The CANADIAN FIELD-NATURALIST

A JOURNAL OF FIELD BIOLOGY AND ECOLOGY

Volume 131, Number 2 **April–June 2017**

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

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The Canadian Field-Naturalist

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The Thomas H. Manning fund, a special fund of the OFNC, established in 2000 from the bequest of northern biologist Thomas H. Manning (1911–1998), provides financial assistance for the publication of papers in the CFN by independent (non-institutional) authors, with particular priority given to those addressing arctic and boreal issues. Qualifying authors should make their application for assistance from the Fund at the time of their initial submission.

COVER: The terrestrial snail study area at Constance Bay, Ontario consisting of Northern Red Oak (*Quercus rubra*) – Large-toothed Aspen (*Populus grandidentata*) woods (left) and Red Pine (*Pinus resinosa*) plantation (right). Both habitats were scrub savannah approximately 60 years ago. See the article in this issue by Paul Catling and Brenda Kostiuk, pages 128–132. Photos: Paul Catling, September 2014.

The Canadian Field-Naturalist

Volume 131, Number 2 April–June 2017

Has the Eastern Red-backed Salamander (*Plethodon cinereus*) Declined in Ontario?

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Seburn, David C., and Erin Mallon. 2017. Has the Eastern Red-backed Salamander (*Plethodon cinereus*) declined in Ontario? Canadian Field-Naturalist 131(2): 115–119. https://doi.org/10.22621/cfn.v131i2.1981

Amphibians are known to be declining around the world. Although often only reported for frogs, declines among salamanders are also known to be occurring. In Ontario, for example, citizen science monitoring indicates the Eastern Red-backed Salamander (*Plethodon cinereus*) has not been found in the last 20 years in many areas where it was historically known to occur. To test whether this decline is real or the result of lack of recent observations, we conducted targeted surveys in 25 grid squares with no recent records of the species and confirmed the presence of the Eastern Red-backed Salamander in 84% of these squares. It made up 90% (183 of 202) of all six species of salamanders encountered and was also the first salamander species detected in 90% of the squares. The median number of cover objects needed to detect a species was 34 (range 1–145) for Eastern Red-backed Salamanders, 129.5 (range 34–204) for Blue-spotted Salamanders (*Ambystoma laterale*), and 154 (range 6–187) for Spotted Salamanders (*Ambystoma maculatum*), and these detection rates differed significantly ($H = 9.46$, $P < 0.01$). Our study suggests that Eastern Red-backed Salamanders have not declined. We caution researchers using citizen science data that a lack of sightings of a "cryptic species" does not mean a species has declined.

Key Words: Eastern Red-backed Salamander; *Plethodon cinereus*; amphibian decline; Ontario

Introduction

Amphibian populations are known to be declining around the world (Wake and Vrendenburg 2008; Collins and Crump 2009; Collins 2010), and a global assessment of all known amphibian species concluded that a third were threatened with extinction (Stuart *et al.* 2004). Although amphibian declines are often associated only with frogs, salamanders are also declining with at least two apparent extinctions (Rovito *et al.* 2009). Salamander declines have been reported in Europe (van der Sluijs *et al.* 2013), Central America (Rovito *et al.* 2009), and North America (Bank *et al.* 2006; Means and Travis 2007). Declines have been observed in both aquatic (Wheeler *et al.* 2003; Lowe 2012) and terrestrial salamanders (Maerz *et al.* 2009; Caruso and Lips 2013). Some species have even declined within protected areas where habitat loss has not been an issue (Bank *et al.* 2006). The cause of many of these declines remains uncertain, although newly emerging diseases (Bosch and Martínez-Solano 2006; Martel *et al.* 2014), pollution (Bank *et al.* 2006), invasive species (Maerz *et al.* 2009), habitat loss (Arntzen 2015), and climate change (Parra-Olea *et al.* 2005; Caruso *et al.* 2014) or some combination of factors are all probable.

Salamander declines are important because these amphibians are a critical component of forest ecosystems. For example, the biomass of woodland salamanders is substantial and in some areas can be greater than that of birds or small mammals (Burton and Likens 1975). Salamanders are significant predators of forest floor invertebrates, and their loss from forest ecosystems could alter invertebrate diversity and soil dynamics as well as carbon and nutrient cycling (Davic and Welsh 2004; Best and Welsh 2014), although not all salamander removal experiments have detected significant changes (e.g., Hocking and Babbitt 2014).

The Ontario Reptile and Amphibian Atlas (ORAA; Ontario Nature 2016) is documenting the current distribution of amphibians and reptiles across Ontario, using 10-km by 10-km grid squares, modeled after the provincial Breeding Bird Atlas (Cadman *et al.* 2008). The ORAA is a citizen science project that relies on volunteer observers, researchers, and land managers to report sightings. Currently, over 3000 people have contributed over 350 000 records. The atlas database builds on the Ontario Herpetofaunal Summary (Oldham and Weller 1989), started in 1984, which includes historical records from published literature, unpublished government reports, and museum records. The overall goal of the ORAA is to document occurrences of herpetofauna across Ontario and identify trends in distribution.

Data from the ORAA suggest that salamanders have declined significantly. For example, there are no recent records (defined as the last 20 years) of the Eastern Red-backed Salamander (*Plethodon cinereus*) from over 400 grid squares where it was historically known to occur.

A contribution towards the cost of this publication has been provided by the Thomas Manning Memorial Fund of the Ottawa Field-Naturalists' Club.

Such absences could indicate that this species has been extirpated from more than 40 000 km^2. To assess whether the apparent decline is real or a result of lack of observations, we conducted targeted surveys of salamanders in 25 grid squares that lacked recent reports of Eastern Red-backed Salamanders. Although there are similar trends for other woodland salamanders, we selected the Eastern Red-back Salamander as the target species as it is typically more common, often accounting for more than 90% of individuals in salamander surveys in northeastern North America (Degraaf and Yamasaki 1992; Moore 2005; Pearce and Venier 2009).

Methods

We selected a study area west of Ottawa and north of Peterborough because a large number of ORAA grid squares in this region lacked recent reports of salamanders and also contained numerous parcels of easily accessible public land. Within this area, we identified grid squares with historical records from the ORAA (before 1995) of the Eastern Red-backed Salamander, but with no recent records (from 1995 onward). Historical records included citizen science observations, records obtained by the ORAA from published papers, government reports, and museum records. For each grid square with a historical record, we determined whether it contained accessible public land (provincial parks or Crown land). The presence of public land was determined by using Google Maps (2015) for provincial parks and the Ontario government's Crown Land Use Policy Atlas (MNRF n.d.) for Crown land. For each square containing public land, we determined the last year of observation for all other woodland salamander species. Priority was given to squares with multiple species of salamanders but only historical records, but an effort was also made to include squares from across the region.

We drove along roads adjacent to (or on) public land to select sites with suitable habitat for woodland salamanders (predominantly deciduous or mixed woods). Selected sites were surveyed in a standardized manner to ensure consistency of results. The two authors, both experienced field biologists, searched under appropriate cover objects (woody debris such as branches, small logs, bark, and anthropogenic debris, such as boards or sheet metal) for 1 h (two person-hours). Cover objects were carefully replaced as accurately as possible to minimize disturbance to the microhabitat. Surveys were stopped before 1 h elapsed if all historically reported salamander species had been detected.

We recorded the number of cover objects searched in each square, the number of cover objects searched to first detect each species, as well as the number of individuals of each species. The location (determined using a handheld Global Positioning System unit), date, time, and weather conditions were recorded for each survey. At four sites, only one biologist (D.C.S.) conducted the surveys and, in these cases, the survey was conducted over 2 h to compensate for the reduction in surveyors. Some Blue-spotted Salamanders (*Ambystoma laterale*) encountered in this study may have been unisexual polyploids. Given that polyploids must co-occur with Blue-spotted Salamanders, the presence of apparent Blue-spotted Salamanders is evidence that the species occurs at the site (Bogart and Klemens 2008). The median number of salamanders per square includes only squares with full, 1-h surveys and does not include squares where the species was not detected. We did not include squares where the Eastern Red-backed Salamander was not detected because it is possible it was not present. Our interest was in how many cover objects must be searched, on average, to detect each species when it is known to be present.

The non-parametric Kruskal-Wallis test was used for statistical comparisons using Minitab 8.3 (Minitab Inc., State College, Pennsylvania, USA). QGIS 2.0 (QGIS 2017) was used for data mapping.

Results

From 15 July to 18 September 2015, we surveyed 25 grid squares that lacked recent records of the Eastern Red-backed Salamander: 12 within provincial parks and 13 on Crown land. All but three squares were surveyed from 11 to 18 September. Substantial rainfall occurred on the weekend of 12–13 September and soils under cover objects were damp to wet for the following week when most of our surveys were undertaken. Eastern Red-backed Salamanders were detected in 21 of the 25 squares (Figure 1). The four squares where Eastern Red-backed Salamanders were not detected were not spatially clustered. Five other species of salamanders were detected in seven or fewer squares (Table 1). The median number of species detected in squares where full surveys were conducted was two (range 0–3, $n = 17$). Although the other salamander species were detected in few grid squares, at least 50% of the species detections resulted in the first recent report of the species in the square (Table 1).

There was no significant difference between the date of the last historical observation of Eastern Red-backed Salamanders in squares where we detected them (median date 1988, range 1977–1994) and squares where we did not detect them (median date 1987, range 1984–1993; $H = 0.01$, $P > 0.9$).

Eastern Red-backed Salamanders made up 90% (183 of 202) of all salamanders encountered. Considering the three most common species, the median number of individuals per square was eight for Eastern Red-backed Salamanders (range 2–37, $n = 13$), one for Blue-spotted Salamanders (range 1–2, $n = 3$), and one for Spotted Salamanders (*Ambystoma maculatum*; range 1–1, $n = 6$).

We surveyed 3876 cover objects in the 25 grid squares. A median of 205 (range 148–272) cover objects were checked per square when full surveys were conducted. Eastern Red-backed Salamander was the first species detected in 90% (19 of 21 squares) of the squares where they were found. For species found in

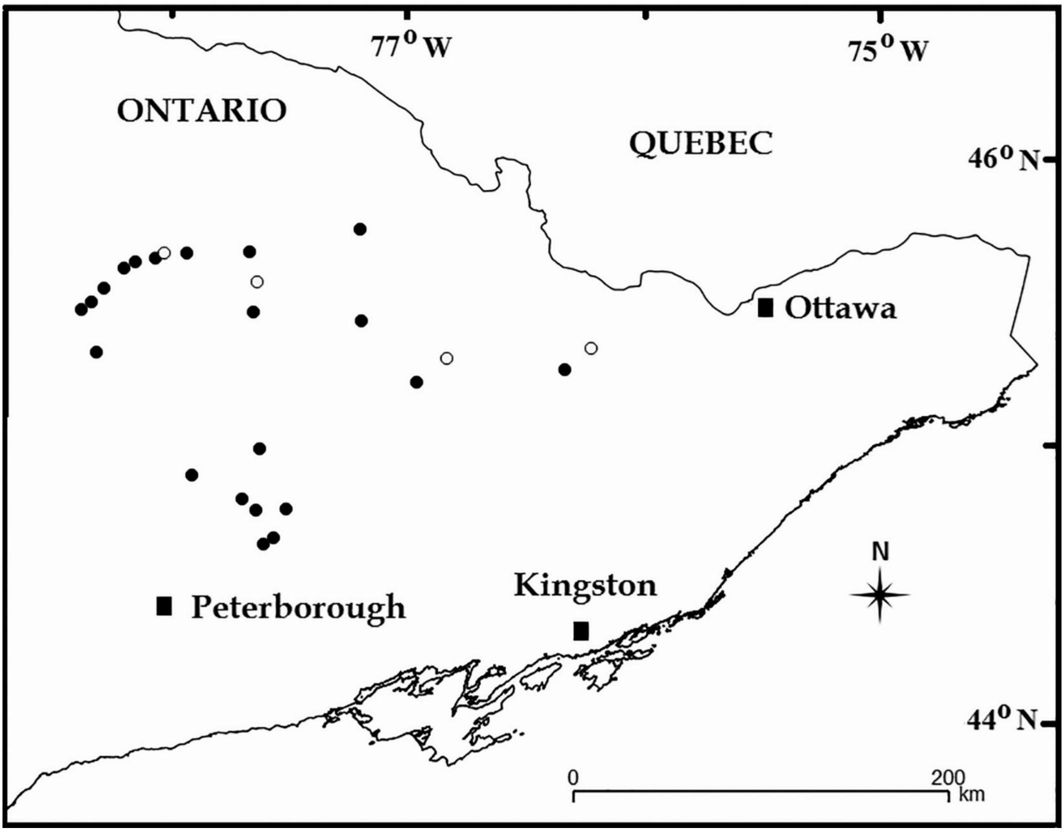

Figure 1. Location of salamander survey sites in Ontario. Solid circles indicate sites where Eastern Red-backed Salamander (*Plethodon cinereus*) was detected and open circles indicate where the species was not detected.

TABLE 1. Salamanders detected during surveys in 25 grid squares (10-km × 10-km) in Ontario in 2015. Squares with first recent record indicates the number of squares where this observation was the first recent (last 20 years) report of the species.

Species	Detected, no. squares	First recent record, no. squares (%)	No. found	Maximum no./square
LUNGLESS SALAMANDERS				
Red-backed Salamander (*Plethodon cinereus*)	21	21 (100)	183	37
Four-toed Salamander (*Hemidactylium scutatum*)	1	1 (100)	1	1
Northern Two-lined Salamander (*Eurycea bislineata*)	2	1 (50)	4	3
MOLE SALAMANDERS				
Blue-spotted Salamander (*Ambystoma laterale*)	4	2 (50)	5	2
Spotted Salamander (*Ambystoma maculatum*)	7	5 (71)	7	1
NEWTS				
Eastern Newt (*Notophthalmus viridescens*)	2	2 (100)	2	1

four or more squares, the median number of cover objects checked to detect a species was 34 for Eastern Red-backed Salamanders (range 1–145, $n = 21$), 129.5 for Blue-spotted Salamanders (range 34–204, $n = 4$), and 154 for Spotted Salamanders (range 6–187, $n = 7$), and these detection rates were significantly different ($H = 9.46$, $P < 0.01$).

Discussion

The Eastern Red-backed Salamander was easily detected in 84% of the squares we surveyed. A longer survey might have detected Eastern Red-backed Salamanders in more squares; however, detection probability for this species under natural cover objects reaches approximately 100% after 45 minutes (Otto and Roloff 2011).

Given that each grid square is 100 km^2 and that we surveyed only one small site for two person-hours, it is likely that, if we had surveyed multiple sites per grid square, we would have detected Eastern Red-backed Salamanders in an even greater percentage of squares. Thus, there appears to be no evidence that this species has been eliminated from parts of our study area. However, it is possible that the Eastern Red-backed Salamander has declined in other parts of the province as salamanders were rarely encountered in systematic amphibian surveys in southern Ontario, possibly because of widespread loss of forest cover (Hecnar 1997).

Eastern Red-backed Salamander made up 90% of the salamanders detected in this study. Other studies in Canada or the northern United States have found that Eastern Red-backed Salamanders make up at least 81% of the salamanders encountered (Bonin and Bachand 1997) and usually 90–99% of all salamanders (Degraaf and Yamasaki 1992; Moore 2005; Pearce and Venier 2009).

Eastern Red-backed Salamanders were easily detected in most grid squares, sometimes under the first cover object searched. Although salamanders are easy to find in the appropriate habitat, they are not often reported to the ORAA, where they make up only 2.5% of all amphibian and reptile observations in the last 20 years (unpublished data from the ORAA). Similarly, salamanders account for only 11% of observations contributed to the Carolina Herp Atlas and the low percentage was partially attributed to the cryptic nature of the species (Price and Dorcas 2011). Unlike most other amphibians and reptiles, salamanders are rarely encountered when not actively sought.

Citizen science has been widely demonstrated to be valuable in ecological science (e.g., Delaney *et al.* 2008; Dickinson *et al.* 2010; Ries and Oberhauser 2015). Nonetheless, it has limitations. Volunteers can overlook low-density patches of invasive species (Fitzpatrick *et al.* 2009), and the same may also be true for low-density or cryptic native species. Our results imply that many volunteers may have little interest in actively searching for salamanders. This is supported by the fact that we confirmed the presence of Eastern Red-backed Salamanders in 11 of the 12 squares surveyed within provincial parks, in easily accessible areas, usually along major hiking trails.

Although data from the ORAA are valuable in demonstrating where salamanders are known to occur, a lack of recent reports should not be assumed to indicate a current absence of the species without additional survey effort. Volunteers should be encouraged to visit squares with historical records and survey for salamanders to provide a more complete understanding of the current distribution in Ontario given the global concern over salamander declines. Our results suggest that at least 30 cover objects must be searched under to achieve a 50% probability of detecting Eastern Red-backed Salamanders at a site with suitable habitat, although more than 150 objects need to be checked to have a 50% chance of detecting some other species of woodland salamanders. We encourage individuals surveying for salamanders to record the number of cover objects checked to provide a measure of survey effort. Recording other data such as weather conditions, soil moisture under cover objects (e.g., wet versus dry), and forest type are also valuable. Great care should always be taken to replace cover objects. We also caution researchers using citizen science data that lack of records of a "cryptic species" does not mean a species has declined.

Acknowledgements

This research was funded by the Ontario Wildlife Foundation and the Research Fund of the Ottawa Field-Naturalists' Club. Valuable support was provided by Tanya Pulfer and Mackenzie Nichols of Ontario Nature. We are deeply grateful to everyone who contributed salamander observations to the Ontario Herpetofaunal Summary and the Ontario Reptile and Amphibian Atlas.

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Received 7 February 2016
Accepted 10 May 2017

Note

Marine Mammal and Sea Turtle Sightings During a Survey of the Endeavour Segment of the Juan de Fuca Ridge, British Columbia

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Holst, Meike. 2017. Marine mammal and sea turtle sightings during a survey of the Endeavour Segment of the Juan de Fuca Ridge, British Columbia. Canadian Field-Naturalist 131(2): 120–124. https://doi.org/10.22621/cfn.v131i2.1873

Marine mammals and sea turtles were documented as part of a monitoring and mitigation program during a seismic study offshore (~250 km) from Vancouver Island, British Columbia, during August–September 2009. Forty-one marine mammals in nine groups were sighted. Dall's Porpoise (*Phocoenoides dalli*) was the most frequently sighted species. A Sperm Whale (*Physeter macrocephalus*), a pod of Pacific White-sided Dolphins (*Lagenorhynchus obliquidens*), an unidentified toothed whale, a Northern Elephant Seal (*Mirounga angustirostris*), and a Leatherback Turtle (*Dermochelys coriacea*) were also observed. These data augment current knowledge on the occurrence of marine mammals and sea turtles in the offshore waters of British Columbia.

Key Words: Dall's Porpoise; *Phocoenoides dalli*; Leatherback Turtle; *Dermochelys coriacea*; Northern Elephant Seal; *Mirounga angustirostris*; Sperm Whale; *Physeter macrocephalus*; Pacific White-sided Dolphins; *Lagenorhynchus obliquidens*; seismic survey; marine mammal; Vancouver Island; British Columbia; Endeavour Hydrothermal Vent Marine Protected Area

Introduction

Limited information is available on the occurrence and distribution of marine mammals and sea turtles inhabiting the offshore waters of British Columbia. Although marine mammal surveys have taken place in deep offshore waters out to the edge of the exclusive economic zone approximately 200 nautical miles off the coast of Washington (e.g., Barlow and Forney 2007; Barlow 2016), surveys have generally not occurred that far offshore in Pacific waters of Canada. Surveys by Fisheries and Oceans Canada off British Columbia have typically occurred within 50 km of the shelf break and did not extend more than 150 km offshore (Ford *et al.* 2010); the most frequently sighted species were Humpback Whale (*Megaptera novaeangliae*), Fin Whale (*Balaenoptera physalus*), Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*), and Dall's Porpoise (*Phocoenoides dalli*). In addition, systematic surveys have taken place in inshore coastal waters (e.g., Williams and Thomas 2007; Best *et al.* 2015). Opportunistic sightings in offshore waters have also been reported to the British Columbia Cetacean Sightings Network (BCCSN), but these records are not corrected for effort.

As part of the marine mammal monitoring and mitigation program for Lamont-Doherty Earth Observatory's Endeavour Tomography (ETOMO) experiment, biologists watched for marine mammals and sea turtles in and adjacent to the Endeavour Hydrothermal Vent Marine Protected Area (EHV MPA) during an academic seismic survey in August–September 2009. The EHV MPA is a unique ecosystem consisting of hydrothermal vents and associated fauna located ~250 km southwest of Vancouver Island, British Columbia. It covers ~93 km^2 and lies in water ~2250 m deep. The increased concentration of vent-derived material in the EHV MPA is likely enhancing the abundance of zooplankton there, leading, in turn, to increased productivity throughout the entire water column above the venting region (Tunnicliffe and Thomson 1999). However, it is uncertain whether this translates into higher densities of marine mammals and sea turtles above the vent fields (Gisiner *et al.* 2009; Soule *et al.* 2009).

This study was not designed as a systematic marine mammal and sea turtle survey, but rather as part of a program to reduce the possible effects of seismic survey operations on marine animals. Nonetheless, it allowed for determination of encounter rates and contributes to our understanding of the occurrence and distribution of cetaceans, pinnipeds, and turtles in deep, offshore waters of British Columbia.

Methods

The ETOMO experiment took place in and around the EHV MPA, located ~250 km southwest of Vancouver Island, British Columbia, within the area bounded by 47°–49°N and 127°30'–130°W (Figure 1). The seismic vessel *Marcus G. Langseth* left Astoria, Oregon, on 22 August 2009. During the study, a 36-airgun array with a total discharge volume of 6600 in^3 (108 155 cm^3) was towed behind the *Langseth*. The source array had an acoustic output (downward) of 259 dB re 1 µPa m$_{\text{zero-to-peak}}$. A brief (~0.1 s) pulse of sound was emitted every ~250–500 m along designated transect lines. Airgun operations occurred day and night on a daily basis starting on 26 August and concluding on 11 September. During seismic acquisition, the vessel traveled 7–9 km/h; when not towing gear (e.g., during transits to the study area), the *Langseth* cruised at 20–24 km/h. Water depth in the survey area was > 2000 m.

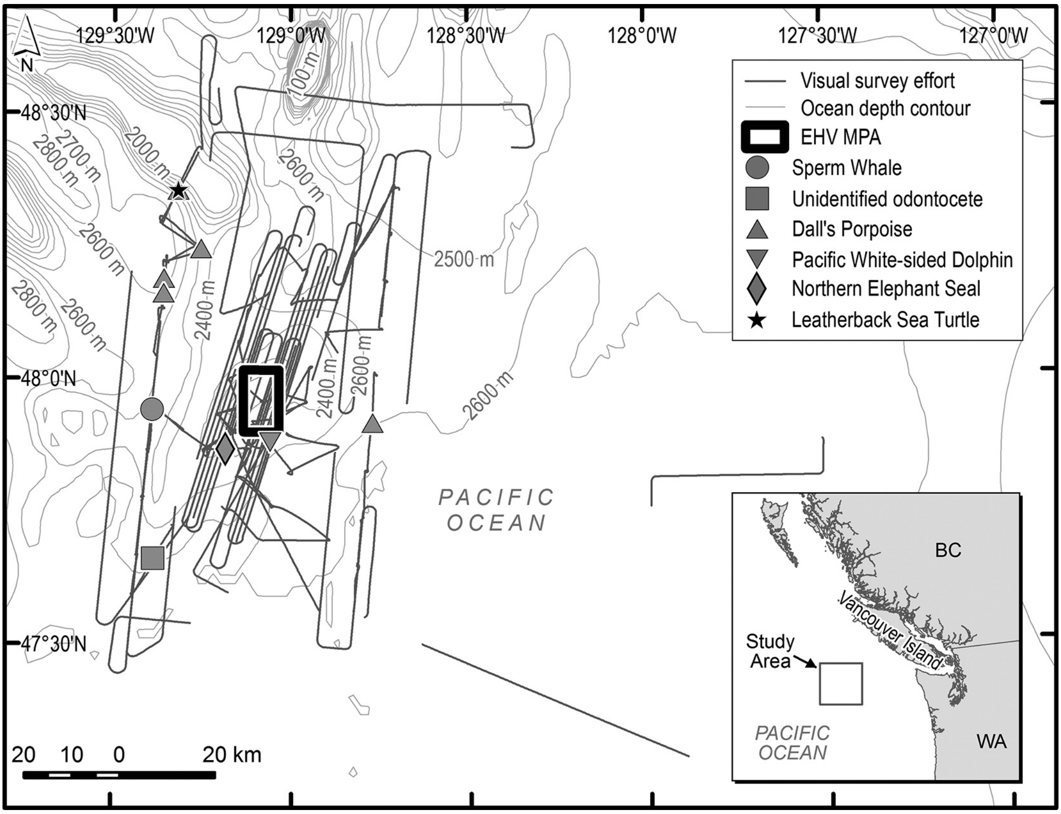

FIGURE 1. The Endeavour Tomography survey area showing observation effort and sightings of marine mammals and a sea turtle, 23 August to 18 September 2009. Note: EHV MPA = Endeavour Hydrothermal Vent Marine Protected Area.

Standard monitoring and mitigation measures were implemented during the study, including ramp-up, power-down, and shut-down procedures (e.g., Nowacek *et al.* 2013; Wright and Cosentino 2015). Visual observations commenced 23 August and continued until 18 September. One or two experienced observers (out of a team of six) watched for marine mammals and sea turtles from approximately 0700 to 2030 from the *Langseth*'s observation tower, ~20 m above sea level. Observers were on watch for shifts no longer than 4 h. The observers used 7 × 50 reticle binoculars, 25 × 150 big-eye binoculars, and the naked eye to look for marine mammals and sea turtles around the vessel. While on watch, observers kept written records of environmental conditions and vessel activities every 30 minutes. For each sighting, species, identification reliability, number of individuals, environmental conditions (glare, visibility, Beaufort wind force), date, time, and vessel position and activity were recorded on a datasheet.

Encounter rates (number of sightings per 1000 km surveyed and number of individuals per 1000 km) were determined for all species seen during periods without airgun activity. These "non-seismic" periods included only data collected before or more than 6 h after seismic operations had ceased; the 6-h period was used to distinguish seismic periods from those periods where seismic surveys were sufficiently far in the past that it could be assumed that they had no residual effect on current animal behaviour or distribution. In addition, only data obtained during Beaufort wind force ≤ 5 and when the vessel travelled at speeds over 3.7 km/h were used to determine encounter rates.

Results

The ETOMO experiment included 330 h of observations covering ~2714 km; 121 h of observations (~1036 km) took place during periods when the seismic source was not operating, and the remaining effort occurred when airguns were operational. During non-seismic periods, nearly half of all observations (47%) were made by one observer; the remainder were made by two observers. Although the variable number of observers introduced a source of bias, we did not correct for it. Most observation effort (67%) occurred during Beaufort wind force ≤ 4.

A total of 41 marine mammals in nine groups were sighted; none were seen within the EHV MPA (Figure 1). Dall's Porpoise was the most frequently sighted species (five groups totalling 28 individuals); a Sperm Whale (*Physeter macrocephalus*), a pod of ten Pacific White-sided Dolphins, one unidentified odontocete, and one Northern Elephant Seal (*Mirounga angustirostris*) were also observed. In addition, one Leatherback Sea Turtle (*Dermochelys coriacea*) was seen. Except for the pod of Pacific White-sided Dolphins, which was observed on 25 August before seismic operations commenced, all sightings were made during September after all airgun activity had ceased. Thus, all sightings occurred during non-seismic periods. The encounter rate was highest for Dall's Porpoise (5.0 groups/1000 km surveyed or 31.4 individuals/1000 km); the encounter rate for Pacific White-sided Dolphin was 16.5 individuals/1000 km. All other species were encountered at a rate of 1.7 groups/1000 km.

Discussion

Although the ETOMO experiment was designed to obtain information on the sub-seafloor structure of volcanic and hydrothermal features that form as a result of movements of the Earth's tectonic plates, useful information on the occurrence of marine mammals and a sea turtle in the area was also collected. Numerous sightings of Leatherback Turtles have been made throughout the waters of British Columbia, including offshore from Vancouver Island (McAlpine *et al.* 2004; Pacific Leatherback Turtle Recovery Team 2006; Spaven *et al*. 2009). Our sighting on 11 September is one of the farthest offshore observations — if not the farthest — reported for British Columbia. Most other reported sightings have occurred in August, followed by September (Spaven *et al*. 2009). Sightings of Leatherback Turtles have also been made off Washington in 1989 and 1990; most turtles occurred in continental slope waters, although some were found over the shelf (Green *et al.* 1992). During that study, all sightings were reported for June–September, with most in July.

There is a lack of information on the at-sea distribution of Northern Elephant Seals in British Columbia (Best *et al.* 2015). However, Elephant Seals are known to transit through the offshore waters of Vancouver Island, including our study area, as they move between southern rookeries and northern feeding areas (e.g., Le Boeuf *et al.* 2000; Ganong 2012; Robinson *et al.* 2012). Elephant Seals and Northern Fur Seals (*Callorhinus ursinus*) have been seen in the deep offshore waters of British Columbia and Washington (Bonnell *et al.* 1992; Ford 2014). Steller Sea Lions (*Eumetopias jubatus*) have been sighted in coastal waters of British Columbia (Ford 2014) and in shelf and slope waters of Washington (Bonnell *et al.* 1992).

Based on information from sightings in the offshore waters of Washington (e.g., Green *et al.* 1992; Barlow and Forney 2007; Becker *et al.* 2014; Barlow 2016), Dall's Porpoises, Pacific White-sided Dolphins, Northern Right Whale Dolphins (*Lissodelphis borealis*), and Risso's Dolphins (*Grampus griseus*) were expected to be common in the ETOMO study area. Dall's Porpoise and Pacific White-sided Dolphin have been reported most often in this area, based on opportunistic sightings found in the BCCSN database[1], with more than 25 sightings each, followed by Fin and Humpback Whales with fewer than ten sightings each (BCCSN, unpublished data 1956–2015). The encounter rates (number per 1000 km) for Pacific White-sided Dolphin and Dall's Porpoise derived from the ETOMO study were greater than those for offshore areas of Washington, where 3.2–8.2 and 1.6–4.6/1000 km were found during summer and fall, respectively (Green *et al.* 1992).

In contrast to expectations based on surveys off Washington, only four sightings of Northern Right Whale Dolphins and no Risso's Dolphins were made in the ETOMO study area (BCCSN, unpublished data 1956–2015). Other opportunistic sightings in the ETOMO study area west of 127.5°W include two sightings each of Grey (*Eschrichtius robustus*), Sperm, Killer (*Orcinus orca*), and Short-finned Pilot (*Globicephala macrorhynchus*) Whales; and single sightings of Blue (*Balaenoptera musculus*) and Sei (*B. borealis*) Whales (BCCSN, unpublished data 1956–2015). Short-finned Pilot Whales and Pacific White-sided Dolphins have also been reported in offshore waters of Vancouver Island, including within the ETOMO study area (Stacey and Baird 1991; Baird and Stacey 1993; Ford 2014). Other species reported off the west coast of Vancouver Island within 150 km of shore include Cuvier's Beaked Whale (*Ziphius cavirostris*), Harbour Porpoise (*Phocoena phocoena*), and Risso's Dolphin (Ford *et al.* 2010; Ford 2014).

Our Sperm Whale sighting is one of the farthest offshore sightings made for this area (see Ford 2014); previous sightings occurred east of 128.2°W (BCCSN, unpublished data 1956–2015). Opportunistic sightings of Dall's Porpoise ($n = 6$), Pacific White-sided Dolphin ($n = 4$), Fin Whale ($n = 2$), and Humpback Whale ($n = 1$) have been made within the EHV MPA during June, July, and September (BCCSN, unpublished data 1956–2015). In addition, seismometers deployed near the hydrothermal vent fields from 2003 to 2006 detected Fin and Blue Whale calls every year (Soule *et al.* 2009). Fin and Blue Whale calls had previously been detected by bottom-mounted hydrophones deployed just south of the ETOMO study area (McDonald *et al.* 1995). No sightings were made within the EHV MPA during the ETOMO study, but only 220 km (65 km during non-seismic and 155 km during seismic operations) of the total 2714 km of survey effort occurred within the EHV MPA.

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[1] Data obtained from the BCCSN were collected opportunistically with limited knowledge of the temporal or spatial distribution of observer effort. As a result, absence of sightings at any location does not demonstrate absence of cetaceans.

As all sightings during the ETOMO study occurred during non-seismic periods, it is possible that marine mammals actively avoided the area around the operating source, thereby reducing encounter rates. Localized and short-term behavioural responses that include movement away from the sound source have been reported for some cetaceans during seismic surveys (e.g., Richardson *et al.* 1995; Gordon *et al.* 2004; Nowacek *et al.* 2007; Southall *et al.* 2007). Despite this limitation, our study allowed for the first effort-corrected sighting data to be collected >150 km off Vancouver Island and contributes to our understanding of marine mammal and sea turtle distribution and occurrence in offshore waters of British Columbia. Given the limited amount of data currently available, it is not possible to assess whether the EHV MPA is a concentration area for marine mammals; additional surveys would need to be undertaken in and around the area.

Acknowledgements

This work was conducted under an Incidental Harassment Authorization issued to Lamont-Doherty Earth Observatory (L-DEO) by the United States National Marine Fisheries Service, Office of Protected Resources, and under permits obtained from Fisheries and Oceans Canada. The survey was funded by L-DEO and the National Science Foundation. L-DEO also provided the logistical support for this cruise and the associated monitoring program. I thank the geophysics team from the University of Oregon, who helped make the cruise a success and the dedicated observers (J. Beland, G. Caltavuturo, K. Graham, B. Dawe, M. Myer, and J. Nicolas). The paper was improved by comments from J. Beland, M. Demarchi, B. Koski, and two anonymous reviewers. M. Fitzgerald provided assistance with data processing and mapping. In addition, I thank the Vancouver Aquarium Marine Science Centre and Fisheries and Oceans Canada for providing sightings from the British Columbia Cetacean Sighting Network's database for offshore Vancouver Island, 1956–2015.

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Received 7 November 2016
Accepted 9 June 2017

Note

Common Nighthawks (*Chordeiles minor*) Can Take Off from Water

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McGuire, Liam P., and R. Mark Brigham. 2017. Common Nighthawks (*Chordeiles minor*) can take off from water. Canadian Field-Naturalist 131(2): 125–127. https://doi.org/10.22621/cfn.v131i2.1830

Common Nighthawks (*Chordeiles minor*) are aerial insectivores that often forage over water, at high speeds, and sometimes at high densities. Foraging nighthawks have regularly been observed flying < 1 m from the surface of water. Under these circumstances, navigation errors or mid-air collisions could result in birds falling into the water, with the risk of drowning. We report two observations of Common Nighthawks that fell into a river and were able to take off from the surface of the water easily without any noticeable detrimental effects.

Key Words: Common Nighthawk; *Chordeiles minor*; foraging behaviour; flight ability

Common Nighthawks (*Chordeiles minor*) forage by capturing insects in flight (Brigham *et al.* 2011). Common Nighthawks are widespread and common over much of North America, but are declining in many parts of their range (Nebel *et al.* 2010) and are currently listed as threatened in Canada (COSEWIC 2007; Species at Risk Public Registry 2016). Habitat is variable across the species' range, including prairies, forests with clearings (including areas recently burned or thinned), rocky terrain, or gravel rooftops in urban areas, all typically including open ground cover for nesting (Brigham 1989; Hagar *et al.* 2004; Brigham *et al.* 2011; G. Foley and A. Sidler, unpublished data).

Crepuscular foraging may occur in any part of the home range in which flying insects are found, but is often associated with aquatic emergent insects over water (Brigham and Fenton 1991; Brigham and Barclay 1995; Ng 2009; Taylor 2009). Foraging frequently occurs close (< 1 m) to the water surface and may involve high densities of birds (Taylor 2009; Brigham *et al.* 2011). At our field site in British Columbia, we regularly observe several hundred birds foraging simultaneously along a short (~300 m long and 50 m wide) stretch of river. We have also observed nighthawks fluttering over water and dipping their bill into the water to drink, as reported elsewhere (Brigham *et al.* 2011).

Given the habit of Common Nighthawks to forage over water, in high-density flocks and at high flight speeds (about 6.5 m/s; Brigham *et al.* 1998), it seems likely that navigation errors or mid-air collisions result in some birds falling into the water. Aside from the obvious risk of drowning, in our work with Common Nighthawks at this site, we have observed that handling birds when hands are moist or wet from river water or sweat results in the loss of many ventral body feathers. Thus, birds falling into the water could be at additional risk of losing body feathers, which may have implications for thermoregulation when they roost on the ground.

