited by Crother (2012) for committee formed by the Society for Study of Amphibians and Reptiles and more generally adopted by professional

herpetologists and journals (see Cook review of the latter *in press*).

This pocket guide is useful for all naturalists to carry with them in eastern Canada. It is especially ideal for junior naturalists as a "starter" guide. The only lizard and all eight of the native freshwater turtles that occur there are included in the 17 accounts presented. Also included is the Box Turtle which apparently is recorded in Canada from escaped captives. The only missing species of those recorded from eastern Canada is the non-native Red-eared Slider, *Pseudemys scripta elegans*, which frequently has escaped or been deliberately released in southern Ontario and Quebec.

FRANCIS R. COOK

Curator Emeritus and Research Associate, Canadian Museum of Nature, Ottawa, Ontario K1A 6P4

## Owls of the World: A Photographic Guide

By Heimo Mikkola. 2012. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 512 pages. 49.95 CAD. Cloth.

Heimo Mikkola's first book, *Owls of Europe*, in 1983, shared his extensive knowledge, immediately recognized as a classic, one still available electronically after printed copies sold out. By nature benevolent and altruistic, Heimo then shared his other expertise, in zoology and agriculture. He joined FAO, the Food and Agriculture Organization of the United Nations "that leads international efforts to defeat hunger" and moved to Africa to assist struggling farmers improve their methodology.

After Heimo retired from FAO, Jim Martin from Bloomsbury Publishing approached Heimo and suggested he write a new book on the world's owls. This new book, *Owls of the World*, is the first comprehensive guide to the world's owls. It contains the finest collection of owl photographs I have seen in one book, up to eight for each of the 249 species. Legends for each colour photograph point out clues for recognition of each species and some subspecies. There are up-to-date maps of each species' distribution. Literature cited continues through the end of 2011, proof that the content is up-to-date.

To me, additional pleasure was derived from reading Heimo's insightful chapters. Under "What makes an owl?" the specialized and unique vision, especially night vision, hearing, silent flight, bill and claws are succinctly explained. Under "The nature of owls," similar attention is given to: shape and size, calls, colour variation and ageing, abnormalities in plumage, moult, food and hunting, habitat, behaviour, interspecific aggression, breeding strategies, longevity records, and movements. Shorter selections explain the evolution, distribution, taxonomy, DNA-sequencing, and conservation of owls. Altogether it provides an entire mini-encyclopedia for enjoyable reading and subsequent

ready access. Prior to reading it, I had failed to appreciate that 68 per cent of owl species live in the Southern Hemisphere! The remaining 32 percent are found in the Northern Hemisphere.

Heimo helps readers to better understand why they are so attracted to owls, as follows:

"With very few exceptions, owls look like nothing other than owls. They are soft-plumaged, short-tailed, big-headed birds, with large eyes surrounded, usually, by a broad facial disc. Owls probably have the most frontally situated eyes of all birds. This, together with their ability to blink with the upper eyelids, gives them a semi-human appearance, in which surely lies much of their appeal to man."

No book is perfect. The index is restricted to species and an occasional subspecies, but omits other topics. Sadly, Mikkola erroneously follows König in accepting the term *wapacuthu* for the northernmost subspecies of Great Horned Owl (Pennant had given the name to a Snowy Owl!, long ago discredited by Browning and Banks in 1990 and Houston et al. in 2003).

Every student of owls should buy this book. If hesitant, borrow a library copy, admire the photographs, read the first 70 pages, which cover the general topics mentioned above – and I promise you will then buy it.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

### References

- Browning, M. R., and R. C. Banks. 1990. The identity of Pennant's "Wapacuthu Owl" and the subspecific name of the population of *Bubo virginianus* from west of Hudson Bay. *Journal of Raptor Research* 24: 80–83.
- Houston, C. S., T. Ball, and M. Houston. 2003. *Eighteenth-Century Naturalists of Hudson Bay*. McGill-Queen's University Press, Montreal, page 167.



## BOTANY

**Rhizobia in China**

By Chen Wenxin and Wang Entao. 2012. Beijing Science and Technology Press, 16 Xizhimen South Street, Beijing 100035 China. 496 pages. 108.00 CNY. Cloth.

Rhizobia are soil diazotrophs that form a symbiotic association with legumes, and fix nitrogen after becoming established inside root nodules of legumes (Fabaceae). OLINK "[http://en.wikipedia.org/wiki/Root\\_nodule](http://en.wikipedia.org/wiki/Root_nodule)" "Rootnodule") In general, they are Gram-negative, motile, non-sporulating rods. Rhizobia belong to a paraphyletic group that fall into two classes of the proteobacteria, the alpha- and beta-proteobacteria. Most of them belong to the order Rhizobiales, but several rhizobia occur in distinct bacterial orders of the proteobacteria. The taxonomy of rhizobia has changed considerably over the last 20 years, with the original genus *Rhizobium*, a member of the alpha-Proteobacteria, now divided into several genera. There are currently six phylogenetically distinct genera of rhizobia. The taxonomy of these organisms is still in flux due to rapidly advancing analytical techniques.

Nitrogen is the most critical nutrient needed to support plant growth. Unfortunately, atmospheric dinitrogen is extremely stable due to triple bonds which can only be broken by energy intensive ways, including electrical  $N_2$  fixation by lightning, the Haber-Bosch process and biological  $N_2$  fixation in legumes by bacterial symbionts. The reduction of atmospheric dinitrogen into ammonia has been considered the second most important biological process on earth after photosynthesis. Biological fixation of nitrogen can contribute large amount of plant usable nitrogen to the soil nitrogen pool. Estimates of the amount of fixed  $N_2$  range from 57–600 kg/ha per year and vary widely. Symbiotic nitrogen fixation is noted to reduce the need for excessive synthetic fertilizer additions by replacing man-made nitrogen with a naturally produced form. Simply by utilizing crop rotation with legumes could save millions or billions of dollars currently being spent on synthetic nitrogen forms used extensively in monoculture agriculture, namely continuous corn production. Biological fixation of nitrogen was the leading form of annual nitrogen input until the last decade of the 20th century. It is gaining attention once again as sustainability becomes a central focus to feed a world population of over 7 billion people.

So far, many works relating to rhizobia research are occurring on North American and Europe, but less in other regions. Actually, rhizobium research has been done in many areas, but not all of their works have been reported, thus, less been known to the outside world. The recently published book *Rhizobia in China* systematically reported the rhizobium research works in China in the last 30 years, which may strengthen rhizobium research in China, promote information exchange

internationally and the application of rhizobia in the agriculture, forestry and animal husbandry.

The book of *Rhizobia in China* is divided into 20 chapters and four parts. The first part is general introduction, mainly including the rhizobium characteristics, function, origin and evolution, classification history and classification system, molecular mechanisms of rhizobium and legume symbiosis, genomics and post-genomics research on rhizobium. The second part is rhizobia diversity and systematics of modern research techniques and methods. The third part is rhizobium resource diversity in China and the descriptions of genus and species. The fourth part is rhizobium ecology in China, including the geographical distribution of rhizobia, application history and prospect, rhizobia selection principles and methods, the mutualism effects between the inter-cropping leguminous crops and gramineous crops, as well as rhizobium role in the restoration of the environment.

The book is by far the most systematic monograph on Chinese rhizobium research. The book not only systematically introduced the worldwide latest achievements in the field of rhizobium research in recent years to Chinese readers, but also the main results of Chinese rhizobium research to the world. The book has obvious theoretical and application values, but, there are still a number of weaknesses or some points need to be improved. The first and second parts have not sufficiently and systematically introduced the progresses made in rhizobium research worldwide in recent years. The number of literature citations was relatively small and scattered. New discoveries in recent years in this field were not introduced comprehensively, and even some much more important results were not mentioned. Some of the introductions to the earlier and popularly recognized knowledge on rhizobium need to be compressed so as to save some space. The recent changes in rhizobium classification system and the latest and important results in rhizobium molecular biology have not been clarified enough. Of course, completely doing all these works mentioned above may not be the compulsory responsibility for the book focusing on introducing the rhizobia of China, but a concise generalization, refining and introduction to the latest advancements in this field still could be done if more effort was made. The third part on the rhizobium resource diversity and genus, species description is the core of the book, with a large amount of information. However, since so far there have not been so many in-depth mechanistic studies on rhizobia in China, this part can only be written based on the actu-

al situations and real materials in such a manner to represent the present. Hopefully, along with the gradual accumulation of the in-depth, systematic and mechanistic research results on rhizobia in China, this part of the book would be further strengthened and enriched in the second edition.

The title of the fourth part is the rhizobium ecology in China, but the contents were somewhat erratic. When writing this part, the authors probably found that there were less material directly related to this subject, thus, they collected some material that was not closely related to this subject. For the structural integrity and coordination of the whole book, it might be better if the present fourth part would be treated as follows: deleting the title of part four, but some contents might be included in the first part of the book, and some others

might be included in the third part of the book; new chapters or sections may be set up if necessary.

Small defects cannot obscure the great virtues. As a first most systematic monograph on Chinese rhizobium research, the book might be of especially obvious values to the researchers outside China who would be interested in the rhizobia in China.

LI DEZHI<sup>1</sup> AND QIN AILI<sup>2</sup>

<sup>1</sup>Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 500, Dongchuan Rd. Shanghai, China, 200214.

<sup>2</sup>Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Road, Songjiang, Shanghai, China, 201600.

## OTHER

### **Biodiversity in Agriculture: Domestication, Evolution and Sustainability**

By Paul Gepts, Thomas R. Famula, Robert L. Bettinger, Stephen B. Brush, Ardeshir B. Damania, Patrick E. McGuire and Calvin O. Qualset (editors). 2012. Cambridge University Press, Cambridge, United Kingdom. 630 pages. 70.95 CAD. Paper.

The publisher's summary describes this book as "Bringing together research from a range of fields including anthropology, archaeology, ecology, economics, entomology, ethnobiology, genetics and geography, this book addresses key questions relating to agriculture ... A synthesis of the most recent research results and implications for the origin of crops and domesticated animals". It's unfortunate that they do not mention in any of the advertising that this is in fact the proceedings of a conference. Given the advertising, I was expecting a high-level, multi-disciplinary review of the origin and development of agriculture. What we get instead is a collection of research articles, some of which are the promised synthetic reviews, while others are more narrowly focussed papers that remain within the bounds of a single discipline.

This book is the result of the Harlan II Symposium held in California in 2008. It contains 27 contributions in five sections. The first provides archaeological perspectives on the development of crops and farming in prehistory. The second and third sections address biological issues in the domestication of animals and plants, respectively. The fourth section presents the management of biodiversity in various cultures. The book concludes with a section on current and future development of agricultural biodiversity.

One of the highlights is the first paper, in which Jared Diamond presents a case for the biological pre-requisites for the development of agricultural societies. He argues that only a small subset of plants and animals are amenable to domestication, and the traits that make them good candidates arise in response to environmental pressures. Consequently, only humans living in ap-

propriate environments had the biological materials available to develop agricultural economies. Diamond's argument is only 10 pages, and quite accessible to the general reader.

From here we move into a series of more detailed archaeological papers. I found the topic fascinating: how did we move from foraging to agricultural societies? The subject is illustrated with several regional case studies. However, the detail was overwhelming at times. That is to be expected if your audience is professional archaeologists. But as a reader coming from another discipline in search of a synthetic review, I don't have the context to understand the significance of the difference between bifacially shaped tools and polished axes in 7500 year old societies. Since the authors don't provide this context, I assume they're writing for people that don't need it.

Thinking I might be missing the point, I jumped ahead to the plant papers. As a botanist, I should have the background to properly appreciate this work. Indeed, the genetic characterization of Brazilian crop systems presented in chapter 15 was familiar territory for me. That said, I wonder if the archaeologist that appreciates the extensive data presented in the first section would also have the training to make sense of the dendrograms and molecular variance analysis in this section. This is not to say that these tools aren't useful beyond the people that use them. Rather, due to the focus on the data rather than the larger context, these chapters were clearly directed towards readers in the same discipline.

The last two sections of the book provide less technical material that will be more accessible to general readers. I particularly enjoyed the chapter on aquacul-

ture. Most of the book focuses on our efforts to unravel our agricultural past using imperfect archaeological and biological data. Since aquaculture is really just beginning, we will be able to study the domestication process as it happens, rather than be left trying to infer what happened in retrospect. This promises to provide a valuable counter-point to our understanding of terrestrial systems.

On the whole, if this book had been advertised as the proceedings of an important conference on the topic of evolution and diversity in agriculture, I would recommend it unreservedly to researchers in related fields. Most of my misgivings arise from the poor description, rather than the actual content of the volume. At a list price of \$70.95, I don't think this is good value for a general audience.

TYLER SMITH

8 Hillcrest Avenue, Wolfville, Nova Scotia, B4P 1T4

## The 2010 Norwegian Red List for Species

By J. A. Kålås, Å. Viken, S. Henriksen, and S. Skjølseth (editors), 2010. Norwegian Biodiversity Information Centre, Norway. 480 pages.

This publication of 26 chapters covering virtually all biodiversity species groups in Norway might be of general interest for the Canadian Naturalist. This latest 480 pages long 2010 Red List (updated from 2006) for Norway follows the IUCN standards. This publication comes as a hard copy or freely available online at <http://www.artsdatabanken.no/Article.aspx?m=207&amid=8737>. It comes with a 6 page glossary, 9 pages of literature citations and with a 23 page species index (in Latin and Norwegian); some photos, drawings and maps are provided also. An affiliated online database and more information on general species occurrence in Norway is found at [www.artsdatabanken.no](http://www.artsdatabanken.no) (but without good and obligatory metadata).

Red Lists such as this one are essentially biological dead-lists, because once a species is on it, it hardly comes back from it due to the ongoing and usually irreversible environmental degradation (unless political interference or bookkeeping methods are used to imply otherwise). The Red List text states that it tries to be a "...forecast of the risk that a species will die out in Norway". Norway pronounced boldly years ago that it aimed to stop all loss of biodiversity by 2010. But as obvious from this book, Norway failed in that delivery, and this book is a reference in time documenting how western society tries to deal with such things in times of a serious biodiversity crisis on a global scale.

I like this book, based on the fact that it provides the reader with much good and new information and documentation of the status quo. For instance, 2,300 vascular plants are reported for Norway; but only 46% of the plants are natural. Norway has the highest moss flora in Europe. Authors show that grassland fungi declined the last 50 years by 30–50%; and Bearded Lichens are shown to decline too. As found elsewhere in the world, old-growth forest is in short supply now. Forty Norwegian gastropod species are on the Red List also. One whale and one rodent are classified as recently extinct in Norway. For the first time, pseudo-scorpions and harvestman are now red listed too. The last 4 of the well-structured 26 chapters have most of the

hot discussed species in public though: fish, amphibians, birds and mammals (red listed are for instance Arctic fox, lynx, river otter, wolf, wolverine, Polar Bear, Brown Bear, Atlantic puffin and some bats).

Here are more details (taken from the numerous tables in the text): Finnmark and Troms reports the least amount of species on the Red List (350 and 411), Svalbard even only lists 71 species, but Oslo/Akershus shows already 1,462 species (the location where most Norwegians live). This confirms (a) that the Norwegian way of life resulted so far in many Red Listed species, and (b) that in times of climate change, probably too few Arctic species are already listed for meaningful assessments. Knowing the small mammal situation in Alaska and elsewhere, the Norwegian red listing for this species group, e.g., Svalbard and coastal islands and relevant meta populations, must already appear as widely underachieving (only *Sorex isodon* is listed for Svalbard). Auks like the Atlantic Puffin, Dovekie, Razorbill and Thick-billed Murre are in trouble now, one way or another.

