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The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

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

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

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Subscription rates for individuals are \$40 (online only) or \$70 (print + online) for volume 125. Libraries and other institutions may subscribe at the rate of \$55 (online only) or \$85 (print + online) for volume 125. The Ottawa Field-Naturalists' Club annual membership fee of \$40 (individual) \$45 (family) \$50 (sustaining) and \$500 (life) includes an online subscription to *The Canadian Field-Naturalist*, with printed issues costing an additional \$30. All foreign subscribers and members (including USA) must add an additional \$8 to cover postage. The club's regional journal, *Trail & Landscape*, covers the Ottawa District and regional Club events and field trips. It is mailed to Ottawa area members, and is available to those outside Ottawa on request. It is available to libraries at \$33 per year. Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be mailed to: The Ottawa Field-Naturalists Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2. Canada Post Publications Mail Agreement number 40012317. Return Postage Guaranteed. Date of this issue: January-March 2011 (August 2011).

COVER: J. Gilhen. Two brown and one bluish-grey Northern Ringneck Snakes (*Diadophis punctatus edwardsii*) from Big Tancoo Island, Mahone Bay, Lunenburg County, Nova Scotia. See pages 69-71 in this issue.

THE CANADIAN
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The Ottawa Field-Naturalists' Club Transactions

Promoting the study and conservation
of northern biodiversity since 1880

THE OTTAWA FIELD-NATURALISTS' CLUB

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Welcome

A New Approach for *The Canadian Field-Naturalist*

The Canadian Field-Naturalist has encouraged the development of numerous careers in the natural sciences since well back into the 19th Century, and publishing it has been the most significant scientific contribution of The Ottawa Field-Naturalists' Club. We are very proud of over a century of documenting important original research concerning the natural environment of northern North America. As the current stewards of its legacy, we take our responsibility to continue the journal's vital contribution into the foreseeable future very seriously.

The current reshaping of *The Canadian Field-Naturalist* is undertaken with care, optimism and determination, humbled somewhat by our historic responsibility. The production of an electronic version of the journal is a reflection of our times; it is the approach of most contemporary cutting edge natural sciences documentation. (You are encouraged to read Jay Fitzsimons' article below on the benefits and opportunities to *The Canadian Field-Naturalist* of 'going electronic'). Electronic publishing also permits us to provide valuable new research, observations and reviews in a timelier manner; an increasingly important consideration going forward. And of course, the economic considerations of the publication and distribution of original research are huge. We *must* produce the journal in a fiscally sustainable manner if we are to continue to meet our responsibilities to the natural science community.

We are well aware of our obligation to preserve these ecologically important articles in a secure and enduring way so we will continue to produce the paper copy

of the journal as well. Producing a hard copy for all subscribers and members is, however, prohibitively expensive. Those who wish to continue to receive the paper copies can do so but we are unfortunately obliged to pass on the extra cost to those readers.

Adding to the historic weight of the moment is the passing of the editorial torch from long time editor Francis Cook to Carolyn Callaghan. Carolyn, with the aid of a strong team within and beyond the OFNC, is directing this reformation of *The Canadian Field-Naturalist*. It is an exciting and important opportunity for all involved. Francis Cook, it must be remembered, oversaw the production of more volumes and more pages of the hard copy version of the journal than any editor in the 132 year history of OFNC. His extraordinary record of production is noteworthy in North American history.

We welcome everyone to this new beginning for *The Canadian Field-Naturalist* and invite you not only to enjoy its continuing and expanded features but also to participate by submitting manuscripts or reviews. We also encourage you to make the updates to *The Canadian Field-Naturalist* known to like-minded associates who value the enduring contribution of the research findings presented in its pages. In portions of three centuries now, *The Canadian Field-Naturalist* has been an important instrument of the field naturalist community. With the support and commitment of naturalists across Canada and beyond, we will ensure that this contribution continues into the foreseeable future.

ANN MACKENZIE,
President, Ottawa Field-Naturalists' Club

DANIEL BRUNTON,
Chairman, Publications Committee

Editorial

The Importance of Natural History and *The Canadian Field-Naturalist* to Natural Science

The discipline of Natural History spans hundreds of years. As a formal discipline, its roots can be traced back to the 18th century Age of Enlightenment (Mayr 1982), and it has spawned a plethora of natural science disciplines, such as geology, palaeontology, biology, ecology, ethology, systematics, and genetics (Arnold 2003). As a practice, however, it has existed since the dawn of humans. Indeed, the very survival of early humans depended on their prowess as naturalists (Fleischer 2005).