R.M.B. has studied Common Nighthawks in British Columbia for 30 years (Brigham 1989). For many projects over that period, Common Nighthawks have been captured in mist nets set across the Okanagan River in sx̌ʷəx̌ʷnitkʷ Provincial Park (formerly Okanagan Falls Provincial Park) near the town of Okanagan Falls, British Columbia, Canada (49°20'26.59"N, 119°34'48 .87"W).

In June 2016, we captured 158 nighthawks over six nights as part of an ongoing research project. For the first time, after capturing more than 1000 nighthawks at this site over the years, we observed two birds (one each on two separate nights) fall into the water. Both birds had been released at the net and landed in the water rather than flying away easily as all other birds had done. One bird immediately flapped its wings and took off from the water. The other bird spread its wings and floated downstream on the surface of the river for 3–4 s, travelling about 4 m before flapping and taking off. Neither bird had any difficulty taking off from the surface of the water, nor did they have any difficulty flying after being in the water. Further, we did not observe any feather loss in these birds.

On both nights when a bird ended up in the water, there was a very high density of birds foraging at the capture site. Exact numbers are difficult to determine, but we conservatively estimate that about 400 individuals were foraging over the river. At this time of year, all birds are adult, ruling out the possibility of inexperienced flight. Although it is unclear why the two birds fell into the water, the high density of birds may have interfered with their ability to fly away from the net, and perhaps they ended up in the water to avoid a mid-air collision with another bird. Regardless of the reason, both birds were able to take off easily from the surface of the water and did not appear to suffer any ill effects. Given the long wings and high aspect ratio of Common Nighthawks (Brigham and Fenton 1991), it is somewhat surprising that the birds were able to thrust themselves into the air from the surface of the water. However, their low wing loading could make it easier.

To our knowledge, this is the first report of the ability of Common Nighthawks (and only the second bird of the family Caprimulgidae) to take off from the surface of a body of water. With high foraging densities and a habit of foraging very close to the surface of the water, it is perhaps not a rare occurrence for a bird to fall into the water. The situation is likely to be even more pronounced when volant juveniles further increase the density of foraging birds, perhaps with less agility than experienced fliers. Fluttering over water and drinking by dipping the bill into the moving current also adds to the risk of falling into the water. Our observations suggest that there is little risk to birds that fall into the water, as they can easily take off from the surface and fly away unharmed.

Among other Caprimulgids, the only record of being on water is for a Chuck-will's-widow (*Antrostomus carolinensis*). Thayer (1899) reported that one alighted on the surface of water and took off. Birds of North America accounts for other aerial insectivores suggest that Tree Swallows (*Tachycineta bicolor*; Winkler *et al.* 2011), Cliff Swallows (*Petrochelidon pyrrhonota*; Brown *et al.* 2017), Bank Swallows (*Riparia riparia;* Garrison 1999), and Barn Swallows (*Hirundo rustica*; Brown and Brown 1999) all paddle their wings and swim to shore if they fall into water. There is no information for Violet-Green Swallows (*Tachycineta thalassina*; Brown *et al.* 2011). Black Swifts (*Cypseloides niger*; Lowther and Collins 2002) are reported not to swim, but there are no reports for other swifts found in Canada. Thus, taking off from water by nighthawks appears to be unlike the strategy employed by other aerial-feeding insect-eating birds.

Acknowledgements

We are grateful to A. Brigham for assistance in the field, and to G. Foley and A. Sidler (University of Regina) for information about nesting habitat. Funding for this research was provided by Texas Tech University and the Natural Sciences and Engineering Research Council of Canada. All research was approved by the Animal Care and Use Committees at Texas Tech University and the University of Regina and conducted under permits from Environment Canada and the British Columbia Ministry of the Environment.

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Received 25 July 2016
Accepted 24 May 2017

Reduced Diversity and Relative Abundance of Terrestrial Snails in a Red Pine Plantation Compared with a Surrounding Northern Red Oak – Large-toothed Aspen Woods

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Catling, Paul M., and Brenda Kostiuk. 2017. Reduced diversity and relative abundance of terrestrial snails in a Red Pine plantation compared with a surrounding Northern Red Oak – Large-toothed Aspen woods. Canadian Field-Naturalist 131(2): 128–132. https://doi.org/10.22621/cfn.v131i2.1982

A Red Pine (*Pinus resinosa* Aiton) plantation and adjacent Northern Red Oak (*Quercus rubra* L.) – Large-toothed Aspen (*Populus grandidentata* Michx.) woods, both of which developed from a savannah scrub beginning approximately 60 years ago, were compared with regard to terrestrial snail diversity and abundance. The comparison involved a 30-minute search of ten 1-m^2 quadrats at ten sites in each habitat. In the Northern Red Oak – Large-toothed Aspen woodland, 13 species and 661 individuals were recorded, whereas, in the Red Pine plantation, six species and 24 individuals were recorded. In the Northern Red Oak – Large-toothed Aspen woodland, the most characteristic and abundant species was *Novisuccinea ovalis* (Say, 1817), which was present in 74 of the 100 quadrats and was represented by 460 individuals. In the pine plantation, the most common species was *Zonitoides arboreus* (Say, 1816)*,* which was present in 16 quadrats and was represented by 17 individuals. This species was the second most common in the Northern Red Oak – Large-toothed Aspen woodland where 70 individuals were found in 34 quadrats. In both habitats, *Z. arboreus* was associated with downed wood. Other species occurring in more than 15% of quadrats in the Northern Red Oak – Large-toothed Aspen woodland were *Strobilops labyrinthicus* (Say, 1817), *Glyphyalinia indentata* (Say, 1823), and *Euchemotrema fraternum* (Say, 1824). Although a lower number and diversity of terrestrial snails in the conifer plantation was expected, the contrast was greater than anticipated. The estimated abundance of 46 000 *N. ovalis* per hectare suggests the potential importance of these medium-sized snails in the relatively dry Northern Red Oak – Large-toothed Aspen ecosystem.

Key Words: Terrestrial snails; land snails; *Novisuccinea ovalis*; *Zonitoides arboreus*; savannah; oak woodland; pine plantation; diversity; abundance; Constance Bay; Ontario

Introduction

At Constance Bay, Ontario, an open scrubby savannah of unusual composition (Catling and Brunton 2010; Catling *et al.* 2010) and with rare species followed two different succession paths. Some of it became a dry Northern Red Oak (*Quercus rubra* L.) – Large-toothed Aspen (*Populus grandidentata* Michx.) woodland (Figure 1a), a natural succession favoured in the case of fire suppression. The other path has been the unnatural conversion of the savannah to Red Pine (*Pinus resinosa* Aiton) plantation (Figure 1b), beginning with extensive planting of that species in the 1950s (Catling and Brunton 2010; Catling and Kostiuk 2010; Catling *et al.* 2010). The negative impact of pine plantations on biodiversity in native habitats has been studied in Canada for some groups of organisms, such as vascular plants and grasshoppers (Catling and Kostiuk 2010, 2015). Experimental removal of planted pine trees and pine needle litter at Constance Bay has successfully restored a portion of the savannah (Catling and Kostiuk 2010). Such restorations should be based on data concerning benefits to flora and fauna (Catling and Kostiuk 2010; Spitale 2011; Catling 2013).

The objective here was to determine the impact of plantation on terrestrial snails, by exploring the difference in snail assemblages in the two succession types after about 60 years. An added benefit is a contribution to better understanding of snail ecology and, particularly, the importance of snails in relatively dry ecosystems.

Study Area

The study area included lands in and near (within 1 km) the Constance and Buckham's Bay Community Centre (45.49944°N, 76.09325°W). The plantation was a pure stand of Red Pine without understory vascular plants but sometimes with a carpet of bryophytes. The Northern Red Oak – Large-toothed Aspen area included old, spreading Northern Red Oaks, as well as young oaks and young aspens; occasional dying Jack Pine (*Pinus banksiana* Lambert); persisting depauperate shrubs from an earlier period of more open conditions, including Early Lowbush Blueberry (*Vaccinium angustifolium* Aiton), Susquehana Sand Cherry (*Prunus susquehanae* Willdenow), Sweet-fern (*Comptonia peregrina* (L.) J. M. Coulter), Black Huckleberry (*Gaylussacia baccata* (Wangeheim) K. Koch), and Poison Ivy (*Toxicodendron radicans* (L.) Kuntz); herbs including Bracken Fern (*Pteridium aquilinum* (L.) K. Kuhn); and graminoids such as Canada Bluegrass (*Poa compressa* L.), Kentucky Bluegrass (*Poa pratensis* L.), and Dry-spike Sedge (*Carex siccata* Dewey).

A contribution towards the cost of this publication has been provided by the Thomas Manning Memorial Fund of the Ottawa Field-Naturalists' Club.

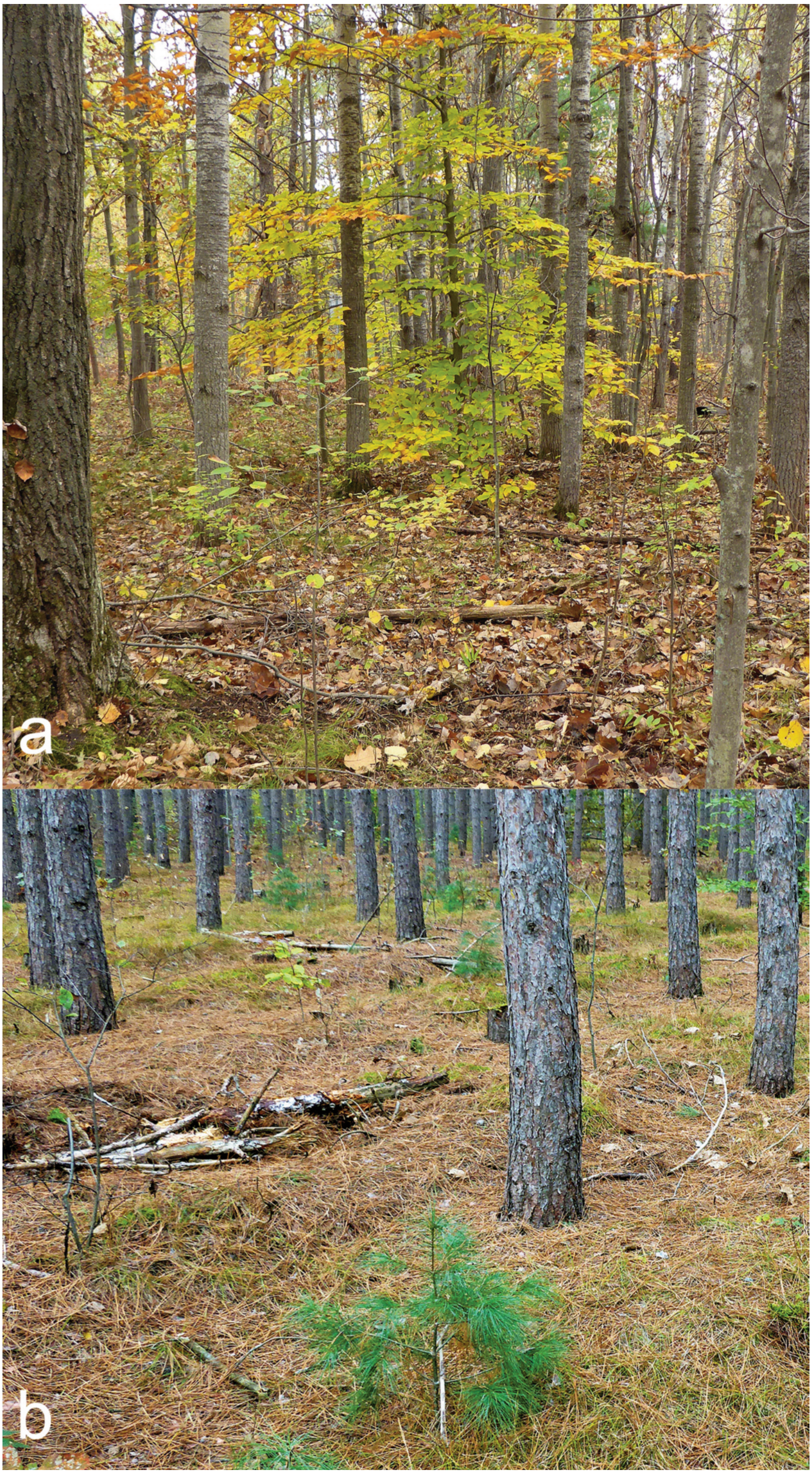

FIGURE 1. Constance Bay study area. a. Northern Red Oak (*Quercus rubra*) – Large-toothed Aspen (*Populus grandidentata*) woods. b. Approximately 60-year-old Red Pine (*Pinus resinosa*) plantation. Both habitats were scrub savannah approximately 60 years ago. Photos: P. M. Catling.

Methods

Data Collection

Species of terrestrial snails and their numbers (both dead and alive) were recorded in ten 1-m^2 quadrats at 5-m intervals in 20 transects of which ten were in Red Pine plantation and ten were in Northern Red Oak – Large-toothed Aspen woodland. Each quadrat was searched for 30 minutes. No minor adjustments were made to include woody debris or other potentially important microhabitat, but it was occasionally necessary to avoid trees. Usually, little was found after the first 20 minutes of searching; thus, 30 minutes was considered a sufficient amount of search time. Only visual hand-searching was carried out. All leaf litter and the upper 2 mm of hard soil was searched. The survey was conducted during mild, 5–15°C, clear weather in September 2014 before leaf fall. Transects were laid out in such a way as to avoid habitat edges and each other by at least 20 m. They were parallel and 50 m in length. The approximate areas of available habitat within which the survey took place were 10.28 ha for the Northern Red Oak – Large-toothed Aspen woodland and 10.54 ha for the Red Pine plantation.

Identification

Specimens were collected for identification and vouchers identified by the authors were donated to the Canadian Museum of Nature with the assistance of curator Dr. Jean-Marc Gagnon. Living snails were placed in 70% alcohol and, subsequently, dried for storage. Both living snails and empty shells were included in the study and were identified on the basis of shell characteristics using Pilsbry (1939, 1940, 1946, 1948), Burch (1962), and Grimm *et al.* (2010) as well as some recent monographs (e.g., Nekola and Coles 2010) and updates (e.g., Badra 2008; Forsyth and Oldham 2014; Nekola *et al.* 2015). The names of snails used here are taken from Grimm *et al.* (2010) despite some limitations of that work (Nekola 2010a).

Results

Manually searching a defined area, for a prescribed period has been considered an efficient method for estimating diversity and relative abundance of millipedes (Mesibov *et al.* 1995) and should work well for snails provided small species are not overlooked and they are not deep in the soil. Because many micro-snails were recorded and few living snails were found in the upper 2 mm of harder soil, we think that the method was satisfactory for our purposes.

The identification of *Novisuccinea ovalis* (Say, 1817) is appropriate according to the way in which this group of snails is currently defined, although some authors have stressed the taxonomic difficulty of this group (Grimm *et al.* 2010). Other succineids, such as *Catinella vermeta* (Say, 1829), *Oxyloma retusum* (I. Lea, 1834), and *Succinea putris* (L., 1758), occur in this part of Ontario, but these are relatively distinctive genera of wetlands, shores, and disturbed habitats and differ in size, colour, and/or aperture shape.

The specimens of *Helicodiscus* had relatively broad whorls and a relatively deep umbilicus suggesting *H. parallelus* (Say, 1817) rather than *H. shimeki* Hubricht 1962. *Strobilops* shells clearly had five or six basal and parietal folds and, in a few shells where this could not be reliably evaluated, the spires were convex; thus, all were identified as *Strobilops labyrinthicus* (Say, 1817).

A few taxa identified with "*cf.*" were listed that way because of either inadequate material or complexity of the group. The *Euconulus* are treated as *fulvus* on the basis of relatively weak spiral striae on the base of the shell, but this and other characteristics were found to be difficult to evaluate. Because they are few and only found in the red oak woods, the lack of a positive identification does not affect the comparison. The specimens of *Pupilla muscorum* (L., 1758) had shallow sutures unlike the recently described *P. hudsonianum* Nekola and Coles, 2015 (Nekola *et al*. 2015). The shells of *Columella* were immature.

In the Northern Red Oak – Large-toothed Aspen woodland, 13 species and 661 individuals were recorded, whereas in the Red Pine plantation both the number of species (six) and relative abundance (24 individuals) were much lower (Table 1). There was much variation among the quadrats: 85 contained no snails, whereas 36 snails including six species were found in the quadrat that contained the most snails.

The most abundant species in the Northern Red Oak – Large-toothed Aspen woodland was the succineid snail *N. ovalis* (Figure 2, family Succineidae), which was present in 74 of the 100 quadrats and was represented by 460 individuals. We estimated that there were 46 000 of these snails per ha. The most common species in the Red Pine plantation was *Zonitoides arboreus* (Say, 1816), which was present in 16 quadrats and represented by 17 individuals. This species was the second most common in the Northern Red Oak – Large-toothed Aspen woodland where 70 individuals were found in 34 quadrats. In both habitats *Z. arboreus* was in or on rotting wood. Other species occurring in more than 15% of quadrats in the Northern Red Oak – Large-toothed Aspen woodland were *Strobilops labyrinthicus, Glyphyalinia indentata* (Say, 1823), and *Euchemotrema fraternum* (Say, 1824) (Table 1).

Discussion

What was a single scrub savannah habitat approximately 60 years ago diverged into two habitats: a planted conifer plantation and dry deciduous woodland. Ten examples of the conifer plantation differed from ten examples of the deciduous woodland in having less diversity and smaller numbers of terrestrial snails. The data suggest that the diversity and numbers of snails will decline when a savannah or dry deciduous woodland transforms into a conifer plantation. However, the snail fauna can likely be re-established by restoration of the

TABLE 1. Occurrence and numbers of land snails found in 100 1-m^2 quadrats in a Northern Red Oak (*Quercus rubra*) – Large-toothed Aspen (*Populus grandidentata*) woods and a Red Pine (*Pinus resinosa*) plantation at Constance Bay, Ontario.

Species	Northern Red Oak – Large-toothed Aspen woods		Red Pine plantation	
	No. quadrats	No. individuals	No. quadrats	No. individuals
Oval Ambersnail, *Novisuccinea ovalis* (Say, 1817)	74	460	2	2
Quick Gloss, *Zonitoides arboreus* (Say, 1816)	34	70	16	17
Maze Pinecone, *Strobilops labyrinthicus* (Say, 1817)	18	33	1	1
Carved Glyph, *Glyphyalinia indentata* (Say, 1823)	17	22	0	0
Upland Pillsnail, *Euchemotrema fraternum* (Say, 1824)	15	22	0	0
Whitelip, *Neohelix albolabris* (Say, 1817)	7	8	0	0
Immature Polygyridae	7	7	1	1
Compound Coil, *Helicodiscus parallelus* (Say, 1817)	6	6	0	0
Trumpet Vallonia, *Vallonia parvula* Sterki, 1893	4	4	0	0
Angular Disc, *Discus catskillensis* (Pilsbry, 1896)	3	23	0	0
Brown Hive, *Euconulus fulvus* (Müller, 1774)	2	2	2	2
Widespread Column, *Pupilla cf. muscorum* (L., 1758)*	2	2	0	0
Bottleneck Snaggletooth, *Gastrocopta contracta* (Say, 1822)	1	1	0	0
Comb Snaggletooth, *Gastrocopta pentodon* (Say, 1822)	1	1	0	0
Grovesnail, *Cepaea nemoralis* (L., 1758)*	0	0	1	1
Toothless Column, *Columella cf. edentula* (Draparnaud, 1805)	0	0	1	1
Total		661		25

*Introduced.

habitat, as in the case of other flora and fauna (Catling and Kostiuk 2010), leading to a diverse assemblage possibly dominated by the Oval Ambersnail, *N. ovalis* (Figure 2).

The small number of species and relative abundance of terrestrial snails in the conifer plantation was expected on the basis of numerous reports for both conifer forests and conifer plantations (Burch 1955; Karlin 1961; Solem 1984; Bonham *et al.* 2002; Jordan and Black 2012). A characteristic thick layer of pine needle litter occurred in the conifer plantation, but there was much less leaf litter in the dry deciduous woodland and areas of litter accumulation were localized. Downed wood was present in both habitats and substrate moisture appeared to be higher in the conifer plantation. The understory was generally much more extensive in the dry deciduous woodland. Any of these, and other differences, may account for differences in snail populations. The depressed terrestrial snail fauna associated with conifers is often accounted for by the high acidity of the needle duff and lack of decaying broadleaf vegetation (Nekola 2010b).

The habitat of *N. ovalis* is often dry, and this species can survive months of desiccation (Oughton 1948: 75); this snail may occur in large numbers after rain in dry woods (Latchford 1885: 229 *sub Succinea obliqua*). It is generally reported to be most common in upland woods and rock outcrops (Nekola 2003), but Pilsbry (1948: 804) reported it from both moist and dry ground, possibly based on more than one species. Although the Constance Bay habitat of periodically very dry, rolling, and elevated Northern Red Oak – Large-toothed Aspen woodland on well-drained sandy soil may seem to be an unlikely one for snails, *N. ovalis* was not uncommon there. The calculation of 46 000 *N. ovalis* per hectare in the dry deciduous woods draws attention to the potentially significant role of this medium-sized (adult length

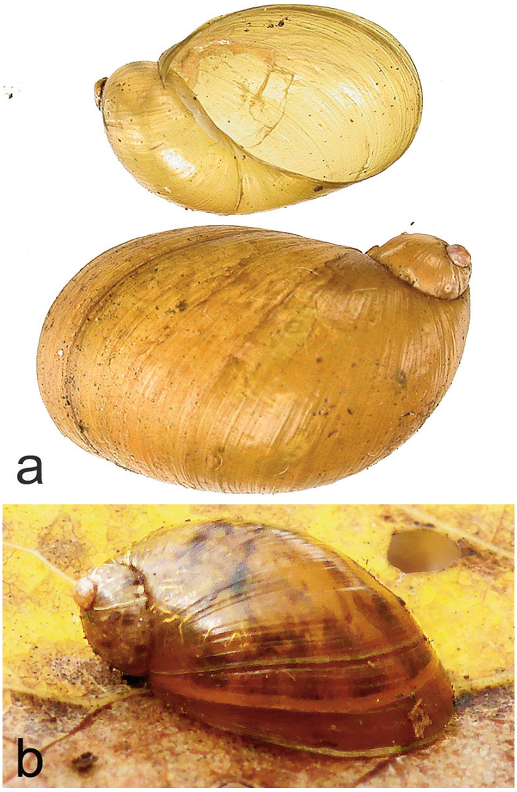

FIGURE 2. Oval Ambersnail (*Novisuccinea ovalis* (Say, 1917)), 10–15 mm in length, were common in the dry Northern Red Oak (*Quercus rubra*) – Large-toothed Aspen (*Populus grandidentata*) woods at Constance Bay with an estimated 46 000/ha. a. Shell with characteristic large aperture and few whorls. b. The animal below the transparent final whorl is blotched. Photos: P. M. Catling and B. Kostiuk.

at this site 10–15 mm) snail dispersed throughout the ecosystem (74% of quadrats) over an area of 10.28 ha.

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Received 15 November 2015
Accepted 7 June 2017

Habitat Use by Nuttall's Cottontails (*Sylvilagus nuttallii nuttallii*) at their Northern Range Edge (British Columbia, Canada)

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Herdman, Emily J., and Karen E. Hodges. 2017. Habitat use by Nuttall's Cottontails (*Sylvilagus nuttallii nuttallii)* at their northern range edge (British Columbia, Canada). Canadian Field-Naturalist 131(2): 133–140. https://doi.org/10.22621/cfn.v131i2.1827

In Canada, Nuttall's Cottontails (*Sylvilagus nuttallii nuttallii)* occur in southcentral British Columbia (BC), where they are federally listed as a species of Special Concern due to their presumed small populations and limited distribution in fragmented habitats. Their habitat use and movement patterns are poorly known at this northern edge of their distribution. We used live-trapping, radio-collaring, and fecal pellet surveys to examine Nuttall's Cottontails' use of remaining patches of native habitat as well as use of human-impacted areas. Cottontails were present in low densities and only about half of presumably suitable patches of native sagebrush-steppe were occupied. Cottontails were more likely to occur in shrubby habitat, but at a fine scale cottontails used areas that had a lower density of shrubs and finer substrates. Movement patterns differed significantly between areas of varying habitat quality, with longer movements in natural habitat. One radio-collared male cottontail used anthropogenic habitats adjacent to native habitat; this use corresponds with landowner reports. However, it is not clear whether Nuttall's Cottontails are able to use anthropogenically-impacted areas to maintain populations or in areas where such habitats are not near native habitats. Our results suggest that these animals are rare and occur primarily in remnant patches of shrub-steppe within BC.

Key Words: Nuttall's Cottontail; movement; pellet survey; fragmentation; peripheral population; sagebrush-steppe

Introduction

Nuttall's Cottontail, *Sylvilagus nuttallii nuttallii* (Bachman), is a species of shrub-steppe habitats of the North American Great Basin ecosystems that extend from southern British Columbia, Canada south to Utah, Nevada, and California, USA. In southern British Columbia (BC), Nuttall's Cottontails arrived and spread into the Okanagan and Similkameen valleys in the 1930s and 1940s, at the same time as White-tailed Jackrabbits (*Lepus townsendii*) were being extirpated from this region (Cowan and Hatter 1940; Sullivan *et al.* 1989; Carter *et al.* 1993; Nagorsen 2005). The Nuttall's Cottontail has expanded its BC range to include known areas of appropriate habitat since their first sighting in 1939, moving as far north as Keremeos and Okanagan Mountain Provincial Park (Carter *et al.* 1993; Nagorsen 2005). These cottontails are at the periphery of their northern range; the species is more common in the United States, with the range reaching as far south as Arizona and New Mexico (Chapman 1975). Nuttall's Cottontails can be locally abundant in parts of the USA range (McKay and Verts 1978a,b; Verts *et al.* 1984) and they are legally harvested in Washington and Idaho, adjacent to their Canadian range (WDFW 2015; IFG 2016).

Lagomorphs are significant prey in several ecosystems, including shrub-steppe habitats. In southern BC, Nuttall's Cottontails are likely prey for Coyotes (*Canis latrans*), Great Horned Owls (*Bubo virginianus*), Red-tailed Hawks (*Buteo jamaicensis*), Golden Eagles (*Aquila chrysaetos*), Badgers (*Taxidea taxus*), and Bobcats (*Lynx rufus*; COSEWIC 2006). Nuttall's Cottontails are not known to cause significant damage to agricultural crops in the Okanagan and Similkameen valleys where they are found in BC (Sullivan *et al.* 1989), but their use of crops may vary with the availability of natural food.

The BC population of Nuttall's Cottontails is listed as Special Concern under Canada's *Species at Risk Act* (SARA Registry 2017). Despite limited knowledge of their ecology and demography, this listing is based on presumed low numbers in a limited range, and the continued conversion of sagebrush-steppe habitat for agricultural and urban development (COSEWIC 2006). This rabbit species is under-studied, particularly in comparison to other closely-related leporid species. Nuttall's Cottontails are most commonly found in shrub-steppe habitats with Antelope-brush (*Purshia tridentata* (Pursh) DC.) and Big Sagebrush (*Artemisia tridentata* Nutt.; McKay and Verts 1978a; COSEWIC 2006). In BC, shrub cover is a strong predictor of cottontail occupancy (Sullivan *et al.* 1989). Nuttall's Cottontails prefer habitats with refuges in the form of rocky outcrops, where they can escape from predators (Powers and Verts 1971; Johnson and Hansen 1979). In the south Okanagan Valley, Nuttall's Cottontails are predicted to occur in shrubland and grassland habitats below 700 m elevation (Carter *et al.* 1993; COSEWIC 2006). Habitat use by Nuttall's Cottontails shows significant variation across their range. At the extreme southern extent of their range, in New Mexico, Nuttall's Cottontails move into higher elevations and use coniferous forests; their habitat use is expanded enough that they may overlap with Snowshoe Hares (*Lepus americanus*; Frey and Malaney 2006; Malaney and Frey 2006).

The majority of research into Nuttall's Cottontail has occurred in the USA, raising questions about the extent to which cottontails in their northern range periphery use habitats in the same ways as more southern populations, or are subject to unique habitats and climatic conditions. Here, we address a knowledge gap about northern populations by surveying areas containing suspected high-quality habitats, as well as areas of atypical habitat but with previous sightings or other records. Our goals were to assess relative abundance and to characterize habitat features at two scales that predicted presence or absence of Nuttall's Cottontails.

Methods

Surveys for cottontails

Our pellet surveys took place in the south Okanagan and Similkameen valleys, BC (49.400°N, 119.669°W), from May to November in 2007 and 2008. The valleys occur in an area of ecosystem abutment; they contain forested habitats common to more northerly areas and those from the Great Basin ecosystems to the south. We surveyed areas predicted to be suitable Nuttall's Cottontail habitat based on past sightings and a literature review, resulting in three main habitat types being surveyed: grasslands (n = 19), habitats dominated by Antelope-brush (n = 8), and sagebrush shrubland (n = 12). We further restricted our sites to those below 700 m, as this is the elevation where forest begins to dominate and Snowshoe Hares become more common (Carter *et al.* 1993). Based on these restrictions, Geographic Information System (GIS) maps with habitat overlays were used to choose 33 sites distributed across the area suspected to contain Nuttall's Cottontails in the south Okanagan and Similkameen regions (Figure 1). In addition, six of the seven live-trapping sites described below were surveyed for pellets; we did not conduct pellet plots at the Naramata live-trapping site as plots had already been completed at a nearby location

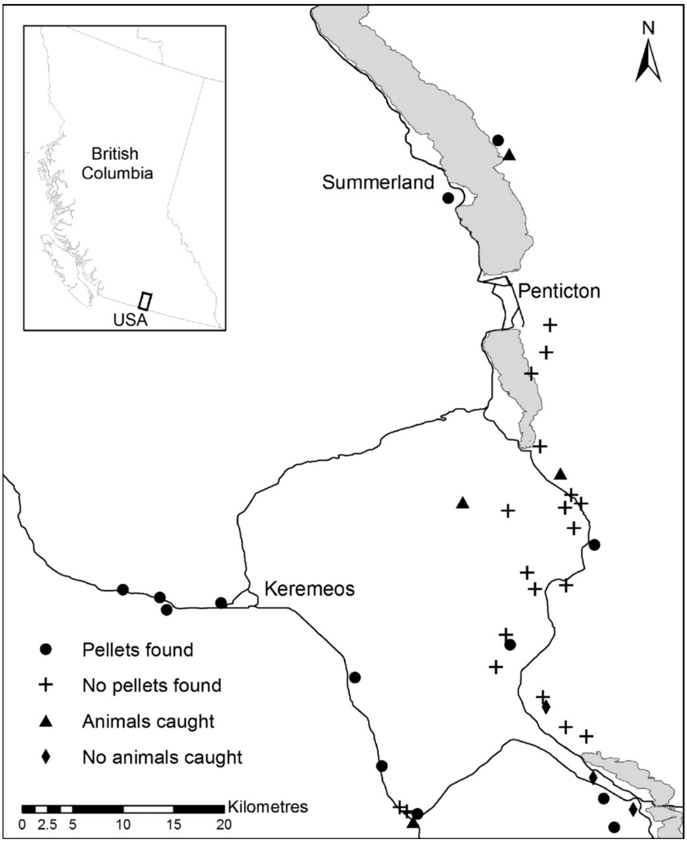

FIGURE 1. Map of south-central British Columbia (Okanagan Valley) showing sampled locations with and without documented presence of Nuttall's Cottontails (*Sylvilagus nuttallii nuttallii)* in 2007–2008. Dots indicate locations of Nuttall's Cottontail fecal pellets. Crosses were surveyed for pellets but none were found. Diamonds indicate sites that were trapped but where no animals were caught. Triangles indicate sites where Nuttall's Cottontails were captured. Six of seven trapped sites also had pellet surveys with pellets found; the seventh trapped site had pellets on a nearby site.

with natural habitat. At each location, we surveyed within a 31.5 ha rectangle (150 × 210 m). Many patches of natural vegetation in the study area are small and irregularly shaped as a result of agricultural and urban development, and these rectangles fit within these patches better than squares would have. The dominant agricultural crops in the region are tree fruits (cherries, apples, peaches, etc.) and wine grapes.

We used fecal pellet counts as a method to survey presence and relative abundance of Nuttall's Cottontails (following Krebs *et al.* 1987, 2001 for Snowshoe Hares). We surveyed 50 transects within each site, with starting points randomly selected in GIS prior to the fieldwork. In the field, we navigated with a handheld Global Positioning System receiver (eTrex, Garmin International Inc., Olathe, Kansas, USA) to the assigned point. At each point, the pellet plot was delineated using a nail placed at the point anchoring a string stretched due true north for 305 cm. Intact pellets were counted if at least half of the pellet was found within 2.55 cm on either side of the string. This produced a pellet plot of the dimensions recommended for lagomorphs (Krebs *et al.* 1987; BC Environment 1998). Pellets were counted only if they were intact and medium to dark brown. We are confident pellet counts represented recent (about one year) or current occupation of a site by cottontails; we had no sites that had only degraded or whitened pellets, so this decision rule did not lead to excluding evidence of cottontail presence. Because our sites were all in non-forested habitats, i.e., habitats that Snowshoe Hares would not use, all pellets were assumed to belong to Nuttall's Cottontails.

At each site, we surveyed vegetation at a pre-determined and randomized subset of 25 of the 50 pellet count locations. We characterized shrub cover to species; shrubs were defined as woody vegetation with multiple stems 50–200 cm tall. We estimated the percentage ground cover in the following categories: grasses, forbs, cactus, biological soil crust (including lichens and mosses), shrubs, dead wood, litter (dead leaves, needles, forbs), rocks (greater than 25 cm in diameter), cobble (5 cm to 25 cm in diameter), pebbles (2 mm to 5 cm in diameter), and fine substrate (less than 2 mm in diameter). These variables were comprehensive in characterizing ground cover in our study areas.

Live-trapping and radio-telemetry

During 2007–2008, we live-trapped for rabbits at seven pellet locations within the Okanagan Valley (Table 1, Figure 1). These sites were predicted to support Nuttall's Cottontail populations on the basis of habitat and elevation. At all but one location, > 48 traps were deployed in a grid with 30 m spacing between traps. The grid dimensions varied among locations because of the irregular shapes of habitat patches. At the Osoyoos Golf Course, we deployed 30 traps along a line because of limits in the amount and distribution of natural habitat adjacent to the course. We used collapsible live traps (Model 205, Tomahawk Live Trap, Hazelhurst, Wisconsin, USA) baited with alfalfa and apples or carrots and covered traps with wood or tarpaper to protect animals from sun or precipitation. Traps were set in the evening and checked within an hour of sunrise. Trapped animals were aged (juveniles versus adults, based on size), sexed (scrotal testes or engorged nipples or via everting the genitals to assess morphology), ear-tagged (Self-piercing Ear Tag 1005-4, National Band & Tag Company, Newport, Kentucky, USA), and weighed. Trapping was conducted at every site for at least six nights.

We radio-collared adult cottontails at the Osoyoos Desert Centre (three males, one female) and Osoyoos Golf Course (one male, two females). We used 16 g collars (less than 2.8% body mass; SOM-2380, Wildlife Materials Inc., Murphysboro, Illinois, USA). Each radio-collared animal was followed hourly from 1900–0700 h for a mean of eight nights (range 2–13). We attempted to avoid driving animal movement by remaining greater than 5 m away, using red lights, remaining

TABLE 1. Summary of live-trapping for Nuttall's Cottontails (*Sylvilagus nuttallii nuttallii)* in the south Okanagan Valley, BC. The numbers of traps per site varied because of differences in habitat areas and configurations.

Location	Trapping dates	Total trap nights	# traps	# individuals	# captures	Average pellets/plot	Habitat type
Osoyoos Desert Centre	May, July–Aug, Oct–Nov 2007 and Jan, Apr, Jul 2008	2760	72	34	124	22.31	Antelope-brush shrubland
Osoyoos Golf Course	Aug–Sept, Nov 2007 and Jan, Jul 2008	780	30	19	51	8.34	Antelope-brush shrubland
Bradley's	May–June 2007	597	87	1	1	0.05	Sagebrush shrubland
Blue Mountain	June–July 2007	816	48	0	0	0.20	Antelope-brush shrubland
Naramata	Sept 2007	252	42	0	0	—*	Orchard/sagebrush shrubland
Nighthawk	May 2007	504	72	0	0	1.34	Sagebrush shrubland
White Lake	June–July 2007	1104	48	0	0	0.00	Sagebrush shrubland

*This site was not sampled for pellets because an adjacent area of sagebrush shrubland was sampled.

quiet, and moving slowly. We could interpret from the radio-signal if animals moved in response to our approach and this was quite rare. We recorded the dominant habitat type (sagebrush shrubland, Antelope-brush shrubland, grassland, orchard, and junkyard) where cottontails were located. In addition, at a fine scale, we recorded the dominant vertical cover type and amount within a 5 m radius of the animal's location. We surveyed the vegetation after the animal had moved away from the fix location.

