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COVER: Rock Ptarmigan (*Lagopus muta townsendi*) on Amchitka Island, Alaska, in late May to very early June. Male Rock Ptarmigan on mainland Alaska and northern Canada during this same period are mostly white, a difference that has been used to describe subspecies of Rock Ptarmigan. See the article in this issue by Clait Braun *et al.*, pages 49–55. Photo: Steve Ebbert, 10 June 2015.

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Characteristics of Wolverine (*Gulo gulo*) dens in the lowland boreal forest of north-central Alberta

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Abstract

We investigated Wolverine (*Gulo gulo*) denning ecology in the boreal forest of northern Alberta. During winters 2015/2016 and 2016/2017, we used live traps to capture four female Wolverines and fitted them with global positioning system (GPS) collars programmed to take a location every two hours. We determined reproductive status at capture and GPS location data were used to identify den sites. One female denned in one of the two years, one female denned in two consecutive years, and two females did not den during the study. Seven of the eight Wolverine den sites were in mature or old Black Spruce (*Picea mariana*) stands, where dens consisted of a hollow, moss-covered mound originating from a partially uplifted root mass caused by a leaning or fallen tree. One den was located under decayed logging debris with an overstorey dominated by dense deciduous regeneration. Maximum snow depth recorded (December–March) at weather stations in the study area was 32–51 cm. Spring snow coverage was scarce in our study area (<1%) and always associated with ice cover on lakes and large ponds; mean distance from dens to nearest spring snow coverage was 15.19 km (SD = 2.73, n = 8). Female Wolverines appear to be using locally-available denning structures in the lowland boreal forest, despite a lack of deep snow, persistent spring snow cover, or large boulders documented in other studies.

Key words: Alberta; boreal forest; den; lowlands; snow; Wolverine

Introduction

Wolverines (*Gulo gulo*) are well adapted to cold, snowy environments with their compact body, large paws, dense, frost-resistant fur, and capacity to store significant body fat (Banci 1994). Because Wolverines give birth in winter, females must find suitable den sites that are protected from predators, disturbance, cold temperatures, and melting spring snow (Magoun and Copeland 1998). Most verified Wolverine dens were under 1–5 m of snow (Pulliainen 1968; Magoun and Copeland 1998), suggesting that a deep snowpack offers important benefits throughout the denning season (Magoun and Copeland 1998). The majority of Wolverine den locations documented around the world (n = 562 dens) overlapped areas with persistent spring snow; a small subset of dens that were outside this mapped area of persistent spring snow cover (hereafter, the spring snow coverage) were visited and later confirmed to be snow dens (Copeland *et al.* 2010).

Deep snow and/or persistent spring snow cover has been associated with Wolverine dens throughout their distribution (Magoun and Copeland 1998; Copeland *et al.* 2010; May *et al.* 2012), but few dens have been described in low elevation, forested habitats. The majority of published information on Wolverine dens is from regions where deep snow was associated with steep, rugged terrain, and large boulders in Norway (May *et al.* 2012), woody debris and boulders in British Columbia (Krebs and Lewis 2000), long complex tunnels (Magoun and Copeland 1998) and drainage features in Alaska (Magoun *et al.* 2017), and fallen trees or boulders in Idaho (Copeland 1996; Magoun and Copeland 1998). A Wolverine denned under large boulders and downed trees in the low-elevation boreal forest of Ontario (n = 1 den; Dawson *et al.* 2010) and females used boulder complexes in mature, mixed-coniferous boreal forests in Sweden (n = 49 dens; Makkonen 2015). Given a lack of steep terrain and large boulders, a shallow snowpack, and relatively early spring snowmelt in the lowland boreal forest of northern Alberta (Webb *et al.* 2016), it was unclear what resident Wolverines were using for denning structures.

Similar to Wolverines, American Black Bear (*Ursus americanus*) gives birth in winter and need to select den sites that will keep cubs dry, warm, and safe. In the northern boreal forests, most black bear dens are excavated, typically beneath ground level, under the roots of standing or partially blown-down trees, into hillsides, or into riverbanks (Fuller and Keith 1980; Klenner and Kroeker 1990). American Black Bear dens are typically in more upland forest stands, and peatland is avoided (Tietje and Ruff 1980). We hypothesized that in northern boreal landscapes, Wolverine dens located in upland habitat with mature forest cover and deeper snowpack would provide the best protection and insulation available, while more lowland, wet areas would not be used.

Although long-term fur harvests and images captured at camera traps suggest a reproducing population of Wolverines in northern Alberta (Webb *et al.* 2016), very little is known about denning ecology. Documenting den structures, snow conditions near dens, and duration of use, particularly in areas outside of the expected distribution of spring snow cover, could help clarify the relationship between Wolverines and snow and be useful information for timber harvest planning. Currently, Alberta's timber harvest guidelines list Wolverine dens under the "other species/sensitive site" section of the document, suggesting a forested buffer distance of 100 m (Alberta Agriculture and Forestry 2016); yet, there is no description of how to identify a potential Wolverine den. Our objectives were to: (1) document the general forest characteristics and specific structures associated with Wolverine den sites; (2) characterize snow, land cover, and industrial disturbance surrounding Wolverine den sites; and (3) summarize female Wolverine movements during the denning period (February–May).

Methods

The study area, roughly 4600 km^2 in size, is located ~500 km north of Edmonton and 100 km northeast of Red Earth Creek in north-central Alberta (57°N, 114°W; Figure 1). The landscape is typical of Alberta's boreal region (Natural Regions Committee 2006), with a mosaic of aspen (*Populus* spp.)-dominated and aspen/White Spruce (*Picea glauca* (Moench) Voss) mixedwood forests in the uplands and extensive areas of Black Spruce (*Picea mariana* (Miller) Britton, Sterns & Poggenburgh) treed fens and bogs in the surrounding wetlands. Approximately 42% of the study area is comprised of wetlands (fens, bogs, swamp, open water, and marsh), which were predominantly peatland forms (fens or bogs; 30% of the study area; AEP 2015). Mean elevation of overlapping townships within the study area is 616.98 m (SD = 89.56, n = 75 townships) and ranged from 500 to 800 m. Summers are short and cool, and winters are cold with snow typically covering the ground from November to mid-April. Mean August temperature in the study area was 13.68 ± 1.86 (SD) °C (mean maximum August temperature = 18.2°C, n = 5 weather stations, 2003–2009; ACIS 2015).

The study area supported low numbers of Moose (*Alces americanus*) and White-tailed Deer (*Odocoileus virginianus*), and had a limited number of American Beaver (*Castor canadensis*); Gray Wolf (*Canis lupus*) occurred in small numbers when compared to other regions of the province. Caribou (*Rangifer tarandus*) are rare, but known to occur in the northern portion of the study area. American Black Bear, Canada Lynx (*Lynx canadensis*), American Marten (*Martes americana*), Fisher (*Pekania pennanti*), Ermine (*Mustela erminea*), Snowshoe Hare (*Lepus americanus*), Red Squirrel (*Tamiasciurus hudsonicus*), Spruce Grouse (*Falcipennis canadensis*), and Ruffed Grouse (*Bonasa umbellus*) were common.

The study area is remote and uninhabited, with little human activity due to limited access and extensive wetlands. The industrial footprint is small and comprised primarily of oil and gas development (e.g., all-season gravel roads, seismic lines from past exploration, and well-sites), with active forest harvesting occurring only in the extreme southern portion of the study area. Many of the seismic lines had experienced considerable regrowth of alder (*Alnus* spp.) and other shrubs. Active wells are visited on a regular basis by oil field staff, while unmaintained wells in the area (some of which were reclaimed and having shrub regrowth) receive little to no winter visitation based on our observations while working there. Gravel road and well-site density (including active and unmaintained wells) was 0.04 km/km^2 and 0.13 wells/km^2, respectively. Large wildfires were the primary disturbance in the area and approximately one-third of the study area had burned in the past 50 years (1961–2016).

We used baited run pole camera traps during winters 2014/2015 (n = 8 run poles), 2015/2016 (n = 7 run poles), and 2016/2017 (n = 14 run poles) to document the presence of individual Wolverines based on unique markings (Magoun *et al.* 2011). During winters 2015/2016 and 2016/2017 (November–March), we live-trapped Wolverines using 10 and 17 log box traps, respectively (Copeland *et al.* 1995). The run poles and live traps were spaced ~5–10 km apart and were baited with beaver carcasses. Traps were outfitted with TT3 trap transmitters (Vectronic Aerospace, Berlin, Germany), which instantly sent an email message via satellite communication when a trap was triggered. On the advice of a wildlife veterinarian,

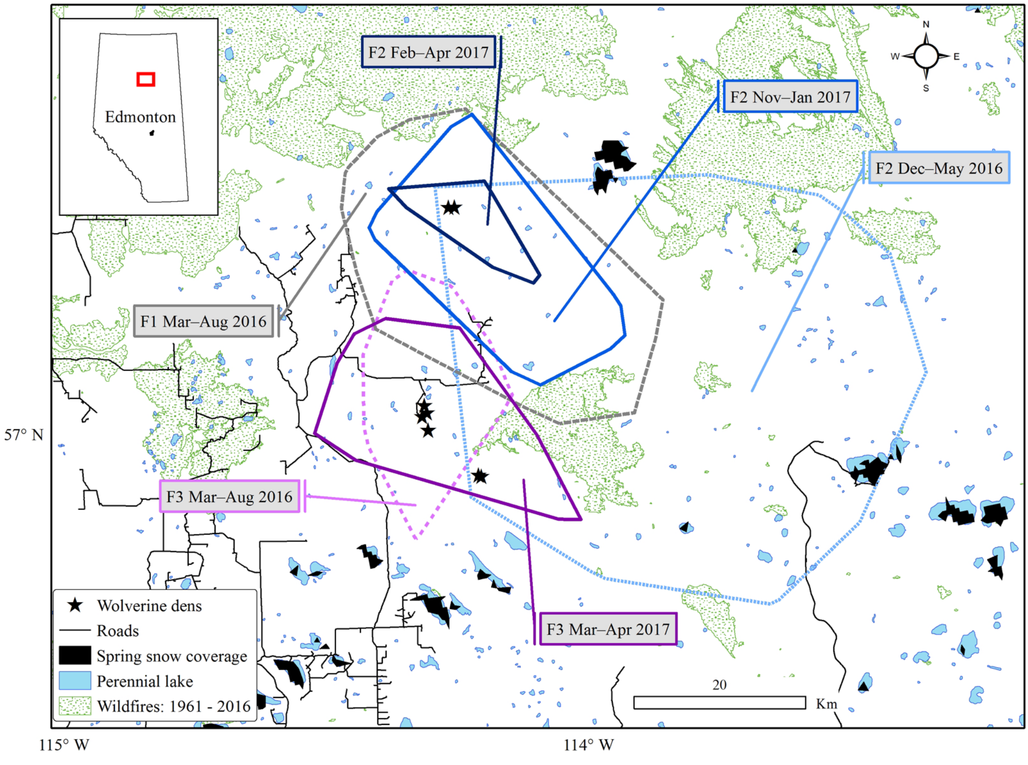

FIGURE 1. Wolverine (*Gulo gulo*) den locations (stars) and 100% minimum convex polygon home ranges for three female Wolverines from 2015–2017 in north-central Alberta, Canada (inset).

Wolverines were immobilized using a jab stick (Dan-Inject, Borkop, Denmark) loaded with ketamine hydrochloride, 100 mg/ml (Ketalean; Bimeda-MTC Animal Health Inc., Cambridge, Ontario) and medetomidine hydrochloride, 1 mg/ml (Cepetor; Modern Veterinary Therapeutics, Miami, Florida, USA) at a dosage of 10.6–11.9 mg/kg and 0.1–0.12 mg/kg, respectively. Wolverines were equipped with Tellus ultralight global positioning system (GPS) collars (Followit, Lindesberg, Sweden) that were programmed to take a location every two hours. Atipamezole hydrochloride 5 mg/ml (Revertor; Modern Veterinary Therapeutics) was hand injected to reverse the effects of the sedative. The animals were returned to the trap on a bed of spruce boughs until fully recovered and then released.

Collars uploaded data to a secure website via satellite communication, but there was typically a 2–3 day time lag until locations became available. We visually inspected GPS collar data to identify potential reproductive den sites. Potential dens had a repeated pattern of collar locations within 100 m of each other and movements to/from a localized area, in addition to associations with long periods of GPS time-outs when we assumed females were underground in the den and satellites were not able to get a fix (February–April). The primary den was the first den we documented and secondary dens were subsequent dens used by female Wolverines (Makkonen 2015). We used the terms primary and secondary dens, similar to Makkonen (2015), because collaring sometimes occurred after kits were born; therefore, we could not be certain that the primary den was actually the natal den.

We used a geographic information system (ArcMap 10.4, Esri, California, USA) for all spatial calculations. We created a 5 km buffer around each den (estimated average female home range during the denning season; Makkonen 2015) and calculated density of gravel roads and well-sites (active and unmaintained). We measured distance of each den site to nearest gravel road and well-site rounded to the nearest whole number. We used multiple sources of data to characterize the study area climate. During winter 2016/2017, we established winter weather stations (n = 12) that were 10–20 km apart to measure local climate variables throughout the study area. Air temperature was recorded every hour using a Kimo KT50 compact temperature logger (Chevry-Cossigny, Seine-et-Marne, France). The temperature logger was not able to record temperatures below −40°C; however, these were infrequent events. Snow depth was recorded by field staff on a weekly to biweekly basis using a stationary metal metre stick. Study weather stations were established in areas avoiding direct sunlight and unnatural tamping, drifting, or interception of snow. In addition to the winter weather stations we established, we summarized long-term (2005–2017) mean monthly temperature (°C) at the nearest (<20 km) five government-maintained weather stations surrounding the study area (i.e., Trout Mountain/Peerless Lake, Chipewyan Lake, Loon River, Panny River, and Picadelly; ACIS 2015).

We used the spring snow coverage data from Copeland *et al.* (2010), which was estimated across the Wolverine's circumboreal range using MODIS, to classify 500 × 500 m pixels over seven years (2000–2006). For each year, pixels received a one when the raster image was classified continuously as snow without any bare ground during the approximate end of the Wolverine denning period (24 April–15 May); the total number of years with continuous snow cover until mid-May was summed to get a value between one and seven for each pixel (Copeland *et al.* 2010). We created a 5 km buffer around each den site and calculated percent of area with spring snow coverage. We also used snow depth data from the Canadian Meteorological Centre (CMC) which was derived using interpolation models that incorporated actual daily snow measurements from weather stations, meteorological aviation reports, and special aviation reports from the World Meteorological Organization information system (Brasnett 1999; Brown and Brasnett 2010). We summarized long-term (1998–2014) mean monthly snow depths for CMC locations within our study area. We also inferred snow conditions using remote cameras and ground and aerial observations during a field visit in April 2017.

We created a 500 m buffer around each den site to characterize upland land cover (circa 2010; Castilla *et al.* 2014) and wetlands (circa 2015; AEP 2015). Land cover near dens included coniferous forest, broadleaf/deciduous forest, mixed forest, grassland, and shrubland. Wetland classes near dens included swamp, fen, and bog. We also overlapped den sites with the Derived Ecosite Phase, which is a representation of the vegetation, soil, and moisture conditions (wetland and upland; Figure 2) based on Alberta Vegetation Inventory and LiDAR (circa 2017; Alberta Agriculture and Forestry 2017).

We collected additional details related to forest structure and ecological classification at den sites during November and December 2017. Forest structure data were collected at five, 5.64 m radius plots. One plot was established at the den and the additional four plots were 30 m from the den in the four cardinal directions. Plot trees were identified to species and diameter at breast height was measured using a steel diameter tape for all trees >5 m in height. Tree heights were measured with a clinometer and tree ages were determined using an increment borer, typically from the two trees having the largest diameter within each plot. We defined stand age class as young (20–49 years), mature (50–119 years), and old (≥120 years), similar to Stelfox (1995). Each plot was classed to an ecosite phase, which is an Alberta-based field guide that subdivides forest types using site characteristics (moisture and nutrient regime), plant community type, soil type, and forest productivity information (Beckingham and Archibald 1996). Internal den dimensions were strictly based on a visual estimate as we did not want to enlarge the entrance and alter den structures.

Means ± SD are reported for all parameters, unless otherwise indicated.

Results

The nature of the terrain (bogs and extensive wetlands), limited our ability to operate in the field beyond March. The transition from frozen to thawed ground occurred quickly (early April) and access to our remote field camp and the bulk of the study area was impractical. Therefore, we were unable to collect weather station data or monitor dens and litters during the denning months of April and May.

Female Wolverines

We captured four females (F1, F2, F3, and F4) over two winters (2015/2016 and 2016/2017). A year prior to our live captures, we identified F1 from camera images at run poles. F1's home range during the denning season (March–May) was similar (859 km^2, 100% minimum convex polygon [MCP], n = 746 locations) to her overall home range from 21 March to 2 August 2016 (869 km^2, 100% MCP, n = 1046 locations; Figure 1). We had no evidence that she was lactating or denning.

We captured F2 during two winters. F2's home range 19 December 2015 to 15 May 2016 was 2254 km^2 (100% MCP, n = 1642 locations; Figure 1), which was similar to her home range during the denning season that year (February–May; 2219 km^2, 100% MCP, n = 1163 locations). She showed no sign of lactation or denning during this first winter and we suspect that she may have been a young female that ultimately took over the neighbouring F1's territory. We recaptured F2 on 30 November 2016 and again on 21 February 2017, and discovered she was lactating. Based on her subsequent movements and GPS time-outs, we believe she gave birth to her first litter of kits on or shortly after 22 February 2017, ~9 km from where she was captured. Her collar largely timed-out

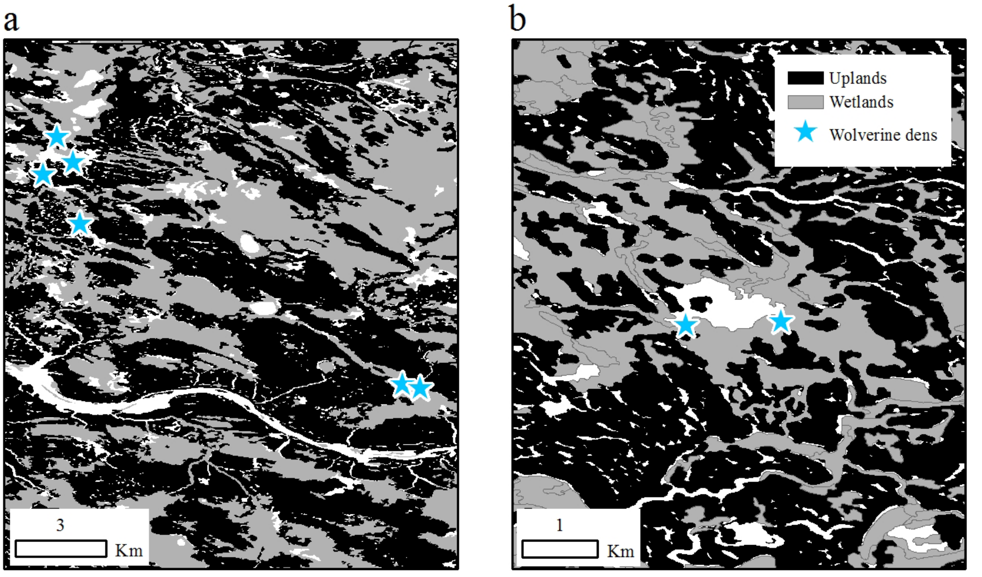

FIGURE 2. Upland and wetland matrix surrounding F3 (a) and F2 (b) den locations during 2016 and 2017 in north-central Alberta—only one den (F3 den 2, 2016) was within the upland category.

over a week-long period starting on 23 February and continued to time-out on a regular basis over the next several weeks. We monitored her movements until 9 April 2017 (premature collar failure) and documented her primary and secondary den (Figure 2b). F2 demonstrated strong fidelity to the primary den during the first four weeks (Table 1). The greatest movement she made was ~12.5 km from her secondary den on 23 March 2017 to a location she had visited earlier in the winter, to feed on remnants of an American Black Bear hide. F2 used her primary den 22 February–13 March and secondary den until at least 26 March; the distance between the two dens was ~700 m. We suspect that F2 had another den (26 March–9 April), but we were not able to locate a third den when we searched a cluster of locations in late April. At a location where F2 had spent time (1–9 April), we did find three mounds of dead spruce limbs that had recently been broken off the lower section (~0.8 m) of spruce trees. The breaking and piling of limbs appeared deliberate and bed-like, similar to the observation reported by a Finnish Wolverine hunter/trapper in Pulliainen (1968). F2's home range from November to January was 484 km^2 (100% MCP, n = 555 locations), and 90 km^2 (100% MCP, n = 309 locations) while she was denning (February–April; Figure 1). F2's mean daily movements from February to April were <5 km, providing further evidence of raising young in 2017, especially when compared to the previous year when she did not raise young and her daily movements were 8–15 km during the same time period (Table 1).

We captured F3 during two winters. During the first winter, our staff set up trail cameras close to her secondary den and she moved immediately afterwards to a third den (Figure 2a); camera images documented F3 and her three kits leaving the den on the evening of 19 April 2016. Based on this experience, we chose not to visit female den sites during the denning period as we would not be able to determine whether the use of multiple dens was natural or influenced by researchers. We did receive collar location data for F3 after 4 May 2016, which was the last day she occupied den 4. Over the next 27 days, F3 spent six days at one GPS cluster location and three

TABLE 1. Summary of daily movements (number of days, mean ± SD km) made by female Wolverines (*Gulo gulo*) in each month of the denning season during 2016 and 2017 in north-central Alberta.

Female_Year	February		March		April		May	
F1_2016	—	—	11	8.58 ± 6.10	30	11.18 ± 8.80	31	11.19 ± 5.13
F2_2016	29	8.22 ± 7.12	31	10.92 ± 7.26	30	15.19 ± 8.16	15	13.03 ± 4.95
F2_2017	7	2.67 ± 4.22	31	3.62 ± 5.03	8	4.58 ± 3.31	—	—
F3_2016	—	—	9	6.89 ± 6.65	30	10.23 ± 8.50	31	8.48 ± 8.12
F3_2017	—	—	10	9.11 ± 5.64	23	13.83 ± 10.69	—	—

days at two additional locations but these remaining GPS clusters were not visited. F3's home range during the denning season (March–May) was 315 km^2 (100% MCP, n = 500 locations), which was similar to her overall home range 22 March–16 August 2016 (338 km^2, 100% MCP, n = 878 locations; Figure 1). We recaptured F3 on 21 March 2017 and she was lactating; indicating that F3 had litters in two consecutive years. F3 used her primary den until 9 April and then occupied a secondary den 400 m away until at least 23 April (premature collar drop; Figure 2a). Her home range 21 March–27 April 2017 was 406 km^2 (100% MCP, n = 193 locations; Figure 1). Distance between F3's 2016 and 2017 primary dens was ~8 km. Although home range size was similar between years, F3 moved further distances in 2017 compared to 2016, and daily movements were much greater than the denning F2 (Table 1).

We captured F4 twice during March 2017, but she showed no signs of lactation in camera images or while we handled her 2 March and 26 March 2017. Her collar malfunctioned and we were not able to determine home range.

Den descriptions

Because we did not not disturb females while dens were in use and due to the challenges of working in the study area during April and May, most den sites were confirmed the following winter season. We found that using repeated patterns of GPS collar locations in combination with long periods of GPS time-outs to be an effective method of estimating den site locations. In 2016, F3's primary den was 20 m off our estimated GPS location and was confirmed with fresh Wolverine tracks leading in and out of the den. F3's secondary den in the regenerating cutblock was 10 m off our estimated location and was confirmed by very high frequency (VHF) signal and trail camera images. In 2017, F2's primary den was 10 m off our estimated location and was confirmed with packed snow/paths leading into the den. The remaining den locations that were visited the following season were an average of 21 m off the point derived from GPS clusters and time-outs. Alternative den structures in the immediate area of the estimated den locations were limited.

Seven of the eight Wolverine dens (n = 3 primary, n = 5 secondary) were in the hollow created by a partially uplifted root mass (i.e., root ball, root wad; hereafter uplifted root mass) of a leaning or fallen spruce tree. Seven of eight dens were located in mature (50–119 years) or old (>120 years) Black Spruce stands. Two of the seven dens were in mossy formations originating from an uplifted root mass where the trees had decayed, while the other dens were braced by the roots of intact leaning or fallen spruce trees. Root mass dens require little to no excavation by a Wolverine because a natural cavity is created when a thick moss blanket separates from the soil below as the shallow roots of a leaning or fallen tree upheave. Essentially, the lateral roots form the skeleton of the den, which supports a dense mat of soil and moss

FIGURE 3. Wolverine (*Gulo gulo*) F3 2016 primary den was in a partially uplifted root mass of a leaning spruce tree. The den entrance is located along the upper side of the tree trunk in the centre of the den cavity. Photo: Michael Jokinen.

FIGURE 4. An example of a Wolverine (*Gulo gulo*) den underneath a partially uplifted root mass (F3 den 4, 2016) in the lowland boreal forest of north-central Alberta. The den entrance is located at the exposed root; the tree is lying on the ground (upper right) while the lateral roots opposite the entrance have curved, creating a natural cavity. Photo: Michael Jokinen.

creating the den walls (Figures 3 and 4). It is important to note that these root dens are not wind throw trees characterized by roots that have been pulled out of the ground and are left standing on end. Such trees also existed within the study area, but exposed standing roots do not create the mound and associated cavity that the Wolverines used in our study.

Estimated internal den dimensions were slightly variable in size, but den size was ultimately determined by the extent of the root heave (~1 m × 1 m). A soccer ball-sized opening (~30 cm) often created the den entryway and most dens had alternate openings or potential escape routes in the walls. No material was brought into the dens by Wolverine, but spruce cone bracts often lined the floors. Cone seeds have been reported in Wolverine scat (Copeland 1996). However, we observed Red Squirrel caching of intact cones and cone feeding sites, where stripped cones lay beside piles of cone bracts in and around the den location. We did not observe animal remains or Wolverine scat inside or outside the dens. Snowshoe Hare sign was widespread around denning areas when we visited sites in November and December 2017.

One of the eight dens was located under decayed logging debris, which appeared to have been within or adjacent to a landing area used during previous forest harvesting activities. At the time of the observed den use, the overstorey was dominated by dense deciduous regeneration; the landing area and within-block roads were no longer apparent on the ground. We estimated that the cutblock was 27 years old based on tree aging and historical imagery from Google Earth (Google, Mountainview, California, USA), which suggested that the block was harvested in 1987. We could not determine the interior characteristics of this den without destroying the integrity of the structure.

Ecosite classification at den sites

Three primary and three secondary dens were revisited in November and December of 2017 to collect forest structure data. Two of F3's secondary dens from 2016 were not included in this den site forest assessment; however, they were similar in structure (uplifted root mass) and were dominated by old spruce forest based on observations made during a September 2016 visit. The study area is located within the transition zone of the Boreal Mixedwood and Boreal Highlands ecological areas (Beckingham and Archibald 1996). The Boreal Mixedwood and Highlands are ecologically similar, but the Highlands are slightly cooler (1.7°C cooler in summer) and have higher precipitation in both summer and winter (28 mm higher in summer; winter comparison not available; Beckingham and Archibald 1996).

Based on the ecosite field guide of Beckingham and Archibald (1996), three of five dens (not including the den in the regenerating aspen stand) were an ecosite of Common Labrador Tea (*Rhododendron groenlandicum* (Oeder) Kron & Judd)/horsetail (*Equisetum* spp.) in the Boreal Mixedwood ecological area and two were an ecosite of horsetail and White Spruce in the Boreal Highlands. Of the three Boreal Mixedwood den locations, all sample plots but one (treed poor fen) were identified to a Labrador Tea/horsetail phase. The most common indicator species that we found at these ecosites included Black and White Spruce, alder, Labrador Tea, and horsetail. All but one sample plot (Labrador Tea-hygric Black Spruce-Jack Pine (*Pinus banksiana* Lambert)) at the two dens located in the Boreal Highland ecological area were identified to a horsetail and White Spruce ecosite phase. Indicator species at the two dens in this ecosite were similar to those found at Boreal Mixedwood ecosites. The conifer forest bordering the regenerating deciduous cutblock, in which F3's secondary den was located, appeared to consist primarily of a Labrador Tea/horsetail ecosite class of the Boreal Mixedwood. Table 2 lists the tree species, count and average tree diameter, height, and age measured at sample plots.

Disturbance, land cover, and climate

The elevation of dens ranged from 535 to 687 m above sea level (601.5 ± 52.6 m, n = 8; Table 3). F2's dens were at similar elevations to the mean elevation of the surrounding township (681 m). F3 denned in the same township over two consecutive winters (township elevation = 557 m). Dens were typically far from roads and wells (Table 3); however, that could simply reflect available habitat within the study area. Gravel road density within a 5 km buffer of each den was 0–0.18 km/km^2 (0.07 ± 0.08 km/km^2, n = 8 dens). Well density (active and unmaintained) within the 5 km buffer of each den was 0.04–0.08 wells/km^2 (0.06 ± 0.02 wells/km^2, n = 8 dens).

Conifer forest was the dominant land cover within the 5 km buffer for six of the eight dens (range: 50–100%). One den was 54% deciduous forest, 21% mixed forest, 21% conifer forest, and 3% shrub within this buffer area. The area surrounding the logging debris den had been classified as 65% shrub (primarily regenerating *Populus* spp. within a cutblock), 30% conifer forest, 3% grassland, and 2% deciduous forest; however, the regenerating cutblock had reached heights >10 m by 2016. There was a wide range in the amount of wetland within 500 m of each den (range: 10–74%; 33.7 ± 21.28%, n = 8 dens). The wettest den (74% wetland) was classified as 53% swamp, 18% fen, and 3% bog within 500 m (F2's primary den). Six of the eight dens, however, had 10–35% wetland (mostly peatlands) within 500 m. Moreover, based on the Derived Ecosite Phase data, six of eight dens fell within the wetland category. This category is described as hydric/poor dominated by shrubby, treed bog vegetation (Alberta Agriculture and Forestry 2017).

Wolverine dens were 4–7 km to the nearest study weather station. Mean snow depths for each month were 32.4 ± 12.6 cm in December, 37.6 ± 11.1 cm in January, 41.4 ± 14.7 cm in February, and 34.0 ± 17.8 cm in March (n = 12 stations; Table 4). Maximum snow depth recorded (December–March) at individual weather stations was 32–51 cm. Hourly temperatures in the study area increased by the latter half of March (16–29 March, daily −3.6°C), as compared to the first half of the month (1–15 March, −16.8°C). Mean monthly temperatures increased slightly with each month, while monthly ranges were highly variable: December −14.4 ± 6.8°C (range −36.0 to 2.9°C),

TABLE 2. Forest stand structure (count, mean ± SD) associated with Wolverine (*Gulo gulo*) dens (n = 6) during 2017 in the lowland boreal forest of north-central Alberta.

Den	Tree DBH* (cm)		Tree height (m)		Tree age (yrs)		Stem count†
F3_1_2016	32	49.1 ± 20.4	10	17.6 ± 4.7	10	116.9 ± 44.9	23 Sb, 8 Sw, 1 Lt
F3_2_2016	83	31.3 ± 10.5	10	14.5 ± 3.5	10	26.6 ± 0.7	19 Pb, 18 Aw, 15 Sw
F2_1_2017	113	23.4 ± 12.2	10	13.4 ± 3.1	10	70.5 ± 22.7	87 Sb, 19 Sw, 7 Lt
F2_2_2017	84	30.6 ± 15.9	10	16.0 ± 4.1	10	85.8 ± 28.7	51 Sb, 22 Sw, 10 Lt
F3_1_2017	70	42.8 ± 25.7	10	19.0 ± 6.1	10	121.9 ± 37.5	70 Sb
F3_2_2017	40	57.6 ± 25.5	10	24.2 ± 4.2	10	114.6 ± 18.3	40 Sb

*Diameter at breast height (DBH).
†Trees in plot >5 m tall. Species: Trembling Aspen (Aw; *Populus tremuloides* Michaux), Balsam Poplar (Pb; *Populus balsamifera* L.), Black Spruce (Sb; *Picea mariana* (Miller) Britton, Sterns & Poggenburgh), Tamarack (Lt; *Larix laricina* (Du Roi) K. Koch), and White Spruce (Sw; *Picea glauca* (Moench) Voss).

TABLE 3. General summary of Wolverine (*Gulo gulo*) dens found in the lowland boreal forest during 2016 and 2017 in north-central Alberta.

Den	Date occupied	Elevation (m)	Entrance aspect	Nearest road (km)	Nearest active wellsite (km)
F3_1_2016	mid Feb–9 Apr*	561	S	2.0	2.0
F3_2_2016	10 Apr–19 Apr	590	S	0.4	0.4
F3_3_2016	20 Apr–23 Apr	607	E	1.0	0.9
F3_4_2016	24 Apr–4 May	615	NW	1.0	0.9
F2_1_2017	22 Feb–13 Mar	673	N	12.0	10.4
F2_2_2017	14 Mar–26 Mar	687	SE	12.0	10.3
F2_3_2017	27 Mar–9 Apr†‡	—	—	—	—
F3_1_2017	mid-Feb–9 Apr*	544	W	10.0	10.9
F3_2_2017	10 Apr–23 Apr†	535	S	10.0	11.0

*F3 denning start date is approximate, as she was collared after kits were born in both instances.
†Collar failure or premature collar drop.
‡Unconfirmed den location.

January −14.0 ± 10.2°C (range −40.0 to 10.5°C), February −12.7 ± 10.1°C (range −40.0 to 19.2°C), and March −10.6 ± 10.8°C (range −38.8 to 14.4°C; Table 4). Mean monthly temperatures were similar between long-term data from nearby government stations (2005–2017) and monthly study station temperatures measured during winter 2016/2017 (Table 4).

CMC model grid points were 7–13 km from Wolverine den sites and indicated that snow depths are typically shallow in our study area (December–March, 21.66 ± 1.77 cm, range 19.74–25.03 cm, n = 10 stations; Brown and Brasnett 2010). Snow depths interpolated for points within the study area were slightly higher than mean monthly snow depth trends in the boreal forest of Alberta (February: 25.57 cm, March: 24.24 cm, n = 686 stations; Webb *et al.* 2016).

Spring snow coverage (Copeland *et al.* 2010) was limited (0.38%) and patchy (mean size 1.6 ± 2.68 km^2, n = 11 patches) in our study area. There were no instances of spring snow coverage predicted near Wolverine dens. Mean distance from dens to nearest spring snow coverage was 15.19 ± 2.73 km (n = 8). All patches of the spring snow coverage in the study area corresponded to lakes or large ponds that would be expected to retain at least some ice cover beyond when snow in the forest had melted.

We used trail cameras to document spring snow conditions for F3's primary and secondary dens in 2016. Her primary den was completely snow-covered on 30 March 2016 and 20 days later the snow had all melted. There was no snow cover surrounding the area of F3's secondary den on 19 April 2016. We visited the study area 25–27 April 2017 to retrieve dropped radio collars and observed patchy snow cover across the entire region, from the air (Figure 5) and on the ground. We used an Argo (New Hamburg, Ontario, Canada) to access the area of F2's primary den (2017) as she had not used this den for several weeks and patchy snow cover was encountered at the time. We did not locate F2's secondary den until November 2017 as we were not confident that she was finished using the den during our April visit. We flew over (Figure 5) and hiked within 1 km of F3's 2017 dens while retrieving her dropped radio collar and encountered sparse snow cover throughout the area.

Discussion

Wolverine pregnancy is largely dependent on body

TABLE 4. Mean temperature and snow depths (± SD) recorded at study weather stations (2017), government weather stations (2015–2017), and Canadian Meteorological Centre (CMC) locations (1998–2014) during December–May in north-central Alberta.