The Norwegian freshwater management problems are exemplified by the 133 species of molluscs that are on the Red List. And despite claims of a sustainable fishery, 9% of Norwegian saltwater fish are already red listed. Oddly, however, salmon was not listed (but this species is locally extinct now in already over 50 rivers; and as the book states, a 20% population reduction occurred just within the last 10 years). Regarding some major fish species, the book reads: "*Despite this serious decline in the stock, a directed and unlimited fishery is allowed for several months a year, thus worsening the situation*". Any naturalist must wonder how can that be pre-cautionary, sustainable or even meaningful?

The deficiencies in this book include for instance an absence of (bird) data and few herpetological experts. Due to no data coverage, the adjacent Swedish (bird) data got employed for this Norwegian Red List. Population sizes of many birds were simply taken from BirdLife International (2004; a coarse international reference and already over 8 years old). Moreover, an ex-

pert group of just one individual contributed the relevant Red List information for amphibians and frogs, nation-wide. Authors state that "...species die out without our being aware". But this is not so surprising, given that only 2,500 marine species got evaluated out of 6,000 multicellular species known to occur for this Norwegian Red List.

Red Lists do not really report unhealthy population explosions, like the recent skua populations in Arctic Norway. And these indicators of a rather unnatural state are not provided here for a better context, unfortunately. However, some of the text deals with introduced species like musk ox, wild boar and fallow deer. Disease as a causal factor to listing is not well covered in the text. But for underlying causes, this book widely misses the impact of the Norwegian life-style, as well as the inherent economic growth conflict (as it is typical for most IUCN publications). Clear-cut logging, as well as selective cutting, is thought to have negative effects on species and habitats. Pollution (contamination) makes for the second-next cause, but the concept and term of a 'toxic tort' (=many interacting contaminations with a low concentration) still is virtually ignored (but widely known to occur, e.g., in Norwegian polar bears, some seals, fish and seabirds). Terrestrial and aquatic fertilization is reported as a leading cause for threatened and near-threatened species. Acidification is also mentioned as a bold problem, e.g., acid rain (but not for coastal waters yet). Besides the regular 'development' problems, 30% of the lakes have also been lost, affecting amphibians dramatically. Seabirds are reported to suffer from predation by mink (via population range increases), from fisheries, and drown-

ing in fishing gear (human pursuit is not mentioned though). Impacts of wind parks and coal mining (Svalbard) are virtually not discussed by the Norwegian Biodiversity Information Centre. Whaling is also widely not mentioned as a problem (Norway is a member state of the International Whaling commission but has continued to whale commercially since the IWC ban on commercial whaling in 1986).

While the red list topic is always very fascinating and stimulating indeed, this technical text (provided in Norwegian and in English) makes for dry reading. My officially-bought copy was missing pages 24–33 and double-printed pages 33–40 (evidently some print-runs seem to have that error).

As this book re-confirms once again IUCN Red Lists are a rather poor and bureaucratic platform for dealing appropriately with ecosystem, contamination and stressed population issues, and for conservation progress. They are hardly pro-active at all and do not call for a reduction in carbon emissions, for less consumption of natural resources and for a more effective management for instance. But this publication shows us clearly that Norway has widely overcommitted itself (already this Red List effort of 26 committees and 100 members suffers from a stated lack of money, and the future will see even more intense listing pressures). Arguably, and like many other Arctic nations, Norway only has 4.8 million inhabitants but lives already widely over its sustainable carrying capacity.

FALK HUETTMANN

Institute of Arctic Biology, Biology & Wildlife Department,  
University of Alaska-Fairbanks (UAF), Alaska USA

## A Primer of Ecological Statistics, Second Edition

By Nicholas J. Gotelli and Aaron M. Ellison. 2013. Sinauer Associates, Inc., 23 Plumtree Road, P.O. Box 407, Sunderland, Massachusetts 01375-0407 USA. 614 pages, 120 illustrations. 54.95 USD. Paper.

Given that statistics are used to support arguments and learning in ecology at multiple levels of technical depth, an overview text on ecological statistics that can clearly explain the application of various tests is worth its weight in gold. Whether an in-field technician, ardent naturalist or academic, the changing use of statistics in ecology can be daunting for those among us who rely on a few tests based on experience, or who are long-removed from our university statistics courses.

The first edition of 'A Primer of Ecological Statistics' sought to meet the particular needs of ecologists and environmental scientists first through introducing probability theory and then the specific experimental designs used within ecological studies. Released almost ten years later, the second edition adds sections on the process of estimation, useful for community ecology and demography studies.

A deceptively dense book, the heavy Primer is printed on thin, glossy paper with two shades of blue used

as colour accent. Asides are presented as footnotes rather than boxes in-text, which may make reading more streamlined. The text is clearly aimed at senior science classes and above, as there are very few graphics used to illustrate founding statistical principles and almost no photographs. However, it is generalist in coverage, so for more in-depth treatment and application of particular tests or types of test (e.g., multivariate statistics) further reading might be required.

Fourteen chapters are logically laid out over four sections: fundamentals of probability and statistical thinking; designing experiments; data analysis; and the new section on estimation. There is an appendix reviewing matrix algebra, a glossary and an extended works cited section. Many texts will cover statistical basics, and the real strength of this text is in its treatment of experimental design from a statistical perspective. As the authors note in their forward, statistical use in ecology is shifting as computing power improves and can

be used for calculations more sensitive to the chaotic reality of nature. The shift includes a move from basic testing of hypotheses to estimating possible parameters.

In ecology, we know that we can likely never measure everything and are working with only small samples of diversity and using these samples to reflect their greater, more variable populations. All illustrative examples in the book use a hypothetical ecological situation, which while to be expected in an ecological statistics text, makes the content more useful in its application as any student using a biostats text in a non-medical context can attest. The Primer illustrates the difference in ecological experiment type depending on window of time used for the study, which is especially relevant for graduate students and impact assessment ecologists as both face budget and temporal restrictions.

The way the book is written and presented is more discursive than instructional. Mathematical equations are used to further explain how certain tests work, when truly the majority of ecologists rely on computer programs to perform the calculations and only concern themselves with whether the test is appropriate or not to their study needs. The inclusion of so many equations can be off-putting to a reader who only wants to know if the test is applicable, and its pros and cons. Other statistical books do quite well in this arena by not only clearly explaining when a test should be used or not, but also providing decision trees to assist re-

searchers in selecting a correct test.

More graphic illustration would be beneficial to explain how certain tests work in theory to help reinforce knowledge. For visual learners, far more illustration is required. Margin notes would help quickly find relevant points or takeaway information, providing a further layer of visual complexity and ease of navigation. As previously stated, this is not an entry-level or very advanced text; however, it could stand to incorporate more tools to create a book that can be readily used to learn statistical tests quickly and when they should or should not be used.

The Primer is, in fact, a decent introduction to considerations unique to ecological study and within its text are many useful ideas to retain while developing research studies. Where it is less effective is in instructing on how to use tests and when, especially the multivariate. Other books are far more user friendly in this respect and are equally aimed at the ecological sciences. Nevertheless, the theoretical discussion about how tests can be used in an ecological context and emerging areas such as estimation is excellent. I learned new tips and considerations in statistical design, and I think this book would be an excellent addition to the technical library for that reason alone. Otherwise, try and borrow the book from a library to determine if it fulfills an empty niche within your own technical collection.

TREMAINE STANTON-KENNEDY

Ottawa, Ontario

## NEW TITLES

Prepared by Roy John

† Available for review \* Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

## ZOOLOGY

\* **Contributions to the History of Herpetology, Volume 3.** Edited by Kraig Adler. Issued to commemorate the 7<sup>th</sup> World Congress of Herpetology Vancouver, British Columbia. 2012. Society for the Study of Amphibians and Reptiles. SSAR Publications, Post Office Box 58517, Salt Lake City, Utah 84158-0517 USA. 564 pages. 75.00 USD. Cloth.

\* **A Pocket Guide to Lizards and Turtles of Pennsylvania.** By Walter E. Meshaka, Jr. and Joseph T. Collins. 2012. The Commonwealth of Pennsylvania Bureau of Publications, 1650 Bobali Drive, Harrisburg, Pennsylvania 17104 USA. 51 pages. 4.71 USD. Paper.

\* **Salamanders of Pennsylvania.** By Walter E. Meshaka, Jr., Joseph T. Collins and Suzanne L. Collins. 2012. The Commonwealth of Pennsylvania Bureau of Publications, 1650 Bobali Drive, Harrisburg, Pennsylvania 17104 USA. 51 pages. 4.71 USD. Paper.

## OTHER

\* **More than Birds – Adventurous Lives of North American Naturalists.** By Val Shushkewich. 2012. Dundurn Press, 500-3 Church Street, Toronto, Ontario M5E 1M2 Canada. 296 pages. 27.99 CAD. Paper.

**Eastern Alpine Guide: Natural History and Conservation of Mountain Tundra East of the Rockies.** By M. Jones and L. Willey. 2012. Beyond Ktaadn Inc., 90 Whitaker Road, New Salem, Massachusetts 01355 USA. 348 pages. 34.95 USD. Cloth.

\* **A Primer of Ecological Statistics (Second Edition).** By N. Gotelli and A. Ellison. 2012. Sinauer Associates, Inc., 23 Plumtree Road, P.O. Box 407, Sunderland, Massachusetts 01375-0407 USA. 614 pages. 54.95 USD. Paper.

**An Environmental History of Canada.** By L. S. MacDowell. 2012. UBC Press, University of British Columbia, 6344 Memorial Road, Vancouver, British Columbia V6T 1Z2 Canada. 352 pages. 49.95 CAD. Paper.

**Environmental Science – Science-based Problem Solving in Today's World.** By Karen Root. 2012. Sinauer Associates, Inc., 23 Plumtree Road, P.O. Box 407, Sunderland, Massachusetts 01375-0407 USA. Online textbook. 65.00 USD.

**Saving Global Fisheries.** By J. S. Barkin and E. R. DeSombre. 2013. The MIT Press, Five Cambridge Center, Cambridge, Massachusetts 02142-1493 USA. 288 pages. 29.00 USD. Cloth.

**Harvesting the Biosphere.** By V. Smil. 2013. The MIT Press, Five Cambridge Center, Cambridge, Massachusetts 02142-1493 USA. 312 pages. 29.00 USD. Cloth.

**Parks, Peace, and Partnership: Global Initiatives in Transboundary Conservation.** By Michael S. Quinn, Len Broberg and Wayne Freimund (Editors). 2012. University of Calgary Press, 2500 University Drive N.W., Calgary, Alberta T2N 1N4 Canada. 400 pages. 31.96 CAD. Paper.

**Wildlife, Conservation, and Conflict in Quebec, 1840-1914.** By D. Ingram. 2013. UBC Press, University of British Columbia, 6344 Memorial Road, Vancouver, British Columbia V6T 1Z2 Canada. 230 pages. 95.00 CAD. Cloth.

**Inventing Stanley Park.** By S. Kheraj. 2013. UBC Press, University of British Columbia, 6344 Memorial Road, Vancouver, British Columbia V6T 1Z2 Canada. 304 pages. 95.00 CAD. Cloth.

## CHILDREN

**Caterpillars.** By Chris Early. 2013. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 32 pages. 19.95 CAD. Cloth.

**Dragonflies.** By Chris Early. 2013. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 32 pages. 19.95 CAD. Cloth.

**Weird Sea Creatures.** By Erich Hoyt. 2013. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 64 pages. 19.95 CAD. Cloth.

# News and Comment

## Yorke Edwards, 1924–2011

Yorke Edwards died 16 August 2011 in retirement in British Columbia. For nearly 50 years, Yorke was a major contributor to studies of wildlife biology, nature education, and conservation. In 1950, he obtained his Master's degree in zoology at the University of British Columbia with Ian McTaggart Cowan as supervisor. He joined the British Columbia Forest Service in 1951 as a research officer and in 1959 championed nature

interpretation in provincial parks. In 1967 he joined the Canadian Wildlife Service and in 1972 joined the British Columbia Provincial Museum as Assistant Director and subsequently was Director from 1975 to 1984. He was elected an Honorary Member of the Ottawa Field-Naturalists' Club in 1980 in recognition of his contributions to parks and wildlife interpretation.

## The Canadian Herpetologist (TCH) 2(2), Fall 2012

The Canadian Herpetologist (TCH) is a publication produced twice each year by the Canadian Association of Herpetologists and the Canadian Amphibian and Reptile Conservation Network.

CONTENTS: Executive Members of Societies — Instructions for Authors — Editorial Notes — Meetings — Feature Articles: Northern Alligator Lizard – Lezard-alligator Boreal (*Elgaria coerulea principis*) by P. Rutherford; Common Five-lined Skink – Scinque pentaligne (*Plestiodon fasciatus*) by C. Seburn and B. Howes — Field Notes: Sharp-tailed Snake Discovery by L. Anthony; Automated Audio Monitoring of Introduced American Bullfrogs in the Okanagan by N. Lukey, M. Baxter and S. Ashpole — Reviews — Thesis Abstracts in Canadian Herpetology: Boyle, K. M.Sc.

2012. University of Victoria, Victoria, British Columbia. (Supervisor: Pat Gregory). Life in a Drawdown Zone: Natural history, reproductive phenology, and habitat use of amphibians and reptiles in a disturbed habitat. — Perez, A. M.Sc. 2012. Université de Montréal, Montréal, PQ. (Supervisors: Marc J. Mazerolle and Jacques Brisson). Le roseau commun (*Phragmites australis*) influence-t-il la composition spécifique et le développement larvaire d'amphibiens? — Riley, J. M.Sc. 2012. Laurentian University, Sudbury, Ontario. (Supervisor: Jacqueline Litzgus). The Importance of Nest Environment for Turtle Conservation. Hatchling Overwintering Strategy, and Fitness. — Recent Publications in Canadian Herpetology — News and Announcements — Membership Forms: CARCNET.

## Erratum The Canadian Field-Naturalist 126(3): 245

The title of the article should be: Gray, David R., and Sally E. Gray. 2012. A tribute to Stewart Dixon MacDonald, 1927–2010. Canadian Field-Naturalist 126(3): 245–251.

## The Ottawa Field-Naturalists' Club Awards for 2011, Presented April 2012

KEN ALLISON, IRWIN BRODO, JULIA CIPRIANI, CHRISTINE HANRAHAN, AND ELEANOR ZURBRIGG

At the Club's Annual Soiree, held on 21 April 2012, at St. Basil's Church in Ottawa, awards were once again given to members who distinguished themselves by accomplishments in the field of natural history and

conservation, or by extraordinary activity within the Club. The following five citations for those who received an award were read to the members and guests assembled for the event.

### Anne Hanes Natural History Award: Colin Freebury

The Anne Hanes Natural History Award recognizes outstanding contributions of an amateur naturalist to our understanding and knowledge of the natural history of the National Capital Region. This year, the worthy recipient is Colin Freebury.