Statistical analyses

We used analysis of variance (ANOVA) to compare vegetation attributes across the different habitat types for the 39 pellet plot sites. We used logistic regression to relate fine-scale habitat characteristics and presence or absence of cottontail pellets. All calculations were performed using JMP 8 (SAS Institute Inc., Cary, North Carolina, USA). We calculated the average straight-line distance moved per hour for each radio-collared animal and compared these rates using a *t*-test between animals at the Osoyoos Golf Course and the Osoyoos Desert Centre.

Results

Nuttall's Cottontail pellets were found on 49% of sites surveyed (Figure 2). Over all sites, a mean (± 1 SE) of 1.24 ± 0.61 pellets was found per plot. For sites that had pellets, we found 2.54 ± 1.19 pellets per plot. Antelope-brush and sagebrush-dominated habitats were more likely to have cottontail pellets than were grasslands, although pellets were found on all habitat types (Figure 2).

At a fine scale, the three habitat types surveyed for pellets varied substantially in vegetation/ground cover characteristics. Unsurprisingly, percent shrub cover was lowest in grassland habitat (6.0 ± 1.4%), with Antelope-brush (17.9 ± 3.0%) and sagebrush (16.9 ± 2.3%) shrubland showing near equal amounts (ANOVA, $F_{2,36} = 5.77$, $P = 0.001$). Cobble and pebble ground cover was lower in Antelope-brush shrubland and litter was lower in sagebrush shrubland (Table 2). Rock outcrops are common throughout the Okanagan Valley and were present on all sites surveyed for pellets. The presence of pellets of Nuttall's Cottontails was best predicted by percent shrub cover and the percent of ground cover that was biological crust, shrub or fine substrate (Table 3). Cottontail pellets were positively associated with fine substrate, but negatively associated with shrub cover and biological crust.

We captured Nuttall's Cottontails on only three of seven trapped sites in 2007–2008, despite an effort of 6813 trap nights (Table 1). One site yielded only one capture. We had a capture rate of 5% for two other sites (Osoyoos Golf Course and Osoyoos Desert Centre), with 175 captures of 55 individuals (39 adults, 16 juveniles; 30 females, 23 males, 2 unknown) caught over 3540 trap nights. The three locations where cottontails were trapped had pellet densities of 10.23 ± 6.50 pellets/plot (mean ± 1 SE). The sites where no animals were captured had pellet densities of 0.51 ± 0.42 pellets/plot.

Radio-collared cottontails were tracked for an average of 70 locations per animal. Cottontails tracked at the Osoyoos Desert Centre moved an average straight-

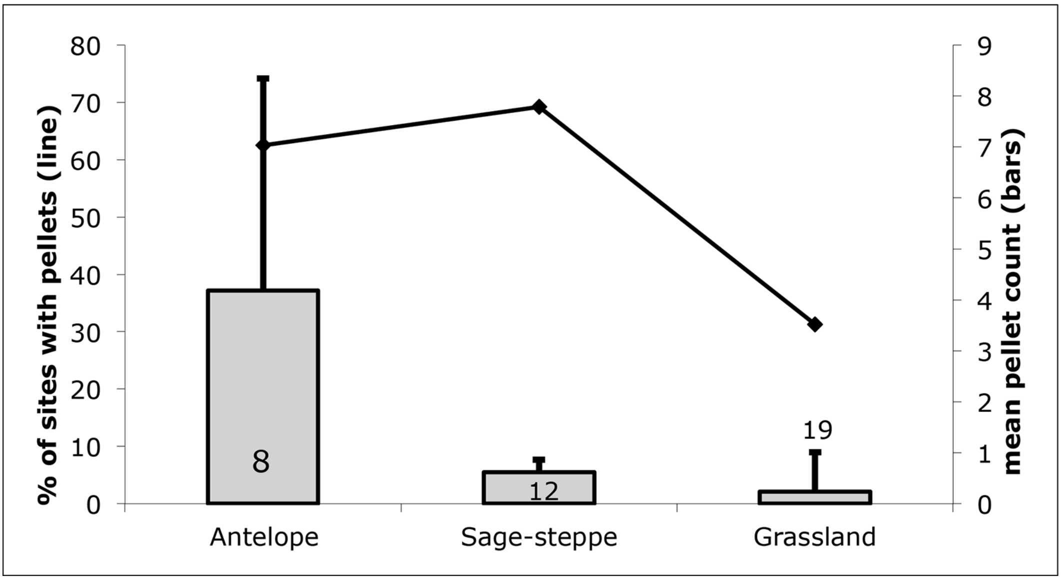

FIGURE 2. Mean Nuttall's Cottontail (*Sylvilagus nuttallii nuttallii*) pellet counts (bars) by habitat type (Antelope = Antelope-brush shrubland, Sage-steppe = sagebrush shrubland). Sample sizes are indicated for each habitat type and mean pellets ± SE are shown. Percent of sites with pellets is reported for each habitat type (line).

TABLE 2. Ground cover characteristics for each habitat type surveyed for Nuttall's Cottontails (*Sylvilagus nuttallii nuttallii)*. Values are reported as means across sites ± 1 SE. ANOVAs were used to compare habitat characteristics across habitat types.

Percent ground cover	Antelope-brush shrubland (n = 8)	Sagebrush shrubland (n = 12)	Grassland (n = 19)	$F_{2,36}$	P
Grass	23.2 ± 4.0	27.4 ± 5.1	27.4 ± 2.9	1.46	0.238
Cactus	3.2 ± 1.3	4.5 ± 2.7	0.9 ± 0.3	0.79	0.538
Biological crust	28.6 ± 5.6	25.0 ± 4.8	16.9 ± 2.6	2.24	0.086
Forbs	8.8 ± 1.9	10.0 ± 5.1	7.5 ± 1.6	0.17	0.952
Shrub	4.3 ± 1.6	3.9 ± 1.1	2.6 ± 0.6	0.58	0.680
Dead wood	5.2 ± 2.3	2.8 ± 0.6	4.7 ± 1.0	0.82	0.523
Rocks	1.0 ± 0.8	2.3 ± 0.6	6.2 ± 2.0	1.93	0.129
Cobble	1.1 ± 0.7	5.0 ± 1.9	6.8 ± 2.5	2.66	0.050
Pebble	0.9 ± 0.7	3.2 ± 0.8	5.1 ± 1.7	5.05	0.003
Fine substrate	12.7 ± 3.3	8.9 ± 4.0	10.5 ± 3.0	0.41	0.802
Litter	10.5 ± 4.8	3.3 ± 1.5	9.0 ± 3.0	3.40	0.020

TABLE 3. Logistic regressions quantifying the relationship between presence/not detected of Nuttall's Cottontail (*Sylvilagus nuttallii nuttallii)* pellets with measured habitat characteristics including both vertical shrub cover and 12 components of percent ground cover (including shrubs covering ground). Individual logistic regressions were completed for each habitat characteristic, followed by a stepwise multiple logistic regression to determine which habitat characteristics were involved in the best-fit model. The best-fit model included % shrub cover ($P = 0.0006$), % grass ($P < 0.0001$), % cactus ($P = 0.0346$), % deadwood ($P = 0.0010$) and % fine substrate ($P = 0.0001$). The best-fit model correctly classified 66.4% of sites into pellets presence versus pellets not detected categories.

Vegetation characteristics	β_0	Estimate	χ^2	P	% classified correctly
% vertical shrub cover	1.455	-0.114	7.208	0.018	78.1
% ground cover:					
Grass	-1.221	0.051	3.928	0.064	—
Cactus	0.293	-0.082	1.538	0.281	—
Biological crust	1.337	-0.056	5.205	0.033	70.0
Forbs	0.273	-0.020	0.408	0.541	—
Shrub ground cover	0.970	-0.267	5.574	0.038	68.1
Dead wood	-0.400	0.126	2.302	0.162	—
Rocks	0.380	-0.074	1.779	0.214	—
Cobble	0.579	-0.107	4.158	0.103	—
Pebble	0.035	0.020	0.105	0.748	—
Fine substrate	-0.752	0.096	7.595	0.030	75.0
Litter	-0.322	0.063	3.591	0.093	—

line distance of 51.0 ± 2.8 m/h while those at the Osoyoos Golf Course moved 34.2 ± 3.0 m/h ($t = -4.1$, $P < 0.01$). Cottontails at the Osoyoos Golf Course had access to anthropogenic habitat in the form of a junkyard, the golf course greens, and an orchard; most of the radio-collared animals restricted activity in anthropogenic habitat to the golf course greens. However, one male cottontail at the Osoyoos Golf Course often used both the junkyard and the orchard, with 66% of his locations within these non-native habitats. The natural habitat at both locations was dominated by Antelope-brush shrubland with patches of sagebrush shrubland and grassland. Cottontails at the Osoyoos Golf Course were located 74% of the time in Antelope-brush shrubland, 7% in sagebrush shrubland, and 19% in anthropogenic habitat. At the Osoyoos Desert Centre, radio-collared animals were located 53% of the time in Antelope-brush shrubland, 5% in sagebrush shrubland, 40% in grassland habitat, and 2% in anthropogenic habitat. Within a 5 m radius around each animal location, the amount of cover varied with habitat type. In grasslands this was 17.6 ± 0.8%, 9.5 ± 4.3% in anthropogenic landscapes, 74.8 ± 3.9% in sagebrush shrubland, and in Antelope-brush shrubland it was 67.8 ± 1.4%.

Discussion

Our results suggest that Nuttall's Cottontails occur at extremely low densities in scattered localities within our study area. Although we sampled sites of apparently suitable habitat, about half had no sign of cottontails. For sites that did have cottontails, the trapping rates and the very low pellet counts both indicate low densities. Similarly, opportunistic and low intensity surveys in 2009 found low numbers of cottontail pellets in only 10 of 18 sites in the south Okanagan (Marks and Young 2009). Given the fragmented nature of remaining shrub-steppe habitats in this region, we suspect Nuttall's Cottontail may occur in a metapopulation and that some patches are simply too small or too isolated to support cottontails. Detailed demographic work would be necessary to confirm whether cottontail populations occur in discrete areas linked by dispersal, whether dispersal is high enough to reflect a connected but very low density regional population, or whether populations are actually isolated in habitat fragments. We note that the Management Plan for the Nuttall's Cottontail (Environment Canada 2015) specifies that key goals are to identify and protect habitats and connectivity corridors. This suggests that the patchy distribution of cottontails as a major concern for their management.

Nuttall's Cottontail pellets were more likely to be present in shrubby than in grassy habitat. This is consistent with previous research on this species both in BC and in the USA (McKay and Verts 1978a; MacCracken and Hansen 1982; Sullivan *et al.* 1989). Fecal pellets were more common in more open habitats within shrub-lands, i.e., with locally lower densities of shrubs and with fine substrate. This result agrees with Pierce *et al.* (2011), who found *Sylvilagus* spp. pellet densities in Utah were relatively high in sagebrush-steppe areas near to agricultural lands or in areas of steppe with lower shrub densities. We are not certain if these patterns arise because more open habitats have preferred forage plants, enable better predator detection, or have some other attraction for the animals. Given that cottontails eat grasses, forbs, and shrubs (MacCracken and Hansen 1984; Verts *et al.* 1984), our results showing preferred habitat types and microhabitats containing these resources may reflect foraging decisions. We believe different pellet degradation across sites can be ruled out as affecting our detection rates, because these arid environments are likely to prolong rather than shorten the persistence of fecal pellets and Snowshoe Hare pellets can persist for years in wet forests (Krebs *et al.* 1987).

Natural habitat patches in southcentral BC are found within a matrix of human-impacted habitat and developed areas, potentially impacting movement decisions by Nuttall's Cottontails. Nuttall's Cottontail use of these anthropogenic habitats in this study was dominated by a single radio-collared male who used orchards and a junkyard. However, informal discussions with landowners of orchards and wineries indicated that Nuttall's Cottontails make some use of these non-traditional habitats. Based on these conversations and our own observations, we do not think cottontails are making heavy use of these agricultural areas, although we did not survey these areas. In the context of metapopulations or patch-matrix analyses, we do not yet know if these agricultural landcovers enable cottontails to disperse among the remnant patches of high quality shrub-steppe habitat or whether they act as barriers to movement. We suspect movements by Nuttall's Cottontails between high-quality patches are limited, in part based on the low movement rates we detected and because other *Sylvilagus* species do not show high dispersal rates or distances (Robinson *et al.* 2016).

Within the two sites with radio-collared cottontails, animals had a much higher percentage of horizontal cover nearby when they were within Antelope-brush and sagebrush shrubland than when they were in grassland or anthropogenic cover types. We cannot tell if this pattern only reflects cover availability or also reflects actual selection at a fine scale for such cover, but we suspect both are at play. Crowell *et al.* (2016) found that captive Nuttall's Cottontails in Washington preferred eating near cover. The cottontails also showed significant differences in movement speeds in relation to availability of natural habitat. Nuttall's Cottontails at the Osoyoos Desert Centre, a prime area of natural habitat, had longer hourly movements than did animals near the Osoyoos Golf Course. We suspect these patterns reflect higher resource availability in the natural habitats; at the Osoyoos Golf Course, animals had quite limited natural patches of habitat and appeared to move within them, except for one male who regularly used anthropogenic habitats.

Our results are similar to patterns seen in other *Sylvilagus* species. Animals in this genus seem to prefer native environments, but are sometimes capable of using anthropogenic landscapes if there is a substantial amount of cover in the human-altered areas. For example, Eastern Cottontails (*S. floridanus*) foraging in college campuses and gardens in Illinois preferred areas with substantially higher shrub cover (Baker *et al.* 2015). The authors interpreted this as being at least partly an anti-predator tactic. Hunt *et al.* (2014) found Eastern Cottontails in a city park in Chicago occurred in higher densities and potentially had smaller home ranges than did animals in native habitats. But this context differed from ours in that the park was surrounded by development, rather than adjacent to wild habitats. In Missouri, Eastern Cottontails were positively associated with increasing urban cover near habitat fragments and negatively associated with Coyotes, suggesting habitat selection by cottontails is affected by predation risk (Jones *et al.* 2016). Robinson *et al.* (2016) examined Swamp Rabbits (*S. aquaticus*) in southern Illinois that use patches of bottomland hardwood and appear to exist in metapopulations with limited dispersal. For them, agricultural lands seem to be more of a barrier than habitat.

Collectively, our results suggest that there is a small, fragmented population of Nuttall's Cottontails in southcentral BC. Although cottontails can use some agricultural and recreational habitats, such sites did not seem to be as resource-rich or to support as many animals as native habitats. Near their southern range limit in New Mexico, Nuttall's Cottontails use higher elevation sites (> 3000 m) and even some forested areas. This suggests that cottontails are capable of using a wide range of habitats even if some types are clearly strongly preferred. In BC, we have not observed this breadth of habitat use by the cottontails. Instead, cottontails here seem to be quite limited in their distribution. As land conversion continues in the south Okanagan, we expect some patches of natural habitat will see the extirpation of cottontails as patches become smaller, more isolated, or surrounded by habitat types that are more difficult for cottontails to cross. We encourage more survey efforts, radio-tracking, and genetic analysis to determine if the existing populations are isolated or connected. At present, it seems likely that ongoing habitat loss is severely damaging this species in BC.

Acknowledgements

We thank Stephanie Pascuzzo, Sharon Watson, Astrid Boeckelmann, Natalie Melaschenko, Adam Collins, Natasha Lukey, Jordan Edwards, and other volunteers who assisted with field work. We also thank Orville Dyer (British Columbia Ministry of the Environment) for help gaining land access and determining plot locations, the Canadian Wildlife Service, Parks Canada, The Osoyoos Golf and Country Club, The Osoyoos Desert Centre, BC Parks, the Nature Trust of British Columbia, The Dominion Radio Astrophysical Observatory (National Research Council of Canada), and private landowners for allowing access to their properties. Funding for this project was provided by Environment Canada and the University of British Columbia Okanagan. Trapping and radio-collaring were conducted under protocol A06-0322 of the Animal Care Committee of the University of British Columbia.

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Received 13 July 2016
Accepted 30 May 2017

Note

A Review and the Conservation Implications of Aquatic Behaviour and Drowning in Jumping Mice (Dipodidae: Zapodinae)

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Frey, Jennifer K. 2017. A review and the conservation implications of aquatic behaviour and drowning in jumping mice (Dipodidae: Zapodinae). Canadian Field-Naturalist 131(2): 141–143. https://doi.org/10.22621/cfn.v131i2.1869

Jumping mice (Dipodidae: Zapodinae) have a generalized terrestrial quadrupedal locomotion with specializations for saltatory and scansorial locomotion. I reviewed first-hand accounts of aquatic behaviour in the literature and confirmed that jumping mice are semi-aquatic, using both primitive quadrupedal paddling on the surface as well as the more derived simultaneous bipedal pelvic paddling while swimming underwater. Although proficient swimmers, jumping mice are also prone to drowning, especially in human-made pools. Management of populations of jumping mice with conservation concern should consider potential hazards faced by jumping mice in an aquatic environment.

Key Words: Endangered species; jumping mouse; *Eozapus*; *Zapus*; *Napaeozapus*; pitfall trap

Introduction

The jumping mice (Dipodidae: Zapodinae) include four North American species, Meadow Jumping Mouse (*Zapus hudsonius*), Pacific Jumping Mouse (*Zapus trinotatus*), Western Jumping Mouse (*Zapus princeps*), and Woodland Jumping Mouse (*Napaeozapus insignis*), all found in Canada (Banfield 1974), and one palearctic species, Chinese Jumping Mouse (*Eozapus setchuanus*; Wilson and Reeder 2005). The Zapodinae are generalized quadrupeds, but they are the sister taxon to the more specious jerboas (Dipodinae, Allactaginae, Cardiocraniinae, and Euchoreutinae), which are highly specialized for arid environments and use highly derived bipedal locomotion (Lebedev *et al.* 2012).

All species of jumping mice are commonly associated with wet habitats and are frequently found along streams and rivers or in marshes, swamps, and other freshwater wetlands (Krutzsch 1954). Consequently, an ability to swim might be a valuable adaptive trait for life in these environments. However, jumping mice are considered to have a generalized terrestrial quadrupedal mode of locomotion with some morphological specialization for saltatory and scansorial locomotion (Samuels and Van Valkenburgh 2008; Wright and Frey 2014). Other than somewhat small external pinnae with an antitragal flap, which can cover the external auditory meatus, and reduced size of testes and scrotum, jumping mice lack many of the specialized adaptations often found in semi-aquatic small mammals, such as interdigital webbing or fringes, dense non-wettable underfur, laterally compressed tail, valvular nares, and nictitating membranes (Krutzsch 1954).

Because of their association with fragile and declining wetland habitats, some populations of jumping mice are of conservation concern, and two forms (*Zapus hudsonius preblei* and *Z. h. luteus*) are now listed under the United States *Endangered Species Act* (Malaney and Cook 2013; USFWS 2014). Although no jumping mice have been assessed by the Committee on the Status of Endangered Wildlife in Canada (SARA Public Registry 2017), it is important to understand more clearly the behavioural relation of jumping mice with water, which is a frequent component of their habitat. For instance, some endangered populations of jumping mice occur in irrigated valleys where human-constructed canals and ditches convey water and could pose barriers to jumping mice if they are poor swimmers (e.g., Wright and Frey 2015). Thus, the purpose of this report was to review existing, first-hand information about aquatic behaviour in jumping mice (swimming or drowning) and to evaluate the conservation implications of that information.

Methods

I searched for published, first-hand observations of aquatic behaviour in jumping mice. Search terms included: *Zapus*, *Napaeozapus*, *Eozapus*, aquatic, swim, swam, swimming, drown, drowned, and drowning. Search engines included: Google Scholar, Google Books, and Web of Science. I categorized accounts of swimming by species and by nature of the observation (i.e., free-ranging animals or animals forced to swim in laboratory or natural water body). I categorized accounts of drowning by species and the type of water body (i.e., natural or artificial). Quotes and references to first-hand observations of swimming and drowning are detailed in supplementary material Appendices S1 and S2, respectively.

Results and Discussion

Swimming

I found 18 papers that described swimming behaviour in Zapodinae (Appendix S1). Of the observations where the species was identified, 13 were of *Z. hudsonius*, three were of *Z. princeps*, and three were *N. insignis*; no information about aquatic behaviour was

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A contribution towards the cost of this publication has been provided by the Thomas Manning Memorial Fund of the Ottawa Field-Naturalists' Club.

found for *Eozapus*. Most of the reports were anecdotal observations of free-ranging animals. Four accounts were of animals forced to swim: Quimby (1951) observed five *Z. hudsonius* that were taken out into a lake and observed from a boat; Whitaker (1963) forced two *Z. hudsonius* to swim, although it was not stated where the observation occurred; Dagg and Windsor (1972) recorded data from a *Z. hudsonius* forced to swim in an aquarium; and Wrigley (1972) observed a *N. insignis* forced to swim in an aquarium.

Although swimming behaviour in jumping mice has not been rigorously tested, these first-hand accounts of swimming behaviour allow some conclusions to be made. Jumping mice enter water both accidentally (e.g., following an erratic jump when frightened) and intentionally. Jumping mice are capable of swimming on top of water, underwater, and against a current. Most observers thought that the jumping mice swam with ease and relatively swiftly. Duration of swimming was up to about 5 minutes. Jumping mice swam underwater for up to about 1 minute before surfacing for air. Underwater swimming usually occurred about 10–30 cm below the surface, but up to about 45 cm below the surface.

In parallel with their dual quadrupedal and saltatory modes of terrestrial locomotion, jumping mice exhibit two major modes of swimming. In all cases propulsion is via the limbs, and the elongated hindlimbs, feet, and toes, which are normally adaptations associated with saltatory locomotion (Banfield 1974), serve double duty as powerful swimming devices. On the surface, jumping mice may swim via quadrupedal paddling, which involves alternate use of both limbs in a vertical plane, as typified by a Dog (*Canis familiaris*; Fish 1996). This is considered the most primitive form of drag-based swimming propulsion, and it is used by both terrestrial and semi-aquatic mammals (Fish 1996). However, jumping mice were more frequently observed using simultaneous pelvic paddling, especially when swimming underwater. In this mode, which is used by more derived semi-aquatic mammals, such as the River Otter (*Lontra canadensis*), propulsion is via simultaneous strokes of the hind limbs (Fish 1996). Surface swimming is energy inefficient because of the increased drag at the surface (i.e., wave drag). Because wave drag increases with speed, the relatively slow quadrupedal paddling economizes energy expenditures when swimming on the surface. However, underwater bipedal paddling offers greater energy efficiency and speed. The optimum depth for reducing wave drag is greater than three body diameters, which is consistent with observations of jumping mice swimming about 10–30 cm underwater (Fish 1996).

Although bipedal paddling is relatively efficient because it reduces interference from the other limbs, *N. insignis* was also observed to use simultaneous pelvic paddling in conjunction with simultaneous pectoral paddling when swimming on the surface (Wrigley 1972). In this mode, the forelimbs stroked as the hind limbs were brought up to the body, which was followed by the propulsive stroke of the hind limbs. Thus, the limb motions resembled the saltatory hop on land. The overall effect of a swimming jumping mouse using this mode was a dorsal rocking motion that created an audible rhythmic splashing in time with the strokes. Presumably the actions of the forelimbs helped keep the head above water during this more vigorous surface swimming mode.

Jumping mice can transition from surface swimming to underwater swimming by diving. Although most mammals can swim, underwater swimming is uncommon and is generally limited to species that live in close association with water (Dagg and Windsor 1972). When jumping mice are swimming underwater, air is apparently trapped by the fur, which makes the animals appear silvery. However, Wrigley (1972) reported that the pelage of *N. insignis* did not hold air as well as that of deer mice (*Peromyscus*) and, thus, provided less buoyancy. Dagg and Windsor (1972) reported that *Z. hudsonius* swam horizontally on the surface of the water with its back submerged (in contrast with animals with dense fur, which allows them to float with their backs above water) and that, as the fur became wetted and they lost buoyancy, their body position shifted to a 25° angle to the water surface.

The tail is not used in swimming, either for propulsion or as a rudder, as it either drags behind limply or is carried arched up in the middle. In other semi-aquatic mammals, the tail is often laterally compressed; however, the tail of jumping mice is narrow and roundish in cross section providing relatively little surface area. Swimming jumping mice are able to steer purposefully to travel to specific points; the exact mechanism for steering is unknown but presumably is similar to that of other semi-aquatic rodents (Fish *et al.* 2002).

Drowning

I found 11 accounts of jumping mice drowning: ten free-ranging *Z. hudsonius* and one captive neonatal *N. insignis* (Appendix S2). All instances of drowning in free-ranging *Z. hudsonius* where the nature of the water body could be determined ($n = 8$) were in small artificial pools of liquid that acted as pitfall traps: milk pan, water tub, post hole, fish hatchery pond, pitfall traps filled with water, goldfish pond, plastic sheeting filled with rain water, plastic wading pool. It seems likely that jumping mice inadvertently enter these pools, perhaps as a result of their jumping behaviour or via scansorial locomotion in overhanging vegetation. However, they were unable to escape because of steep or slick walls and relatively deep fluid that prevents effective jumping.

Conservation implications

Jumping mice are semi-aquatic and capable of both surface and more advanced underwater swimming. Thus, small bodies of water likely do not represent barriers to them, and small streams may provide important escape habitat. However, jumping mice appear to tire of swimming after several minutes, which would limit their ability to cross larger bodies of water.

Although capable swimmers, jumping mice also seem to be particularly vulnerable to drowning in both natural and human-constructed pools of liquid, such as post holes, goldfish ponds, and fish hatchery runs. Compared with other small mammals, jumping mice may be more vulnerable to drowning in pools because of their normal modes of locomotion and escape behaviours; they may inadvertently enter pools, including artificial above-ground pools, through their saltatory locomotion or via their scansorial climbing in overhanging vegetation (Wright and Frey 2014). Further, the normal escape behaviour of a frightened jumping mouse consists of a few erratic ricochetal hops followed by an abrupt stop and remaining motionless (Whitaker 1963). However, a ricochetal hop may not be possible if the mouse is in water that is too deep or it may be ineffective if the pool sides are too close or steep to allow escape. It is also possible that steep or slippery sides preclude jumping mice from climbing out of pools. Jumping mice appear to be particularly vulnerable to capture in pitfall traps (Williams and Braun 1983; Handley and Kalko 1993; Kalko and Handley 1993; Murphy *et al.* 2007). Augmentation of water-filled pitfall traps with slabs of wood still resulted in large numbers of dead rodents, including *Zapus* (Murphy *et al.* 2007), although it is unknown to what extent addition of other structures in pitfall traps (e.g., sticks, strings) could facilitate escape by jumping mice while also retaining target species, such as amphibians.

Thus, because pitfall traps or plastisc reptile cover sheets can partly fill with water or rain, they should not be used in areas with vulnerable populations of jumping mice. Smooth, steep-sided canals and ditches also might pose a drowning hazard. Some techniques used for fish sampling or angling, such as electrofishing or submerged minnow traps, may be a concern in areas occupied by vulnerable populations of jumping mice. Management of vulnerable populations should consider potential impacts of large aquatic predators such as American Bullfrog (*Lithobates catesbeianus*), Brown Trout (*Salmo trutta*), and black bass (*Micropterus* spp.), which could target swimming jumping mice as prey.

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Received 25 October 2016
Accepted 20 June 2017

SUPPLEMENTARY MATERIAL:

APPENDIX S1: First-hand accounts of swimming behaviour in the Zapodinae.

APPENDIX S2: First-hand accounts of drowning in the Zapodinae.

Searching for Black Swift (*Cypseloides niger*) Nests in Southern British Columbia

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Levesque, Paul G., and Christine A. Rock. 2017. Searching for Black Swift (*Cypseloides niger*) nests in southern British Columbia. Canadian Field-Naturalist 131(2): 144–150. https://doi.org/10.22621/cfn.v131i2.1805

Black Swifts (*Cypseloides niger*) are thought to breed throughout southern British Columbia, however few nests have been described in the region. Population trend estimates from British Columbia show significant declines, prompting the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to assess Black Swift as Endangered in Canada. We identified potential nesting locations and searched for nests at 16 sites in southern British Columbia between 2001 and 2015. Two active Black Swift nests were discovered during surveys: Brandywine Falls south of Whistler, and Highfalls Creek Falls northwest of Squamish. The Brandywine Falls nest was revisited annually from 2009 to 2015, and the nest was active during at least five of the seven years of monitoring. Evening surveys were not effective for detecting Black Swift nest attendance.

Key Words: Black Swift; *Cypseloides niger*; aerial insectivore; nesting; British Columbia; Brandywine Falls; Highfalls Creek

Introduction

The Alaskan and Canadian breeding range of Black Swift (*Cypseloides niger* (Gmelin, 1789)) includes southeastern Alaska, mountainous areas of southwestern Alberta, and the southern half of British Columbia (American Ornithologists' Union 1998). However, nesting has not been confirmed in Alaska (Johnson *et al.* 2008), and few Black Swift nest sites have been documented in Alberta (Bent 1940; Kondla 1973; Holroyd and Holroyd 1987) and British Columbia (Jobin 1955; Beebe 1959; Grant 1966; Campbell *et al.* 1990; Tyson 2004; Levesque 2015). Using Breeding Bird Survey (BBS) data, Partners in Flight has estimated that British Columbia has 86% (60000) of the North American breeding population of Black Swifts (Partners in Flight Science Committee 2013). The main challenges in locating Black Swift nests are the cryptic and inaccessible nest locations often situated near waterfalls and deep canyons (Lowther and Collins 2002) and long foraging sessions resulting in infrequent nest attendance (Marín 1999).

The Black Swift is an aerial insectivore; a group of birds that is experiencing population declines in Canada (Nebel *et al.* 2010). Based on BBS data, the long-term (1973 to 2012) population trend estimates that Black Swifts in Canada have declined at an annual rate of 6.5% (Environment Canada 2014). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has assessed the Black Swift as Endangered (COSEWIC 2015). Long-term monitoring of Black Swift nests in California has documented a breeding range contraction at coastal sites (Roberson and Collins 2008). The causes of the decline in the Black Swift population are poorly understood.

Increasing the number of known Black Swift nesting locations is a conservation priority for this species. Annual nest site fidelity is very high, with many sites being used for decades (Kondla 1973; Collins and Foerster 1995; Levad *et al.* 2008; Levesque 2015); this strongly suggests that nest sites are important habitat and are in need of protection. Because Black Swifts spend most of their time in flight, nest sites are the only locations to answer basic questions regarding life history traits such as longevity, age of first breeding, and annual and lifetime productivity.

Currently, the best available monitoring program for estimating population trends of Black Swifts is the North America BBS. However, the BBS methodology has detectability issues for monitoring Black Swift populations in North America. This results in low confidence in survey estimates (Wiggins 2004; Levad 2007; Partners in Flight Science Committee 2013; COSEWIC 2015; Sauer *et al.* 2017), in part due to the species' limited breeding distribution and the inaccessibility of its preferred nesting habitat (Wiggins 2004). It has been argued that the Partners in Flight Black Swift population estimates based on BBS data are most likely overestimated (Levad 2007). Annual nest monitoring at multiple sites throughout the species' northern breeding range would provide a better method of determining population trends.

Given the lack of known Black Swift nesting sites in Canada, the importance of nest sites, and concerns about population declines, our objectives were to locate additional nest sites in southern British Columbia, and to comment on inventory methodology. If British Columbia is home to 86% of the North American breeding population, (up to 60 000 Black Swifts; Partners in Flight Science Committee 2013), there must be many undiscovered nest sites.

Methods

We identified potential Black Swift nesting sites in southern British Columbia by using Google to search terms such as "waterfalls" + "British Columbia". We prioritized search results by ranking images against nest site attributes observed in Colorado by Knorr (1961, 1993). If a site lacked one or more of Knorr's site attributes (high physical relief, close proximity to flowing water, inaccessible to terrestrial predators, darkness, open flight corridors to the nests, and suitable niches for nests) the site received a lower rank and was deemed a lower priority for a site visit.

Nest searches were conducted at potential nesting sites following methods in Schultz and Levad (2001) within the known breeding season in British Columbia (early June to early September; Campbell *et al.* 1990). Surveyors searched potential nest sites for the presence of active nests or signs of occupancy (i.e., presence of adults) during midday and in favourable weather. Nest searches were conducted during the day by methodically scanning all of the substrate surrounding waterfalls using 10 × 42 binoculars and a 15–45 × 60 field scope. Once all of the visible substrate had been searched for nests, the observer(s) moved to a new vantage point and continued scanning the substrate. When additional observers were present, they watched the general area around the waterfall and recorded the presence/absence of adult Black Swifts. Once a nest was located, the site was revisited in following years, when possible, to determine site fidelity and re-occupancy.

Evening surveys followed methods in Schultz and Levad (2001) and were conducted to determine whether Black Swifts were using the waterfall for nesting or roosting. Observers positioned themselves at the bottom of the waterfall when possible, and watched for Black Swifts returning to or leaving the waterfall during the last two hours of daylight. The survey was terminated once it was too dark to observe Black Swifts.

Between 2001 and 2015, 16 potential Black Swift nesting sites were surveyed on Vancouver Island (*n* = 7), Vancouver/Sea to Sky area (*n* = 6), and the southern interior (*n* = 3; Figure 1). All sites, including those deemed low suitability, were surveyed at least once in daylight. During daytime surveys, we conducted 30 h of nest searching (scanning substrate) and 42 h of watching for adult Black Swift flying near or into the waterfalls.

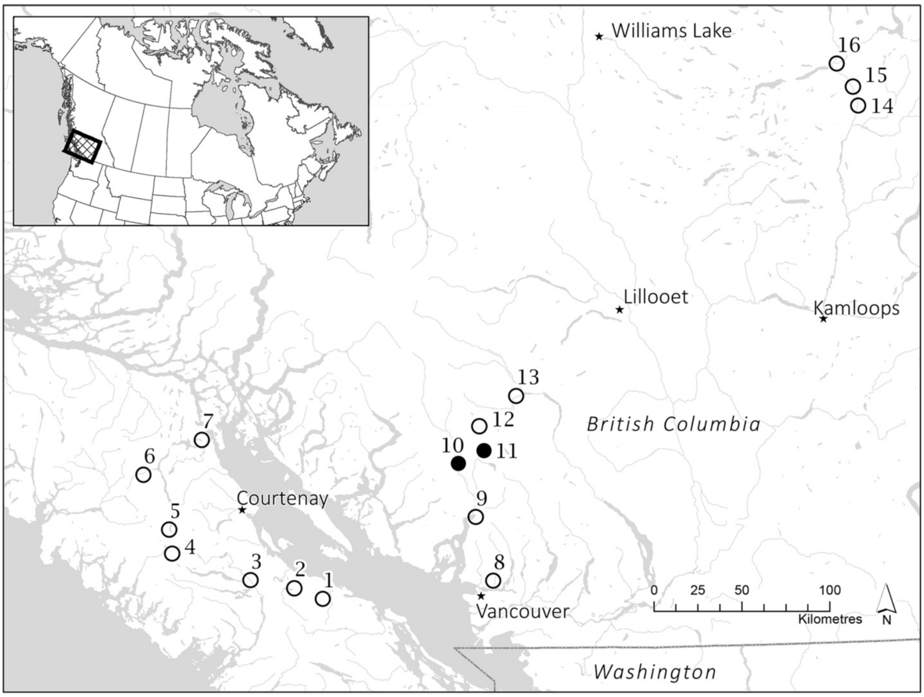

FIGURE 1. Black Swift (*Cypseloides niger*) nesting surveys were conducted at seven sites on Vancouver Island: 1 Englishman River Falls, 2 Little Qualicum Falls, 3 Stamp Falls, 4 Della Falls, 5 Myra Falls, 6 Lady Falls, 7 Elk Falls. Surveys were conducted at six sites in the Vancouver/Sea to Sky area: 8 Lynn Canyon, 9 Shannon Falls, 10 Highfalls Creek, 11 Brandywine Falls, 12 Alexander Falls, 13 Nairn Falls. Surveys were conducted at three sites in the southern interior: 14 Spahats Falls, 15 Moul Falls, and 16 Helmcken Falls. Solid circles ● indicate nest locations, open circles ○ indicate survey sites where nests were not found.

Results

Twelve of the 16 sites visited met all of Knorr's (1961, 1993) physical requirements for Black Swift nesting habitat. Adult Black Swifts were observed flying over three sites on five occasions, and one adult was seen flying into an active nest on three occasions (Table 1). Active Black Swift nests were located at Brandywine Falls and Highfalls Creek Falls (Table 1).