So, what precisely is natural history? Definitions vary (Sears 1944; Greene and Losos 1988; Bates 1990; Green 1994; Wilcove and Eisner 2000), but most are based on the notion of direct field observation of living organisms in their environment. Wilcove and Eisner (2000) define natural history as "the close observation of organisms – their origins, their evolution, their behaviour, and their relationships with other species."

The role of natural history as the foundation of good ecological investigation rather than the simple, antiquated musings on nature is understated in the literature and inadequately recognized among scientists in many of the disciplines (ironically) spawned by natural history. Some have argued that the heyday of natural history has passed; that other, more quantitative disciplines, such as ecology and molecular biology, have eclipsed natural history (Peters 1980). The reasons for this are varied, not the least of which is that new generations of scientists naturally migrate to avant-garde developments in their fields (Arnold 2003). Lopez (2001) captured another element of the estrangement: "Firsthand knowledge is enormously time consuming to acquire; with its dallying and lack of end points, it is also out of phase with the short-term demands of modern life." Emerging scientists faced with demands imposed by academic institutions in the fast-paced world of on-line publishing could easily eschew natural history in favour of other, more efficient and "marketable" means of acquiring data.

In response to the marginalizing of natural history by quantitative ecologists, the rebranding terminology of 'scientific naturalist' (Futuyama 1998) was crafted to propose a counter-argument. Moreover, Arnold (2003) noted that: "equations and computer simulation can be powerful weapons in the arsenal of the naturalist." I submit that the corollary is also true: natural history is a powerful weapon in the arsenal of the quantitative ecologist. Natural history, practiced in its raw, descriptive state by professionals and amateurs alike, provides real value to other disciplines of natural science, regardless of whether or not the work is pub-

lished as a stand-alone or incorporated into quantitative analyses.

The collateral damage of the retreat from natural history by other disciplines includes liquidation of natural history collections and dismantling of natural history-oriented curricula within many academic institutions in North America (Noss 1996; Futuyama 1998; Schmidley 2005). The upshot is that field training for undergraduates in most North American Universities is impoverished. One bizarre outcome is that in the absence of in-house expertise, self-taught field naturalists have had to be hired by Canadian universities to provide organism identifications in support of post-graduate field-based studies. The few exceptions offering natural history training include Texas A&M University, Texas Tech University, Evergreen State University, Fort Hayes State University, and University of Vermont (Schmidley 2005) as well as McGill University.

In addition to the degraded quality of natural history training in universities, young children have become increasingly alienated from nature. Whereas children of up to a generation ago received early naturalist training simply as a consequence of the parental mantra 'go outside and play', children today are less exposed to nature due to overprotective parental and community instincts and the omnipotent electronic world. Consequently, children are thrust into a highly-scheduled existence that includes precious little time to explore the world around them. Exposure to nature is the spark that ignites a passion among children with naturalistic intelligence (Gardner 1999). Fortunately, awareness of the pandemic alienation of children from nature is reaching mainstream, and has spawned a movement to remedy effects of the 'nature deficit syndrome' (Louv 2005). It should be noted that organizations such as The Ottawa Field-Naturalists' Club have, and continue to provide excellent training opportunities for naturalists of all ages.

It is ironic that at a time of declining field-based natural history training in North America, our need for highly-skilled field naturalists is greater than ever (Bartholomew 1986; Noss 1996; Dayton and Sala 2001). As habitats and species become increasingly threatened by the unprecedented pace of land-use intensity; as climate change spearheads shifting ranges of species and ecosystems, we will need to have a depth of understanding of species, their taxonomy, habitat requirements, biogeography, and response to anthropogenic threats. As Bartholomew (1986) put it: "knowing natural history allows an investigator to phrase questions with precision."

As an anecdote to the division between natural history and other related disciplines. Bury (2006) advised that: "We need to merge the best natural history, field ecological data, and biological questions with the latest advances in other fields of inquiry if we are to advance science and solve key environmental issues." Publications such as *The Canadian Field-Naturalist* (CFN) provide an important role in disseminating raw natural history information as well as merging various disciplines for the benefit of greater scientific understanding of the natural world. Moreover, published natural sciences data ages well. Unlike physical sciences data, which may become immaterial within a few years, credibly documented natural history data maintains its value. Given that baseline data is critically important to measuring change, one could argue that it increases in value with the passage of time. Natural History documentation from the 19th and 20th Century is regularly referenced in the execution of 21st Century natural sciences. As such, it holds a key place in the broader scientific community.