Colin is known to many Club members because of his outstanding photographic skills. In fact, he was practicing those skills on a lichen-hunting field trip a few years ago and became fascinated with the lichens themselves. Anyone who knows Colin wouldn't be at all surprised at this, because Colin has a passion for knowledge coupled with a keen intellect. Once started on his journey to learn more about lichens, there was no looking back. Early on, he decided that he would explore Gatineau Park for its lichens, to contribute whatever he could to what we already knew about the flora. Armed with a collecting permit, knife, hammer, chisel and hand lens, he began to sample the lichens he found throughout the park, photographing many, thereby creating an image library that can be (and has been) used in lectures about the lichens of the park. Each trip brought new discoveries and new names for the list of Gatineau Park lichens. With patience and a keen eye, he found many rarities, a few of them new to the Ottawa Region as a whole. He created an Excel file with information on all the lichens he collected and the ones already deposited in the lichen herbarium at the Canadian Museum of Nature. Each new record was carefully documented. When the list reached 300 and kept on growing (it is now at 324), he thought it was time to share the information, especially since he knew that a new checklist of Quebec lichens was being finalized. The result was an excellent article in *Trail & Landscape* (April – June 2011) on the Lichens of Gatineau Park based on a

careful study of herbarium specimens, new field work and the literature. Colin now regularly attends the annual Gatineau Park research seminars run by the NCC to give updates of his findings.

Although the publication of the Gatineau Park lichens is the main reason for the award, it is pertinent to mention other lichenological activities occupying Colin's time. He volunteers at the Canadian Museum of Nature Research and Collections Division, mounting lichen specimens, entering label data into the data processing program, preparing exchanges and loans, and helping out retired lichenologist, Irwin Brodo, in countless other ways. Colin's superb skill in communicating to the public (in both official languages) has not gone unnoticed by the Museum, and they have enlisted his help at Museum "Open Houses" and "Meet the Scientist" events.

Colin has recently deepened and broadened his interest in lichen research. A few summers ago, he travelled to Maine to take a course on crustose lichen identification at Eagle Hill taught by Irwin Brodo. He and Dr. Brodo are now collaborating on a study of the frosted rosette lichen, *Physcia aipolia*, and its newly discovered sister species, *Physcia alnophila*, and the manuscript should be submitted soon. His main lichenological project, however, is outside the Ottawa Region. Colin has been visiting and collecting lichens in Grasslands National Park in Saskatchewan for several years, and he is well on his way towards the completion of this mammoth treatment. It seems that Gatineau Park was just the beginning.

All these activities, interests and accomplishments make Colin Freebury a fitting recipient of the Anne Hanes Award for 2011.

### George McGee Service Award: Ann Prescott

The OFNC George McGee Service Award is given in recognition of a member who has contributed significantly to the smooth running of the Club over several years.

Ann Prescott has been a member of the Club since 1996, prompted to join by her cousin Dave Moore who was Club president at the time, and by her interest in

birding. In 2004 Ann joined the Education and Publicity Committee and got involved in a range of activities to support the Club's publicity efforts.

Ann has been the welcoming face behind the sales table at the Club's monthly meetings since 2004. She has tirelessly transported the promotional materials, set up the display of pamphlets, t-shirts, publications,



including copies of CFN, and greeting cards before members arrive at 7:00 p.m. and taken it all down at 7:30 for the start of the meeting.

In June 2011, she set up the sales table for the first time at the Club's Annual Native Plant Sale at the Fletcher Wildlife Garden. She managed a brisk trade, selling Club T-shirts and several copies of Dan Brunton's *Nature and Natural Areas in Canada's Capital*, earning over \$200.

For the past several years Ann has been an anchor at the entrance table for the Club's Annual Soirée, sharing responsibility for selling and taking tickets and managing in-coming traffic.

She has played an important role in the Education and Publicity Committee's drive to increase member-

ships. She has set up and staffed the OFNC display at Mud Lake, at Eco-fairs at the RA Centre and the Rideau Trail and at the Wildlife Festival at Billings Bridge, among other places.

Ann participated in the Club's promotional efforts in a number of government departments, including Agriculture Canada, NRCan and Telesat Canada. This involved setting up the Club's display, welcoming the public and answering questions regarding the Club.

She took over the task of ensuring that the Club's pamphlets were on display at the bulletin boards at Stoney Swamp and Jack Pine Trails.

It is for her quiet, behind the scenes generosity of time and energy that we wish to honour Ann with the George McGee Service Award for 2011.

### Conservation Award – Member: Dr. Theodore Mosquin

The Conservation Award for a member is given in recognition of 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.

Ted Mosquin has been involved with many conservation issues and projects in the Ottawa Valley over many years. The OFNC would like to particularly recognize his role as a guardian and advisor with relation to the Purdon Fen Conservation Area in Lanark County. Ted prepared a long-term management plan for the fen and then served for many years as an interpreter and advisor as well as leading fundraising efforts to pay for interpretive signage and to develop the area for public uses. In recognition of Ted's key role in the ongoing development of the Purdon Fen Conservation Area, the "Ted Mosquin Highland Trail" in the Conservation Area was named in his honour. In 2007, Ted received the Conservation Pioneer Award from the Latornell Conservation Foundation on the recommendation of the Mississippi Valley Conservation Authority for his role in the long term protection of the Showy Lady's-Slipper colony in the fen. Thousands of people visit this

site each year and learn about the ecology of orchids and the conservation of wetlands.

In 2002 Ted established the Mississippi-Madawaska Land Trust Conservancy and served as its first president until 2010. This trust enabled private citizens to protect land in its natural state through both agreements and purchase. Almost 2000 acres have already been protected, including some old growth forest areas.

Since 2001 he has been a board member for the Mississippi Conservation Foundation in Lanark, Ontario.

Ted has also served on the Lanark Highlands Environmental Advisory Committee since 2009. This committee was established by the Lanark Highlands Municipal Council to offer advice to the elected members of Council.

In addition to the local involvements for which he is being recognized this year, Ted has been involved in a vast number of national and even international conservation projects and natural history organizations for over 30 years.

For his many years of involvement in conservation issues in the Ottawa valley, the OFNC is pleased to present to Ted Mosquin with the Conservation Award for a Member for 2011.

### Mary Stuart Education Award: Dr. Fred Schueler and Aleta Karstad

The Mary Stuart Education Award is given in recognition of outstanding achievements in the field of natural history education in the Ottawa Region.

Fred Schueler and Aleta Karstad are a talented biologist-artist team well-known in Eastern Ontario for their decades of work researching and documenting natural history observations, through a combination of science and art. The Ottawa Field-Naturalists Club (OFNC) is recognizing two of their projects which relate to natural history education – the popular mudpuppy nights, and the NatureList. Through both of these activities, many people have had their interest in nature either started or strengthened.

Since 1998 Fred and Aleta have offered "Mudpuppy Night in Oxford Mills" to interested observers, leading them on a nocturnal outing at the dam on Kemptville Creek at Oxford Mills. The outing is kid-friendly, and has become a regular annual outing for the OFNC and the Macoun Field Club. Most Friday nights throughout the winter, Fred and Aleta – joined by a group of hardy observers — can be seen in hip waders with flashlights searching the waters for mudpuppies (*Necturus maculosus*). When spotted, a mudpuppy is dipnetted, admired, photographed, and natural history notes recorded. Through Mudpuppy Nights, the Schuelers have given many youngsters (and even adults) their first

“hands-on” experience with wildlife – including teaching them the correct way to hold a mudpuppy in their hands (a very special experience) – and demonstrating to them how much they can learn about biology and conservation through this experience.

Another project that Fred and Aleta have initiated is the Eastern Ontario Natural History e-mail listserv, also known as the NatureList. The NatureList began in 1999 as an e-mail listserv, but since September 2008 has been hosted as a Google group. The listserv provides a lively forum for the sharing of nature observations throughout eastern Ontario with a view to getting them on the public record. As well, list members can help one another with species identification and nature interpretation, and discuss issues of interest. Some recent topics on the NatureList have included a discussion about snapping turtles (they are a species at risk yet hunting is allowed); a note posted from another listserv on the types of fruit and the sequence of their consumption by robins; snow type data from snowpack fields; and posting of first spring sightings of various flora and fauna (first red-winged blackbirds, first return-

ing Canada geese, and so on), which often leads to further discussion by various members of the listserv on related topics. Natural history observations are linked to Fred and Aleta’s natural history database which contains some 100,000 records and is growing. Through the interchange of observations, facts and interpretations that occurs on NatureList, the level of knowledge of natural history is raised for a host of amateurs. The listserv is quite lively!

In 2004, Fred and Aleta launched the NatureJournal, an archival journal system that facilitates the recording and preservation of everyone’s nature observations.

Over the years Fred and Aleta have also given occasional workshops for OFNC. They have also published a number of illustrated books covering aspects of natural history and conservation.

For their many years of exceptional service raising awareness of natural history conservation in the Ottawa area, the OFNC is pleased to present Fred Schueler and Aleta Karstad with the Mary Stuart Education Award for 2011.

### Member of the Year Award: Barry Cottam

The OFNC’s Member of the Year award recognizes the member judged to have contributed the most to the club in the previous year. Barry Cottam is this year’s Member of the Year for his dedicated work as a volunteer at the Fletcher Wildlife Garden (FWG).

Barry became a volunteer at the FWG in 2010 and very quickly discovered the invasive alien plant, dog-strangling vine (DSV for short) (*Cynanchum rossicum*). It was, he has said, hate at first sight. He was so appalled at how widespread the plant was, that he decided then and there he must help do something about it. Recognizing that many volunteers had previously tackled DSV, he reckoned that a different, more consistent approach was needed. He spent the winter familiarizing himself with the species, reading everything he could find, and talking to others who had first-hand experience with it. Barry’s idea was to form an invasive species group that would regularly tackle all invasive plants at the garden, but with a strong emphasis on DSV, especially in the first few years. Thus, The Invasive Species Group (TISG) was born.

In early 2011, Barry gathered together a group of dedicated volunteers, who met every Tuesday morning, spring through fall, to tackle invasive plant species, in particular, DSV. With Barry’s input and advice, one of the volunteers set up a blog charting the weekly progress in text and photos. Barry was also responsible for four DSV work bees that averaged 20 people on each occasion. Not content with working only on the regular Tuesday morning, or with the work bees, Barry often

put in long hours at other times too. But apart from the sheer physical labour involved in this very hands-on project, Barry had to coordinate the volunteers. In addition to contacting them if there was a change in plans, and being available for questions and advice, he had to make sure they knew which areas to tackle each week and had the right equipment for the work.

Knowing that control was the key word in this battle against DSV, Barry’s main objective was to remove as many seed pods as possible from active production. Two hundred and twenty-five industrial sized bags and innumerable piles of DSV were removed from large sections of the garden. Regular visitors to the FWG commented on the difference. However, Barry knows that one year’s work is just the beginning, and the DSV will be back, but so will Barry and his volunteers in 2012 and beyond. He has plans to refine the approach to DSV removal, and also has plans for attracting more volunteers. With his unwavering dedication to this important task, he has made a huge difference at FWG.

As if all this was not enough, Barry also joined the FWG Management Committee where he has quickly become an invaluable member. He has taken on numerous tasks, including researching and overseeing the purchase of a new garden shed (not as simple as it sounds); helping to develop plans for better organizing the nursery, and many other tasks both big and small.

For all of these reasons, we believe that Barry is a fitting recipient of the 2011 Member of the Year Award.

# Index to Volume 126

Compiled by Leslie Cody

- Abies balsamea*, 1,234,295  
  *lasiocarpa*, 189
- Abraham, K.F., 20
- Acanthis hornemanni*, 113
- Acer* sp., 15  
  *negundo*, 32,282  
  *rubrum*, 1  
  *saccharum*, 32
- Acinonyx jubatus*, 333
- Acipenser fulvescens*, 204
- Aegolius acadicus*, 41
- Aegolius acadicus*) Egg, An Anomalous Northern Saw-whet Owl, 41
- Agropyron cristatum*, 104,148,221,226
- Ailanthus altissima*, 32
- Alaska, Sea Ice Crossing by Migrating Caribou, *Rangifer tarandus*, in Northwestern, 217
- Alberta, An Extra –  
  Limital Population of Black-tailed Prairie Dogs, *Cynomys ludovicianus*, in Central, 46
- Alces alces*, 189,234
- Alces alces* Winter Browsing, The Influence of Willow *Salix* sp. Rose Insect Galls on Moose, 189
- Alder, 1  
  Mountain, 136
- Alfalfa, 104,148,158,221,226
- Alliaria petiolata*, 307
- Alnus* sp., 1,15  
  *incana* ssp. *tenuifolia*, 136
- Amelanchier alnifolia*, 136,303  
  *arborea*, 282
- American Society of Mammalogists Annual Meeting 2013, 265
- Anas acuta*, 113  
  *platyrhynchos*, 41
- Anser albifrons*, 111
- Anthus rubescens*, 113
- Antrozous* sp., 38
- Apodemia mormo*, 34
- Apodemia mormo*) Oviposition Behaviour in Canada, First Observations of Mormon Metalmark, 34
- Apoemia mormo langei*, 36
- Arctostaphylos uva-ursi*, 298
- Arenaria interpres*, 113
- Ash, Green, 282
- Asio flammeus*, 41,113
- Aspen, 47  
  Large-tooth, 32  
  Quaking, 282  
  Trembling, 295
- Aspen (*Populus tremuloides*) Chronosequence in Central Yukon, Stand-level Attributes of Snowshoe Hare (*Lepus americanus*) Habitat in a Post-Fire Trembling, 295
- Atkinson, J., Review by, 177
- Avocettina gilli*, 210  
  *infans*, 210
- Aythya affinis*, 16  
  *americana*, 16  
  *fuligula*, 16  
  *marila*, 15,113  
  *valisineria*, 16
- Aythya marila*, Nest Site Characteristics on Grassy Island, New Brunswick, Greater Scaup, 15
- Badger, American, 47,95,221,226,234  
  European, 221
- Badgers, *Taxidea taxus*, in Southwestern Saskatchewan, Observations of Nocturnal Hunting Behaviour of American, 226
- Badgers, *Taxidea taxus*. Use of a Dorsal Radio-Transmitter Implant in American, 221
- Baeolophus atricristatus*, 143  
  *bicolor*, 143
- Ballard, Jr. 19472012, Dr. Warren Baxter, 86
- Ballard, W.B., 15
- Barber-Meyer, S. Severe Maxillary Osteomyelitis in a Gray Wolf (*Canis lupus*), 238
- Barkema, H.W., 288
- Barley, 221,226
- Bat, 125  
  Big Brown, 38,117,127  
  Eastern Red, 117  
  Hoary, 117  
  Little Brown, 39  
  Silver-haired, 118  
  Tricolored, 118,127
- Bat Populations and Cave Microclimate Prior to and at the Outbreak of White-Nose Syndrome in New Brunswick, 125
- Bats, Emergency COSEWIC Assessment for Three Species of, 182
- Bats (*Eptesicus fuscus*) in Pennsylvania, Barn Owl (*Tyto alba*) Predation on Big Brown, 38
- Bats (Family Vespertilionidae) at Five Locations in New Hampshire and Massachusetts, Foods of, 117
- Bear, American Black, 224,234,321  
  Grizzly, 224
- Bearberry, Common, 298
- Beaudoin, A.B. and Y. Beaudoin. Urban White-tailed Jackrabbits (*Lepus townsendii*) Eat Spike Plants (*Cordyline australis*) in Winter, 157
- Beaudoin, A.B., Reviews by, 77,179,263
- Beaudoin, Y., 157
- Beaver, American, 283,321
- Bectle, 121
- Berns, A.M., 160
- Betula* sp., 1,25,296,320