During daytime surveys on 26 July 2004, an adult Black Swift was observed attending a nest behind Brandywine Falls in Brandywine Provincial Park, approximately 14 km south of Whistler (50.036°N, 123.119°W). Brandywine Falls is a plunge type waterfall that drops 70 m into a large pool. The nest was approximately 25 m below the crest of the waterfall, and was positioned behind the eastern edge of the falls. The nest was positioned on a small ledge on a larger section of undercut rock that was approximately 2 m from the main flow of the waterfall. The nest was made entirely of moss, and the nest and rock surface immediately surrounding the nest was wet (Figure 2).

TABLE 1. Summary of sites visited, survey dates, effort, and Black Swifts (*Cypseloides niger*) observed during day, evening, and nest monitoring surveys, 2001 to 2015.

Site name	Date	Nest searching (h)	Watching falls (h)	Black Swifts observed	Number of observers	Total time at site (h)
DAY SURVEYS						
English River Falls	27 Jun 2004	2.0	0.0	0	1	2.0
Little Qualicum	13 Jun 2004	1.0	1.0	0	1	2.0
Stamp Falls	28 Jun 2004	1.0	1.0	0	2	2.0
Della Falls	3 Aug 2001	3.0	6.0	0	2	9.0
Myra Falls	29 Jun 2004	1.0	1.0	0	2	2.0
Myra Falls	7 Aug 2004	1.0	1.0	0	2	2.0
Lady Falls	8 Aug 2004	2.0	2.0	0	2	4.0
Elk Falls	7 Aug 2004	1.5	1.5	0	2	3.0
Lynn Canyon	7 Aug 2010	2.0	2.0	0	2	4.0
Shannon Falls	26 Jul 2004	1.0	0.0	0	1	1.0
High Falls Creek	25 Jul 2015	2.0	2.0	5[*] 1[†]	2	4.0
Brandywine Falls	26 Jul 2004	2.0	2.0	1[†]	1	4.0
Brandywine Falls	2 Aug 2004	0.0	9.0	1[‡] 1[†]	3	9.0
Brandywine Falls	3 Aug 2004	1.0	1.0	1[§]	2	2.0
Brandywine Falls	5 Aug 2004	1.5	1.5	5[*] 1[§]	2	3.0
Alexander Falls	3 Aug 2004	1.0	1.0	0	2	2.0
Narin Falls	4 Aug 2004	2.0	2.0	0	2	4.0
Spahat Falls	21 Aug 2010	1.0	1.0	0	2	2.0
Moul Falls	22 Aug 2010	1.0	2.0	0	2	3.0
Helmcken Falls	21 Aug 2010	2.0	2.0	0	2	4.0
EVENING SURVEYS						
English River Falls	13 Jun 2004	0.0	2.0	6[*]	1	2.0
English River Falls	21 Jul 2004	0.0	3.0	0	1	3.0
English River Falls	27 Jun 2004	0.0	2.5	1[*]	1	2.5
English River Falls	5 Aug 2004	0.0	4.0	2[*]	2	4.0
Myra Falls	29 Jun 2004	0.0	4.0	0	2	4.0
Myra Falls	7 Aug 2004	0.0	4.0	0	2	4.0
Lynn Canyon	26 Jul 2013	0.0	2.0	0	1	2.0
Brandywine Falls	3 Aug 2004	0.0	4.0	1[§]	2	4.0
Alexander Falls	2 Aug 2004	0.0	4.5	0	3	4.5
NEST MONITORING						
Brandywine Falls	23 Jul 2009	1.0	1.0	1[‡] 1[†]	2	2.0
Brandywine Falls	8 Aug 2010	1.0	1.0	0	2	2.0
Brandywine Falls	30 Aug 2011	0.5	0.5	n/a	2	1.0
Brandywine Falls	5 Aug 2012	1.0	1.0	1[‡] 1[§]	2	2.0
Brandywine Falls	3 Aug 2013	1.0	1.0	1[§]	2	2.0
Brandywine Falls	2 Aug 2014	1.0	1.0	1[§]	2	2.0
Brandywine Falls	25 Jul 2015	1.0	1.0	1[†]	2	2.0

[*] Adult Black Swift(s) flying above the waterfall.

[†] Adult Black Swift(s) at nest.

[‡] Adult Black Swift observed flying into the nest.

[§] Black Swift nestling observed, no adult at nest.

n/a, unable to view nest due to high water.

FIGURE 2. Two adult Black Swifts (*Cypseloides niger*) attending the nest at Brandywine Falls, 2 August 2004. Photo: L. Savard.

The Black Swift nest at Brandywine Falls was revisited each breeding season 2009–2015 (Table 1). The same nest used in 2004 was reused in 2009, 2012, 2013, 2014, and 2015, but was not active on 10 August 2010, and the nest could not be viewed on the 30 June 2011 visit due to high water levels obscuring the nest. Adult Black Swifts were seen flying into the active nest in 2004, 2009, and 2012.

During daytime surveys on 25 July 2015, an adult Black Swift was observed attending a nest on the eastern side of Highfalls Creek Falls, 27.3 km northwest of Squamish (49.944°N, 123.296°W). Highfalls Creek flows over a three-tiered plunge type waterfall approximately 100 m high. The upper two tiers are approximately 10–15 m high, and the lower section is approximately 80 m high. The nest was 3 m from the eastern edge of the lower tier, 15 m from the top of the lowest tier (Figure 3). This nest was made of moss, and the nest and the surrounding area was dry.

Evening surveys were conducted on nine evenings at five sites. Black Swifts were not observed flying into waterfalls during any of the evening surveys (30 observer hours); this includes four observer hours at the active Brandywine Falls nest. Black Swifts were observed flying approximately 100 m above Englishman River Falls on two of the four evening surveys.

Discussion

Identifying potential Black Swift nesting sites by examining images of waterfalls collected from internet searches was effective. However, site visits revealed that some required physical attributes (particularly: physical relief, suitable niches, and direct sunlight) were not reliably determined from photographs. There was a bias toward readily accessible waterfalls being well documented by the public, and remote or more inaccessible sites being undocumented.

Searching for Black Swift nests by methodically scanning substrate during daytime surveys resulted in locating two active nests. Because observers could not safely access vantage points that permitted viewing of all potential nesting substrate, some active nests could have gone undetected. The waterfalls obscured some potential nesting substrate, and this was most problematic during high water flow in June and early July. Site visits in the latter half of July and August when water volumes tend to be lower may increase success in locating active nests. Schultz and Levad (2001) also recom-

FIGURE 3. Nest location of Black Swift (*Cypseloides niger*) at Highfalls Creek Falls, denoted by the black square in the center of the image. 25 July 2015. Photo: C. Rock.

mend conducting daytime nest searches in late July and August to avoid high water flow, and they noted that adult nest attendance was more frequent in the 12 days after hatching.

Black Swift nest occupancy monitoring data in British Columbia are limited, partly due to the lack of known nest sites and partly to the lack of a formal monitoring program. Our annual monitoring of the Brandywine Falls nest (2009 to 2015) showed high annual site reuse. Although the nest was not active on 8 August 2010, at that late date it is possible that a nest was initiated, but failed. Nest failures have been documented in Colorado; Hirshman *et al.* (2007) monitored 160 Black Swift nesting attempts over an 11 year period, and observed 35 nest failures. There is likely a tradeoff between surveying for nests in the latter half of July and August, when water levels have subsided, and detecting failed nesting attempts. Potential sites should therefore be surveyed for more than one breeding season to determine occupancy.

The strength of evening surveys is to detect sites where active nests are undetectable. Nesting can be confirmed by observing adult Black Swifts flying into the site to attend the nest at dusk (Foerster and Collins 1990). Evening surveys have been used to estimate the number of nests at sites and to estimate the size of regional populations (Foerster and Collins 1990; Levad *et al.* 2008). We observed Black Swifts flying well above the forest canopy during evening surveys, but we did not observe Black Swifts flying into waterfalls. Furthermore, we did not detect Black Swifts during an evening survey at Brandywine Falls while monitoring the active nest. In 2003, the American Bird Conservancy conducted an ambitious Black Swift nesting inventory that involved 103 field observers conducting 513 h of evening surveys at 82 waterfalls from northern California to southeast Alaska, with the majority of surveys conducted in Oregon, Washington, and Alaska (Altman 2003). The project resulted in the location of two nest sites, including one active nest at Cascade Falls near Mission, British Columbia located after an evening detection on 2 August 2003 (Tyson 2004). Black Swifts were observed flying into waterfalls at four additional sites, but nests were not located.

The effectiveness of evening surveys may vary spatially and temporally through the breeding season. Udvardy (1954) reported that low-pressure weather systems concentrated foraging flocks of Black Swifts in coastal areas of southern British Columbia and suggested that low-pressure systems would result in long distance, multiday foraging trips. The passage of low-pressure systems is a regular occurrence in June and July in British Columbia and could influence the frequency of evening nest attendance. In southern California, Marín (1999) noted that the timing of nest attendance shifted from mornings (8:00–12:00) to evenings (18:00–20:00) once Black Swift nestlings were 15 days old and that morning feedings were not observed after the nestlings were 30 days old. Following the known nesting phenology in Hirshman *et al.* (2007), Black Swift nestlings would be 15 and 30 days old on 10 August and 25 August, respectively. If food deliveries are more common in the mornings during incubation and the first half of the nestling phase, conducting evening surveys during this period may result in low detection rates, assuming the timing of nest attendance in British Columbia is similar to the timing in southern California.

We recommend that determining the timing and frequency of Black Swift nest attendance throughout the nesting cycle, and in relation to weather systems, should be a research priority for the British Columbia population. If Black Swift nest attendance can be determined, the timing of nest searches could then be optimized and would increase the number of known nest sites in the region. We recommend that at least 10 to 15 active Black Swift nest sites be monitored across a range of habitat types (i.e., coastal, dry interior, and eastern British Columbia) for at least a decade to understand reproductive trends and their influence on population trends.

Acknowledgements

We thank Laurie Savard for her assistance in the field, and for her photography. Joel Crawford (Environmental Resources Management Inc.) created the map for Figure 1. Greg Sharam (Environmental Resources Management Inc.) provided helpful review comments on an early version of the manuscript. The manuscript was greatly improved by comments from Anthony Gaston and two anonymous reviewers.

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Received 29 May 2016
Accepted 6 June 2017

Short-term Change in Forest Metrics at Grand Portage National Monument, Minnesota

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Sanders, Suzanne, and Jessica Kirschbaum. 2017. Short-term change in forest metrics at Grand Portage National Monument, Minnesota. Canadian Field-Naturalist 131(2): 151–163. https://doi.org/10.22621/cfn.v131i2.1986

Forest health monitoring programs can provide routine feedback of key indices and periodic updates of ecosystem health. A forest monitoring program was initiated at Grand Portage National Monument in 2007 with plots resampled in 2014. Grand Portage National Monument is within the southern boreal forest and the suitable habitat for most of its common overstorey species is expected to shift northward and out of the park as climate change progresses. We assessed short-term change in forest health on 20 plots by specifically evaluating change in overstorey density and basal area, forest community composition, and White-tailed Deer (*Odocoileus virginianus*) browsing impacts on the herbaceous layer. Pooled across all overstorey species, both density and basal area increased between sampling events, but neither differed among habitats. For individual species of interest, responses were varied, although Balsam Fir (*Abies balsamea*) increased in both density and basal area over the seven years. The frequency of quadrats supporting at least one preferred browse species did not differ between sampling years although this was greater in upland plots (81%) compared with wet mesic sites (66%). The effect of sampling year on species' richness depended on habitat. In 2007, richness was higher in upland plots, although in 2014, richness was higher in wet mesic plots. Pooled across both sampling years, modified floristic quality index was greater in wet mesic plots. Our work demonstrates the increasing dominance of *A. balsamea* at Grand Portage National Monument and that notable differences in forest metrics can be observed over relatively short times.

Key Words: Boreal forest; browse ecological monitoring; forest change; Grand Portage National Monument; White-tailed Deer

Introduction

Forest health monitoring programs can provide information on the abundance and structure of individual species of interest (Duchesne *et al.* 2005; Fiedler and McKinney 2014), as well as the composition and integrity of plant communities as a whole (Steinman 2004; Auclair 2005). Provided they are designed properly, these monitoring programs can reveal relationships among biota such as herbivores and insect and fungal pests. Although parks and other natural areas are often designated as "unmanaged", park personnel may be tasked with promoting healthy forests that would otherwise occur in the absence of ongoing anthropogenic influences. Actions such as reductions in herbivore abundance (Tanentzap *et al.* 2011), prescribed fire (Mutch and Parsons 1998), thinning as a fire surrogate (Schwilk *et al.* 2009), seedbed preparation (York *et al.* 2012), snag creation (Brandeis *et al.* 2002), and invasive species removal (Flory and Clay 2009) are all examples of active management within parks. Ongoing forest health monitoring programs are needed by land managers to evaluate if management interventions may be necessary to promote ecological integrity (Lutes *et al.* 2006; Apostle Island National Lakeshore 2014).

Grand Portage National Monument (GPNM; 47.9607°N, 89.6866°W) is a 287 ha tract in northeastern Minnesota, near the boundary of northern mixed temperate forests and southern boreal forests. This park was established largely to commemorate the cultural legacy of the fur trade era and the native peoples of the region. It includes a 13.7 km foot path connecting Lake Superior with the Pigeon River, which serves as a portage trail, bypassing several major waterfalls on the lower reaches of the river. The park is surrounded by the Grand Portage Band of Lake Superior Chippewa reservation, a mosaic of forest and wetlands with large areas managed for timber.

Cultural resources at GPNM are tightly linked to natural resources, as both the fur traders and native peoples relied heavily on the forest. GPNM managers wish to promote species of cultural interest that are more resilient to impending climate-induced changes, thereby promoting both cultural and biological integrity. These species include Sugar Maple (*Acer saccharum* Marshall), Tamarack (*Larix laricina* (Du Roi) K. Koch), Red Pine (*Pinus resinosa* Aiton), Eastern White Pine (*Pinus strobus* L.), and both Trembling Aspen (*Populus tremuloides* Michaux) and Bigtooth Aspen (*Populus grandidentata* Michaux). These actions will aid in visitor interpretation of the fur trade, help maintain traditional uses of plants by the Ojibwa people, and restore the species composition of the forests to what was historically maintained via natural disturbance processes (National Park Service 2003).

Early settlement (prior to 1870) forest vegetation of GPNM varied along the trail. On the lower trail, nearer to Lake Superior, a matrix of *P. tremuloides*, Paper Birch

(*Betula papyrifera* Marshall), Yellow Birch (*Betula alleghaniensis* Britton), and mixed conifers were dominant, while further inland, *P. strobus* and *P. resinosa* were most common on the landscape (Marschner 1974). Park managers especially wish to promote the pine component, namely *P. strobus*, due to its historical dominance. The current structure and composition are largely a result of human-induced fires during and after European settlement (ca. 1870–1910), followed by decades of fire suppression (White and Host 2003). Two early successional species, *B. papyrifera* and *P. tremuloides*, are now prominent as scattered mature individuals amid large numbers of standing dead trees and downed boles. Gaps are largely filled with young Balsam Fir (*Abies balsamea* (L.) Miller), along with dense Mountain Maple (*Acer spicatum* Lamarck) and Beaked Hazelnut (*Corylus cornuta* Marshall). In addition, selective foraging by both White-tailed Deer (*Odocoileus virginianus*) and Moose (*Alces americanus*) drive forest composition in the region (Pastor and Naiman 1992; White 2012). Deer browse heavily on *P. strobus* and Eastern White Cedar (*Thuja occidentalis* L.; White 2012) while *A. balsamea* is a preferred winter forage for Moose (De Jager and Pastor 2009). Both ungulates use a number of hardwood species during summer, limiting understorey development and initiating feedbacks with long-term consequences (Pastor and Naiman 1992; White 2012). Deer browse strongly impacts herbs by causing reductions in frequency (Balgooyen and Waller 1995) and loss of diversity (Rooney and Waller 2003).

The National Park Service (NPS) Great Lakes Inventory and Monitoring Network initiated a long-term monitoring program in 2007, at which time 20 permanent forest monitoring plots were established and sampled at GPNM. The overarching goal of this program is to conduct routine assessments of forest health by documenting the impacts of drivers (browse, climate change, etc.), stressors (pathogens, insect pests, precipitation, etc.), succession, and any other currently unforeseen impacts. These assessments will be used to guide forest management in the park. The initial 20 plots were resampled in 2014 and an additional three plots were established. Here we report on forest change from 2007–2014 to answer the following broad questions:

1) Have density or basal area of trees changed during the sampling interval? We posed this question first by including all species sampled, then by looking only at key species of interest, specifically: *A. balsamea*, *P. tremuloides*, *B. papyrifera*, *P. strobus*, and Black Ash (*Fraxinus nigra* Marshall).

2) How has ungulate browsing impacted GPNM forests? We tested for evidence of browse impacts on the herbaceous layer. Browsing herbs often consumes the entire above-ground portion. Rather than bite marks, herbaceous browse generally results in fewer and smaller herbaceous species that are only indirectly evident over time. Therefore, we examined the collective frequency of eight preferred browse species, then also assessed height for two targeted taxa on which additional data were collected.

3) How has the plant community changed? We tested for differences in both species richness and the modified floristic quality index (mFQI; Rooney and Rogers 2002) between habitats and sampling events. The mFQI quantifies the degree of habitat faithfulness by species. Higher values indicate the presence of more specialist species, while lower values point to more generalists. We also used non-metric multidimensional scaling to see how plot locations shifted in ordination space during the seven-year sampling interval.

Study Area

GPNM is located within the Northern Superior Upland section (212L) of the Laurentian Mixed forest province (Ecoregion 212; Cleland *et al.* 1997). The mean July temperature high and low in Grand Portage during 1992–2014 were 23.3°C and 11.4°C, respectively. For January during that same period, the mean high and low were −6.2°C and −16.8°C, respectively. Mean annual precipitation from 1992–2014 was 75.4 cm with 44% falling from May through August (www.climateanalyzer.org).

GPNM is composed of a 13.7 km foot trail connecting Lake Superior with the Pigeon River; the park boundary provides a forested buffer of about 100 m on both sides of the trail for most of its length. At the Lake Superior terminus, a 28 ha tract of culturally maintained vegetation (mowed, garden, etc.) and historical buildings occupy the site. The Pigeon River trail terminus includes an expanded area of 44 ha, which is forested, with small openings for two primitive campsites. The Grand Portage Trail generally traverses high ground although several small streams cross it; moist pockets and forested wetlands are not uncommon within the buffer area on either side of the trail. A 2.1 ha American Beaver (*Castor canadensis*) pond is located along the trail, 9.4 km from the Lake Superior terminus.

Our sampling frame included all park lands except the Lake Superior tract, and the nearest 1.0 km of trail to the lake, because the park boundary here was only slightly wider than the trail itself.

Methods

Data collection and treatment

Sampling was conducted at GPNM during the summers of 2007 and 2014. Plot locations were chosen via a generalized random-tessellation stratified algorithm (Stevens and Olsen 2004), which ensured sites were randomly placed throughout the sampling frame, while also being spatially balanced. Specific details of the plot layout and field techniques are described by Sanders and Kirschbaum (2015), with an abbreviated version presented here.

To answer our first question, we recorded the diameter at breast height (DBH), species, and live/dead status for all trees ≥ 2.5 cm DBH, within the 900 m^2 tree sampling area of each plot (Figure 1).

Our second question addressed the impacts of ungulate browsing on herbaceous demography. These impacts are generally only indirectly observed over time as fewer and smaller individuals of preferred browse species (Webster *et al.* 2001; Kirschbaum and Anacker 2005), rather than as bite marks on individual plants. We used our personal knowledge to identify preferred browse species as those that are both relatively common in the region, and favoured by White-tailed Deer. While we are primarily interested in impacts by deer, browse from other herbivores was possible. Because browsing by Moose on herbaceous plants is generally limited to aquatic species, and that on terrestrial species typically occurs on woody shrubs and small tree branches (Aho and Jordan 1976), we assumed that impacts on herbs due to Moose were minimal. In addition, regional Moose densities have remained low for the decade preceding this work (DelGiudice 2015). Snowshoe Hare (*Lepus americanus*), however, do browse many of the same herbaceous species as White-tailed Deer (Belovsky 1984; Rouleau *et al.* 2002; Frerker *et al.* 2013); attributing browse impacts to either mammal is only possible using supporting, ancillary data. The preferred browse species we identified were White Baneberry (*Actaea pachypoda* Elliott), Red Baneberry (*A. rubra* (Aiton) Willdenow), Wild Sarsaparilla (*Aralia*

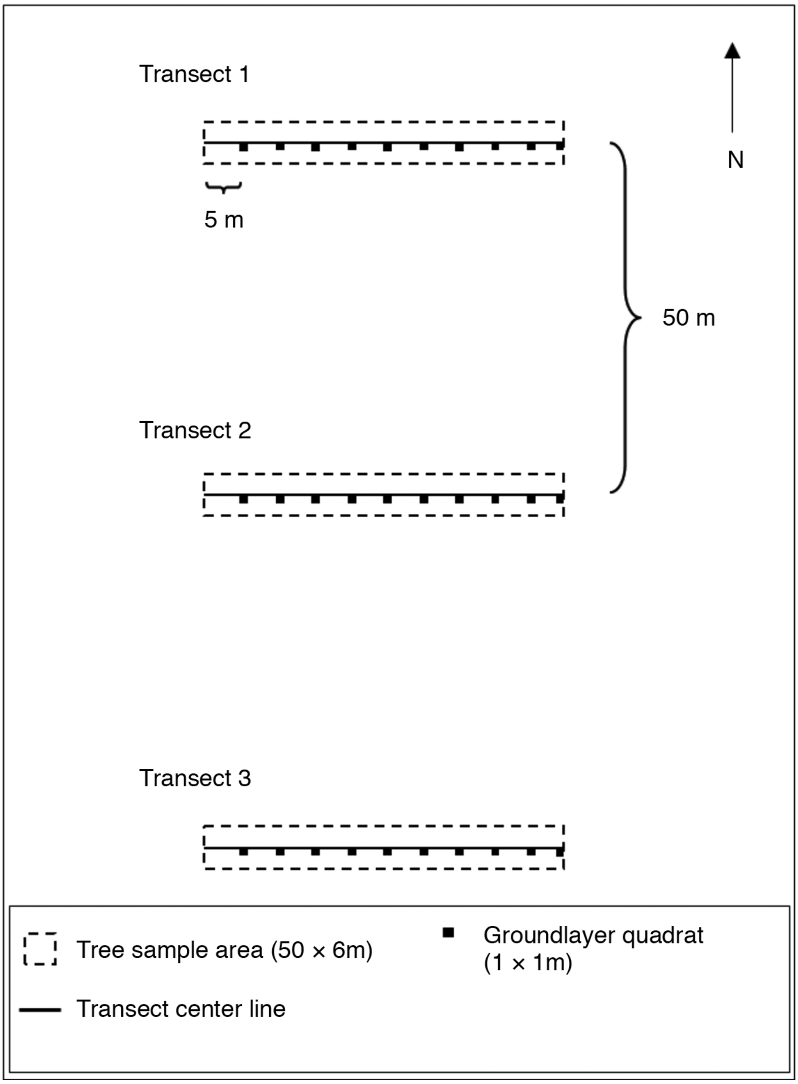

FIGURE 1. Plot layout, showing the three transects and 30 groundlayer quadrats. All data for herbaceous browse assessments were from the groundlayer quadrats.

nudicaulis L.), Bluebead Lily (*Clintonia borealis* (Aiton) Rafinesque), False Solomon's Seal (*Maianthemum racemosum* (L.) Link), Clasping-leaved Twisted-stalk (*Streptopus amplexifolius* (L.)), Rosy Twisted-stalk (*S. lanceolatus* var. *roseus* (Michx.) Reveal), and Nodding Trillium (*Trillium cernuum* L.). As part of our sampling protocols, we recorded all herbaceous species present in each of 30, 1 m^2 quadrats throughout the plot (Figure 1). We then used the groundlayer data to look at presence frequency from which we pooled all preferred browse species and determined the frequency of quadrats within plots where at least one of these species was present. We also assessed indirect impacts of browse by measuring the tallest of two target taxa (*C. borealis* and *Streptopus* spp.) within each quadrat where they were present. For each taxon we then calculated maximum height as the mean value of the tallest individuals in the plot.

We assessed plant community (the focus of our third question) by supplementing quadrat-level data with that obtained in a 30 min time-delimited search of each plot. Any species not previously noted were recorded.

We identified all plants to species while in the field, to the extent possible. When this was not possible, we collected specimens for later identification. In some instances, however, a lack of reproductive parts allowed identification only to genus or family. Examples include sedge (*Carex* sp.), shinleaf (*Pyrola* sp.), and Poaceae (grass family). For serviceberry (*Amelanchier* sp.), a genus that presented notable identification challenges, we assigned individual plants to one of three groups of species complexes, with Group 1 containing *A. bartramiana*; Group 2 containing *A. arborea*, *A. laevis*, and *A. interior*; and Group 3 containing an uncertain number of species (Smith 2008). All nomenclature follows the Integrated Taxonomic Information System System (ITIS 2014).

We grouped plots into similar types using cluster analysis. We constructed separate multivariate matrices based on abundance indices of both tree and groundlayer species within each plot. For the tree matrix, we calculated the importance value, determined by the mean of the relative density and relative basal area, for each species-plot combination (Dyer 2006; Elliott and Swank 2008). For the understorey (herb and shrub/woody vine) matrix, the abundance for each species-plot combination was determined by the proportion of groundlayer quadrats in which each species was located within that plot. For both trees and understorey, we limited inclusion in the cluster analysis to those taxa that were present in at least 8% (3 of 23) of the plots. For this analysis we used PC-ORD software (McCune and Grace 2002) and selected a Sørenson distance measure and a flexible beta linkage ($ß = -0.25$). Habitat type names were assigned based on the dominant trees in these groups. We used non-metric multidimensional scaling (NMS) to verify the legitimacy of these groups, using PC-ORD.

We identified coefficient of conservatism (CoC) values for all species located during the sampling at GPNM. These values quantify the habitat faithfulness of species (Swink and Wilhelm 1994; Wilhelm and Masters 1995) and range from 0 (either non-native species or generalists with no faithfulness to any particular habitat) to 10 (conservative species found only within limited niches of certain non-degraded habitats). Because CoC values have not been assigned for terrestrial species in Minnesota, we used the values defined for Ontario (Oldham *et al.* 1995) for species present during our sampling. Two species, however, (Tea-leaved Willow [*Salix planifolia* Pursh] and Squashberry [*Viburnum edule* (Michaux) Rafinesque]) were not listed by Oldham *et al.* (1995), so we used CoC values assigned for wetland species in Minnesota (Milburn *et al.* 2007). We then used CoC values to calculate the modified floristic quality index (mFQI; Rooney and Rogers 2002; Sanders and Grochowski 2014) where mFQI is simply the mean of the CoC values for all species present within that plot.

Forest change analyses

To address our first question about forest change, we used two-way repeated measures analysis of variance (ANOVA) and tested whether density and basal area differed between sampling periods and between habitat types. We performed this analysis pooling all species, then individually for each key species of interest. For all two-way repeated measure ANOVA tests, two treatment effects (habitat and year) and their interaction (habitat × year), were considered fixed effects; the plot (habitat) term, and its interaction with year, were considered random effects. We also tested whether total sapling density differed between sampling periods or habitats, using the same model. All ANOVA tests were conducted using JMP (v. 7; SAS Institute Inc., Cary, North Carolina, USA). Lastly, we compared the diameter-distribution of trees in 2007 with that in 2014, by carrying out the Kolmogorov-Smirnov test using the R statistical software package (R Core Team 2012).

Our second question focused on ungulate browsing impacts. We tested for change between 2007 and 2014 using two indirect browse indices: the frequency of quadrats in each plot supporting at least one preferred browse species (i.e., frequency of presence), and the mean plot height of preselected target taxa. Again, we used two-way repeated measures ANOVA and tested whether these indices differed between years and habitats, as well as tested their interaction term.

Our third question asked whether plant communities differed between the sampling periods; we answered this using a suite of approaches. We first tested whether plot-level species richness and the mFQI differed between years or habitats, using two-way repeated measures ANOVA. For all 20 plots that were resampled, we then used non-metric multi-dimensional scaling (NMS) (McCune and Grace 2002) to view the similarity of plots relative to each another, in ordinal space. We applied vectors to denote the change in location of each plot between 2007 and 2014. Because we are assessing change in only a seven-year interval, we performed separate analyses for the overstorey (trees) and understorey (herbs and shrubs/woody vines). We felt the changes observed in the overstorey would largely be due to longer-term successional dynamics, while variation in the understorey would likely be in response to shorter-term impacts, including variation in browse pressure and precipitation. As with cluster analysis, the NMS was based on the importance value of trees for the overstorey analysis and the frequency of herbs and shrubs/ woody vines for the understorey analysis. We limited our dataset to taxa with at least three occurrences over the two sampling events. We also eliminated data on plants only identified to *Carex* sp. and Poaceae due to the broad ecological width occupied by these groups. We used an automated procedure beginning with 250 runs of real data and 250 runs to evaluate stability. These resulted in solutions with a final stress of 8.67 in the overstorey dataset and 10.85 for the understorey data.

Results

Among all 23 plots, we identified 20 tree species, 31 shrub and woody vine taxa, and 148 taxa of herbs. Plots were classified as one of two habitat types: upland spruce-fir-aspen (18 plots) and wet mesic mixed conifer/hardwood (five plots).

Changes in density or basal area

Our first question addressed whether density and/or basal area changed between sampling intervals. For all species collectively, both total density ($F_{1,22}$ = 75.83, $P < 0.0001$) and total basal area ($F_{1,22}$ = 4.90, P = 0.0400) increased significantly between the two sampling periods, although neither differed between habitats (Figure 2), nor depended on the sampling period × habitat interaction term.

We also tested if density and basal area are changing for key species of interest. *Abies balsamea* density and basal area depended on both year and habitat; both metrics were significantly greater in 2014 and in upland habitat (Table 1, Figure 3). Density of *P. tremuloides* was significantly greater in 2014 (525 ± 35.5 [SE] trees/ha versus 232 ± 89.5 [SE] trees/ha in 2007), but did not differ significantly between habitats; *P. tremuloides* basal area did not differ significantly by habitat or year (Table 1). For *B. papyrifera*, neither metric differed significantly by habitat or year. Likewise, neither metric for *P. strobus* differed significantly on the year sampled; we could not test for differences between habitats due to inadequate sample size. *Fraxinus nigra* density did not differ significantly between years or habitats, although basal area tended toward being greater in 2007 (0.731 ± 0.309 [SE] m^2/ha versus 0.603 ± 0.242 [SE] m^2/ha in 2014; Table 1).

Across both habitat types, the density-diameter class distributions differed significantly between the sampling periods (Kolmogorov-Smirnov test; $P < 0.0001$; Figure 4).

Impacts of deer browsing

A test of the indirect impact of deer browsing on herb abundance showed that the frequency of quadrats supporting at least one preferred browse species did not differ between years ($F_{1,22}$ = 0.31, P = 0.5846) although it tended to depend on habitat ($F_{1,22}$ = 4.06, P = 0.0572). Across both years, 81% of quadrats in upland plots supported at least one preferred browse species, while only 66% of wet mesic sites did so. For *C. borealis*, mean height within plots was significantly greater among sampling years ($F_{1,15}$ = 5.17, P = 0.0344) with a tendency for mean height to also differ between habitats ($F_{1,15}$ = 3.65, P = 0.0698; Figure 5). Across both habitats, mean plot height of *C. borealis* was 12.4 ± 0.592 [SE] cm in 2007 and 13.2 ± 0.527 [SE] cm in 2014; across both years, mean height was 12.4 ± 0.439 [SE] cm in upland habitat and 14.4 ± 0.690 [SE] in wet mesic sites. *Streptopus* sp. height did not differ significantly between habitats ($F_{1,18}$ = 0.76, P = 0.3937) or sampling years ($F_{1,18}$ = 2.69, P = 0.1183).

Plant community composition

The effect of sampling year on mean plot species richness depended on habitat (i.e., significant interaction term, $F_{1,1}$ = 12.85, P = 0.0020; Figure 6). In 2007, richness was higher in upland plots (61.2 ± 1.53 [SE]

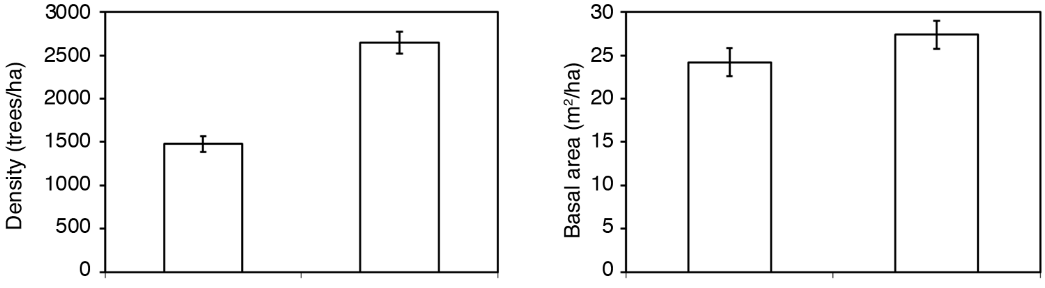

Figure 2. Density and basal area for live trees of all species in both 2007 and 2014. Results are pooled across both habitat types. Both indices were greater in 2014. Error bars reflect the standard error.

TABLE 1. ANOVA *P* values for density, basal area, and their interaction, of five key species of interest.

Species	Metric	Habitat	Year	Habitat × Year
Balsam Fir (*Abies balsamea*)	density	0.0161	<0.0001	0.7287
	basal area	0.0002	0.0034	0.1159
Trembling Aspen (*Populus tremuloides*)	density	0.0710	0.0002	0.1042
	basal area	0.9996	0.3461	0.1556
Yellow Birch (*Betula papyrifera*)	density	0.6964	0.2028	0.8989
	basal area	0.5271	0.6437	0.6258
White Pine (*Pinus strobus*)*	density		0.2053	
	basal area		0.1951	
Black Ash (*Fraxinus nigra*)	density	0.2209	0.0973	0.8342
	basal area	0.0856	0.0552	0.8931

*Inadequate sample size precluded tests of habitat and interactive effects on *Pinus strobus*.

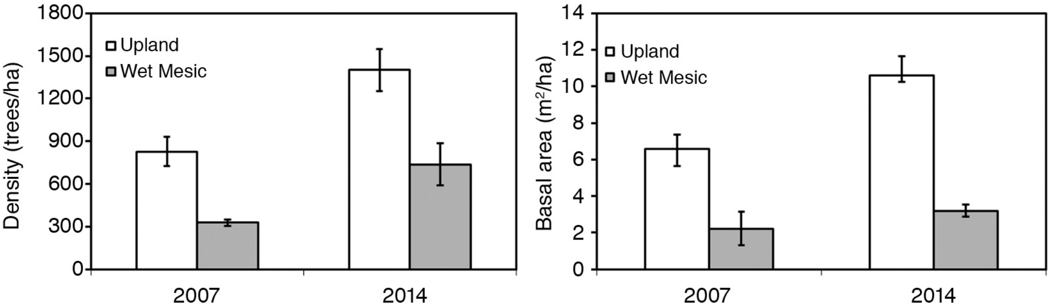

FIGURE 3. Density and basal area of Balsam Fir (*Abies balsamea*) in both habitats and years. Both metrics were greater in 2014 and in upland habitat. Error bars reflect the standard error.

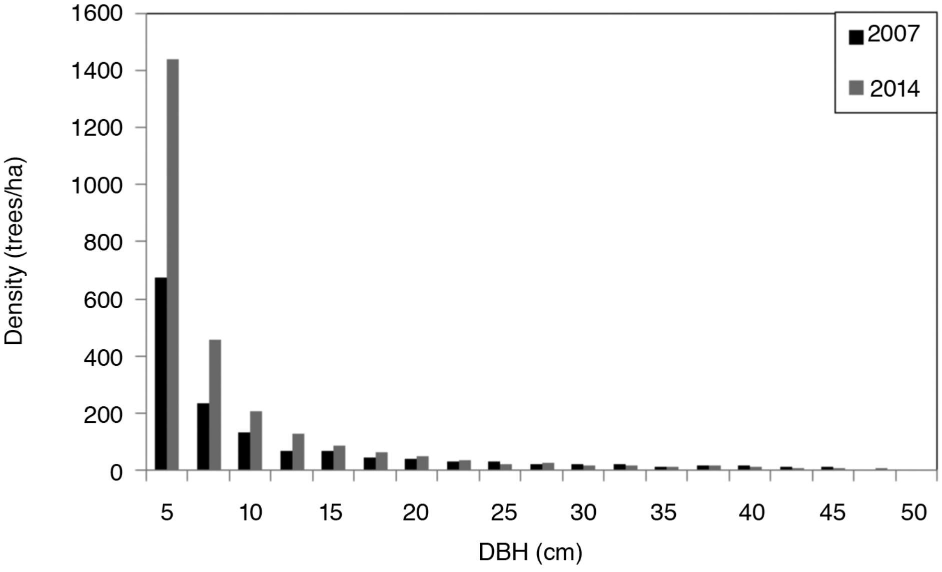

FIGURE 4. Density-diameter at breast height (DBH) distributions for trees differed between the two sampling periods. Results are pooled across both habitat types and included all species.