Despite the peaks and troughs in popularity of natural history, *The Canadian Field-Naturalist* has maintained one of the world's longest traditions of publishing natural history for professionals and amateurs. This issue marks the 125th volume of publication (an unbroken production that, with the CFN's predecessors, extends back over 130 years (Brunton 1986; Brunton 2004). This record is astounding and unmatched by any comparable Canadian publication. All the more impressive considering that it is published *independently* and solely with the support of subscribers and the membership of The Ottawa Field-Naturalists' Club. That remarkable production was substantially assisted in the last decade by proceeds from the generous bequest of former Ottawa Field-Naturalists' Club Honorary Member Thomas Manning (Halliday 2002, Carter 2004).

The team behind this feat deserves note. As the longest-serving Editor of the CFN, Francis Cook has experienced the widening rift between natural history and other disciplines. He has also experienced peaks and troughs of support for his beloved journal, of which he has been a tenacious defender. Francis has also proven to be magnanimous as a mentor of young scientists and amateur naturalists and has amassed a vast network of contacts and correspondents within the natural history world. I am certain that many of you, as you read this, will recall submitting your first paper to Francis during his tenure as Editor of the CFN. Throughout his 34 years as Editor, Francis continued to practice the craft and science of natural history. His expertise as a herpetologist spans far and wide. Moreover, Francis built up an impressive team of Associate Editors who are fellow practitioners of natural history. The fact that almost all Associate Editors have continued with *The Canadian Field-Naturalist* past the tenure of Francis Cook is a testament to his dedication to maintaining a high quality journal of natural history.

I am pleased that Francis will continue to serve the journal as Associate Editor. I also welcome Tom Jung and Claude Renaud as our newest Associate Editors, and Trina Rytwinski as our new Assistant Editor.

I am honoured to have been selected to be the new editor of *The Canadian Field-Naturalist*. It is a position I take with great pride in the journal and in the practice of natural history. Among the many scientific journals that I read professionally, *The Canadian Field-Naturalist* holds the greatest interest for me. I consistently read more articles in the CFN than in other journals. I believe in the important role the journal plays in disseminating natural history as well as in the development of the naturalist community, both professional and amateur.

I am grateful for the support of The Ottawa Field-Naturalists' Club Council and the oversight of the Publications Committee. The high quality of the journal would not be possible without the magnificent talents of Liz Morton, Copy-Editor, Wendy Cotie, Typesetter, Leslie Cody, Indexing, Roy John, Book Review Editor, Frank Pope, Business Manager, Jay Fitzsimmons, Incoming Journal Manager, Sandy Garland, Webmaster, and Jim Ward, who kept the operation running for many years. Chuck Graham of Gilmore Printers provides printing services, and mailing services are provided by Donna Morin of the BMR Group. We thank the contributors for their hard work and the dedication of reviewers, who practice and believe in the peer review system.

We are making every effort to get the journal up to date and published in a timely manner. Great strides in that regard have been achieved in the last year. To maintain this going forward, we have made several changes, not the least of which is to adopt the Open Journal System of on-line publishing. Jay Fitzsimmons reports in this issue on the specifics of the on-line publishing changes we are making to improve efficiency. I am pleased to report that all back issues of *The Canadian Field-Naturalist* from Volume 33 – 120 are now available via the Biodiversity Heritage Library. These issues can be accessed via our website www.ofnc.ca.

It is my hope that we continue publishing this journal independently. Dear readers, enjoy this issue and continue to practice the craft and science of natural history in the tradition of Linnaeus, Darwin, Wallace, Buffon, Macoun, Fletcher, Taverner, Leopold, Schindler, and all of the great naturalist trailblazers.

CAROLYN CALLAGHAN

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The Canadian Field-Naturalist Online

Online publication: A natural progression for *The Canadian Field-Naturalist*

Without dismissing potential limitations, the benefits and opportunities of electronic publication are numerous. For *The Canadian Field-Naturalist*, these are focussed within three main areas, as summarized below.