- occidentalis*, 136  
*papyrifera*, 282  
 Biederman, T., 204  
 Birch, 1,296,320  
     Dwarf, 25  
     Paper, 282  
     Water, 136  
 Bishop, C.A., 135,152  
*Blarina brevicauda*, 2,38,93  
 Bluebird, Mountain, 113  
     Western, 41  
 Bluet, Long-leaved, 62  
 Bobcat, 231  
 bois de plomb, 86  
 Bousfield, E.L. and F.R. Cook. A Tribute to Charles Hogg Douglas, 1923–2004, 164  
*Brachyramphus inarmoratus*, 6  
     *inarmoratus perditix*, 6  
     *perditix*, 6  
*Brachyramphus perditix*, in North America, Body Condition and Survival of Vagrant Long-billed Murrelets, 6  
 Brant, Black, 111  
*Branta bernicla nigricans*, 111  
     *hutchinsii*, 111  
 British Columbia. First Specimens of the Marine Eels *Venefica ocella* and *V. tentaculata* (Nestastomatidae) from, 210  
 British Columbia, Size of Territories and Home Ranges of Male Western Yellow-breasted Chats (*Icteria virens auricollis*) in, 152  
 Britton (1923–2012), Canada's Premier Pteridologist, A Tribute to Donald M., 252  
 Brodo, I.M. and F.R. Cook. A Tribute to Phillip Merrill Youngman: 1927–2011, 167  
 Brome, 104,148,221,226  
*Brouis* sp., 104,148,221,226  
 Brook, R.W., K.F. Abraham, K.R. Middel and R.K. Ross. Abundance and Habitat Selection of Breeding Scoters (*Melanitta* spp.) in Ontario's Hudson Bay Lowlands, 20  
 Brunton, D.F. A Tribute to Donald M. Britton (1923–2012), Canada's Premier Pteridologist, 252  
*Bryum caespiticium*, 297  
*Bubo scandiacus*, 113  
 Buckbrush, 221,226  
 Buckwheat, Few-flowered, 34  
 Buffaloberry, 298  
 Bullsnake, 195  
 Bunting, Snow, 113  
 Burg, T.M., 143  
 Burg, T.M. and R.F. Lauff. An Anomalous Northern Saw-whet Owl (*Aegolius acadicus*) Egg, 41  
*Buteo lagopus*, 113  
 Butterfly, 36  
  
*Calamagrostis* sp., 15  
     *canadensis*, 1  
     *purpurascens*, 298  
*Calathus* sp., 121  
*Calcarius lapponicus*, 113  
*Calidris bairdii*, 111  
     *fuscicollis*, 113  
     *himantopus*, 111  
     *melanotos*, 113  
     *pusilla*, 113  
 Callaghan, C., Review by, 83  
*Camporhynchus labradorius*, 329  
 Canada, A Partial Albino Hatchling Northern Ring-necked Snake, *Diadophis punctatus edwardsii*, from Big Tan-cook Island, Mahone Bay, Lunenburg County, Nova Scotia, 336  
 Canada, A Significant Range Extension for the Eastern Rib-bonsnake, *Thamnophis sauritus*, in Nova Scotia, 231  
 Canada, A Specimen of the High Arctic Subspecies of Atlantic Puffin, *Fratrercula arctica naumanni*, in, 50  
 Canada, First Observations of Mormon Metalmark (*Apodemia mormo*) Oviposition Behaviour in, 34  
 Canada, First Record of Parasites from Cougars (*Puma con-color*) in Manitoba, 324  
 Canada, Genetic Evidence Supports Boreal Chickadee (*Poecile hudsonicus*) × Black-capped Chickadee (*Poecile atricapillus*) Hybridization in Atlantic, 143  
 Canada, Population Structure of Harvested Red Foxes (*Vulpes vulpes*) and Coyotes (*Canis latrans*) on Prince Edward Island, 288  
 Canada's Premier Pteridologist, A Tribute to Donald M. Britton (1923–2012), 252  
*Canadian Field-Naturalist* 119(3): 359, *Erratum The*, 265  
*Canadian Field-Naturalist* 126(3): 245, *Erratum The*, 353  
*Canadian Field-Naturalist* Instructions for Authors, *The*, 186,278  
 Canadian Herpetologist (TCH) 2(1), Spring 2012, *The*, 182  
 Canadian Herpetologist (TCH) 2(2), Fall 2012, *The*, 353  
*Canis* sp., 237  
     *familiaris*, 321  
     *latrans*, 47,95,288,321,324  
     *lupus*, 238,324  
     *lupus lycaon*, 235  
     *lupus rufus*, 143  
*Canis (latrans)* on Prince Edward Island, Canada, Population Structure of Harvested Red Foxes (*Vulpes vulpes*) and Coyotes, 288  
*Canis lupus*, Severe Maxillary Osteomyelitis in a Gray Wolf, 238  
 Canvasback, 16  
 Capercaillie, 331  
*Capra pyrenaica*, 192  
*Carduelis hornemanni*, 113  
*Carex* sp., 15,25  
     *macloviana*, 62  
     *soperi*, 62  
 Caribou, 217  
 Caribou, *Rangifer tarandus*, in Northwestern Alaska, Sea Ice Crossing by Migrating, 217  
 Carter, H.R., 6  
 Carter, R.A., 320  
*Carya* sp., 28  
*Castanea* sp., 255  
*Castor canadensis*, 283,321  
 Caswell, G., 336  
 Cat, 47  
     Domestic, 321  
     Feral, 286  
 Catling, P.M., Review by, 71

- Ceanothus* sp., 221,226  
 Cedar, Eastern White, 160  
*Celtis occidentalis*, 32  
     *tenuifolia*, 62  
     *tenuifolia* var. *soperi*, 62  
*Ceratodon purpureus*, 297  
*Cervus elaphus*, 46,320  
*Chamaedaphne calyculata*, 24  
*Chamerion angustifolium*, 298  
*Charadrius semipalmatus*, 113  
 Chat, Eastern Yellow-breasted, 135  
     Western Yellow-breasted, 135,152  
     Yellow-breasted, 135,152  
 Chat (*Icteria virens auricollis*) at the Northern Edge of its Range, Site Fidelity and Annual Survival of the Western Yellow-breasted, 135  
 Chats (*Icteria virens auricollis*) in British Columbia. Size of Territories and Home Ranges of Male Western Yellow-breasted, 152  
 Cheetah, 333  
*Chen caerulescens*, 113  
*Chenopodium album*, 32  
 Cherry, Black, 32  
 Chickadee, Black-capped, 143  
     Boreal, 143  
     Carolina, 143  
     Mountain, 143  
 Chickadee (*Poecile atricapillus*) Hybridization in Atlantic Canada, Genetic Evidence Supports Boreal Chickadee (*Poecile hudsonicus*) × Black-capped, 143  
 Chickadee (*Poecile hudsonicus*) × Black-capped Chickadee (*Poecile atricapillus*) Hybridization in Atlantic Canada, Genetic Evidence Supports Boreal, 143  
*Chionoecetes tanneri*, 210  
 Chokecherry, 282  
*Chrysolmelidae* sp., 121  
*Clangula hyemalis*, 113  
 Clark, H.O. Jr., Review by, 68  
 Coad, B.W., Review by, 173  
 Cochran, P.A., M.A. Ross, T.S. Walker, and T. Biederman. Early Spawning by the American Brook Lamprey (*Lethenteron appendix*) in Southeastern Minnesota, 204  
*Colaptes auratus*, 41,143  
*Coluber constrictor flaviventris*, 195  
     *taeniatus*, 199  
 Cook, F.R., 164,167  
 Cook, F.R., Reviews by, 340,341,342,344,345  
*Cordyline* sp., 157  
     *australis*, 157  
*Cordyline australis* in Winter, Urban White-tailed Jackrabbits (*Lepus townsendii*) Eat Spike Plants, 157  
*Cornus* sp., 15  
     *racemosa*, 282  
     *stolonifera*, 136  
*Corvus corax*, 113,235  
     *corone cornix*, 41  
     *corone corone*, 41  
*Corylus cornuta*, 234,303  
*Corynoptera phili*, 170  
 Cottonwood, Black, 136  
     Eastern, 32,282  
*Cottus cognatus*, 207  
 Cougar, 236,320,324,333  
 Cougar (*Puma concolor*) Kittens with Live Prey: Implications for Learning and Survival, Observations of Wild, 333  
 Cougars (*Puma concolor*) in Manitoba, Canada, First Record of Parasites from, 324  
 Cougars, *Puma concolor*, in Ontario: Additional Evidence, 320  
 Coyote, 47,95,288,321,324  
 Coyotes (*Canis latrans*) on Prince Edward Island, Canada, Population Structure of Harvested Red Foxes (*Vulpes vulpes*) and, 288  
 Crab, Tanner, 210  
 Cranberry, Bog, 298  
     Low-bush, 303  
 Crane, Sandhill, 111  
*Crataegus* sp., 282  
 Crimmins, S.M., 28  
 Crins, W.J., Review by, 178  
*Crotalus oreganus*, 199  
     *viridis*, 195  
 Crow, Carrion, 41  
     Hooded, 41  
 Cucumber, Burr, 32  
 Curlews, Eskimo, 329  
*Cyema atrum*, 210  
*Cygnus columbianus*, 113  
*Cynomys* sp., 15,46  
     *ludovicianus*, 46  
*Cynomys ludovicianus*, in Central Alberta, An Extra-Limital Population of Black-tailed Prairie Dogs, 46  
*Cystopteris* sp., 255  
     *fragilis*, 253  
 Dare, O.K. and W.G. Watkins. First Record of Parasites from Cougars (*Puma concolor*) in Manitoba, Canada, 324  
 de Bie, F., 288  
 Deer, 194,237,242  
     Mule, 320,326,334  
     White-tailed, 47,160,237,242,320,326  
 Deer Herbivory and Drought on Population Growth of *Goodyera pubescens* (Orchidaceae) in Southwestern Quebec, The Impact of, 242  
*Delichon urbicum*, 143  
*Dendroica occidentalis*, 143  
     *townsendii*, 143  
 Dezhi, L. and Q. Aili, Review by, 347  
*Diadophis punctatus edwardsii*, 336  
*Diadophis punctatus edwardsii*, from Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia, Canada, A Partial Albino Hatchling Northern Ring-necked Snake, 336  
*Dicranum* sp., 329  
     *scoparium*, 329  
 Dilworth, T.G., 15  
*Dirca decipiens*, 86  
     *mexicana*, 86  
     *occidentalis*, 86  
     *palustris*, 86  
*Dirca palustris*, On the Discovery of Eastern, Leatherwood, 86  
 Dog, Domestic, 321

- Dogwood, Grey, 282  
 Red-osier, 136
- Dorosoma cepedianum*, 10
- Douglas-fir, 189
- Douglas, 1923–2004, Tribute to Charles Hogg, 164
- Dracaena indivisa*, 157
- Drake, C., 336
- Dryopteris* sp., 253  
*algonquinensis*, 253  
*filix-mas* spp. *brittonii*, 255  
*fragrans*, 253
- Duck, Labrador, 329  
 Long-tailed, 113  
 Tufted, 16
- Dunn, E.H., 59
- Echinococcus* sp., 288
- Editor's Report for Volume 125 (2011), 184
- Edwards, 1924–2011, Yorke, 353
- Eel, Marine, 210
- Eels *Venefica ocella* and *V. tentaculata* (Nettastomatidae) from British Columbia, First Specimens of the Marine, 210
- Egret, Reddish, 328
- Egret (*Egretta rufescens*) in Nova Scotia During the 19th Century and its Association with the McCulloch Collection of Birds, Evidence for the Collection of a Reddish, 328
- Egretta rufescens*, 328
- Egretta rufescens* in Nova Scotia During the 19th Century and its Association with the McCulloch Collection of Birds, Evidence for the Collection of a Reddish Egret, 328
- Eider, Common, 113  
 King, 111
- Elaeagnus angustifolia*, 307
- Elateridae* sp., 121
- Elbroch, L.M. and H. Quigley. Observations of Wild Cougar (*Puma concolor*) Kittens with Live Prey: Implications for Learning and Survival, 333
- Elk, North American, 46,320
- Elm, 47  
 American, 282
- Elymus trachycaulus*, 104,148,221,226
- Emydoidea blandingii*, 89,232
- Emydoidea blandingii*, in Barren Meadow and Keddy Brooks, Nova Scotia, Ecology of a Recently Discovered Population Segment of Blanding's Turtles, 89
- Eptesicus fuscus*, 38,117,127
- Eptesicus fuscus* in Pennsylvania, Barn Owl (*Tyto alba*) Predation on Big Brown Bats, 38
- Erbilgin, N., 34
- Eremophila alpestris*, 113
- Erethizon dorsatus*, 326
- Ericameria nauseosa*, 34
- Eriogonum pauciflorum*, 34
- Ermine, 228
- Falco columbarius*, 113  
*peregrinus*, 113
- Falcon, Peregrine, 113
- Feeske, D.M., 281
- Felis catus*, 47,286,321
- Fern, Bracken, 235  
 Britton's Male, 255  
 Britton's Oak, 255  
 Fragile, 253
- Fir, Balsam, 1,234,295  
 Subalpine, 189
- Fireweed, 298
- Fisher, 234,281,321
- Fisher, *Martes pennanti*, In situ Caching of a Large Mammal Carcass by a, 234
- Fishers, *Martes pennanti*, in North Dakota, A Direct Comparison of Enclosed Track Plates and Remote Cameras in Detecting, 281
- Flicker, Northern, 41,143
- Fly, 170
- Forbes, G., 1
- Forbes, G.J., 125
- Fortier, J.L., 320
- Fortney, A.N., R.G. Poulin, J.A. Martino, D.L. Parker and C.M. Somers. Proximity to Hibernacula and Road Type Influence Potential Road Mortality of Snakes in Southwestern Saskatchewan, 194
- Fox, Arctic, 114  
 Kit, 224  
 Red, 95,235,231,288
- Foxes (*Vulpes vulpes*) and Coyotes (*Canis latrans*) on Prince Edward Island, Canada, Population Structure of Harvested Red, 288
- Fratercula arctica arctica*, 50  
*arctica grabae*, 50  
*arctica naumanni*, 50
- Fratercula arctica naumanni*, in Canada, A Specimen of the High Arctic Subspecies of Atlantic Puffin, 50
- Fraxinus* sp., 15  
*pennsylvanica*, 282
- Frederick, C.F., 160
- Gallagher, E., 28
- Gartersnake, Plains, 195  
 Wandering, 195
- Gaston, A.J. and J.F. Provencher. A Specimen of the High Arctic Subspecies of Atlantic Puffin, *Fratercula arctica naumanni*, in Canada, 50
- Gavia adamsii*, 113  
*pacifica*, 113  
*stellata*, 113
- Geomyces destructans*, 127
- Geomys bursarius*, 226
- Gilhen, J., A. Jones, J. McNeil, and A.W. Tanner. A Significant Range Extension for the Eastern Ribbonsnake, *Thamnophis sauritus*, in Nova Scotia, Canada, 231
- Gilhen, J., G. Caswell, C. Drake, M. MacDonald, and H. McKinnon-Ramshaw. A Partial Albino Hatchling Northern Ring-necked Snake, *Diadophis punctatus edwardsii*, from Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia, Canada, 336
- Glaucidium gnoma*, 43
- Global Wildlife Resources — Wildlife Handling Job Board, 182
- Gloeophyllum trabeum*, 161
- Glycine javanica*, 31