Weather station	December	January	February	March	April	May
Study stations						
Temperature (°C) n = 12	−14.4 ± 6.8	−14.0 ± 10.2	−12.7 ± 10.1	−10.6 ± 10.8	—	—
Snow depth (cm) n = 12	32.4 ± 12.6	37.6 ± 11.1	41.4 ± 14.7	34.0 ± 17.8	—	—
Government stations and CMC estimates						
Temperature (°C) n = 5	−15.8 ± 0.7	−18.1 ± 0.8	−13.9 ± 0.8	−7.5 ± 0.6	2.5 ± 0.2	8.7 ± 0.2
Snow depth (cm) n = 10	14.7 ± 1.2	21.3 ± 1.5	26.5 ± 2.1	24.2 ± 2.6	5.6 ± 1.2	0.2 ± 0.1

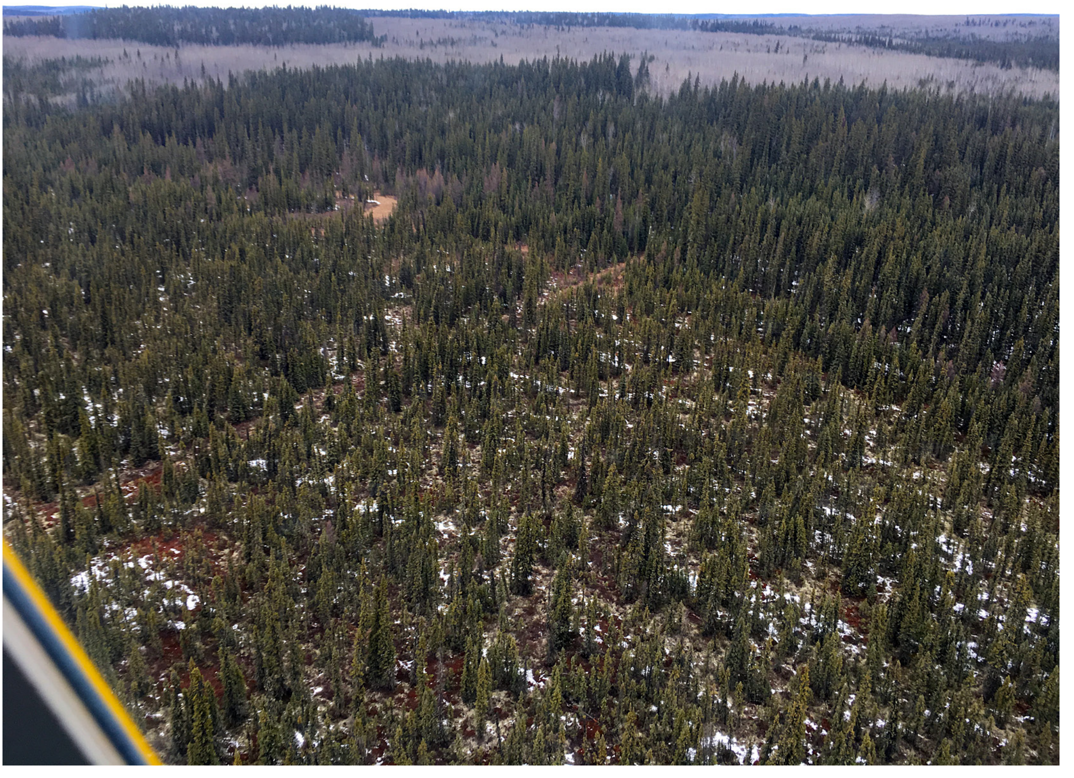

FIGURE 5. Snow cover near Wolverine (*Gulo gulo*) F3 primary den on 27 April 2017 in north-central Alberta. Photo: Michael Jokinen.

condition and winter food availability (Persson 2005), because of delayed implantation (Banci 1994). It has been hypothesized that dens that provide females and their offspring with secure shelter from disturbance (e.g., predation, weather, people), thermal insulation (Magoun and Copeland 1998), and access to adequate food resources (Inman *et al.* 2012) may be more likely to produce successful litters. Nearly all documented Wolverine dens in the world have been associated with deep snow (Magoun and Copeland 1998) and/or persistent spring snow cover (Copeland *et al.* 2010); however, Wolverines have not been studied equally across their range (Banci 1994), particularly in North America. We recognize that our sample size of denning females was small and that reproductive success was not measured for those females; however, our study detected a Wolverine denning strategy that is largely undescribed. We documented Wolverine dens in low elevation forests lacking boulders and deep or persistent spring snow, where a core, resident population has supported Wolverine harvests for over 30 years (Webb *et al.* 2016). Our results provide further evidence that Wolverines are adapted to exploiting cold, low productivity environments, but females appear to be selecting denning habitat that differs from what we hypothesized and what has been reported elsewhere.

In addition to shallow snow cover, our study area had other unique differences from other Wolverine studies. Ungulates can be important in the diet of female Wolverines (Banci 1994; Inman *et al.* 2012), yet ungulates were in low abundance in our study area and in much of the boreal forest, where smaller prey including American Beaver, Snowshoe Hare, and grouse are more common. Female Wolverine in northern British Columbia were positively associated with rugged terrain in alpine environments, where Hoary Marmot (*Marmota caligata*) and Columbian Ground Squirrels (*Urocitellus columbianus*) were common (Krebs *et al.* 2007). Although the Omineca region of British Columbia is at similar latitude, our study area does not support this prey or terrain selection. Not unlike the difference between northern mountain and boreal ecotypes of Woodland Caribou (Wood and Terry 1999; ASRD & ACA 2010), Wolverines in our study area must meet their needs in a very different environment. Although we lacked data on winter food availability, we documented one female that denned in two consecutive years, with three kits confirmed to be alive at ~4–6 weeks of age in the first year. Snowshoe Hare and Canada Lynx sign was common during our study. Based on Canada Lynx harvests, Snowshoe Hare cycle peaks in Alberta have occurred around 1980, 1990, 2000, and 2010 (Webb *et al.* 2013). Snowshoe Hare numbers were increasing during our study (N. Kimmy pers. comm. 30 January 2019). The habitat within our study area was highly mosaic, likely a result of frequent fires and abundant wetlands. Female Wolverines may rely on hunting small prey, such as Snowshoe Hare (Banci 1994; Scrafford and Boyce 2015), and this varied landscape may provide hares the forage, concealment, and thermal cover to persist in relatively good numbers throughout the various habitat types (Hodges 2000; Gigliotti *et al.* 2018). Krebs *et al.* (2018) state that the Snowshoe Hare is one of the few prey species available to predators during the winter in the boreal forest. All avian and mammalian predators in the boreal forest eat Snowshoe Hare (Krebs *et al.* 2018). Wolverine and Canada Lynx harvest data have shown that a pattern may exist between Wolverine harvest and the Snowshoe Hare cycle (Webb *et al.* 2013; Boonstra *et al.* 2018). By denning within mature conifer, female Wolverines in the boreal forest may have access to a prey source in close proximity.

Inman *et al.* (2012) suggest there may be a connection between food storage, persistent spring snow cover, and Wolverine denning requirements. If deep snow may provide an opportunity for food caching in other settings, it begs the question: How are Wolverines meeting this need in a landscape where snow is far less abundant? We do not have the data required to answer this question, but local knowledge may have provided a hypothesis worth testing with future studies. On three independent occasions, trappers in our study area observed a Wolverine having depredated a harvested Canada Lynx from a trap, bringing it into an adjacent peatland area, and caching it. In each case, the trapper reported seeing that the Wolverine had dug through the snow and down into the organic peat layer, then buried the carcass up to 45 cm below the surface with a mixture of snow, moss, and other vegetation. In one case, the trapper reported that the Wolverine had urinated on top of the location before leaving; another reported finding it very challenging to dig into the cache as the infill had frozen solid. Scrafford and Boyce (2015) also documented Wolverines caching in bogs in northern Alberta. We observed instances where it appeared that a wolverine had returned to a peatland cache and excavated and fed on food remnants (M.E.J. unpubl. data). Burying foods into bogs may help preserve excess food for later use (Verhoeven and Liefveld 1997; Moldowan and Kitching 2016) or hinder competitors from locating it. Future research into boreal Wolverine ecology should seek to test this hypothesis.

Wolverine dens have been documented under wind-drifted snow, large boulders, and trees in areas with deep snow (Magoun and Copeland 1998; Krebs and Lewis 2000; Copeland *et al.* 2010; May *et al.* 2012; Makkonen 2015; Magoun *et al.* 2017), but these features are lacking in the boreal forests of northern Alberta. Instead, most dens in our study (n = 7) were under partially uplifted root masses of leaning or fallen trees in older spruce forests, while one den was under decayed logging debris in an ~30 year old regenerating deciduous forest. We realize that our sample size of two denning females and their choice of denning structure could be a result of individual preference. However, Scrafford and Boyce (2015) also found Wolverines denning in an uplifted root mass and timber slash pile near Rainbow Lake in northwestern Alberta. Approximately 42% of our study area is comprised of various wetland forms, including a majority made up by peatlands, with a mean elevation of 600 m. Makkonen (2015) notes that no dens were found in peat bogs, despite their abundance on the boreal landscape in Sweden, but Wolverines had access to and used large boulders at higher elevations for denning. Pulliainen (1968) found that half of the Wolverine dens in the boreal forest of Finland were associated with standing or fallen spruce trees; however, the dens and tunnels were established under the length of a fallen tree and were always under deep snow cover (>1 m). In contrast, maximum snow depth in our study rarely exceeded half a metre and was meaningfully absent for the final third of the denning season.

American Black Bears use a variety of den structures across their range, but adequate thermal cover is critical for successful reproduction in northern climates. The most common black bear den was under the roots or stumps of standing or partially blown down trees in the boreal forest of Ontario (Kolenosky and Strathearn 1987), Manitoba (Klenner 1982), and Alberta (Tietje and Ruff 1980), and the den chamber was similar in size to what we measured inside Wolverine dens (~1 m^3). Contrary to black bear dens, however, the Wolverine dens we investigated were not deliberately lined with other materials (e.g., grass, moss, leaves, twigs; Klenner 1982). Instead, most of the Wolverine dens had cone bracts inside that had been discarded by feeding Red Squirrels. Squirrel middens have also been associated with marten den sites (Ruggiero *et al.* 1998) and Western Toad (*Anaxyrus boreas)* hibernation sites (Browne and Paszkowski 2010), where it has been suggested that they may provide some thermal benefit. Marten will utilize root masses of fallen trees for winter rest sites (Gilbert *et al.* 1997) and den sites can occur underground (Bull and Heater 2000). Browne and Paszkowski (2010) note that Western Toad hibernation sites in north-central Alberta were also located within peat hummocks and decayed root channels.

Mosses are the prevalent ground cover in the wetland environments of the boreal forest. Instead of deep snow (>1 m) providing thermal protection (Magoun and Copeland 1998), it is possible that the thick moss layer insulates Wolverine dens from cold temperatures and excess moisture. Snow accumulation in our study area averages only 30–40 cm, but when combined with the thick, mossy root layer, these den structures may provide adequate thermal insulation. Moss was traditionally used by Laplanders and other circumpolar people for bedding and insulation in both dwellings and clothing (Kimmerer 2003). Various species of moss have been shown to have thermal properties that insulate and limit the fluctuation of soil temperature and moisture (Soudzilovskaia *et al.* 2013). Marchand (2014) suggests that under 40–50 cm of snow, air temperature fluctuations have little influence on subnivean conditions. We suspect that typical late winter snow depth in our study area, in combination with the layer of moss, may also approximate those conditions.

The ecosites in which our dens were located are naturally wet and are rated as having high excess moisture (Beckingham and Archibald 1996). Even though these ecosites have elevated water tables near the ground surface, the den cavities are shallow and not far below the mossy forest floor. Because snow cover is relatively light and the den floor close to ground level, the probability of the den flooding during spring melt would be low.

Wind-throw hazard (i.e., potential for trees to become partially or completely uprooted) is rated as medium-high/high for the ecosites where dens were found in our study area (Beckingham and Archibald 1996). The potential for ready-to-move-in den structures in this forest type is therefore greater. The lateral roots and soil lining create a barrier, although the walls are relatively thin (~15–30 cm) and appear fragile even when snow-covered. The root mass walls provide limited protective shielding from potential danger, so females may be more susceptible to disturbance. However, this did not seem to result in them moving denning sites more frequently, as other studies documented similar number of dens per female as we did (Magoun and Copeland 1998). The proximity of a den structure to potential human disturbance is likely important (Banci 1994). Our study area was remote and most dens were located far from roads and trails, where encounters with people would be rare. In addition to potential direct disturbance at the den, Scrafford *et al.* (2018) suggested that roads may negatively influence Wolverines by altering both habitat use and movement rates through habitat near roads. However, the density of roads near den sites in our study was an order of magnitude less than that of Wolverine home ranges in their study, suggesting that these females may be less impacted by roads. In addition, ungulates were not abundant in our study area, so wolf numbers were not high. This may lessen the need to have a secure den structure as would be provided by a snow cave or large boulders.

Forest companies seeking to provide long term Wolverine denning habitat within low elevation boreal forests have been operating with a paucity of information, trying to determine how to apply what is known about dens from a mountain environment to one largely devoid of boulders and a deep, persistent snow pack. Although our observations are limited, these females, and those of the Scrafford and Boyce (2015) study, provide a glimpse into the unique denning ecology of boreal Wolverines. Until more detailed information can be obtained, forest companies should retain mature representative samples of high-wind-throw-risk ecosites within their planning area. In some cases, forest harvesting may have the potential to create future suitable denning habitat when structure is left behind (e.g., brush piles, log landings). Although the availability of partially wind thrown trees may not be limiting on the boreal landscape, their suitability for den sites may be influenced by the degree of disturbance in the surrounding area.

In the absence of deep snowpack, Wolverines in our study area have found a way to persist in the lowland boreal forest. Our small sample size limits our ability to draw robust conclusions. As such, our observations and speculation about potential ecological processes should be viewed as the basis for hypotheses that can be tested with further study. In a landscape lacking deep snowpack and large boulders, we speculate that Wolverines are able to meet their needs through locally available features such as the cavity created by a partially uplifted root mass, the thermal properties of thick moss, and the caching opportunities provided by deep peat accumulations. Wolverines are resourceful and may be more flexible in their denning requirements than documented by studies in other landscapes.

Author Contributions

Writing — Original Draft: M.J., S.W., and R.A.; Writing — Review & Editing: M.J., S.W., and R.A.; Conceptualization: M.J., S.W., D.M., and R.A.; Investigation: M.J., S.W., and R.A.; Methodology: M.J.,

S.W., and R.A.; Formal Analysis: M.J., S.W., and R.A.; Funding Acquisition: R.A., D.M., and S.W.

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Note

Wolf (*Canis* sp.) attacks life-like deer decoy: insight into how wolves hunt deer?

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Abstract
We know of no documented observations of wolves (*Canis* sp.) detecting and then attacking a White-tailed Deer (*Odocoileus virginianus*) during spring, summer, or fall. We describe an observation of a wolf attacking a life-like, two-dimensional deer decoy in November 2017 near Killarney Provincial Park, Ontario, Canada. The wolf appeared to locate the decoy by sight rather than sound or scent, suggesting that the profile of a deer is sufficient to trigger an attack by a wolf.

Key words: Wolf; *Canis*; carnivore; hunting behaviour; predation; predator-prey; White-tailed Deer; *Odocoileus virginianus*; Killarney Provincial Park

White-tailed Deer (*Odocoileus virginianus*) are the primary prey of wolves (*Canis* sp.) throughout much of the southern boreal ecosystem in North America (Potvin *et al*. 1988; Benson *et al*. 2017; Gable *et al*. 2018). How and where wolves hunt and kill deer during winter is well understood because of the ease of observing wolf-hunting behaviour and locating kill sites from the air (Mech and Frenzel 1971; Fuller 1989; Mech *et al*. 2015). However, equivalent information for the snow-free months is rare, as wolves and deer primarily co-occur in densely forested areas (Demma *et al*. 2007). For example, there are no estimates of wolf kill rates of White-tailed Deer (adults or fawns) during spring to fall, and little information exists about where and how wolves successfully hunt and kill deer during this period (Demma *et al*. 2007; Mech *et al*. 2015). In a comprehensive review of wolf–deer interactions, Mech *et al*. (2015) provided descriptions of eight such interactions during the snow-free season. However, all of these observations occurred after the wolf or wolves had already detected and attempted to chase deer. To our knowledge, there are no observations that demonstrate how wolves find deer during spring to fall. Herein, we document a wolf (*Canis* sp. according to Rutledge *et al*. 2016) attacking a life-like deer decoy that provides rare insight into how wolves locate and detect deer during this period.

During the first week of November, D.P.G. was hunting White-tailed Deer on McGregor Island (46°04′49″N, 81°35′18″W), about 2 km west of Killarney Provincial Park, Ontario, Canada. Before hunting, D.P.G. set-up a life-like, two-dimensional decoy of a squatting doe ("Estrous Betty", Montana Decoys, Hummelstown, Pennsylvania, USA). The decoy consisted of a life-size photograph of a deer with an internal wire frame, ~1.3 cm thick, for support (Figure 1). The decoy was oriented in an east–west direction so that profile views of the decoy could be seen from the north or south (Figure 2). D.P.G. also left doe urine (details on manufacturer not available) on a branch 1.5 m off the ground 1 m north of the decoy.

At about 1515, after setting up the decoy and dispensing the doe urine, D.P.G. situated himself in a tree stand on a rocky point 23 m west of the decoy. The stand faced east and overlooked a 100-m wide valley dominated by mature Sugar Maple (*Acer saccharum* Marshall) forest between two steep rock ridges (north and south of the stand; Figure 2). On both sides of the valley at the base of the ridges were prominent deer trails running east to west. Immediately to the west of the tree stand was a dense Balsam Fir (*Abies balsamea* (L.) Miller) lowland. About 50 m north of the northern ridge was a 0.5–1.0 km wide channel of

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Figure 1. Life-like decoy of a White-tailed Deer (*Odocoileus virginianus*) that was attacked by a wolf (*Canis* sp.) 2 km west of Killarney Provincial Park, Ontario, Canada, during the first week of November 2017. Photo: Daniel Gable.

water; this channel surrounds McGregor Island. The maple forest that the stand overlooked had minimal understorey for about 150 m before transitioning to marshy lowland, which abutted a small shallow cove that was connected to the main water channel. D.P.G. accessed the stand by parking his boat at the northwestern opening of this cove (~300 m east by northeast of the stand). There was no snow cover during this period.

The sky was overcast with moderate (8–16 km/h) winds blowing from the west/southwest. At 1600, D.P.G. noticed a wolf about 150 m east by southeast of the stand trotting along the deer trail on the southern edge of the valley (Figure 2). Given the position of the decoy and the structure and arrangement of the trees, the wolf would have been unable to see the decoy when D.P.G. first spotted the wolf. We later verified this by walking to the wolf's location. The wolf continued at the same pace, moving east to west, until it was about 70 m southeast of the decoy (Figure 2). Without stopping, the wolf turned abruptly and started travelling directly toward the decoy. As the wolf approached, it appeared to be intently focussed on the decoy; however, it maintained a trotting pace for another 30 m. When about 40 m from the decoy, the wolf suddenly sprinted toward the decoy and, when only a few metres away, lunged at it, latching onto its neck, leaving punctures in the fabric of the decoy. The force of the contact ripped the decoy from the ground and caused the wolf and decoy to tumble for about 10 m (total time 2–3 s). After the wolf had stopped its fall, it promptly stood up and jumped back about 10 m. It stood looking at the decoy for a few seconds with both ears and tail lowered. Within a few more seconds, the wolf ran quickly over the steep ridge to the south and disappeared from view.

We know of no other observation of a wolf travelling, detecting, and then attacking a deer or deer facsimile during the snow-free season. Although the decoy was not an actual deer, it looked exactly like a deer (Figure 1) and behaved (stood still staring at the wolf) as deer do when approached by predators (DeYoung and Miller 2011; Mech *et al*. 2015). Given this and the observed changes in the wolf's behaviour after it appeared to detect the deer, we believe that the wolf was convinced the decoy was a deer. As a result, we assert that the wolf's behaviour on detecting and approaching the decoy provides insight into how this

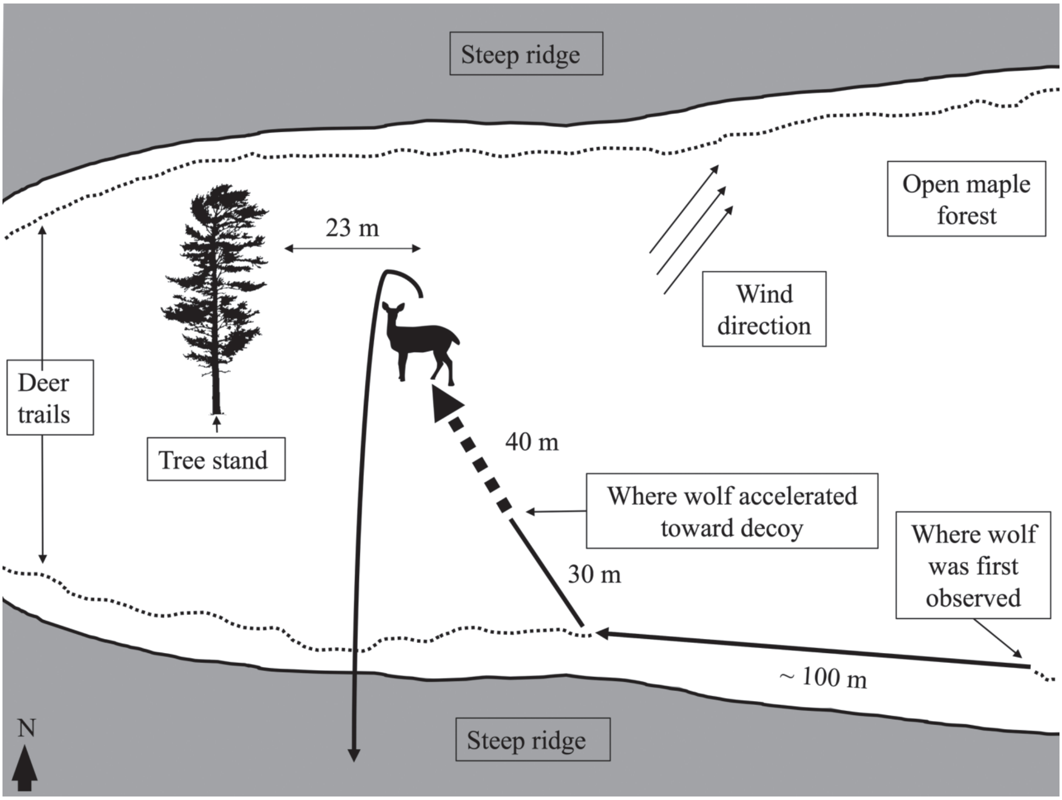

FIGURE 2. Route taken by a wolf (*Canis* sp.) that detected and then attacked a life-like decoy of a White-tailed Deer (*Odocoileus virginianus*) near Killarney Provincial Park, Ontario, Canada, in early November 2017.

wolf, and likely other wolves, may locate deer.

The wind direction and consistent wind flow would have made the doe urine difficult, and likely impossible (Conover 2007), for the wolf to detect during its approach, which strongly suggests that the wolf located the decoy visually. Wolves are thought to be adept at visually detecting slight movements, which likely helps in locating prey (Harrington and Asa 2003), but our observation suggests that wolves are capable of detecting motionless prey from considerable distances. We estimate that the wolf detected the decoy about 70 m away, although detection was likely aided by the minimal understorey and daylight conditions.

Although wolves likely rely on scent to locate deer when hunting (Mech *et al*. 2015), it appears they can also use visual detection, even if not associated with odour, sound, or any other cues. Dense vegetation throughout most of wolf–deer range likely limits visual detection of deer during the summer. However, events that reduce forest or understorey cover (e.g., forest fires, clear-cuts) could enhance the ability of wolves to detect deer and increase encounter rates between wolves and deer (Whittington *et al*. 2011) and possibly wolf kill rates (Sand *et al*. 2005; Vander Vennen *et al*. 2016).

Mech *et al*. (2015: 26) noted that "when wolves detect deer, they usually proceed slowly and deliberately, ever on the alert". However, this wolf approached relatively rapidly after detecting the decoy, closing a ~70 m distance in a matter of seconds. Once 30 m away from the decoy, the wolf apparently decided that the deer (i.e., the decoy) was indeed vulnerable, possibly because it did not move, and sprinted toward it. Wolves generally assess the vulnerability of deer by approaching, chasing, and testing them. Most deer are not vulnerable to predation because they are in sufficiently good physical condition to easily out-run and evade wolves; therefore, most hunting attempts are short lived as wolves realize their efforts are futile (Mech *et al*. 2015).

Our observation provides the only information we are aware of about how at least one wolf approached and attacked what it thought was an adult White-tailed Deer during the snow-free season. Thus, whether the observation is the exception or represents normal behaviour is unknown. Still, it does provide new insight into the predatory behaviour of wolves.

The lack of information on wolf predation of deer—both fawns and adults—during the snow-free season is surprising given the amount of research on wolves, deer, and their interactions. Because of this, we recommend intensive research on wolf–deer interactions during summer as has been done recently with caribou (*Rangifer tarandus;* e.g., Whittington *et al*. 2011; Latham *et al*. 2013; Mumma *et al*. 2017). Indeed, as the range of White-tailed Deer continues to expand northward (Dawe and Boutin 2016), thereby increasing the area that wolves and deer co-occur, such information will only become more valuable and relevant for the conservation and management of both species (Latham *et al*. 2011).

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Birds of Mansel Island, northern Hudson Bay

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Abstract
A recent review of bird distributions in Nunavut demonstrated that Mansel Island, in northeastern Hudson Bay, is one of the least known areas in the territory. Here, current information on the birds of Mansel Island is summarized. A list published in 1932 included 24 species. Subsequent visits by ornithologists since 1980 have added a further 17 species to the island's avifauna. The list includes 17 species for which breeding has been confirmed and 10 for which breeding is considered probable. The island seems to support particularly large populations of King Eiders (*Somateria spectabilis*) and Tundra Swans (*Cygnus columbianus*) and the most southerly breeding population of Sabine's Gull (*Xema sabini*) and Red Knot (*Calidiris canuta*; probably).

Key words: Mansel Island; Hudson Bay; birds; breeding

Introduction
At 3180 km^2, Mansel Island, Qikiqtaaluk Region, Nunavut, is the 28th largest island in Canada. It is one of three large islands in northern Hudson Bay, the others being Southampton and Coats Islands. Although the birds of Coats and Southampton Islands have been documented (Sutton 1932a; Gaston and Ouellet 1997), those of Mansel Island are comparatively poorly known. Only one publication provides information on the avifauna of the island: a list prepared by G.M. Sutton (1932b) based on specimens provided to him by A.T. Swaffield, the Hudson Bay manager who established the trading post at Swaffield Harbour, near the northern tip of the island, in 1929.

At its nearest point, Mansel Island is 56 km from the mainland of Quebec (Figure 1). The topography is mostly low elevation (maximum 138 m), without any prominent hills or gullies except for a shallow central valley running east–west across the island. Underlying bedrock throughout is Silurian limestone, which is covered, over large parts of the island, by raised beach deposits of Holocene age. There are extensive wetlands throughout, especially in the southwest portion of the island. Sutton (1932b: 41) commented: "an exceedingly flat, dull-gray piece of land". Dry areas support low-growing shrubs, including willow (*Salix* spp.), cranberry (*Vaccinium* spp.), and Four-angled Mountain Heather (*Cassiope tetragona* (L.) D. Don), as well as the tussock forbs, Entire-leaved Mountain Avens (*Dryas integrifolia* Vahl) and Purple Mountain Saxifrage (*Saxifraga oppositifolia* L.). Marshes support extensive sedge (*Carex* spp.) meadows.

The Hudson Bay post on the island closed in 1945, and there has been no permanent habitation on the island since then, although people from the nearby Inuit community of Ivujivik, Nunavik, sometimes visit in summer to hunt Caribou (*Rangifer tarandus*) and Polar Bear (*Ursus maritimus*; Gaston *et al.* 1985).

Sutton's list comprised 24 species, but only 17 of them were collected in summer and, hence, potential breeders, and no evidence of breeding was included (Sutton 1932b). Species were collected at various dates between September 1929 and June 1930. Sutton commented on their likely breeding status, but there was no definite evidence available to support his suggestions. Subsequent ground surveys, all of only one or two days' duration, have added another 17 species to the island's list, and breeding has been confirmed for some. Although this information is based on very brief visits, it is assembled here to give an up-to-date summary of what little is known about the avifauna of Mansel Island.

Methods
Subsequent to Swaffield's collection, three ground surveys have been carried out by ornithologists. In July 1984, R. Decker visited the island for one day by helicopter, landing at several sites. Information

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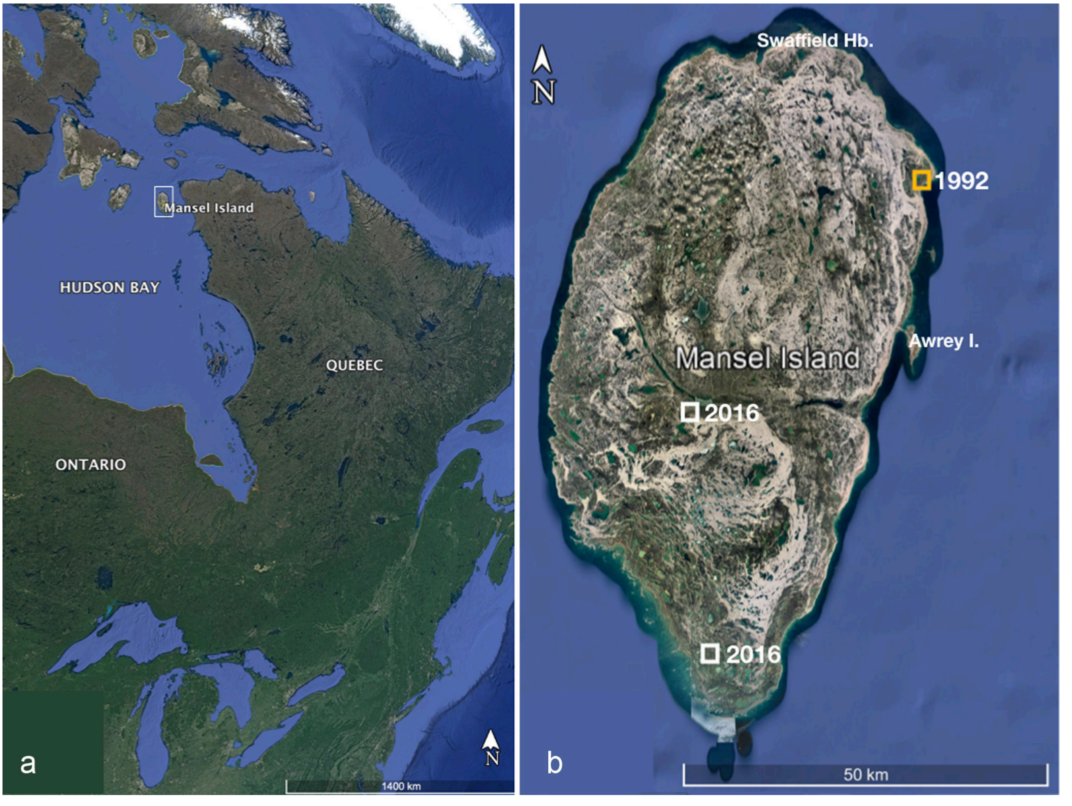

FIGURE 1. a. Location of Mansel Island in Hudson Bay. b. Localities visited in 1992 and 2016. Source: Mansel Island, Nunavut, 61°59′23.31″N, 79°56′12.54″W. Google Earth Pro 7.3.2.5776. Imagery date: 13 December 2015. Data provider: Landsat/Copernicus 2018. Accessed: 30 July 2018.

from his survey was incorporated into the Land Use Information Series map of Mansel Island (Environment Canada 1970), which includes a list of "avian species which occur or are thought likely to occur within this map-area", but I have only included species definitely sighted on the island during the survey. On 8 and 9 August 1992, A.J.G., V. Johnston, and I. Storm landed from the *M.V. Teregluk* near the easternmost point of the island and spent 10 h ashore surveying an area of lakes, ponds, and marshes adjacent to a shallow bay (Figure 1).

On 20 and 21 June 2016, Y. Aubry, M. Robert, F. Shaffer, and C. Marcotte carried out systematic surveys of breeding birds in two areas (Figure 1), using the protocol of the Program for International and Regional Shorebird Monitoring (PRISM; Bart and Johnston 2012). In addition to total bird counts, species presence or absence was recorded by 1-ha squares. They also touched down at several other sites to make additional observations.

In addition, on 12 July 1984, an aerial survey (Cessna 337) was carried out by R. Decker along the entire coastline and over selected parts of the interior. I did not have access to the original data, but some information from this survey was incorporated into a general survey of larger birds in Foxe Basin and northern Hudson Bay (Gaston *et al.* 1986).

Results and Discussion

Combining the species listed by Sutton (1932b) with subsequent surveys yields 41 species reported from Mansel Island to date, of which definite evidence of breeding, in the form of nests or flightless young, has been obtained for 17 species. A further 10 species were considered by at least one survey to be "probably breeding" (Table 1). Major concentrations of Arctic Terns (*Sterna paradisaea*) and Common Eiders (*Somateria mollissima*) were noted on the aerial surveys of 1984, with an estimated 1000 pairs of Common Eiders on Awrey Island and several colonies of 50–75 pairs of Arctic Terns on the east and southwest coasts (Gaston *et al.* 1986).

Because of the timing of surveys, breeding could be confirmed for fewer than half of the species recorded during the breeding season. The 1992 survey

TABLE 1. Bird observations and breeding status* at Mansel Island based on four data sets. At-sea records are included where the birds might have been visible from the island.

Species	Sutton 1932b (season)	Decker 1984 (status)	Sightings 1992		PRISM 2016			Surveys recorded	Combined status†
			No. seen	Status	No. squares present	No. seen	Status		
Snow Goose (*Anser caerulescens*)	Fall		250	?	2	3	PR	2	PR
Cackling Goose (*Branta hutchinsoni*)	Summer	B	2	PR	2	3	B	4	B
Canada Goose (*Branta canadensis*)			100	PO	11	27	B	2	B
Brant (*Branta bernicla*)	Summer	B						2	B
Tundra Swan (*Cygnus columbianus*)	Summer	B	2	PR	3	7	B	4	B
Northern Pintail (*Anas penelope*)		B			7	12	PR	2	B
Red-breasted Merganser (*Mergus serrator*)		PR						1	PR
Common Eider (*Somateria mollissima*)	Summer	B	5	PO				2	B
King Eider (*Somateria spectabilis*)	Summer	PR	47	B	10	25	PR	4	B
Long-tailed Duck (*Clangula hyemalis*)	Summer	PR	20	PR	6	10	PR	4	PR
Northern Fulmar (*Fulmarus glacialis*)			2	at sea				1	
Willow Ptarmigan (*Lagopus lagopus*)					5	9	PR	1	PR
Red-throated Loon (*Gavia stellata*)	Summer	B	4	PR	3	7	PR	4	B
Pacific Loon (*Gavia pacifica*)		B	15	B	3	4	PR	3	B
Common Loon (*Gavia immer*)		PR						1	PR
Black-bellied Plover (*Pluvialis squatarola*)	Summer		5	PR	5	8	PR	3	PR
American Golden-plover (*Pluvialis dominica*)	Summer		12	PR	5	12	PR	3	PR
Semipalmated Plover (*Charadrius semipalmatus*)					1	1	PO	1	PO
Whimbrel (*Numenius phaeopus*)	Fall							1	
Red Knot (*Calidris canuta*)	Summer							1	PR‡
Semipalmated Sandpiper (*Calidris pusilla*)			20	PR	4	12	B	2	B
Purple Sandpiper (*Calidris maritima*)	Summer				1	1	PO	2	
White-rumped Sandpiper (*Calidris fuscicollis*)	Summer							1	
Dunlin (*Calidris alpina*)			6	PO	5	8	B	2	B
Ruddy Turnstone (*Arenaria interpres*)	Summer							1	B§
Red-necked Phalarope (*Phalaropus lobatus*)					2	3	PR	1	PR
Red Phalarope (*Phalaropus fulicarius*)	Summer		4	PO	1	2	PO	3	PO
Sabine's Gull (*Xema sabini*)	Summer	B	10	PR	2	4	PR	4	B
Ivory Gull (*Pagophila eburnea*)	Winter							1	
Glaucous Gull (*Larus hyperboreus*)		B						1	B
Herring Gull (*Larus smithsonianus*)	Fall	B	30	B	9	15	PR	4	B
Arctic Tern (*Sterna paradisaea*)		B	50	PR	5	5	PR	3	B
Parasitic Jaeger (*Stercorarius parasiticus*)	Fall		2	PR	3	5	PR	3	PR
Long-tailed Jaeger (*Stercorarius longicaudus*)					1	1	PO	1	PO
Thick-billed Murre (*Uria lomvia*)	Fall		4	at sea				1	

TABLE 1. *Continued.*

Species	Sutton 1932b (season)	Decker 1984 (status)	Sightings 1992		PRISM 2016			Surveys recorded	Combined status†
			No. seen	Status	No. squares present	No. seen	Status		
Black Guillemot (*Cepphus grylle*)	Fall	B						2	B
Horned Lark (*Eremophila alpestris*)			2	B	4	8	PO	2	B
Snowy Owl (*Nyctea scandiaca*)	Summer							1	
Barn Swallow (*Hirundo rustica*)	Summer							1	
Lapland Longspur (*Calcarius lapponicus*)			5	PR	4	12	PR	2	PR
Snow Bunting (*Plectrophenax nivalis*)					1	1	PO	1	PO
Total (breeding)	24	17 (13)	597	(15)	26	205	(20)		B (17), PR (10)

*B = definite evidence of breeding, PR = probable breeding, PO = possible breeding.
†Combined breeding evidence from all surveys to give likeliest status.
‡A satellite-tracked Red Knot was recorded in summer on Mansel Island by Lathrop *et al.* (2018).
§A geolocator-tracked Ruddy Turnstone spent the summers of 2014 and 2015 on Mansel Island and showed evidence of incubation in 2015 (R. Porter pers. comm. August 2018).

was conducted after most shorebirds would have completed breeding, and breeding could not be confirmed in that season for any shorebird species. Those species for which breeding could be confirmed were those that have longer breeding periods. Conversely, surveys in 2016 found the island partly covered in snow, which presumably delayed breeding for many species, making the surveys earlier than ideal. Breeding could be confirmed for only five species, although it was considered probable for another 15 species. Among species for which breeding was confirmed, Canada and Cackling Geese (*Branta canadensis*, *Branta hutchinsoni*), Northern Pintail (*Anas penelope*), and Dunlin (*Calidris alpinus*) are not shown as breeding on Mansel Island by Richards and Gaston (2018).