Online Content

Scientific journals have embraced digital dissemination of information. Among peer-reviewed biology journals, 77% are published online, and this number is growing annually (UlrichsWeb 2011). As the content of scientific journals has become available online, researchers' reading habits have changed (Rowlands 2007). Academic researchers now read more articles from more journals than previously (Ollé and Borrego 2010), get most of the articles they read from the Internet (Tenopir et al. 2009), and overwhelmingly prefer online over printed journals (De Groote and Dorsch 2003). Providing content online, while continuing printed issue publication, is expected to increase access to *The Canadian Field-Naturalist* among researchers. By offering current issues online, *The Canadian Field-Naturalist* is joining the major natural history journals with North American content that are offering such services.

Providing online content should particularly increase readership of *The Canadian Field-Naturalist* among young researchers. While contemporary researchers tend to rely more on online journals than print, this is especially true of young researchers (Tenopir et al. 2009). Thus, if natural history research is to reach young scientists, that research needs to be available online.

Online publication facilitates three actions beyond increased content availability: searching, authorship analysis, and rapid awareness of new issue publication. First, searching for articles via Google Scholar and other public search engines is now a common way for researchers and the public to find research articles. An analysis of *The Canadian Field-Naturalist* website revealed many visitors were directed to our site by Google searches for words in article titles, keywords, or author names. Users can also search for content within the website, which can be more efficient than browsing printed volume indices. Second, authorship analysis is a good way to discover trends in a journal, and such analyses are easier to conduct with digitized journals than print journals because authorship information is already stored in "metadata" associated with each article. Third, readers are now able to register to receive tables of contents by e-mail whenever a new

issue of *The Canadian Field-Naturalist* is published. Such online services enable researchers to stay abreast of current literature (Ollé and Borrego 2010).

Online Manuscript Management

While online journal content affects readers, online manuscript management affects authors, editors, and reviewers. In recent years, manuscripts submitted to *The Canadian Field-Naturalist* have been sent between authors, editors, and reviewers by e-mail, or occasionally by postal mail. This system involved time-consuming work on the part of the editor tracking correspondence. Our new online manuscript management system should improve transparency and efficiency. Authors will submit their manuscript on the journal website and can then track its progress as it is assigned to associate editors and reviewers. Reviewers are automatically reminded of manuscripts they agreed to review if they take longer than the agreed-upon time. Surveys of authors, editors, and reviewers indicate that the majority of people in all three roles prefer online manuscript management systems to e-mail systems (Ware 2005). After incorporating manuscript management systems, journals tend to experience 30% faster manuscript processing (i.e., reviews, revisions, etc.), and 25% higher volume of submissions (Ware 2005). Our editors and reviewers will experience a learning curve as they get accustomed to this new system, but we anticipate it will result in faster, more efficient publication of *The Canadian Field-Naturalist*.

Faster publication is important for two reasons. First, most ecologists consider manuscript processing time when deciding to which journal they should submit their manuscript (Aarssen et al. 2008). Second, given that some articles in *The Canadian Field-Naturalist* have implications for conservation management policies, prompt publication of such articles reduces the risk of delays in conservation policy action (O'Donnell et al. 2010).

Supplementary Files

There are severe limitations to including lengthy supporting data in traditional publications due to the high cost of the additional pages. With electronic publication, however, material that is related to an article but not essential to its message can be published as supplementary files available on the journal website. For example, an article may present statistical summaries of findings, and the raw data file could be included as a supplementary file. Authors will soon

have the option of including supplementary files in *The Canadian Field-Naturalist*.

Over the past 132 years *The Canadian Field-Naturalist* and its predecessors have adapted in response to the needs of those particular times. The changes outlined above will respond to the needs of today's authors and will bring *The Canadian Field-Naturalist* to more people more quickly than previously possible. We also recognize that many readers still appreciate printed copies of *The Canadian Field-Naturalist*. Moreover, maintaining printed copies of the journal safeguards the archives of this very important component of Canadian heritage. We are therefore pleased to continue to provide the printed version of *The Canadian Field-Naturalist*.

JAY M. FITZSIMMONS

Journal Manager, *The Canadian Field-Naturalist*

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Verification of a Forest Rating System to Predict Fisher, *Martes pennanti*, Winter Distribution in Sub-boreal Forests of British Columbia, Canada

GILBERT PROULX

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

Proulx, Gilbert. 2011. Verification of a forest rating system to predict Fisher, *Martes pennanti*, winter distribution in Sub-boreal forests of British Columbia, Canada. *Canadian Field-Naturalist* 125(1): 7–11.