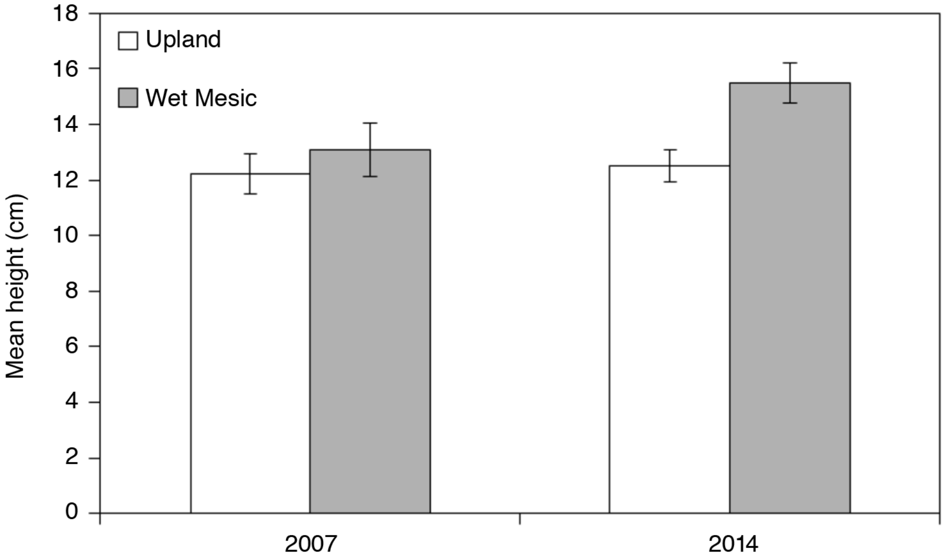

Figure 5. Height of Bluebead Lily (*Clintonia borealis*), a target preferred browse species, in both habitats and sampling periods. Height was greater in 2014 and tended toward being greater in wet mesic habitats. Error bars reflect the standard error.

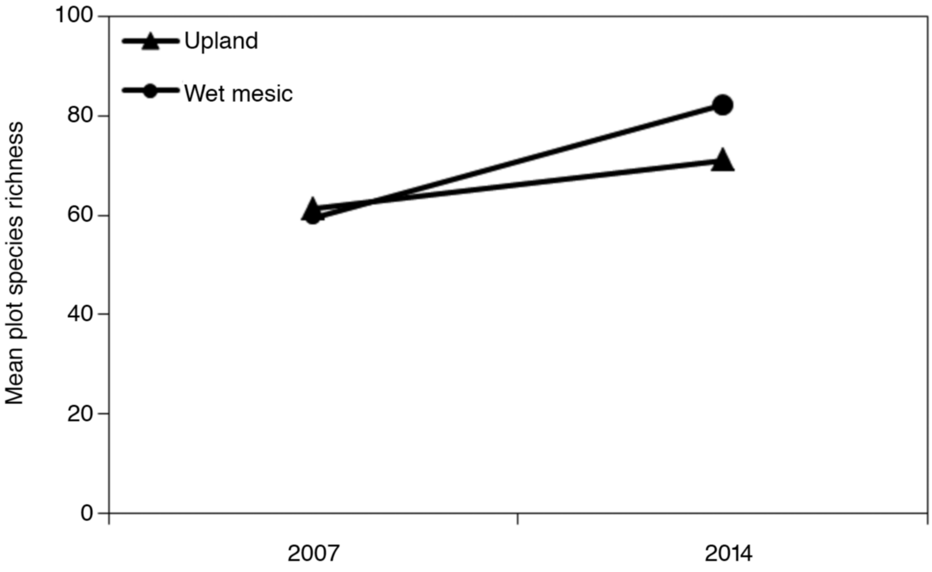

Figure 6. Mean plot species richness in both habitats and sampling periods.

versus 59.5 ± 2.02 [SE]), although in 2014, richness was higher in wet mesic plots (82.2 ± 3.5 [SE] versus 71 ± 2.3 [SE]).

The mFQI did not differ significantly between years ($F_{1,22} = 0.10$, $P = 0.7575$) although there was a trend toward significant difference between habitats ($F_{1,22} = 4.13$, $P = 0.0540$). Pooled across both sampling years, mFQI was 4.88 ± 0.044 [SE] in upland plots and 5.08 ± 0.086 [SE] in wet mesic plots.

The NMS ordination results on overstorey data (Figure 7) support our other findings of marked increases in both *A. balsamea* and *P. tremuloides*. Vectors corresponding with increasing values of both Axes 1 and 2 (i.e., pointing toward the upper right) represent

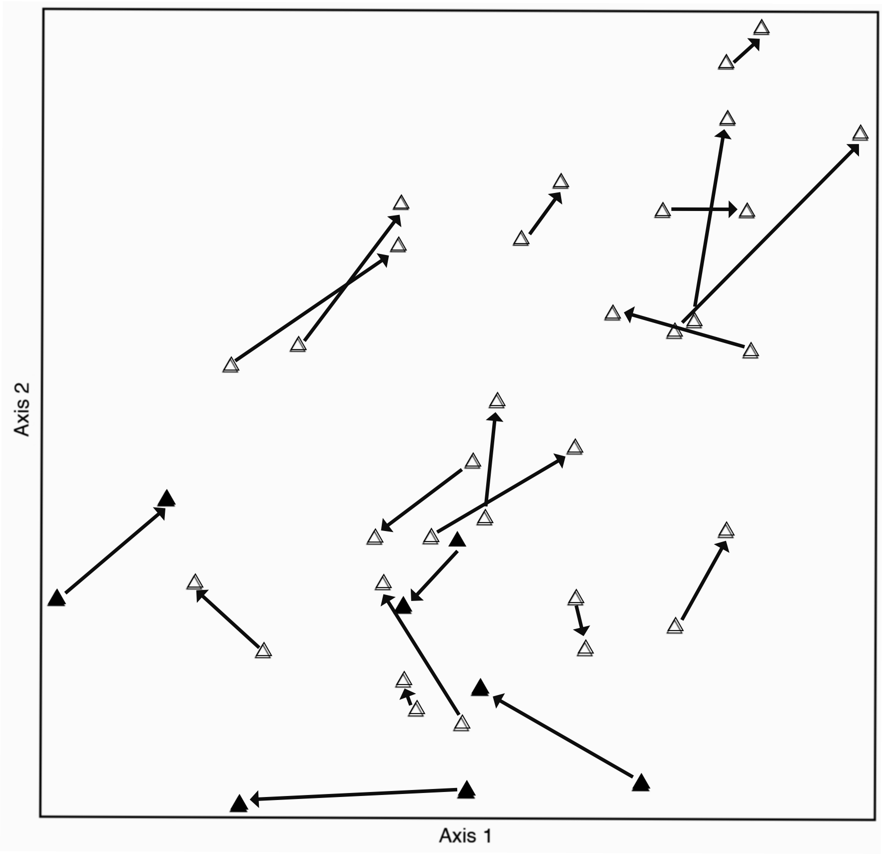

FIGURE 7. Nonmetric Multidimensional Scaling ordination of overstorey data with vectors drawn from the 2007 location to the 2014 location for each plot. Open triangles are plots in in upland habitat; solid triangles are plots in wet mesic habitat.

plots with large increases in density of *A. balsamea*. Those vectors pointing toward the upper left, representing decreasing values of Axis 1 and increasing values of Axis 2, correspond with plots with large density increases in both *A. balsamea* and *P. tremuloides*. The correlation coefficient (*r*) for each overstorey species on Axes 1 and 2 (Table 2) reflects this; low Axis 2 values are also observed for *F. nigra* and *A. spicatum*, which experienced substantial ingrowth in a small handful of plots.

The NMS Ordination on understorey abundance showed a strong directional pattern, with all plots increasing along Axis 2 (Figure 8). While this signal appeared particularly strong for a small number of herbs

TABLE 2. Nonmetric Multidimensional Scaling axis correlations for overstorey species present in at least three plots.

Species	Axis 1	Axis 2
White Pine (*Pinus strobus*)	−0.638	0.007
Trembling Aspen (*Populus tremuloides*)	−0.409	−0.429
Balsam Poplar (*Populus balsamifera*)	−0.363	−0.288
White Spruce (*Picea glauca*)	−0.323	0.116
Black Ash (*Fraxinus nigra*)	−0.310	−0.520
White Cedar (*Thuja occidentalis*)	−0.310	−0.340
Bebb Willow (*Salix bebbiana*)	−0.191	0.088
Mountain Maple (*Acer spicatum*)	−0.116	−0.603
Choke Cherry (*Prunus virginiana*)	−0.014	−0.012
Mountain Ash (*Sorbus decora*)	−0.013	0.157
Sugar Maple (*Acer saccharum*)	0.145	0.191
Black Ash (*Picea mariana*)	0.177	−0.059
Paper Birch (*Betula papyrifera*)	0.267	−0.421
Balsam Fir (*Abies balsamea*)	0.756	0.913

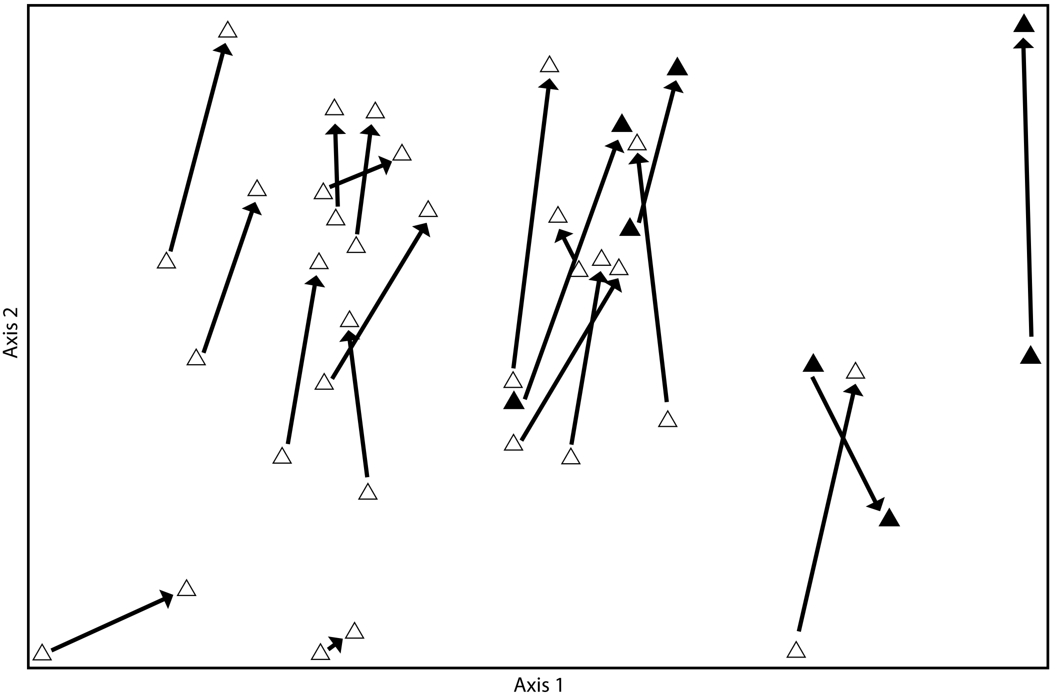

Figure 8. Nonmetric Multidimensional Scaling ordination of herbaceous and shrub data with vectors drawn from the 2007 location to the 2014 location for each plot. Open triangles are plots in upland habitat; solid triangles are plots in wet mesic habitat.

(including Wood Anemone [*Anemone quinquefolia* L.] and Bunchberry [*Cornus canadensis* L.]) the directional pattern was also present in those plots where decreases in these species were observed.

Discussion

Our results of overstorey change observed over the seven-year sampling interval mirror those of other studies throughout the region (Friedman and Reich 2005; Frelich and Reich 2009a). Early successional hardwoods, which were established at the time of stand initiation, have aged and shade tolerant species dominated by *A. balsamea* became established. As most stands are now nearing or beyond 100 years old, those early successional species, dominated by *P. tremuloides*, are being killed by a mix of factors, including windthrow, root disease, Forest Tent Caterpillar (*Malacosoma disstria*), and drought. The gap-phase forest is now a mosaic of young *A. balsamea*, with *A. spicatum* and clones of *P. tremuloides* colonizing the gaps. Our observation of dual high density of both *A. balsamea* and *P. tremuloides* is somewhat unusual because they generally occur on opposite ends of the successional spectrum. As stands aged, *A. balsamea* gradually became established under the *P. tremuloides* canopy; subsequent losses of individuals from the oldest *P. tremuloides* cohort, composed of trees typically > 30 cm diameter, most likely promoted root suckering and adventitious shoot growth of clones, in response to the loss of apical dominance (Wan *et al.* 2006). High density of both of these species is not commonly observed in managed forests because harvest of early successional species often occurs before later-successional species become well established.

Pinus strobus, while historically common, now exists at low densities across the landscape; an arrangement that limits the spatial extent of seed rain which, in turn, hinders regeneration. In the absence of fire, *A. balsamea* dominance will likely increase as other species adapted to fire become less prominent. One possible check on *A. balsamea* dominance, however, is a future outbreak of Spruce Budworm (*Choristoneura fumiferana*), a native species that attacks spruce, fir, and several other genera of conifer. An infestation in spruce-fir stands in Minnesota in the 1970s resulted in a reduction in stand basal area from 79% to 31% of the total (Batzer and Popp 1985).

Precipitation differences between the two sampling years may explain the patterns observed in understorey plant communities. Precipitation during the mean growing season (May–August) from 1992 to 2014 was 33.5 cm (Climate Analyzer 2015). The 2007 sampling occurred during a relatively dry period with 24.5 cm and 17.4 cm of precipitation during the 2006 and 2007 growing seasons, respectively. The climate was wetter during the later sampling when mean growing season precipitation totalled 39.0 cm in 2013 and 41.3 cm in 2014. In 2014, wet mesic sites supported 11.2 more species than upland sites while in 2007, a dry year, wet mesic sites support 1.7 fewer species. It is possible that species adapted to more moist areas may have been reduced in abundance by more competitive generalists. Specialist species, by definition, will have higher coefficients of conservatism. Greater mFQI in wet mesic sites, relative to upland sites is therefore, not surprising.

The lower frequency of preferred browse species in wet mesic plots relative to upland sites suggests these areas with wet pockets constitute poorer habitat for our target species. Throughout the wet mesic plots were patches of Bluejoint (*Calamagrostis canadensis* (Michx.) P. Beauv.), Spotted Touch-me-not (*Impatiens capensis* Meerburgh), and Common Lady Fern (*Athyrium filix-femina* (L.) Roth). While we observed only a minimal amount of standing water at these sites during our sampling, these species suggest the presence of water was greater in the spring, likely limiting the areas where target species occur. Our finding of a trend that *C. borealis* was taller in wet mesic sites could suggest that browse pressure may be reduced here, although we did not find this with our other target species, *S. lanceolatus* var. *roseus*. In future sampling, we will measure height of three target species allowing for a fuller assessment of browse impacts on herb height.

The findings presented here for browse should not be interpreted too robustly. In general, neither deer, nor hare browsing pressure is currently high in the area. While White-tailed Deer abundance has increased over the previous decade on the Grand Portage Reservation, the density is still relatively low. Winter helicopter surveys counted 56 White-tailed Deer in 2007 and 205 White-tailed Deer in 2014 over the 193 km^2 reservation land base (E. Isaac, personal communication). Conservatively, these would correspond to spring densities of 0.29 and 1.08 deer/km^2, respectively. These values are low compared with both current densities throughout the Upper Midwest Region (Rooney and Waller 2003) and with pre-European settlement estimates of 2–4 deer /km^2 in deciduous and mixed deciduous-conifer forests of the region (Alverson *et al.* 1988). As such, the current White-tailed Deer density is not likely to suppress regeneration of these herbs. Deer densities are low due to deep winter snow accumulation in northeast Minnesota (Nelson 1995). As climate change progresses, and winter snow loads decrease, our data from 2007 and 2014 can be used to assess any changes in browsing impacts to vegetation.

Snowshoe Hare impacts are less clear. Hare densities peak then crash on a 10-year cycle driven largely by the interacting effects of predation and food availability (Krebs *et al.* 2001). While the herbaceous dietary preferences of hare are similar to those of deer (Belovsky 1984; Rouleau *et al.* 2002; Frerker *et al.* 2013), Wolff (1978) showed that herbs composed about 50% of the diet of hare in central Alaska only during the month of May, while in April and in the summer, herbs represented only about 10% of the hare diet. In northern Minnesota, Snowshoe Hare density peaked in 2011 with nearly 5 hares/100 km of survey line (Erb 2014); hare densities at the time of both of our sampling events (2007 and 2014) were at the cycle mid-point, half way between the high and low. We are unaware of any work quantifying the relationship between hare abundance and impacts to the herbaceous layer.

The differences observed in this study between sampling events for the overstorey, and especially for the herbaceous layer were somewhat surprising, given the short time interval between them. Obviously, the different time between sampling dates for the 2007 (8 June – 19 July) and 2014 (22 June – 19 August) event could contribute to this, although we feel would only be a minor factor, if any at all. The latest-emerging species at GPNM are the July-flowering asters that were observed (pre-flowering) during our training period in early June. Conversely, the taxa which typically exhibit the earliest sign of senescence in the park are Starflower (*Trientalis borealis* Rafinesque) and various fern species. Although chlorosis was evident during the final week of sampling in 2014, they were still distinctive, and were easily identified throughout the park, at least through the final sampling day. The degree to which our observed differences reflect true directional change versus simply a response to stochastic year-to-year variation is unclear. Dynamics such as deer abundance (and hence, browsing), precipitation, and severe wind can vary highly between years leading to large differences between closely-timed sampling events. Analyses of vegetation change are often opportunistic resampling events on the order of 50 years (Jones *et al.* 1994; Johnson *et al.* 2014), rather than shorter-term studies with planned revisit schedules and pre-identified questions (for an exception, see Taverna *et al.* [2005]). Interpretation of results of these long-term studies may warrant a brief discussion on the drivers and stressors that may be acting on the systems near the time of both the initial and follow-up sampling events. For this current project, we are scheduled to sample a third time in 2024 with repeated sampling approximately every 9–10 years. This should allow us to parse out long-term trends versus shorter term variability.

Management and Climate Change

While our work follows convention by using traditional statistical approaches to test for change, we caution against a strict interpretation. Forests may be in the early stages of displaying climate change-induced shifts and managers need to recognize these changes, whether statistically significant or not. GPNM is situated at the boundary between the boreal forest to the north and Laurentian mixed forest to the south. As such, many boreal species present in the park are near their southern range limits; favourable habitat conditions for their reproduction and growth are predicted to migrate northward and out of the region (Frelich and Reich 2009a). In their stead, the growing conditions are expected to become more favourable for oaks (*Quercus* spp.) and pines (*Pinus* spp.; Frelich and Reich 2009b). It is currently unclear, however, whether the migration rates of these groups can keep pace with the migration rate of their climate envelope (Frelich and Reich 2009a).

Climate change resilience strategies focus on promoting the growth of species expected to remain in the area, while minimizing the spread of newly arriving invasive species. Park managers have implemented a project to promote *P. strobus* regeneration within the park by outplanting for seed rain restoration, releasing advance regeneration, and also manually controlling *A. balsamea*. This project encourages current regeneration of *P. strobus* so that seed sources may be available for future regeneration once *A. balsamea* begins to die out. Managers may also wish to promote the growth of other species expected to remain in the area, including *B. papyrifera* and *T. occidentalis*. While the former species is often early successional, the latter can be slow-growing and long-lived (Fowells 1965). Germination and seedling growth of *T. occidentalis* preferentially occurs under a *Thuja* canopy (Cornett *et al.* 1997) and on coarse wood substrates (Cornett *et al.* 2001); because of this feedback, maintaining and promoting existing populations and coarse woody structures should be a priority. Indeed, long-term goals of the park include promoting conifer cover in riparian corridors, in conjunction with *T. occidentalis* seed rain. This may create a feedback loop by promoting greater moisture and shading, and hence providing refugia for southern boreal conifers.

While climate change is an important concern to the park, a more immediate concern to park managers is the arrival of Emerald Ash Borer (*Agrilus planipennis*). As of spring 2015, this exotic insect is now established in Duluth, Minnesota, approximately 233 km to the southwest of GPNM. *Fraxinus nigra* was located in 16 of the 23 plots; most of these plots were located in the half of the trail closer to Pigeon River. None were in the nearest 3 km to Lake Superior. In areas where we observed *F. nigra*, we also commonly observed populations of Speckled Alder (*Alnus incana* subsp. *rugosa* (Du Roi) R.T. Clausen) with smaller inclusions of Green Alder (*Alnus viridis* subsp. *crispa* (Aiton) Turrill). It is likely that populations of these species of alder will expand and fill niches left vacant by ash trees once Emerald Ash Borer arrives and ash trees begin to succumb to it.

Broader Relevance

While our work is limited to GMNP, its relevance extends throughout northern Minnesota. This region is heavily forested, and includes a state forest, numerous state parks, and the Superior National Forest. The latter encompasses the 441 000 ha Boundary Waters Canoe Area Wilderness and is adjacent to the 460 000 ha Quetico Provincial Park in Ontario. Both of these areas are largely unmanaged and are subject to the same pressures as GPNM. Our results demonstrate what can happen in the absence of fire; they can be used by managers of these other areas as one part of a decision tool, where prescribed fire is a valid option.

Perhaps the most relevant aspect of our work may also be in advancing efforts to assess browsing by deer, particularly in the summer and/or on herbaceous species. While the deer population is not currently high at GPNM, high deer densities elsewhere in the northern Great Lakes Region are the norm (Rooney and Waller 2003). Deer browsing is driving regional species loss and homogenization in forests (Li and Waller 2015), and there is great interest in developing methods to assess its impacts. There is also growing recognition that assessing herbaceous browse by bite marks is of limited value because deer frequently consume entire plants. While our specific methods may not necessarily fit the monitoring protocols of others, our work shows how monitoring for change over time in the frequencies of understorey species can be used to monitor impacts by deer browsing.

Much of northern Minnesota is heavily forested. With Lake Superior to the east, and grasslands to the west, this region may emerge as a corridor through which species migrate northward and northeastward as temperatures warm and associated climate change continues. Because of the key biogeographic role that the forests of northern Minnesota may play in the future, we need to learn about current, shorter-term vegetation dynamics. Regeneration successes and failures, browsing impacts, and species' competitive abilities will likely all weigh heavily on forest management decisions in the region over the next 50 years. Our work here may serve as one resource that managers draw on as they face these decisions.

Acknowledgements

Major funding was provided by the National Park Service, Inventory and Monitoring Division. Additional funding was provided by Anthony D'Amato and the University of Minnesota. We are grateful for the vegetation monitoring field crew of Christine Groebner and Kaylee Nelsen. Without their assistance, this project would not have been possible. We are also indebted to Brandon Seitz, Bill Clayton, and many others on staff at the Grand Portage National Monument for planning, logistical, and administrative assistance. We wish to thank Edmund Isaac of the Grand Portage Band of the Minnesota Chippewa for providing deer density estimates (14 October 2015). Finally, we greatly appreciate Anthony D'Amato, Brandon Seitz, Mark White, Rolf Peterson, and two anonymous reviewers for providing reviews of earlier drafts of this manuscript.

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Received 27 October 2015
Accepted 24 May 2017

Note

The First Record for Altai Fescue, *Festuca altaica* (Poaceae), in Nova Scotia, from an Eastern Alpine Site on Cape Breton Island

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Darbyshire, Stephen, Sean Blaney, and Sean Basquill. 2017. The first record for Altai Fescue, *Festuca altaica* (Poaceae), in Nova Scotia, from an eastern alpine site on Cape Breton Island. Canadian Field-Naturalist 131(2): 164–169. https://doi.org/10.22621/cfn.v131i2.1861

Altai Fescue, *Festuca altaica* Trinius, is an amphi-Beringian grass species also known from isolated, but widespread, locations in northeastern North America. The occurrence reported here, at the southern limit of eastern alpine habitat in Canada, represents the first for Nova Scotia.

Key Words: Altai Fescue; *Festuca altaica*; conservation; rare plants; floristics; alpine vegetation; Nova Scotia

The distribution of *Festuca altaica* Trinius ranges from the Altai Mountains of central Asia (Tsvelev 1983) eastward and northward across the Bering Sea to northwestern North America and, from there, southward in British Columbia and western Alberta in alpine tundra (Pavlick and Looman 1984; Alexeev 1985; Harms 1985; Darbyshire and Pavlick 2007; Saarela *et al.* 2017). It also occurs in scattered areas in boreal forest and alpine regions of eastern North America, including northern Michigan, Quebec, Labrador, and western Newfoundland (Darbyshire and Pavlick 2007; Figure 1).

Here we document its first known occurrence in Nova Scotia, where a small but well established population was discovered during a qualitative botanical survey north of Polletts Cove, Cape Breton Island (Figure 2), in 2013. Although only a single localized population was found near the edge and crest of the plateau, more sites may well be found in this poorly explored region of fragmented barrens. This site is approximately 150 km and 340 km from the species' nearest locations in western Newfoundland and southeastern Quebec, respectively, which are isolated by ocean water (Figure 1). The plant occurred in small, scattered patches (none larger than a few square metres) over an area of about 50 × 10 m, within a tundra-like grassland, treeless (except for a few scattered krumholtz White Spruce, *Picea glauca* (Moench) Voss) and containing scattered forbs and shrubs. This habitat is classified as eastern alpine vegetation, which is one of the habitats in eastern Canada most vulnerable to environmental and climatic changes (Jones and Wiley 2012; Capers *et al.* 2013).

The scattered meta-populations of *F. altaica* in eastern Canada have sometimes been referred to other taxa in the taxonomically controversial Rough Fescue complex (section *Breviaristatae*), including Plains Rough Fescue (*F. hallii* (Vasey) Piper; Alexeev 1985) and Mountain Rough Fescue (*F. altaica* subsp. *scabrella* (Torrey) Hultén (= *F. campestris* Rydberg); Harms 1985). As indicated by Pavlick and Looman (1984), populations in eastern North America appear to be most closely linked with *F. altaica* (in the narrow taxonomic sense) through morphological, phytogeographical, and ecological aspects (Darbyshire and Pavlick 2007).

Festuca altaica occupies a wide range of substrates and habitats throughout its range, including sandy plains, rocky slopes, cliffs, and talus in open boreal, subarctic, and subalpine forests, as well as low arctic and alpine tundra. It is often present in serpentine barrens in British Columbia, Quebec, and Newfoundland, but is also present on limestone and Precambrian bedrock (herbarium label data). The northern plateau of Cape Breton Island, where the population occurs at 412–427 m above sea level, is composed of Precambrian igneous and metamorphic rock (Roland 1982; Barr *et al.* 1992). Soil at the site consists of a 6-cm layer of humus over a fine, loamy-textured mineral soil about 20 cm deep.

In 2013, close associates of *F. altaica* and community structure were analyzed in two 25-m^2 plots within the area where this species is the dominant component. Plot SB1066 was at the crest of the slope on the plateau and SB1216 was on the upper slope (Figure 2, Table 1). The fieldwork was the first botanical exploration of the Polletts Cove plateau, and it documented numerous other provincially rare species with northern affinities both on the plateau and in the adjacent Blair River Valley (Table 2). Taxonomy and nomenclature in the tables follow Brouillet *et al.* (2010+), Esslinger (2015), and Ireland

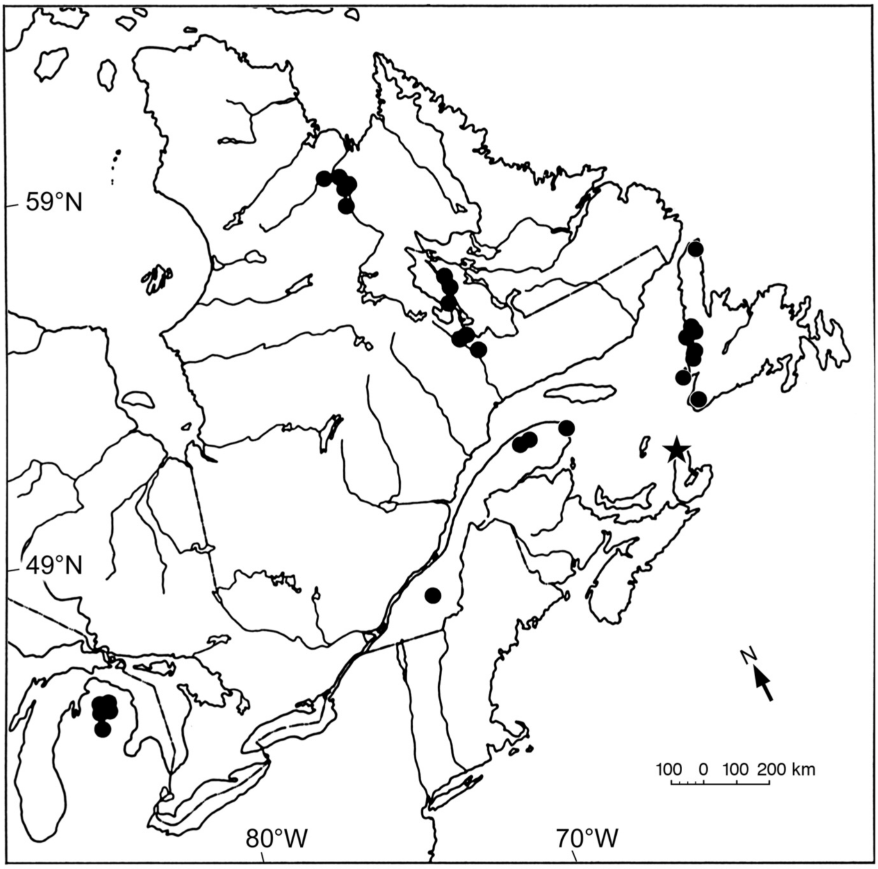

FIGURE 1. Distribution of Altai Fescue (*Festuca altaica*) in eastern North America, including the collection reported here from Nova Scotia (star). Sources: Aiken and Darbyshire (1990) and Atlantic Canada Conservation Data Centre, Sackville, New Brunswick, Canada.

(1982); common names of vascular plants are from Brouillet *et al.* (2010+). Provincial status ranks (S-ranks) in Table 2 were developed using the methods of NatureServe (2017).

The widespread and isolated occurrences of *F. altaica* in eastern North America suggest that current metapopulations are relicts of a more continuous distribution when tundra vegetation followed the glacial margin retreat northward and was subsequently modified by long-term (Hypsithermal) and short-term Holocene climate variation (Roland and Smith 1969; Webb *et al.* 1983; Ritchie 1987; Viau *et al.* 2006; Capers *et al.* 2013). Species of plants (and animals) responded to these changes in complex ways, both as communities and individualistically (Overpeck *et al.* 1992; Henry and Molau 1997; Jump and Peñuelas 2005; Walther 2010). A somewhat similar distribution is seen for Timber Oatgrass (*Danthonia intermedia* Vasey; Cayouette and Darbyshire 1987; Darbyshire 2003). Although this latter species has not been found in Nova Scotia, both are relatively large-seeded grasses with boreal, arctic, or alpine affinities and no obvious means of long distance seed dispersal.

A combination of character states easily distinguished *F. altaica* from other species of *Festuca* in Nova Scotia in either vegetative or reproductive states. Measurements and observations of the limited material of *F. altaica* available from the Nova Scotia population showed character states well within the range reported for the species as a whole as listed below (Darbyshire and Pavlick 2007). It is a densely tufted grass with plentiful sterile shoots arising from within the persistent old leaf sheaths (intravaginal shoots) and, unlike Red Fescue (*F. rubra* L.) and Proliferous Fescue (*F. prolifera* (Piper) Fernald), creeping rhizomes are absent, although short extravaginal shoots may sometimes be present. Other species of *Festuca* present in Nova Scotia — Hair Fescue (*F. filiformis* Pourret), Nodding Fescue

FIGURE 2. Alpine vegetation on Polletts Cove plateau, Nova Scotia, with Altai Fescue (*Festuca altaica*) in foreground. A. 15 July 2016. Photo: S. Blaney. B. 4 October 2013. Photo: S. Basquill.

TABLE 1. Percentage cover of vegetation in two plots (25 m^2) containing Altai Fescue (*Festuca altaica*) at Polletts Cove plateau, Nova Scotia. The total number of species (and unique species) at plot SB1066 at the crest of the slope and plot SB1216 on the upper slope were 22 (7) and 32 (17), respectively.

		Cover, %	
Species		Plot SB1066	Plot SB1216
WOODY PLANTS			
Green Alder	*Alnus alnobetula* subsp. *crispa* (Aiton) Raus	1.50	3.00
Black Chokeberry	*Aronia melanocarpa* (Michaux) Elliot	0.10	0.03
Beaked Hazel	*Corylus cornuta* Marshall	— *	0.10
Northern Bush-honeysuckle	*Diervilla lonicera* Miller	—	0.10
Mountain Holly	*Ilex mucronata* (L.) M. Powell, Savolainen & S. Andrews	0.50	—
White Spruce	*Picea glauca* (Moench) Voss (single tree < 0.5 m tall)	0.50	—
Virginia Rose	*Rosa virginiana* Miller	0.05	0.20
Broad-leaved Meadowsweet	*Spiraea alba* var. *latifolia* (Aiton) Dippel	1.00	0.10
Lowbush Blueberry	*Vaccinium angustifolium* Aiton	15.00	—
Northern Blueberry	*Vaccinium boreale* I. V. Hall & Aalders	—	1.00
HERBACEOUS PLANTS			
Common Yarrow	*Achillea millefolium* L.	0.10	0.10
Rough Bentgrass	*Agrostis scabra* Willdenow	—	0.10
Alpine Bistort	*Bistorta vivipara* (L.) Delarbre	—	< 0.01
Canada Bluejoint	*Calamagrostis canadensis* (Michaux) Palisot de Beauvois	15.00	—
Sedge species	*Carex* sp.	0.02	—
Bluebead Lily	*Clintonia borealis* (Aiton) Rafinesque	0.10	0.30
Goldthread	*Coptis trifolia* (L.) Salisbury	—	0.10
Bunchberry	*Cornus canadensis* L.	0.01	—
Wavy Hairgrass	*Deschampsia flexuosa* (L.) Trinius	5.00	1.00
Flat-topped White Aster	*Doellingeria umbellata* (Miller) Nees von Esenbeck	0.50	4.00
Stiff Eyebright	*Euphrasia stricta* J. F. Lehmann	—	0.10
Altai Fescue	*Festuca altaica* Trinius	30.00	60.00
Wild Strawberry	*Fragaria virginiana* Duchesne	—	0.02
Hairy Woodrush	*Luzula acuminata* Rafinesque	—	0.10
Three-leaved Rattlesnakeroot	*Nabalus trifoliolatus* Cassini	1.00	0.01
Whorled Wood Aster	*Oclemena acuminata* (Michaux) Greene	0.50	—
Three-tooth Cinquefoil	*Sibbaldia tridentata* (Aiton) Paule & Soják	0.03	1.00
Downy Goldenrod	*Solidago puberula* Nuttall	2.00	0.03
Mountain Cranberry	*Vaccinium vitis-idaea* L.	0.10	0.10
BRYOPHYTES AND LICHENS			
Stubby Stalked Lichen	*Cladonia caespiticia* (Persoon) Flörke	—	0.01
Forking Lichen	*Cladonia furcata* (Hudson) Schrader	—	0.01
Pebbled Pixie-cup Lichen	*Cladonia pyxidata* (L.) Hoffmann	—	0.01
Wavy-leaved Broom Moss	*Dicranum polysetum* Swartz	—	0.01
Stairstep Moss	*Hylocomium splendens* (Hedwig) Schimper	—	1.00
Pellucid Plait Moss	*Hypnum imponens* Hedwig	—	0.10
Red-stemmed Feather Moss	*Pleurozium schreberi* (von Bridel) Mitten	0.01	1.00
Yellow-green Rock Moss	*Racomitrium heterostichum* (Hedwig) von Bridel	—	0.01
Wooly Rock Moss	*Racomitrium lanuginosum* (Hedwig) von Bridel	—	0.01

*Indicates absence or undetected.

(*F. subverticillata* (Persoon) E. B. Alexeev), and Hard Fescue (*F. trachyphylla* (Hackel) Krajina) — lack rhizomes entirely.