Only seven species were reported by all four surveys: Cackling Goose, Tundra Swan (*Cygnus columbianus*), King Eider (*Somateria spectabilis*), Long-tailed Duck (*Clangula hyemalis*), Red-throated Loon (*Gavia stellata*), Sabine's Gull (*Xema sabini*), and Herring Gull (*Larus argentatus*). Black-bellied Plover (*Pluvialis squatarola*), American Golden-plover (*Pluvialis dominica*), and Arctic Tern were recorded on all three post-1930 surveys. According to the 2016 survey, the most widespread species (seen in nine or more survey squares) were Canada Goose, King Eider, and Herring Gull. In 1992, 38 pre-flying King Eider ducklings were seen in four separate creches, along with nine adults and the species was the second most widespread on the 2016 survey. These observations suggest that Mansel Island may be an important breeding area for this species. Likewise, Tundra Swan, as well as being seen on all surveys, was the most widespread species reported on the aerial survey in 1984. Mansel Island appears to support a significant population of this species.

Overall, the avifauna of Mansel Island is very similar to that of the better-known Coats Island, immediately to the west (Gaston and Ouellet 1997). Like Coats, it supports Caribou but apparently not lemmings (*Dicrostonyx* and *Lemmus* spp.; Gaston *et al.* 2012). The absence of the latter probably determines the lack of specialist lemming predators, such as Snowy Owl (*Nyctea scandiaca*) and Long-tailed Jaeger (*Stercorarius longicaudus*). The very flat topography, lacking cliffs, may determine the absence of Peregrine Falcon (*Falco peregrinus*) and Common Raven (*Corvus corax*) and the relative paucity of Snow Bunting (*Plectrophenax nivalis*), all common on adjacent parts of mainland Quebec (Gaston *et al.* 1985). However, the breeding of Sabine's Gull and the probable breeding of Red Knot (*Calidris canutus*) on Mansel Island represent the most southeasterly extension of these species' known ranges in Canada (Richards and Gaston 2018).

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Note

Behaviour of a porcupine (*Erethizon dorsatum*) swimming across a small boreal stream

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Abstract

The swimming behaviour of North American Porcupine (*Erethizon dorsatum*) is largely unrecorded, even though much of its habitat is bisected by innumerable rivers and streams. Moreover, the literature is inconsistent regarding how readily porcupines take to the water and how well adapted they are for swimming. I observed a porcupine swimming across a relatively placid and shallow braid in the Klondike River (Yukon, Canada), after it had aborted three apparent attempts to swim at a relatively fast-flowing, deep channel upstream. This observation provides evidence of porcupine swimming across moving water and suggests that they may be reluctant to do so and selective of where they cross rivers and streams.

Key words: Behaviour; *Erethizon dorsatum*; North American Porcupine; swimming

Observations of North American Porcupine (*Erethizon dorsatum*) swimming are rare in the literature, suggesting that it may be uncommon behaviour. Yet, much of their range is within the boreal forest (Woods 1973; Roze and Ilse 2003), which is interspersed and divided by numerous water bodies. The few observations reported involve swimming in ponds and lakes (Dean 1950; Woods 1973; Roze 2009), with no observations of them crossing rivers or streams. An unusual observation of a Bull Trout (*Salvelinus confluentus*) embedded with porcupine quills provided circumstantial evidence of a porcupine swimming in moving water (Cott and Mochnacz 2007).

The willingness of porcupines to swim is unclear, particularly across rivers and streams. Some authorities suggest that porcupines are not averse to swimming (Roze and Ilse 2003; Roze 2009), and that swimming is an important means for them to access seasonal food resources. For instance, there are observations of porcupines feeding on water lilies (Nymphaeaceae) in shallow ponds and swimming to retrieve food items that they then bring to shore to consume (Dean 1950; Roze and Isle 2003). Moreover, their quills may also be adapted, in part, to help them swim; specifically, Roze and Ilse (2003: 376) surmised that "their watertight, sponge-filled interiors aid in floatation, enhancing the porcupine's swimming capabilities". Alternatively, Woods (1973: 4) opined that "they do not like to swim", although he conceded that they have been observed crossing small water bodies. In an early "experiment", Murie (1926: 112) noted:

> One day I tried to make a porcupine swim across a narrow stream. I shoved it toward the water with a stick and intercepted it whichever way it turned. Nothing could induce it to swim, although I almost shoved it bodily into the water. It came straight toward me, rather than cross the stream, and I finally gave up the attempt.

Here, I provide an observation of a porcupine swimming across a small boreal stream and note its apparent indecision in doing so.

While angling on a braid of the Klondike River, ~15 km east of Dawson City, Yukon, Canada (64.059°N, 139.433°W), I observed a porcupine approaching and, eventually, swimming across the river. At approximately 1705 Pacific Daylight Time, on 6 July 2018, an apparently full-grown porcupine emerged from tall shrubs on the far side of the stream. I did not know its age or sex. The porcupine came to the shore (point A in Figure 1) and, after about 15 s of apparently sniffing toward the far shore, it stepped about 30 cm into the stream, immersing its front

FIGURE 1. Photograph of the site where a North American Porcupine (*Erethizon dorsatum*) swam across a braid in the Klondike River, Yukon, Canada. At sites A, B, and C, the porcupine stepped into the stream but did not cross it; the dashed line (D) indicates where it swam across the stream. Photo: T.S. Jung.

legs. However, rather than swim across the stream, it backed out of the water and sniffed across the stream again. It immediately moved about 6 m downstream and repeated the same actions at point B (Figure 1). The porcupine moved another 15 m downstream along the shore to point C (Figure 1) and again entered the stream, this time without apparently sniffing the far shore, and it waded deeper until its belly and both legs were under water; however, it again returned to the shore within approximately 30 s. The porcupine then moved into the shrubs and was not seen for about 5 minutes. I then observed it ~35 m downstream of point C, at point D (Figure 1), where it entered the water and swam across the stream, after standing in the stream with both legs and its belly under the water for about 1 minute. The porcupine reached the far shore after swimming for about 2 minutes, and then entered the forest on the other bank and was no longer observed.

I do not know why the porcupine crossed the stream. It was on a small island in the Klondike River that was largely covered with willow (*Salix* spp.) and alder (*Alnus* spp.), whereas, the other side of the stream was covered by mature boreal forest, dominated by Balsam Poplar (*Populus balsamifera* L.) and White Spruce (*Picea glauca* [Moench] Voss) trees. It may have been attracted to something not available on the island at that time.

Points A–C, where the porcupine entered the stream but did not cross it, were in the section of the stream with the swiftest water and a relatively deep channel (~1.2 m deep). In contrast, point D (Figure 1), where the porcupine entered and crossed the stream, was immediately downstream of the riffle, and the water there was more placid and only about 0.5 m deep. However, the stream here was about 30 m wide, compared to about 8 m wide at the riffle (points A–C). It appeared that the porcupine was hesitant to enter the stream and cross the riffle and selected a location to cross where the stream was comparatively slow flowing. This observation suggests that porcupines may not be strong swimmers and seek areas with slow-moving water to cross rivers and streams.

This observation is of scientific value from two perspectives. First, to the best of my knowledge, this is the first record of a porcupine crossing a stream or river, despite the fact that this must be relatively common behaviour for porcupines given the innumerable streams and rivers in the boreal forest, even if it is not regularly observed by humans. Second, given the apparent indecision of the animal about whether to cross the stream, this observation suggests that some porcupines may be averse to swimming, supporting the assertion of Woods (1973). In addition, this observation suggests that porcupines may be selective in terms of where they cross rivers and streams, avoiding deep, turbulent water in favour of more placid and shallow sections. Although the porcupine swam across the stream with apparent ease, its head and body were quite low in the water; thus, waves and riffles may pose a substantial risk of drowning. A swift current could also quickly take a porcupine downstream during a crossing into hazards, such as rough water or waterfalls.

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More Mountain Chickadees (*Poecile gambeli*) sing atypical songs in urban than in rural areas

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Abstract
Urbanization results in novel ecosystems with unique challenges. These may lead to problems during song learning or development and could result in the singing of atypical songs. During studies of Mountain Chickadees (*Poecile gambeli*) and urbanization in British Columbia, Canada, we observed males singing atypical songs along an urbanization gradient. We found that eight of 78 males consistently sang atypical songs and the odds of singing atypical songs increased with urbanization. We explored several explanations including habitat quality, population density, and bioacoustics. Future studies investigating causes and consequences of atypical singing will clarify effects of urbanization on Mountain Chickadees.

Key words: Mountain Chickadee; *Poecile gambeli*; Paridae; communication; atypical songs; urbanization; urbanization index

Introduction

Among songbirds, unusual songs are those that differ from species-specific local song types. These unusual songs may be (a) rarely heard 'special' songs (such as whisper songs), (b) juvenile songs, the result of early song development, (c) uncommon mimicry of other species, or (d) dialectal songs in an abnormal geographic location (Borror 1968). Unusual songs that do not fit these four categories are considered atypical (e) and may be the consequence of errors in learning or developmental problems (Borror 1968).

Occasionally, young males make 'mistakes' when learning their songs. Perhaps they have few tutors, or cannot hear their tutors well, or perhaps their tutors are a closely related species (e.g., Black-capped Chickadees [*Poecile atricapillus*] and Carolina Chickadees [*P. carolinensis*] learn each other's songs; Sattler *et al.* 2007). There may also be developmental problems, as poor-quality habitat can lead to poor-quality songs (e.g., poor-quality Black-capped Chickadee songs appear less dominant to both males and females; Grava *et al.* 2012, 2013a), which, in extreme cases, could be considered atypical. Alternatively, changes to habitat acoustics may result in young males incorrectly hearing their tutors' songs or actively modifying their own song to reduce interference and increase transmission (e.g., Slabbekoorn and den Boer-Visser 2006).

Many situations leading to atypical songs may occur as a result of urbanization. Urbanization creates a novel ecosystem with unique challenges for many species. Among birds, urbanization can lead to changes in habitat quality that may be positive (e.g., increased food availability from bird feeders; Robb *et al.* 2008) or negative (e.g., habitat loss, competition with invasive species, or environmental pollutants; McKinney 2002), and may influence population dynamics. Urbanization can also lead to altered habitat acoustics (e.g., echoes and reverberation from buildings and pavement; Warren *et al.* 2006) and anthropogenic noise pollution, which can interfere with vocal communication through masking of lower frequencies (Patricelli and Blickley 2006; Shannon *et al.* 2015).

Mountain Chickadees (*Poecile gambeli*) live in montane forests in western North America. They are found in urban areas, although they occur at lower densities than they do in rural areas (LaZerte 2015; S.E.L. and K.L.D.M. pers. obs.) and may thus be less urban-adapted than Black-capped Chickadees. Here we present a short exploration of the relationship between atypical songs and urbanization in Mountain Chickadees using the combined data from Marini (2016) and LaZerte (2015).

Methods

We analyzed recordings of 78 adult male Mountain Chickadees vocalizing at dawn in the spring during nest-building and egg-laying (2012 through 2015). These recordings were obtained from two studies investigating effects of urbanization: communication and individual condition (Marini *et al.* 2017a, n = 42), and vocal plasticity (LaZerte *et al.* 2017, n = 36). Recordings were made in and around the cities of Williams Lake (n = 12; 52.129°N, 122.138°W), Kamloops (n = 60; 50.676°N, 120.341°W), and Kelowna (n = 6; 49.884°N, 119.493°W), British Columbia (BC), Canada. Each male was recorded a maximum of once per year. We used site territoriality to distinguish among males within a year, but sites in Kamloops were revisited between years. Known duplicate recordings of males (if the male was banded or identified by distinctive atypical singing) were omitted. Habitat urbanization was evaluated as a continuous index (low = rural, high = urban) by comparing satellite Google Earth images (Google Inc. 2012) of territories (defined as a circular area 150 m in diameter around the recording location of the focal male) and scoring the amount of natural vegetation (natural grass or trees) versus urban ground cover (pavement, buildings, or lawn; for more details see LaZerte *et al.* 2017; for scripts and tutorial see https://github.com/steffilazerte/urbanization-index). The lowest habitat urbanization value (−0.95) reflected sites with 100% natural vegetation (no pavement, no buildings, no lawns). The highest value (2.01) reflected sites with only 11% natural vegetation cover, and 89% pavement, buildings, or lawn.

We only included samples with a minimum of five minutes of vocalization and 25 songs (as Mountain Chickadees use both songs and calls during the dawn chorus; McCallum *et al.* 1999; Grava *et al.* 2013b). Part of LaZerte *et al.*'s (2017) experimental protocol involved exposing males to five minutes of experimental noise. Although they found no effect of this exposure on song variation, we excluded all songs recorded during the noise exposure period and in the five minutes following.

Mountain Chickadees in BC typically sing songs with 3–5 notes in descending order (Grava *et al.* 2013b; Figure 1a). We therefore defined songs as atypical if they were monotone (multiple notes sung on a single frequency; Figure 1b top), contained a reverse frequency change (ascending note[s] as opposed to descending; Figure 1b middle), or contained novel notes (e.g., a note with an extreme upwards frequency sweep; Figure 1b bottom). We used categorical designations for songs as opposed to measuring song characteristics because our data were obtained from two prior studies. In one study, songs had been categorized, but there were no compiled data on individual songs. Although atypical songs are unusual, it is not uncommon for an individual to occasionally sing a few atypical songs. Therefore, we classified males as atypical singers only if they consistently sang atypical songs (>80% of all songs recorded were atypical, most males sang <5% atypical songs).

To determine whether the odds of being an atypical singer increased with urbanization, we performed a logistic regression of male singer type (atypical/typical) against the urbanization index using R statistical software (version 3.3.2; R Core Team 2016). We calculated bias-corrected and adjusted (BCa) bootstrap 95% CI for coefficients. We performed 10 000 replicates using the boot package for R (version 1.3-20; Angelo and Ripley 2017). Figures were created using the R package ggplot2 (version 2.2.1; Wickham 2009). Spectrograms were created with Hanning window lengths of 1024 using the R packages ggplot2 and seewave (version 2.0.5; Sueur *et al.* 2008).

Results

Eight of 78 individuals consistently sang atypical songs. Roughly categorizing urban areas as those with an urbanization index greater than the mean (0) showed that 21% of urban males consistently sang atypical songs whereas only 2% of rural males did (Figure 2a).

The odds of a male consistently singing atypical songs increased significantly with the continuous urbanization index (Log odds = 1.10, 95% CI = 0.28–2.30, SE = 0.42, z = 2.61, P = 0.009; Figure 2b); expressed as an odds ratio, for every 1 unit increase in the urbanization index, males were 3.00 (95% CI = 1.32–9.95) times as likely to be atypical singers. The probability of individuals in the most rural habitats being atypical singers was 2.4% (95% CI = 0.3–11.2%). In the most urban habitats, the probability was 39.0% (95% CI = 11.6–68.0%).

Discussion

Consistently singing atypical songs was not common; however, the odds of doing so increased with increasing urbanization. Because these recordings were collected during the breeding period before juveniles were present, it is highly unlikely that atypical songs

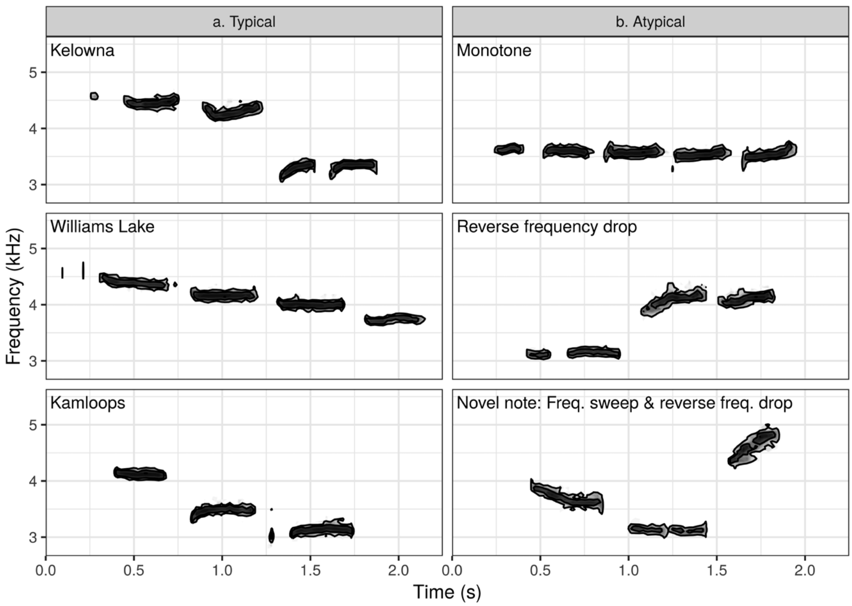

FIGURE 1. Variation in Mountain Chickadee (*Poecile gambeli*) songs in British Columbia, Canada. a. Typical regional variation; all songs show descending frequencies. b. Some examples of atypical songs include monotone songs (top), songs with a reverse frequency drop (middle), and songs with novel notes (bottom).

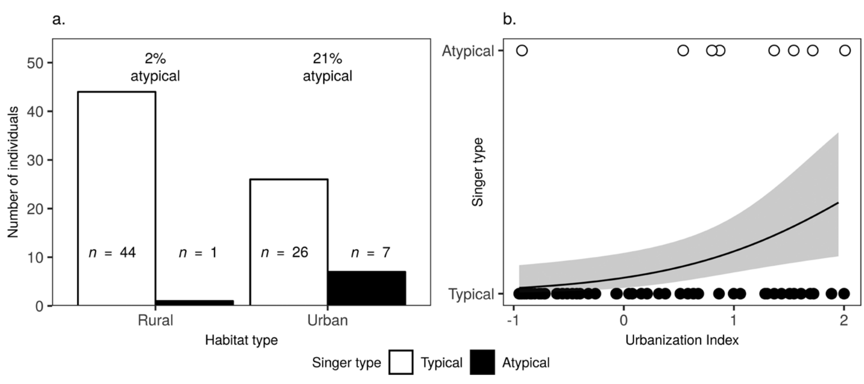

FIGURE 2. Male Mountain Chickadees (*Poecile gambeli*) are more likely to consistently sing atypical songs in urban areas. a. By categorizing urban sites as those with an urbanization index > 0 and rural sites as those with an urbanization index ≤ 0, urban sites show 21% of males singing atypical songs versus 2% in rural areas. b. As urbanization increases, the likelihood of being an atypical singer increases. The line represents the predicted logistic regression, the grey area shows the 95% CI interval around the predicted model. Each point represents a male Mountain Chickadee. The outlier (top left panel b) was recorded in a rural area on the outskirts of Kamloops. There were no sources of water, nor any other obvious sources of noise. It is possibly it could have been a windy location as it was on the side of a hill, but excessive wind was not noted. It was up slope of the train tracks, ~1.5 km away, a distance unlikely to have had an effect. Possibly this individual migrated to the area from an urban area.

represent early song development. Further, as these cities are relatively small (the largest, Kamloops, has a population of 90 280; Statistics Canada 2017) and are surrounded by rural habitat, it seems unlikely that birds from different populations (and with different song types) would have exclusively settled in urban areas, or that these urban habitats are isolated enough to facilitate cultural evolution of song (cf. Gammon and Baker 2004; Luther and Derryberry 2012). Consequently, atypical singers in urban areas may result from differences in habitat quality, population density, or environmental acoustics.

Poor-quality habitat may be associated with poor-quality males, either because males in urban habitats do not get enough resources or because only poor-quality males will settle in urban habitats. This, in turn, may lead to poor-quality song (e.g., nutritional stress hypothesis; Nowicki *et al.* 2002; male quality; Grava *et al.* 2012) which could explain the increase in atypical singers. However, our previous studies of Mountain Chickadees in Kamloops suggest that urban habitat seems to be of at least equivalent quality to rural habitat (Marini *et al.* 2017b). Thus, poor-quality habitat may not fully explain the presence of atypical singers we found.

Mountain Chickadees are less abundant in urban than in rural areas (LaZerte 2015; S.E.L. and K.L.D.M. pers. obs.). In some species, greater urban population densities affect song variation, by influencing male-male interactions (e.g., Eurasian Blackbird [*Turdus merula*]; Ripmeester *et al.* 2010; Great Tits [*Parus major*]; Hamao *et al.* 2011). However, it is unclear how reduced competition could lead to singing atypical songs in Mountain Chickadees. Alternatively, low population density may result in fewer tutors or tutors that are farther away, making it difficult for young chickadees to learn songs correctly (similar to Laiolo and Tella 2005). Further, low densities may also result in the direct introduction of unusual song types by juveniles and less social pressure to conform to local song types (Gammon *et al.* 2005; Gammon 2007).

Urban areas are often noisy (LaZerte *et al.* 2015) and more pavement and concrete leads to altered acoustics (Warren *et al.* 2006). These changes may interfere with vocal communication leading to adjusted songs and/or calls. Male Mountain Chickadees are known to adjust their vocalizations in noisy habitats and in response to noise exposure (LaZerte *et al.* 2017). In a study on closely related Great Tits, Slabbekoorn and den Boer-Visser (2006) found that, throughout Europe, urban males sang more atypical song types (songs with fewer or more notes than the typical 2–4) than rural males, and suggested this could be due to noise interference. If, during song learning, only un-masked and well transmitted aspects of tutor songs are learned properly, changes in bioacoustics could result in atypical songs (Rabin and Greene 2002; Slabbekoorn and den Boer-Visser 2006). Depending on the situation, these atypical songs could be beneficial or detrimental. Atypical songs, which are the result of learning only the least-masked aspects of a normal song (e.g., Mountain Chickadee monotone songs may represent songs which have lost low-frequency notes), could result in less noise-interference and better transmission, and could thus be an adaptation to urban environments. Alternatively, atypical songs may be a symptom of poor learning in urban areas wherein young males settling in urban areas are learning songs incorrectly from tutors that results in poor quality songs.

While atypical songs were uncommon overall, urban Mountain Chickadees in BC were more likely to consistently sing atypical songs than rural males. However, it is not clear whether these songs represent a response to the urban acoustic environment, or a symptom of low population densities. Studies in progress suggest that atypical songs may transmit better in noisier conditions than typical songs (S.E.L. unpubl. data). However, Gammon *et al.* (2005) observed more atypical songs in Black-capped Chickadees in quiet, rural populations as opposed to presumably noisier, urban populations, suggesting a stronger role for population density than urban noise. There are fewer studies on Mountain Chickadees and it is thus less clear how prevalent atypical songs are in more natural landscapes. Possibly, they might be more common than in Black-capped Chickadees, simply because their song varies more among populations than do Black-capped Chickadees (e.g., Grava *et al.* 2013a). Further studies exploring the interaction between noise and population densities (such as in a 2×2 factorial design, varying density of birds and levels of urban noise) could help clarify the potential mechanism. The research could be an observational study or a manipulative experiment (e.g., alter population density through removing birds, use audio speakers to vary the amount of urban noise). It is also unclear what consequences these changes may have on communication or reproductive success, which further studies may also help to clarify.

Author Contributions

S.E.L., K.A.O., and H.S. contributed to the development and design of the LaZerte (2015) study, and K.L.D.M., K.A.O., and M.W.R. contributed to the development and design of the Marini (2016) study. S.E.L. and K.L.D.M. collected data and conducted data cleaning and preparation. S.E.L. conducted the analysis and wrote the manuscript. All authors contributed to development of ideas and commented on draft versions of the manuscript.

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Body mass as an estimate of female body condition in a hibernating small mammal

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Abstract
In hibernating squirrels, the amount of energy stored as fat may influence several important demographic traits, but is difficult to quantify in living animals. Thus, several non-destructive indices of body condition are used, including simple indices that use body mass and scaled indices that correct body mass for structural size. However, the accuracy of these indices for hibernating squirrels is poorly known. We used measurements of total body electrical conductivity (TOBEC) from adult female Golden-mantled Ground Squirrels (*Callospermophilus lateralis*) to characterize body composition (lean mass versus fat mass) and condition (fat stores) at multiple stages in the circannual cycle. Body mass explained a high proportion of the variation in fat mass during the emergence and pre-hibernation stages, but less during the reproduction stage. Contrary to expectation, correcting for structural size did not markedly improve the condition index. Our results suggest that body mass is a good estimate of body condition during the periods of emergence and pre-hibernation fattening, and therefore may be useful to predict important components of fitness such as reproductive success and overwinter survival.

Key words: Body mass; body condition; condition index; mass-length residuals; fat; ground squirrel; *Callospermophilus lateralis*

Introduction

Seasonal variation in energy supply is a central problem for many mammals, which may respond to periods of environmental energy shortage by storing energy, reducing energy expenditure, or both (Humphries *et al.* 2003). Hibernation, which reduces metabolic demands during winter, is one life-history adaptation to seasonal energy scarcity, but sufficient energy stores are essential to its success (Pulawa and Florant 2000).

In hibernating squirrels, the amount of energy stored as fat may influence several important demographic traits such as overwinter survival (Murie and Boag 1984; Lenihan and Van Vuren 1996), timing of reproductive maturity (Barnes 1984), male breeding effort (Delehanty and Boonstra 2011), female reproductive success (Dobson and Michener 1995; Rieger 1996), offspring sex allocation (Allainé *et al.* 2000), and natal dispersal (Nunes and Holekamp 1996; Neuhaus 2006). Additionally, estimating fat stores is essential for bioenergetic models of hibernation, which can be used to project distribution changes of hibernating species under changing climatic conditions (Humphries *et al.* 2002). However, quantifying body condition (defined here as fat stores, in grams; Kiell and Millar 1980; Dark *et al.* 1989) is difficult to do non-destructively. Because determining the effects of body condition on future life-history outcomes requires that the animal survive measurement, several non-destructive indices for estimating condition have been developed (Schulte-Hostedde *et al.* 2005; Peig and Green 2010). These include simple condition indices that use body mass (e.g., Hock 1960), and scaled condition indices that attempt to correct body mass for structural size (e.g., Reid 1988). Many studies use total body mass as a simple condition index, with the implicit assumption that greater mass reflects greater relative fat stores (Barnes 1984; Sauer and Slade 1987; Lenihan and Van Vuren 1996; Neuhaus 2003; Lane *et al.* 2011). However, larger animals may have greater mass due to larger structural size (skeleton and associated lean tissue) instead of greater fat stores (Dobson 1992). Thus, some studies use a scaled condition index based on residuals derived from a regression of body mass on structural size, with the expectation that correcting body mass by the structural size of an individual improves the estimate of its condition (Bachman 1993; Dobson and Michener 1995; Dobson *et al.* 1999; Allainé *et al.* 2000). Positive residuals suggest the animal contains more tissue (presumably fat) than predicted for a given structural size, while negative residuals suggest the animal contains less tissue than predicted for a given structural size.

Scaled indices are appealing because they correct for variance in body mass that is unrelated to energy stores, but available evidence indicates that size-corrected measures do not necessarily improve estimates of body condition compared to use of body mass alone (Krebs and Singleton 1993; Green 2001; Schamber *et al.* 2009). However, most evaluations of condition indices have focussed on mammals that do not store fat for hibernation or energy reserves, and the poor relationship between the scaled condition index and measured fat content may occur because residuals of these relatively lean species primarily reflect differences in protein or water content rather than fat (Schulte-Hostedde *et al.* 2001). Scaled indices might be more appropriate for species in which fat content is a greater proportion of body mass, such as hibernators (Schulte-Hostedde *et al.* 2001), but the predictive ability of simple versus scaled condition indices for hibernating squirrels is poorly known.

Fat storage in hibernating squirrels follows circannual cycles of accumulation and depletion (Buck and Barnes 1999), reflecting seasonal changes in the balance between energy acquisition and expenditure (Kenagy *et al.* 1989). For an index to be an appropriate estimate of body condition, it should explain a high proportion of the variation in fat storage, preferably across multiple stages of the circannual cycle. Adult females are often excluded from condition index validation because of the confounding effect of fetal lean tissue elaboration during gestation (Krebs and Singleton 1993; Schulte-Hostedde *et al.* 2005), yet energetic costs associated with hibernation and reproduction deplete fat stores, and therefore affect body condition, in adult females as well as males (Kenagy 1989; Michener and Locklear 1990; Buck and Barnes 1999). In this paper we use measurements from adult female Golden-mantled Ground Squirrels (*Callospermophilus lateralis*) to evaluate fat stores during four major stages (emergence, reproduction, post-reproduction, and pre-hibernation) in their circannual cycle. Our goal is to assess body mass as a simple index of body condition in each stage, and determine if using a scaled index improves estimates of body condition.

Methods

We studied Golden-mantled Ground Squirrels over three years (2003–2005) in the northern Sierra Nevada mountains of California. These squirrels are locally abundant, medium-sized (200–300 g), and relatively well-known both ecologically and physiologically (Bartels and Thompson 1993).

Our study was conducted in the Plumas National Forest (40.004012°N, 120.810829°W) near Quincy, California, at an elevation of ~2100 m. In this area, adults emerge from hibernation in May and pups are weaned in late July; all squirrels gain weight during September before immerging into hibernation in October. Gestation in Golden-mantled Ground Squirrels is 28 days (Cameron 1967) and weaning occurs when pups reach 30 days old (Phillips 1981). We divided the active season into four circannual stages, defined broadly to encompass individual variation in circannual timing: emergence, 15 May–15 June (emergence from hibernation through mating and early gestation); reproduction, 16 June–31 July (late gestation through lactation); post-reproduction, 1 August–31 August (after lactation but before late summer fattening becomes pronounced); and pre-hibernation, 1 September–early October (when pre-hibernation fattening occurs). Because we did not determine reproductive status for all females in this study, our sample may have included non-reproductive females.

We captured adult female squirrels with Tomahawk live traps (Model 201, Tomahawk Live Trap Co., Hazelhurst, Wisconsin, USA) baited with rolled oats and black oil sunflower seeds coated with peanut butter. Traps were set in the early morning and checked mid-morning. Our methods were conducted according to a protocol approved by the Animal Care and Use Committee of the University of California, Davis, and followed guidelines approved by the American Society of Mammalogists (Sikes *et al.* 2016). At first capture, squirrels were fitted with a uniquely numbered metal tag (Self-piercing fish tag, Style 1005-1, National Band & Tag Company, Newport, Kentucky, USA) in each ear for permanent identification. We attempted to capture all squirrels monthly, but due to differential trapping success not all squirrels were captured each month. We transported captured squirrels to a laboratory near Quincy, where we anesthetized them with an intramuscular injection of ketamine hydrochloride (100 mg/ml). We recorded body mass to the nearest 0.1 g using a portable electronic balance and body length (measured as tip of nose to anus) to the nearest 0.1 cm (Pulawa and Florant 2000). We used body length as a measure of structural size (Bachman 1993; Allainé *et al.* 2000); our measurements of body length showed good repeatability for individuals recaptured in the same stage (Pearson correlation $r = 0.83$, $n = 5$). We quantified body fat using an EM-SCAN SA-3000 body composition analyzer (EM-SCAN, Springfield, Illinois, USA; no longer available from the manufacturer) to measure total body electrical conductivity. Total body electrical conductivity (TOBEC) is a non-destructive method to analyze the body composition of animals (Scott *et al.* 2001) that has been used to obtain estimates of lean and fat mass from free-living small mammals (Walsberg 1988; Koteja 1996), including ground squirrels (Nunes and Holekamp 1996; Buck and Barnes 1999; Pulawa and Florant 2000). The TOBEC method uses electrical current, which travels differentially through fat versus lean tissue, to generate measures of electrical resistance; resistance measures are then converted to fat mass using species-specific calibration equations (Bachman 1994; Koteja 1996; Walsberg 1998; Scott *et al.* 2001).

EM-SCAN readings are known to vary with animal movement during measurement, differences in gut contents, changes in ambient temperature, and changes in body temperature greater than 4°C (Walsberg 1988; Scott *et al.* 2001). To minimize variation due to movement, we placed immobilized squirrels on a plastic sample tray and lightly restrained them with rubber bands to maintain each squirrel in the same position (dorsoventrally, ventral side down, with the tail tucked under the body). To minimize variation due to gut contents, we only trapped squirrels early in the morning (as foraging began) and did not provide food or water until after TOBEC measurement. To minimize variation due to ambient temperature, we performed measurements in a laboratory at a field station. Anesthesia often causes a drop in body temperature; throughout our study, however, the mean change in body temperature was −1.6 ± 0.3°C (SE), and no individuals lowered their body temperatures more than 4°C. Body composition was calculated as the mean of five replicate measurements; we recorded seven replicate measurements and then discarded the highest and lowest values, though variation in measurements was minimal (coefficient of variation = 0.03). We determined lean mass (M_L) using the calibration curve for Golden-mantled Ground Squirrels:

$$M_L = 18.0 + 0.3M_B + 1.2\sqrt{L_B \times EM}$$

where M_B is body mass, L_B is body length, and EM is the EM Scan measurement ($r^2 = 0.98$; Pulawa and Florant 2000). We calculated fat mass by subtracting lean mass from body mass.

We characterized the body composition (lean mass versus fat mass) and condition (fat mass) of adult female ground squirrels during emergence, reproduction, post-reproduction, and pre-hibernation stages. Because female energetic needs shift throughout the active season from expenditure on reproduction to acquisition before hibernation (Kenagy *et al.* 1989), potentially changing the relationship between body mass and fat mass, we considered each circannual stage separately. We assessed fat stores of 23 adult female Golden-mantled Ground Squirrels; seven were measured in a single circannual stage, six were measured in two circannual stages, eight were measured in three circannual stages, and two were measured in all four stages. Sample size varied by stage, and each female was included only once per stage. If females were measured more than once within the same stage, we randomly selected a single measurement from those taken in the same year ($n = 5$ females), and we considered measures to be independent if taken in different years ($n = 2$ females; Broussard *et al.* 2005). We also tried averaging measurements for the same female within a year, but the results were similar whether we averaged or chose measurements at random. We used analysis of variance (ANOVA) with Tukey's HSD *post-hoc* tests to test for significant differences in mean body length and mean body composition among circannual stages. We used linear regression to examine the relationship between body length and mass by each circannual stage.

Next, we used bivariate linear regression to evaluate the relationship between body mass and fat mass for each circannual stage, and also the relationship between mass-length residuals, calculated from regressing body mass on body length, and fat mass. In addition, because percent fat (fat mass/total body mass) is sometimes used as a measure of body condition in hibernating squirrels (Barnes 1984; Nunes and Holekamp 1996; Neuhaus 2003) we performed the same regressions for percent fat as we did for fat mass. The use of body mass as a variable in both the TOBEC calibration equation and as a predictor of fat mass may introduce some underlying structure to the data, with the potential to inflate the r^2 values. While this is unavoidable, we therefore report r^2 values associated with linear regressions for comparison among stages and indexes, and without associated significance tests (Wasserstein and Lazar 2016).

Finally, because our data contained substantial individual and annual variation in percent fat, which may confound relationships between condition indices and percent fat inferred through linear regression, we fitted linear mixed models with individual female identity and year as random effects, and circannual stage and condition index specified as fixed effects. Models were estimated with Bayesian inference. We used a Bayesian, mixed-effects approach for two reasons: 1) the hierarchical structure of our data suggested the use of mixed effects models that produce more accurate estimates of all parameters, and 2) Bayesian approaches more accurately partition variance among mixed effect parameters than likelihood-only approaches (McElreath 2016). We developed four models: two with fat mass (in grams) as the response variable, predicted by either mass or mass-length residuals, and two with percent fat as the response variable, predicted by either mass or mass-length residuals. We included all measurements (n = 61) of the 23 adult females in this analysis.

We used a model comparison approach to evaluate the ability of each index to predict fat mass and percent fat. Specifically, we used the Watanabe-Akaike Information Criterion (WAIC) to rank models, based on WAIC differences (ΔWAIC) and Akaike weights. Such values are analogous to other information criteria, where low ΔWAIC values indicate preferred model, and high weight indicates increased probability that the model will successfully predict new data (Gelman *et al*. 2014; McElreath 2016). All analyses were run in R version 3.5.2 (R Development Core Team 2016); we used the packages RStan (Stan Development Team 2016) and rethinking (McElreath 2016) to fit and compare mixed models, and ggplot2 (Wickham and Chang 2013) to plot figures.

Results

Lean mass of adult female Golden-mantled Ground Squirrels varied among circannual stages ($F_{3,51}$ = 3.52, P = 0.02; Table 1), and was lowest at emergence from hibernation and highest before immergence. Estimated fat mass also varied among circannual stages ($F_{3,51}$ = 7.35, P < 0.001), and was lowest at emergence from hibernation and highest before immergence. Percent fat varied among circannual stages ($F_{3,51}$ = 5.90, P = 0.002), and appeared stable throughout the first three stages before showing a sharp increase in the pre-hibernation stage. Additionally, mixed models revealed a generally positive effect of the pre-hibernation stage on fat mass, after controlling for year, individual, and mass or mass-length residual (Table 2).

The relationship between body mass and body length was positive during emergence (r^2 = 0.55, n = 12, P < 0.01), reproduction (r^2 = 0.41, n = 15, P < 0.01), and post-reproduction stages (r^2 = 0.33, n = 16, P = 0.02), but was no longer apparent during the pre-hibernation stage (r^2 = 0.00, n = 12, P = 0.98; Figure 1).

Body mass explained a very high proportion of the variation (93–96%) in fat mass during the emergence, post-reproduction, and pre-hibernation stages, but a lower proportion (84%) during the reproduction stage (Figure 2). Correcting for structural size, as measured by head and body length, did not improve fit within any stage: the proportion of variation explained by mass-length residuals was less than that for the simple index based on body mass during the emergence, reproduction, and post-reproduction stages (57–70%), and equivalent to that explained by body mass during the pre-hibernation stage (96%).