This study verified the ability of a forest rating system to predict the winter distribution of Fisher (*Martes pennanti*) in the Sub-boreal Spruce Biogeoclimatic Zone of central interior British Columbia. Forest polygons (i.e., homogenous areas with similar forest stand characteristics) were classified according to their age and structural development, canopy closure, basal area in mature trees, average tree diameter at breast height, and percentage of shrub cover. Approximately 170 km of transects randomly distributed across polygons were inventoried (snowshoed) from December to February 2005–2008. A total of 278 Fisher tracks were recorded. The observed frequency of Fisher tracks per polygon type was significantly ($P < 0.05$) different from expected. The majority (245 or 88.1%) of tracks were recorded in excellent- and high-quality polygons corresponding mostly to mixed coniferous stands. On average, these stands were 138.2 years old, and had 54.4% canopy closure, 38.1 m²/ha basal area, 27.8 cm dbh, and 11.4% shrub cover. This study showed that the forest rating system was adequate to predict Fisher winter distribution, and could be used to develop forest management plans that are compatible with the species habitat requirements.

Key Words: Fisher, *Martes pennanti*, habitat rating, sub-boreal forest, winter habitat, British Columbia.

In order to predict the distribution of Fisher (*Martes pennanti*) in the Sub-boreal Spruce (SBS) Biogeoclimatic Zone of British Columbia, Proulx (2006a) developed a forest rating system where forest polygons (i.e., homogenous areas with similar forest stand characteristics) were classified according to their age and structural development, canopy closure, basal area in mature trees, average tree diameter at breast height (dbh), and percentage of shrub cover. Proulx (2006a) tested his polygon rating system in Tree Farm License 30 (TFL 30), a relatively small area of the Sub-boreal Spruce (SBS) Biogeoclimatic Zone (Figure 1), and concluded that it was possible to predict Fisher winter distribution using forest inventory data. The SBS Biogeoclimatic Zone is, however, a large area with considerable geographic variation in regional climate and soils (Figure 1). Also, Proulx (2006) recommended that his rating system be tested in other regions of the SBS zone to ascertain his findings.

The objective of this study was to assess and predict the late-winter distribution of Fisher in various regions of the SBS Biogeoclimatic Zone of British Columbia.

Study Area

The study was conducted in central interior British Columbia, within the SBS Biogeoclimatic Zone (Figure 1) where Hybrid White Spruce (*Picea engelmannii*

× *glauca*) and Subalpine Fir (*Abies lasiocarpa*) were the dominant climax tree species (Meidinger et al. 1991). Lodgepole Pine, *Pinus contorta*, occurred in mature forests in the drier parts of the zone, and both Lodgepole Pine and Trembling Aspen (*Populus tremuloides*) were pioneered species in many early-successional stands. Douglas-fir (*Pseudotsuga menziesii*) was at the northernmost border of its natural range and sporadically occurred on dry, warm and rich sites at lower elevations. Black Spruce (*Picea mariana*) was occasionally found in climax upland forests (Meidinger et al. 1991).

The SBS Biogeoclimatic Zone had various subzones on the basis of relative precipitation and temperature (Meidinger et al. 1991; Stevens 1995*). Warmer, drier subzones included Douglas-fir, Soopalie (*Shepherdia canadensis*), Pinegrass (*Calamagrostis rubescens*), and Rough-leaved Ricegrass (*Oryzopsis asperifolia*). Moister, cooler zones typically had Subalpine Fir, Five-leaved Bramble (*Rubus pedatus*), Palmate Coltsfoot (*Petsites frigidus* var. *palmatius*), Clasping-leaved Twistedstalk (*Streptopus amplexifolius*), and Oak Fern (*Gymnocarpium dryopteris*). In order to properly assess Fisher winter distribution across subzones, track surveys were conducted in Supply Blocks of Canadian Forest Products Ltd. and Pope & Talbot Ltd. In the Prince George Forest District (53°55'N, 122°44'W),