Leaf blade characters are useful for identifying *Festuca* species (Darbyshire and Pavlick 2007). The leaf blades of the sterile shoots of *F. altaica* are conduplicate or convolute (rarely flat), 2–4 mm wide, up to about 50 cm long, strongly scabrous on the abaxial surface, and short pubescent (sometimes sparsely) on the adaxial surface. In cross section, "girders" of sclerenchyma tissue are present at the major veins, extending from the abaxial to adaxial epidermis, while, at the minor veins, "pillars" of sclerenchyma tissue extend from the abaxial epidermis to the vein. In Nova Scotia, only *F. subverticillata* has sclerenchyma girders, but this species has flexuous leaf blades (3) 5–10 mm wide (see illustrations in Darbyshire and Pavlick 2007) and grows in lowland deciduous or mixed forests.

Lemmas of *F. altaica* are (6.5) 7.5–9.0 (12.0) mm long with a terminal awn to about 1.5 mm long, whereas the lemmas of *F. filiformis* and *F. subverticillata* are shorter (≤ 4.5 mm long) and lack awns. The lemmas of *F. trachyphylla* are 3.8–6.5 mm long and awned. Anthers of *F. altaica* are 2.6–4.5 (5) mm long, whereas the anthers of *F. filiformis* and *F. subverticillata* are ≤ 2.2 mm long and those of *F. trachyphylla* and *F. rubra* are

TABLE 2. Additional significant species at the Polletts Cove site and the Blair River ravine, Nova Scotia.

Species		Affinity	Status in Nova Scotia,† no. known sites‡
Cream-flowered Rockcress	*Arabis pycnocarpa* M. Hopkins	Widespread	S1S2, 7
Field Wormwood	*Artemisia campestris* L.	Boreal	S1, 2
Bog Birch	*Betula pumila* L. var. *pumila**	Boreal	S2, 11
Alpine Bistort	*Bistorta vivipara* (L.) Delarbre*	Arctic/alpine	S1, 2
Hair-like Sedge	*Carex capillaris* L.	Boreal, arctic/alpine	S2, 13
Single-spike Sedge	*Carex scirpoidea* Michaux subsp. *scirpoidea*	Arctic/alpine	S2, 13
Laurentian Bladder Fern	*Cystopteris laurentiana* (Weatherby) Blasdell	Eastern	S2, 10
Rock Draba	*Draba arabisans* Michaux	Eastern	S2, 16
Meadow Barley	*Hordeum brachyantherum* Nevski	Western (also northwestern Newfoundland and southern Labrador)	S1, 2
Spiked Woodrush	*Luzula spicata* (L.) de Candolle*	Boreal	S1, 4
Highland Rush	*Oreojuncus trifidus* (L.) Záveská, Drábková & Kirschner*	Eastern	S2S3, 18
Saint John River Locoweed	*Oxytropis campestris* var. *johannensis* Fernald	Eastern	S1S2, 5
Glaucous Bluegrass	*Poa glauca* Vahl*	Boreal	S2S3, 20
Nodding Saxifrage	*Saxifraga cernua* L.	Arctic/alpine	S1, 1
Purple Mountain Saxifrage	*Saxifraga oppositifolia* L.	Arctic/alpine	S1, 2
Laestadius' Saxifrage	*Saxifraga paniculata* subsp. *laestadii* (Neuman) T. Karlsson	Boreal, arctic/alpine	S2, 16
Multi-rayed Goldenrod	*Solidago multiradiata* Aiton	Boreal	S2, 10
Quill Lichen	*Cladonia amaurocraea* (Flörke) Schaerer*	Boreal, arctic/alpine	S1, 1

*Species found in close proximity to Altai Fescue (*Festuca altaica*) on the plateau crest and upper slopes; others were found on cliff or riparian habitats in the adjacent ravine. All species except Nodding Saxifrage (*Saxifraga cernua*) were found during the same 2013 survey that detected *F. altaica*.

†Source: Atlantic Canada Conservation Data Centre, Sackville, New Brunswick, Canada. Accessed 1 June 2017.

‡Includes the ones reported here.

mostly 2–3.5 mm long, although the anthers of Rock Red Fescue (*F. rubra* subsp. *pruinosa* (Hackel) Piper) may be up to 6.5 mm long. The apex of the ovaries in *F. altaica* is usually sparsely pubescent, but densely pubescent in *F. subverticillata* and glabrous in other *Festuca* species present in Nova Scotia.

Voucher specimens

Canada, Nova Scotia, Inverness Co., 46.927°N, 60.669°W, alpine summit, plateau barren, 18 July 2013, *C.S. Blaney, D.M. Mazerolle, and S.P. Basquill 8330*. (ACAD, DAO, NBM, NSPM).

Acknowledgements

We thank Eugene Quigley and David Mazerolle for assistance with fieldwork.

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Received 23 September 2016
Accepted 9 August 2017

Trends in Bird Densities at a Remnant Fescue Grassland in Saskatchewan

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Pylypec, Bohdan. 2017. Trends in bird densities at a remnant fescue grassland in Saskatchewan. Canadian Field-Naturalist 131(2): 170–178. https://doi.org/10.22621/cfn.v131i2.1904

Populations of grassland birds in North America have declined greatly in the past five decades. Hypothesized drivers of decline include habitat loss, fragmentation, and adverse impacts from human activities. At a remnant fescue grassland in Saskatoon, Saskatchewan numbers of Savannah Sparrow (*Passerculus sandwichensis*), Western Meadowlark (*Sturnella neglecta*), Brewer's Blackbird (*Euphagus cyanocephalus*), and Vesper Sparrow (*Pooecetes gramineus*) have been stable. Numbers of Clay-colored Sparrow (*Spizella pallida*) have increased since the 1960s. Sprague's Pipit (*Anthus spragueii*), Upland Sandpiper (*Bartramia longicauda*), and Burrowing Owl (*Athene cunicularia*) are no longer present. Baird's Sparrow (*Ammodramus bairdii*), Bobolink (*Dolichonyx oryzivorus*), and Horned Lark (*Eremophila alpestris*) have become irregular visitors. In the past 50 years, 91 species have been observed displaying territorial behaviour, feeding, nesting, or migrating at this remnant native grassland. With encroaching urban development and increased human influence at the prairie and surrounding area, the impacts on the bird communities at the site in the future are unknown.

Key Words: Bird population density trends; fescue grassland; grassland bird specialists; Saskatchewan

Introduction

In the Prairie Ecozone of southern Saskatchewan native grasslands comprise 21% of the land area (51 628 km^2; Acton *et al*. 1998; Hammermeister *et al*. 2001). Most of these grasslands occur as small, fragmented patches except for a few larger contiguous patches in the extreme southwest portion of the province. In the Moist Mixed Grassland Ecoregion within this region, only 5.3% is native grassland usually in remnant patches (Gauthier and Wiken 2003), and in local areas of prime cropland less than 2% of the original prairie remains (Hammermeister *et al*. 2001).

One of the largest remnants of this type of grassland is the Kernen Prairie, a 130 ha Fescue Prairie now within the city limits of Saskatoon, Saskatchewan (52.167°N, 106.55°W, elevation 510 m). The prairie is in the Saskatoon Plain Landscape Area in the Moist Mixed Grassland Ecoregion of the Prairie Ecozone (Acton *et al*. 1998). Coupland and Brayshaw (1953) and Coupland (1961) described the Fescue Prairie in Saskatchewan, and native plant communities at Kernen Prairie have been described by Baines (1964, 1973), Pylypec (1986), and Gross and Romo (2010a,b). Plains Rough Fescue (*Festuca hallii* (Vasey) Piper) is the dominant graminoid species with Northern Porcupine Grass (*Hesperostipa curtiseta* (Hitchcock) Barkworth), Thick-spike Wildrye (*Elymus lanceolatus* (Scribner & J.G. Smith) Gould), and Slender Wildrye (*Elymus trachycaulus* (Link) Gould ex Shinners) also important species. Important shrub communities are dominated by Western Snowberry (*Symphoricarpos occidentalis* Hooker), Wolf-willow (*Elaeagnus commutata* Bernhardi ex Rydberg), Prairie Rose (*Rosa arkansana* Porter), Woods' Rose (*Rosa woodsii* Lindley), and White Meadowsweet (*Spiraea alba* Du Roi). Tree species are not prominent in the prairie; four bluffs and several small patches of Trembling Aspen (*Populus tremuloides* Michaux) are present as well as several Bebb's Willow (*Salix bebbiana* Sargent) stands in depressional sites. In total, 165 species of vascular plants representing 34 families have been recorded at Kernen Prairie (Pylypec 1986).

Kernen Prairie was part of the Kernen family homestead in 1917 and was used for grazing by cattle and horses until the 1930s (Baines 1964). Between that period and the 1970s it was disturbed only minimally; some areas were lightly grazed and mowed periodically. One small area (1300 m × 10 m) 700 m from the bird study plot was tilled in 1963. That tract of land was used as an airstrip until the mid-1970s, and was revegetated with the exotic grass Smooth Brome (*Bromus inermis* Leysser) and also with native prairie species. In 1977, Mr. Fred Kernen bequeathed the prairie to the University of Saskatchewan and since that time it is being managed as an ecological reserve. The site, however, has been affected by altered disturbance regimes, invasive species, and encroaching urbanization.

Fire, either started by lightning or indigenous peoples, was a historically essential process in the prairie landscape that maintained a mosaic of vegetation patches and biodiversity (Romo 2003). At the Kernen Prairie fire was suppressed for at least a century although prescribed burns of different sizes have been used various times beginning in 1986 (Gross and Romo 2010a).

Kernen Prairie is currently undergoing invasion by a number of non-native species mainly Smooth Brome with lesser amounts of Kentucky Bluegrass (*Poa pratensis* L.), Field Sow-thistle (*Sonchus arvensis* L.), and Canada Thistle (*Cirsium arvense* (L.) Scopoli). Vegetation surveys in 2006 (B.P., unpublished data) indicated approximately 15% of the prairie was occupied by these species. Smooth Brome is an introduced species that has naturalized in Canada, and combined with its competitive superiority over several native grasses has displaced native species in many grasslands in North America including the fescue grassland at Kernen Prairie (Grilz and Romo 1995; Otfinowski *et al*. 2007). To control the spread of this species, conservation grazing with cattle at light grazing loads (0.3–0.4 animal units/ha) was initiated in 2006 for the May to September grazing period (Mori 2009) and the grazing is on-going.

Kernen Prairie can be considered as an island of native vegetation in a matrix of cropland and urban development (Forman 1995). Aerial photographs of the area from 1944 show this remnant prairie was already surrounded by cropland. Gravel roads along the north and east sides were established in the 1960s. In 2010 urban housing development began 800 m west of the prairie, and in 2015 the area at the northern boundary of the prairie was developed for future urban expansion.

Grassland birds have declined sharply over the past five decades due to habitat loss and degradation (Owens and Myres 1973; Kantrud and Kologiski 1982; Davis 2004; Askins *et al*. 2007; Henderson and Davis 2014). These grassland bird declines are more severe than those documented for any other behavioural or ecological guild of North American birds (Knopf 1994; Sampson and Knopf 1994). Eight species recorded at Kernen Prairie have been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; SARA Registry 2017). Burrowing Owl (*Athene cunicularia*) is listed in Schedule 1 of the *Species at Risk Act* (SARA) as endangered while Loggerhead Shrike (*Lanius ludovicianus*) and Sprague's Pipit (*Anthus spragueii*) are listed as threatened. Long-billed Curlew (*Numenius americanus*), Short-eared Owl (*Asio flammeus*), and Baird's Sparrow (*Ammodramus bairdii*) are listed as species of special concern (SARA Registry 2017). Bobolink (*Dolichonyx oryzivorus*) and Lark Bunting (*Calamospiza melanocorys*) have been assessed as threatened by COSEWIC but are not yet on Schedule 1 (SARA Registry 2017).

The objectives of this study are to (1) document changes in the densities of breeding populations of grassland bird specialists over the past 50 years at a remnant native fescue grassland, (2) relate these to habitat and landscape changes at the study site over the same period, and (3) compare with trends in southern Saskatchewan as indicated in the Breeding Bird Survey (BBS) for 1970–2012.

Methods

Breeding bird densities were studied at an 18.6 ha gridded plot with grid markers at 60 m intervals that was established in 1966. Bird populations were first studied by M. R. Lein and D. J. Karasiuk from 1966 to 1970 (Lein 1968; Karasiuk 1973). This study was from 1987 to 1989 (Pylypec 1991) and then from 2005 to 2016. All of these studies were conducted on the same plot and the same methods were used to determine breeding bird densities.

Breeding birds were censused using the mapping method described by Kendeigh (1944) and Davis (1965). Censuses of approximately 2.5 h duration were conducted approximately twice weekly during the breeding season from May to July in each of the years of this study. The censuses were conducted between 08:00 and 10:30 when weather conditions were favourable for seeing and hearing singing males. During each census, locations of birds exhibiting territorial behaviour such as singing at perches, aerial flight displays, and conflicts between neighbouring males were recorded on a map of the plot. These data points were used to map the breeding territories of each species and to determine their breeding density. For example, if 30 territories were noted on the plot, the density was determined to be 1.61 pairs/ha.

Brewer's Blackbirds (*Euphagus cyanocephalus*) nested in two loose colonies at the plot. As these birds do not exhibit well-defined individual breeding territories, their densities were estimated from the maximum number of males observed showing territorial behaviour at the colonies. Observations of migrating birds and birds in the immediate vicinity of the plot were also noted.

Bird population data and habitat descriptions prior to this study were obtained from earlier studies at the site (Lein 1968; Karasiuk 1973; Pylypec 1991). Also, historical aerial photographs of the prairie were examined. Status and abundance for all species observed at the prairie were determined using definitions given by Roy (1996), Smith (1996), Leighton *et al*. (2002), and Saskatoon Nature Society (2010; Table 1). Annual trend, indicated as average annual percent change in the population, was noted for each species using BBS data for the pothole region of southern Saskatchewan (BCR11) for the 1970–2012 period (Environment Canada 2014).

Results and Discussion

A total of 91 species were observed displaying territorial behaviour, feeding, nesting, or migrating at Kernen Prairie from 1966 to 2016. Twenty-one species were recorded with definite breeding records, 52 species as summer residents in the Saskatoon area but with no definite breeding records at the Kernen Prairie, five species as permanent residents in the Saskatoon area but with no definite breeding records at the prairie, and 13 spring transients (Table 1).

Table 1. List of species observed at Kernen Prairie, their occurrence* and abundance[†] at Kernen Prairie and in the Saskatoon area, and Breeding Bird Survey (BSS) trends[‡] in southern Saskatchewan.

	Abundance				BBS trend in southern SK
	Kernen Prairie			Saskatoon area	
Occurrence	1966–1970	1987–1989	2005–2016	2002	1970–2012
A. Summer and permanent residents with definite breeding records ($n = 21$)					
Gadwall (*Anas strepera*)	common	fairly common	fairly common	common	4.140
Mallard (*Anas platyrhynchos*)	common	common	common	common	−1.230
Blue-winged Teal (*Anas discors*)		fairly common	fairly common	fairly common	1.640
Northern Pintail (*Anas acuta*)	common	fairly common	fairly common	common	−4.500
Sharp-tailed Grouse (*Tympanuchus phasianellus*)		fairly common	fairly common	fairly common	−1.240
Northern Harrier (*Circus cyaneus*)	common	fairly common	fairly common	fairly common	−1.740
Swainson’s Hawk (*Buteo swainsoni*)	common	fairly common	fairly common	fairly common	0.745
Upland Sandpiper (*Bartramia longicauda*)		fairly common	absent	uncommon	4.180
Great Horned Owl (*Bubo virginianus*)	fairly common	fairly common	absent	fairly common	0.455
Burrowing Owl (*Athene cunicularia*)	fairly common	absent	absent	irregular	ID
Eastern Kingbird (*Tyrannus tyrannus*)	common	common	fairly common	common	0.119
Black-billed Magpie (*Pica hudsonia*)		common	common	common	−0.902
Sprague’s Pipit (*Anthus spragueii*)	common	common	irregular	uncommon	−3.830
Clay-colored Sparrow (*Spizella pallida*)	abundant	abundant	abundant	common	−0.366
Vesper Sparrow (*Pooecetes gramineus*)	common	common	common	common	0.595
Savannah Sparrow (*Passerculus sandwichensis*)	abundant	abundant	abundant	common	1.040
Baird’s Sparrow (*Ammodramus bairdii*)	common	common	rare	uncommon	−1.850
Bobolink (*Dolichonyx oryzivorus*)	uncommon	absent	irregular	fairly common	0.703
Western Meadowlark (*Sturnella neglecta*)	common	common	common	common	−2.620
Brewer’s Blackbird (*Euphagus cyanocephalus*)	common	common	common	common	−1.970
Brown-headed Cowbird (*Molothrus ater*)	common	uncommon	uncommon	common	1.190
B. Permanent residents but no breeding records ($n = 5$)					
Gray Partridge (*Perdix perdix*)	fairly common	uncommon	uncommon	fairly common	-0.057
Rock Pigeon (*Columba livia*)		uncommon	uncommon	common	−1.230
Downy Woodpecker (*Dryobates pubescens*)		absent	irregular	fairly common	−0.804
Hairy Woodpecker (*Picoides villosus*)		absent	irregular	fairly common	3.820
Pileated Woodpecker (*Dryocopus pileatus*)		absent	irregular	rare	ND
C. Summer residents but no definite breeding records ($n = 52$)					
Canada Goose (*Branta canadensis*)		fairly common	fairly common	common	9.030
American Wigeon (*Anas americana*)		absent	irregular	common	−3.670
Northern Shoveler (*Anas clypeata*)		irregular	irregular	common	2.330
Green-winged Teal (*Anas crecca*)		absent	irregular	uncommon	1.150
Double-crested Cormorant (*Phalacrocorax auritus*)		irregular	irregular	uncommon	4.680
Great Blue Heron (*Ardea herodias*)		absent	irregular	uncommon	−3.190

TABLE 1. *(continued)* List of species observed at Kernen Prairie, their occurrence* and abundance[†] at Kernen Prairie and in the Saskatoon area, and Breeding Bird Survey (BSS) trends[‡] in southern Saskatchewan.

	Abundance				BBS trend in southern SK
	Kernen Prairie			Saskatoon area	
Occurrence	1966–1970	1987–1989	2005–2016	2002	1970–2012
Turkey Vulture (*Cathartes aura*)		absent	irregular	rare	ND
Red-tailed Hawk (*Buteo jamaicensis*)		irregular	irregular	common	2.500
American Kestrel (*Falco sparverius*)		irregular	irregular	uncommon	−2.190
Merlin (*Falco columbarius*)		irregular	irregular	fairly common	4.820
Sora (*Porzana carolina*)		absent	irregular	common	2.110
American Coot (*Fulica americana*)		absent	irregular	common	2.790
Killdeer (*Charadrius vociferus*)		uncommon	uncommon	fairly common	−0.860
American Avocet (*Recurvirostra americana*)		absent	irregular	common	−0.808
Willet (*Tringa semipalmata*)	irregular	uncommon	uncommon	fairly common	−0.502
Lesser Yellowlegs (*Tringa flavipes*)		irregular	irregular	common	2.110
Long-billed Curlew (*Numenius americanus*)		absent	irregular	uncommon	−0.178
Marbled Godwit (*Limosa fedoa*)		uncommon	uncommon	fairly common	−1.640
Wilson’s Snipe (*Gallinago delicata*)		irregular	irregular	fairly common	3.710
Franklin’s Gull (*Larus pipixcan*)		uncommon	uncommon	common	−0.329
Ring-billed Gull (*Larus delawarensis*)		uncommon	uncommon	common	−1.220
Black Tern (*Chlidonias niger*)		irregular	irregular	common	−0.436
Mourning Dove (*Zenaidura macroura*)		irregular	irregular	fairly common	1.850
Northern Flicker (*Colaptes auratus*)		irregular	irregular	fairly common	−2.750
Western Wood Peewee (*Contopus sordidulus*)		absent	irregular	irregular	2.770
Least Flycatcher (*Empidonax minimus*)		irregular	irregular	common	2.580
Say’s Phoebe (*Sayornis saya*)		absent	irregular	uncommon	2.960
Western Kingbird (*Tyrannus verticalis*)		irregular	irregular	common	1.800
Loggerhead Shrike (*Lanius ludovicianus*)	irregular	absent	irregular	uncommon	−3.050
Red-eyed Vireo (*Vireo olivaceus*)		absent	irregular	common	−0.943
American Crow (*Corvus brachyrhynchos*)		fairly common	fairly common	common	−3.120
Common Raven (*Corvus corax*)		absent	uncommon	uncommon	26.900
Horned Lark (*Eremophila alpestris*)	fairly common	fairly common	uncommon	fairly common	−4.390
Tree Swallow (*Tachycineta bicolor*)		uncommon	uncommon	common	−0.035
Barn Swallow (*Hirundo rustica*)	fairly common	uncommon	uncommon	common	−0.990
House Wren (*Troglodytes aedon*)		irregular	irregular	common	0.355
Sedge Wren (*Cistothorus platensis*)		absent	irregular	uncommon	3.570
American Robin (*Turdus migratorius*)		absent	irregular	common	3.330
Gray Catbird (*Dumetella carolinensis*)		absent	irregular	fairly common	−0.071
Brown Thrasher (*Toxostoma rufum*)		irregular	irregular	fairly common	−0.451
European Starling (*Sturnus vulgaris*)		irregular	absent	uncommon	−3.030
Cedar Waxwing (*Bombycilla cedrorum*)		irregular	irregular	common	0.589
Yellow Warbler (*Setophaga petechia*)		absent	irregular	common	2.440
Ovenbird (*Seiurus aurocapilla*)		absent	irregular	uncommon	2.010

TABLE 1. *(continued)* List of species observed at Kernen Prairie, their occurrence* and abundance† at Kernen Prairie and in the Saskatoon area, and Breeding Bird Survey (BSS) trends‡ in southern Saskatchewan.

	Abundance				BBS trend in southern SK
	Kernen Prairie			Saskatoon area	
Occurrence	1966–1970	1987–1989	2005–2016	2002	1970–2012
Chipping Sparrow (*Spizella passerina*)		absent	irregular	common	1.810
Lark Bunting (*Calamospiza melanocorys*)		irregular	absent	rare	−5.760
Grasshopper Sparrow (*Ammodramus savannarum*)	irregular	absent	absent	irregular	−2.360
LeConte's Sparrow (*Ammodramus leconteii*)		absent	irregular	fairly common	0.996
Song Sparrow (*Melospiza melodia*)		absent	irregular	fairly common	−1.080
Red-winged Blackbird (*Agelaius phoeniceus*)	common	uncommon	uncommon	abundant	−0.286
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)		irregular	irregular	common	1.630
American Goldfinch (*Spinus tristis*)	uncommon	uncommon	uncommon	common	0.016
D. Spring transients (n = 13)					
Greater White-fronted Goose (*Anser albifrons*)		irregular	irregular	abundant	ID
Snow Goose (*Chen caerulescens*)		absent	irregular	abundant	ID
Tundra Swan (*Cygnus columbianus*)		absent	irregular	abundant	ID
Bald Eagle (*Haliaeetus leucocephalus*)		absent	irregular	fairly common	ND
Cooper's Hawk (*Accipiter cooperii*)		absent	irregular	uncommon	−1.200
Rough-legged Hawk (*Buteo lagopus*)		irregular	irregular	uncommon	ID
Sandhill Crane (*Grus canadensis*)		irregular	irregular	common	3.660
American Golden-plover (*Pluvialis dominica*)		irregular	irregular	fairly common	ID
Sanderling (*Calidris alba*)		absent	irregular	fairly common	ID
Snowy Owl (*Nyctea scandica*)		absent	irregular	fairly common	ID
Short-eared Owl (*Asio flammeus*)	irregular	irregular	irregular	irregular	−5.400
White-throated Sparrow (*Zonotrichia albicollis*)		absent	irregular	common	1.330
White-crowned Sparrow (*Zonotrichia leucophrys*)		irregular	absent	fairly common	−2.500

*Occurrence of species in the Saskatoon area (Leighton *et al*. 2002):

Summer resident – species normally arrives in spring and departs in the fall;
Permanent resident – species remains throughout the year;
Spring resident – species passes through area in March to June en-route to northern breeding grounds;
Definite breeding record at Kernen Prairie – nest containing eggs or young, or newly fledged young observed.

†Abundance – indication of likelihood of a sighting assuming an experienced observer is in the preferred habitat of the species (Roy 1996; Smith 1996):

Abundant – can be found without any particular search, often in large numbers;
Common – can be found in substantial numbers with a minimum of searching;
Fairly common – can generally be found but usually in small numbers and with some searching;
Uncommon – may not be found on every trip and usually in small numbers or alone;
Rare – difficult to find because of extremely limited numbers;
Irregular – not present every year.

‡Percent annual change (1970–2012) indicated in BBS data (Environment Canada 2014); ID = insufficient data; ND = no data.

Nine of 21 species with breeding records on the plot (Figure 1) established breeding territories and were recorded regularly in censuses throughout the duration of this study (Lein 1968; Karasiuk 1973; Pylypec 1991). The most common was the Savannah Sparrow (*Passerculus sandwichensis*; Figure 1a). Breeding density averaged 1.50 pairs/ha (or 28 territories on the plot) and numbers have declined somewhat over the past 50 years (R Development Core Team 2016; Spearman rank correlation coefficient, $r_s = -0.641$, $P = 0.007$). Numbers were 1.61 pairs/ha in 1967 (Lein 1968), 1.70 pairs/ha in 1987–1989 (Pylypec 1991) and ranged from 1.18 pairs/ha to 1.75 pairs/ha in 2005–2016. In the pothole region of southern Saskatchewan BBS data for the 1970–2012 period indicates an average annual increase of 1.04% (Environment Canada 2014). This species utilizes shrubs for nesting cover and song perches but also feeds in open grassland vegetation (Lein 1968; Karasiuk 1973); these vegetation types were present throughout the duration of this study.

Clay-colored Sparrows (*Spizella pallida*) averaged 1.40 pairs/ha (26 territories on the plot) (Figure 1b). Densities were lowest (0.38 pairs/ha) in 1968 and 1969 (Karasiuk 1973) and numbers have increased ($r_s = 0.874$, $P < 0.001$) to a high of 2.02 pairs/ha in 2015. In contrast, BBS data indicate an average annual decline of 0.366% for the same period in southern Saskatchewan (Environment Canada 2014). The preferred habitat of this species is dense brush patches (Knapton 1978; Kantrud and Kologiski 1982; Arnold and Higgins 1986; Madden *et al*. 2000). Judging from historical aerial photographs of the Kernen Prairie this vegetation type was less prevalent in the 1960s than at present.

Western Meadowlark (*Sturnella neglecta*) and Sprague's Pipit are two grassland birds that feed and nest primarily in open grassland (Maher 1973). Numbers of Western Meadowlark have declined somewhat ($r_s = -0.637$, $P = 0.004$) averaging 0.21 pairs/ha or 3.91 pairs at the plot since 1968 (Figure 1d). BBS data indicate an annual decline of 2.62% in southern Saskatchewan (Environment Canada 2014). Sprague's Pipits were relatively common (0.27 pairs/ha or 5.0 pairs at the plot) in 1968–1970 (Karasiuk 1973) and 1987–1989 (Pylypec 1991) but since 2005 numbers declined tremendously ($r_s = -0.845$, $P < 0.001$) and the last territory at the plot was noted in 2010 (Figure 1e). The species has declined (−3.83% annually) also in southern Saskatchewan (Environment Canada 2014). Sprague's Pipit is listed as threatened (SARA Registry 2017).

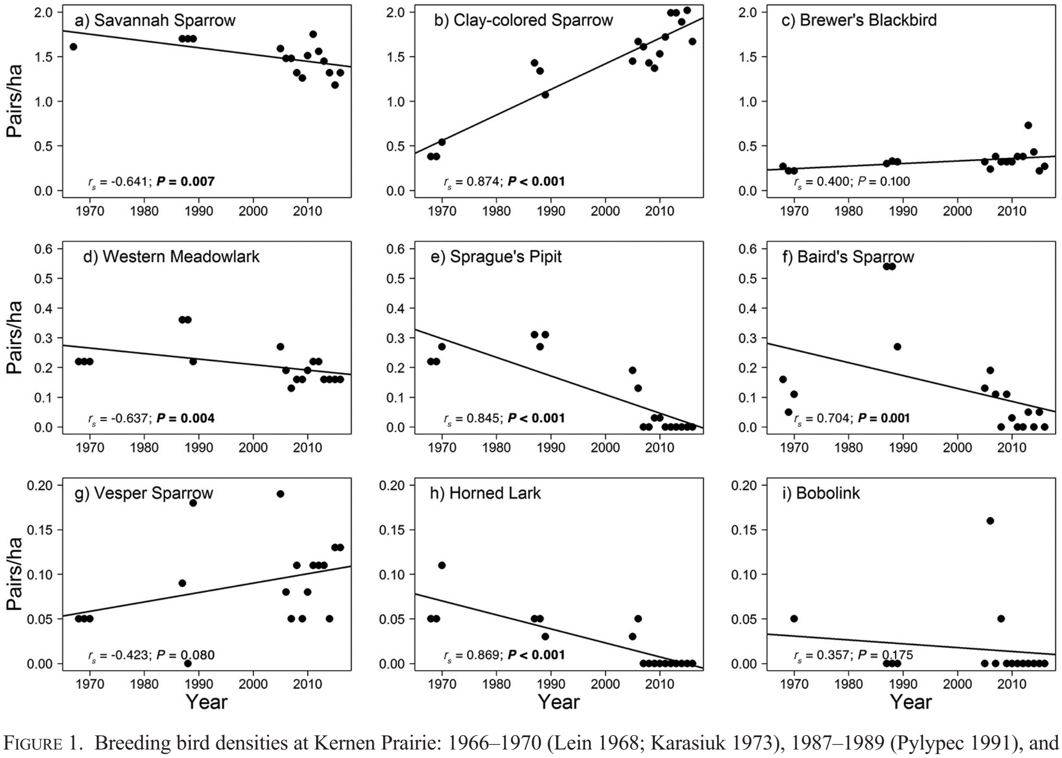

FIGURE 1. Breeding bird densities at Kernen Prairie: 1966–1970 (Lein 1968; Karasiuk 1973), 1987–1989 (Pylypec 1991), and 2005–2016. Spearman's non-parametric correlation coefficients between year and the abundance of each species (r_s) and *P*-values are indicated; bold *P*-values are significant following a Bonferroni correction for multiple tests (0.05/9 = 0.0055).

Baird's Sparrow is another passerine that feeds and nests in open grassland with a thick vegetative canopy (Lein 1968; Maher 1973). This species does not occur in grassland that been heavily grazed, recently burned, or in cultivated areas. The species is "uncommon" in the Saskatoon area (Leighton *et al*. 2002). At the Kernen Prairie highest densities (0.54 pairs/ha) were noted in 1987 and 1988 (Pylypec 1991) but since 2008 it has been observed in very low numbers and was absent in five of nine years ($r_s = -0.704$, $P = 0.001$; Figure 1f). BBS data indicate the species declining 1.85% annually in southern Saskatchewan (Environment Canada 2014). The species is listed as a species of special concern (SARA Registry 2017).

Vesper Sparrow (*Pooecetes gramineus*) numbers were relatively low (averaged 0.09 pairs/ha) but were consistent over the past 50 years (Figure 1g). In southern Saskatchewan, the species has increased annually (0.595%) during 1970–2012 (Environment Canada 2014). Vesper Sparrow is an "edge species" typically occupying fence lines between cultivated fields and native grassland (Owens and Myres 1973) but at Kernen Prairie it was also present in ecotonal areas around dense brush patches and aspen bluffs.

Horned Lark (*Eremophila alpestris*) is a grassland bird whose preferred habitat is grazed native grassland as opposed to "ungrazed" grassland (Maher 1973; Owens and Myres 1973). It also is the only passerine species in fescue grasslands of Alberta that uses cultivated land to any degree (Owens and Myres 1973). At Kernen Prairie the species was present at low numbers (0.05 pairs/ha) in 1968–1970 (Karasiuk 1973), 1987–1989 (Pylypec 1991), and 2005–2006 (Figure 1h). Since 2007 the species was absent at the native grassland ($r_s = -0.869$, $P < 0.001$) but a few individuals were noted in an adjacent cultivated field. In southern Saskatchewan, BBS data indicate a large annual decline (−4.39%) from 1970 to 2012 (Environment Canada 2014).

Two uncommon non-passerine birds of note have nested at Kernen Prairie in the past but are no longer present. Burrowing Owl, listed as endangered (SARA Registry 2017), was recorded as a resident on the prairie in 1966 and 1967 (Lein 1968). Two pairs were last noted in 1980, and the last pair in the area nested 1 km from the prairie in 1982. The species was not recorded in 1987–1989 (Pylypec 1991) or in 2005–2016. Upland Sandpiper (*Bartramia longicauda*), an uncommon summer resident in the Saskatoon area (Leighton *et al*. 2002), nested on the plot in 1988 and was last observed in 1989 (Pylypec 1991). It was not recorded in 2005–2016. However, in southern Saskatchewan BBS data indicate an annual increase of 4.18% (Environment Canada 2014).

Two additional non-passerine birds listed under SARA (SARA Registry 2017) have been observed at the Kernen Prairie. Long-billed Curlew is an "uncommon summer resident" in the Saskatoon area (Leighton *et al*. 2002) and is listed as a species of special concern. This study has only one record (28 June 2010). Loggerhead Shrike Prairie subspecies (*Lanius ludovicianus excubitorides*) is also an "uncommon summer resident" in the Saskatoon area (Leighton *et al*. 2002) and is listed as threatened (SARA Registry 2017). At Kernen Prairie it has been recorded as "irregular" in the past 50 years (Table 1). BBS data indicate the species declining 3.05% annually in southern Saskatchewan (Environment Canada 2014).

Bobolink was assessed as threatened in April 2010 but is not yet on Schedule 1 of SARA (SARA Registry 2017). The species was recorded nesting at Kernen Prairie in 1966 and 1970 (Karasiuk 1973; Leighton *et al*. 2002). Territorial birds were last observed in 2006 and 2008 (Figure 1i). Two males were observed 1 km from the prairie on 8 July 2011 but no birds were observed from 2012 to 2016. In southern Saskatchewan, an annual increase of 0.703% has been noted from 1970 to 2012 (Environment Canada 2014).

Lark Bunting also was assessed as threatened in April 2017 but is not yet on Schedule 1 of SARA (SARA Registry 2017). The species was last seen at Kernen Prairie in 1989 (Pylypec 1991). BBS data indicate significant annual decline (−5.76%) of the species in southern Saskatchewan in 1970–2012 (Environment Canada 2014).

A number of other species have been recorded as nesting at the prairie during the duration of this study (Table 1). Of note, several duck species: Mallard (*Anas platyrhynchos*), Northern Pintail (*Anas acuta*), Blue-winged Teal (*Anas discors*), and Gadwall (*Anas strepera*) have nested in dense vegetation even though no permanent wetlands are present at the prairie. Also, Sharp-tailed Grouse (*Tympanuchus phasianellus*) broods have been observed at the prairie, and a lek 200 m from the plot was used from 1987 to 2013.

One colonial species has nested in loose colonies at Kernen Prairie throughout the duration of this study. Crude density numbers of Brewer's Blackbird were 0.22–0.27 pairs/ha in 1968–1970 (Karasiuk 1973), 0.30–0.33 pairs/ha in 1987–1989 (Pylypec 1991), and 0.22–0.73 pairs/ha in 2005–2016 (Figure 1c).

Conclusions

Kernen Prairie has provided breeding habitat for a number of grassland bird specialists over the past 50 years. This remnant 130 ha fescue grassland has been surrounded by cultivated land for at least 75 years and in the past decade urban development has encroached. Vegetation structure and composition at the prairie has been affected by a number of invasive species, Smooth Brome in particular being prominent. The invasive plant species have decreased the quality of habitat for grassland birds as they utilize patches of Smooth Brome, for example, much less than areas dominated by native vegetation (e.g., Plains Rough Fescue or Western Snowberry). Current management of the prairie using prescribed burns and conservation grazing by cattle is attempting to maintain the composition and structure of native vegetation at the site while also improving the habitat for birds and other animals. Isolation of this native grassland and land uses of surrounding areas probably have also impacted bird populations.

Numbers of Savannah Sparrow, Western Meadowlark, Brewer's Blackbird, and Vesper Sparrow have been stable over this time period and do not appear to have been affected significantly by management practices at the prairie and surrounding areas. In contrast, Clay-colored Sparrow numbers have increased since the 1960s. This may be attributed to an increase in the amount of shrubbery at the prairie that has provided more suitable habitat for the species. The increase in the amount of shrubbery over the last 50 years can probably be attributed to the lack of grazing by cattle since the 1960s to 2006, and low intensity grazing since then.

Horned Larks were last observed at the prairie in 2006. The species preferred habitat is "grazed native grassland" (Maher 1973; Owens and Myres 1973). Absence of the species on the prairie probably can be attributed to unsuitable habitat for the species due to the increase in shrubbery and dense graminoid vegetation.