Overall, a similar pattern was evident for the analysis based on percent fat. Body mass explained a moderate to high proportion of the variation in percent fat during the emergence (r^2 = 0.79), post-reproduction (r^2 = 0.69), and pre-hibernation stages (r^2 = 0.91), but a lower proportion during the reproduction stage (r^2 = 0.56). Correcting for structural size did not markedly improve fit within most stages, though mass-length residuals did explain a significant proportion of the variation in percent fat (emergence r^2 = 0.61, post-reproduction r^2 = 0.46, pre-hibernation r^2 = 0.91). Correcting body mass by body length improved model fit only in the reproduction stage (r^2 = 0.86). While both mass and mass-length residuals showed strong positive effects on fat mass and percent fat, WAIC metrics showed a clear preference for the mass models (w_i =1, ΔWAIC=0.0; ΔWAIC for the second model >69 for fat grams and >20 for percent fat; Table 2).

Discussion

Our results suggest that body mass is a useful estimate of body condition during the critical periods of emergence from hibernation and pre-hibernation fattening, and perhaps during the post-reproductive period, supporting the use of body mass as a simple index to predict important components of fitness such as female reproductive success (Rieger 1996) and overwinter survival (Murie and Boag 1984). Body mass

TABLE 1. Mean length and body composition (± 1 SE) of adult female Golden-mantled Ground squirrels (*Callospermophilus lateralis*) near Quincy, California, from 2003 to 2005, by circannual stage.

	Emergence 15 May–15 June	Reproduction 16 June–31 July	Post-reproduction 1–31 August	Pre-hibernation 1 September–1 October
n	12	15	16	12
Mean length (cm)	17 ± 0.4	18 ± 0.3	17 ± 0.3	18 ± 0.3
Mean total mass (g)	158 ± 8.5^{a1}	175 ± 5.3	167 ± 5.9^{a1}	198 ± 9.4^{b1}
Mean lean mass (g)	124 ± 4.8^{a2}	135 ± 3.4	130 ± 3.6	142 ± 4.5^{b2}
Mean fat mass (g)	35 ± 3.9^{a3}	39 ± 2.1^{a3}	38 ± 2.5^{a3}	56 ± 5.1^{b3}
Mean percent fat	21 ± 1.7^{a4}	22 ± 0.8^{a4}	22 ± 0.8^{a4}	28 ± 1.4^{b4}

$^{a\#}$Statistically different value(s) from $^{b\#}$ across circannual stages for that variable, according to Tukey HSD *post-hoc* test.

TABLE 2. Parameter estimates from linear mixed models predicting fat mass (left of dividing line) and percent fat (right of dividing line) of adult female Golden-mantled Ground Squirrels (*Callospermophilus lateralis*), with mass and mass-length residuals used as predictor variables. Estimates in bold indicate fixed effects that are reliably positive. Fixed effects of circannual stage (reproduction, post-reproduction, and pre-hibernation) are compared to the baseline of the emergence stage. Female ID and Year were fitted as random effects with varying intercepts. ΔWAIC values and weights (w_i) are compared between the two models with the same outcome variable.

	Fat grams~mass			Fat grams~MLResiduals			Percent Fat~mass			Percent Fat~MLResiduals		
	Mean ± SD	Lower 0.89	Upper 0.89	Mean ± SD	Lower 0.89	Upper 0.89	Mean ± SD	Lower 0.89	Upper 0.89	Mean ± SD	Lower 0.89	Upper 0.89
Intercept	−35.79 ± 3.36	−40.92	−30.36	40.07 ± 2.70	36.11	43.85	0.77 ± 2.33	−2.68	4.15	22.86 ± 1.65	20.43	25.43
Mass	**0.45 ± 0.02**	**0.42**	**0.48**	—	—	—	**0.13 ± 0.01**	**0.11**	**0.15**	—	—	—
Mass-Length Residual	—	—	—	**0.46 ± 0.04**	**0.40**	**0.52**	—	—	—	**0.14 ± 0.01**	**0.12**	**0.16**
Reproduction	−1.86 ± 1.19	−3.72	0.03	1.36 ± 1.99	−1.86	4.38	−0.25 ± 0.66	−1.29	0.82	0.62 ± 0.77	−0.59	1.85
Post-Reproduction	−1.42 ± 1.30	−3.50	0.63	0.03 ± 2.25	−3.56	3.49	−0.49 ± 0.77	−1.75	0.69	−0.08 ± 0.94	−1.54	1.42
Pre-Hibernation	2.23 ± 1.78	−0.43	5.15	**6.45 ± 2.95**	**2.08**	**11.35**	0.22 ± 1.12	−1.46	2.09	1.29 ± 1.30	−0.71	3.45
ΔWAIC	0.0			69.4			0.0			20.7		
w_i	1			0			1			0		

was less reliable during the reproductive stage, when females likely varied in their reproductive status. Because variation in reproductive status is associated with differences in body composition (Holekamp and Nunes 1989), combining non-reproductive, pregnant, and lactating females likely weakened the relationship between body mass and fat mass; this pattern was more pronounced when condition was defined as percent fat. In pregnant females, increased mass reflects additional lean fetal tissue instead of fat mass (Boswell *et al.* 1994). Reproductive females also vary in litter size (McKeever 1964), and hence fetal mass.

Our study faced two limitations, besides small sample sizes. First, we did not directly measure fat content of squirrels through destructive sampling and chemical extraction. Second, although the TOBEC method has been validated for Golden-mantled Ground Squirrels (Pulawa and Florant 2000), we did not calibrate the TOBEC machine for our population of the species. TOBEC equations derived from one population have been successfully applied to new individuals in another rodent species (Dickinson *et al.* 2001), but the accuracy of TOBEC among populations of ground squirrels is unknown. Consequently, our measurements of fat content are estimates only.

Adult female Golden-mantled Ground Squirrels showed seasonal changes in body composition consistent with other hibernating squirrels, gaining both lean mass and fat mass during the active season (Kiell and Millar 1980; Rickart 1982). Other studies have demonstrated that ground squirrels appear to catabolize both lean and fat tissues to fuel hibernation, but restore these once the vegetative growing season begins (Jameson and Mead 1964; Kiell and Millar 1980; Pulawa and Florant 2000). A late season gain in fat mass is characteristic of hibernating species (Kunz *et al.* 1998; Buck and Barnes 1999; Hilderbrand *et al.* 2000), and it was during this stage that fat mass was best predicted by body mass.

In general, our finding that body mass explained substantial variation (84–96%) in female fat mass is consistent with those of previous studies that combined male and female squirrels: body mass explained 76% of the variation in fat mass in Belding's Ground Squirrels (*Urocitellus beldingi*) collected throughout the active season (Morton and Tung 1971), and 82% of the variation in percent fat in Arctic Ground Squirrels (*Urocitellus parryii*) held in captivity (Lee *et al.* 2011).

Surprisingly, adjusting for structural size using body length did not improve estimates of body condition, except during the reproduction stage for estimates of percent fat. Body length and body mass were linearly related in our squirrels at emergence, supporting the premise that greater mass in some stages was due, at least in part, to larger structural size. However, the relationship between body length and mass almost disappeared by the pre-hibernation stage (Figure 1). Because the regression of body mass on length had a slope of zero in the pre-hibernation stage, and the magnitude of residuals was equal to relative body mass, the fit of mass-length residuals was identical to that of body mass in this stage.

We suggest three reasons why the scaled index may have performed poorly. First, measures of structural size may be particularly susceptible to measurement error (Yezerinac *et al.* 1992; Blackwell *et al.* 2006; Martin *et al.* 2013). Although we reduced this error by measuring body length on anesthetized squirrels, which are more amenable to measurement than active, unanesthetized squirrels, and this measurement displayed high repeatability within stage, some measurement error remained. Second, measures of structural size such as body length may sometimes be a poor indicator of lean mass that is not associated with energy storage. As with the relationship between body length and total mass noted above, the strength of the relationship between body length

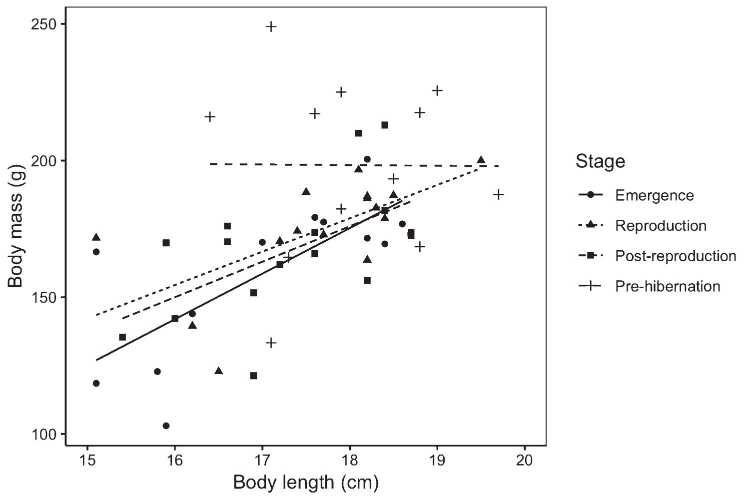

FIGURE 1. Linear relationships between adult female Golden-mantled Ground Squirrel (*Callospermophilus lateralis*) body mass and body length, by circannual stage.

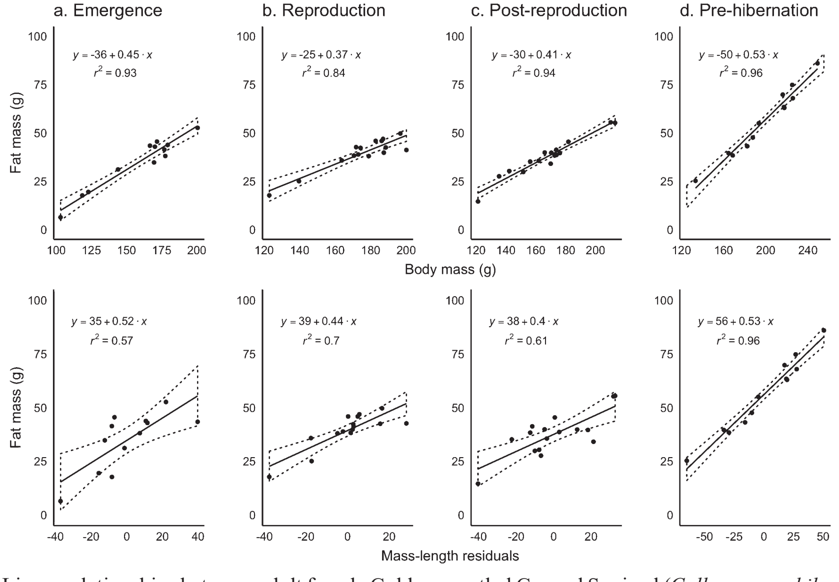

FIGURE 2. Linear relationships between adult female Golden-mantled Ground Squirrel (*Callospermophilus lateralis*) total body mass and fat mass (top row), and mass-length residuals and fat mass (bottom row), by circannual stage (columns). Dotted lines represent a 95% CI (two standard errors).

and lean mass declined over the active season (from $r^2 = 0.64$ at emergence to $r^2 = 0.01$ before hibernation). Some individuals that emerged from hibernation with lower body mass than expected for their body size still had substantial fat stores; perhaps these individuals preferentially lost lean mass during hibernation (Pulawa and Florant 2000) to retain fat stores necessary for initiating reproduction. Finally, although body length commonly has been used in ground squirrel studies (Morton *et al.* 1974; Kiell and Millar 1980; Pulawa and Florant 2000), it may simply be a poor measure of structural size. Other studies have used breadth across the zygomatic arches as a measure of structural size (Dobson *et al.* 1999; Viblanc *et al.* 2010). Zygomatic arch breadth has a significant but not especially strong linear relationship with body length for adult females of this species (r^2 = 0.44, P < 0.01, n = 18; C.P.W. unpubl. data), however, highlighting the uncertainty of using a single measure to quantify as complex a trait as structural size.

Body condition is an important trait in the life history of ground squirrels, but measuring condition directly requires sacrificing the animal. Our results suggest that the simple measure of body mass is a useful indicator of body condition, especially early and late in the active season, and that scaled indices do not improve on mass estimates during most stages in the circannual cycle.

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Desiccation of herpetofauna on roadway exclusion fencing

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Abstract
Significant advances have been made to minimize the detrimental effects of roads on wildlife, but little is known about unintended negative consequences of mitigation strategies. Here, we present observations of adverse effects on herpetofauna of exclusion fencing at Presqu'ile Provincial Park, Ontario. A total of 15 individuals (one salamander, nine anurans, and five snakes) were found dead on unburied fencing, apparent victims of desiccation and/or heat exposure. Air temperatures did not differ between days when dead herpetofauna were and were not found on the fence; however, the fence surface was significantly warmer than the air. Our study shows that fence temperature and design may hinder animals escaping from the road to cooler refugia, and we discuss possible solutions.

Key words: Road ecology; road-effect mitigation; snakes; frogs; Presqu'ile Provincial Park; protected areas; southern Ontario

Introduction
Although herpetofauna are often overlooked compared with other taxa (Andrews *et al*. 2008, 2015; Popp and Boyle 2017), the negative effects of roads on these species are becoming increasingly clear and well documented (Gibbs and Shriver 2002; Andrews *et al*. 2008, 2015; Baxter-Gilbert *et al*. 2015). As a countermeasure, wildlife exclusion fencing (WEF), typically combined with crossing structures, is an increasingly common tool employed by biologists and conservation practitioners to mitigate the effects of road mortality on herpetofauna (Glista *et al*. 2009; Beebee 2013; van der Ree *et al*. 2015). In several instances, WEF has been shown to reduce the number of amphibians and reptiles killed in wildlife–vehicle collisions (Dodd *et al*. 2004; Aresco 2005; Colley *et al*. 2017; Markle *et al*. 2017). However, negative consequences associated with factors other than spatial ecology or road mortality have rarely been attributed to WEF (see Boarman *et al*. 1994; Ferronato *et al*. 2014; Eye *et al*. 2018). Because reducing road mortality is critical to maintaining population viability, WEF has important implications for conservation (Jaeger and Fahrig 2004). As such, documenting and understanding unintended negative consequences of WEF is an important step in conservation efforts.

Although road mortality is a major threat to herpetofauna, care must be taken to ensure that mitigation techniques used to address this threat do not produce undesirable side effects. Unfortunately, potential negative side effects of WEF on individuals and populations are somewhat difficult to predict and may include fence by-catch (Ferronato *et al.* 2014), an increase in the barrier effect (Jaeger and Fahrig 2004), disruption of important movement patterns (Clark *et al.* 2010; Rouse *et al.* 2011), hyperthermia from excessive sun exposure (Peaden *et al.* 2017; Eye *et al.* 2018), and increased road mortality rates resulting from improperly installed or maintained fencing (Baxter-Gilbert *et al.* 2015; Markle *et al.* 2017). Further complicating the matter is the variety of WEF materials, installation methods, terrain, and management regimes, with each combination presenting a unique set of potential side effects (e.g., solid versus mesh WEF; OMNRF 2016; Peaden *et al.* 2017).

In 2013, a six-year project was undertaken in Presqu'ile Provincial Park, Ontario, Canada (43.9944°N, 77.7201°W) to identify the local road-crossing patterns of herpetofauna (Boyle *et al.* 2017) and to test the effectiveness of various strategies to mitigate road mortality and habitat fragmentation. While completing road mortality surveys for this project, we noticed several desiccated herpetofauna on portions of a WEF during its installation. This prompted an investigation to determine whether the installation of the WEF, specifically the possibility that it could expose wildlife to extended periods of heat, was causing mortality of reptiles and amphibians. We hypothesized that if the WEF contributed to mortality associated

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with desiccation, then the fence's bottom lip would be warmer than the air on days when we found dead animals. Second, if desiccation was a result of high temperatures, we expected that either the day or the day before we found desiccated animals on the fence would be warmer than days when no desiccated herpetofauna were found. To inform other road ecology practitioners and to contribute to the improvement of techniques, it is important to document negative secondary effects of various types of WEF and investigate potential solutions.

Methods

The main road of Presqu'ile has a posted speed limit of 40 km/h and an average daily traffic volume of ~3000 vehicles during July and August; thus, this is a high-impact roadway for wildlife (S.P.B. unpubl. data).

Installation of ~1000 m of exclusion fencing (Animex vertical above-ground black exclusion fencing, Knowle, Hampshire, England) began in June 2016 and was completed in August 2016. Fencing was installed ~1 m from the road's edge. The fencing was 0.865 m high and composed of solid, high-density polyethylene (HDPE) sheets, each 16.7 m long. At both the top and bottom of the fence, a lip (0.15 m) was folded over in opposite directions. The bottom lip, folded at a 90° angle toward the road, increased stability of the fence once buried, and the upper lip, also folded at 90° but facing away from the road, was intended to reduce the ability of animals to climb over the fence onto the road. The fencing was installed in two phases: in phase one, the entire fence was fastened against plastic support stakes for stability, with sheets zip-tied together through small holes drilled at either end (20 June to 15 August 2016); in phase two, the bottom lip was buried under 0.10 m of mixed aggregate (mid-August 2016). The addition of aggregate on the road side of the fence precluded the need to bury the fence in a trench, which is costly, labour intensive, and potentially ecologically destructive. On completion, the fence was contiguous except at three intersections (two roads and a bicycle path), where it was curved in on itself away from the road, to create a minimum 5 m turn-around.

We report here observations made during the mid-construction phase (i.e., from the time when the fence was installed until its bottom lip was covered with aggregate) when small vertebrates could move under the fence. Visual encounter surveys were conducted daily by foot beginning at ~0915 along the 1250 m fenced portion of the road from 1 May to 30 August 2016. During surveys, either S.P.B. or R.D. searched the road and roadside for live and dead herpetofauna. No effort was made to detect herpetofauna on the habitat (non-road) side of the fence.

Shaded air temperature at waist height was measured daily along the road at the start of each survey. In addition, we measured air and fence lip surface temperatures using a digital thermometer (Marathon, BA080008, ± 2.0°C, San Leandro, California, USA) each time an animal (alive or dead) was found on the fence. Maximum air temperatures recorded at the nearest weather station, Trenton A, ~20 km northeast of Presqu'ile were also referred to (Environment and Natural Resources 2016).

We completed all analyses in R v.3.4.1 (R Development Core Team 2014). We used Wilcoxon signed rank tests to make three comparisons: (1) air temperature on days in July and August when we found dead herpetofauna versus days on which we found no dead herpetofauna on the fence's bottom lip, (2) maximum temperature of the previous day (Environment and Natural Resources 2016) on days when we found dead herpetofauna versus days when we found no herpetofauna on the fence's bottom lip, and (3) fence temperature versus air temperature when we observed dead herpetofauna.

Results

On 14 July 2016, a dead, desiccated, but undamaged Wood Frog (*Lithobates sylvaticus*) was discovered on the unburied bottom lip (road side) of the WEF. Typically, amphibians that are struck by vehicles sustain moderate to severe visible damage; thus, an apparently undamaged individual was noteworthy. Over the course of surveys, 12 amphibians (10 dead; one salamander and five species of frog; Table 1) and 10 snakes, all Common Gartersnakes (*Thamnophis sirtalis*; five dead; Table 1) were found on the bottom lip of the fencing. Additional individuals were observed before 14 July but no detailed notes were taken. Dead animals all appeared to be mostly intact, but had undergone various levels of desiccation (Table 1). Although not the main goal of our study, it is noteworthy that all of the desiccated herpetofauna were found at previously identified road mortality hotspots (Boyle *et al.* 2017). Of the 10 dead amphibians, all but two were fully desiccated (Figure 1a). The two live frogs detected on the fence behaved normally but appeared to be unable to find a way through the fence, despite the bottom lip being unburied. In addition, one of the live snakes was coiled on the bottom lip of the fence, possibly basking, while the others demonstrated signs of stress (i.e., erratic movements, sluggishness, mouth gaping) possibly because of dehydration.

We did not find differences in air temperature between days we did or did not find deceased herpetofauna (W = 155, P = 0.30), nor between the

TABLE 1. Reptiles and amphibians observed dead or alive on Animex exclusion fencing in Presqu'ile Provincial Park, Ontario, from 14 July to 30 August 2016, along with demographic and climatic information for each sighting.

Date	Time	Weather	Species*	Sex/lifestage†	Air temperature, °C	Fence temperature, °C	Dead or alive
9 Aug.	0935	Sunny	Blue-spotted Salamander	Juvenile	27.6	31.8	Dead
12 Aug.	0927	Overcast	Gray Treefrog	Juvenile	28.5	32.1	Dead
12 Aug.	0932	Overcast	Gray Treefrog	Juvenile	25.1	35.4	Dead
12 Aug.	0939	Overcast	Gray Treefrog	Juvenile	25.1	35.4	Dead
5 Aug.	0900	Light rain	American Bullfrog	Female	26.7	29.1	Alive
12 Aug.	1339	Overcast	Green Frog	Adult	25.1	35.4	Dead
12 Aug.	1039	Overcast	Northern Leopard Frog	Adult	25.1	35.4	Dead
5 Aug.	0927	Overcast	Northern Leopard Frog	Juvenile	27.3	29.2	Dead
14 Jul.	0940	Overcast	Wood Frog	Juvenile	24.3	27.1	Alive
9 Aug.	0935	Sunny	Wood Frog	Juvenile	27.6	31.8	Dead
12 Aug.	1139	Overcast	Wood Frog	Juvenile	25.1	35.4	Dead
12 Aug.	1239	Overcast	Wood Frog	Juvenile	25.1	35.4	Dead
22 Jul.	0925	Sunny	Common Gartersnake	Adult	24.0	27.2	Alive
15 Aug.	1002	Mostly cloudy	Common Gartersnake	Adult	23.6	27.2	Dead
22 Aug.	1120	Overcast	Common Gartersnake	Adult	21.1	29.3	Alive
2 Aug.	0926	Sunny	Common Gartersnake	Female	23.9	25.6	Alive
23 Aug.	1004	Sunny	Common Gartersnake	Female	24.4	26.9	Alive
17 Jul.	0924	Sunny	Common Gartersnake	Juvenile	21.6	22.6	Alive
29 Jul.	0941	Partly cloudy	Common Gartersnake	Juvenile	26.3	32.1	Dead
2 Aug.	0940	Sunny	Common Gartersnake	Juvenile	23.9	25.6	Dead
2 Aug.	1024	Sunny	Common Gartersnake	Juvenile	28.7	31.9	Dead
5 Aug.	0930	Sunny	Common Gartersnake	Juvenile	26.7	31.2	Dead

Note: Although all individuals demonstrated some desiccation, this was not quantified *in situ*.
*Blue-spotted Salamander (*Ambystoma laterale*), Gray Treefrog (*Hyla versicolor*), American Bullfrog (*Lithobates catesbeianus*), Green Frog (*Lithobates clamitans*), Northern Leopard Frog (*Lithobates pipiens*), Wood Frog (*Lithobates sylvaticus*), and Common Gartersnake (*Thamnophis sirtalis*).
†Snakes designated as "adult" were either not captured or not sexed to minimize additional stress on the animal.

maximum temperatures of days previous to detections versus those without detections ($W = 156$, $P = 0.91$). However, the fence was significantly warmer than the air ($W = 96$, $P = 0.002$; Table 2) on days when dead herpetofauna were observed on the fence.

Discussion

Contrary to our expectations, air temperature was a poor predictor of the presence of dead animals. However, the fence itself was warmer than the air when we found dead herpetofauna, supporting our hypothesis that the fence contributed to the desiccation and mortality. Individuals that moved to the edge of the fence in an attempt to exit the road's right of way would have bypassed the exit path available underneath the fence because of the folded lip. Thus, we conclude that the fence contributed to the observed mortality, likely by reducing the ability of animals to return to cooler refugia.

Consequences of fencing and thermal exposure

Although negative interactions between herpetofauna and exclusion fencing have been previously acknowledged (Boarman *et al.* 1994; Clark *et al.* 2010; Rouse *et al.* 2011; Ferronato *et al.* 2014; Baxter-Gilbert *et al.* 2015; OMNRF 2016), we are unaware of any reports of herpetofauna being found dead or desiccated on the fencing surface. Peaden *et al.* (2017) suggested mesh exclusion fencing may subject herpetofauna to an increased level of sun exposure because of time they spend trying to bypass it. Similarly, Eye *et al.* (2018) suggested increased time spent navigating WEF could be detrimental because of increased heat exposure. We witnessed animals that had breached the fence line, but were unable to return to the habitat side and spent much time walking the length of the fencing trying to find a breach. However, we suspect that solid fencing may partly alleviate the threat of sun exposure (especially in heavily vegetated conditions or on the habitat side). It seems likely that the mortality documented here is the result of extended heat stress leading to hyperthermia and desiccation.

Roads constitute an ecological trap for reptiles because they are attractive for thermoregulation (Andrews *et al.* 2015) and are used as nesting sites by some freshwater turtle species (Steen and Gibbs 2004). Furthermore, if animals that are initially attracted to the road's heat for thermoregulation or nesting opportunities cannot avoid extreme

FIGURE 1. Examples of herpetofauna found dead along the bottom lip (facing the road) of Animex fencing in Presqu'ile Provincial Park, Ontario. a. Heavily desiccated adult Wood Frog (*Lithobates sylvaticus*) with ants scavenging the carcass. b. Partly desiccated adult female Common Gartersnake (*Thamnophis sirtalis*). Note: The unburied bottom lip of the fence is visible in photo b. c. Exclusion fencing buried by approximately 0.1 m of mixed aggregate. The completion of the fence may have contributed to fewer frogs on the road. Photos: Rachel Dillon (a,b), 2016; Sean Boyle (c), 2017.

temperatures by returning to cooler refugia, they risk desiccation and possibly death (Heatwole and Taylor 1987). Although air and fence temperatures were below the thermal maxima of *T. sirtalis* (voluntary = 35°C, critical = 38–41°C; Brattstrom 1965), on some days, these maxima were approached, and the thermal tolerance of snakes decreases if they are dehydrated (i.e., because of prolonged exposure; Ladyman and Bradshaw 2003). Particularly at risk may be amphibians and juvenile snakes because of their higher surface area to volume ratio. Although we cannot estimate how long the individuals we detected were exposed to extreme heat, even a short time could cause heat stress, especially if the individuals were already compromised or dehydrated quickly once on the fence's bottom lip.

Potential sources of bias

We considered alternative causes of mortality. Because we did not observe obvious wounds on the carcasses, mortality from failed depredation is unlikely. Although it is possible that individuals were struck by traffic and subsequently ricocheted onto the fence, this also seems unlikely for multiple reasons. First, individuals were largely undamaged and roughly maintained their shape (Figure 1a,b);

TABLE 2. Average shaded air and fence temperatures recorded on detecting live and dead herpetofauna along Animex exclusion fencing in Presqu'ile Provincial Park, Ontario, in July and August 2016.

Herpetofauna	Air temperature, °C ± SE	Fence temperature, °C ± SE
Living animals		
Amphibians (n = 2)	25.5 ± 1.2	28.1 ± 1.0
Snakes (n = 5)	23.0 ± 0.7	26.3 ± 1.1
Dead animals		
Amphibians (n = 10)	26.16 ± 0.4	33.73 ± 0.7
Snakes (n = 5)	25.8 ± 0.9	29.6 ± 1.3

typically, when snakes and amphibians are struck by cars, they suffer major injuries and are often flattened (S.P.B. pers. obs.). Second, we did not find individuals in the same desiccated condition on the grass or gravel between the fence and the road surface. Third, we saw live frogs and snakes on the bottom lip of the fencing (where we also found the dead individuals), indicating that they used, or at least travelled along the fence, possibly looking for a way to bypass it.

Although our detection rates for dead individuals were likely not 100% (because of scavengers, deterioration, and camouflage), we assumed that the detection probability was equal among all surveys and that detection rate was high because of the slow and methodical nature required for walking surveys specifically targetting small-bodied and often heavily damaged carcasses (Baxter-Gilbert *et al.* 2017). Given that the number of animals we found on surveys (Boyle *et al.* 2017) generally was much higher than the number we found on the fence (reported here), it is also likely that many individuals visited the fence but were able to escape before our surveys and, as such, the risk of thermal exposure and desiccation affects a relatively small proportion of the population.

Precautions and solutions

Although the number of dead animals observed on the mitigation fencing may be inconsequential compared with the road mortality that the fence prevents (i.e., thousands versus dozens; S.P.B. unpubl. data), this likely heat-related source of mortality should be addressed. Exclusion fencing is often installed in areas with at-risk species, where losing even a single individual could have significant consequences for population persistence (Steen and Gibbs 2004). A white version of this fencing, which has a lower heat capacity (Animex International 2016), could be used to limit hyperthermia risk for animals. In many mitigation scenarios, however, white fencing would not be appropriate because of its conspicuousness and increased rate of photo-degradation and consequent reduced lifespan (D. Swensson pers. comm. 8 March 2017).

Although fence temperature may have played a role in the observed mortality, it may be less important than the inability of animals to seek cooler locations. In the summer following our study, several animals were detected along the now back-filled fence line, but none were found dead. Three main differences were apparent between 2016 and 2017: (1) the road side of the fencing had now been backfilled with gravel, reducing access to the road; (2) the weather was much drier in 2016 than in 2017; and (3) vegetation was cut during fence installation in 2016, whereas, in 2017, it had recovered thus providing shade (Figure 1c).

Therefore, to reduce the risk of desiccation of herpetofauna, we recommend that backfilling the fence with gravel be viewed as a time sensitive priority and, when logistically possible, backfilling take place as the fence is installed. In addition, removal of vegetation should not occur during dry periods with high temperatures. Ramps (i.e., one-way jump-outs) built at frequent intervals in the fence to allow animals to exit the road and avoid prolonged heat exposure may also mitigate this issue; however, further investigation is required. Although mortality caused by overheating on fences is not likely to be a major source of population decline, especially when compared to the threat the fence mitigates (i.e., road mortality), it is an example of a conservation action that reduces one threat while potentially creating another and, thus, an additional issue to be considered when planning and installing road mortality mitigation devices.

Author Contributions

Writing – Original Draft: S.P.B., R.D., J.D.L., and D.L.; Writing – Review & Editing: S.P.B., R.D., J.D.L., and D.L.; Conceptualization: S.P.B. and R.D.; Investigation: S.P.B. and R.D.; Formal Analysis: S.P.B. and R.D.

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Monitoring Rock Ptarmigan (*Lagopus muta*) populations in the Western Aleutian Islands, Alaska

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Abstract
Knowledge of population fluctuations of Aleutian Islands Rock Ptarmigan (*Lagopus muta*) is limited because of isolation and access. We reviewed the available but limited data on ptarmigan counts on islands in North America and evaluated the use of point counts to estimate changes in apparent numbers of Rock Ptarmigan on three islands (Adak, Amchitka, and Attu) in the Western Aleutian Islands in Alaska. We developed a standardized protocol to count numbers of Rock Ptarmigan (males and females) seen and/or heard on 5-minute point counts at 0.8 km intervals along marked global positioning system routes on Adak (2015–2017), Amchitka (2015), and Attu (2015) islands. Apparent densities based on Rock Ptarmigan seen and/or heard at 98 stops on 10 routes varied and were highest (1.9 birds per stop in 2015, 1.4 in 2016, and 1.0 in 2017) on Adak, lower (0.4 birds per stop) on Amchitka, and lowest (0.0 birds per stop) on Attu in late May–early June 2015. These island populations represent three subspecies and unique conservation units. Continuation of point-count surveys of these three subspecies in future years will provide baseline data over time and lead to a better understanding of any fluctuations in and synchrony among Rock Ptarmigan populations on these islands. This information is necessary for both theoretical (how are ptarmigan breeding populations regulated on islands) and practical reasons (identifying the optimal period for possible translocation to islands where ptarmigan were extirpated by introduced Arctic Fox [*Vulpes lagopus*]).

Key words: Rock Ptarmigan; *Lagopus muta*; Adak; Amchitka; Attu; Aleutian Islands; point counts; Alaska; USA

Introduction
Animal population fluctuations have long been of interest (Elton 1924), especially in insular areas that have no obvious corridors or where populations are otherwise isolated. Rock Ptarmigan (*Lagopus muta*) has a circumpolar distribution in northern latitudes with multiple subspecies: up to 14 in North America alone (AOU 1957; the last time subspecies were listed by the American Ornithologists' Union). Populations of Rock Ptarmigan occupy remote areas and their distribution can be highly fragmented including on islands. Thus, documentation of population fluctuations over time can be difficult. It is important to monitor the status and population changes of species, such as Rock Ptarmigan, and to investigate any underlying factors affecting long-term changes (Pedersen *et al.* 2005; Tesar *et al.* 2016). Measuring changes over time can be problematic in isolated areas such as in the Arctic and substantial efforts to learn how to effectively monitor population status of ptarmigan have been made (Pelletier and Krebs 1997; Bart *et al.* 2011).

There is some evidence that Rock Ptarmigan are cyclic on islands (Iceland; Magnússon *et al.* 2004), but population trends are poorly documented in North America (Weeden 1965; Cotter 1999; Taylor 2013). Peaks in Rock Ptarmigan cycles may represent a 10-fold increase from lows as discussed by Holder and Montgomerie (1993: 15), who cited studies in Scotland (Watson 1965) and Canada (Cotter 1991). Grouse cycles may be correlated with changes in their predator numbers or parasites and not only immigration or emigration from the local population (Dobson and Hudson 1992; Hudson *et al.* 1992; Cattadori *et al.* 2005).

As many as seven to eight subspecies of Rock Ptarmigan have been described from the Aleutian Archipelago, Alaska (AOU 1957). This number has been condensed into four groups (*L. m. evermanni, L. m. townsendi, L. m. atkhensis*, and *L. m. nelsoni*) of which *nelsoni* also occur on mainland Alaska to

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the east (Gibson and Kessel 1997; Montgomerie and Holder 2008). The *evermanni* subspecies occurs in the Near Islands (Attu and Agattu); *townsendi* occurs in the Rat Islands, including Amchitka and Kiska islands, while *atkhensis* occurs in the Andreanof Islands group including Adak, Tanaga to Atka, and possibly other islands. We studied three subspecies (*atkhensis*, *evermanni*, and *townsendi*), all of which are considered endemic groups or unique conservation units (Pruett *et al.* 2010).

Pelletier and Krebs (1997) tested line transect methods to estimate densities of breeding male ptarmigan and concluded they cannot be censused in small areas alone (size of their multiple study sites ranged from 3.0 to 13.5 km^2) as the results were too variable. Others (Brodsky and Montgomerie 1987; Cotter 1999; Watson *et al.* 2000; Favaron *et al.* 2006; Pedersen *et al.* 2012) used methods such as marking and reobservation, point transects, and distance sampling to estimate changes in population size. Bart *et al.* (2011) experimented with use of helicopter and fixed-wing aircraft to survey ptarmigan (and other species) over large areas in northern Canada and Alaska. All of these methods are either labour intensive and/or costly.

The Breeding Bird Survey protocol was developed in the early 1960s to estimate population trends in bird populations over time across large areas and variable habitats in North America (Bystrak 1981; Robbins *et al.* 1986; Droege 1990). It initially used 3-minute count intervals along routes with 50 stops at 0.8 km intervals with routes being surveyed once each year, during the breeding period. More recently 5-minute point counts have been used to better represent population indices of selected species (Ralph *et al.* 1995). All birds (males and females) both seen and heard are recorded at point-count stops.

Male Rock Ptarmigan during the breeding period (late April to early June) are conspicuous (they can range in colour from white to mottled shades of light brown to almost black [Attu] with white bellies and wings), perch up, and make flights from conspicuous sites while calling as they advertise and defend territories (Holder and Montgomerie 1993; Pelletier and Krebs 1997). Males in late May and early June can be solitary or paired with females, which are drab brown (in flight they have white wings) or mottled and inconspicuous in many, if not most, situations (some may be on nests).

Our objectives were to review the available literature on surveys of Rock Ptarmigan on three islands in the Western Aleutian Islands and develop and implement a 5-minute point count protocol to estimate trends in breeding populations of Rock Ptarmigan on Adak, Amchitka, and Attu islands in the Western Aleutian Islands (Figure 1).

Study Area

We reviewed the published and other available literature on Rock Ptarmigan (no other species of ptarmigan occur on these islands) on Adak (51.883°N, 176.65°W), Amchitka (51.35°–51.65°N, 178.617°–

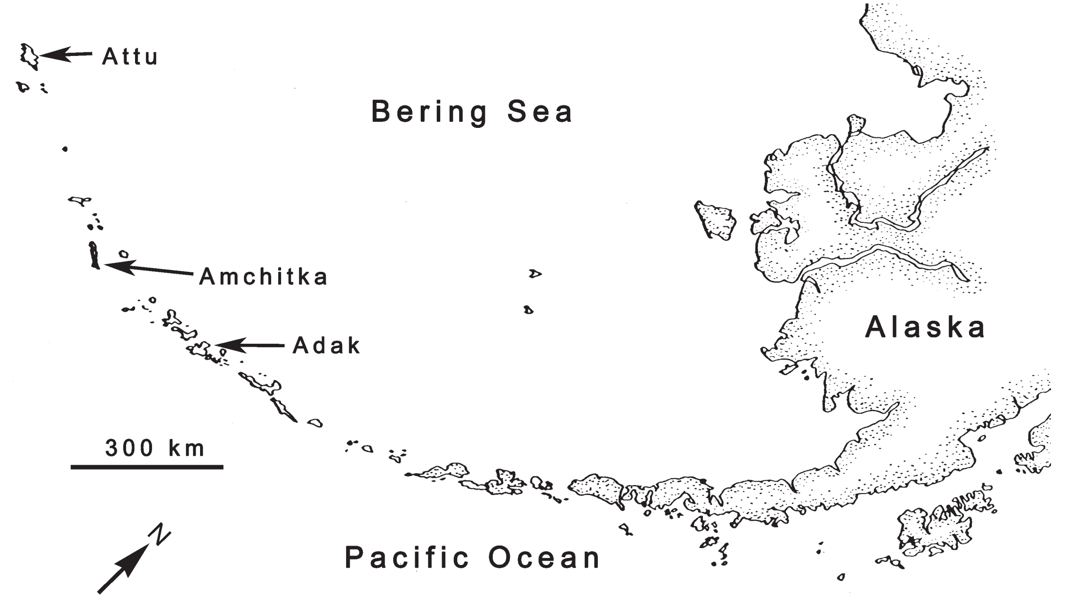

FIGURE 1. Aleutian Archipelago, Alaska showing Adak, Amchitka, and Attu islands.