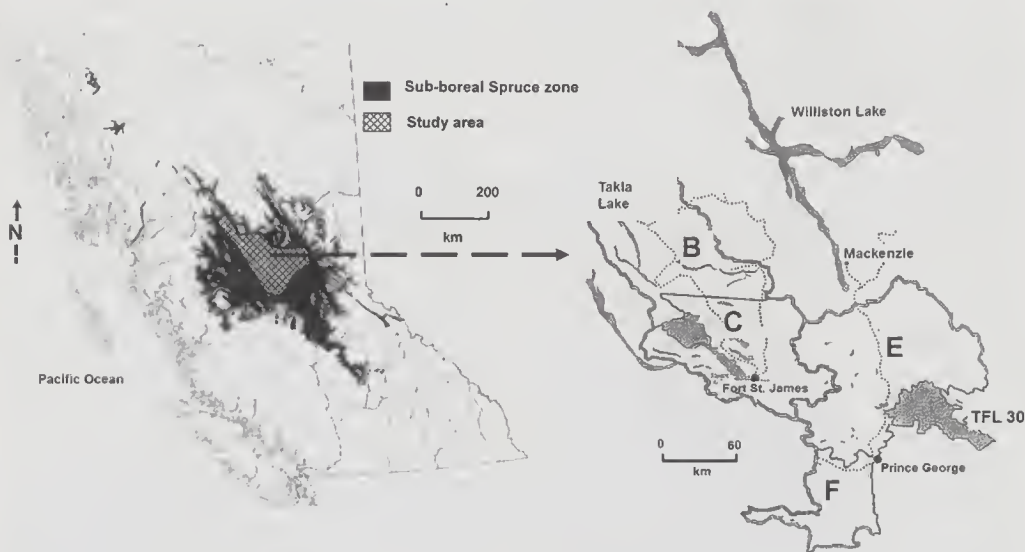


FIGURE 1. Location of study area in central interior British Columbia.

field investigations occurred in Supply Block F (700 000 ha of forested area; dry warm subzone) in the southwest portion of the district, and in Supply Block E (905 000 ha; wet cool and moist cool subzones) in the north (Figure 1). In Fort St. James District ($54^{\circ}27'N$, $124^{\circ}15'W$), the study was conducted in an area (B-C) overlapping the northern portion of Supply Block C and the southern portion of Supply Block B (708 000 ha of forested area; dry warm, moist cool, and wet cool subzones) (Figure 1).

Methods

Predictive Fisher distribution maps

On the basis of Proulx's (2006a) work in TFL 30, I used the British Columbia Vegetation Resources Inventory (VRI; BC Ministry of Sustainable Resource Management 2003*) to rate and classify polygons according to a series of criteria, and produce predictive Fisher distribution maps. The polygon classification considered forest disturbance (presence: 0; absence: 4 points), age (≤ 60 years: 0; 61-80: 1; 81-100: 2; 101-120: 3; and >120 : 5 points), presence of mature or old structural stages (2 points), basal area ≥ 20 m²/ha in mature trees (1 point), $\geq 30\%$ canopy closure (2 points), shrub cover (0%: 0; 5-20%: 1; 20-40%: 2; > 40 : 3 points), and dbh ≥ 27.5 cm: 1 point) (Proulx 2006a). Polygons were classified as excellent- (14-18 points), high- (11-13 points), medium- (6-10 points), or low- (< 6 points) quality. Resulting predictive maps were mosaics of polygons with different potential for Fisher depending on stand characteristics.

Field assessment of polygons

Field assessments were conducted from December to February 2005-2008, in Supply Blocks F (43 transects), E (32 transects), and B-C (71 transects). Transects averaging ≥ 1 -km long on a yearly basis and ≥ 1 -km apart were randomly laid across landscapes and crossed all polygon types. Transect lengths varied according to accessibility, safety, and environmental conditions. Transects were plotted on predictive maps, and starting points were tied by compass bearings and distance to distinctive topographic features. They were inventoried (snowshoed) under various environmental conditions (snow depths: 45-180 cm; temperatures: $-25^{\circ}C$ to $2^{\circ}C$) using a compass, 1:50 000 scale maps, and a hip chain (device with filament) to record linear distances.

We recorded only well-defined tracks, those not melted or deformed, not filled with crusty snow, and judged to be fresh, i.e., ≤ 48 h old since last snow fall (subjective assessment based on the experience of the researcher). Due to the similarity between Fisher and American Marten (*Martes americana*) footprints (Halfpenny et al. 1995), when mustelid tracks were encountered, they were investigated on both sides of transects and within forest stands to find the best tracks available. The combination of footprint (pattern and size, presence/absence of toe pad prints) and trail (gait, distance between jumps, and dragging of the feet) characteristics was used to identify all tracks (Murie 1975; Rezendes 1992; Halfpenny et al. 1995). American Marten tracks are usually smaller, although the foot-

TABLE 1. Winter distribution of Fisher tracks according to polygon types, central interior British Columbia, 2005-2008.