Burrowing Owl, Sprague's Pipit, and Upland Sandpiper are no longer present at the prairie. All of these species are rare or uncommon in Saskatchewan (Smith 1996), and with the exception of Upland Sandpiper, have been assessed by COSEWIC and are listed as species at risk (SARA Registry 2017). Also listed (SARA Registry 2017) are Baird's Sparrow, Loggerhead Shrike Prairie subspecies, Long-billed Curlew, and Short-eared Owl; these species plus Bobolink and Lark Bunting (assessed but not listed) have been recorded as "irregular" summer residents. Absence or rarity of these species at the prairie probably can be attributed to its isolation as a native grassland surrounded by cropland and urban development. The prairie has been surrounded by cropland for at least the past 75 years. Until 2000 the city limits of Saskatoon were 5 km away. Urban development started 800 m from the prairie in 2010 and by 2015 had encroached to the prairie. Impacts of fragmentation of habitat on grassland birds have also been shown by other studies (e.g., Bakker *et al.* 2002; Ribic *et al*. 2009; Buxton and Benson 2016).

A number of studies (e.g., Herkert 1994; Knopf 1994; Askins *et al*. 2007; Henderson and Davis 2014) have documented the decline in grassland bird specialists in North American native grasslands (tall grass prairie, shortgrass prairie, and mixed prairie types) due to habitat loss. This long-term study documented similar declines of some species of grassland specialist birds at a remnant Fescue Prairie also impacted by encroachment of urban development and long-term habitat alteration.

Acknowledgements

I thank R. E. Redmann, J. T. Romo, and E. G. Lamb for their encouragement to conduct this long-term study. Special thanks to two anonymous reviewers for their helpful comments. The support of the Department of Plant Sciences, University of Saskatchewan is greatly appreciated.

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Received 6 October 2016
Accepted 28 August 2017

Thematic Collection

The Canadian Field-Naturalist, Documenting Species New to Canada for Nearly a Century

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Martin, Amanda E. 2017. Thematic Collection: *The Canadian Field-Naturalist*, documenting species new to Canada for nearly a century. Canadian Field-Naturalist 131(2): 179–186. https://doi.org/10.22621/cfn.v131i2.1989

There are many reasons why a species not previously known to occur in Canada is subsequently found there. For example, species distributions may shift due to climate change, moving the upper limit of the species' range northward into Canada (Chen *et al*. 2011). Species not native to Canada may also be introduced – either intentionally or by accident – from other parts of the world. Observations of species in areas previously thought to be outside the species' distributions may also occur simply because the field biologist is in the right place at the right time to observe a cryptic species, or because new surveys occurred in areas not previously studied.

The Canadian Field-Naturalist (CFN) has played an important role documenting observations of species new to Canada[1], and has been adding to the known flora and fauna of Canada for nearly a century. This is due, at least in part, to its long and continuous publication history, and its focus on the natural history of Canadian species. CFN has to date published 99 volumes, starting in 1919[2]. In total, this Thematic Collection includes 163 articles published in CFN, each documenting the first known observation of a given species (or subspecies) in Canada (Figure 1). The earliest documented the first observation of the Common Morel (*Morchella esculenta* (L.) Pers.) in Canada (Odell 1920), while the most

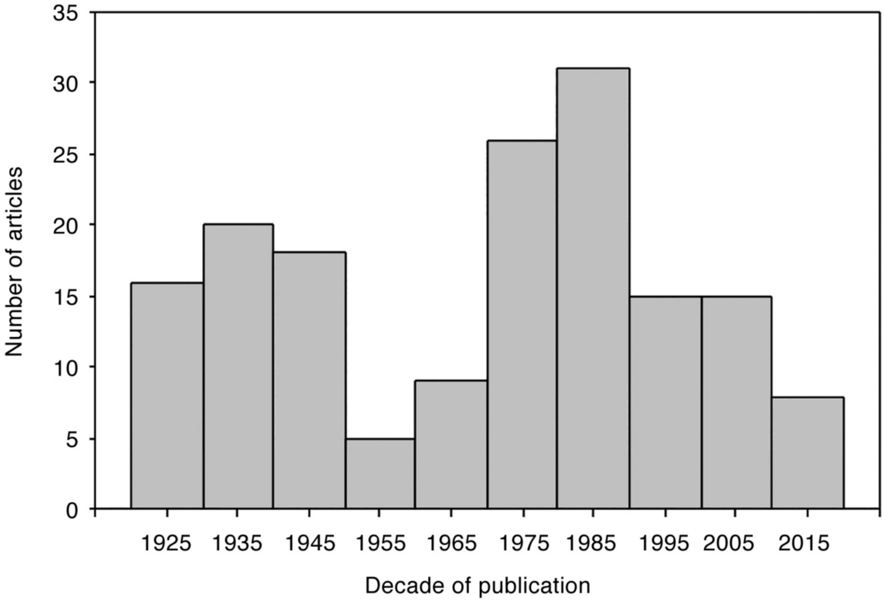

Figure 1. Number of articles documenting the first observation of a species (or subspecies) in Canada published in *The Canadian Field-Naturalist* since its inception in 1919.

[1] The general goal of the Thematic Collection is to highlight published contributions to both CFN and the Ottawa Field-Naturalists' Club's (OFNC's) regional publication, *Trail & Landscape*, on a given theme. However, in this Collection I have included only publications in CFN, because my focus was on articles identifying new species at a national, rather than regional, extent.

[2] Prior to 1919, the OFNC published *The Ottawa Naturalist*. Its first issue was published in 1987, and 32 volumes were published by the OFNC under this name. Publication of *The Ottawa Naturalist* ceased with the first issue of CFN. The first issue of CFN began at volume 33.

A contribution towards the cost of this publication has been provided by the Thomas Manning Memorial Fund of the Ottawa Field-Naturalists' Club.

recent documented the first known occurrence of a Pacific Angel Shark (*Squatina californica*) off the coast of British Columbia (King and Surrey 2016). This collection of articles includes a broad array of taxa, including fungi (Odell 1920), lichens (Lewis 2010), plants (Duncan 1973), arachnids (Klugh 1920), insects (Morris 1986), molluscs (Te and Clarke 1985), fishes (Sylvester *et al*. 2005), mammals (Cowan 1945), birds (Taverner 1934), amphibians (Uzzell 1962), and reptiles (Sternberg 1932), and articles on both extant and long-extinct species (identified by their fossil remains; Gilmore 1923).

Understanding what species occur in Canada (and where) is an important first step in their conservation and management. For example, this Thematic Collection includes CFN articles documented the first known observations of species now listed as endangered in Canada and protected under the *Species at Risk Act*, including Hotwater Physa (*Physella wright*; Te and Clarke 1985; SARA Registry 2017a), Small-mouthed Salamander (*Ambystoma texanum*; Uzzell 1962; SARA Registry 2017b), and Tri-colored Bat (*Perimyotis subflavus*; Saunders 1920; SARA Registry 2017c). CFN has also documented the first known occurrences of invasive species such as Kudzu (*Pueraria montana* (Lour.) Merr.; Waldron and Larson 2012) which is considered to be one of the top 100 worst invasive species in the world (Global Invasive Species Database 2017). This Kudzu population is now being managed by the Canadian Food Inspection Agency (CFIA 2017).

The known flora and fauna of Canada are likely to continue to change, and at increasingly rapid rates. For example, Canada is likely to gain species as their distributions rapidly shift northward in response to climate change. In their global meta-analysis, Chen *et al.* (2011) found that species ranges were shifting to higher latitudes at a median rate of 17 km/decade. Rates of species invasions have also been increasing over time (Hulme 2009), suggesting that there will be an increasing number of non-native species to discover in Canada in the future. Thus, we expect that CFN will continue its important role documenting observations of species new to Canada, contributing to our knowledge of Canadian species and to their conservation and management.

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Received 7 September 2017
Accepted 12 September 2017

Book Reviews

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

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

BOTANY

Ancient Pathways, Ancestral Knowledge: Ethnobotany and Ecological Wisdom of Indigenous Peoples of Northwestern North America. Volume 1: The History and Practice of Indigenous Plant Knowledge. Volume 2: The Place and Meaning of Plants in Indigenous Cultures and Worldviews

By Nancy J. Turner. 2014. McGill-Queen's University Press. 1056 pages, 125.00 CAD, Cloth. Also available as an E-book.

Nancy Turner is without doubt among the pre-eminent ethnobotanists of our time. I first encountered her work in the early 1990s and, since then, I have often drawn on her publications as I undertake palaeoenvironmental research. She has strongly influenced my understanding of the role of plant use in Indigenous lifeways and how that might be reflected in postglacial palaeoecological records. So it was an especial pleasure for me to encounter these encyclopedic volumes that pull together threads from those earlier publications and present a comprehensive synthesis of her knowledge. Decades of thoughtful scholarship and collaboration with Indigenous people have gone into this work. It is magisterial in the true sense of that word: the distillation of a career's experience and learning.

Although split into two volumes, this work is a seamless whole. It discusses relationships among people, plants, and environments, with a focus on British Columbia and adjacent areas including the Yukon, panhandle Alaska, and Washington. From her base at the University of Victoria, Turner sets out her intent to investigate "people-plant relationships in northwestern North America in an effort to better understand the pathways and processes by which ethnobotanical and ethnoecological knowledge systems of Indigenous peoples in this area have developed, accumulated, spread, and evolved over time" (V1, p. 3). Following an introduction, the first volume explores the history (three chapters) and development (three chapters) of plant use by Indigenous people in western North America. The second volume discusses Indigenous peoples' integration and management (four chapters) and underlying philosophy (three chapters) of plant use.

Throughout her discussion, Turner emphasizes that this work builds "on the knowledge shared by numerous Indigenous cultural and botanical specialists" (V1, p. 5). Her Indigenous collaborators and informants are acknowledged and thanked while many also share co-authorship on publications arising from this concerted work. The reference list includes 119 publications on which Turner is an author, including 83 on which she is first or sole author. The books are illustrated with black-and-white photographs, including many of plants discussed in the text, of plant-derived foods, and of tools used to harvest and process plant foods and materials. In several images, Elders show how to harvest and use plants and plant material. In others, children harvest berries (V2, p. 65) and gather edible seaweed (V2, p. 36), highlighting continuity and the living tradition of plant use.

Turner lists an impressive array of plants that have been used, and continue to be used, by Indigenous groups in northwest North America. At least 82 taxa are listed as "traditional plant foods" (V1, Table 5.1, pp. 270–278). The most numerous are roots or tubers (24 taxa) or berries (24 taxa). Plants in the Apiaceae, Fabaceae, Liliaceae, and Portulacaceae families feature prominently as sources for roots and tubers, while berry plants are predominantly drawn from the Rosaceae, Ericaceae, and Grossulariaceae families. There are 106 entries for "plant materials used in Indigenous technology" (V1, Table 6.1, pp. 339–345), and a further 174 entries for "medicinal plants" (V1, Table 7.1, p. 429). Trees and shrubs, especially from the Betulaceae, Cupressaceae, Rosaceae, Salicaceae, and Pinaceae families, are important sources for fibre and wood, both for fuel and construction. Some plant taxa appear more than once in each list. For example, Bearberry (*Arctostaphylos uva-ursi*) appears twice on the food list and three times for different medicinal applications. Useful plants are found in many habitats, from lowlands and wetlands (*Sagittaria latifolia*, *Typha latifolia*), to uplands and alpine slopes (*Oxyria digyna*, *Lewisia rediviva*). Many plants, such as Scouring Rush (*Equisetum hyemale*), Chokecherry (*Prunus virginiana*), and spruces (*Picea* spp.) appear on all three lists. Turner points out that these lists are selective, not exhaustive, and indicates that "about 200 plant species are used, or have been used, medicinally in some way" (V1, p. 419), while 160 species have technological applications and 150 species have food uses.

There is much to ponder in these volumes. As a palaeoecologist, I was especially interested in the sections that discussed purposeful translocation and trading of plants and also landscape management techniques, such as controlled burning, that affected vegetation composition and distribution. These subjects are explored in depth in the second volume, where Turner reviews the use of plants as technology, as well as trade in plants among coastal and interior Indigenous groups. She gives many examples of plant management practices, including selective harvesting, partial harvesting that leaves most of the source plant intact, pruning (especially of berry bushes), and cultivation, such as aerating the soil by using digging sticks. Such practices require a thorough and sophisticated knowledge of plant biology and ecology. Moreover, they imply active intervention in the way in which plants are distributed across the landscape and their relative abundance in different localities. Turner is clear that "people systematically manipulated many different plant resources and habitats to enhance the productivity, reliability, and sustainability of the plants they used for food, materials, and medicines – that they, in fact, *cultivated* their environments and plant resources" (V1, p. 265). This a very different perspective from that which posits that active landscape management in western Canada began when the first Euro-Canadian started to plough.

The take-home message here is that a distinction between "agricultural" and "hunter-gatherer" lifeways is too sharp a dichotomy (V1, p. 265). The plant and landscape management practices of Indigenous people that Turner describes are far from the passive acquiescence to environment that the word "gatherer" conjures up. She comments that the "stereotypical 'hunter-gatherer' paradigm is being increasingly challenged as more becomes known of Indigenous peoples' often subtle but sometimes quite obvious manipulation of species and their environments" (V1, p. 265). This also reflects my understanding as I find the compartmentalism between "hunter-gatherer", "horticulturalist", and "agriculturalist" blurring. In my experience, the archaeological record in western Canada privileges the "hunter" part of the "hunter-gatherer" lifeway, mainly because animal-derived food remains, such as bones, tend to be well-preserved and well-represented, whereas plant-derived food remains are not. Similarly, technology associated with hunting, such as stone projectile points, are also persistent in the archaeological record and have been used as the basis for distinguishing past cultural phases. In contrast, plant food remains or technology associated with plant food processing, such as gathering baskets or grinding stones, either do not preserve or have not, until recently, received the same attention from archaeologists. Today, new techniques, such as residue analysis, are being applied more frequently in research on artifacts and are revealing new details about plant use in the past. Turner also points out that the importance of plant foods may have been overlooked in the ethnographic record because "it is primarily 'women's work,' and the majority of ethnographic information from the Indigenous cultures of the region was recorded by men of European background and culture" (V1, p. 265). Yet she cites research suggesting that for some groups in the interior, plant foods may have "contributed as much as 70 per cent of total dietary calories" (V1, p. 264). This emphasizes the importance of such plant foods to long-term community viability.

In this discussion, I have touched on only a few of the wide-ranging and important themes that weave throughout this study. Turner's synthesis is dense, richly textured, and thought provoking. She writes lucidly and with great authority. This is not, however, a work to be tackled as a continuous narrative. I took several months to work through both volumes, savouring and thinking about each chapter. I found this an enjoyable and rewarding experience. My copies are now filled with marginal notes, underlined passages, and marker flags. I have no doubt that this synthesis will be one of my "go to" works as I continue my palaeoecological research. Nancy Turner offers valuable perspectives on plants of western Canada that complement and extend insights from biology and natural history. I highly recommend these volumes to anyone with an interest in Indigenous lifeways and plant use.

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Some Useful Wild Plants: A Foraging Guide to Food and Medicine from Nature. Revised Edition

By Dan Jason. 2017. Harbour Publishing. 186 pages, 16.95 CAD, Paper.

First published over 45 years ago, *Some Useful Wild Plants* has been revised and reprinted, to help guide and inspire a new generation of foragers and amateur naturalists. The book is a cute, pocket-sized, casual reference guide to edible and medicinal plants found in British Columbia (BC). As the author points out in his introduction, the book was expanded soon after its initial publication to contain species found elsewhere in BC, beyond the Slocan Valley, which was the focus of the first edition. In fact, many of the plants contained in this book are found throughout Canada and are familiar to this reviewer, who has spent all his time in Canada in southern Ontario. (Incidentally, I am travelling tomorrow to BC for the first time – albeit a little late for this review!)

The book's format is simple and easy to digest, typically with each double-page spread containing a description of the habitat in which the species is found, key identification points, and how and when it flowers and/or fruits, in addition to how to utilize each plant for food (preparation, cooking methods, recipe ideas, and uses) and medicinal purposes. Each plant is also accompanied by the original and delightful line illustrations by the author's friend, Robert Inwood.

The medicinal use descriptions tend to be somewhat brief, but they do contain a wealth of information on potential uses and preparation methods, frequently incorporating examples of usage by First Nations people, gleaned first hand from interviews with "herbalists and Doukhobor wild-crafters" (p. 7). There are sufficient simple directions for the beginner herbalist, but I imagine these sections serve as a jumping off point for the serious medicinal forager, who would likely want to consult other resources to obtain more detailed preparation methods.

At first glance, the illustrations are very simple and I questioned their usefulness for positive identification. But further exploration makes one realize how well they fit this field guide and, coupled with an existing knowledge and/or interest in botany, they do provide sufficient key details when matched with the text to help guide oneself to a positive identification. There is not much in the way of technical botanical jargon, which is both a positive for the newcomer and a drawback for seasoned or serious plant nerds. Additionally, given the relatively narrow scope of the species detailed (this is not a comprehensive botanical guide), there is not much potential for confusion in identification. The illustrations have a simplistic beauty to them, which fits well with this guide overall.

The plants covered are organized conveniently into groups such as Herbs & Shrubs, Trees, Seaweeds, and Berries. There is also a rather essential section on Poisonous Plants which, despite containing the same detailed botanical and life history information as the non-poisonous species, perhaps fails to incorporate much in the way of examples of, or links to, non-poisonous species with which they may be confused.

The section on Trees is particularly captivating. Many are species or at least genera with which many of us are familiar. What stands out here is the long list of food and, particularly, medicinal uses for the various parts of these trees, with which many of us are not familiar. Many of the species accounts also detail how to forage sustainably, with tips on how to support the continued growth of the plant. This is a key component of foraging practice which I am very grateful the author included.

Another feature of this book that I particularly enjoyed and found useful was the appendix, which conveniently groups species by their potential use – for example, for food uses, species are listed under "boiled", "candied", "ground for flour", etc. The medicinal uses are grouped by ailment or symptom you want to treat, and the appendix is nicely rounded off by a few "other uses" such as dyes, insect repellents, and soap.

Having not seen the original version of *Some Useful Wild Plants*, it was difficult to know what this revised edition has updated from the original, and the author doesn't detail this in the introduction. Regardless, this is a beautifully printed, accessible, and convenient pocket-sized guide, ideal for referencing in the field, perusing during mundane city commutes (whilst wishing you were in the wilderness!), during peaceful reflection time under a tree during a long hike, or whilst sheltering on a windswept BC beach (I would imagine!). However, to fully embrace foraging for both food and medicinal purposes, and to be 100% sure of what you are consuming or using, I suggest that this guide be accompanied by conventional botanical field guides for plants, shrubs, or trees. Regardless, this serves as an excellent introduction to plant foraging in both BC and throughout Canada.

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ZOOLOGY

Birdmania: A Remarkable Passion for Birds

By Bernd Brunner. 2017. Translated by Jane Billinghurst from the 2015 German edition. Greystone Books. 292 pages, 39.95 CAD, Cloth.

This is a book of trivia ostensibly about the fantastical creatures we know as birds, but mostly about some of the fanatical humans who have wondered about, observed, tracked, caged, killed, and protected them over the centuries.

The 19 chapters are arranged somewhat chronologically, starting with the early Greeks and Romans, through the Medieval Period and the Age of Enlightenment to modern times. It also roughly traces the evolution of bird knowledge from the hypothesis (for example) that birds lacked kidneys and that any excess fluid in their system was directed to the formation of feathers, not urine (put forward by Aristotle), to the rudimentary beginnings of rigorous observation that laid the groundwork for scientific understanding of the lives of birds. There are fewer character sketches from the late 20th century or this century; perhaps because modern scientists are not quirky enough? Or, more likely, they are still alive and it is more difficult to write about their eccentricities!

However, there are really no linkages between chapters and most chapters are quite short, so one can pick up the book and read a chapter, or even part of a chapter, at random because some of the character sketches are only a paragraph or two long. I did find the two longest chapters quite repetitive, with too many similar examples: Chapter 8, "In the company of birds", mostly chronicles numerous people who associated with individual birds, sometimes for decades, or who owned hundreds or thousands of birds in aviaries, while Chapter 11, "To kill or not to kill", became a litany of slaughter. While the author does include some well-known bird devotees such as Alexander Wilson and John James Audubon, he dug deep into the archives to introduce many lesser-known amateurs and professionals. However, the "selected bibliography and source of quotes" at the back of the book would have been a more useful starting point for those wishing to read more about these individuals if it had been arranged by chapter and had page numbers for the quotes.

The illustrations, which are liberally scattered throughout and take up almost a third of the book, are predominantly exquisite colour reproductions from the 18th and 19th centuries. They are well chosen to illustrate the birds or activities written about in each chapter. However, I would have preferred the captions to be with the illustrations, rather than in a list at the back of the book. Also at the back of the book are separate indices for birds and people.

Ultimately this is a book about people passionately pursuing their hobby of interacting with birds in many and varied ways.

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Flock Together: A Love Affair with Extinct Birds

By B. J. Hollars. 2017. University of Nebraska Press. 244 pages, 37.50 CAD, Cloth.

"What must it feel like to be the last person to ever see a species?" (p. 116)

Goosebumps rose across my skin as I read this line, and my imagination immediately ran away. Throughout this entire book, that thought kept crossing my mind. What would it have been like to see the last Ivory-billed Woodpecker (*Campephilus principalis*), or to visit Martha, the Passenger Pigeon (*Ectopistes migratorius*), at the Cincinnati Zoo, knowing this was the last of her kind? *Flock Together* is a tragic love story between humans and extinct birds, the quest to find them again, and the hope that history will stop repeating itself.

I was surprised to learn that the author was neither an ornithologist nor a birder. Normally, I would be slightly sceptical of a book about birds not written by someone who studies them or identifies himself/herself as a birder; however, I found that this characteristic added to the charm of the book. While the book doesn't seem to have a particular audience in mind, it would likely engage those who may be intimidated reading a non-fiction book about birds because little jargon was used throughout. Whether you have an interest in conservation, are a beginning birder, or are a seasoned ornithologist, you will be able to identify with the author's year-long journey. The book documented the author's pursuit of knowledge and his growth as he explored and learned more about these extinct species. It reminded me of what attracted me to the environmental field in the first place, that feeling of hope, wonder, and longing to preserve our natural world.

Flock Together is divided into four sections: glimpsing, spotting, seeing, and knowing. These sections organize Hollars's journey into learning more about extinct species and the people who observed and studied them, as well as his observations on species today. Throughout, the reader is intimately acquainted with the Ivory-billed Woodpecker, to which Hollars refers as his "spark bird", the bird that began his interest in our avian friends. Though the main focus was on the Ivory-billed Woodpecker, we are also briefly introduced to the Passenger Pigeon, the Carolina Parakeet (*Conuropsis carolinensis*), and the Dusky Seaside Sparrow (*Ammodramus maritimus nigrescens*).

While the title suggests a "love affair with extinct birds", we also see Hollars's "love affair" and admiration for those who sought to save the species. We become acquainted with several people including: naturalist Francis Zirrer, conservationist and Passenger Pigeon expert Bill Shorger, painter Don Eckelberry, modern birder Steve Betchkal, and museum curators such as Paula Holahan.

While I was surprised that this book tends to focus more on the people striving to save species from extinction than the species themselves, it was a wonderful read. Hollars did a thorough job researching and trying to understand the lives and perspectives of these individuals in his writing, he projects a modesty that many of us can relate to at a time when we were (or are) fledglings in a field of study. His writing style is also one that is very easy to connect with, free of jargon yet effectively communicating the history of endangered species and the urgency facing many species still alive today. Hollars manages to sound the alarm on human-induced extinction without being overly preachy.

Toward the end of the book, Hollars paves the way for future thought and discussion regarding our role in extinction. While the book did focus on extinct birds, it brings into question the status of all species still present today and how human desires often shape their futures. However, Hollars noted it best when he said, "What we often fail to realize… is how their futures shape our own" (p. 176). This circular narrative is what I enjoyed most about this book. Many of the insights, from both Hollars and others in his book, make us value not only what we could travel to see, but also what is in our own neighbourhood. It reminds us that while we need to strive and protect species that are at risk, we must also place value on keeping common species common.

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Fireflies, Glow-worms, and Lightning Bugs: Identification and Natural History of the Fireflies of the Eastern and Central United States and Canada

By Lynn Frierson Faust. 2017. University of Georgia Press. 376 pages, 32.95 USD, Paper.

This book has a cool cover (a firefly courting in the dark, leaving a glow-trail), reflecting the overall cool of this book (go ahead, read the book and judge for yourself). Second impression: the front cover and opening end paper both unfold to reveal a key to flash/glow patterns and colours of more than 60 species (who knew there were that many?). Very cool.

This book is set up very much like many other family-level monographs; that is, several introductory chapters precede the species accounts. Terminating this book is not only an extensive references section (as in other monographs), but a glossary (not rare, but sadly not universal) and, uniquely in this book, The Selangor Declaration, which briefly explains the issues fireflies (and other species) face, and proposes to governments to encourage more understanding of fireflies and to take steps to protect them.

The first introductory chapter is an introduction to the genera. This is useful, but in my mind, should have ended with a key. The target audience of this book seems to be serious naturalists who may want to explore the fireflies more deeply, and to them a key to specimens would be necessary. In this chapter, we are also introduced to the railroad-worm, *Phengodes*: another glowing insect, but not a firefly. Yes, we are told what it is not, but never told what it is. (Just so you know, it is part of the glow-worm beetle family, Phengodidae, and they are closely related to the fireflies, Lampyridae.)

Further introductory chapters cover diversity, development, survival, predation and parasites, and research advice. There was also a "Frequently Asked Questions" chapter: I've never seen such a treatment outside the internet. I found it an odd collection of miscellanea and, as with similarly-named internet pages, I wonder if all these questions truly are "frequently asked", or if the information presented just didn't fit nicely anywhere else.

The "Species Accounts" are the meat of this book. They are organized by genus, well-described, and profusely illustrated. Just as I lamented the lack of a key to genera, keys to the species are notably absent. I do realize that there are species groups of uncertain composition, but a key could then justifiably end in, for example, "*Photuris versicolor* group" or "*Pyractomena linearis* complex". That aside, all the classic subheadings are here: appearance, range (maps would have been better than text), habitat, similar species, a synopsis of some of the key research, and other notes. The flash pattern is reproduced here, which is convenient despite the patterns being on the front pullouts. Reproducing them meant that no continuous flipping back and forth was required.

As with the great majority of insects, most fireflies do not have common names. However, Faust has included names for each species, most coined by her, a few by others. Some I can live with (e.g., Shadow Ghost, Little Gray) whereas some just seem silly, perhaps intended to catch the attention of children (e.g., Loopy 5, Mr. Mac, Low Slow Glows). I just can't imagine saying some of those names out loud in front of other adults. However, giving a creature a common name brings it an important step closer to being cared about by the general public, so I do applaud that this has been done.

It is conventional in scientific writing to write the formal species name in full (e.g., *Homo sapiens*) the first time it's used, thereafter abbreviating the genus (*H. sapiens*). A problem arises when one deals with two genera, each starting with the same letter. In this book, there are seven genera of fireflies beginning with the letter 'P' (as well as the railroad-worm, *Phengodes*). Despite this, Faust abbreviates the genera in the text, leaving the non-expert unsure of the genus.

Within the "Species Accounts" is a section, "Similar Species". Perhaps just a minor point, but when a similar species is mentioned, the reader will likely want to have a quick look, so a page reference would have been convenient.

Many personal anecdotes describe interactions with dangerous wildlife, traipsing through marshes, the discovery of a new population; all of these should intrigue the novice and bring a sense of déjà vu to those of us who engage in such pursuits. "If you think you can remember everything [that happened in the field], well you can't, and you won't" (p. 66). Truer words were never spoken about a field biologist, one that bears repeating over and over (Randy, are you listening?).

Despite there being a glossary of over 100 terms (which is great!), words are routinely parenthetically defined (and not infrequently redefined over and over) within the text of the book, creating annoying speed bumps in one's reading. Also, the author ignores some standard anatomical terminology and uses alternates that are confusing. For example, Faust uses the phrase "lower margin" of a sternite (a ventral body plate) to mean the "posterior margin". She does this because the photos for which this term is used show a ventral aspect of the specimens with heads pointing to the top of the book, thus making the posterior margin low in the photograph. Why not just use the standards that many readers know, and not introduce non-standard terminology to the new folks?

Despite my few critiques, I enjoyed the book and, more importantly, was inspired by it. I will go to my museum and find out more about our local species, their phenologies, and develop a stronger appreciation for them. Everyone who's seen fireflies aglow is pleased, comforted, or amazed with what they've seen. Who dislikes fireflies? This book will be with you outside at night, with your book light attached, while you try to identify your first flashing firefly to species.

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OTHER

Mourning Nature: Hope at the Heart of Ecological Loss and Grief

Edited by Ashlee Cunsolo and Karen Landman. 2017. McGill-Queen's University Press. 332 pages, 37.95 CAD, Paper, 110.00 CAD, Cloth.

I went out of my usual comfort zone to review this book, feeling that it might be too intellectual for me, but wanting to extend myself a bit. The subject is grief and mourning for environmental change and I have had a share of that, so I felt somewhat qualified. Pamela Banting opines on the cover that, "while scholarly in nature, it [the book] is accessible to general readers who might be struggling with … environmental loss, geographical displacement and activist burnout". There can't be many thinking people who don't qualify in one or more of those categories.

The material in the eleven main chapters covers a huge range of topics, from the fairly obvious (in this context) – mourning in different traditional societies (Chapter 2, Menning) and the ramifications of the decline of sparrows in the United Kingdom (Chapter 4, Whale and Ginn) – to the much less obvious: the way that extinction affects natural soundscapes (Chapter 1, Krause), the role of art in ecological grieving (Chapter 8, Barr), and podcasting environmental grief (Chapter 9, Mark and Battista). A thread that seems to hold many of the chapters together is the idea that grieving is a necessary process in the context of loss, that some sort of catharsis will help us to move on from the source of our grief. The problem with environmental grief is that it seems endless. We are besieged by bad news at every turn: coral bleaching, melting permafrost, species extinctions, particulates in the air, plastic in the ocean: the bombardment never relents. As Arundhati Roy says, in *The God of Small Things*: "…the less it mattered, the less it mattered. It was never important enough. Because Worse Things had happened… Worse Things kept happening".

Krause's chapter on natural soundscapes added another grief for me. Krause suggests that these soundscapes form the basis for human music, surely our greatest achievement and one that impinges very little on the environment. If the gradual fading of nature's sounds – the songs of birds, whales, and frogs, everywhere much diminished, the wind in the trees, the bubbling of free streams, already everywhere channeled and impounded, and the lapping and crashing of the ocean waves, soon to be tamed by wave-power installations – impinges on our ability to create and sustain music, the loss for all of us will be catastrophic.

A much more relevant subject is the role of public grieving via ceremonies, songs, monuments, blogs, and art installations in helping to raise awareness and hence change behaviour towards an ecologically sustainable lifestyle. Most of the chapters touch on this topic, and the authors describe many ingenious ways in which consciousness is being raised, but it is hard not to recognise that after several decades of increasingly shrill warnings, nothing much seems to change.

Who will enjoy reading this book, apart from the obvious audience of similarly interested academics? Actually, enjoy is not the right word here. It is impossible not to be touched by sadness when reading many of the chapters. Perhaps the act of reading the book can become part of our grieving process? I think it will appeal to those who appreciate the sweet sorrow of melancholia, and have some useful and perhaps counterintuitive lessons for those involved, professionally or by avocation, in conservation messaging. However, don't pick it up for a light read. Both in terms of content and of style, this is very heavy going.

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This River Beneath the Sky: A Year on the Platte

By Doreen Pfost. 2017. University of Nebraska Press. 198 pages, 18.95 USD, Paper.

A few years ago, I had the pleasure of spending a couple of days in late March watching Sandhill Cranes (*Antigone canadensis*) along the Platte River near Kearney, Nebraska. I can still conjure up the sight and sound of tens of thousands of cranes flying in to roost for the night on sandbars in the river and leaving again at sunrise. It was deafening and exhilarating. In *This River Beneath the Sky*, Doreen Pfost's lyrical prose brings this grand spring spectacle alive for the reader, but goes beyond the cranes to describe a river that has undergone tremendous changes since Europeans arrived in the area and, more recently, limited restoration. This book is an ode to falling in love with a place where Pfost had despaired of finding magic to hold her (she admits to having hated almost everything about the area when she first moved there).

This River Beneath the Sky is a collection of 12 chapters (essays, really) roughly corresponding to the calendar year, starting with welcoming the cranes back in late March (Chapter 1: "Swept up in a wind-borne river"). In Chapter 2 ("Regarding the aftermath") Pfost discusses the impact of diverting over half of the Platte's flow for agriculture and power generation. This means not just less water overall, but also narrower, incised channels and fewer sandbars; no seasonal flooding of riverside meadows that the cranes depend on for feeding; changes in the timing of the flow; and more riparian forest and invasive weeds because spring floods no longer scour the seedlings away. Pfost goes on to describe these changes in other chapters, through careful observations during rambles throughout the seasons.

While historical anecdotes are sprinkled throughout, Pfost highlights the first impressions of emigrants on the Oregon and Mormon trails in Chapter 3 ("Trails and consequences"), and those of the early homesteaders in Chapter 4 ("Rooted in sand"). Unfortunately, the Pawnee tribe of Plains Indians is only mentioned briefly, in their relationship to bison: when the bison were extirpated, the Pawnee left, too. In the 25 years between 1841 and 1866, it is estimated that some 350 000 emigrants passed westward along the Platte River valley. The trails followed the meandering river through a sea of grass, a "featureless" landscape that drove many early travellers to despair. Within a decade some of the emigrants stopped to homestead in the area and all that grass has now been replaced by irrigated corn fields, towns, cities, and highways.

Pfost returns to the river itself in Chapter 5 ("Of legendary worth"), when she follows the North and South Platte rivers to their headwaters in Wyoming and Colorado. (The simple sketch map included in the book is useful, but a few more place names on it would have been helpful; for instance, Pfost frequently refers to The Big Bend, which I assume is just upstream of where the Platte joins the Missouri River, but it isn't labelled.) Along the way she encounters the series of dams and big irrigation projects that fundamentally altered the river along its entire length. There is often "more river on the fields than in channel" (p. 81). Of course, the impacts from climate change are uncertain, but include less snow in the Rocky Mountains to feed the river and higher temperatures, which will increase evaporation from the fields thus requiring more irrigation water. These human needs will compete more and more with the needs of aquatic systems and wildlife.

Efforts at restoring the river's character, its flow and seasonality, are highlighted in Chapter 6 ("River walkers") and Chapter 7 ("Flickering light on the flyway"). Restoration efforts include removing trees, excavating sloughs, reshaping islands into sandbars, and changing the flow so that water runs through braided channels. Much of the restoration work started at the National Audubon Society's Lillian Annette Rowe Sanctuary, where Pfost volunteers. While in an airplane conducting Whooping Crane (*Grus americana*) surveys, Pfost notices the long, indented streaks where the ground dips in old river channels and writes that "No matter how much water humans take from the river or how much we forget about the Platte's old ways, the land remembers", and she imagines "spreading a great sheet of paper over the fields and rubbing them with chalk to preserve this channel's epitaph", like rubbings made of ancient art (pp. 113–114). In a short recounting of Whooping Crane recovery, Pfost likens the barely two dozen cranes that were the entire population in the 1940s to two cartons of eggs on the kitchen counter, "one sharp elbow away from destruction" (p. 105).

The next four chapters ("Outside home", "This living planet", "Teaching ourselves to see", and "Wonders close to home") are more introspective, perhaps befitting the time of year, late November through February. She takes short walks in nasty weather … "sometimes even a short walk is enough to reset the mind's gyre" (p. 154). She joins other volunteers to count wintering Bald Eagles (*Haliaeetus leucocephalus*) – "when you share what you see with other people, you begin to notice more yourself" (p. 150), and writing observations down is also a way to observe more.

Finally, in Chapter 12 ("Swept up, still and again"), the cranes return. With them come tens of thousands of visitors, wanting to experience one of the last great migrations on the continent. When naturalists and biologists were fighting grand water diversion schemes in the 1960s and 1970s there was little notice of the changes happening to the Platte, but now the influx of visitors has drawn the attention of local communities, businesses, and chambers of commerce, "so the Platte River may benefit from the same principle that protects large flocks of vigilant migrating birds: anything is safer when many eyes are watching" (p. 15).

Ultimately, this is a book of hope, encouraging the reader to "travel not farther but deeper" (p. 170).

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The Book that Changed America. How Darwin's Theory of Evolution Ignited a Nation

By Randall Fuller. 2017. Viking. 304 pages, 27.00 USD, Cloth.