- max.* 33  
 Goat, Iberian Wild, 192  
 Golden-Plover, American, 111  
*Goodyera pubescens*, 242  
*Goodyera pubescens* (Orchidaceae) in Southwestern Quebec, The Impact of Deer Herbivory and Drought on Population Growth of, 242  
 Goose, Cackling, 111  
   Greater White-fronted, 111  
   Snow, 113  
 Gooseberry, Missouri, 282  
 Gopher, Northern Pocket, 96  
   Plains Pocket, 226  
   Pocket, 167  
 Grape, Riverbank, 32  
 Gray, D.R. and S.E. Gray. A Tribute to Stewart Dixon MacDonald, 1927–2010, 245  
 Gray, S.E., 245  
 Grouse, Black, 331  
   Red, 292,331  
*Grus canadensis*, 111  
 Gull, American Herring, 113  
   Glaucous, 113  
   Great Black-backed, 15  
   Ring-billed, 15  
   Sabine's, 113  
   Thayer's, 111  
*Gulo gulo*, 234  
*Gymnocarpium* sp., 255  
   *brittonianum*, 255  
  
 Haber, E. A Tribute to James Herbert Soper, 1916–2012, 61  
 Hackberry, 32  
   Dwarf, 62  
 Hamilton, D.A., 28  
 Hanke, G.F. and S.M. Roias. First Specimens of the Marine Eels *Venefica ocella* and *V. tentaculata* (Nettastomatidae) from British Columbia, 210  
 Hare, Snowshoe, 237,295,303  
 Hare (*Lepus americanus*) Habitat in a Post-Fire Trembling Aspen (*Populus tremuloides*) Chronosequence in Central Yukon, Stand-level Attributes of Snowshoe, 295  
 Hawk, Rough-legged, 113  
 Hawthorn, 282  
 Hazelnut, Beaked, 234,303  
 Hellebore, California False, 55  
   Green False, 55  
 Helleiner, F., Review by, 69  
 Henderson, J. and G. Forbes. Occurrence of the Maritime Shrew (*Sorex maritimensis*) in Black Spruce (*Picea mariana*) Forest Stands in Southeastern New Brunswick, 1  
 Herman, T.B., 89  
*Heterodon nasicus*, 195  
 Hickory, 28  
*Hirundo rustica*, 143  
*Histiobranchus bathybius*, 210  
 Holroyd, G.L., 46  
 Holt, J., 117  
*Homo sapiens*, 321  
  
*Hordeum vulgare*, 221,226  
*Hormathophylla spinosa*, 192  
 Houston, C.S.. Reviews by, 174,346  
*Houstonia longifolia*, 62  
   *longifolia* var. *soperi*, 62  
 Huettmann, F., Review by, 349  
 Human, 321  
 Hüner, E.A. and J.F.B. Peter. *In situ* Caching of a Large Mammal Carcass by a Fisher, *Martes pennanti*, 234  
 Hussell, D.J.T., J.A.T. Hussell, and E.H. Dunn. New Avian Breeding Records for Iqaluit, Nunavut, 59  
 Hussell, J.A.T., 59  
*Hydrilla verticillata*, 307  
 Hydrilla, 307  
*Hylocomium splendens*, 299  
*Hypnum imponens*, 329  
  
*Ichthyomyzon unicuspis*, 207  
*Icteria virens*, 135,152  
   *virens auricollis*, 135,152  
   *virens virens*, 135  
*Icteria virens auricollis* at the Northern Edge of its Range, Site Fidelity and Annual Survival of the Western Yellow-breasted Chat, 135  
*Icteria virens auricollis* in British Columbia, Size of Territories and Home Ranges of Male Western Yellow-breasted Chats, 152  
*Isoetes* sp., 253  
   *brittonii*, 255  
   *dodgei*, 253  
   *virginica*, 255  
 Iudica, C.A., 38  
  
 Jackrabbit, White-tailed, 157  
 Jackrabbits (*Lepus townsendii*) Eat Spike Plants (*Cordyline australis*) in Winter, Urban White-tailed, 157  
 Jaeger, Long-tailed, 113  
   Parasitic, 113  
   Pomarine, 113  
 Janelle, J., 34  
 John, R., Reviews by, 70,71,172,176,260,261  
 Johnston, D., 288  
 Joly, K. Sea Ice Crossing by Migrating Caribou, *Rangifer tarandus*, in Northwestern Alaska, 217  
 Jones, A., 231  
*Junco hyemalis*, 60  
 Junco, Dark-eyed, 60  
 Jung, T.S., 295  
  
 Kehoe, F.P., 15  
 Kenn, I.S., 320  
 Khalafalla, S.M. and C.A. Iudica. Barn Owl (*Tyto alba*) Predation on Big Brown Bats (*Eptesicus fuscus*) in Pennsylvania, 38  
 Kingsnake, Prairie, 201  
 Kudzu, 307  
  
*Lagopus lagopus*, 113  
   *lagopus scotica*, 331  
   *lagopyus scoticus*, 292

- muta*, 113
- Lait, L.A., R.F. Lauff, and T.M. Burg. Genetic Evidence Supports Boreal Chickadee (*Poecile hudsonicus*) × Black-capped Chickadee (*Poecile atricapillus*) Hybridization in Atlantic Canada, 143
- Lamb's-quarters, 32
- Lampetra appendix*, 204
- Lamprey, American Brook, 204
- Sea, 206
- Silver, 207
- Lamprey (*Lethenteron appendix*) in Southeastern Minnesota, Early Spawning by the American Brook, 204
- Lampropeltis calligaster calligaster*, 201
- Larix laricina*, 1,24
- Lark, Horned, 113
- Larson, B.M.H., 31
- Larus argentatus smithsonianus*, 113
- delawarensis*, 15
- hyperboreus*, 113
- marinus*, 15
- thayeri*, 111
- Lasionycteris noctivagans*, 118
- Lasiurus borealis*, 117
- cinereus*, 117
- Lauff, R., Review by, 262
- Lauff, R.F., 41,143
- Leatherleaf, 24
- Leatherwood, Eastern, 86
- Mexican, 86
- Western, 86
- Leatherwood (*Dirca palustris*), On the Discovery of Eastern, 86
- Lefebvre, J., S.W. Mockford, and T.B. Herman. Ecology of a Recently Discovered Population Segment of Blanding's Turtles, *Emydoidea blandingii*, in Barren Meadow and Keddy Brooks, Nova Scotia, 89
- Lemming, 114
- Lepus americanus*, 237,295
- townsendii*, 157
- Lepus americanus*) Habitat in a Post-Fire Trembling Aspen (*Populus tremulooides*) Chronosequence in Central Yukon, Stand-level Attributes of Snowshoe Hare, 295
- Lepus townsendii*) Eat Spike Plants (*Cordyline australis*) in Winter, Urban White-tailed Jackrabbits, 157
- Lespedeza cuneata*, 307
- Lespedeza*, Sericea, 307
- Lethenteron appendix*, 204
- Lethenteron appendix*) in Southeastern Minnesota, Early Spawning by the American Brook Lamprey, 204
- Letter to the Editor, 183
- Lichen, Dog Tongue, 298
- Lindgren, C.J. and D. Walker. Predicting the Spread of Purple Loosestrife (*Lythrum salicaria*) in the Prairies, 306
- Linnaea borealis*, 299
- Lion, 224
- Locust, Black, 32
- Lok, C.M. and J.A.J. Vink. Trends and Fluctuations in Bird Populations on the Tundra at Cambridge Bay, Nunavut, 111
- Longspur, Lapland, 113
- Lontra canadensis*, 28
- Lontra canadensis*, in Southern Missouri, Implantation and Parturition Dates of North American River Otters, 28
- Loon, Pacific, 113
- Red-throated, 113
- Yellow-billed, 113
- Loosestrife, Purple, 306
- Loosestrife (*Lythrum salicaria*) in the Prairies, Predicting the Spread of Purple, 306
- Lophodytes cucullatus*, 41
- Lophura imperialis*, 143
- Loughry, S.C., M.D. Triska, D.M. Fecske, and T.L. Serfass. A Direct Comparison of Enclosed Track Plates and Remote Cameras in Detecting Fishers, *Martes pennanti*, in North Dakota, 281
- Lupine, Arctic, 298
- Lupinus arcticus*, 299
- Lynx canadensis*, 295,321
- rufus*, 321
- Lynx, Canada, 295,321
- Lythrum salicaria*, 15,306
- Lythrum salicaria*) in the Prairies, Predicting the Spread of Purple Loosestrife, 306
- MacDonald, M., 336
- MacDonald, 1927–2010, A Tribute to Stewart Dixon, 245
- MacKenzie, K., 103
- MacKenzie, N., 103,221,226
- Mallard, 41
- Malloch, D., 125
- Mallory, F.F., R.A. Carter, J.L. Fortier, I.S. Kenn, L. Weis, and B.N. White. Cougars, *Puma concolor*, in Ontario: Additional Evidence, 320
- Manitoba, Canada, First Record of Parasites from Cougars (*Puma concolor*) in, 324
- Maple, Manitoba, 32,282
- Red, 1
- Sugar, 32
- Marmot, Bobak, 56
- Golden, 56
- Hoary, 56
- Long-tailed, 56
- Olympic, 56
- Steppe, 56
- Vancouver Island, 55
- Yellow-bellied, 55
- Marmota bobak*, 56
- caligulata*, 56
- caudate*, 56
- flaviventris*, 55
- monax*, 56
- olympus*, 56
- vancouverensis*, 55
- Marmota vancouverensis*) Consume Plants Containing Toxic Secondary Compounds, Vancouver Island Marmots, 55
- Marmots (*Marmota vancouverensis*) Consume Plants Containing Toxic Secondary Compounds, Vancouver Island, 55
- Marten, American, 234
- European Pine, 234



- Martes americana*, 234  
*martes*, 234  
*pennanti*, 234,281,321
- Martes pennanti*, in North Dakota, A Direct Comparison of Enclosed Track Plates and Remote Cameras in Detecting Fishers, 281
- Martes pennanti*, *In situ* Caching of a Large Mammal Carcass by a Fisher, 234
- Martin, Common House, 143  
 Northern House, 143
- Martino, J.A., 194
- Massachusetts, Foods of Bats (Family Vespertilionidae) at Five Locations in New Hampshire and, 117
- McAlpine, D.F., 125
- McKibbin, R. and C.A. Bishop. Site Fidelity and Annual Survival of the Western Yellow-breasted Chat (*Icteria virens auricollis*) at the Northern Edge of its Range, 135
- McKibbin, R. and C.A. Bishop. Size of Territories and Home Ranges of Male Western Yellow-breasted Chats (*Icteria virens auricollis*) in British Columbia, 152
- McKinnon-Ramshaw, H., 336
- McNeil, J., 231
- McRoberts, J.T, N.T. Quintana, W.A. Smith, W.B. Ballard, F.P. Kehoe, and T.G. Dilworth. Greater Scaup, *Aythya marila*, Nest Site Characteristics on Grassy Island, New Brunswick, 15
- Meadowlark, Eastern, 143  
 Western, 143
- Medicago* sp., 104,148,221,226  
*sativa*, 158
- Meerkat, 333
- Megachile sculpturalis*, 33
- Melanitta* sp., 20  
*americana*, 20  
*fusca*, 20  
*perspicillata*, 20
- Melanitta* spp.) in Ontario's Hudson Bay Lowlands. Abundance and Habitat Selection of Breeding Scoters, 20
- Meles meles*, 221
- Mephitis mephitis*, 150,283
- Merganser, Hooded, 41  
 Red-breasted, 113
- Mergus serrator*, 113
- Merlin, 113
- Metalmark, Lange's, 36  
 Mormon, 34
- Metalmark (*Apodemia mormo*) Oviposition Behaviour in Canada, First Observations of Mormon, 34
- Microtus pennsylvanicus*, 38
- Middel, K.R., 20
- Mills, E.L. Evidence for the Collection of a Reddish Egret (*Egretta rufescens*) in Nova Scotia During the 19th Century and its Association with the McCulloch Collection of Birds, 328
- Mills, E.L., Review by, 81
- Minutes of the 133<sup>rd</sup> Annual Business Meeting of The Ottawa Field-Naturalists' Club January 10, 2012, 266
- Minnesota, Early Spawning by the American Brook Lamprey (*Lethenteron appendix*) in Southeastern, 204
- Missouri, Implantation and Parturition Dates of North American River Otters, *Lontra canadensis*, in Southern, 28
- Mockford, S.W., 89
- Moose, 189,234
- Moose *Alces alces* Winter Browsing, The Influence of Willow *Salix* sp. Rose Insect Galls on, 189
- Moosewood, 86
- Moosman, P.R. Jr., 117
- Morus alba*, 32
- Moss, 329  
 Bryum, 297  
 Fire, 297  
 Pioneer, 298  
 Stairstep, 299
- Moth, 121
- Mottiar, Y. On the Discovery of Eastern Leatherwood (*Dirca palustris*), 86
- Mouse, Deer, 2,321  
 Northern Grasshopper, 96  
 Olive-backed Pocket, 96  
 Western Harvest, 95
- Mouse, *Reithrodontomys megalotis*, An Addition to the Mammalian Fauna of Saskatchewan: The Western Harvest, 95
- Mulberry, White, 32
- Murre, Thick-billed, 50
- Murrelet, Long-billed, 6  
 Marbled, 6
- Murrelets, *Brachyramphus perdix*, in North America, Body Condition and Survival of Vagrant Long-billed, 6
- Mustard, Garlic, 307  
 Yellow, 226
- Mustela erminea*, 228  
*eversmanni*, 168  
*frenata*, 95,228,234
- Myodes gapperi*, 2
- Myotis* sp., 38,121,127  
*leibii*, 118  
*lucifugus*, 39,117,127  
*septentrionalis*, 118,127  
*sodalis*, 118
- Myotis, Eastern Small-footed, 118  
 Indiana, 118  
 Little Brown, 117  
 Northern, 117
- Nemichthys avocetta*, 210  
*larseni*, 210  
*scolopaceus*, 210
- Neospora caninum*, 288
- Neotoma cinerea*, 96
- New Brunswick, Bat Populations and Cave Microclimate Prior to and at the Outbreak of White-Nose Syndrome in, 125
- New Brunswick, Greater Scaup, *Aythya marila*, Nest Site Characteristics on Grassy Island, 15
- New Brunswick, Occurrence of the Maritime Shrew (*Sorex maritimensis*) in Black Spruce (*Picea mariana*) Forest Stands in Southeastern, 1
- New Hampshire and Massachusetts, Foods of Bats (Family Vespertilionidae) at Five Locations in, 117
- North America, Body Condition and Survival of Vagrant Long-billed Murrelets, *Brachyramphus perdix*, in, 6