179.483°E), and Attu (52.85°N, 173.183°E) in the Western Aleutian Islands, Alaska (Appendix S1). Areas surveyed on the three islands by us and others were similar low elevation sites (i.e., marine and stream terraces) adjacent to rarely-used trails (Amchitka and Attu) and occasionally used roads (Adak) that tended to follow coastal areas. The islands vary in size from ~300 km^2 (Amchitka) to 711 km^2 (Adak) and 894 km^2 (Attu). Adak is in the Andréanof group while Amchitka is in the Rat Island group and Attu is in the Near Islands. All are bounded by the North Pacific Ocean to the south and west and the Bering Sea to the north and east. The three islands are distant from each other with Amchitka being 301 km southwest of Adak that is 720 km east of Attu. There are no human residents on Amchitka and Attu and the resident population on Adak is variable and <100 people.

The geology of the three islands is complex with multiple inactive volcanos and volcanic flows as well as past glacial and marine erosion (Coats 1956; Fraser and Snyder 1959; Powers *et al.* 1960). Topography varies from gently sloping marine terraces to undulating tundra ranging to rugged mountains. We surveyed ptarmigan at an elevation of 10 to 300 m on all three islands. Lower and well-drained sites are occupied by grasses and sedges (*Calamagrostis* spp., *Leymus* spp., *Carex* spp.), and low-growing forbs including *Caltha* spp., *Ranunculus* spp., and *Lupinus* spp. with higher slopes dominated by crowberry (*Empetrum* spp.), *Empetrum*-*Cladonia* tundra, *Cladina* spp. lichens, and other mosses with some low-growing heather (*Cassiope* spp., *Phyllodoce* spp.), willow (*Salix* spp.), and Kamchatka Rhododendron (*Rhododendron camtschaticum* Pallas) shrubs (Amundsen and Clebsch 1971; Everett 1971; White *et al.* 1977).

The climate on all three islands is moist marine with frequent high velocity winds, rain, and fog (Gates *et al.* 1971). Mean daily average temperatures vary seasonally ranging from 0.4°C in January to 11°C in August. Daily (3.9°C in all seasons) and seasonal (9.4°C) ranges in temperature are limited (Armstrong 1971, 1977). Wind speeds are highly variable, and the mean annual precipitation ranges from 83 to 139 cm, depending on the island, with June and July being the months with lowest precipitation (Weatherbase 2015).

Methods

We established and conducted 5-minute point stations (protocol in Table 1) in 2015 following Ralph *et al.* (1995) at 0.8 km intervals along trails and roads on all three islands (dates in Table 2). All routes were conducted using an all-terrain vehicle. Starting points were at trail junctions or easily recognized local features and were recorded as global positioning system coordinates (on file with Alaska Maritime National Wildlife Refuge, Homer, Alaska, USA). Point-count routes were in areas where at least four stops at 0.8 km intervals could be established. There were four routes on Adak with from six to 17 stops, three routes on Amchitka with from four to 21 stops, and three routes with from four to seven stops on Attu (Table 2).

TABLE 1. Protocol for Rock Ptarmigan (*Lagopus muta*) surveys on Adak, Amchitka, and Attu islands, Western Aleutians, Alaska.

5-minute point counts
Count and record all Rock Ptarmigan seen (as male or female) or heard at each point stop. Rarely, the vehicle stopped near a ptarmigan which did not call or flush during the 5-minute count but flushed when the vehicle departed. These birds were included in the count.
Use of two counters is best (one front and one back). A central spot should be chosen.
Consolidate and record totals at end of each point count before returning to the vehicle.
Conduct point-count route prior to 10:00 AM.
Try to avoid high winds (>30 km per hr) and heavy rain.
Adak (use GPS locations at >0.8 km points)
Old Loran Road (10 stops).
Finger Cove (six stops).
Navfac Creek to past Clam Cove (17 stops).
Lake Andrew (six stops).
Amchitka (use GPS locations at >0.8 km points)
Jones Lake/Engineer Road (17 stops).
Charlie-Baker Taxiway south (four stops).
Infantry Road (21 stops).
Attu (use GPS locations at >0.8 km points)
Casco Cove to old airstrips (four stops).
Engineer Hill (top towards Peace monument) from Massacre Creek Beach Trail (seven stops).
Navytown (two stops) to Quonset Valley (four stops).

TABLE 2. Point-count (5-minute) surveys of Rock Ptarmigan (*Lagopus muta*; RP) on Adak, Amchitka, and Attu islands, Alaska, 2015–2017.

Island	Routes	Date	*n* points	RP seen/heard	Birds/Stop
Adak 2015	Finger Bay	29 May 2015	6	6	1.0
	Navfac Creek-Clam Lagoon	29 May 2015	17	12	0.7
	Old Loran Station Road	30 May 2015	10	49	4.9
	Andrew Lake	30 May 2015	6	6	1.0
Mean					1.9
Adak 2016	Finger Bay	18 May 2016	6	3	0.5
	Navfac Creek-Clam Lagoon	3 June 2016	17	16	1.4
	Old Loran Station Road	27 May 2016	10	10	2.1
	Andrew Lake	20 May 2016	6	10	1.7
Mean					1.4
Adak 2017	Finger Bay	1 June 2017	6	0	0.0
	Navfac Creek-Clam Lagoon	29 May 2017	17	16	0.9
	Old Loran Station Road	30 May 2017	10	16	1.6
	Andrew Lake	3 June 2017	3*	4	1.3
Mean					1.0
Amchitka	Infantry Road	9 June 2015	21	12	0.6
	Jones Lake-Engineer Road	9 June 2015	17	3	0.2
	Charlie to Baker Taxiway	9 June 2015	4	0	0.0
Mean					0.4
Attu	Old Loran/Old Runways	3 June 2015	4	0	0.0
	Massacre to Top Engineer	4 June 2015	7	0	0.0
	Navytown to Quonset Valley	4 June 2015	6	0	0.0
Mean					0.0

*High winds did not allow completion or resurveys of three of six routes.

Results

Rock Ptarmigan were heard or seen on all but one (2017 only) point-count routes on Adak and two of three on Amchitka but none was recorded on any of the three point-count routes on Attu (Table 2). However, one ptarmigan pair was seen and four males were heard prior to establishment of point-count routes but not near any of the point-count stops on Attu. Numbers of ptarmigan per stop recorded on point-count routes were highest (1.9, 1.4, 1.0; 2015–2017, respectively) on Adak, lower (0.4) on Amchitka, and non-existent (0.0) on Attu.

Discussion

A literature review of surveys and reports of Rock Ptarmigan on Adak, Amchitka, and Attu Islands revealed that Rock Ptarmigan were mentioned but that few surveys occurred over time with the exception of Amchitka with less information for Attu and Adak (Appendix S1). Large populations were documented for Amchitka (White *et al.* 1977) and Attu (Braun *et al.* 2014) over short periods. Overall, the literature suggests populations of Rock Ptarmigan on the three islands were historically low, especially on Attu.

Our point counts indicate the Rock Ptarmigan population was highest on Adak (2015–2017), lower in 2015 on Amchitka, and very low on Attu in 2015. Our point-count survey data on Attu in 2015 confirmed the ongoing decline on this island reported by Braun *et al.* (2014) from an intensive survey area conducted in 2003–2009. No effort was made to quantify ptarmigan numbers on Attu at higher elevations but ptarmigan were common at lower elevations in 2003–2005 (Braun *et al.* 2014).

The areas that we surveyed on all three islands had similar relief (low marine and stream terraces), were highly disturbed in the mid 1940s and 1950s (Amchitka and Attu) to the late 1990s (Adak), but are now well vegetated with low to non-existent recent human occupation. The three islands have similar predator assemblages (no ground mammals except rats, but with eagles, falcons, gulls, jaegers, owls, and ravens), but we have no estimate of densities. We have no basis to expect that predators (Gilg *et al.* 2003; Therrien *et al.* 2014) affected ptarmigan numbers on the three islands in 2015. We also detected no evidence that male aggressive behaviour was a factor at the densities we observed (Mougeot *et al.* 2003). The possibility that herbivory (Sinclair *et al.* 1988) could affect populations of ptarmigan across islands at substantial distances from each other through plant compounds was considered but was deemed unlikely because of isolation, few deciduous shrubs, and distances involved.

We documented three different levels of abundance of Rock Ptarmigan on Adak (high), Amchitka (lower), and Attu (very low) in 2015. The apparent, long-term decline on Attu since 2003 (Braun *et al.* 2014) appears to have stabilized from 2009 to 2014 (Braun *et al.* 2014). We agree with the hypothesis of Sandercock *et al.* (2005) that animal cycles in Arctic marine and terrestrial environments are most likely affected by latitudinal gradients in the north and altitudinal gradients elsewhere. The islands we studied are surrounded by the North Pacific Ocean and the Bering Sea and we worked at or below 300 m, thus the birds on these high latitude islands are mostly affected by the marine environment. We further agree that systematic surveys (Tesar *et al.* 2016) to detect trends in breeding populations (Nichols and Williams 2006) of different populations of Rock Ptarmigan are needed at least at 3–5 year intervals for both theoretical and practical reasons and should be able to detect population changes. It is possible that further translocations, similar to the one from Attu to Agattu in 2003–2005 (Kaler *et al.* 2010), may be considered to re-establish populations where they were extirpated by introduced Arctic Fox (*Vulpes lagopus*). Braun *et al.* (2014) documented the immediate recovery of ptarmigan after removal of Arctic Fox. But before such future translocations can be considered, a better survey protocol was needed to determine population status and trends of ptarmigan on these other islands. Knowing when ptarmigan populations may be ‘high’, especially if they cycle, also would be important so adequate numbers can be captured for immediate release on islands currently unoccupied by Rock Ptarmigan. This should reduce costs and improve chances for success of the transplants. Understanding fluctuations of Rock Ptarmigan populations, if they occur, is also important in the Arctic as the results from studies on islands may have relevance to ‘cycles’ and management of species of ptarmigan in mainland areas.

Point counts may be the most efficient and least expensive method to obtain standardized data (all birds seen and/or heard) for Rock Ptarmigan in areas with road or trail systems because large areas can be surveyed with few personnel. Early counts (May) should provide an opportunity to record more females than counts in early to mid June when females will be nesting. The three islands of Adak, Amchitka, and Attu each have different Rock Ptarmigan subspecies of conservation importance (Pruett *et al.* 2010) and their population dynamics deserve further study. There is a continuing need for population data to provide insight into whether cycles exist and their periodicity and synchronicity among islands.

Author Contributions

Conceptualization: C.E.B., W.P.T., and S.M.E.; Funding Acquisition: S.M.E.; Investigation: C.E.B., W.P.T., S.M.E., and L.M.S.; Writing – Original Draft: C.E.B; Writing – Review & Editing: C.E.B., W.P.T., S.M.E., and L.M.S.

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SUPPLEMENTARY MATERIAL:

Appendix S1. Historical review of information and previous studies and surveys for Rock Ptarmigan (*Lagopus muta*) on three islands (Adak, Amchitka, and Attu) in the Western Aleutian Islands in Alaska.

The Canadian Field-Naturalist

Note

Japanese Chaff-flower, *Achyranthes japonica* (Amaranthaceae), on the Erie islands, an invasive plant new to Canada

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Kamstra, J. 2019. Japanese Chaff-flower, *Achyranthes japonica* (Amaranthaceae), on the Erie islands, an invasive plant new to Canada. Canadian Field-Naturalist 133(1): 56–59. https://doi.org/10.22621/cfn.v133i1.2161

Abstract

Japanese Chaff-flower, *Achyranthes japonica* (Miquel) Nakai (Amaranthaceae) was found growing on two islands in western Lake Erie: East Sister Island and Middle Island. These are the first documented reports for this species in Canada, and these locations are approximately 300 km north of the nearest reported observations in southern Ohio. Japanese Chaff-flower is a non-native plant from Asia, which is highly invasive in the United States and has the potential to become so in Canada.

Key words: Japanese Chaff-flower; *Achyranthes japonica*; East Sister Island; Middle Island; Ontario; non-native invasive plant; range extension

During a visit to East Sister Island Provincial Nature Reserve in Lake Erie (Essex County, Ontario) on 27 September 2018, I found a small population of Japanese Chaff-flower, *Achyranthes japonica* (Miquel) Nakai (Amaranthaceae) in the shade of moist deciduous forest co-dominated by American Elm (*Ulmus americana* L.) and Common Hackberry (*Celtis occidentalis* L.; Figure 1). The location was at 41.81230°N, 82.85764°W in the island's interior, at least 100 m from the Lake Erie shoreline. The population consisted of 15 plants, up to 50 cm tall. One specimen was collected.

Two larger and taller stands of the plant were encountered on East Sister Island at ~41.8117°N, 82.8587°W in a small gap in a similar type of forest and at 41.8120°N, 82.8582°W. These were ~50 m from the shoreline. Both stands were more robust and dense than those at the first location, each consisting of several dozen plants over 60 cm tall. They were growing on moist, level ground that may receive seasonal inundation and were partly shaded by Common Elderberry (*Sambucus canadensis* L.) and associated with Stinging Nettle (*Urtica dioica* L.), Common Pokeweed (*Phytolacca americana* L.), Spotted Jewelweed (*Impatiens capensis* Meerburgh), and Dwarf Clearweed (*Pilea pumila* (L.) A. Gray).

On 5 October 2018, I visited Middle Island, part of Point Pelee National Park, also in Lake Erie and situated ~20 km southeast of East Sister Island. I observed two patches of Japanese Chaff-flower on the west end of that island within 15 m of the shoreline. Five plants were at the base of a limestone shingle berm in shade under a moist deciduous forest dominated by Common Hackberry at 41.68366°N, 82.68593°W. There were few other plants in the ground layer. The second larger nearby patch, at 41.68358°N, 82.68620°W, consisted of several dozen individuals. This patch was in semi-shade under forest dominated by Common Hackberry, associated with Stinging Nettle and Common Pokeweed. The island was surveyed quite comprehensively and no other patches of Japanese Chaff-flower were found. T. Dobbie (pers. comm. 3 December 2018) reported finding and photographing a plant that she did not recognize while conducting a plant survey on Middle Island on 8 June 2018. The plant was nondescript with no fruit or flowers because it was early in the season. She sent the photo to me, as I was now familiar with the species, and I confirmed that it was Japanese Chaff-flower, making that the earliest documentation of the species in Canada. Discussions with leading field botanists, the Canadian Food Inspection Agency (C. Wilson pers. comm. January 2019) and a check of the records and specimens available at the herbaria of the Canadian Museum of Nature, Agriculture and Agri-Food Canada, the Database of Vascular

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FIGURE 1. Japanese Chaff-flower (*Achyranthes japonica*) observed on East Sister Island, 27 September 2018. The plant was growing in partial shade. Photo: James Kamstra.

Plants of Canada (VASCAN 2019), and the Ontario Ministry of Natural Resources and Foresty revealed no previous reports of this species in Canada.

Japanese Chaff-flower is native to Japan, Korea, and China, where it is known for its medicinal properties (Jung *et al.* 2007). The first North American record of Japanese Chaff-flower was from Martin County in eastern Kentucky, in August 1981 (Medley *et al.* 1985). Within a decade, the plant had dominated the floodplains in the area where it was first discovered and, within 15 years, had spread over 500 km along the Ohio River valley (Evans and Taylor 2011). The first documentation in Ohio was from 1992 (Vincent and Cusick 1998). In Flora of North America, Robertson (2003) indicated the plant's presence in Kentucky, West Virginia, and Ohio. Evans and Taylor (2011) mapped the distribution in the United States at the time showing that, by 2011, it had been confirmed in every county along the Ohio River from West Virginia to Illinois, with isolated populations in Georgia and Tennessee.

Japanese Chaff-flower is on the watch list for several states including Michigan (Michigan Invasive Species 2018) and Wisconsin (Wisconsin DNR 2018), both states where it has not yet been reported. None of the available mapping shows Japanese Chaff-flower to be currently present near Lake Erie. Both EDDMapS (2018) and iNaturalist (2018) show that the nearest reported observations are in the vicinity of Cincinnati, Ohio, ~300 km south of the Erie Islands. R. Gardner (pers. comm. 22 January 2019), confirmed that, currently, Japanese Chaff-flower has been recorded only from the southern counties bordering the Ohio River in that state.

At first glance, Japanese Chaff-flower superficially resembles Lopseed (*Phryma leptostachya* L.) because of the narrow erect spikes crowded with deflexed fruits and opposite leaf arrangement. However, the flowers of Japanese Chaff-flower have five deflexed tepals, and the ovate-elliptical leaves are glabrous and lack teeth (Robertson 2003). The fruits hang tightly on the spike; each one contains a pair of spiny bracts that adhere to fur and feathers. The seeds are mainly spread by animals or water transport (Evans and Taylor 2011). Japanese Chaff-flower is typically 0.75–1.5 m tall (Robertson 2003), but can reach 3 m (Schwartz *et al.* 2016). Throughout its introduced range in the United States, it most frequently grows in semi-shaded moist soils, but can also occur in drier and sunny sites (Schwartz *et al.* 2016) and is, therefore, capable of colonizing a variety of habitats.

The origin of the plants on the two Erie islands can only be speculated. Middle Island is ~18.5 ha in area and located 4.5 km south of Pelee Island, the nearest land mass. East Sister Island is ~13 ha in area and more remote at 10 km north of North Bass Island, Ohio, the nearest land mass of more than 2.5 ha. Both East Sister and Middle Islands support large nesting colonies of Double-crested Cormorants (*Phalacrocorax auritus*) numbering in the thousands (McGrath and Murphy 2012) as well as smaller numbers of nesting Herring Gulls (*Larus argentatus*), Black-crowned Night-herons (*Nycticorax nycticorax*), Great Blue Herons (*Ardea herodius*), and Great Egrets (*Ardea alba*; IBA Canada 2018). Because the seeds of Japanese Chaff-flower can readily attach to fur or feathers, the plants may have been carried to both islands by cormorants or other birds. Cormorant nests were present in trees in the vicinity of Japanese Chaff-flower patches on both islands.

Choi *et al.* (2010) examined nearly 4000 birds for the presence of plant propagules on a remote island off Korea. Three species of migratory birds were found to have seeds of Japanese Chaff-flower attached to their feathers, including two marsh species: Eurasian Bittern (*Botaurus stellaris*) and Swinhoe's Rail (*Coturnicops exquisitus*). Choi *et al.* (2010) suggest that birds may have been responsible for the spread of Japanese Chaff-flower to offshore islands in Korea where it has become highly invasive.

Considering the relatively intense floristic survey of the Lake Erie Islands (Duncan *et al.* 2010), it seems likely that Japanese Chaff-flower is a recent arrival. Given that Japanese Chaff-flower is not known from the south shore of Lake Erie (R. Gardner pers. comm. 22 January 2019), it seems likely that birds were the means for its spread onto East Sister and Middle Islands. The sheer abundance of cormorants, which nest all over both islands, make them a likely vector. Japanese Chaff-flower also spreads by water, but the plant is not known to be present elsewhere along the Lake Erie shore. Furthermore, the plants found on East Sister Island were inland and not along the immediate shoreline.

Japanese Chaff-flower has the potential to become an aggressive invasive plant in southern Ontario. Because of the seriousness of this new threat, several fact sheets have been produced to inform the public about control methods and encourage them to report sightings (Evans and Taylor 2011; Rathfon and Eubank 2013; Schwartz *et al.* 2015). The plant has spread rapidly along river systems in the United States and has been identified as a high priority invasive in Indiana (Rathfon and Eubank 2013). A single large plant can produce more than 1000 seeds and 94% of the seeds have been shown to be viable (Evans and Taylor 2011). Infestations can attain densities of more than 70 plants/m^2, which will shade out all other plants below them (Evans and Taylor 2011). They also have the ability to invade undisturbed forests that have not been previously impacted (Schwartz *et al.* 2016).

The United States Department of Agriculture (USDA 2014) has evaluated the plant's weed risk potential and, based on its native range, determined that it can survive in hardiness zones 5–10. Consequently, it has the potential to spread to all of Ontario south of the Canadian Shield, as well as parts of Quebec, the Maritimes, and even parts of British Columbia. The Canadian Food Inspection Agency, Canada's national plant protection authority, is conducting a full risk assessment of the Japanese Chaff-flower to determine its invasive potential in the country (C. Wilson pers. comm. January 2019). Control, research, and ideally eradication should be high priorities before the plant gains a strong foothold, although this may not be possible given its spread in the USA.

Voucher specimens

Canada, Ontario: Essex County, Pelee Township, East Sister Island. 41.81230°N, 82.85764°W. About 15 plants growing in moist soil in deciduous forest co-dominated by American Elm and Common Hackberry, 27 September 2018, *CAN-10091002* (CAN).

Canada, Ontario: Essex County, Pelee Township, Middle Island, Point Pelee National Park. 41.68358°N, 82.68620°W. About 35 plants growing in moist soil near shoreline in deciduous forest dominated by Common Hackberry, 5 October 2018, *CAN-10091001* (CAN).

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Gray Wolf (*Canis lupus*) recolonization failure: a Minnesota case study

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Abstract
During the past few decades, Gray Wolves (*Canis lupus*) have recolonized many areas in the United States and Europe. In many other cases, however, although dispersing wolves reached areas with adequate prey, a population failed to recolonize. Herein, we provide a case study detailing how a wolf pack attempted for three years to recolonize an area 55 km from a long-established population and within 25 km of Minneapolis and St. Paul, Minnesota, but failed. The pack produced three litters of pups and at one time included 11–19 members, but it preyed on livestock and dogs and, consequently, was lethally removed. The history of this pack's attempt to recolonize an area long devoid of wolves exemplifies the issues that have prevented earlier recolonizations in non-wild lands in Minnesota and elsewhere and that promise to do so well into the future.

Key words: *Canis lupus*; depredation; distribution; Gray Wolf; livestock; recolonization

Introduction

During the past several decades, Gray Wolves (*Canis lupus*) have been recolonizing many areas of the world (Boitani 2003; Chapron *et al.* 2014; Mech 2017). In the contiguous United States, they have recolonized Wisconsin, Michigan, the northwestern USA, and new areas of Minnesota, and are dispersing into adjacent states (Mech 2017). Biologically, wolves are prolific and can survive anywhere with sufficient food. Because they can subsist not only on prey but also on carrion and even garbage, the only constraints on where they recolonize are anthropogenic factors, including vehicle strikes, legal harvest, illegal killing (including poisoning), and legal livestock-depredation control.

Humans persecuted wolves throughout much of their original range; thus, those that survived lived primarily in wilderness or areas with low human density. That gave some biologists the impression that wilderness was required for their survival, and early models to predict potential wolf habitat in the Upper Midwest made that assumption (Mladenoff *et al.* 1995, 1999, 2006), although it was later challenged (Mech 2006a,b). Eventually the models were refined (Mladenoff *et al.* 2009) to reflect the fact that wolves do not require wilderness (Mech 2015). However, to survive and repopulate a new location for multiple generations, wolves do need to avoid areas and behaviours that bring them into conflict with human activities (Erb and Don Carlos 2009; Mech 2017).

In Minnesota, wolves have been expanding their range from a wilderness reservoir in the northeastern part of the state. Since the early 1970s, they have been gradually recolonizing westward and southward toward semi-wilderness, agricultural areas, and a major metropolitan area (Fuller *et al.* 1992; Erb and Don Carlos 2009; Erb *et al.* 2017). As their numbers and distribution have increased, so have depredations of livestock and the number of wolves killed for livestock-depredation control (Mech 1998; Harper *et al.* 2005; Ruid *et al.* 2009). By 1997–1998, the annually estimated Minnesota wolf population of 2445–2856 had reached the extent of its current distribution (Figure 1) and has since failed to further recolonize the state (Berg and Benson 1999; Erb *et al.* 2017).

Individual maturing male and female wolves have dispersed far and wide from their northern Minnesota reservoir to all parts of the state and have entered nearby states including Wisconsin, Michigan, South Dakota, and North Dakota (Fritts and Mech 1981; Gese and Mech 1991; Merrill and Mech 2000). To recolonize a new area, unrelated males and females

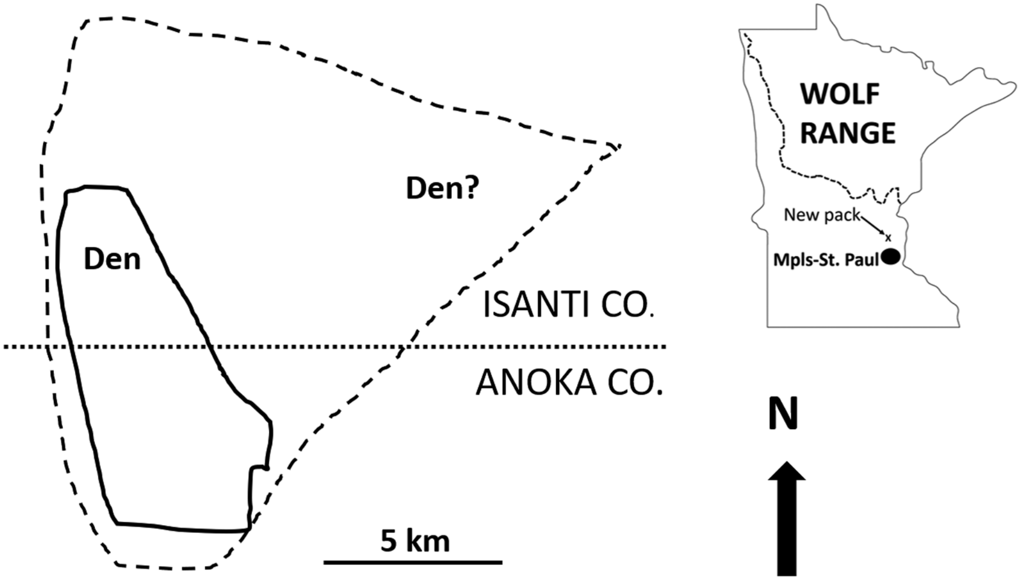

FIGURE 1. Study area where the Isanti Gray Wolf (*Canis lupus*) pack attempted to recolonize. Dashed line connects outermost locations where wolf signs were found and represents the minimum area the pack used from 2014 through 2017. Solid line represents approximate boundary of the Cedar Creek Ecosystem Science Reserve.

must find each other in a suitable location, establish a territory there, pair bond, produce pups, and survive for several years. If pets or livestock are available locally, resident wolves often begin preying on them. Such depredations decrease human tolerance of wolves (Williams *et al.* 2002; Karlsson and Sjostrom 2007; Olson *et al.* 2015), and state and/or federal wolf depredation control agencies often lethally remove them or translocate them depending on applicable laws. Thus, wolves are only able to recolonize areas with low human presence.

In Minnesota, wolves have attempted to recolonize and establish a breeding population southward ~25 km north of the Minneapolis–St. Paul suburbs, at about 45°43′N (Erb and Don Carlos 2009; Erb *et al.* 2017). During 1997, a pack or pair was recorded about 45 km west of there near the Sherburne National Wildlife Refuge (Berg and Benson 1999), but by 2004 that pack no longer existed for reasons unknown (Erb and Benson 2004). In 2010–2011, a new pack survived for two years about 25 km south of the current wolf range, but two adults, a yearling, and four pups were then lethally removed for depredation control.

In 2014, a new pack (the Isanti pack) formed 55 km south-southeast of the current wolf range, and within 25 km of the Minneapolis–St. Paul suburbs in an area with 0–10% chance of wolf recolonization according to the latest wolf habitat models, which consider road density and agriculture (Mladenoff *et al.* 2009). This article details the 3-year attempt by wolves to recolonize that area.

Study Area

The study area (at about 45°27′N, 93°08′W) comprises ~80 km^2 in northern Anoka and southern Isanti counties in east-central Minnesota (Figure 1). Most of the area is rural residential and agricultural, interspersed with patches of uninhabited lowland and woodlots, the largest being the University of Minnesota Cedar Creek Ecosystem Science Reserve (CCESR) covering about 21 km^2. Roughly 50–60% of the study area is open agricultural fields, and the area is heavily roaded; the most remote location in the area is 1.54 km from the nearest road. Much of the known territory of the Isanti pack fell in Athens township, which had a 2016 population density of 24 people/km^2 (Towncharts 2018) and Linwood township with a density of 62 people/km^2 (calculated from the township area of 84.992 km^2 and the 2016 total population of 5284; American Factfinder 2019). Estimated pre-fawning White-tailed Deer (*Odocoileus virginianus*) density for this area of the state in 2016 was 8.5 deer/km^2 (D'Angelo *et al.* 2016), and Wild Turkeys (*Meleagris gallopavo*) were common. Small herds of cattle are widely scattered throughout the study area. Some 9452 cattle, including calves, occupied Isanti County (1157 km^2) in 2012 (USDA 2012). Domestic dogs are common, and some are free-ranging.

Methods and Results

The first record of wolves having bred in the study area was a trail camera photo of three and possibly four adult-sized wolves during winter 2014–2015. Although a pair of wolves can form at any time, a pair with at least one other adult-sized wolf in winter would almost certainly indicate that the pair had established a territory and produced at least one pup, most likely in the previous spring (Mech and Boitani 2003). There was also a report of a Coyote (*Canis latrans*) trapper catching a wolf in the area in winter 2014–2015.

During summer 2015, wolves denned on the CCESR within 1.4 km of an occupied residence and produced at least eight pups that were observed and photographed several times. Throughout summer, researchers associated with the reserve frequented areas within 100 m of the den multiple times a week during the course of their previously established research. During autumn 2015, nine wolves were seen twice on CCESR property and, in November 2015, 11 (which could indicate that nine pups were produced). In mid-January 2016, a Coyote trapper captured and released a wolf from a snare just outside the CCESR.

In mid-winter 2015–2016, L.D.M. drove the roads throughout the study area and found several places where, between 1 January and 6 February 2016, up to eight wolves had crossed. The greatest distance between locations where wolf tracks, or in one case wolf fur on a barbed-wire fence, were found was 14 km, with the centre of that area being 5.5 km from the 2015 den (Figure 1). By calculating the area enclosed by all the locations where such wolf sign was found, we estimated that the minimum area used by this wolf pack was 80 km^2.

From August 2015 to April 2016, within the area covered by these wolves, three cattle were killed and one wounded, and three dogs were killed by wolves (Table 1). Thus, in April 2016, Wildlife Services, the federal government's depredation control agency (Ruid *et al.* 2009), lethally removed three male wolves, weighing 35, 42, and 47 kg.

Trail cameras on the CCESR continued to record wolf presence throughout summer 2016. In June, wolves killed a 91-kg calf, and Wildlife Services lethally removed a 36-kg male wolf, a 27-kg yearling female, and a 32-kg breeding female from the study area; sign of additional adult wolves remained. Four pups were captured alive during depredation control in late June and released on site according to United States Fish and Wildlife Service requirements that all young of the year be released before 2 August when wolves are protected by the *Endangered Species Act* as they were in 2016. One pup was dead in a snare so could not be released.

Local residents had reported seeing up to eight pups nearby before this. Because the 2015 den at the CCESR was unused in 2016, and trail cameras on CCESR failed to indicate concentrated wolf use of the CCESR, the 2016 den was very likely off CCESR property. Based on where the five pups were caught in late June 2016, on reports of local residents, and on the nearest remote area, we judged that the 2016 den was about 10 km east-northeast of the 2015 den.

During autumn 2016, trail camera photos indicated that at least one wolf still used the study area, and, in May 2017, wolves killed another calf in the same area as the 2016 depredations; Wildlife Services lethally removed a 32-kg male wolf and a 26-kg, non-breeding female. Since 2015, all but one complaint of wolves attacking livestock or dogs in this area were verified by authorities. As of February 2019, CCESR trail cameras have recorded only a single wolf.

Table 1. Estimated numbers of Gray Wolves (*Canis lupus*), verified complaints, and numbers of wolves removed by year for the Isanti pack, Minnesota.

	2014	2015	2016	2017
Estimated number of wolves in Isanti pack				
Adults/yearlings	2	3	11	3
Pups	≥1	8	8	0
Total	≥3	11	19*	3
Number of verified complaints				
Dog complaints	0	2	1	0
Livestock complaints	0	1	2	1
Total	0	3	3	1
Number of wolves removed				
Adults/yearlings	0	0	6	2
Pups	0	0	1	0
Total	0	0	7†	2

*Assumes eight pups were born in early April before three adults were lethally removed later in that month.
†In addition to the seven wolves removed, four wolf pups were captured and released on site according to United States Fish and Wildlife Service guidelines because they were caught before 2 August.

Discussion

Although wolves have recolonized much of the northern half of Minnesota as well as many areas of Wisconsin and Michigan over the last few decades, they have failed to recolonize many other adjacent areas with adequate natural prey. These latter areas are those with considerable populations of people and domestic animals. However, it is not for lack of trying (Mech 2017).

This case history illustrates the details of how and when wolves begin to establish in areas with livestock and dogs, they may begin treating these domestic animals as natural prey. This usually happens soon after the wolves start reproducing, especially when a third age class is present. Domestic animals are easy targets because they can nearly always be found in the same place, unlike most natural prey, which require hunting down. The increase in domestic animal depredations with the presence of a third age class or a larger pack (Bradley *et al*. 2015) may result from reduced natural local food resources and more dependent wolves to feed.

Regions similar to our study area were predicted to have probabilities of wolf recolonization of 0–10% (Mladenoff *et al.* 1995, 1999, 2006), and our findings explain why. Wolves can and do inhabit these areas (Mech 2006a,b) but tend to persist longer in wilderness and wild lands where they conflict much less with human interests (Mech 2017). Given the great variation in land use across large areas, gradients of wolf-recolonization suitability exist; thus, along the frontiers of established wolf populations, wolves will continue to attempt to expand into areas with higher predicted probabilities of recolonization, with varied results.

The large body masses of the wolves captured in this study area showed that their lack of success in recolonization and their predation on domestic prey were not because they were desperate for food. All the wolves caught were in excellent condition. Four of the eight were above average for wolves feeding on all-natural prey (Mech 2006c), including the 47-kg male that weighed more than all but two of 873 captures of Minnesota wolves on a natural-prey diet (L.D.M. and S.B. Barber-Meyer unpubl. data).

Despite living among people and livestock close to the suburbs of Minneapolis and St. Paul, the Isanti wolf pack was able to use small areas away from humans to den and raise their young and, in that way, persist for at least three years. Like so many other wolf attempts to recolonize similar areas of Minnesota and other states, this one nevertheless failed because of the conflict that often results from wolves living close to areas with high densities of people, livestock, and pets. Wolf survival in the long term requires large areas of extensive wild lands (Young and Goldman 1944; Mech 1970, 2017; Ruid *et al.* 2009). This case study details why.

Author Contributions

Writing – Original Draft: L.D.M.; Writing – Review & Editing: L.D.M., F.I., J.K., and J.H.; Conceptualization: L.D.M. and F.I.; Investigation: L.D.M., F.I., J.K., and J.H.; Methodology: L.D.M., F.I., J.K., and J.H.; Formal Analysis: L.D.M.; Funding Acquisition: L.D.M. and F.I.

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The Canadian Field-Naturalist

Book Reviews

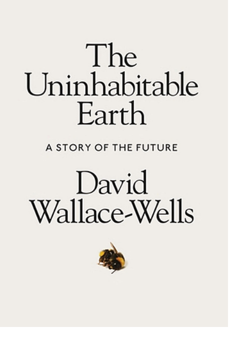
Book Review Editor's Note: *The Canadian Field-Naturalist* is a peer-reviewed scientific journal publishing papers on ecology, behaviour, taxonomy, conservation, and other topics relevant to Canadian natural history. In line with this mandate, we review books with a Canadian connection, including those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

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

Climate Change

The Uninhabitable Earth: Life After Warming

By David Wallace-Wells. 2019. Tim Duggan Books, Penguin Random House. 320 pages, 27.00 USD, Cloth.



"We run carelessly over the precipice after having put something in front of us to prevent us seeing it."—Blaise Pascal, *Pensées* (1623–1662)

I can summarize this review in a single sentence. Everyone should be compelled to read this book to truly appreciate the nature of the threat from climate change.

David Wallace-Wells lays out in elegant, yet blunt, language the nature and potential extent of the inevitable disruption to humanity from climate change. The threat is ubiquitous and inexorable, it is occurring now, accelerating much more rapidly than we think, and the outcome is, to quote from his opening sentence, "worse, much worse, than you think" (p. 3). Our response to this horrific scenario has been and continues to be inadequate. One can read all manner of apocalyptic claims about climate change and less dire public warnings from the climate scientists themselves who fear to sound alarmist. These proclamations are always couched in sugary dribbles of "but there is still hope". Most of this hope emanates from ignorance and from the belief that the calamity is far down the arrow of time and can be alleviated by technology. Wallace-Wells puts paid to this dream by noting the rapidity with which the current 1.1°C and causal doubling of atmospheric CO_2 have occurred. I worked it out; 90% of greenhouse gases have been accumulated since Bob Dylan was born, and 80% since he sang the "The Times They are a Changin". In one baby boomer generation, this catastrophe has occurred.