This is a stimulating history set in the 1860s but still germane today. It centres on the American (USA) reception of Darwin's *Origin of Species*, focussing on one copy of the book and on a small group of New England intellectuals and their enthusiastic embrace of Darwin's careful logic and reliance on empirical evidence (aka facts), a marked contrast to the prevailing transcendental thinking of the time. In the preface, Fuller states, "This book is a biography of the single most important idea of the nineteenth century. It is also an account of issues and concerns that are still with us, including racism … and the enduring conflict between science and religion". My own biases would claim the theory of natural selection the most important idea ever and that this book reveals other enduring social ills than just racism.

As someone who has read and thought a great deal about evolution and Darwin for several decades, I have found books on these topics often struggle for novelty of ideas. This book achieved novelty for me in that I had never thought of the *Origin* as a weapon in the war against slavery and virulent racism, despite being aware of Darwin's strong abolitionist sentiments (see *Darwin's Sacred Cause*, by Adrian Desmond and James Moore, 2009, Penguin Books). Indeed, I have always thought that the *Origin* could be used to support slavery given the alternate title "The Preservation of Favoured Races in the Struggle for Life". And Fuller allows that such was the case in the USA, but that the real impact was to "disprove" arguments that African slaves were not merely inferior to "whites" but were a separate and inferior species.

By 1859, America was heading for a conflict over slavery with northerners generally becoming more opposed to slavery whereas in the south slavery was becoming more entrenched. Into this developing cauldron Darwin sent the first copy of his book to a Harvard botanist and good friend Asa Gray. Gray championed the book and the theory of natural selection and the book was passed among four other men, the abolitionist Franklin Sanborn, the philosopher Branson Alcott, the naturalist Henry David Thoreau, and the child welfare reformer Charles Loring Brace. In addition, three influential writers were early readers, Louisa May Alcott, Ralph Waldo Emerson, and Frederick Douglas. The responses and activities of these leading abolitionists are a significant part of the book. Fuller makes the claim that the *Origin* was a bombshell that "blasted American intellectual life to pieces" and led to its reconstitution. I am not so sure he makes this case, but he has put together a wonderful portrait of the religious, social, and scientific battles as America headed into the disastrous civil war, whose tensions still, of course, reverberate today.

Focussed as it is on about three years (1859–1862) and this handful of intellectuals, the book shows splendidly how a single powerful idea can infiltrate and transform every part of a culture and, to some extent in this case, replace its myths with new ones. In this case, the idea was Darwin's brilliant presentation of his theory and the culture was that of pre-civil war America steeped in its beliefs that all species were separately created by a divine being, and that humans were being guided to perfection by this same creator. This culture was being ripped apart by the issue of slavery.

Today, America is writhing in crises engendered by the growing wealth gap and by the continuing discord of rampant sexism and racism, even in our most cherished institutions. But these current battles pale compared to the seething struggle over slavery reflected in the dramatic contrast between the language of the American constitution and the reality of a country built on the brutal institution of slavery. (I won't digress into the systematic extermination of much of the indigenous population nor of the comparatively minor, terrible treatment of various immigrant minorities.) As one reads this historical account, one can't help but drift into thinking about the current chaos in America, or "western" culture for that matter, and wonder if anything has really changed or "progressed" in the century and a half since the publication of the *Origin*.

The central theme of Fuller's account is that the early reception of the *Origin* by the abolitionist forces was enthusiastic, taking it as scientific support for their contention that all "races" were derived from a common origin and were not separate creations, as claimed by many biblical scholars, Christians, and plantation owners. To many abolitionists, the arguments and data in the *Origin* showed that the assessment that black slaves were a lesser, subhuman species was not correct. Fuller expands on this core by recounting the discussion by Gray and the gang of five on the merits of Darwin's theory. Although Fuller includes *Darwin's Sacred Cause* in his bibliography, as far as I can tell he does not mention or refer to it in his text. This is unfortunate because this book makes the argument that Darwin to some extent structured his arguments to reflect his view that slavery and its racist claims were an abomination. I wonder if that bias made the *Origin* more palatable to American abolitionists.

A second theme of the book is that these intellectuals were deeply adherent to the study of nature as a means of revealing the "mind" of the creator and as a guide to how this creator had put humans on a path to "perfection". They pursued these goals by positing "first causes" (i.e., spiritual causes), and as a more mundane matter investigated secondary causes such as physical laws derived from first causes. People often rejected Darwin because he did not address first causes, but instead adhered to clearly empirical, material explanations that could be tested. This approach was attractive to the abolitionists, and they initially overlooked the conflict with their "spiritual" views.

A third theme is that an enthusiastic response to the *Origin* did not extend to all or even most who read it. Many scientists/biologists fulminated against Darwin, perhaps none more famously than the most notorious scientist of the day, Louis Agassiz, like Gray, a Harvard professor. Agassiz campaigned against Darwin and evolution and whole heartedly defended the separate creation of species. He had a profound distaste for African-Americans. He and Asa Gray battled in public, and Agassiz travelled extensively seeking support for his views that blacks were inferior to whites in many ways, though he was against slavery. After Agassiz arrived in America to take his chair in Harvard, his scientific research declined in quality as he became more of a public speaker, making claims such as the study of Nature leading to the "free conception of the Almighty Intellect". Amen!

As the debate over Darwin's ideas hardened, it began to occur to many of his supporters that there was a problem. Gray and others in their initial fervour managed to ignore the contradiction between their religious views and those of the culture of transcendentalism, versus the meat of Darwin's main message. Natural selection is a brutal, totally materialistic explanation, not requiring a divine designer, or any other "spiritual" force. This lack of spirit and the apparently accidental nature of human existence, one no different than that of any of the lesser species, drove even the most committed Darwinists to start bending the theory to fit what they had believed before. Fuller even inserts a smidgen of the dispute between Darwin and Alfred Russell Wallace over Darwin's dismay at Wallace's embracing "spiritualism" and his refusal to accept that humans were not special creations of a great designer.

This sad state of affairs leads to one of the most interesting parts of the book for me. In reading the comments and writings of the key intellectuals included by Fuller, two things seemed apparent. First, not much appears to have changed since 1860. Yes, we now have much greater support for the theory of evolution by natural selection from all areas of science and, yes, we have greatly expanded the culture of Western liberalism regarding civil rights, universal suffrage, equality of race, gender, ethnicity, sexual preference, etc., but creationism, racism, sexism, misogyny, homophobia, and more continue to exist just under the surface, or even above it, in a significant proportion of citizens. Some of these views are less brutal and visible today. Slavery, for example, is not a cornerstone of modern society, but it is not gone nor is it terribly unlikely that it could arise again.

Perhaps the key conundrum of the 1860s was whether all humans descended from a common ancestor like Adam and Eve, or were they separately created and, if so, did this contradict or support biblical "evidence"? This argument seems comical today, doesn't it? Second, the battle between science and religion has barely dimmed. Even though much organized religion has declined in America, the beliefs in gods, spirit, miracles, souls, and the search for "meaning" beyond the cold blade of science continue without abatement. Fuller notes that in his defense of the *Origin*, Asa Gray "suggested" that readers of Darwin had to be open to the possibility that everything they had taken for granted was in fact wrong. That is a difficult possibility to be open to. Fuller states that the tone of Darwin's book, so reserved, so reasonable, cloaked insights that were explosive and unsettling. Even though many of the early supporters of the theory saw this from the start, it took time for those insights to become problematic. Darwin reduced the importance of humans much as Copernicus and Galileo before him and muddled "our" relationship with God. These threats caused unease and still do.

I was surprised by Fuller's assessment of the effect of the *Origin* on Henry David Thoreau. Fuller argues that Thoreau read the *Origin* most closely and was changed by it substantially. "The simple fact that animals must consume other animals to survive" upset Thoreau, yet he saw that Darwin provided an explanation for this "murderous subtext". Competition and struggle influenced the whole economy of nature, created new forms, and was, to use Fuller's phrase, "the cost of doing business". Thoreau made a huge shift in thinking, from seeing Nature as a creation meant to serve man's needs to a view that Nature's organization was accidental, a product of random and haphazard occurrences. There was no design, no plan, and at the individual level chance prevailed. This perspective could hardly be more different than the prevailing "Christian" view of Nature. Thoreau eventually came to revel in the prodigious capacity of life to adapt and multiply. At this point (p. 144), Fuller inserts the inspiring final paragraph of the *Origin*, "It is interesting to contemplate…". Eventually, Thoreau, who collected myriads of data on his daily walks, realized he needed to be organized, like Darwin, and he invented a spreadsheet and meticulously on winter days filled it with his unorganized field notes. He became a scientist searching for a grand unifying pattern of life.

Ultimately, Fuller concludes that Darwin's methodical use of material evidence and hypothesis testing became central to biology, except for those many who could not see the evolution of complex adaptations without the guiding hand of Providence. Loren Eiseley, intellectual heir to Thoreau, summarized the Darwinian view nicely: "We have played roles as amphibians, then reptiles far longer than we have been men. Our identity is a dream" (p. 245). Humans, opined Thoreau, were not products of a divine miracle maker, but a product of lineal descent and geographical distribution. Yet like racism, misogyny, and spiritualism, the divine planner still reigns in the minds of many today.

In summary: I have omitted mention of at least a third of this book. It is filled with stimulating discussion of biology, philosophy, racial issues, and more. It is a great read, don't pass it up.

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The Arctic Guide: Wildlife of the Far North

By Sharon Chester. 2016. Princeton University Press. 544 pages, 27.95 USD, 22.95 GBP, Paper.

The Arctic is often seen as a vast wilderness, or even a frozen wasteland, that could only support a small number of living things, such as Polar Bears (*Ursus maritimus*) and Reindeer (*Rangifer tarandus*). Yet in *The Arctic Guide*, Sharon Chester gives a wonderful overview of the diversity of life in the Arctic and truly demonstrates that the Arctic has a plethora of incredible organisms living there. *The Arctic Guide* is formatted like most standard field guides, with hundreds of pages of species descriptions, distribution maps, and colour plates for identification. However, unlike most field guides, *The Arctic Guide* covers a very wide range of taxa, including plants, some insects, and all vertebrate fauna. And even with this large volume of fauna and flora, the guide is still relatively compact and can easily fit in a small backpack with other essential field gear. Not only does *The Arctic Guide* cover a wide range of taxa, but it also covers a wide geographic range, including all eight countries that lie within the Arctic Circle. Overall, this guide is an excellent overview of Arctic biodiversity for new Arctic travellers interested in biodiversity.

Author Sharon Chester is a wildlife photographer, illustrator, and naturalist who has written several other books about wildlife and natural history, including *A Wildlife Guide to Chile* (2008, Princeton University Press) and *Antarctic Birds and Seals* (1993, Wandering Albatross). She has spent a lifetime learning about the natural world and has thoroughly researched the wildlife presented in this guide. She even provides common names in multiple languages, including local indigenous languages.

An important criticism of this book is that it covers far too many species to go into proper detail for species identification. The small amount of text and single image for most species are not sufficient to differentiate between similar species. This is especially apparent for small mammals, such as shrews and voles. Experienced naturalists should use an appropriate taxa-specific guide for more details about species identification. Similarly, not all scientific names are correct. The author states that scientific names were up-to-date at the time of writing, but may have become out of date during the publication process. Yet some names are more than 10 years out of date at the time of publication. For example, the Wood Frog is called *Rana sylvatica* in the text, yet it has been known as *Lithobates sylvaticus* since 2006 (Crother 2012). Readers interested in up-to-date scientific names should look in taxa-specific reference materials.

The author introduces the Arctic with an overview of different definitions of where the Arctic begins (such as the Arctic Circle [66°34'N] and the tree line), as well as common physical features and zones within the Arctic. This is a very useful section that can help a first-time visitor to the Arctic understand the region. Despite this very clear introduction to what the Arctic is, the author doesn't seem to stick to any given definition when including different species in this book. Species from the boreal and taiga ecozones are included in the guide if they live past the Arctic Circle, and are discussed as much as species that are found only in the Arctic. Perhaps less emphasis should be placed on these sub-Arctic species. Similarly, for species with more southerly distributions, information is presented that is only specific to populations living in the southern extent of their range. For a book focussed on species of the Arctic, the information presented for these species should be specific to populations that live in the Arctic.

The author made a small attempt to include invertebrates in this guide with the section on flies, bees, and butterflies. However, most of this section focuses on butterflies: 3.5 pages were devoted to flies and bees and 20.5 pages to butterflies. Either the chapter could have just focussed on butterflies or more information should have been presented on the other insects. Moreover, this section represents only a small fraction of invertebrate taxa in the Arctic, so justification is needed for the exclusion of other invertebrate taxa. A similar criticism can be made for the section on flora. It is introduced as a section on plants, but then spends 10 pages discussing cyanobacteria, mushrooms, and lichens. This section should therefore be titled a bit more broadly.

Despite these criticisms, *The Arctic Guide* is an excellent introduction for those interested in a wide range of taxa, so long as they are not looking for detailed species accounts or identification information. Then again, a guide covering this same wide range of taxa across the entire Arctic that also included detailed identification features and keys would be at least twice the size, which would remove its current utility as a portable field guide. I would recommend this guide to any naturalists traveling to the Arctic for the first time as a broad overview of the biodiversity that they might encounter.

Literature Cited

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Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming

Edited by Paul Hawken. 2016. Penguin Books. 256 pages, 22.00 USD, Paper.

Climate change is a complex, multi-scale issue that needs to be discussed in the context of its social, ethical, environmental, economic and political drivers, impacts, and solutions. *Drawdown* is part of an emerging conversation that clearly identifies viable solutions while also asking difficult questions about finding our moral compass: What future do we want for humanity? How can wealth be shared more equitably? and How do we create a livable planet for humans and all biodiversity?

The book is a compilation of credible, science-based solutions intended to halt and, more importantly, reverse human caused greenhouse gas (GHG) emissions. Hence the name "Drawdown", something they say we need to embrace if we are to successfully prevent catastrophic impacts of climate change. The book avoids jargon and acronyms, providing a plain language, straightforward discussion of 80 possible solutions under the headings of Energy, Food, Women and Girls, Buildings and Cities, Land Use, Transport, and Materials. There are also 20 Coming Attractions recognizing this is a field of emerging solutions, some of which might work, others not. Nevertheless, there are serious efforts looking for solutions!

Project Drawdown's long list of distinguished "Fellows" and "Advisors" (short biographies provided) have selected and ranked 80 viable climate solutions based on the number of gigatons of carbon dioxide they can reduce or remove in 30 years (2020 to 2050). You will be surprised at the top three solutions: 1. Refrigerant Management (CFCs and HCFCs are 1000 to 9000 times more potent than carbon dioxide as drivers of climate change, and air conditioning and refrigeration use is on the rise globally); 2. Wind Turbines – Onshore (cited as now being the lowest cost source of new electrical capacity); and 3. Reduced Food Waste (efficiency reduces emissions associated with agriculture and food production and transportation, and increases carbon storage by preventing unnecessary deforestation).

The numbers presented are said to be conservative estimates, recognizing the modelled scenarios could do even better with potential declining costs (e.g., solar panels), new technologies, and our willingness to invest. For most solutions the "net cost" of implementation (purchase, install, operate) and "net savings" (based on the cost of the solution compared to following a "business as usual" approach) over the 30 years of analysis are also presented. Cost effectiveness is highly variable and it is not linked to amount of GHG reduction: for solar farms there is a negative net cost of $80.6 billion (i.e., solar farms generate revenue as electricity is sold) and net savings of $5 023.8 billion over conventional electricity generation; for electric vehicles there is a net cost of $14 148.0 billion (people need to manufacture, purchase, and maintain cars) and net savings of $9 726.4 billion (i.e., it's cheaper to stick with conventional internal combustion engine cars). So there are both obvious smart choices (solar farms) and moral choices (consumer driven purchase of electric cars). (See http://www.drawdown.org for the data, analysis, and references associated with each solution.)

Drawdown includes an array of topics presented as concise (2–4 page) discussions that will appeal to a wide audience. You can thumb through the book choosing interesting pieces or focus on specific areas. Did you know peatlands cover 3% of the earth's land surface and are second only to oceans in the amount of carbon they store! *Drawdown* also includes some remarkable essays, such as an excerpt from Pope Francis' encyclical letter "On Care for Our Common Home" and an essay on food by Michael Pollan, author of *The Omnivore's Dilemma*.

Drawdown is enlightening, it's not afraid to criticize itself, exposing data that are weak or probabilities of uptake might be low, and it gives climate change solutions the human dimension needed for us all to embrace the new ethos required to face the new climate world we have created for ourselves. *Drawdown* is highly recommended for those looking for hope that we will be able to face the challenges of the 21st century.

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The Sustainability Dilemma: Essays on British Columbia Forest and Environmental History

By Robert Griffin and Richard A. Rajala. 2017. Royal BC Museum. 448 pages, 34.95 CAD, Paper.

Part of the Royal BC Museum (RBCM) catalogue, the meticulously researched *Sustainability Dilemma* examines British Columbia's (BC's) questionable implementation of post Second World War sustained-yield forestry and multiple-use resource policies. Despite the book's title, the authors do not dwell on sustainability theories; rather, they maintain their focus on negotiations and conflict inherent in the BC Forest Service's execution of "sustained yield" in a system of industrial forestry. In the immediate post-war era, the forest was considered a farm growing a perpetual crop of trees from which to derive revenue. The best way to manage such imagined farms thus became a pressing question, as strategies pursued would either help or harm a range of social and environmental interests. The book begins with Griffin's three-chapter essay that investigates the emergence of sustained yield policies and then those same policies in action. In the second part, Rajala pens two case studies on the conflicts which arose between those attempting to maximize forests and fish. Collectively, the essays discover and analyze rich new archival sources and so extend BC's forest history literature.

Both contributing authors have longstanding relationships with the museum. Both authors also have a tremendous depth of knowledge regarding BC's forest history. Dr. Robert Griffin served as the RBCM history curator for more than 30 years and has written many articles on the forest and mining industries. His most recent output includes *Stewards of the People's Forests: A Short History of the British Columbia Forest Service* (with fellow curator Lorne Hammond; 2014, RBCM). Dr. Richard Rajala is an associate professor of History at the University of Victoria, and a Research Associate at the RBCM. Prior to the volume under review, Rajala's previous book was another fine museum publication, 2006's *Up-Coast: Forests and Industry on British Columbia's North Coast, 1870–2005* (2006, RBCM).

Griffin's shorter three-chapter essay begins the book. Chapter 1, starts in the late 1940s and ends in the late 1970s. Through the period a sustained-yield policy was implemented and thought to be functioning somewhat satisfactorily, despite the forest bureaucracy's inability to shift policies and procedures fast enough to match community expectations. Chapter 2 examines industry responses to the overwhelming task of implementing sustained-yield policies, as represented by an in-depth study of the central-interior company Western Plywood (later known as Weldwood and then West Fraser). This eye-opening material portrays simultaneous cooperation and competition between smaller operators as they sought to manage the provincial timber sales process themselves, via collusion, rather than the Forest Service's bidding practice. Collusion occurred within very specific limits, duplicating similar European industry cartels of the 1890s. Griffin places blame for timber shortages on operator greed and government policy, not Forest Service incompetence as has sometimes been suggested in other unnamed studies. Finally, Chapter 3 explores the major policy changes that sought to maximize use of the resource by minimizing sawmill waste. What waste could not be avoided was redirected as an input for pulp and paper mills.

Griffin sticks very close to the archives, with minimal wider contextualization; almost all of the references are to primary sources with very few to the allied supporting secondary literature. Pace through time was fairly quick, which meant a fast parade-past of individuals, companies, and locations. This would tend to make it a narrative for insiders, rather than the uninitiated. So structured, the text demands some degree of existing knowledge of both logging and forestry; for example, the purpose of planer mills is assumed rather than explained (p. 10). At the outset, the narrative is related from the Forest Service's point of view, rather than politicians, industry, or labour; this changes in the later chapters, which are told from the viewpoint of a particular company. There are many interesting images, though they are left to speak for themselves and were not contextualized as well as they might have been.

The much larger portion of the book is devoted to Rajala's two themed case studies. Both explore the constitutionally-rooted conflicts between provincial forest managers' aspirations to maximize the harvest of wood, and the competing aims of federal fisheries managers and proto-environmentalists who sought to safeguard the spawning habitat of salmon, prized by the commercial fishery, and trout, highly valued by the recreational rod and gun clubs. Chapter 4 provides a very close reading of the Stellako River controversy as it unfolded between 1950 and 1970. In short, this is a local story with national significance, one of "the grandest and most destructive traditions of North American lumbering—the river drive" (p. 121). Conservation discourse of the time suggested that when science was combined with the regulatory power of the State to pursue sustainable practices, conflicts could be resolved via the philosophy of multiple-use. Rajala does a good job of reminding the reader that such an outlook did not imply an equality of uses. The BC forest industry's pre-eminence as a generator of revenues and jobs meant that its requirements more often than not ranked first in the hierarchy. The result being that log drives were allowed on the Stellako, and logs gouged gravel spawning beds and shed tree bark that covered what fish habitat remained. Writer and conservationist Roderick Haig-Brown and fishing-resort owner and anti-log-drive crusader Doug Kelly emerge as heroes of this story, highlighting the environmental leadership provided by sportsmen during the 1960s.

The book's fifth and final chapter turns from the interior to the north coast. One theme that unites Rajala's two cases is the role of science and, more importantly, scientific uncertainty, exploited by capital and the province, to urge inaction with regards to protecting fish spawning habitat in the light of competing resource uses. Here, Riley Creek on Haida Gwaii is the site of higher elevation logging that some feared would result in devastating landslides, slope failures that indeed did occur depositing tonnes of material in the watercourse. This is another story of power and control, with losers such as federal fisheries officer Jim Hart and Haida fisherman Charlie Bellis, and short-term winners like BC Forests Minister Tom Waterland and QC Timber. Rajala insightfully observes that no one won in the end, because those with power wielded it in ways that led to their own ultimate embarrassment (p. 335). Those who thought they had won by successfully advocating for logging practices with unknown risks ultimately assured their loss in subsequent Haida Gwaii land use conflicts. Multiple-use forestry became increasingly discredited, along with the sustained-yield concept, legitimizing a zoning concept of conflict resolution, parks, and a postponement of "meeting the full range of human needs in truly sustainable ways" (p. 335).

Rajala provides a great quantity of fine-grained detail, having scoured every available source and included it in the narrative and notes. The job of deciding what was of greater and lesser importance is left to the reader, a strategy that will limit the potential audience for this important scholarship. For both Chapters 4 and 5, synthesis and contextualization are saved for concluding sections, important larger-scale insights that may have been more profitably shared, or at least alluded to, in the introduction of both pieces, or invoked throughout in a more condensed telling.

In sum, this is an important book by subject matter experts that goes a great distance to understanding BC resource conflicts from the latter half of the 20th century. The essays demand a lot of the reader and are far more specific than the general title would suggest. The layperson might be attracted to the topic but these essays will be most welcome by those already well-familiar with the details of British Columbia's forest industry. The neophyte might more profitably begin with political scientist Jeremy Wilson's 1998 *Talk and Log* (UBC Press), historian Gordon Hak's 2006 *Capital and Labour in the British Columbia Forest Industry* (UBC Press), or even some of Rajala's own previous books. For those more familiar with the field, *The Sustainability Dilemma* charts new archival ground and builds a strong foundation for further work in late 20th century human-environment relations. Perhaps its greatest contribution is in pointing a path forward to understanding the origins of the modern BC environmental movement.

DAVID BROWNSTEIN

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NEW TITLES

Prepared by Barry Cottam

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BOTANY

***Plant Ecology: Origins, Processes, Consequences. Second Edition.** By Paul A. Keddy. 2017. Cambridge University Press. 624 pages, 74.95 CAD, Cloth, 52.00 USD, E-book.

Invasive Plant Species of the World: A Reference Guide to Environmental Weeds. Second Edition. By Ewald Weber. 2017. CABI Publishing. 596 pages, 320.00 USD, 195.00 GBP, Cloth.

Drosera of the World, Volume 2: Oceania, Asia, Europe, North America. By Allen Lowrie, Alastair S. Robinson, Richard Nunn, Barry Rice, Greg Bourke, Robert Gibson, Stewart McPherson, and Andreas Fleischmann. 2017. Redfern Natural History. 554 pages and 665 colour photographs, 33.24 GBP, Cloth.

Plant Conservation Science and Practice: The Role of Botanic Gardens. Edited by Stephen Blackmore and Sara Oldfield. Foreword by Sir Ghillean T. Prance. 2017. Cambridge University Press. 253 pages, 114.95 CAD, Cloth, 51.95 CAD, Paper, 36.00 USD, E-book.

Plant Families: A Guide for Gardeners and Botanists. By Ross Bayton and Simon Maughan. 2017. University of Chicago Press. 224 pages and 300 colour plates, 25.00 USD, Cloth. For sale in North America only.

Nature's Fabric: Leaves in Science and Culture. By David Lee. 2017. University of Chicago Press. 512 pages and 514 colour plates, 35.00 USD, Cloth, 21.00 USD, E-book.

Phylogeny and Evolution of the Angiosperms. Revised and Updated Edition. By Douglas Soltis, Pamela Soltis, Peter Endress, Mark Chase, Steven Manchester, Walter Judd, Lucas Majure, and Evgeny Mavrodiev. 2017. University of Chicago Press. 560 pages, 80.00 USD, Cloth or E-book.

ENTOMOLOGY

***The Secret Life of Flies.** By Erica McAlister. 2017. Firefly Books. 248 pages, 29.95 CAD, Cloth.

The Book of Caterpillars: A Life-Size Guide to Six Hundred Species from around the World. Edited by David G. James. 2017. University of Chicago Press. 656 pages and 2400 colour plates, 55.00 USD, Cloth, 33.00 USD, E-book.

Spiders of North America: An Identification Manual. Second Edition. Edited by Darrell Ubick, Pierre Paquin, Paula E. Cushing, and Vince Roth. Illustrations by Nadine Dupérré. 2017. American Arachnological Society. 425 pages and 1400+ black and white line drawings, 95.00 USD (50.00 USD to AAS members), Spiralbound.

Ant-Plant Interactions: Impacts of Humans on Terrestrial Ecosystems. Edited by Paulo S. Oliveira and Suzanne Koptur. 2017. Cambridge University Press. 452 pages, 97.95 USD, Cloth, 68.00 USD, E-book.

Victory Gardens for Bees: A DIY Guide to Saving the Bees. By Lori Weidenhammer. 2016. Douglas & McIntyre. 240 pages, 22.95 CAD, Paper.

Bee Quest. By David Goulson. 2017. Jonathan Cape. 272 pages, 16.99 GBP, Cloth.

***Insects: Their Natural History and Diversity**: **With a Photographic Guide to Insects of Eastern North America**. **Second Edition, Revised and Updated.** By Stephen A. Marshall. 2017. Firefly Books. 736 pages and 4000 colour photographs, 95.00 CAD, Cloth.

Pheromone Communication in Moths: Evolution, Behavior, and Application. Edited by Jeremy D. Allison and Ring T. Carde. 2016. University of California Press. 416 pages, 75.00 USD, 62.95 GBP, Cloth, 75.00 USD, E-book.

ZOOLOGY

***The Australian Bird Guide.** By Peter Menkhorst, Danny Rogers, Rohan Clarke, Jeff Davies, Peter Marsack, and Kim Franklin. 2017. Princeton University Press and CSIRO Publishing. 560 pages, 39.95 USD, Paper.

The Peregrine Returns: The Art and Architecture of an Urban Raptor Recovery. By Mary Hennen with Peggy Macnamara. Illustrations by Peggy Macnamara and photographs by Stephanie Ware. 2017. University of Chicago Press. 208 pages and 159 colour plates, 25.00 USD, Cloth, 18.00 USD, E-book.

The Seabird's Cry: The Lives and Loves of Puffins, Gannets and Other Ocean Voyagers. By Adam Nicolson. Illustrations by Kate Boxer. 2017. William Collins (Harper Collins imprint). 228 pages, 34.99 CAD, Paper.

Owls: A Guide to Every Species. By Marianne Taylor. 2017. Harper Design (Harper Collins Canada). 256 pages, 60.00 CAD, Cloth, 34.99 CAD, E-book.

Vanished and Vanishing Parrots: Profiling Extinct and Endangered Species. By Joseph M. Forshaw. Illustrations by Frank Knight. Foreword by Noel F. R. Snyder. 2017. Cornell University Press. 344 pages, 95.00 USD, Cloth.

Avian Cognition. Edited by Carel ten Cate and Susan D. Healy. 2017. Cambridge University Press. 348 pages, 114.95 CAD, Cloth.

The Most Perfect Thing: Inside (and Outside) a Bird's Egg. By Tim Birkhead. 2017. Bloomsbury Publishing. 296 pages, 8.99 GBP, Paper, 9.99 GBP, E-book.

Painting the Ice Bear: A Visual Investigation of Polar Bears. By Mark Adlington. 2017. University of Chicago Press. Distributed for Unicorn Press Ltd. 160 pages and 150 colour plates, 37.95 USD, Cloth.

†Moose: Crowned Giant of the Northern Wilderness. By Mark Raycroft. 2017. Firefly Books. 160 pages and 80 colour photographs, 19.95 CAD, Paper.

†Great White Shark: Myth and Reality. By Alexandrine Civard-Racinais. Photographs by Patrice Héraud. 2017. Firefly Books. 144 pages and 116 colour photographs, 19.95 CAD, Paper.

***Encyclopedia of Whales, Dolphins and Porpoises.** By Erich Hoyt. 2017. Firefly Books. 300 pages, 49.95 CAD, Cloth.

Deep Thinkers: Inside the Minds of Whales, Dolphins, and Porpoises. Edited by Janet Mann. 2017. University of Chicago Press. 192 pages and 150 colour plates, 35.00 USD, Cloth, 21.00 USD, E-book.

Pacific Reef & Shore: A Photo Guide to Northwest Marine Life. By Rick M. Harbo. 2017. Harbour Publishing. 96 pages and 300 colour photographs, 12.95 CAD/USD, Paper.

Monkeytalk: Inside the Worlds and Minds of Primates. By Julia Fischer. Translated by Frederick B. Henry, Jr. 2017. University of Chicago Press. 288 pages, 25.00 USD, Cloth, 18.00 USD, E-book.

America's Snake: The Rise and Fall of the Timber Rattlesnake. By Ted Levin. 2016. University of Chicago Press. 520 pages, 35.00 USD, Cloth, 21.00 USD, E-book.

***A Natural History Study of Leech (Annelida: Clitellata: Hirudinida) Distributions in Western North America North of Mexico.** By Peter Hovingh. 2016 (Limited print version), 2017 (Digital version). Self-published. 460 pages. Freely available; the author may be contacted at phovingh@xmission.com for further information.

OTHER

†**The Magnificent Nahanni: The Struggle to Protect a Wild Place**. By Gordon Nelson. 2017. University of Regina Press. 240 pages, 34.95 CAD, Paper.

†**Curators: Behind the Scenes of Natural History Museums.** By Lance Grande. 2017. University of Chicago Press. 432 pages, 35.00 USD, Cloth, 21.50 USD, E-book.

Routledge Handbook of Ecological and Environmental Restoration. Edited by Stuart K. Allison and Stephen D. Murphy. 2017. Routledge. 604 pages, 225.00 USD, Cloth, 59.95 USD, E-book.

Biological Individuality: Integrating Scientific, Philosophical, and Historical Perspectives. Edited by Scott Lidgard and Lynn K. Nyhart. 2017. University of Chicago Press. 400 pages, 75.00 USD, Cloth, 25.00 USD, Paper or E-book.

Messages from Islands: A Global Biodiversity Tour. By Ilkka Hanski. 2016. University of Chicago Press. 272 pages, 100.00 USD, Cloth, 32.50 USD, Paper or E-book.

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

Wildness: Relations of People and Place. Edited by Gavin Van Horn and John Hausdoerffer. 2017. University of Chicago Press. Published in association with the Center for Humans and Nature, https://www.humansandnature.org. 272 pages, 90.00 USD, Cloth, 30.00 USD, Paper or E-book.

Common Ground: Encounters with Nature at the Edges of Life. By Rob Cowen. 2016. University of Chicago Press. 352 pages, 29.00 USD, Cloth, 18.00 USD, E-book.

Patterns in Nature: Why the Natural World Looks the Way It Does. By Philip Ball. 2016. University of Chicago Press. 288 pages and 250 colour plates, 35.00 USD, Cloth, 21.00 USD, E-book.

Orange Omelettes & Dusky Wanderers: Studies and Travels in Seychelles Over Four Decades. By Chris J. Feare. 2017. Calusa Bay Publications. 342 pages and 16 plates with colour photographs, 13.99 GBP, Paper.

The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins. By Anna Lowenhaupt Tsing. 2017. Princeton University Press. 352 pages, 29.95 USD, Cloth, 19.95 USD, Paper.

The Running Hare: The Secret Life of Farmland. By John Lewis-Stempel. 2017. Black Swan. 304 pages, 8.99 GBP, Paper.

The Serengeti Rules: The Quest to Discover How Life Works and Why It Matters. Sean B. Carroll. 2017. Princeton University Press. 263 pages, 16.95 USD, Paper.

100 Nature Hot Spots in Ontario: The Best Parks, Conservation Areas and Wild Places. By Chris Earley and Tracy C. Read. 2016. Firefly Books. 224 pages, 29.95 CAD, Paper.

The Rights of Nature: A Legal Revolution That Could Save the World. By David R. Boyd. 2017. ECW Press. 280 pages, 19.95 CAD, Paper.

The Lost Species: Great Expeditions in the Collections of Natural History Museums. By Christopher Kemp. 2017. University of Chicago Press. 256 pages, 30.00 USD, Cloth, 18.00 USD, E-book.

Our Oldest Task: Making Sense of Our Place in Nature. By Eric T. Freyfogle. 2017. University of Chicago Press. 240 pages, 45.00 USD, Cloth, 36.00 USD, E-book.

Tracks and Shadows: Field Biology as Art. By Harry W. Greene. 2016. University of California Press. 280 pages, 18.95 USD, 14.95 GBP, Paper, 18.95 USD, E-book. Cloth edition published in 2013.

Darwin's Backyard: How Small Experiments Led to a Big Theory. By James T. Costa. 2017. W.W. Norton & Co. 464 pages, 27.95 USD, Cloth.

Half-Earth: Our Planet's Fight for Life. By Edward O. Wilson. 2017. W.W. Norton & Co. 272 pages, 25.95 USD, Cloth, 16.95 USD, Paper.

The Death and Life of the Great Lakes. By Dan Egan. 2017. W.W. Norton & Co. 384 pages, 27.95 USD, Cloth.

Dynamic Forest: Man Versus Nature in the Boreal Forest. By Malcolm F. Squires. Foreword by John Kennedy Naysmith. 2017. Dundurn. 160 pages, 19.99 CAD, Paper or E-Book (PDF), 9.99 CAD, E-book (EPub).

Life at the Edge of Sight: A Photographic Exploration of the Microbial World. By Scott Chimileski and Roberto Kolter. 2017. Belknap Press. 350 pages, 35.00 USD, Cloth.

Planet of Microbes: The Perils and Potential of Earth's Essential Life Forms. By Ted Anton. 2017. University of Chicago Press. 288 pages, 25.00 USD, Cloth, 18.00 USD, E-book.

News and Comment

Upcoming Meetings and Workshops

The Committee on the Status of Endangered Wildlife in Canada

The next Wildlife Species Assessment Meeting of COSEWIC will be held 26 November–1 December 2017 at the Lord Elgin Hotel in Ottawa, Ontario. See how COSEWIC assigns status to Canadian wildlife species, the first step in protection and recovery under the federal *Species at Risk Act*. Please contact ec.cosepac-cosewic.ec@canada.ca for the procedure to attend as an observer at least one week before the meeting begins. More information about COSEWIC is available at http://www.cosewic.gc.ca.

The Society for Integrative & Comparative Biology Annual Meeting

The Society for Integrative & Comparative Biology Annual Meeting, with the American Microscopical Society and The Crustacean Society, to be held 3–7 January 2018 at the San Francisco Marriott Marquis, San Francisco, California. Registration is currently open. More information is available at http://www.sicb.org/meetings/2018/index.php.

Canadian Conference for Fisheries Research

The Canadian Conference for Fisheries Research to be held 4–7 January 2018 at the Westin Edmonton, Edmonton, Alberta. Registration is currently open. More information is available at http://www1.uwindsor.ca/glier/ccffr.

Midwest Fish and Wildlife Conference

The 78th Midwest Fish and Wildlife Conference to be held 28–31 January 2018 at the Hilton Milwaukee City Center, Milwaukee, Wisconsin. The theme of the conference is: ‘Strengthening Natural Resources Through Collaboration’. Registration is currently open. More information is available at http://www.midwestfw.org.

Book Reviews

News and Comment

Upcoming Meetings and Workshops

Mailing date of the previous issue 131(1): 30 August 2017

THE CANADIAN FIELD-NATURALIST **Volume 131, Number 2** **2017**

(continued on inside back cover)

ISSN 0008-3550