- North Dakota, A Direct Comparison of Enclosed Track Plates and Remote Cameras in Detecting Fishers, *Martes pennanti*, in North Dakota, 281
- Northeast Natural History Conference 2013, 265
- Notropis atherinoides*, 10
- Nova Scotia, Canada, A Partial Albino Hatchling Northern Ring-necked Snake, *Diadophis punctatus edwardsii*, from Big Tancook Island, Mahone Bay, Lunenburg County, 336
- Nova Scotia, Canada, A Significant Range Extension for the Eastern Ribbonsnake, *Thamnophis sauritus*, in, 231
- Nova Scotia During the 19<sup>th</sup> Century and its Association with the McCulloch Collection of Birds, Evidence for the Collection of a Reddish Egret (*Egretta rufescens*) in, 328
- Nova Scotia, Ecology of a Recently Discovered Population Segment of Blanding's Turtles, *Emydoidea blandingii*, in Barren Meadow and Keddy Brooks, 89
- Nunenius borealis*, 329
- Nunavut, New Avian Breeding Records for Iqaluit, 59
- Nunavut, Trends and Fluctuations in Bird Populations on the Tundra at Cambridge Bay, 111
- O'Neill, J., Reviews by, 77,80
- Oahandley, R.M., 288
- Oak, 28  
Burr, 282  
Northern Red, 160  
Red, 32
- Odocoileus* sp., 194,237  
*hemionus*, 320,326,334  
*virginianus*, 47,160,237,242,320,326
- Oenanthe oenanthe*, 59
- Oleria onega*, 36
- Olive, Russian, 307
- Ontario: Additional Evidence, Cougars, *Puma concolor*, in, 320
- Ontario, Kudzu Vine, *Pueraria montana*, Adventive in Southern, 31
- Ontario's Hudson Bay Lowlands, Abundance and Habitat Selection of Breeding Scoters (*Melanitta* spp.) in, 20
- Onychomys leucogaster*, 96
- Ottawa Field-Naturalists' Club Awards for 2011, Presented April 2012, The, 254
- Otter, North American River, 28
- Otters, *Lontra canadensis*, in Southern Missouri, Implantation and Parturition Dates of North American River, 28
- Owl, Barn, 38  
Northern Pygmy, 43  
Northern Saw-whet, 41  
Short-eared, 41,113  
Snowy, 113
- Owl (*Aegolius acadicus*) Egg, An Anomalous Northern Saw-whet, 41
- Owl (*Tyto alba*) Predation on Big Brown Bats (*Eptesicus fuscus*) in Pennsylvania, Barn, 38
- Panthera leo*, 224
- Parker, D.L., 194
- Passer domesticus*, 38
- Passerculus sandwichensis*, 59,113
- Pellaea* sp., 253
- Peltigera aphthosa*, 299  
*malacea*, 299
- Pennsylvania, Barn Owl (*Tyto alba*) Predation on Big Brown Bats (*Eptesicus fuscus*) in, 38
- Perimyotis subflavus*, 118,126
- Perognathus fasciatus*, 96
- Peromyscus maniculatus*, 2,321
- Peter, J.F.B., 234
- Petromyzon marinus*, 206
- Phakopsora pachyrhizi*, 33
- Phalaris* sp., 15
- Phalarope, Red, 111  
Red-necked, 111
- Phalaropus fulicarius*, 111  
*lobatus*, 111
- Pheasant, Imperial, 143
- Picea* sp., 47,296  
*albertiana* ssp. *albertiana*, 296  
*glauca*, 234  
*mariana*, 1,24,295
- Picea mariana*) Forest Stands in Southeastern New Brunswick, Occurrence of the Maritime Shrew (*Sorex maritimensis*) in Black Spruce, 1
- Pine, 28  
Eastern White, 1,234  
Lodgepole, 296
- Pintail, Northern, 113
- Pinus* sp., 28  
*contorta* var. *latifolia*, 296  
*strobus*, 1,234
- Pipit, American, 113
- Pituophis catenifer*, 199  
*catenifer sayi*, 195
- Plant, Cane, 157  
Dracaena, 157  
Spike, 157
- Plants (*Cordyline australis*) in Winter, Urban White-tailed Jackrabbits (*Lepus townsendii*) Eat Spike, 157
- Plectrophenax nivalis*, 113
- Pleurozium schreberi*, 330
- Plover, Black-bellied, 111  
Semipalmated, 113
- Pluvialis dominica*, 111  
*squatarola*, 111
- Poecile atricapillus*, 143  
*carolinensis*, 143  
*gambeli*, 143  
*hudsonicus*, 143
- Poecile atricapillus*) Hybridization in Atlantic Canada, Genetic Evidence Supports Boreal Chickadee (*Poecile hudsonicus*) × Black-capped Chickadee, 143
- Poecile hudsonicus*) × Black-capped Chickadee (*Poecile atricapillus*) Hybridization in Atlantic Canada, Genetic Evidence Supports Boreal Chickadee, 143
- Polecat, Beringian, 168
- Polypodium* sp., 253
- Polystichum* sp., 253
- Poplar, 320  
Balsam, 282
- Populus* sp., 47,320  
*basamifera*, 282

- deltoides*, 32,282  
*grandidentata*, 32  
*tremuloides*, 282,295  
*trichocarpa*, 136  
*Populus tremuloides* Chronosequence in Central Yukon, Stand-level Attributes of Snowshoe Hare (*Lepus americanus*) Habitat in a Post-Fire Trembling Aspen, 295  
Porcupine, North American, 326  
Poulin, R.G., 194  
Prairie Dog, 46  
    Black-tailed, 46  
Prairie Dogs, *Cynomys ludovicianus*, in Central Alberta, An Extra-Limital Population of Black-tailed, 46  
Prince Edward Island, Canada, Population Structure of Harvested Red Foxes (*Vulpes vulpes*) and Coyotes (*Canis latrans*) on, 288  
*Procyon lotor*, 93,286  
Proulx, B.P., 95  
Proulx, G. and B.P. Proulx. An Addition to the Mammalian Fauna of Saskatchewan: The Western Harvest Mouse, *Reithrodontomys megalotis*, 95  
Proulx, G. and N. MacKenzie. Observations of Nocturnal Hunting Behaviour of American Badgers, *Taxidea taxus*, in Southwestern Saskatchewan, 226  
Proulx, G. and N. MacKenzie. Use of a Dorsal Radio-Transmitter Implant in American Badgers, *Taxidea taxus*, 221  
Proulx, G. High Spring Mortality of Adult Richardson's Ground Squirrels, *Urociellus richardsonii*, Associated with a Severe Rainstorm in Southwestern Saskatchewan, 148  
Proulx, G., K. MacKenzie, and N. MacKenzie. Distribution and Relative Abundance of Richardson's Ground Squirrels, *Urociellus richardsonii*, According to Soil Zones and Vegetation Height in Saskatchewan During a Drought Period, 103  
Provencher, J.F., 50  
*Prunus serotina*, 32  
    *virginiana*, 282  
Pruss, S., 34  
*Pseudotsuga menziesii*, 189  
Ptarmigan, Rock, 113  
    Willow, 113  
*Pteridium aquilinum*, 235  
*Pueraria lobata*, 31,307  
    *montana*, 31  
*Pueraria montana*, Adventive in Southern Ontario, Kudzu Vine, 31  
Puffin, Atlantic, 50  
Puffin, *Fratercula arctica naumanni*, in Canada, A Specimen of the High Arctic Subspecies of Atlantic, 50  
*Puma concolor*, 236,320,324,333  
    *concolor congnar*, 322  
*Puma concolor*) in Manitoba, Canada, First Record of Parasites from Cougars, 324  
*Puma concolor*, in Ontario: Additional Evidence, Cougars, 320  
*Puma concolor*) Kittens with Live Prey: Implications for Learning and Survival, Observations of Wild Cougar, 333  
Quebec, The Impact of Deer Herbivory and Drought on Population Growth of *Goodyera pubescens* (Orchidaceae) in Southwestern, 242  
*Quercus* sp., 28  
    *macrocarpa*, 282  
    *rubra*, 32,160  
Quigley, H., 333  
Quillwort, Britton's, 255  
    Dodge's, 253  
Quintana, N.T., 15  
Rabbitbrush, Rubber, 34  
*Rabdophaga* sp., 189  
    *rosaria*, 189  
    *salicisrhodoides*, 190  
    *strobiloides*, 189  
Raccoon, 93,286  
Racer, Eastern Yellow-bellied, 195  
*Rangifer tarandus*, 192,217  
*Rangifer tarandus*, in Northwestern Alaska, Sea Ice Crossing by Migrating Caribou, 217  
Raspberry, 282  
Rattlesnake, Prairie, 195  
Raven, Common, 113,235  
Rea, R.V. The Influence of Willow *Salix* sp. Rose Insect Galls on Moose *Alces alces* Winter Browsing, 189  
Reddoch, A.H., 242  
Reddoch J.M. and A.H. Reddoch. The Impact of Deer Herbivory and Drought on Population Growth of *Goodyera pubescens* (Orchidaceae) in Southwestern Quebec, 242  
Redhead, 16  
Redpoll, Arctic, 113  
Reedgrass, Bluejoint, 1  
    Purple, 298  
Reindeer, 192,220  
*Reithrodontomys megalotis*, 95  
    *megalotis dychei*, 95  
    *megalotis megalotis*, 95  
*Reithrodontomys megalotis*, An Addition to the Mammalian Fauna of Saskatchewan: The Western Harvest Mouse, 95  
*Rhododendron groenlandicum*, 24  
*Rhus typhina*, 32  
*Rhytidadelphus triquetrus*, 329  
Ribbonsnake, Eastern, 231  
    Northern, 232  
Ribbonsnake, *Thamnophis sauritus*, in Nova Scotia, Canada, A Significant Range Extension for the Eastern, 231  
*Ribes missouriense*, 282  
Richter, D.L., A.M. Berns, and C.F. Frederick. Resistance of Canada Yew (*Taxus canadensis*) Branch Wood to Two Wood Decay Fungi, 160  
Roberts, N.M., S.M. Crimmins, D.A. Hamilton, and E. Gallagher. Implantation and Parturition Dates of North American River Otters, *Lontra canadensis*, in Southern Missouri, 28  
Robin, American, 60  
*Robinia pseudo-acacia*, 32  
Roias, S.M., 210

- Rosa* sp., 189  
*acicularis*, 136, 299  
*gymnocarpa*, 136  
*nutkana*, 136  
*woodsii*, 136
- Rose, Wild, 136, 298
- Rose Insect Galls on Moose *Alces alces* Winter Browsing, The Influence of Willow *Salix* sp.
- Ross, M.A., 204
- Ross, R.K., 20
- Rubus* sp., 282
- Rust, Soybean, 33
- Salix* sp., 24, 136, 189, 296  
*sconleriana*, 190
- Salix* sp. Rose Insect Galls on Moose *Alces alces* Winter Browsing, The Influence of Willow, 189
- Sandpiper, Baird's, 111  
 Buff-breasted, 111  
 Pectoral, 113  
 Semipalmated, 113  
 Stilt, 111  
 White-rumped, 113
- Sapsucker, 143
- Sarcocystis* sp., 288
- Saskatchewan During a Drought Period, Distribution and Relative Abundance of Richardson's Ground Squirrels, *Urocitellus richardsonii*, According to Soil Zones and Vegetation Height in, 103
- Saskatchewan, High Spring Mortality of Adult Richardson's Ground Squirrels, *Urocitellus richardsonii*, Associated with a Severe Rainstorm in Southwestern, 148
- Saskatchewan, Observations of Nocturnal Hunting Behaviour of American Badgers, *Taxidea taxus*, in Southwestern, 226
- Saskatchewan, Proximity to Hibernacula and Road Type Influence Potential Road Mortality of Snakes in Southwestern, 194
- Saskatchewan: The Western Harvest Mouse, *Reithrodontomys megalotis*, An Addition to the Mammalian Fauna of, 95
- Saskatoon, 136, 303
- Scaup, Greater, 15, 113  
 Lesser, 16
- Scaup, *Aythya marila*, Nest Site Characteristics on Grassy Island, New Brunswick, Greater, 15
- Scirpus* sp., 25
- Scoter, 20  
 Black, 20  
 Surf, 20  
 White-winged, 20
- Scoters (*Melanitta* spp.) in Ontario's Hudson Bay Lowlands, Abundance and Habitat Selection of Breeding, 20
- Sculpin, Slimy, 207
- Sealy, S.G. and H.R. Carter. Body Condition and Survival of Vagrant Long-billed Murrelets, *Brachyramphus perdix*, in North America, 6
- Seburn, D., Review by, 175
- Sedge, 15, 25, 62  
 Thick-headed, 62
- Serfass, T.L., 281
- Serrivomer* sp., 211  
*jesperseni*, 210
- Serviceberry, Downy, 282
- Setophaga occidentalis*, 143  
*townsendi*, 143
- Shad, Gizzard, 10
- Shepherdia canadensis*, 299
- Shiner, Emerald, 10
- Shrew, American Pygmy, 2  
 Arctic, 1  
 Cinereus, 2  
 Maritime, 1  
 Northern Short-tailed, 2, 38, 93  
 Smoky, 2
- Shrew (*Sorex maritimensis*) in Black Spruce (*Picea mariana*) Forest Stands in Southeastern New Brunswick, Occurrence of the Maritime, 1
- Sialia currucoides*, 113  
*mexicana*, 41
- Sicyos angulatus*, 32
- Sinapis alba*, 226
- Skunk, Striped, 150, 283
- Smith, T., Review by, 348
- Smith, W.A., 15
- Snake, 194  
 Northern Ring-necked, 336  
 Western Hog-nosed, 195
- Snake, *Diadophis punctatus edwardsii*, from Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia, Canada, A Partial Albino Hatchling Northern Ring-necked, 336
- Snakes in Southwestern, Proximity to Hibernacula and Road Type Influence Potential Road Mortality of, 194
- Snowberry, Common, 136
- Somateria mollissima*, 113  
*spectabilis*, 111
- Somers, C.M., 194
- Soper, 1916–2012, A Tribute to James Herbert, 61
- Sorex arcticus*, 1  
*cinereus*, 2  
*fumeus*, 2  
*hoyi*, 2  
*maritimensis*, 1
- Sorex maritimensis* in Black Spruce (*Picea mariana*) Forest Stands in Southeastern New Brunswick, Occurrence of the Maritime Shrew, 1
- Soybean, 33
- Sparrow, House, 38  
 Savannah, 59, 113  
 White-crowned, 59
- Spermophilus* sp., 47, 148  
*beldingi*, 148  
*columbianus*, 148  
*richardsonii*, 103, 148
- Sphyrapicus* sp., 143
- Spruce, 47, 296  
 Black, 1, 24, 295  
 Western White, 296, 298  
 White, 234
- Spruce (*Picea mariana*) Forest Stands in Southeastern New Brunswick, Occurrence of the Maritime Shrew (*Sorex maritimensis*) in Black, 1
- Squirrel, Belding's Ground, 148