This book starts with one stunning fact after another and never falters through 225 pages of text. It leaves one breathless and raw. In Section 1, "Cascades", Wallace-Wells describes the cascading effects of climate change, emphasizing the interconnectedness of our earthly paradise. He reminds the reader of the five great mass extinctions and points out that four of them involved increases in greenhouse gases and warming temperatures of up to 5°C. But these events took thousands or even millions of years to develop, we have only had Dylan's lifetime. Mind you, we have known since the mid-19th century that the simple fact of adding certain gases to the atmosphere would warm the planet, but until recently the idea that we would release hundreds of millions of years of accumulated hothouse carbon in just one century never really sank in. Indeed, for 30% of the population, it is still fake news. Wallace-Wells is Al Gore on steroids and presents an endless mass of facts from every facet of our earthly sphere, and yet we still act as though climate change is something distant, to be fixed by recycling, getting a smaller car, becoming vegetarian, and all manner of single issue fixes that most people resist and resent. Why? Because we can't easily grasp the big picture: the frailty of permanence, the cumulative impact of eight billion of us and our fossil fuel technologies. And thus, we are doing too little.

Section II, "Elements of Chaos", is a series of chapters on specific disastrous effects of climate change, such as heat, hunger, drowning, wildfire. I won't try to recount the terrors that Wallace-Wells chronicles, there are far too many. Suffice to say these make depressing and startling reading. Section III, "The Climate Kaleidoscope", covers a range of issues: storytelling, capitalism, technology, the politics of consumption, history after progress (a very interesting read), and ethics at the End of the World. All of this is provocative and suitably disturbing. Finally, section IV discusses the concept of the Anthropic Principle. I will try to paint the context Wallace-Wells presents: how fragile our civilization and ecosystems are, and how inevitable, drastic and long-term climate change will be.

Wallace-Wells lists several major misconceptions that we hold about climate change, "myths" that encourage us to be blasé about the end of the world envisioned by so many climate scientists. First, he says we believe the "fairy tale" that climate change is slow. It isn't. By geological or even human timescales, it is advancing at terrifying speed. Check your news stories of 2019; climate change is here. Second, many see climate change as a problem largely confined to the Arctic. Climate change is global of course. In 2019, Karachi recorded the hottest April of any city on earth ever, and in 2019 earth itself experienced the hottest June ever recorded. Third, many see climate change as a problem for the natural world and some species, like Polar Bears, but not for humanity. This misapprehension arises from our failure to see ourselves as part of nature, and a disruptive yet wholly dependent part at that. Fourth, many see climate change as a matter of slowly rising sea levels relevant only to low-lying coastal areas and remote tropical atolls. A fifth pernicious myth is that burning fossil fuels is a necessary price we pay to foster "economic growth and good paying jobs". These necessary benefits pay for themselves by creating the technologies needed to repair the problems caused by the resultant climate change, using, for example, carbon capture, cold fusion, daring experiments spraying other gases into the atmosphere or lead powder into the oceans, or building giant reflective umbrellas. In other words, more of the same hubris that got us here. Throughout the book Wallace-Wells drops 'fact bombs' that support my view that we are insane. Example, bitcoin (p. 33) consumes more electricity than is produced by all the solar panels on our planet. The same bitcoin produces as much CO_2 annually as one million transatlantic flights (p. 179), and nearly 2% of the global total CO_2 emissions.

We deeply embrace the belief that progress is built into our civilization and society. There will be more and better food, time-saving devices, medical life extending treatments, poverty eliminated, and endless entertainment and travel opportunities. This myth is readily embraced by the wealthy fractions of society and the well-off eagerly endorse claims, such as those of the biologist and prolific writer Steven Pinker (Pinker 2018), that every measure shows human progress, that wealth, the economy, longevity, health, human rights, etc., are improving and that the Cassandras have been repeatedly proven wrong. Malthus, Ehrlich, the Club of Rome, even David Attenborough can hang their heads in shame for doubting the sharp upward thrust of history. We tend to forget that for 95% of human history progress was, to say the least, minimal, that population growth was almost invisible (see Hardin 1995), and economic growth was not a concept, much less a reality. Only in the last 5% of our time on earth have we seen notable changes from the 200 000 years of hunter gatherers and even that period of "progress" has regularly been blighted by setbacks from wars, diseases, and various genocides and pogroms. So-called progress has been largely over the past 200 years a product of the massive consumption of fossil fuels. A major result has been the staggering increase to eight billion large, warm blooded, consumptive apes. A large portion still wallows in poverty and can't afford to attend a Raptor's game much less a holiday in space.

The glorious irony of climate change is, of course, that we are entirely to blame and that the fabulous wealth and sumptuous lifestyles we have created are the exact reasons we are careening to calamity. Several times Wallace-Wells highlights this important point. For example, on p. 53, "The graphs that show so much recent progress in the developing world (i.e., decline in poverty and hunger, improvement in life expectancy, education gender relations, and more) are, practically speaking, the same graphs that trace the dramatic rise in carbon emissions that has brought the planet to the brink of overall catastrophe". Everyone reading this review was/is/will be a major creative participant in climate change.

Climate change is occurring now, will accelerate in the future, will endure for thousands of millennia, and is entirely a product of the very recent past. Our impact on climate will last not until our grandchildren die off but for millions of years. We need more books like this one to slap us hard, to not sugarcoat reality with false reassurances. If we continue our current insanity, then our civilization will be a tiny blip of an afterthought in the eternity of climate change.

"Man is not clever enough to limit his greed to courses that will not destroy the ecosystem." —Gregory Bateson, *Mind and Nature* (E.P. Dutton, 1968)

Note: I have deliberately omitted the myriad terrifying scenarios recounted by Wallace-Wells. Read the book. Meanwhile, I include Corn and Yalkin (2019), an examination of the great physical and mental toll on those scientists conducting research on climate change.

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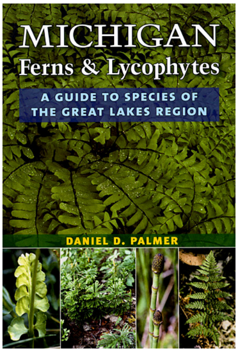
BOTANY

Michigan Ferns & Lycophytes: A Guide to Species of the Great Lakes Region

By D.D. Palmer. 2018. University Michigan Press. 381 pages, 29.95 USD, Paper.



The state of Michigan, USA, enjoys exceptionally rich floristic coverage and is admirably served both by the *Field Manual of Michigan Flora* by E.G. Voss and A.A. Reznicek (University of Michigan Press, 2012) and the excellent Michigan Flora Online (https://michiganflora.net/home.aspx). The *Field Manual* is widely seen to serve more than 'just' a local state flora function and to also provide a regional (Great Lakes) perspective. For decades, however, a curious gap in the state coverage has been with pteridophytes. Although a fern treatment was provided earlier by C. Billington's *Ferns of Michigan* (Cranbrook Institute of Science, 1952), and the University of Michigan was home base for American fern guru W.H. (Herb) Wagner for much of the time thereafter, no modern fern treatment existed. The current volume corrects that omission.

The book begins with a variety of standard introductory elements for a flora, including a brief summary of fern investigations in the state, a discussion of what makes pteridophytes 'tick', and a review of the abundance and distribution (including habitats) of pteridophytes in the state. A map showing the landscape diversity and/or major vegetation zones of Michigan would have been helpful here for understanding local distributions, especially for out-of-state readers, but the text does satisfy our basic needs in that regard. Similarly, it would have been useful to have a brief discussion of what makes Michigan's fern flora special on a regional or even continental scale. We eventually get some of this with discussion of endemics, but there are several broad biogeographic and evolutionary themes well represented in the Michigan pteridophyte flora that also could have been profitably discussed here.

It is quickly evident that *Michigan Ferns & Lycophytes* provides an admirable introduction and review of the distribution and identification of pteridophytes in that state. There are excellent photographic and line drawing illustrations of key identification features, only slightly hampered by the absence of scale bars. The *Isoetes* photo montage (p. 290), for example, is particularly effective for this tricky group. Individual treatments provide effective, clearly expressed technical descriptions for the taxon in question with an emphasis on identification. The comparative feature tables provided for most complex groups such as *Botrychium*, *Dryopteris*, *Equisetum, Lycopodiella*, and *Woodsia*, are very helpful. The identification keys for each genus are sound and are not overly laden with technical jargon. Distributional information seems to be quite up-to-date and accurate, although the unreferenced report of *Cystopteris tennesseensis* being (disjunct) in northern Ontario (p. 101) is news to us.

In some cases, we suspect treatments may be over-simplified. For challenging members of Lycopodiaceae, for example, it would be great to believe Great Lakes taxa are as straightforward to identify as they are presented to be in *Michigan Ferns & Lycophytes.* More than 30 years of wrestling with them on this side of the border suggests they are often otherwise!

Michigan Ferns & Lycophytes prominently claims a secondary objective, professing to share the same regional scope as that of the *Field Manual of Michigan Flora*. Yes, most Great Lakes pteridophyte taxa are found in Michigan, but that is equally true for New York, Ontario, Ohio, etc. To truly be a regional guide, however, also requires that a local treatment explicitly reflect the regional context. *Michigan Ferns & Lycophytes* falls short in this, particularly regarding

Canadian input. At least seven species are listed (pp. 11 and 238) as occurring in the Great Lakes portion of adjacent Ontario, Minnesota, and Wisconsin but not in Michigan, without further discussion. Another species—*Isoetes tuckermanii* A. Braun—and at least seven more hybrids known in Ontario from within this region are not even mentioned.

The discussion of *Dryopteris* hybridization (pp. 150–153) omits reference to any of the regionally—indeed, globally—significant cytological research on this genus undertaken by Ontario's Donald M. Britton. Similarly, the discussion of *Botrychium* (*s. l.*) diversity also makes no mention of how sites along the Ontario shore of Lake Superior were critical to the taxonomic discoveries and innovations of the University of Michigan team studying this group.

Simply put, Wagner and Britton made the largest contributions of anyone to our understanding of the pteridophytes of the Great Lakes. Accordingly, the absence of even a single citation from Britton's voluminous Great Lakes-relevant literature—not even W.J. Cody and D.M. Britton's 1989 *Ferns and Fern Allies of Canada* (Agriculture Canada)—is surprising, even within just a Michigan ferns context. Together, these various omissions present a significant credibility problem for *Michigan Ferns & Lycophytes*' claim to offer a regional perspective on Great Lakes pteridophytes.

There are 108 species treated in *Michigan Ferns & Lycophytes* (121 full treatments including a selection of some additional subspecies, varieties, or hybrids). Taxa within some genera are treated in considerable detail while others receive more basic consideration. The *Equisetum* treatment, for example, employs 42 pages of text for the treatment of 13 taxa. This includes species-comparable treatments for four sterile hybrids because they are "quite common and often form large clones" (p. 51). The considerably more ecologically, genetically, and biogeographically significant *Dryopteris* genus, however, is addressed in only 27 pages treating 12 taxa. This treatment includes stand-alone discussions of the two hybrids considered to be most common in the state. Another 16 hybrid combinations are listed as occurring in Michigan but without any supporting documentation or references. Why stop there? Readers should at least have been directed to some pertinent references from Britton's Ontario literature on *Dryopteris* hybrids and/or to James Montgomery's excellent 1982 North American treatment (Fiddlehead Forum 9: 23–30). The paucity of supporting references is a problem throughout, in fact, with the References section of the book having a surprisingly low total of fewer than 50 citations.

Etymology is discussed for each taxon that receives a stand-alone treatment. There is no harm in that because the origin of names has some popular interest. When these cultural/biographical discussions use large amounts of text space that could otherwise be profitably applied to the core identification objective of the book, however, they become counter-productive. The excessively long, biography-like etymological discussion for *Huperzia ×josephbeitelii* A. Haines (p. 318), for example, is twice the length of the remaining text available for the technical description of this difficult taxon.

At its core, *Michigan Ferns & Lycophytes* presents a valuable tool for the identification of pteridophytes in Michigan and substantially fills a long-standing need. It also is an asset for the understanding of pteridophyte diversity in a geographically wider area as well. Out-of-state (especially Canadian) readers, however, will need a range of supplementary literature in order to gain the appropriate regional perspective.

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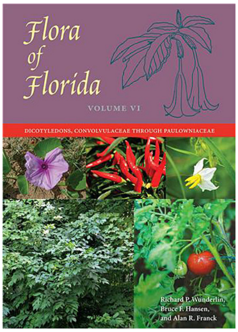
Flora of Florida Volume 6 (Dicotyledons, Convolvulaceae through Paulowniaceae)

By R.P. Wunderlin, B.F. Hansen, and A.R. Franck. 2019. University Press of Florida. 372 pages, 70.00 USD, Cloth.



The monumental *Flora of Florida* project is now over half completed. With the publication in 2000 of Volume 1 and a flurry of additional publication activity in recent years (for reviews of earlier *Flora of Florida* volumes see *The Canadian Field-Naturalist* 130: 248–249, 2016 [Volumes 2 and 3]; 131: 375, 2017 [Volume 4]; and 132: 68, 2018 [Volume 5]), there is but one more volume necessary to achieve complete coverage of the dicot taxa. The final three volumes treating the monocot species are then to be published. The authors' goal of having all 10 volumes in print by 2020 may not be achieved; putting out four volumes in less than a year and a half seems unlikely from both a production and marketing perspective. The good news, however, is that their ambitious completion objective may not be far off the mark.

A total of 470 species in 19 vascular plant families are treated here. That number of taxa addressed is increased by the description of additional subspecies, varieties, and/or named hybrids within particular species accounts. With the completion of Volume 6 some 2375 species have been described. All told, 62% of the 3834 species identified in Volume 1 as occurring or to have once occurred outside of cultivation in the state, have now been described. The names of a substantial number of excluded species that were reported in error or unconfirmed are also enumerated.

As within those parts of *Flora of Florida* that preceded Volume 6, effective species identification keys updated from Wunderlin's *Guide to the Vascular Plants of Florida* (University of Florida Press, 1998) are placed immediately after each genus description. Alphabetically arranged species treatments follow, each employing up-to-date nomenclature and commencing with the detailed and comprehensive compilation of synonyms that is a trademark of *Flora of Florida*. No compilation in the present volume, however, approaches the astonishing 75 synonyms listed in Volume 3 (pp. 220–223) for *Crataegus michauxii* Persoon!

The physical characteristics of each taxon are described in the text (and keys) with precise but not overly technical terminology. The text is presented in a small but easily readable type on good quality paper within a hard cover binding. That readability is particularly important because the text is un-illustrated. This is understandable in an already voluminous text but is nonetheless unfortunate, particularly for non-local readers who are likely less familiar with the Florida flora. Readers are encouraged to consult the online *Atlas of Florida Plants* (http://florida.plantatlas.usf.edu) for photos of most taxa, however, and for more detailed range information than is in the brief statements provided here.

Habitat and (especially) other life history considerations are described sparsely, this presumably also a reflection of space limitations and cost control. That is also unfortunate for readers 'from away' who could benefit from comparing ecological characteristics of Floridian plants with those of their own local populations. As with the other treatments Volume 6 addresses many species that extend northward into southern Canada. That range limit seems to be quite accurately reflected for the most part.

The copy examined for this review was weakly bound, the spine panel separating from the side boards after minimal use. This is contrary to my experience with the firmly bound copies examined for reviews of earlier volumes, however, and likely represents an infrequent aberration.

A considerable number of taxa in Volume 6 are in families such as Convolvulaceae, Solanaceae, and (especially) Acanthaceae which typically do not contribute substantially to floristic diversity in northern areas of this continent. Some families with more prominent northern diversity are well represented however, including Plantaginaceae, Lamiaceae, and Lentibulariaceae. Floridian representation of the insectivorous genus of bladderworts (*Utricularia*, Lentibulariaceae) for instance, includes four species which occur in eastern Canada. The description of Floridian populations of taxa such as the Eastern Purple Bladderwort (*U. purpurea* Walter) suggest striking differences may exist with the Canadian populations of this species—and perhaps with others as well.

The *Flora of Florida* is a grand undertaking that is providing a valuable floristic tool applicable far beyond the limits of that state. Were Volume 6 a standalone analysis, however, I would not recommend it as a high priority acquisition for northern botanists because of its lesser representation of north-related taxa than seen in earlier contributions. Just the same, however, it warrants serious consideration for northern libraries as a significant component of what will undoubtedly be a classic of North American botanical literature almost immediately upon its completion.

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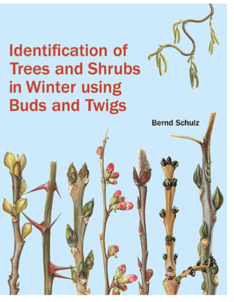
Identification of Trees and Shrubs in Winter using Buds and Twigs

By Bernd Schulz. 2018. Royal Botanic Gardens, Kew, distributed by University of Chicago Press. 368 pages, 45.00 GBP, 80.00 USD, Cloth or E-book. Originally published in German as: Gehölzbestimmung im Winter: mit Knospen und Zweigen, 2013.



As a Canadian naturalist, how will you be spending the upcoming winter? Perhaps a Christmas Bird Count shortly after the landscape transforms into snow and ice, and then as frigid weather lingers toward a seemingly relentless polar vortex, maybe be an occasional excursion such as hiking the trails in snowshoes and perhaps a nocturnal Mudpuppy hunt by the local dam? Many nature lovers by then become relatively dormant, and begin to dream about early spring arrival of migrating birds or of Skunk Cabbage bursting through a melting snowpack, only a month or two away.

How about hunting for trees and shrubs? Woody plants are always available for study, and are perhaps best observed during the winter months when distinctive twig features are fully developed and easily visible without being obscured by deciduous leaves (in contrast to herbaceous plants which may be withered and hidden under snow; e.g., Levine 1995). Besides being a rewarding and easily accessible winter activity from cultivated yards to remote wilderness, real contemporary conservation questions are awaiting resolution such as occurrences of populations for rare/threatened species: relevant examples from this writer's current work are establishing the locations of Red Spruce populations in the greenbelt of Ottawa, and documenting the presence of new Rock Elm populations in Quebec along the land border of eastern Ontario and Quebec (Vaudreuil-Soulanges; FloraQuebeca 2009). Spotting trees and shrubs is frequently best done in winter, coincidentally when there may be little else obvious for the naturalist to do outdoors. But how does one confirm that plant species of interest have really been found?

The 'fingerprint' of woody plant species identification is their twigs. All features of woody plants, from growth form to bark, leaves, flowers, and fruit, are useful to observe, but the only identification trait reliably present and virtually invariant among individual plants of a given species, at any age from sapling to centuries-old giant, is the twigs. Trees and shrubs can nearly always be accurately determined to genus via mature twig features (leaf scars, buds, etc.), and usually to species with a trained eye.

Bernd Schulz's *Identification of Trees and Shrubs in Winter using Buds and Twigs* is an excellent resource to learn the key features for differentiating woody plants from family to genus to species. The book is at its essence a thoroughly modern textbook sorely needed for a curriculum which, one may state with little exaggeration, is no longer actively taught. The book has useful and accessible chapters regarding the history of twig-identification botany, twig structure and terminology, and identification keys, but is at its core a comprehensive species-by-species treatment of the trees and shrubs found in central Europe with detailed descriptions and hundreds of technically sound and attractive colour illustrations. A number of high-quality twig identification books relevant to eastern North America were published from early to mid 20th century (e.g., Blakeslee and Jarvis 1911; Trelease 1918; Harlow 1941; Graves 1952; Core and Ammons 1958; Petrides 1958; Symonds 1958, 1963). These classic books are still very much useful and worth studying but suffer from being stuck in an historical era before the current "globalization" of cultivated plants, and the corresponding emergence of widespread naturalization and invasive species as dominant ecological features. Little on the subject was published from the 1960s until the 2010s. Schulz's book is therefore a major step forward toward modernization for the subject, with comprehensive descriptions and illustrations showing the native, cultivated, and naturalized plants of central Europe in the 21st century; there is much species overlap with the woody plants of eastern North America in modern times. The classic 20th-century books, in contrast, often give at most a light treatment of non-native plants, some of which have only arrived and become dominant in the wild in the last few decades.

It is worth noting that the subject matter of Schulz's book is not just relevant to winter: "winter" twig features (mature buds, etc.) are indeed present from late summer until spring, approximately two thirds of the year from August to April.

Despite being an authoritative and high-quality publication, a few features are worth considering which may be drawbacks to some of the intended audience. The book is large and heavy, with a typical 'textbook form' factor and so is not a portable handbook to be easily tossed in one's backpack. The book was written from a central European perspective, and so is a comprehensive treatment of the native, naturalized, and commonly cultivated trees and shrubs of that region specifically. While there is much overlap of naturalized and commonly cultivated woody plants of Europe and North America, as noted above, some woody plants of Canada are not included. Evergreen trees and shrubs are not treated, so one cannot use this book to learn their identification traits: e.g., spruces versus firs or Sheep-laurel versus Bog-laurel. This book only considers twigs, and despite doing this with unprecedented breadth and depth, does not treat other aspects of woody plants such as growth form, leaves, etc. which many of the classic books cover in addition to twigs.

Overall, Schulz's book is highly recommended to anyone interested in temperate zone woody plants and their conservation, and is available at reasonable prices (~50.00–70.00 CAD) from a variety of sellers.

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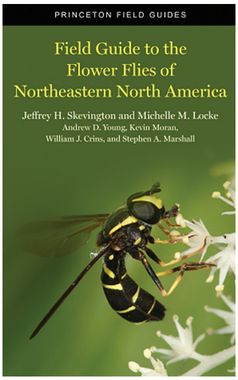
Entomology

Field Guide to the Flower Flies of Northeastern North America

By Jeffrey H. Skevington, Michelle M. Locke, Andrew D. Young, Kevin Moran, William J. Crins, and Stephen A. Marshall. 2019. Princeton University Press. 512 pages, 3000 images, and 414 maps, 27.95 USD, Flexibound Paper.



This is a beautiful book, big enough to include multiple photographs of all the known, and until recently, a few unknown flower flies, yet small enough to be carried into the field in a largish pocket or small satchel.

The general introduction describes the book's layout and how to use it most efficiently. Techniques on observing and trapping these flies and how to record your data are also included. Identification pointers, including a reference to an online Key to the Genera of Nearctic Syrphidae (Miranda *et al*. 2013), give the reader a good start to determining the species. The book ends with a thorough glossary and several very useful diagrams illustrating much used anatomy.

Prior to the species accounts is a two-page spread illustrating the differences among the four subfamilies of flower flies. Having never attempted to key out one of these flies to species before, I used this two-page spread, largely with success. One then goes to the colour-coded section of the book for the appropriate subfamily to find their insect. And herein lies the one issue I have with this guide. Because there is no further key to identify the species, the reader may have to flip through quite a number of pages before finding their fly. The online Key to the Genera of Nearctic Syrphidae, co-authored by four of the six authors of this book as well as two others, should be downloaded and used in conjunction with the guide to identify your specimen to species.

The species accounts are well done. There are two per double-page spread, with text on the left and images on the right, allowing for rapid flipping while you're trying to find your fly. There is always a dorsal view and lateral view, sometimes more than one if the species is dimorphic. Other salient features, such as wing venation, facial structure, or leg characteristics are also shown, as needed, and nicely magnified. All the photographs are at least adequate, but most are crisp, often beautiful shots.

The text includes a size range, but the silhouette of the fly presented with each species gives a more rapid indication of size. An interesting series of icons that I've not seen before tells the reader if the insect can typically be identified by the unaided eye (surprisingly many), a hand lens or, ultimately, if a microscope will be needed. A map showing records, and usually a range estimate as well, does not restrict itself to the geographic scope of this book, but includes all of North America. The text includes flight times, abundance, and identification tips; I couldn't think of anything else that a field guide should have.

Overall, this is a very nice book that, in conjunction with the online key, will do its job quite well.

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Miranda, G.F.G., A.D. Young, M.M. Locke, S.A. Marshall, J.H. Skevington, and F.C. Thompson. 2013. Key to the Genera of Nearctic Syrphidae. Canadian Journal of Arthropod Identification 23: 23 August 2013. https://doi.org/10.3752/cjai.2013.23

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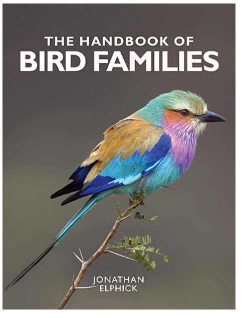
ORNITHOLOGY

The Handbook of Bird Families

By Jonathan Elphick. 2018. Firefly Books and The Trustees of the Natural History Museum, London. 416 pages, 35.00 CAD, Paper.



As most people with more than a slight interest in birds understand, the taxonomy of Aves is at present in flux. Much of the changing taxonomic attribution is a consequence of molecular DNA research. The best thing that may be said about this book is that, published in 2018, it has the most up-to-date presentation of what is understood about avian taxonomic relationships outside of scientific journals. The first thing one notices by thumbing through the book is that it is rather dense with very little white space and a small font. It would seem that reducing publication cost has driven the layout and presentation.

In the two-page introduction, Elphick briefly explains the scientific classification system. In defining families, he follows the arrangement of the fourth edition of *The Howard and Moore Complete Checklist of the Birds of the World* (Aves Press, 2013/2014) and notes that this is a conservative approach. He indicates here there are 36 orders and 234 families of birds by latest account.

The Table of Contents under the heading "The Bird Families" lists 36 orders but, curiously, lists no families. The main text offers a brief explanation of each order followed by the families in that order. Each family is then given a box in which the same basic information is covered, such as: social behaviour, nest, food, voice, and migration. Because the information, in some cases, may cover dozens of genera and hundreds of species I did not find it particularly useful. In fact, the author is often reduced to stating that species vary hugely in these regards.

Under the heading "Conservation Status" he lists the names of those species that are at the highest categories of threat and then, for the less threatened categories, just the number of species in each. There is an appendix in which the definitions of the Birdlife/IUCN Red List categories are presented, but I wish the author, who stated his goal to make this book an accessible presentation, had paraphrased the definitions which, in their original form, are anything but easy to understand.

Following the "quick box" the author provides accounts that vary in length usually depending on the size of the family. The most relevant informative parts of these accounts are the explanations of taxonomic relationships within the family and comparisons to other closely related families. In the past few years, many species have been moved from one family to another, or in some cases to a brand-new family. Many of the new groupings based as they are on DNA evidence will seem counter-intuitive to birders. The author explains that convergent evolution may produce similar appearing birds that are in quite different families.

Within these accounts are numerous interesting factoids that the author has gleaned from his own studies and from the literature. However, as this book is an attempt to provide an easy-to-understand presentation of the classification of bird families, I would have preferred that it stuck to those aspects and left behavioural anecdotes to other books.

So, sticking to taxonomy, the world birder will be fascinated in some cases and perplexed in others about the arrangement and composition of families. Here are a few examples in no particular order that astonished me:

- The rail-babbler of southeast Asia is no longer a monotypic family but is now in the family Eupetidae along with the two rockfowl of West Africa and the two rockjumpers of southern Africa.
- The Wrenthrush and the two Cuban *Teretistris* warblers are lumped into the family Zeledonidae.
- The once huge family Sylviidae or "Old World Warblers" continues to be disassembled and, at present, contains 62 species and is "often referred to as the sylviid babblers" (p. 359). In fact, there are only five species in the once large genus, *Sylvia*. If you hear reference to Juniper Babbler note that it is what you knew as the Abyssinian Catbird (personally I find any taxon with the appellation Abyssinian to be exotic beyond words). It is difficult to believe that the distinctive Asian parrotbills will not soon again be split off from the other sylviids.
- Bird family seekers who made the trek to Kuwait to tick the Hypocolius family may be dismayed to find that Hylocitrea of far-off Sulawesi (one or two species depending on your authority) has been added to the family. It may not remain this way.

To harp on the author's goal of producing an accessible account of families, his decision to not include a representative photograph of each family is a major flaw. Better to dispense with word descriptions and include an image for each family and a photo of distinctively different species within a family such as rockjumper and rail-babbler. I counted at least 11 families with no photo and other highly distinctive and well-known groups within families that would have greatly benefitted from a photo.

The photos are generally good. Picture credits are listed at the end in a tiny print format. I much prefer the photographer to be noted in the caption; this could have been done by reducing the banal captions.

I found numerous errors that might have been detected by better editing. Here are a few examples:

- On p. 160 the order Piciformes is said to comprise four families but then (correctly) five are listed.
- On p. 173 the monotypic Cuckoo Roller is listed as being in one of the families in the order Coraciiformes, whereas earlier on p. 149 it is assigned a unique order, Leptosomiiformes, the latter acknowledged to be the correct positioning.
- Two species of Crescentchests (Melanopareiidae) are described to "inhabit very large areas in east central and central *North* America" (p. 220, italics mine).
- Within the account on Antpittas (Grallaridae) on p. 222, "ant-thrushes are in the new Family Grallariidae". Replace "ant-thrushes" with "antpittas" for this sentence to make any sense.
- On p. 349 the exact same sentence is used twice within the same paragraph to describe the appearance of Cupwings (Pnoepygidae), an error that could easily be picked up by editing.
- On p. 362 Elphick refers to "the renowned British nineteenth century ornithologist" but does not name him.
- On p. 368 the Palmchat (Dulidae) is described as one of only two families endemic to the Caribbean, the other being Todidae, thus forgetting the Warbler Tanagers (Phaenicophiliidae) described on pp. 317–318, all nine species of which are found only in the Caribbean.

In summary, this book provides a 2018 snapshot of ornithological thinking about world bird families. Unfortunately, in this reviewer's opinion the work cut too many corners perhaps based on space and time restrictions. At 35.00 CAD it is likely worth the cost but the *Bird Families of the World* (Lynx Edicions, 2015), while slightly older and thus not as up-to-date as the present volume, would still be a better purchase at 87 Euros for most birders seriously interested in bird families.

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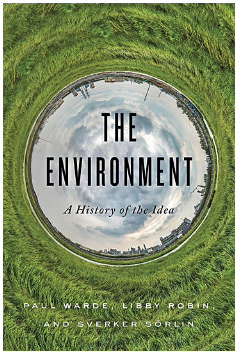
OTHER

The Environment: A History of the Idea

By Paul Warde, Libby Robin, and Sverker Sörlin. 2018. Johns Hopkins University Press. 256 pages, 29.95 USD, Cloth.



Did you know that although the word "environment" has been used in the English language for over 200 years, our present concept of "the environment" only began to take shape about 70 years ago? In *The Environment: A History of the Idea*, authors Paul Warde, Libby Robin, and Sverker Sörlin have put together a fascinating work coalescing the history of our modern concept of the environment. Consisting of a brief prologue, seven chapters, and appended with a detailed notes section, brief bibliographic essay, and index, this book consists of an intellectual history of the relatively recent (post-World War II) environmental concept.

Each of the book's seven chapters illustrates the historical development of various key components of our modern concept of "the environment". Chapter 1 introduces foundational works from the early postwar era that contributed to the modern environmental concept, such as William Vogt's (1948) *Road to Survival* (paid homage by the chapter name and mentioned/discussed numerous times within the book). Additionally, the first chapter sets forth the authors' proposed "Four Dimensions of 'Environment'" (p. 14) consisting of expertise, the future, trust in numbers, and scale/scalability. Chapters 2–7 summarize a variety of evolving concepts and scientific developments, such as computer modelling, post-world war resource conservation concerns, the birth of ecology, climate change, non-governmental organizations, international politics, the concept of the Anthropocene, and the newly emerging field of environmental humanities (to list but a few examples!). Additionally, these chapters detail the major and rapid evolution of the modern concept of the environment, particularly illustrated via summaries of the subjects of environmentally-focussed conferences occurring after 1948.

Each chapter is relatively concise (approximately 25 pages in length) and provides a history of important, interrelated components crucial to the shaping of modern environmental thinking. Although each chapter is largely its own piece, I found some portions of each to overlap at times in terms of content, often referring to other chapters within the book. This does not detract from the work as a whole, however, but illustrates how a number of distinct but interweaving concepts coalesce to form the modern concept of the environment. I found this book to largely avoid technical language, with references and technical notes appended into a considerable Notes section at the end of the book. This makes the book more accessible to the non-specialized reader but allows one to dive further into the material referenced if desired. While each chapter is a summary of historical context, the authors add to its value and interpretation by providing meaningful original commentary and analysis throughout the book.

Should you give it a read? Absolutely. Do not let the "history" in the title dissuade you from giving this book a try if you are not a history buff: this book is intended for a broad audience. The authors have followed their own suggestion by writing this work as a means of "framing a problem or concept as a narrative or story" (p. 178). I felt like much of the writing is presented in almost a 'story-like' narrative. In some parts, I almost felt as if I were listening to the authors discuss the content of the book over coffee. Overall, I found *The Environment: A History of the Idea* to be an accessible, enjoyable, and very informative read: I learned something new at the turn of nearly every page. Also, this work contains many references to other books (in addition to so much more) and as a result has introduced me to a number of titles which are now on my future reading list. I highly recommend *The Environment: A History of the Idea* to anyone with an interest in any aspect of environmental study. This would likely include most readers of *The Canadian Field-Naturalist.*

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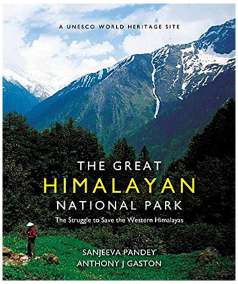
The Great Himalayan National Park: The Struggle to Save the Western Himalayas

By Sanjeeva Pandey and Anthony J. Gaston. 2019. Niyogi Books. 364 pages, 284 colour photos, and 15 maps, 54.00 CAD, Cloth.



The Himalayas: surely this is one of the most evocative names in world geography, for who has not seen inspiring images of the world's grandest peaks and heard epic tales of scaling their summits? This book is set in the Himalayas but to appreciate its significance you must lower your eyes a few degrees, focussing not on the snow-shrouded crags but on the green slopes below, on the meadows and forests. The biological richness of the Himalayas lies at these elevations, not in the awe-inspiring realm of rock, ice, and snow. The mountains' richness rests on three axes: first and most conspicuously, a vertical dimension, driven by the steep climate gradient tied to elevation that generates profoundly different habitats for a diverse suite of species. Secondly, there is a sharp north-south axis because the height of the Himalayan range makes it a barrier between two major biogeographic realms. Thus, you can have Himalayan Brown Bears (*Ursus arctos isabellinus*) and Ibex (*Capra sibirica sakeen*) of the Palearctic realm living just over the ridge from Asiatic Black Bears (*Ursus tibetanus*) and Himalayan Serow (*Capricornis thar*) of the Oriental realm. Finally, there is an important west to east increase in rainfall. All three of these considerations make the area selected for the Great Himalayan National Park a geographic crossroads meriting special protection, especially given the threat of fragmenting ecological continuity. Imagine a species inhabiting forests on the south face of the Himalayas at elevations between 2000–3000 m; their geographic range is essentially a long narrow ribbon, easily severed by deforestation. Indeed, throughout the Himalayas forests at these intermediate elevations are markedly underrepresented in protected area systems. These perspectives are introduced in the book's opening chapter and prominent throughout, along with the other main rationale for siting a park here: the area's low levels of human settlement and concomitant disturbance from logging and livestock grazing.

The next chapter, "Trekking", describes in lovely prose and photos what a visit to the park is like and it has inspired me to try to organize a return. (Full disclosure: I participated in two of the early surveys [spring and fall of 1980] organized by Tony Gaston that became a foundation for park creation but have not been back since.) Unfortunately, as a 'details person' I found it frustrating not to be able to find most of the spots described or photographed on the maps; even the trekking routes are not mapped.

In "Development of GHNP", the book returns to the 1980s and the creation of the park. Some of this chapter is down in the weeds of the requisite steps that are specific to India's governance but of wider interest is how park development was advanced with the local population. Thoughtful park design mitigated some potential conflicts, i.e., by delineating a core area that contained just three villages (120 inhabitants) and then along the western boundary creating a 230 km^2 Ecodevelopment Zone that held 160 villages with 14 000 people. Traditional rights to collect herbs for personal use became a problem when this morphed into commercial sales on which a thousand households were dependent, and inevitably these people became very agitated when this commerce was terminated. The key to recovery came in the formation of 95 Women's Saving and Credit Groups (a large number to accommodate both different villages and different social strata) that earned income from vermicomposting and other activities. Further insights into park-people relations are covered in "People and the GHNP", which has a potpourri of sections including religious traditions (sacred trees and groves), education (from 1989 to 2002 the only school in the park was in a cave), species targetted by herbalists, and the creation of a support organization, Friends of GHNP, with the Western Tragopan (*Tragopan melanocephalus*) as its mascot. The Friends group took the lead in applying for UNESCO World Heritage Site status for the park and adjoining protected areas, collectively an area of 2854 km^2, thus garnering formal recognition of the global significance of this place.

The next three chapters focus on the park's natural history, the first a seasonal chronicle beautifully illustrated with flower photos, followed by two overviews of the park's birds and mammals with special attention on charismatic species like the pheasants and carnivores. In the final chapter, "Future of Biodiversity in the Western Himalayas", the authors ruminate on the on-going process of managing the park in a way that will further the interests of the local people while maintaining its unique biological heritage. This challenge will unfold in the face of ever-changing threats, such as tourism pressures from the millions of Indians who seek cool, pleasant playgrounds to escape Delhi and other cities.