| | Supply blocks | | | | |
|-----------|-------------------------------|---------------|-----------------|-----------------|--------------|
| | F (2005-2007) | E (2006-2008) | B-C (2006-2008) | All (2005-2008) | |
| Low | Total transect length - m (%) | 10716 (26.4) | 11149 (26.2) | 20567 (23.6) | 42432 (24.9) |
| Medium | Number of Fisher tracks (%) | 2 (5.6) | 5 (7.8) | 16 (25) | 2 (1.1) |
| High | | | | | 8 (4.5) |
| Excellent | | | | | 51 (28.7) |
| Total | | | | | 117 (65.7) |
| | | | | | 178 (100)* |
| | | | | | 83219 (48.9) |
| | | | | | 170264 (100) |

*Observed Fisher track distribution significantly different from expected ($P < 0.05$).

prints of female Fishers and male American Martens may be of similar size. In winter, the undersurface of American Marten's feet is heavily covered with hair and toe pads do not show (Murie 1975; Rezendes 1992). The undersurface of Fishers' feet has relatively sparse hair, and pads show well in clear prints (Halfpenny et al. 1995). Fishers tend to create a trough when walking in soft snow, drag their feet, and leave tail drag-marks in the snow (de Vos 1951; Rainc 1983).

Approximate track locations along transects were determined using hip chain distances and forestry maps. Forestry companies provided VRI stand characteristics for polygons where Fisher tracks were recorded; data for a few polygons were not available at time of analysis.

Data analyses

The proportion of inventory transects within each polygon type was used to determine the expected frequency of tracks per type for each supply block, and for all of them together (Proulx 2006a). Chi-square statistics with Yates correction (Zar 1999) were used to compare observed to expected frequencies of track intersects per polygon type (Proulx 2006a; Proulx and O'Doherty 2006). If the chi-square analysis suggested an overall significant difference between the distributions of observed and expected frequencies, a G test for correlated proportions (Sokal and Rohlf 1981) was used to compare observed to expected frequencies for each polygon type (Proulx 2006b). Probability values ≤ 0.05 were considered statistically significant.

Autocorrelation is often present in ecological data and may not be totally avoided (Proulx and O'Doherty 2006). It potentially occurs during analysis of track survey data because of the uncertainty in whether one or more animals have made the tracks being counted. It is difficult to confirm that a series of tracks along a transect belong to the same animal (de Vos 1951) because home ranges overlap (Badry et al. 1997; Weir 2003) and winter dispersal movements are known to occur (Arthur et al. 1993). Because of rugged environmental conditions, we did not follow tracks that crossed close together to learn whether the same animal made them. On the other hand, on the basis of track characteristics, we deduced that two different animals could be as close as 100 m apart along the same transect. To minimize spatial autocorrelation, only tracks ≥ 100 m apart, within the polygon type, were recorded (Proulx and O'Doherty 2006). However, tracks < 100 m apart but in two different polygons were also recorded.

Results

A total of 278 Fisher tracks (36 to 178/supply block) were recorded over 170 264 m of transects (Table 1). In each supply block, $< 8\%$ of Fisher tracks were found in low-quality polygons, but more than two-third of tracks were in excellent- and high-quality polygons (Table 1). In each supply block, the distribution of

tracks per polygon type was significantly ($\chi^2 \geq 8.6$, $df \geq 2$, $P < 0.02$) different from expected (Table 1). Overall, Fishers were selecting for excellent- and high-quality polygons, and avoided low-quality ones (G tests ≥ 6.7 , $P < 0.01$) (Table 1).

VRI information was obtained for 269 tracks. There were 258 tracks in forests: 205 in coniferous (22 in stands dominated by one species, and 183 in mixed coniferous), 43 in coniferous-deciduous, and 10 in deciduous stands. Eleven tracks were recorded in cut blocks and immature stands. On average, forest stands with Fisher tracks were 138.2 ($n = 258$, $SD = 43.6$) years old, and had 54.4 (± 12.6 ; $n = 257$) % canopy closure, 38.1 (± 10.2 ; $n = 255$) m²/ha basal area, 27.8 (± 5 ; $n = 258$) cm dbh, and 11.4 (± 12.9 ; $n = 258$) % shrub cover.