- Columbian Ground, 148,226  
 Ground, 47,226  
 Red, 93  
 Richardson's Ground, 95,103,148,221,226
- Squirrels, *Urocitellus richardsonii*, According to Soil Zones and Vegetation Height in Saskatchewan During a Drought Period, Distribution and Relative Abundance of Richardson's Ground, 103
- Squirrels, *Urocitellus richardsonii*, Associated with a Severe Rainstorm in Southwestern Saskatchewan, High Spring Mortality of Adult Richardson's Ground, 148
- Stanton-Kennedy, T., Reviews by, 81,350
- Stercorarius longicaudus*, 113  
*parasiticus*, 113  
*pomarinus*, 113
- Sterna hirundo*, 15  
*paradisaea*, 113
- Strong, W.L. and T.S. Jung, Stand-level Attributes of Snowshoe Hare (*Lepus americanus*) Habitat in a Post-Fire Trembling Aspen (*Populus tremuloides*) Chronosequence in Central Yukon, 295
- Sturgeon, Lake, 204
- Sturnella magna*, 143  
*neglecta*, 143
- Sumac, Staghorn, 32
- Suricata suricatta*, 333
- Swallow, Barn, 143
- Swan, Tundra, 113
- Symphoricarpos albus*, 136
- Synaphobranchus affinis*, 210
- Tadarida* sp., 38
- Taenia omissa*, 325  
*rileyi*, 325
- Tamarack, 1,24
- Tamiasciurus hudsonicus*, 93
- Tanner, A.W., 231
- Taxidea taxus*, 47,95,221,226,234
- Taxidea taxus*, in Southwestern Saskatchewan, Observations of Nocturnal Hunting Behaviour of American Badgers, 226
- Taxidea taxus*, Use of a Dorsal Radio-Transmitter Implant in American Badgers, 221
- Taxus baccata*, 160  
*brevifolia*, 160  
*canadensis*, 160
- Taxus canadensis* Branch Wood to Two Wood Decay Fungi, Resistance of Canada Yew, 160
- Taylor, B.R., Review by, 75
- Tea, Common Labrador, 24
- Tenebrionidae*, sp., 121
- Tern, Arctic, 113  
 Common, 15
- Tetrao tetrix*, 331  
*urogallus*, 331
- Thalassenchelys coheni*, 210
- Thamnopis elegans*, 199  
*elegans vagrans*, 195  
*radix*, 195  
*sauritus*, 231  
*sauritus septentrionalis*, 232
- Thamnopis sauritus*, in Nova Scotia, Canada, A Significant Range Extension for the Eastern Ribbonsnake, 231
- Thomas, H.H., P.R. Moosman, Jr., J.P. Veilleux, and J. Holt, Foods of Bats (Family Vespertilionidae) at Five Locations in New Hampshire and Massachusetts, 117
- Thomomys bottae*, 167  
*talpoides*, 96
- Thuidium delicatulum*, 330
- Thuja occidentalis*, 160
- Titmouse, Black-crested, 143  
 Tufted, 143
- Toxocara canis*, 288  
*cati*, 325
- Trametes versicolor*, 161
- Tree, Cabbage, 157
- Tree-of-heaven, 32
- Trefry, H.E. and G.L. Holroyd, An Extra-Limital Population of Black-tailed Prairie Dogs, *Cynomys ludovicianus*, in Central Alberta, 46
- Triska, M.D., 281
- Triticum aestivum*, 221,226
- Tryngites subruficollis*, 111
- Turdus migratorius*, 60
- Turnstone, Ruddy, 113
- Turtle, Blanding's, 89,232
- Turtles, *Emydoidea blandingii*, in Barren Meadow and Keddy Brooks, Nova Scotia, Ecology of a Recently Discovered Population Segment of Blanding's, 89
- Twinflower, 298
- Tyto alba*, 38
- Tyto alba* Predation on Big Brown Bats (*Eptesicus fuscus*) in Pennsylvania, Barn Owl, 38
- Ulmus* sp., 47  
*americana*, 282
- Uria lomvia*, 50
- Urocitellus* sp., 226  
*beldingi*, 148  
*columbianus*, 148,226  
*richardsonii*, 95,103,148,221,226
- Urocitellus richardsonii*, According to Soil Zones and Vegetation Height in Saskatchewan During a Drought Period, Distribution and Relative Abundance of Richardson's Ground Squirrels, 103
- Urocitellus richardsonii*, Associated with a Severe Rainstorm in Southwestern Saskatchewan, High Spring Mortality of Adult Richardson's Ground Squirrels, 148
- Ursus americanus*, 224,321  
*arctos*, 224
- Vaccinium vitis-idaea*, 299
- Vanderwolf, K.J., D.F. McAlpine, G.J. Forbes, and D. Malloch, Bat Populations and Cave Microclimate Prior to and at the Outbreak of White-Nose Syndrome in New Brunswick, 125
- Veilleux, J.P., 117
- Venefica* sp., 210  
*ocella*, 210  
*procera*, 210  
*tentaculata*, 210

- Venefica ocella* and *V. tentaculata* (Nettastomatidae) from British Columbia, First Specimens of the Marine Eels, 210
- Venefica tentaculata* (Nettastomatidae) from British Columbia, First Specimens of the Marine Eels *Venefica ocella* and, 210
- Veratrum californicum*, 55  
*viride*, 55
- Vermivora chrysoptera*, 143  
*cyanoptera*, 143
- Viburnum edule*, 303
- Vine, Kudzu, 31
- Vine, *Pueraria montana*, Adventive in Southern Ontario, Kudzu, 31
- Vink, J.A.J., 111
- Vitis riparia*, 32
- Vole, Meadow, 38  
Southern Red-backed, 2
- Vulpes lagopus*, 114  
*macrotis*, 224  
*vulpes*, 95,235,288,321
- Vulpes vulpes* and Coyotes (*Canis latrans*) on Prince Edward Island, Canada, Population Structure of Harvested Red Foxes, 288
- Waldron, G.E. and B.M.H. Larson. Kudzu Vine, *Pueraria montana*, Adventive in Southern Ontario, 31
- Walker, D., 306
- Walker, T.S., 204
- Wapenaar, W., F. de Bie, D. Johnston, R.M. Oahandley, and H.W. Barkema. Population Structure of Harvested Red Foxes (*Vulpes vulpes*) and Coyotes (*Canis latrans*) on Prince Edward Island, Canada, 288
- Warbler, Blue-winged, 143  
Golden-winged, 143  
Hermit, 143  
Townsend's, 143
- Watkins, W.G., 324
- Weasel, Long-tailed, 95,228,234
- Weis, L., 320
- Werner, J.R. Vancouver Island Marmots (*Marmota vancouverensis*) Consume Plants Containing Toxic Secondary Compounds, 55
- Wheat, 221,226
- Wheatear, Northern, 59
- Wheatgrass, Crested, 104,148,221,226  
Slender, 104,148,221,226
- White, B.N., 320
- White-Nose Syndrome in New Brunswick, Bat Populations and Cave Microclimate Prior to and at the Outbreak of, 125
- Wick, A.A., J. Janelle, S. Pruss, and N. Erbilgin. First Observations of Mormon Metalmark (*Apodemia mormo*) Oviposition Behaviour in Canada, 34
- Wicopy, 86
- Willow, 24,136,189,282,296  
Scouler's, 190
- Willow *Salix* sp. Rose Insect Galls on Moose *Alces alces* Winter Browsing, The Influence of, 189
- Wolf, 237  
Eastern, 235  
Gray, 238,324  
Red, 143
- Wolf (*Canis lupus*), Severe Maxillary Osteomyelitis in a Gray, 238
- Wolverine, 234
- Wood, Lead, 87
- Woodchuck, 56
- Woodfern, 253  
Algonquin, 253  
Fragrant, 253
- Woodrat, Bushy-tailed, 96
- Woodsia* sp., 253
- Xema sabini*, 113
- Xenomystax atrarius*, 210
- Yew, Canada, 160  
English, 160  
Pacific, 160
- Yew (*Taxus canadensis*) Branch Wood to Two Wood Decay Fungi, Resistance of Canada, 160
- Youngman: 1927–2011, A Tribute to Phillip Merrill, 167
- Yukon, Stand-level Attributes of Snowshoe Hare (*Lepus americanus*) Habitat in a Post-Fire Trembling Aspen (*Populus tremuloides*) Chronosequence in Central, 295
- Zonotrichia leucophrys*, 59  
*leucophrys leucophrys*, 60

## Index to Book Reviews

### Botany

- Iason, G., M. Dicke, and S. Hartley. *The Ecology of Plant Secondary Metabolites: From Genes to Global Processes*, 178
- Wenxin, C. and W. Entao. *Rhizobia in China*, 347

### Environment

- Bennet-McCuaig, C. *Encountering the Wild*, 77
- Black, B.C. and G.J. Weisel. *Global Warming. Historical Guides to Controversial Issues in America*, 77
- Bodin, Ö. and C. Prell. *Social Networks and Natural Resource Management: Uncovering the Social Fabric of Environmental Governance*, 81
- Galatowitsch, S.M. *Ecological Restoration*, 75
- Hallett, S. with J. Wright. *Life Without Oil: Why We Must Shift To a New Energy Future*, 80
- McAlpine, D.F. and I.M. Smith. *Assessment of species diversity in the Atlantic Maritime Ecozone*, 71
- Townsend, D.W. *Oceanography and Marine Biology: An Introduction to Marine Science*, 81

### Other

- Gepts, P., T.R. Famula, R.L. Bettinger, S.B. Brush, A.B. Damania, P.E. McGuire and C.O. Qualset. *Biodiversity in Agriculture: Domestication, Evolution and Sustainability*, 348
- Gotelli, N.J. and A.M. Ellison. *A Primer of Ecological Statistics, Second Edition*, 350
- Kålås, J.A., Å. Viken, S. Henriksen, and S. Skjelseth. *The 2010 Norwegian Red List for Species*, 349
- Norment, C. *In the Memory of the Map: A Cartographic Memoir*, 179
- Roed, M.A. and R.J. Fulton. *Okanagan Geology South: Geologic Highlights of the South Okanagan Valley, British Columbia*, 263

### Zoology

- Adler, K. *Contributions to the History of Herpetology. Volume 3*, 344
- Ayé, R., M. Schweizer and T. Roth. *Birds of Central Asia: Kazakhstan, Turkmenistan, Uzbekistan, Kyrgyzstan, Tajikistan, Afghanistan*, 260

- Burton, R. and J. Croxall. *A Field Guide to the Wildlife of South Georgia*, 176
- Crother, B.I. *Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding – Seventh Edition*, 340
- de Boer, B., E. Newton and R. Restall. *Birds of Aruba, Curacao and Bonaire*, 70
- Ernst, C. and E. Ernst. *Venomous Reptiles of the United States, Canada, and Northern Mexico. Volume 1*, 175
- Forsman E. and 26 co-authors. *Population Demography of Northern Spotted Owls*, 174
- Grimmett, R., C. Inskipp, and T. Inskipp. *A Guide to the Birds of India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, and the Maldives*, 71
- Heatwole, H. and J.W. Wilkinson. *Amphibian Biology Volume 10. Conservation and Decline of Amphibians: Ecological Aspects, Effect of Humans, and Management*, 341
- Holman, J.A. *The Amphibians and Reptiles of Michigan: A Quaternary and Recent Faunal Adventure*, 342
- Kennedy, A. *Birds of the Masai Mara*, 261
- Kennedy, A. and V. *Animals of the Masai Mara*, 261
- Lovitch, D. *How to be a Better Birder*, 68
- McLaren, I. *All the Birds of Nova Scotia*, 172
- Meshaka, W.E. Jr., and J.T. Collins. *A Pocket Guide to Lizards and Turtles of Pennsylvania*, 345
- Mikkola, H. *Owls of the World: A Photographic Guide*, 346
- Nicholas, E., E. Mandrak, and M. Burrige. *The ROM Field Guide to Freshwater Fishes of Ontario*, 173
- Spotte, S. *Societies of Wolves and Free-ranging Dogs*, 177
- Thorington, R.W., J.L. Koprowski, M.A. Steele and J.F. Whatton. *Squirrels of the World*, 262
- Tozer, R. *Birds of Algonquin Park*, 69

### Children's Books

- Patkau, K. *Ecosystem Series: Who Needs a Swamp?, Who Needs a Jungle?, and Who Needs an Iceberg?*, 83
- Urrutia, M.C. *Who Will Save my Planet?*, 83

# The Canadian Field-Naturalist — Instructions for Authors

## Aim and Scope

The Canadian Field-Naturalist (CFN; ISSN: 0008-3550) publishes peer-reviewed scientific papers on natural history relevant to Canada. Relevance to Canada usually means the species studied must inhabit Canada, even if the research itself occurred outside Canada. e.g., U.S.-based research on a species whose range extends into Canada, or research in Asia on a species introduced into Canada. Natural history comprises organism-scale biological research in diverse fields including behaviour, ecology, conservation, and taxonomy, among others. We publish research on any taxa, from microbes to large-bodied mammals. We encourage manuscript submissions from professional and amateur naturalists. Our journal has been published continuously since 1879 by the non-profit group The Ottawa Field-Naturalists' Club, making it one of the longest-running ecological journals in North America.

## Manuscript Types

**Articles.** Articles report original research and are at least five pages long in printed form. There are no upper-boundary restrictions on the number of pages or references for articles (maximum abstract length: 250 words). Articles are peer-reviewed.

**Notes.** Like articles, Notes report original natural history research. Notes only differ in being shorter (maximum abstract length: 100 words; maximum page length in final printed form: 4 pages, or approximately 2000 words). Many Notes report novel observations of animal behaviour, diet choice, or range extensions of species. Notes are peer-reviewed.

**Book Reviews.** We publish many reviews of books of interest to naturalists, from all over the world (i.e., not necessarily related to Canadian species). Each issue includes a list of new book titles received by our Book Reviews Editor with notation on books available for review, although we are open to suggestions of reviews for other titles. All book reviews and inquiries related to book reviews should be sent to our Book Review Editor, Roy John (r.john@rogers.com). Book reviews are edited by Roy John, but are not considered peer-reviewed.

**Tributes.** Tributes are descriptions of recently-deceased exemplary naturalists who contributed to our understanding of Canadian nature. Please inquire with our Editor-in-Chief, Dr. Carolyn Callaghan, before writing a Tribute. Tributes are not peer-reviewed.

**News, Opinions and Reports.** Short news items, commentary, or reports of interest to naturalist readers. They are not peer-reviewed, and are normally contributed by our Editor-in-Chief. News item suggestions should be directed to our Editor-in-Chief, Dr. Carolyn Callaghan (editor@canadianfieldnaturalist.ca). Commentary may be similar to articles in format or it may be just a series of paragraphs.

**Editorials, Club Reports.** These items are contributed by our editors and Ottawa Field-Naturalists' Club personnel, and are not open to submission by others.

## Manuscript Guidelines

Manuscripts are to be submitted to the Editor-in-Chief by email (editor@canadianfieldnaturalist.ca) or post, written in the journal style. Authors should consult a recent issue of CFN to understand journal format. A sample issue is available for free online at [www.ofnc.ca/cfn/122-1/subscribers-index.php](http://www.ofnc.ca/cfn/122-1/subscribers-index.php).

## Legal issues, ethical conduct

The research reported must be original. Manuscripts cannot have been published, or be under consideration for publication, in part or in entirety in any other publication media including journal, newsletter, book, report, either online or in print. The author(s) is/are expected to confirm that a manuscript submitted for consideration for publication in the Canadian Field-Naturalist has not already been published elsewhere, and will not be published elsewhere unless rejected by the Canadian Field-Naturalist. Published means distributed or otherwise made available in print, either in hard copy or online and with or without peer review.