In summary, this book shares many attributes—such as wonderful photographs and writing—with other volumes that have been written to celebrate the natural wonders of the world's special places. It differs from most analogous books in the depth with which it tells the story of all the hard work that underlies protecting such places—from foundational science to pure politics. I particularly enjoyed the distillation of this that is captured nicely in the Foreword and Afterword, written by Gaston and Pandey respectively, in which they give personal accounts of the decades of work they have devoted to this unique place. All in all, it is a tale that should be of interest to anyone concerned with protected area creation and management, especially in places where the livelihoods of local people are directly and tightly tied to natural resources.

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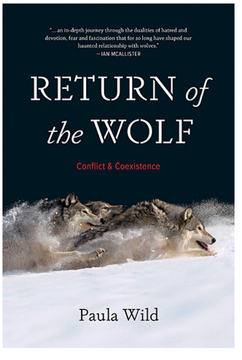
ZOOLOGY

Return of the Wolf: Conflict and Coexistence

By Paula Wild. 2018. Douglas and McIntyre. 272 pages, 32.95 CAD, 29.95 USD, Cloth.



Return of the Wolf by Paula Wild was an easy, enjoyable read about the recovery and return of wolves (*Canis* spp.) throughout the world, focussing much of her time in her home country of Canada studying Gray Wolves (*Canis lupus*). The purpose of the book is to give the real picture of wolves, as neither saint nor sinner nor good versus bad, but rather just another animal (albeit a predator that often conflicts with humans where the two are sympatric) trying to survive in an increasingly human-dominated landscape. Wild provides an historical summary of wolves in both the Old World as well as the New World, given that they were once common throughout North America and Eurasia. Chapters 2 and 3 describe how bounties and organized hunts had drastically reduced their numbers worldwide by the 1900s. However, the wolf is now recovering from near extermination in many areas, especially parts of the United States' lower 48 states, and is becoming more common as evidenced by their recovery in the Yellowstone area (p. 149) and upper mid-west. Throughout the book, Wild expresses amazement at the dualities of hatred and love that she encountered when ascribing emotions about wolves in her mission to set the record straight by letting us appreciate the real animal. I have over 50 books on wolves—not even counting the 25+ I have on their close cousin the Coyote, *Canis latrans*—and I feel like this book is an appropriate summary of all those books. It provides much of the historical background of, say, Barry Lopez's 1978 *Of Wolves and Men* (Scribner, 2004), but also discusses modern happenings such as Yellowstone wolf recovery (see Way 2017) and marine-food-eating coastal wolves discussed in Ian McAllister's book *The Last Wild Wolves: Ghost of the Great Bear Rainforest* (University of California Press, 2007). Curiously, the title of Wild's book is strangely similar to two other books I own, including *The Return of the Wolf* (NorthWord Press, 1999) by Steve Grooms, which presents the wolf's comeback in Canada and the United States, albeit 25 years ago now, and *The Return of the Wolf: Reflections on the Future of Wolves in the Northeast* (University Press of New England, 2000), edited by John Elder, that discusses the implications and potential of wolves returning to the northeast United States.

Return of the Wolf is a mixture of natural history, native peoples' stories, and conversations with scientists and conservationists. We learn how society's attitudes affect the population dynamics, behaviour, and conservation of wolves on the modern landscape, a setting where more and more people appreciate having nature around even if it challenges us both financially and safety-wise. Wild notes that the fate of wolves remains uncertain and she questions how humans will adapt to wolves. She is optimistic that we will, noting that "I want to hear the wolves but I don't want them to come too close. For their safety, not mine" (p. 241). Accordingly, the first Appendix item is a unique 2.5 page "Wolf Safety Checklist" (p. 243–245), one that you might think is more in tune with living in bear country. However, Wild spends much of the second half of her book discussing 'the myth' that wolves are not dangerous and documents that healthy (i.e., not rabid) wolves are increasingly confronting, and sometimes even killing, humans in North America (Chapter 9). She also describes some first-hand accounts of highly habituated wolves living on Vancouver Island, British Columbia (Chapter 10). In fact, the ecology of those animals living in human-dominated areas reminds me of the wolf's smaller cousin, Coyote (e.g., Way 2014), in many respects. Of course, it is important to keep in mind that even with increasing boldness of some wolves, the chance of one harming us is still astronomically small compared to potential dangers from our everyday activities.

Given my interest in studying Eastern Coyotes/coywolves (Way 2014), I was fascinated with Wild's discussion of this animal (pp. 91–96) and her decision—due to their unique genetic background—to call them coywolves. While describing the rapid evolution of the coywolf, Wild also discusses the other lesser known wolves, Eastern Wolf (*Canis lycaon*) and Red Wolf (*Canis rufus*), which are possibly the same species living on opposite ends of their native eastern North American range. Wild circles back to Eastern Wolf a few times when also discussing recent aggressive encounters people have had with wolves, some of those with Eastern Wolves in Algonquin Provincial Park.

Overall, this is an easy-to-read, well researched, timely book. While perhaps not having the exciting flair of a book written by a biologist(s) in their study area, it provides a great up-to-date account of the happenings of wolves worldwide, with a North American focus. Whether you are new to the world of wolves, or a veteran, I recommend adding this book to your library. The nice 16-page colour plate section as well as many black and white photos adds greatly to the read. Hopefully, it will provide food for thought and create compassion for a creature that has been maligned for far too long.

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New Titles

Prepared by Barry Cottam

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

†Available for review *Assigned

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

Biology

Fires of Life: Endothermy in Birds and Mammals. By Barry Gordon Lovegrove. Foreword by Roger S. Seymour. 2019. Yale University Press. 384 pages, 40.00 USD, Cloth.

The Evolutionary Biology of Species. Oxford Series in Ecology and Evolution. By Timothy G. Barraclough. 2019. Oxford University Press. 288 pages, 90.00 USD, Cloth, 45.95 USD, Paper. Also available as an E-book.

The Tangled Tree: A Radical New History of Life. By David Quammen. 2018. Simon & Schuster. 30.00 USD, Cloth, 18.00 USD, Paper, 11.99 USD, E-book.

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Evolution in the Dark: Darwin's Loss Without Selection. By Horst Wilkens and Ulrike Strecker. 2017. Springer International Publishing. 226 pages, 179.99 USD, Cloth or Paper, 139.00 USD, E-book.

Botany

Carnivorous Plants. By Dan Torre. 2019. Reaktion Books. 240 pages, 27.00 USD, Cloth.

Essentials of Developmental Plant Anatomy. By Taylor A. Steeves and Vipen K. Sawhney. 2017. Oxford University Press. 184 pages, 74.00 USD, Cloth. Also available as an E-book.

Flora Unveiled: The Discovery and Denial of Sex in Plants. By Lincoln Taiz and Lee Taiz. 2017. Oxford University Press. 520 pages, 76.95 USD, Cloth.

Great Trees of New Brunswick. Second Edition. By David Palmer and Tracy Glynn. Photographs by Arielle DeMerchant. 2019. Goose Lane Editions. 264 pages, 27.95 CAD, Paper.

Primrose. By Elizabeth Lawson. 2019. Reaktion Books. 256 pages, 27.00 USD, Cloth.

Climate Change

Climate Change and Rocky Mountain Ecosystems. Advances in Global Change Research. By Jessica E. Halofsky and David L. Peterson. 2019. Springer International Publishing. 253 pages, 149.99 USD, Cloth or Paper, 109.00 USD, E-book.

Effects of Climate Change on Birds. Second Edition. Edited by Peter O. Dunn and Anders Pape Moller. 2019. Oxford University Press. 288 pages, 100.00 USD, Cloth. Also available as an E-book.

In Search of the Canary Tree: The Story of a Scientist, a Cypress, and a Changing World. By Lauren E. Oakes. 2018. Basic Books. 288 pages, 16.99 USD / 21.99 CAD, Paper.

†No One is Too Small to Make a Difference. By Greta Thunberg. 2019. Penguin Books. 80 pages, 9.99 CAD, Paper.

Conservation & Ecology

Ecological Forecasting. By Michael C. Dietze. 2017. Princeton University Press. 288 pages, 65.00 USD, Cloth. Also available as an E-book.

Effective Conservation Science: Data Not Dogma. Edited by Peter Kareiva, Michelle Marvier, and Brian Silliman. 2017. Oxford University Press. 384 pages, 100.00 CAD, Cloth, 49.95 CAD, Paper. Also available as an E-book.

Freshwater Ecology and Conservation: Approaches and Techniques. Edited by Jocelyne Hughes. 2019. Oxford University Press. 464 pages, 90.00 USD, Cloth, 45.95 USD, Paper. Also available as an E-book.

Hierarchy: Perspectives for Ecological Complexity. By T.F.H. Allen and Thomas B. Starr. 2017. University of Chicago Press. 352 pages, 125.00 USD, Cloth, 47.50 USD, Paper, 10.00–47.50 USD, E-book.

Time in Ecology: A Theoretical Framework. By Eric Post. 2019. Princeton University Press. 248 pages, 105.00 USD, Cloth, 40.00 USD, Paper. Also available as an E-book.

The North American Model of Wildlife Conservation. Edited by Shane P. Mahoney and Valerius Geist. 2019. Johns Hopkins University Press. 184 pages, 74.95 USD, Cloth or E-Book.

Renewable Energy and Wildlife Conservation. Edited by Christopher E. Moorman, Steven M. Grodsky, and Susan P. Rupp. 2019. Johns Hopkins University Press. 280 pages, 74.95 USD, Cloth or E-book.

Human-Wildlife Interactions: Turning Conflict into Coexistence. Conservation Biology Series. Edited by Beatrice Frank, Jenny A. Glikman, and Silvio Marchini. 2019. Cambridge University Press. 476 pages, 89.99 USD, Cloth, 44.99 USD, Paper, 36.00 USD, E-book.

The Terrestrial Protected Areas of Madagascar: Their History, Description, and Biota. Edited by Steven M. Goodman, Marie Jeanne Raherilalao, and Sébastien Wohlhauser. 2019. University of Chicago Press. Three volumes, 1716 pages, 180.00 USD, Cloth.

ENTOMOLOGY

Papillons de Nuit et Chenilles du Québec et des Maritimes. Guides Nature Quintin. By Michel Leboeuf and Stephane Le Tirant. 2018. Éditions Michel Quintin. 336 pages, 34,95 CAD, Couverture souple, 19,99 CAD, PDF.

The Dark Side of the Hive: The Evolution of the Imperfect Honeybee. By Robin Moritz and Robin Crewe. 2018. Oxford University Press. 208 pages, 80.00 CAD, Cloth. Also available as an E-book.

Saproxylic Insects: Diversity, Ecology and Conservation. Zoological Monographs, Vol. 1. Edited by Michael D. Ulyshen. 2018. Springer International Publishing. 1003 pages, 279.00 USD, Cloth or Paper, 219.00 USD, E-book.

Ecomorphology of Cyclorrhaphan Larvae (Diptera). Zoological Monographs, Vol. 4. By Graham Rotheray. 2019. Springer International Publishing. 295 pages, 179.00 USD, Cloth, 139.00 USD, E-book.

Buzz, Sting, Bite: Why We Need Insects. By Anne Sverdrup-Thygeson. 2019. Simon & Schuster. 256 pages, 26.00 USD, Cloth, 13.99 USD, E-book.

Beneficial Insects. By David V. Alford. 2019. CRC Press. 384 pages and 385 colour illustrations, 99.95 USD, Cloth. Also available as an E-book.

Cerambycidae of the World: Biology and Pest Management. Contemporary Topics in Entomology Series. Edited by Qiao Wang. 2017. CRC Press. 628 pages, 175.00 USD, Cloth. Also available as an E-book.

†The Mosquito: A Human History of Our Deadliest Predator. By Timothy C. Winegard. 2019. Allen Lane Canada. 496 pages, 32.95 CAD, Cloth.

The Last Butterflies: A Scientist's Quest to Save a Rare and Vanishing Creature. By Nick Haddad. 2019. Princeton University Press. 256 pages, 24.95 USD, Cloth. Also available as an E-book.

Raising Butterflies in the Garden. By Brenda Dziedzic. 2019. Firefly Books. 336 pages, 24.95 CAD, Paper.

Honey From the Earth: Beekeeping and Honey Hunting on Six Continents. By Eric Tourneret and Sylla de Saint Pierre. Edited by Dr. Leo Sharashkin. 2018. Deep Snow Press. 352 pages and 300+ colour photos, 64.95 USD, Cloth. Published in French in 2015.

HERPETOLOGY

The Rise of Reptiles: 320 Million Years of Evolution. By Hans-Dieter Sues. 2019. Johns Hopkins University Press. 400 pages and 356 illustrations, 84.95 USD, Cloth or E-book.

The Field Herping Guide: Finding Amphibians and Reptiles in the Wild. Wormsloe Foundation Nature Book Series. By Mike Pingleton and Joshua Holbrook. 2019. University of Georgia Press. 264 pages, 26.95 USD, Paper.

Reptiles of Costa Rica: A Field Guide. Zona Tropical Publications Series. By Twan Leenders. 2019. Cornell University Press. 640 pages, 35.00 USD, Paper.

ICHTHYOLOGY

The Future of Bluefin Tunas: Ecology, Fisheries Management, and Conservation. Edited by Barbara A. Block. 2019. Johns Hopkins University Press. 360 pages, 124.95 USD, Cloth or E-book.

Deep-Sea Fishes: Biology, Diversity, Ecology and Fisheries. By Imants G. Priede. 2017. Cambridge University Press. 492 pages 89.99 USD, Cloth.

ORNITHOLOGY

Birds in Winter: Surviving the Most Challenging Season. By Roger F. Pasquier. Illustrated by Margaret La Farge. 2019. Princeton University Press. 304 pages, 29.95 USD, Cloth or E-book.

Birds of Prey: Biology and Conservation in the XXI Century. By Jose Hernan Sarasola and Juan Manuel Grande. 2018. Springer International Publishing. 530 pages, 219.99 USD, Cloth or Paper, 169.00 USD, E-book.

†The Flying Zoo: Birds, Parasites, and the World They Share. By Michael Stock. 2019. The University of Alberta Press. 296 pages, 29.99 CAD, Paper or PDF.

Pelican. By Barbara Allen. 2019. Reaktion Books. 208 pages and 80 colour plates, 19.95 USD, Paper.

Thinking Like a Parrot: Perspectives from the Wild. By Alan B. Bond and Judy Diamond. 2019. University of Chicago Press. 184 pages, 35.00 USD, Cloth, 10.00–35.00 USD, E-book.

Urban Aviary: A Modern Guide to City Birds. By Stephen Moss. Illustrated by Marc Martin. 2019. White Lion Publishing. 160 pages, 26.00 CAD, Cloth.

Zoology

A Bat's End. The Christmas Island Pipistrelle and Extinction in Australia. By John Woinarski. 2018. CSIRO Publishing. 266 pages, 59.99 AUD, Paper. Also available as an E-book.

Field Guide to the Bats of the Amazon. By A. López-Baucells, R. Rocha, P. Bobrowiec, E. Bernard, J. Palmeirim, and C.F.J. Meyer. 2018. Pelagic Publishing. 175 pages, 48.46 CAD, Paper.

Wildlife on Roads: A Handbook. By Kari E. Gunsen and Frederick W. Schueler. 2019. Eco-Kare International. 232 pages and 140 colour photographs, 29.95 CAD, Paper.

The North Atlantic Right Whale: Disappearing Giants. By Scott Kraus and Kenneth Mallory. 2019. Fitzhenry & Whiteside. 120 pages, 24.95 USD, Paper.

†A Field Guide to Marine Life of the Outer Coasts of the Salish Sea and Beyond. By Rick M. Harbo. 2019. Harbour Publishing. 8-fold pamphlet, 7.95 CAD, Paper.

†A Field Guide to Marine Life of the Protected Waters of the Salish Sea. By Rick M. Harbo. 2019. Harbour Publishing. 8-fold pamphlet, 7.95 CAD, Paper.

Handbook of the Mammals of the World - Volume 9. Bats. Edited by Don E. Wilson and Russell A. Mittermeier. Illustrations by Toni Llobet. 2019. Lynx Edicions in association with Conservation International and IUCN. 160.00 EUR, Cloth.

†Mammal Tracks and Sign: A Guide to North American Species. Second Edition. By Mark Elbroch with contributions by Casey McFarland. 2019. Globe Pequot/Stackpole Books. 680 pages, 49.95 USD, Paper, 47.50 USD, E-book.

A Manual of the Mammalia: An Homage to Lawlor's "Handbook to the Orders and Families of Living Mammals". By Douglas A. Kelt and James L. Patton. 2019. 544 pages, 60.00 USD, Cloth or E-book.

Canids of the World: Wolves, Wild Dogs, Foxes, Jackals, Coyotes, and Their Relatives. Princeton Field Guides. 2018. Princeton University Press. 336 pages, 29.95 USD, Paper.

***The Rise of Wolf 8: Witnessing the Triumph of Yellowstone's Underdog**. By Rick McIntyre. Foreword by Robert Redford. 2019. Greystone Books. 304 pages, 34.95 CAD, Cloth.

Carnivores of the World. Second Edition. Princeton Field Guides. By Luke Hunter. Illustrated by Priscilla Barrett. 2019. Princeton University Press. 256 pages, 29.95 USD, Paper.

The Truth About Animals: Stoned Sloths, Lovelorn Hippos, and Other Tales from the Wild Side of Wildlife. By Lucy Cooke. 2018. Perseus Books. 352 pages, 28.00 USD / 36.50 CAD, Cloth, 16.99 USD / 22.49 CAD, Paper, 11.99 USD / 14.99 CAD, E-book.

Cats in Australia: Companion and Killer. By John Woinarski, Sarah Legge, and Chris Dickman. 2019. CSIRO Publishing. 344 pages, 59.99 AUS, Paper.

Marine Mammals: Adaptations for an Aquatic Life. By Randall W. Davis. 2019. Springer International Publishing. 192 pages, 99.99 USD, Cloth.

Saving the Dammed: Why We Need Beaver-Modified Ecosystems. By Ellen Wohl. 2019. Oxford University Press. 176 pages, 35.00 USD, Cloth. Also available as an E-book.

Guide to Venomous and Medically Important Invertebrates. By David Bowles, James Swaby, and Harold Harlan. 2018. CSIRO Publishing. 240 pages, 59.99 AUD, Paper. Also available as an E-book.

Other

***To Speak for the Trees: My Life's Journey from Ancient Celtic Wisdom to a Healing Vision of the Forest**. By Diana Beresford-Kroeger. 2019. Random House Canada. 289 pages, 32.00 CAD, Paper.

Wild Sea: A History of the Southern Ocean. By Joy McCann. 2019. University of Chicago Press. 256 pages, 28.00 USD, Cloth, 18.00 USD, E-book.

Good Enough: The Tolerance for Mediocrity in Nature and Society. By Daniel S. Milo. 2019. Harvard UP. 320 pages, 28.95 USD, Cloth.

An Alfred Russel Wallace Companion. Edited by Charles H. Smith, James Costa, and David A. Collard. 2019. University of Chicago Press. 416 pages, 60.00 USD, Cloth or E-book.

Community-Based Control of Invasive Species. Edited by Paul Martin, Theodore Alter, Don Hine, and Tanya Howard. 2019. CSIRO Publishing. 288 pages, 99.99 AUS, Cloth.

Wildlife and Wind Farms - Conflicts and Solutions. Volume 4, Offshore: Monitoring and Mitigation. Edited by Martin Perrow. 2019. Pelagic Publishing. 340 pages, 80.43 CAD, Paper.

Collecting Experiments: Making Big Data Biol-

ogy. By Bruno J. Strasser. 2019. University of Chicago Press. 392 pages, 135 USD, Cloth, 45.00 USD, Paper. Also available as an E-book.

Wilding: Returning Nature to Our Farm. By Isabella Tree. Introduction by Eric Schlosser. 2019. Picador. 392 pages, 19.95 USD, Paper. Also available as an E-book.

Naturally Curious. A Photographic Field Guide and Month-By-Month Journey Through the Fields, Woods, and Marshes of New England. Second Edition. By Mary Holland. 2019. Trafalgar Square Books. 496 pages, 32.95 USD, Paper.

Wading Right In: Discovering the Nature of Wetlands. By Catherine Owen Koning and Sharon M. Ashworth. 2019. University of Chicago Press. 264 pages, 30.00 USD, Paper, 90.00 USD, Cloth, 10.00–35.00 USD, E-book.

Inside Science: Stories from the Field in Human and Animal Science. By Robert E. Kohler. 2019. University of Chicago Press. 264 pages, 35.00 USD, Cloth, 10.00–35.00 USD, E-book.

Quantitative Analyses in Wildlife Science. Edited by Leonard A. Brennan, Andrew N. Tri, and Bruce G. Marcot. 2019. Johns Hopkins University Press. 344 pages, 74.95 USD, Cloth or E-book.

Ocean Recovery: A Sustainable Future for Global Fisheries? By Ray Hilborn and Ulrike Hilborn. 2019. Oxford University Press. 208 pages, 37.95 USD, Cloth. Also available as an E-book.

Treed: Walking in Canada's Urban Forests. By Ariel Gordon. 2019. Wolsak & Wynn. 296 pages, 20.00 CAD, Paper.

Rates of Evolution: A Quantitative Synthesis. By Philip D. Gingerich. 2019. Cambridge University Press. 396 pages, 84.99 USD, Cloth.

Collecting Evolution: The Galápagos Expedition that Vindicated Darwin. By Matthew J. James. 2017. Oxford University Press. 304 pages, 34.95 USD, Cloth. Also available as an E-book.

Forest Landscape Restoration: Integrated Approaches to Support Effective Implementation. The Earthscan Forest Library. Edited by Stephanie Mansourian and John Parrotta. 2018. CRC Press. 266 pages, 150.00 USD, Cloth. Also available as an E-book.

The Routledge Handbook of the Polar Regions. Routledge International Handbooks. Edited by Mark Nuttall, Torben R. Christensen, and Martin J. Siegert. 2018. Routledge, Taylor & Francis Group. 530 pages, 260.00 USD, Cloth. Also available as an E-book.

Everyday Creatures. A Naturalist on the Surprising Beauty of Ordinary Life in Wild Places. By G.J. Kenagy. 2018. Dockside Sailing Press. 220 pages, 15.95 USD, Paper, 203 pages, 5.99 USD, E-book.

For the Birds: American Ornithologist Margaret Morse Nice. By Marilyn Bailey Ogilvie. 2018. University of Oklahoma Press. 320 pages, 39.95 USD, Cloth, 34.95 USD, E-book.

Slime: How Algae Created Us, Plague Us, and Just Might Save Us. By Ruth Kassinger. 2019. Houghton Mifflin Harcourt. 320 pages, 26.00 USD, Cloth, 16.99 USD, Paper.

The Canadian Field-Naturalist

News and Comment

Upcoming Meetings and Workshops

Canadian Herpetological Society Annual Conference

The Canadian Herpetological Society Annual Conference to be held 20–23 September 2019 at the Redpath Museum in McGill University, Montreal, Quebec. Registration is currently open. More information is available at http://canadianherpetology.ca/conf/index.html#2019.

Wildlife Society and American Fisheries Society Joint Annual Conference

The first Wildlife Society and American Fisheries Society Joint Annual Conference to be held 29 September–3 October 2019 at the Reno-Sparks Convention Center, Reno, Nevada. Registration is currently open. More information is available at https://afstws2019.org/.

Student Conference on Conservation Science-New York

The 10th annual Student Conference on Conservation Science-New York to be held 2–4 October 2019 at the American Museum of Natural History, New York, New York. Registration is currently open. More information is available at https://www.amnh.org/research/center-for-biodiversity-conservation/convening-and-connecting/student-conference-on-conservation-science-new-york-sccs-ny.

Association of Field Ornithologists and the Wilson Ornithological Society Joint Meeting

The joint meeting of the Association of Field Ornithologists and the Wilson Ornithological Society, hosted by the New Jersey Audubon's Cape May Bird Observatory, to be held 27–30 October 2019 at the Grand Hotel, Cape May, New Jersey. Registration is currently open. More information is available at http://www.cvent.com/events/2019-afo-wos-joint-meeting/event-summary-fc644f2542184eba9fe3b1d37928e0fd.aspx.

Entomological Society of Ontario

The annual general meeting of the Entomology Society of Ontario to be held 1–3 November 2019 at the Bark Lake Conference Centre, Haliburton, Ontario. More information is available at https://www.entsocont.ca/.

Entomology 2019

The annual meeting of the Entomological Society of America to be held 17–20 November 2019 at the America's Center Convention Complex, St. Louis, Missouri. Registration is currently open. More information is available at https://www.entsoc.org/events/annual-meeting.

James Fletcher Award for *The Canadian Field-Naturalist* Volume 132

The James Fletcher Award is awarded to the authors of the best paper published in a volume of *The Canadian Field-Naturalist* (CFN), and first started with Volume 130. The award is in honour of James Fletcher, founder of the Ottawa Field-Naturalists' Club (OFNC) and the first editor of CFN's earliest iteration, *Transactions of the Ottawa Field-Naturalists' Club*. A subcommittee of the OFNC Publications Committee sifted through all papers in Volume 132 of CFN, and came up with a list of the top five papers. From these top five, the committee selected the top paper, which for this volume was actually a tie between two papers, both of which receive the James Fletcher Award. The awards for Volume 132 of CFN go to:

Joseph J. Bowden, Kyle M. Knysh, Gergin A. Blagoev, Robb Bennett, Mark A. Arsenault, Caleb F. Harding, Robert W. Harding, and Rosemary Curley. The spiders of Prince Edward Island: experts and citizen scientists collaborate for faunistics. Canadian Field-Naturalist 132(4): 330–349. https://doi.org/10.22621/cfn.v132i4.2017

- This paper presents the first comprehensive list of spider species on Prince Edward Island, increasing the known list from 44 to 198 species, which is a huge accomplishment. The paper also used a unique collaboration between experts and citizen scientists.

And to:

Richard Troy McMullin, Katherine Drotos, David Ireland, and Hanna Dorval. Diversity and conservation status of lichens and allied fungi in the Greater Toronto Area: results from four years of the Ontario BioBlitz. Canadian Field-Naturalist 132(4): 394–406. https://doi.org/10.22621/cfn.v132i4.1997

- This paper presents data on a concentrated effort to collect observations of lichen species during the Ontario BioBlitz in the Greater Toronto Area over four years, and demonstrates the utility of rapid assessments for monitoring the diversity of lichens. This paper was based on a collaboration between experts and citizen scientists.

Congratulations to Joseph Bowden and co-authors and to Troy McMullin and co-authors for writing these excellent papers.

The runners up for this award are:

Chris R.J. Hay, R. Greg Thorn, and Clinton R. Jacobs. Taxonomic survey of Agaricomycetes (Fungi: Basidiomycota) in Ontario tallgrass prairies determined by fruiting body and soil rDNA sampling. Canadian Field-Naturalist 132(4): 407–424. https://doi.org/10.22621/cfn.v132i4.2027

- This paper used genetic techniques and traditional survey methods to describe the diversity of Agaricomycetes in Ontario tallgrass prairies.

Sue Carstairs, Marc Dupuis-Desormeaux, and Christina M. Davy. Revisiting the hypothesis of sex-biased turtle road mortality. Canadian Field-Naturalist 132(3): 289–295. https://doi.org/10.22621/cfn.v132i3.1908

- This paper tested a long-standing hypothesis that female turtles are more at risk of road mortality than males using a unique dataset collected at the Kawartha Turtle Trauma Centre, and found evidence to refute this hypothesis: both sexes were just as likely to be struck on roadways in three of four turtle species.

Rebekah Neufeld, Cary Hamel, and Chris Friesen. Manitoba's endangered alvars: an initial description of their extent and status. Canadian Field-Naturalist 132(3): 238–253. https://doi.org/10.22621/cfn.v132i3.1865

- This paper describes endangered alvars in Manitoba, describing their extent, plant communities, and land use.

Congratulations to these finalists. We would also like to show our appreciation to all authors who chose to share their interesting and valuable field-based studies with the readers of Volume 132 of *The Canadian Field-Naturalist.*

WILLIAM D. HALLIDAY AND JEFFERY M. SAARELA
OFNC Publications Committee

Diana Beresford-Kroeger: a new book, a life's work

Classical botanist, medical biochemist, and revolutionizer of how we look at forests has—by the time you read this—launched her seventh book. The event is scheduled for 24 September 2019 in Toronto, and we will have a review of it in our next issue of *The Canadian Field-Naturalist*. In the meantime, here is a brief note on Diana, the book, and selected aspects of her work. I spoke with her by telephone—she in Ottawa, I in rural Prince Edward Island—on 13 August 2019 and this account is based in part on our conversation.

The title of her new book, *To Speak for the Trees:*

My Life's Journey from Ancient Celtic Wisdom to a Healing Vision of the Forest (Penguin Random House, 2019), captures the essence of her work, which is a unique combination of almost-lost beliefs in the forest-enabled human connection with nature and the eruption of recent research into the wholeness of land, sky, and waters through the forests. The capacity to hold in the mind—and body and spirit—the knowledge of both modern science and indigenous systems built on that wholeness is rare. Fortunately for the planet, it is becoming less rare, and Diana's lifework is a major stream contributing to this 'new renaissance'. She's particularly encouraged by the range of engagement, from community efforts to improve the health of cities and neighbourhoods to the activism of youth world-wide to combat climate change. Diana informed me of the 2017 passing by the New Zealand Parliament of an Act that gives the Whanganui River the status and rights of a person, a precedent-setting major step forward that settled years of litigation and provided funding for improving the health of the river.

Diana's previous books celebrate and urge preservation of the world's forests, especially the boreal forest ringing the north, the last, relatively intact great forest on Earth. The message is simple: the forests are key to the survival of life on the planet, including human life. And it isn't just the capacity to survive but the quality of life in all its aspects. With their concept of "forest bathing", the Japanese have been aware of this for over 1000 years; through her writings—including a chapter in the forthcoming *International Handbook of Forest Therapy*—and other media, Diana is helping bring this practice to North America. Her research in biochemistry has enabled her both to understand the chemical communications among trees and the impact of that communication on land and waters and how that biochemistry can be harnessed for human health: mental, physical, and spiritual. She is also an accomplished medical researcher with some 300 articles to her name. Perhaps the most easily accessible summary of her work can be found in the inspiring documentary *Call of the Forest: The Forgotten Wisdom of Trees*, which can be viewed on the TVO website (https://www.tvo.org/video/documentaries/call-of-the-forest-the-forgotten-wisdom-of-trees). In the making of this film, Diana travelled to various corners of the world—Tokyo and Hokkaido Island, Ireland's Raheen Oak Wood, the redwoods of California, the Avatar Grove on Vancouver Island, British Columbia, and UNESCO world site Pimachiowin Aki on the eastern shore of Lake Winnipeg—to meet and share experiences with people engaged in restoration of forests and research demonstrating their value is highest and most essential when left intact.

A second key theme of her work is science-based wisdom for living: her 2013 volume *The Sweetness of a Simple Life: Tips for Healthier, Happier, and Kinder Living Gleaned from the Wisdom and Science of Nature* (Random House Canada), contains 60 short chapters organized around "Health and Food", "Home and Garden", and "The Larger World". The book concludes with a description of her Bioplan, a constant third theme in all her work.

The foundation of the Bioplan is simply stated—everyone plants a tree a year for six years—and potentially very effective. She knows not everyone can or will do that, but the science is getting behind it; she cited "The global tree restoration potential" in *Science* (365: 76–79 https://doi.org/10.1126/science.aax0848), as a recent example. Diana consults with many schools and other institutions on how to follow her Bioplan. She also has her own forest and garden, a 65-hectare plot she calls Carriglaith near Merrickville, just outside Ottawa, where she and her husband, Christian Kroeger, work hard to preserve rare species of trees. She goes to phenomenal efforts to find these species.

Awards have flowed in. In 2010, she was elected a Fellow by Wings WorldQuest, an international organization "dedicated to recognizing and supporting visionary women" and the following year, the Utne Reader named her one of their 25 Visionaries for 2011. The Royal Canadian Geographical Society elected her to the College of Fellows in 2013 and named her one of 25 women explorers of Canada in 2016. Diana received an honorary doctorate from Carleton University on 11 June 2019. The citation notes that *Call of the Forest* "was nominated for the Rob Stewart Award for Best Science or Nature Documentary Program at the 2018 Canadian Screen Awards. Her peer reviewed work, *Arboretum America: A Philosophy of the Forest*, won the prestigious National Arbor Day Foundation Media Award for an exceptional educational work on trees and forests" (https://newsroom.carleton.ca/2019/diana-beresford-kroeger-receives-honorary-degree-from-carleton-university/). She has been profiled in many newspapers, the *New York Times*, *Winnipeg Free Press*, and *Ottawa Citizen*, to name only a few; interviewed on Baltimore NPR's Marc Steiner Show, by the CBC, and other radio stations; in October 2018, Andrew Nikiforuk published a two-part article on her work in *The Tyee*, an independent, online, British Columbian news magazine. As well, Diana has written over 300 scientific and 'popular' accounts of her research for various journals and magazines. (See the Media section of http://calloftheforest.ca/about-diana/ for a partial list.) She gives guest lectures and masterclasses and is a science advisor for the Archangel Ancient Tree Archive, which works to preserve the Earth's oldest trees through its Champion Tree Project (https://www.ancienttreearchive.org/). How she does all this while managing to live off-line is a wonder—she's not sure how she does it either, but noted that not having the internet is certainly helpful in getting things done!

A final comment: in addition to inspiring people all over the world, she was recently fictionalized as scientist Patricia Westerford in Richard Powers' near-overwhelming novel about the life and times of trees, *The Overstory*, soon to be reviewed in *The Canadian Field-Naturalist*. Space won't allow recounting her story of how she heard about this, but it became yet another means of getting the message out. Clearly, Diana Beresford-Kroeger's work, like all works of nature, will live on in many forms.

BARRY COTTAM
Book Review Editor –
The Canadian Field-Naturalist

Minutes of the 140th Annual Business Meeting (ABM) of the Ottawa Field-Naturalists' Club, 8 January 2019

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

Fifty-three attendees spent the first half-hour reviewing minutes of the previous ABM, the financial statements, Treasurer's Report, and annual reports of Ottawa Field-Naturalists' Club (OFNC) committees for 2017–2018. The meeting was called to order at 7:30 pm. During the meeting, relevant documents were projected on a screen for the audience's information.

1. Minutes of the Previous Annual Business Meeting (ABM)

It was moved by Lynn Ovenden, seconded by Julia Cipriani, that the minutes of the 139th ABM be accepted as distributed and published in *The Canadian Field-Naturalist* (CFN).

Carried

2. Business Arising from the Minutes

Nil.

3. Communications Relating to the Annual Business Meeting

Nil.

4. Treasurer's Report by Ann Mackenzie

Ann presented a simplified statement of OFNC's major sources of revenue (membership, donations, interest) and the Club's donations and expenses (net of associated revenues) from various club activities. Similar to last year, there was a significant shortfall as we continued to use the proceeds of Violetta Czasak's bequest to further the objectives of the club. How long we can continue to run large deficits before the bequest funds are depleted will depend on interest rates as well as our level of deficit spending.

Subscription fees for *The Canadian Field-Naturalist* increased last year but that increased revenue is deferred until the coming year when the relevant issues are published.

Ann also described some of the electronic technologies and programs that are enabling her and other volunteers to process OFNC financial processes more efficiently, maybe even remotely. The Club increasingly makes payments by direct deposit instead of cheque, and accepts payment by direct bank transfer and credit card.

In response to a question, members were told the budget for 2018–2019 was approved by the Board of Directors at its October 2018 meeting and attached to the minutes, available at http://ofnc.ca/wp-content/uploads/2018/11/OFNC-Board-Minutes-2018-10-15.pdf.

Moved by Ann MacKenzie and seconded by Henry Steger, that the financial statements be accepted as fair representation of the financial position of the Club as of September 30, 2018.

Carried

5. Nomination of the Accounting Firm

Moved by Ann MacKenzie and seconded by Jeff Skevington, that the accounting firm of Welch LLP be contracted to conduct a review of the OFNC's accounts for the fiscal year ending September 30, 2019.

Carried

6. Committee Annual Reports

A few highlights from each report were presented by the chair or a representative of each committee. There was a request to make the reports available on the website.

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

Carried

7. Highlights from 2018

a) Christmas Bird Count (Bob Cermak)

The 100th Ottawa-Gatineau Christmas Bird Count (CBC), a joint effort of the Ottawa Field-Naturalists' Club (OFNC) and the Club des ornithologues de l'Outaouais (COO), was held 16 December 2018. The CBC, worldwide since the first in 1900, is the longest running citizen science survey in the world. Data collected by observers are vital for conservationists. It informs strategies to protect birds and their habitat, and helps identify environmental issues with implications for people as well.

b) Safe Wings Ottawa (Anouk Hoedeman)

Anouk provided an update on Safe Wings' progress in promoting awareness of bird-building collisions and effective solutions. She discussed the importance of monitoring buildings and collecting data and specimens to convince building owners of the seriousness of the problems, and the challenges volunteers face due to widespread misconceptions about preventing collisions and the need to rescue stunned birds. She spoke of the program's unexpected expansion into providing rescue and rehabilitation not only for window collision victims, but for birds requiring care for other reasons as well, due to the high demand for such services.

c) Mer Bleue walk with new Canadians (Jakob Mueller)

At the request of the Ottawa Community Immigrant Services Organization, a nature walk at Mer Bleue was offered to about 30 new Canadians in September. Several members with experience leading walks participated in the event and everyone enjoyed the outing.