All co-authors must have read and approved the submitted version of the manuscript. If institutional or contract approval for the publication of data is required, authors should have obtained it prior to manuscript submission. Authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, or minerals. Animal care should comply with relevant institutions' guidelines and be considered ethical by peers. A cover letter, indicating compliance with the preceding points must accompany the manuscript submission when appropriate.

## Language

Manuscripts can be submitted in English or French. Manuscripts are permitted, but not required, to include abstracts and keywords in both languages. Canadian spelling of the English language is required on manuscripts submitted in English. A contemporary reference for formal Canadian spelling is the *Canadian Oxford Dictionary*.

## Font, page format, file type

Font should be 12-point Times New Roman. Manuscripts should be double-spaced throughout including references with margins 2.5 cm (1 inch) wide. Pages should be numbered sequentially, and lines should be numbered continuously. The file should be saved as .doc (Microsoft Word 2003) file format.

## Nomenclature and units of measurement

Species' common names (when available) and scientific names should both be used at least once in the manuscript. Initial letters of species common names should be capitalized. Authorities' names (e.g., "Kuhl" in *Castor canadensis* Kuhl) should be omitted from scientific names unless the manuscript has taxonomic relevance or in the first reference to a featured species. Units of measurement should follow standard metric SI units.

## Vouchers, location information, GenBank

All voucher material should include the name and location of the collection and the specimens' catalog numbers. All collections or observations of species should include latitude and longitude in decimal degrees at two decimal points or finer depending on the sensitivity of the information. All genetic sequences should be accompanied by GenBank accession numbers.

## Title page

Include the title, a running title (maximum of 35 characters), the list of authors, and the type of submission the manuscript should be considered. For each author provide their



affiliation with postal address (home address is fine for unaffiliated amateurs) and e-mail address. Indicate which author is the corresponding author, and provide their phone number in addition to postal and e-mail address.

#### Abstract page

The second page of the manuscript (for Articles and Notes) should include the abstract and a list of key words (4-10 keywords).

#### Manuscript sections

Articles should typically contain the following sections listed as bolded, 16-point font headings, initial caps only: Introduction, Methods, Results, and Discussion. Alternative headings are permitted. Second-level subheadings are permitted and should be italicized in 12-point font. Notes' headings, if any, are at the authors' discretion. Both Articles and Notes should also include Acknowledgements, Documents Cited, and Literature Cited. Acknowledgements should list authors' funding sources and thank people who contributed significantly to the study. Documents and Literature Cited are described below.

#### Citation format

Below are example citations in CFN style. When more than one document is cited in a citation, sort them chronologically, and alphabetically within the same year, separated by semicolons.

**Single author:** "... fishers in Maine (Coulter 1966)."

**Two authors:** "... been observed (MacKinnon and Kennedy 2009)."

**Three or more authors:** "... diet composition (Arthur *et al.* 1989)."

**Multiple documents cited:** "... birds and tardigrades are very different (Tufts 1961; Nelson *et al.* 2009)."

#### References (Documents Cited and Literature Cited)

Cited references should be listed chronologically under the headings of Documents Cited (for reports of limited circulation and web documents) and Literature Cited (for journal articles, books, book sections, and theses). All references should have hanging indents. Web documents' citations should include their website address and the date they were accessed. Journal names should be written in full. Below are example references in CFN format.

#### Documents Cited

**Environment Canada.** 2008. National Climate Data and Information Archive, Environment Canada. Accessed 5 November 2008. [www.climate.weatheroffice.gc.ca](http://www.climate.weatheroffice.gc.ca).

**Friends of Fish Creek Provincial Park Society.** 2009. Water quality monitoring report 2009. Accessed 20 March 2011. <http://wsow.brbc.ab.ca/reports/FishCreekStudy2.pdf>.

**Stevens, V.** 1995. Wildlife diversity in British Columbia: distribution and habitat use of amphibians, reptiles, birds, and mammals in Biogeoclimatic Zones. Working Paper 04. B.C. Ministry of Forest Research Program, and Ministry of Environment, Lands, and Parks' Habitat Protection Branch, Victoria, British Columbia, Canada. 288 pages.

#### Literature Cited

**Arthur, S. M., W. B. Krohn, and J. R. Gilbert.** 1989. Habitat use and diet of fishers. *Journal of Wildlife Management* 53: 680-688.

**Coulter, M. W.** 1966. Ecology and management of fishers in Maine. Ph.D. thesis, Syracuse University, Syracuse, New York, USA.

**MacKinnon, C. M., and A. C. Kennedy.** 2009. Canada Lynx, *Lynx canadensis*, use of the Chignecto Isthmus and the possibility of gene flow between populations in New Brunswick and Nova Scotia. *Canadian Field-Naturalist* 122: 166-168.

**Nelson, D. R., R. Guidetti, and L. Rebecchi.** 2009. Tardigrada. Pages 455-484 in *Ecology and Classification of North American Freshwater Invertebrates*. Edited by J. H. Thorp and A. P. Covich. Third edition. Academic Press, San Diego, California.

**Tufts, R. W.** 1961. The Birds of Nova Scotia. Nova Scotia Museum, Rolph-Clark-Stone, Maritimes Limited, Halifax, Nova Scotia. 481 pages.

#### Figures and maps

Figures should be pasted on separate pages below the Literature Cited section in the manuscript file. Upon acceptance for publication, the Editor may ask the authors to send figures as separate files with sufficiently high resolution for publication-quality images. Microscopic images should be accompanied by a scale bar. Photographic reproductions of line drawings should be no larger than a standard page. Colour figures can be included in the online version of final articles, but figures are printed in black in printed CFN issues unless authors agree to pay the costs of colour printing (approximately \$650 per figure – contact the Editor-in-Chief if you would like colour printing). Authors should remember that readers often print online articles with black ink printers, so even colour figures online should be interpretable if printed in grayscale.

Not every article requires a map. There is no need for a map that just illustrates the location of a study area. Ideally, a map should make clear the spatial relationship of the data. For example, a paper on a range extension should show how far the species' range has been extended from the previous known limit.

Every map should include a north indicator, using a north arrow or by labeling Longitude (°W) and Latitude (°N) on the map. Although most maps have north at the top, maps can be oriented differently if there is a valid reason. Every map should include a scale bar. A ratio scale (e.g. 1:50000) is not recommended as the scale will change depending upon the published size of the map. An inset map showing the region where the study area is located may be used, and a legend can be used if warranted.

Maps should make use of a strong contrast – a white background with black lines. Avoid using a uniform gray background, but shading is appropriate for certain areas (e.g. lakes) or to indicate affected areas. Maps should be submitted as a separate raster graphic or bitmap file of sufficient resolution to print sharply. The specific file size will depend upon the file format. Some common formats include Windows bitmaps (\*.bmp), graphics interchange format (\*.gif), and joint photographic experts group format (\*.jpg).

#### Figure captions

Figure captions should be listed in the Figure Captions section following Figures. Figure captions should be listed and numbered in the order cited in the document. In text the word "Figure" should appear in small-caps (e.g., Figure 1) and in figure captions large-caps (e.g., "FIGURE 2. A young adult, melanistic American Red Squirrel (*Tamiasciurus lud-*

*sonicus*) observed foraging in Upper Nine Mile River, Nova Scotia." For multi-part figures, each part should be labelled (in text: e.g., Figure 1A).

#### Tables

Tables should be listed on separate pages in the Tables section following Figure Captions, with the word "TABLE" in small-caps.

#### Supplementary Material

Tables, figures, audio files, video files, and data files that compliment Articles or Notes but are not essential to their message can be included as supplementary material at the authors' discretion. Supplementary material will be available online only for subscribers to download. Supplementary material should be submitted during initial manuscript submission. List all supplementary material under the final manuscript heading "Supplementary material." Supplementary material is a new feature for CFN so we do not yet know which file formats can and cannot be accepted; please consult our Journal Manager with any questions about specific formats.

#### Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor, who sends it to two qualified reviewers as well as provides an evaluation of the manuscript. Authors are encouraged to suggest at least three suitable referees that could provide unbiased expert reviews. Authors can also request that their manuscript not be sent to certain referees, if proper justification is given. The Editor-in-Chief makes the final decision on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of *The Canadian Field-Naturalist*. As with any scientific journal, extensive revisions may be requested by editors in an effort to improve the clarity, accuracy, style, and overall quality of manuscripts. Changes made by authors at the proof (galley) stage may result in extra charges to the author.

#### Author Charges, Reprints, pdf files

As a non-profit journal run largely by volunteers devoted to natural history, we make every effort to keep our costs as low as possible. To cover costs we require payment from authors of Articles and Notes: \$90 per printed page, plus \$30 per figure (any size up to one page), and \$90 per page of tables. Under special circumstances, these charges can be waived for authors without grants or institutional support (e.g., amateurs, students, independent researchers). These waivers are courtesy of a generous bequest left by naturalist Tom Manning (1911-1998) to The Ottawa Field-Naturalists' Club. To learn more about Tom Manning and his research, refer to CFN 118(4):618-625 ([www.canadianfieldnaturalist.ca/index.php/cfn/article/view/70/70](http://www.canadianfieldnaturalist.ca/index.php/cfn/article/view/70/70)). Authors requesting charge waivers must make their request when submitting their manuscript and again (as a reminder) when authors return their proofs and order form after manuscript acceptance. Manuscripts of authors requesting waivers will not be treated any differently than other manuscripts during the editorial process.

Reprints can be ordered after acceptance for publication, with authors covering the cost of printing and mailing. Pdf files of published Articles, Notes, and Tributes are e-mailed to authors at no charge. As per the copyright agreement between authors and CFN, authors are permitted to distribute

their pdf file to colleagues and to post it on their research website, but are not permitted to distribute their article commercially.

Although not a requirement, submitting authors are encouraged to maintain personal subscriptions to *The Canadian Field-Naturalist* or membership in The Ottawa Field-Naturalists' Club to further support the mandate and reach of the journal.

#### How to Submit a Manuscript

Please ensure your manuscript complies with the journal style described above, and has been appraised by a qualified expert (listed in the Acknowledgements) prior to submission.

Please e-mail book reviews to Book Review Editor Roy John, [rjohn@rogers.com](mailto:rjohn@rogers.com). Please e-mail all other manuscripts to Editor-in-Chief Dr. Carolyn Callaghan at [editor@canadianfieldnaturalist.ca](mailto:editor@canadianfieldnaturalist.ca). Please also attach a cover letter briefly explaining 1) the significance and novelty of your study in plain terms, 2) why it would be of interest to CFN's readers, 3) confirmation that the submitted manuscript has not been distributed in print, either in hard copy or online and with or without peer review, 4) confirmation that the research was conducted in adherence to all pertinent legislation and institutional guidelines regarding the study, disturbance, or collection of animals, plants, or minerals, 5) the names, affiliations, e-mail addresses, and relevant expertise of at least three experts you feel could evaluate your manuscript without bias or conflicts of interest as referees. You can also request that certain experts not act as referees, as long as you provide adequate justification. We are working to set up a manuscript submission portal on CFN's website in the future that will allow you to track your manuscript as it proceeds along the reviewing process, but until the portal is fully functional please continue to use the e-mail method.

We can also receive manuscripts by postal mail. Please send two copies (double-sided preferably to reduce environmental costs of printing and financial costs of mailing) of your manuscript to:

DR. CAROLYN CALLAGHAN  
Editor-in-Chief, CFN  
Box 35069, Westgate PO  
Ottawa, ON, K1Z 1A2  
Canada

#### Contact Information

CFN website:  
<http://www.canadianfieldnaturalist.ca/index.php/cfn/about>

Ottawa Field-Naturalists' Club (our publisher) website:  
[www.ofnc.ca](http://www.ofnc.ca)

Editor-in-Chief: Dr. Carolyn Callaghan  
[editor@canadianfieldnaturalist.ca](mailto:editor@canadianfieldnaturalist.ca)

Assistant Editor: Trina Rytwinski  
[canadianfieldnaturalistae@gmail.com](mailto:canadianfieldnaturalistae@gmail.com)

Book Review Editor: Roy John  
[rjohn@rogers.com](mailto:rjohn@rogers.com)

Journal Manager: Jay Fitzsimmons  
[subscriptions@canadianfieldnaturalist.ca](mailto:subscriptions@canadianfieldnaturalist.ca)

<b>News and Comment</b>		353
Yorke Edwards, 1924–2011		
The Canadian Herpetologist (TCH) 2(2), Fall 2012		
<i>Erratum</i> The Canadian Field-Naturalist 126(3): 245		
<b>Club Awards</b>		354
<b>Index to The Canadian Field-Naturalist Volume 126</b>	By LESLIE CODY	357
<b>Instructions to Authors</b>		370

Mailing date of the previous issue 126(3): 25 January 2013

## Articles

- A direct comparison of enclosed track plates and remote cameras in detecting Fishers, *Martes pennanti*, in North Dakota  
STEVEN C. LOUGHRY, MAGGIE D. TRISKA,  
DOROTHY M. FECSKE, and THOMAS L. SERFASS 281
- Population structure of harvested Red Foxes (*Vulpes vulpes*) and Coyotes (*Canis latrans*) on Prince Edward Island, Canada  
WENDELA WAPENAAR, FIEP DE BIE, DAVID JOHNSTON,  
RYAN M. O'HANDLEY, and HERMAN W. BARKEMA 288
- Stand-level attributes of Snowshoe Hare (*Lepus americanus*) habitat in a post-fire Trembling Aspen (*Populus tremuloides*) chronosequence in central Yukon  
WAYNE L. STRONG and THOMAS S. JUNG 295
- Predicting the spread of Purple Loosestrife (*Lythrum salicaria*) in the prairies  
CORY J. LINDGREN and DAVID WALKER 306

## Notes

- Cougars, *Puma concolor*, in Ontario: Additional evidence  
FRANK F. MALLORY,  
REBECCA A. CARTER, JENNY L. FORTIER, I. STUART KENN, LINSAY WEIS, and B. N. WHITE 320
- First record of parasites from Cougars (*Puma concolor*) in Manitoba, Canada  
O. K. DARE and W. G. WATKINS 324
- Evidence for the collection of a Reddish Egret (*Egretta rufescens*) in Nova Scotia during the 19<sup>th</sup> century and its association with the McCulloch collection of birds  
ERIC L. MILLS 328
- Observations of wild Cougar (*Puma concolor*) kittens with live prey: Implications for learning and survival  
L. MARK ELBROCH and HOWARD QUIGLEY 333
- A partial albino hatchling Northern Ring-necked Snake, *Diadophis punctatus edwardsii*, from Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia, Canada  
JOHN GILHEN,  
GRAHAM CASWELL, CARRIE DRAKE, MARY MACDONALD, and HEATHER MCKINNON-RAMSHAW 336

## Book Reviews

- ZOOLOGY: Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding – Seventh Edition — Amphibian Biology Volume 10. Conservation and Decline of Amphibians: Ecological Aspects. Effect of Humans, and Management — The Amphibians and Reptiles of Michigan: A Quaternary and Recent Faunal Adventure — Contributions to the History of Herpetology. Volume 3 — A Pocket Guide to Lizards and Turtles of Pennsylvania — Owls of the World: A Photographic Guide 340
- BOTANY: Rhizobia in China 347
- OTHER: Biodiversity in Agriculture: Domestication, Evolution and Sustainability — The 2010 Norwegian Red List for Species — A Primer of Ecological Statistics, Second Edition 348
- NEW TITLES 352