8. Nominations for Board of Directors positions

Fenja Brodo presented the slate of candidates nominated to the Board of Directors for 2019:

EXECUTIVE COMMITTEE

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

DIRECTORS

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

EX OFFICIO:

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

Moved by Fenja Brodo and seconded by Barry Cottam that this slate of nominees be accepted as members of the Board of Directors of the OFNC for 2019.

Carried

Fenja acknowledged Lynn Ovenden's departure from the Board after serving as the Recording Secretary. She warmly welcomed Elizabeth Moore and Bev McBride to the Board. Committee chairs will be approved by the Board of Directors at the January 2019 meeting.

9. New Business and General Discussion

Nil.

10. Presentation: Small Creatures, Big Impact

Jakob Mueller described the seven salamander species that live in eastern Ontario and the important role of salamanders in the deciduous and mixed forests of eastern North America.

11. Adjournment

Moved by Lynn Ovenden, seconded by Eleanor Zurbrigg, that the meeting be adjourned.

Carried

LYNN OVENDEN
Recording Secretary

Annual Reports of OFNC Committees for October 2017–September 2018

Awards Committee

The Awards Committee manages the process to annually recognize those Ottawa Field-Naturalists' Club (OFNC) members and other qualified persons who, by virtue of their efforts and talents, are deserving of special recognition. In late 2017, nominations were received and evaluated (see awards criteria at https://ofnc.ca/about-ofnc/awards), resulting in nominees for four awards being recommended to the Board of Directors for approval. Biographies were written for each award recipient for inclusion in the Club's publications and posting on the website. The awards were presented at the annual Awards Night in April 2018. The recipients' names, type of award and rationale for recognition follow below.

- Annie Bélair—Member of the Year for redesigning *Trail & Landscape* as a communication venue for local members.
- Julia Cipriani—George McGee Service Award for dedicated service on Events Committee and other areas of Club activity.
- David Seburn—Conservation Award for a Member for advocacy efforts influencing the decision to ban hunting of Snapping Turtles in Ontario.
- The Teachers of Regina Street Alternative School—Mary Stuart Education Award for connecting their students with nature at Mud Lake.

President Diane Lepage selected Greg Lutick and Adrienne Jex as the recipients of the 2017 President's Prize for improving service of refreshments at monthly meetings.

The Awards Committee thanks Mark Brenchley for helping with awards certificate design and printing.

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

Birds Committee

Birds Committee (11 members, one ex officio, and one observer), Bird Records Sub-committee (11 members), and Bird Feeders Sub-committee (one member and five volunteers) coordinated OFNC bird related activities and directed and encouraged interest in birds within and outside the OFNC area.

Two committee members administered OFNC's Facebook group (2161 members October 2018) which provides a place for club members and prospective members to discuss ideas and exchange information related to all aspects of natural history, club outings, and club initiatives.

A committee member provided weekly provincial (Ontbirds) reports of OFNC area (Ottawa-Gatineau) bird sightings which with photos by local photographers was also provided on the OFNC Facebook and the OFNC website. This same member authored a four-part, four issue, *Trail & Landscape* article "How to find 250 Bird Species in the OFNC Study Area in a Single Year".

Our committee participated in the Ottawa River Watershed Study and the creation of the Lac Deschênes-Ottawa River Important Bird Area (IBA). We liaised with the Innis Point Bird Observatory and recommended financial support for their Osprey web cam and bander-in-charge. We coordinated updates to the Department of National Defence's (DND's) Shirleys Bay causeway access list which currently contains 385 OFNC members.

Birds Committee collaborated with other OFNC committees throughout the year. Our committee members led field trips and participated in Conservation Committee activities such as supporting the Friends of the Carp Hills with their survey and planning for the conservation and public use of Torbolton Ridge land owned by the City of Ottawa. We provided a significant role in OFNC's efforts to introduce new Canadians to OFNC area natural history by partnering with the Ottawa Community Immigrant Services Organization to organize and help lead a field trip at the Mer Bleue boardwalk and area.

Birds Committee and the Club des ornithologues de L'Outaouais organized the 2017 Christmas Bird Count with 133 field observers and 28 feeder watchers finding 60 bird species. The 2018 Seedathon "Big Day" event was held in early fall to raise funds for purchasing seeds for the five OFNC bird feeders. One hundred and thirty bird species were found and $790 (as of 1 August) was raised.

Although the OFNC Falcon Watch is no longer required because the Heron Road nest site is in a safe location, several members keep an informal watch on the nest. Four more Peregrines successfully fledged from this location this year.

BOB CERMAK, Chair

Conservation Committee

A major accomplishment of the OFNC Conservation Committee in 2018 was successfully documenting Red Spruce (*Picea rubens*) at many sites in eastern Ontario. This tree species is considered a key component of climax forests of eastern Canada and yet was apparently largely "missed" in the forest surveys of eastern Ontario to date. Members of the committee and other interested individuals collaborated to:

- Confirm the presence of Red Spruce is much more abundant and widespread south of the Mer Bleue bog (centred at approximately Anderson Road/Leitrim Road/Highway 417) than was previously known.
- Confirm the presence of Red Spruce at several locations outside of the Ottawa district where it was apparently not previously documented: Hawkesbury, Alfred, near Alfred Bog, Rose Lake, and Vennachar Junction-Denbigh.
- This project was the topic of the October OFNC monthly meeting, and will be summarized in a forthcoming article currently in preparation. Records are being uploaded to iNaturalist as time permits. We anticipate that we will continue to work on this project at a more relaxed pace in 2019 to further resolve uncertainties regarding Red Spruce in Ontario.

It was another busy year for OFNC-Conservation regarding public outreach and active conservation work in the great outdoors. Members of our committee lent their expertise to lead numerous conservation events, including many guided public Nature tours, public lectures, bio-inventories, and attendance/contribution at conservation-related meetings. Our committee members continued to enthusiastically document wildlife near Ottawa and further afield with thousands of observations entered into iNaturalist and other conservation databases.

As in previous years, we met regularly to discuss and plan actions regarding species of conservation concern (both threatened indigenous species, and emerging potentially invasive exotics), habitat conservation/restoration projects, and engaging both naturalists and the general public alike in conserving Canada's natural wildlife heritage. We were pleased to collaborate on conservation work with a number of external organizations and several other OFNC committees throughout the year.

We were pleased to welcome Greg Lutick to the committee this year.

OWEN J. CLARKIN, Chair

Education and Publicity Committee

Storyboards for display at eight sites around the Fletcher Wildlife Garden (FWG) continue to be developed. We now have 24 bilingual stories, eight per season. They are now all laminated so that they can be reused for years. The previous ones on photopaper were unusable after one season.

We held a second Open House at the Resource Centre in collaboration with Jane's Walks. Several members hosted about 100 visitors with drinks, cookies, and tours of the garden. This was approximately double from the previous year.

This year we had two applications for sponsorship to the Youth Summit of Ontario Nature. Both candidates were judged worthy to attend and have done so. Lucy Patterson and Kathy Conlan were again judges at the annual Ottawa Regional Science Fair. They presented three OFNC awards ($100 each) and 1-year club memberships to the winning students.

We hosted numerous group tours of the FWG this year including three tours by home schoolers, seven tours by Scouts/Beavers/Brownies, and two school groups. We also developed seasonal Visual/Audio Scavenger Hunts for use with these groups and one for a tour of Mer Bleue for new immigrants. A flyer was also made for Petrie Island but was never used due to closing of its causeway until 2019. There were also several presentations at a seniors' home, to the DND, and to the Canadian Parks and Wilderness Society (CPAWS).

Bug Day was again a success this year with hundreds of attendees visiting our microscope tables to view insect specimens provide by Fenja Brodo. A callout for volunteers yielded 16 enthusiastic OFNC members who assisted with identifying insects and observing specimens under the microscopes.

Finally, we had one new member confirmed by the Board, Alexandra Brett, with three more possible in the near future. Thanks are extended for the contributions of Mark Brenchley who has stepped down from the committee.

GORDON ROBERTSON, Chair

Events Committee

In 2018, the Events Committee (consisting of Julia Cipriani, Owen Clarkin, Hume Douglas, Bev McBride, Elizabeth Robson-Gordon, and Jakob Mueller) planned or organized field trips, workshops, and presentations for monthly meetings, as well as a Bioblitz-style species inventory. The committee is grateful for the help it received from leaders, volunteers, and experts too numerous to list.

Nine of the club's ten monthly meetings included presentations (the exception was the Annual Business Meeting). Topics ranged from faraway locations (Uganda, Iceland, and Mars), to conservation challenges (freshwater ecosystems, cod stocks, turtles, and Red Spruce), ecology (the importance and role of night), and profiles of taxonomic groups (lichen). The December meeting had 135 people in attendance, the highest for a monthly meeting since the venue moved to the Neatby building several years ago. Of the 48 trips or workshops, primary focusses included birds or birding (19), botany (11), herpetology (three), insects (two), and mushrooms (one), with the remaining 12 trips devoted to general natural history and miscellaneous topics. The annual Members' Photography Night continued, but was postponed to April and held in a new venue due to some logistical challenges in January. In addition, the committee lent their expertise to the coordination of a species inventory for the Nature Conservancy of Canada's property that forms part of the Kenauk Nature reserve north of Montebello, Quebec. Over two days in July, OFNC members and associated scientists recorded 454 species at the property and revealed opportunities for further study.

The Events Committee continues to face the perennial yet pressing challenge of recruiting and developing new leaders for field trips. If you have ideas for events or are willing to share your interests or expertise, please do not hesitate to get in touch.

JAKOB MUELLER, Chair

Finance Committee

This report covers financial matters during fiscal year 2018, which extended from 1 October 2017 through 30 September 2018. Many of these matters go directly to the Board of Directors for resolution. However, they are mentioned here to give OFNC members a sense of the financial issues that occur.

The budget for FY2019 was prepared by the Finance Committee, based on input from the Board of Directors and analysis by the Finance Committee. It was presented to the Board in September 2018, and approved at the October 2018 Board meeting. The budget forecasts revenues of $146 000, expenses of $195 775, for a deficit of $49 775.

During the 2018 fiscal year, the Board dealt with several financial issues that were not foreseen when the budget for FY2018 was prepared. These were:

- A request by the Innis Point Bird Observatory for $4500, to pay a Head Bander. This was approved;
- A request by a local bird sanctuary to support its new educational programs. This was declined;
- A request by a group sponsoring a clean-up at Mud Lake, for $400 for a barbecue lunch for volunteers. This was declined.

A financial issue which comes up from time to time is whether a particular type of volunteer work should be recognized by granting an honorarium. During FY2018, this arose at the Board in the context of Facebook administrators. The Board decided not to grant honoraria for this activity.

The Treasurer continued her work to improve our systems for bookkeeping, donations, and payments.

KEN YOUNG, Chair

Fletcher Wildlife Garden

Volunteers

The FWG had a productive season in spite of periods of low rainfall and high temperatures. Volunteers working through the summer were joined by several corporate work groups, and students from Carleton University and University of Ottawa to carry out work throughout the property. Habitat preservation and rehabilitation took up the majority of our time, with good progress made on combating a growing list of invasive and noxious plants. Agriculture and Agri-food Canada (AAFC) was particularly helpful in this respect. In 2018, our volunteers put in over 5000 hours of time maintaining and improving the property.

Our annual native plant sale was a great success. The sale is a source of revenue, but most important, it promotes the use of native plants in local gardens. In 2018, we also donated native plants to at least 10 school, community, church, and other demonstration pollinator gardens.

Wildlife

This summer saw an unexpected rise in the number of Monarchs and other butterflies at the FWG. Several volunteers collected and reared eggs and caterpillars and released over 150 mature Monarchs. The release events were witnessed by many volunteers and visitors to the FWG, creating opportunities to chat about conservation issues. In conjunction with Wild Pollinator Partners, we also held two workshops in April to make our highly successful Mason Bee boxes and another in fall to look at the pupae in the boxes (128) before storing them for winter. Jessica Forrest of the University of Ottawa gave a workshop on bees and was on hand at the latter workshop to identify wasp and bee pupae. Three Snapping Turtle nests were identified at the FWG this year, and we had help from the Canadian Wildlife Federation in rescuing eggs from a washed-out nest from the Arboretum.

Pond work

The south bank of the pond is now covered with a variety of native plants, much used by Giant and Black Swallowtail butterflies and Goldfinches. Two benches were installed along the trail to allow visitors observation points. Erosion damage to the path around the pond was repaired early in the season as a safety measure. In October, a contractor was hired to install a drainage trench to prevent future problems. We continued to remove Flowering Rush from the pond.

Backyard Garden

The Back Yard Garden (BYG) continues to be a popular area, and the hard work of our Friday morning volunteer group is much appreciated by visitors. Many photographers and artists visited the BYG to take advantage of the colourful variety of flowers and birds. Last fall, several trees were removed to maintain favourable sun/shade conditions of the garden.

The Gully

The area between the west end of the pond and Prince of Wales Drive was a focus of much work this summer. Thanks to students from the Algonquin College horticulture program and the initiative and hard work of FWG volunteers, masses of Dog-strangling Vine and Comfrey were replaced with native plants, such as Swamp Milkweed and Joe-Pye Weed. The transformation of this part of the FWG was inspiring to all involved and rewarding to those of us who saw the many Monarchs and other insects there this summer.

The Ravine

Intensive removal of invasive species on the north side of the ravine in 2017 was followed by planting of Bush Honeysuckle this summer. The addition of a bench overlooking the ravine has created a popular vantage point for photographers and birders.

Tours/Visitors

During this summer, the FWG provided tours to a number of youth groups. A series of questionnaires about plants, animals, birds, and insects that can be found at the FWG were used for the first time this summer by young visitors to look for as they walk along the trails. Storyboards have been placed around the property with seasonally appropriate photos to emphasize the diversity of flora and fauna at the FWG. Visitors to the Resource Centre now enjoy new stand up displays that include actual wildlife specimens.

TED FARNWORTH, Committee Member

Macoun Club

Macoun Field Club activities take place almost every Saturday from September through June, except for public holidays. During 2017–2018, Committee members organized and supervised 17 indoor meetings, at which the children and young people (ages eight to 17) gathered for presentations on mainly zoological and ecological topics. Committee members also planned and led 18 field trips, mostly to either the Club's long-term nature-study area in Ottawa's western greenbelt, or to Gerry Lee's wild lands in the Pakenham Hills of Lanark County (from 1967–2002 known to Macoun Club members as Mary Stuart's property). Part of one field-trip involved a joint outing with the OFNC, at Brewer Park Pond, and one special astronomy trip was held at night. Additionally, there was one overnight camping trip to Gerry Lee's land.

Committee and Macoun Club members hosted the annual nature quiz at the OFNC Awards Night.

The Macoun Club quietly celebrated its 70th year. Committee members maintained an up-to-date, illustrated record of all events on the Club's website, now hosted by the OFNC, and produced the monthly newsletter and issue No. 72 of the Club's annual magazine, *The Little Bear*.

ROBERT E. LEE, Chair

Membership Committee

The distribution of Club membership for 2018 on 30 September 2018 is shown in the table below, with the corresponding numbers shown in brackets for 30 September 2017. "Other" represent mostly affiliate organizations that receive complimentary copies of the Club's publications. There was a slight decrease in membership in 2017. Members within 50 km of Ottawa comprised 713 of the Canadian membership of 827. Families of children in the Macoun Club are given complimentary membership to encourage interest in the Club in the longer term.

HENRY STEGER, Chair

Publications Committee

The Publications Committee manages publication of the Club's scientific journal *The Canadian Field-Naturalist* (CFN), the Club's regional publication *Trail & Landscape*, and Special Publications. Committee members were Annie Bélair (Editor, *Trail & Landscape*), Dan Brunton, Carolyn Callaghan, Paul Catling, Barry Cottam (Book Review Editor, CFN), William Halliday (Online Journal Manager, CFN),

	CANADIAN		USA		OTHER		TOTAL	
Individual	385	(399)	7	(6)	0	(0)	392	(405)
Family	314	(316)	0	(0)	1	(0)	315	(316)
Student	23	(24)	0	(0)	0	(0)	23	(24)
Trail & Landscape	2	(2)	0	(0)	0	(0)	2	(2)
Honorary	24	(25)	0	(0)	0	(1)	24	(26)
Life	40	(41)	3	(3)	1	(1)	44	(44)
Other	24	(24)	0	(0)	1	(1)	25	(25)
Macoun Club	15	(19)					15	(19)
TOTAL	827	(848)	10	(9)	3	(3)	840	(860)

Karen McLachlan Hamilton, Diane Kitching, Dwayne Lepitzki (Editor-in-Chief, CFN), Amanda Martin (Assistant Editor, CFN), Jeff Saarela (Chair), David Seburn, Ken Young, and Eleanor Zurbrigg. Frank Pope resigned from the committee in December 2017, after many years of committee participation.

Trail & Landscape

Four issues of *Trail & Landscape* were published: 51(4) (October–December 2017), 52(1) (January–March 2018), 52(2) (April–June 2018) and 52(3) (July–September 2018). Feedback from Club members on the new, all-colour format of *Trail & Landscape* (launched with vol. 51(3)) continued to be extremely positive and encouraging.

The Canadian Field-Naturalist

Three issues of *The Canadian Field-Naturalist* were published: 131(2), 131(3), and 131(4). In 131(3) a new type of content was introduced in *The Canadian Field-Naturalist*. "Great Canadian Field-Naturalists" recognizes individuals who made significant contributions to our knowledge of the natural history of Canada. Criteria for recognition were established, and Great Canadian Field-Naturalist tributes were published for James Fletcher and John Macoun. Also this year, the James Fletcher Award was established. The award recognizes the best paper published in CFN in a particular volume. The first award, for CFN Volume 130 (2016), was announced in 131(3). Francis Cook, who served as Editor of CFN for more than 30 years, was appointed to the Order of Canada in 2018.

Subscription fees for institutional subscribers were increased, based on a survey of fees for journals similar to CFN, and the fact that our production costs have increased without subscription increase for a long time. Revised author guidelines for preparing manuscripts for CFN were finalized and published online at http://www.canadianfieldnaturalist.ca/public/journals/1/CFNAuthorInstructions.pdf.

The committee completed the consolidation process of back issues of *The Canadian Field-Naturalist*. A small team convened in spring 2018 and moved the back issues, which were stored in the Red Barn on the Farm during the autumn and winter of 2017–2018, to the Fletcher Interpretive Centre, and then sorted and organized the material. Given limited demand for hard copy back issues of the journal, only a small subset of the available back issues was retained; the material is now being stored by Annie Belair. The surplus material was recycled.

Ottawa Field-Naturalists' Club Research Grants

2018 was the fourth year of the Ottawa Field-Naturalists' Club Research Grants program. Research grants support field-based research activities that reflect and promote the Club's objectives within eastern Ontario and/or western Quebec, focussed particularly upon the Club's study area. A total of $15 000 is available each year to fund research proposals. The application deadline was 15 January 2018. A subcommittee convened and chaired by Dr. Tony Gaston reviewed all proposals and submitted funding recommendations to the Board of Directors. A list of recipients of 2018 Research Grants was published in *Trail & Landscape* 52(3).

JEFFERY M. SAARELA, Chair

Safe Wings Committee

2017–2018 was Safe Wings Ottawa's first year as a standing committee of the OFNC, after several years as a program of the Birds Committee. This committee works to address the problem of bird-window collisions through research, education, and rescue.

Between 1 October 2017 and 30 September 2018, Safe Wings volunteers:

- regularly monitored 75+ buildings during spring and fall migration
- documented ±2300 window collisions
- rescued 493 live birds following window collisions
- answered approximately 2500 phone calls
- admitted 610 birds with various types of injuries to our own facility
- provided rescue assistance and transported hundreds of injured birds to Safe Wings and to the Wild Bird Care Centre.

In addition, we produced a brochure on window collisions, and completed a draft Ottawa Bird Strategy. Our outreach efforts led to the adoption of bird-friendly design guidelines by Public Services and Procurement Canada (PSPC), the National Capital Commission, and the City of Ottawa (currently in development), as well as Carleton University and the University of Ottawa. Environment and Climate Change Canada also began working on several initiatives to address collisions.

In 2017–2018, Safe Wings volunteers' workload expanded significantly due to several factors: public awareness of bird-building collisions continued to increase; the City of Ottawa began referring calls about all injured birds to Safe Wings; the Ottawa Valley Wild Bird Care Centre further reduced its own phone hours and increased its reliance on Safe Wings to provide preliminary care to injured birds; and several high-profile, non-collision bird rescues drew media attention, namely the Great Horned Owl family on Petrie Island, a Wild Turkey in downtown Ottawa, the Bluesfest Killdeer (although we did not directly intervene), and a Northern Flicker found hung by its neck.

Safe Wings also generated media coverage for its building monitoring program, its annual bird display at City Hall, the National Art Centre's not-bird-friendly renovation, the National Gallery of Canada's failure to address collisions, PSPC's efforts to retrofit the C.D. Howe building, and Snowy Owls being hit by cars.

ANOUK HOEDEMAN, Chair

Treasurer's Annual Report, 2018

The Financial statements for the year ended 30 September 2018 have been prepared by our accounting firm, Welch LLP based on a review they conducted of our financial records. We do not get our books audited.

There are no major changes to report from last year to this year because many of the trends remain. We are continuing to run deficits as we use the proceeds of the Czasak bequest to further the objectives of the club. During the year we were able to provide a \$10 000 donation towards the publication of *The Birds of Nunavut* by Anthony Gaston, continuing the OFNC's long history of support for the natural history of the Arctic. For the third year we gave \$5000 to the Ottawa-Carleton District School Board to enable more children to spend time at their Outdoor Education Centres. Support was also provided for a bird bander at Innis Point. Both the Invasive Plant Council (annual meeting) and the Entomological Society (Bug Day) also received support.

In the interests of good governance your Board reviewed the length of time we could run substantial deficits before the bequest funds were depleted. How long this takes will depend on interest rates as well as our level of deficit spending. An analysis of these two variables was carried out thanks to a tool developed by Catherine Hessian. If we continue with our current level of a \$80 000 difference between our interest income and budget deficit, then we would be back to our pre-bequest investment level of \$500 000 in 19 years. Using this tool the Board can more prudently consider any significant expenditures that might be proposed in the future. For example, if we donated \$100 000 for the purchase of property then we would have used up the bequest in 17 years.

Last year we reported that we would be closing several funds as part of streamlining of our financial systems and record keeping. This will be the last year that the Seedathon Fund, Anne Hanes Memorial Fund, and the De Kiriline Lawrence Fund will be shown in the statements. These funds have been netted to zero as they are incorporated into the General Fund of the club. The two Macoun funds have been merged into one.

As a result of increased subscription fees for the CFN journal there was a significant increase in revenue from that source. Most of this was deferred until next year because the issues it relates to were not yet published. The apparent increased revenue showing this year reflects deferral rates between the last couple of years.

We are increasingly using technologies and programs to enhance the efficiency of our financial processes. This past year we started making payments using direct deposits rather than cheques. Increasingly payments we receive are similarly direct bank transfers. We also did a trial to accept credit card payments at the Fletcher Wildlife Garden plant sale. That worked so well we decided that we would promote it for 2019.

This has been my second full year as Treasurer. I am pleased that we were able to provide the Board with the financial statements for their consideration at their December meeting prior to presenting them at the Annual Business Meeting in January. It is my intention to continue that practice into the future.

In undertaking my tasks I have been greatly assisted by the club financial/administrative team of Ken Young (Chair Finance, CFN invoices, CFN-by-issue reports), Catherine Hessian (Investments, mail and bank deposits), Tanja Schueler (Paypal deposits), Bob Berquist (Donation Receipts), Eleanor Zurbrigg (CFN Subscriptions), and Henry Steger (Membership). Professional advice and services were provided by Katryna Coltess (bookkeeping), Sue Anderson (Investments), and Eric Leibmann (Accounting Review).

Motions:

Moved that the financial statements be accepted as a fair representation of the financial position of the Club as of September 30, 2018.

Moved that the accounting firm of Welch LLP be contracted to conduct a review of the OFNC's accounts for the fiscal year ending September 30, 2019.

ANN MACKENZIE, Treasurer

Approved final statements available online at: https://www.canadianfieldnaturalist.ca/index.php/cfn/article/view/2337/2217.

The Canadian Field-Naturalist

The Ottawa Field-Naturalists' Club Awards for 2018, presented February 2019

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

On 23 February 2019 members and friends of the Ottawa Field-Naturalists' Club (OFNC) gathered for the Club's Awards Night at St. Basil's Church in Ottawa to celebrate the presentation of awards for achievements in the previous year. Awards are given to members or non-members who have distinguished themselves by accomplishments in the field of natural history and conservation or by extraordinary activity within the Club. Four Club awards were presented for 2018, for: (1) a four-part series on birds in *Trail & Landscape*, (2) long time service managing the Club's membership program, (3) establishing and expanding Safe Wings Ottawa, and (4) nature-based education in Ottawa. As well, a President's Prize was presented.

Member of the Year: Gregory Zbitnew

This award is given in recognition of the member judged to have contributed the most to the Club in the previous year.

In 1977, two local birders, Paul Matthews and Richard Poulin, wrote a series of articles for *Trail & Landscape*, on how to find 200 species a year in the Ottawa area. Fast forward to 2017 when a suggestion was made to update those articles for *Trail & Landscape*. Gregory was asked if he was willing to do this and fortunately for us, he agreed. The result is a comprehensive survey entitled: "How to find 250 bird species in the OFNC study area in a single year".

It is no surprise that a dominant interest for OFNC members is birding. These articles have proven exceptionally valuable for all who are keen on birds whether serious birders or casual observers. Even those whose interests may lie elsewhere will find much to enjoy in this excellent series. A nod should also be given to the outstanding photos by Jacques Bouvier accompanying the articles.

The articles were published in 2018, Volume 52, one per issue starting with Number 1, and culminating with issue Number 4. Along the way, Gregory gave us informative, well-researched, valuable, and eloquent advice and suggestions on how, when, and where to look for birds.

A preamble in the first article talks about "Laying the Foundation" and covers how to find news of recent observations (for example, by checking eBird), and what comprises the OFNC study area. It includes definitions of "common", "uncommon", "rare", and other useful and important points.

Every article focusses on the birds that can be reasonably found in the four seasons covered by each of the different issues. The best locations are highlighted, but not ignored are many other less-visited, excellent spots in which to search for birds. Suggestions as to where some of the seasonal specialties might be found prove especially useful. For example, in issue Number 1, a section called "Chasing Winter Birds" provides tips on where one might see winter finches, Bohemian Waxwings, some of the winter raptors, and other groups of birds more likely to be seen in winter.

Each article also gives a list of "Important Target Birds" to look for during the particular season. These lists include the uncommon to rare species that may be difficult to find but should be found with some effort. As Gregory notes, it "excludes the very rare species" that cannot reliably be predicted.

In the last issue, Number 4, Gregory provides two excellent summaries in the form of tables. In his own words, Table 1 shows the "appropriate activities/places for birding each week" through the year. Table 2 is a list of all the target species "with their usual habitat and the usual time that you can expect to see them". Therefore, at a glance, it is easy to find a bounty of relevant information to help plan birding activities.

The sheer amount of work that Gregory put into these four lengthy articles is staggering. It is clearly a labour of love, and reveals a solid and deep knowledge of the world of birds. A wealth of information is contained within this significant work. These articles will become an essential tool for anyone interested in birding, for many years to come. Indeed, they are already proving very popular.

In addition to preparing the above articles, Gregory also maintains and distributes the OFNC weekly online birding report. And as if all that is not enough, Gregory also leads birding trips for the OFNC throughout the Ottawa area.

For all these reasons we are more than proud to present Gregory Zbitnew with the OFNC Member of the Year award for 2018.

(Prepared by Christine Hanrahan)

George McGee Service Award: Henry Steger

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

It was very fortuitous in late summer 2001 that Henry Steger was retiring soon, and after seeing an article in the *Ottawa Citizen*, dropped by and took an interest in the Fletcher Wildlife Garden (FWG) and joined the OFNC. He met David Hobden, then Chair of the Garden's Management Committee, at an OFNC monthly meeting in early 2002 and offered to volunteer.

Henry's background is in chemistry and mineral processing. His interest in botany came about by serendipity in 1981 and he has pursued it since. So upon his retirement, the FWG seemed a perfect way to follow this interest and he joined the FWG Management Committee in 2002. Apart from his role on the Management Committee, serving as Chair in 2013, he developed a new database for the bird and wildlife sightings at the FWG (computerized almost 2800 hand-written entries recorded between April 1990 and December 2017). He also developed a database for the FWG library. He participated in planning the renewal strategy for the Amphibian Pond and, more recently, in the replanting and weeding around the Amphibian Pond. He continues to help at the annual native plant sales and provides expertise on native species. Henry continues to be a member of this committee, which would make it 17 years and counting.

Henry joined the OFNC Board of Directors as a member at large in 2004 but also was a supportive voice for the FWG at Board meetings. In 2006, when the Membership Committee was about to lose its Chair, Henry graciously accepted the position. In doing so, he inherited a database system that was in desperate need of an update. Undaunted, Henry took up the challenge and developed a new system in Microsoft Access that was tailored to the needs of the Club. As Chair, Henry maintains and updates the database on an ongoing basis due to membership changes, mostly renewals and non-renewals, but has also updated the program itself as new features were needed, for example, going to membership renewal by email. He prints the *Trail & Landscape* (T&L) mailing labels quarterly, manages the emails to members giving them the latest information on upcoming monthly events, and in 2017 created and now updates the list of Club members who want access to the Shirleys Bay causeway.

Henry is also responsible for the "Welcome New Members" seen in every issue of T&L and its "Golden Anniversary Membership List" that appears annually in the second issue. Throughout the years, Henry has written several articles for T&L. In 2010 and then in 2018 he wrote about his struggles with aster seeds collected on a mature plant in one season not growing into that same plant. Then in 2016 his article about the Tubercled Orchid was an intriguing account of his 16 year hunt for this elusive species.

In 2015 when both OFNC Vice-President positions were left vacant, Henry agreed to fill one positon until others could be found. He served as OFNC Vice-President in 2015–2016.

Henry has an analytical mind, is keenly observant and is willing to express his opinions. So, when Henry speaks at Board meetings, you can be sure that it was well thought out and important enough to him to contribute to the conversation. His Jack-of-all-trades skillset was honed throughout his career, making him willing and able to tackle the varied tasks necessary to the Club. That day in 2001 may have been fortuitous, but it has been a real boon for the OFNC. Congratulations Henry for a well-deserved award.

(Prepared by Karen McLachlan Hamilton)

Conservation Award—Member: Anouk Hoedeman

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

For 2018 we are recognizing the initiative and commitment of Anouk Hoedeman for establishing and expanding Safe Wings Ottawa, a program focussed on bird collision research, education, prevention, rescue, and short-term care.

Anouk is well known for her work with the OFNC Birds Committee, including the Falcon Watch. She launched an Ottawa chapter of the Toronto-based FLAP (Fatal Light Attraction Program) in 2014, which later evolved into Safe Wings Ottawa, a separate organization that operates as a committee of the OFNC.

Safe Wings estimates that 250 000 birds collide with glass every year in Ottawa. Anouk and her group document about 2000 to 3000 of these—the rest go unnoticed or unreported. Many dead birds are eaten by scavengers or discarded, while many injured ones are taken by predators or fly away to die elsewhere.

Safe Wings has a core team of about 15 dedicated volunteers who monitor buildings to collect data and dead bodies, rescue birds, and do what is necessary to support one another and the work they do. Anouk and her fellow volunteers have worked hard to build key relationships with groundskeepers, security guards, and maintenance staff at various buildings downtown and in other areas of the city. As they search every nook and cranny that could shelter a bird, they also educate passersby and encourage them to rescue injured birds and report window collisions. Dozens of other Safe Wings volunteers offer their support by transporting birds or helping with other tasks.

Safe Wings volunteers also conduct outreach activities, make presentations to various groups on preventing bird collisions, and provide advice on designing bird-friendly buildings and on retrofitting existing buildings. Anouk's personal efforts have resulted in the National Capital Commission, Public Services and Procurement Canada, the University of Ottawa, and Carleton University adopting bird-friendly design approaches. In addition, she initiated the City of Ottawa's development of bird-friendly design guidelines, which are expected to come into effect this year.

As a result of its reputation, Safe Wings now receives thousands of calls every year for rescue support from individuals and organizations throughout eastern Ontario and western Quebec, including the City of Ottawa, the Ottawa Valley Wild Bird Care Centre, and even the Cornwall SPCA, to name a few.

Because there is such a demand for help, especially outside the Wild Bird Care Centre's operating hours, Anouk obtained federal and provincial rehabilitation permits so she could provide medication, fluids, and other life-saving treatment to injured and sick birds. In 2018, Anouk cared for 742 patients on the third floor of her home, which has been transformed into a short-term rehabilitation centre set up with a variety of cages to accommodate and keep birds safe, warm, and fed until they can be released or transferred to the Wild Bird Care Centre. All of this care also requires keeping the space clean, organized, and stocked with supplies ready for injured birds which may arrive at any time. It all makes for unpredictable demands on her time, and a steep learning curve to determine how to handle different species ranging from hummingbirds to raptors.

We are pleased to recognize the commitment and work of Anouk Hoedeman with this Conservation Award.

(Prepared by Julia Cipriani)

Mary Stuart Education Award: Bill McMullen

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

This year's Mary Stuart Education Award goes to Bill McMullen, a teacher at the Trillium Public School in Orléans on the eastern edge of Ottawa. Bill grew up in a rural community in the Kawartha Lakes region of central Ontario. There, he was able to spend his childhood years exploring the local forests and fields developing a strong interest in the natural world. As a primary school teacher, he found that he could pass on that passion to his students.

On field trips and in the classroom, Bill teaches his young students to be observant of the world around them, and to explore even the small nooks and crannies in search of stories that nature can tell us and to experience the "quiet" of the woods. He teaches them the importance of the environment and the interrelationships between humans, plants, and animals and encourages them to feel they can be a steward of the Earth. Although Bill is an English and math teacher, his knowledge of the natural world gives him the tools he needs. For example, he educates his charges by setting up orienteering courses and taking them skiing, snowshoeing, and hiking. He has even taught children astronomy using his personal telescope.

Bill is also a talented and dedicated nature photographer, spending many hours in the field, especially at the MacSkimming Outdoor Education Centre, photographing plants, mushrooms, and wildlife. He often makes videos to show phenomena that occur after school hours or over a long period of time at the MacSkimming Centre (such as a Monarch Butterfly emerging from a chrysalis, or wildlife that passes by a video cam set up on a trail over a period of three months). He incorporates his photos and videos into his own lessons as often as he can and offers them to other teachers at his school to use with their own classes. He also generously shares these videos online. Bill has donated many of his photos and videos to the MacSkimming Centre for their education programs and also gives students instruction on nature photography. He has also led evening walks with school children to see and hear owls, resulting in experiences some youngsters will cherish their entire lives.

By sharing his experience and experiences with his students, Bill McMullen is an example of the kind of teacher who makes a difference. His students are better equipped to understand the conservation issues of the day, hopefully someday translating that appreciation into action for the benefit of the natural world. The Mary Stuart Education Award is a fitting tribute to his vision, skill, energy, and dedication.

(Prepared by Irwin Brodo based on input from staff at the Ottawa-Carleton District School Board)

President's Prize: Ann MacKenzie

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

The Ottawa Field-Naturalists' Club is blessed to have members with an interest in natural history but with expertise that serves the Club in areas of management and administration. Ann Mackenzie is such a person. She has served the Club very well in the role of President (2012–2013), Past President (2014–2016), and Treasurer (since 2017). I thank her for this.

However, I am recognizing Ann for her on-going work on the Club's financial sustainability and for her dedication to promote financial professionalism and accountability within the Club. If one reviews how the Club's financial operations have changed, there is a constant theme. That is, Ann has striven to enhance the Club's awareness of its financial responsibilities and execution. Today's Club financial procedures and policies have been modernized and in some areas revolutionized.

Before Ann became President, the Club was running unsustainable deficits. Yet there was no attempt to address this issue. Ann dared to suggest an increase in annual fees for the first time in almost 18 years. The practice of a separate fee for paper copies of *The Canadian Field-Naturalist* was implemented. And she fully supported the project to put *The Canadian Field-Naturalist* online to reduce costs.

In November 2015, Ann responded to an announcement of changes to the Ontario *Not-for-Profit Corporations Act* with a review and update of the long-obsolete Articles and By-Laws of the Club's Constitution. This also included a call for all Club committees to update their Terms of Reference. The job is not over. The proclamation of that Act has been delayed.

The receipt of a large bequest from Violetta Czasak led to Ann's recognizing future potential problems with regard to financial management and transparency. She subsequently developed an OFNC Investment Guidelines Policy and initiated the development of Club policy to administer bequests. The latter has supported local community projects in natural history and scientific research projects and has brought increased public recognition for the Club.

Each January the Board of Directors has first-time members. Ann, and probably only she, recognized the need for a guide to help these members become familiar with their roles and expectations. She published the March 2018 Directors' Handbook that all Directors have access to online.

Lastly, Ann has changed how the office of the Treasurer operates. In the past, the Treasurer did it all by his/herself. Within the last year, she brought in "new" volunteers to assist with investment management and the receipt of monies from membership and donations. Hopefully they will stay in the Club and make other contributions in future. It must also be mentioned that Ann has brought in online payment by the Treasurer of financial claims from Club members and the automated printing of income tax receipts for donations.

I wish to award Ann the President's Prize for 2018, with very best wishes and congratulations.

(Prepared by Henry Steger and Diane Lepage, President)

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Book Reviews

News and Comment

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