Discussion

Proulx's (2006a) habitat rating was adequate to predict Fisher winter distribution in the whole SBS Biogeoclimatic Zone. Fisher tracks were found mostly in late-successional mixed-coniferous stands in winter, as was found by Proulx (2006a) and Weir and Corbould (2008) elsewhere in the SBS Zone of British Columbia, and Coulter (1966), Arthur et al. (1989) and Raine (1983) in other regions of North America. Lodgepole Pine was present in association with Subalpine Fir, Spruce, and Douglas-fir in mixed coniferous stands that provided Fishers with a multi-layered overhead cover, usually with > 40% canopy closure. Field observations indicated that these forests were also rich in coarse woody debris and snags. Such forests are known to provide Fisher with protection against predators (Powell and Zielinski 1994; Proulx et al. 1994) and deep snow that may limit their movements and distribution (Krohn et al. 1995), and meet their needs for foraging and resting (Weir 2003; Proulx et al. 2004; Weir and Corbould 2008). Coniferous-deciduous stands also provide Fishers with protection and food, and with large deciduous trees that may be used as maternal dens (Weir 2003), particularly in riparian sites (Weir and Corbould 2008).

The biology of Fisher in western Canada is well known (Weir 2003; Proulx et al. 2004; Weir and Corbould 2008), and its winter distribution may be predicted with the forest rating system presented in this study. Therefore, it is possible to develop forest harvest plans that take into consideration Fisher winter habitat requirements. This is particularly important in British Columbia where the species was listed as vulnerable in 1992 (Weir 2003).

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Territory Size in Mixed-grass Prairie Songbirds

STEPHANIE L. JONES^{1,2}

¹U.S. Fish and Wildlife Service, P. O. Box 25486 DFC, Denver, Colorado 80225 USA

² Corresponding author. E-mail: Stephanie_Jones@fws.gov

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I estimated breeding territory size in mixed-grass prairie songbirds, and explored how it varied among bird species, time-of-season, and year. The study was conducted at Bowdoin National Wildlife Refuge in north-central Montana during 2007–2009. Across all species, months and years, mean breeding territory size was estimated at 0.43 ha (SE = 0.03, $n = 129$). Estimates were nearly identical across study species: Sprague's Pipits (*Anthus spragueii*), Grasshopper (*Ammodramus savaannarum*), and Baird's (*A. bairdii*) sparrows. There was no significant variation in territory size across months, suggesting little to no dependence on nest phase. In contrast, I found significant variation in territory size among years ($P = 0.034$), that did not interact meaningfully with species ($R^2 = 0.02$, $P = 0.603$). This suggests that factors that vary annually appear to be affecting all bird species in a similar manner, which could be related to differences in vegetation structure and/or site quality (perhaps as a function of weather) or less likely, variation in population density.

Key Words: Baird's Sparrow, *Ammodramus bairdii*, Grasshopper Sparrow, *Ammodramus savaannarum*, Sprague's Pipit, *Anthus spragueii*, flush mapping, grassland birds, territory mapping.

Territoriality is a common behavioral pattern exhibited by animals in which a portion of the home range is defended. In birds, territories are often defended using agonistic visual and/or auditory displays that may employ flight, posture, plumage (color and pattern), and song (Nice 1941; Whitaker and Warkentin 2010). Many types of territories have been defined, depending on function and time-of-year, ranging from those of the individual to the colony. Nice (1941) defined a "Type A" breeding territory as an exclusive area in which a bird pair may complete its breeding cycle free from conspecific hindrance. Type A territories function in assisting with pair formation, nest success, ensuring paternity, protecting food resources (particularly for young), and reducing disease (Nice 1941; Lack 1966; Whitaker and Warkentin 2010).

Knowledge of territory size is useful for gauging area requirements necessary setting management and conservation goals for populations of interest (Wiens et al. 1985). Such information is also of value in assessing and comparing site quality and habitat within and between geographic areas (Wiens et al. 1985; Whitaker and Warkentin 2010). Unfortunately, data on territory size for many mixed-grass prairie songbirds is sparse (Vickery 1996, Robbins and Dale 1999; Green et al. 2002). In this paper I present estimates of Type A breeding territory size and how it varied among songbird species, year, and time-of-season. Three northern mixed-grass prairie species that defend Type A breeding territories were chosen for study: Sprague's Pipits (*Anthus spragueii*), Grasshopper Sparrow (*Ammodramus savaannarum*), and Baird's Sparrow (*A. bairdii*).

Study Area

Our study was conducted over three years during 2007–2009 at Bowdoin National Wildlife Refuge (NWR) in Phillips County, near the town of Malta in

north-central Montana (48°24'N, 107°39'W; ca. 750 m above mean sea-level). The study area consisted of mostly flat to gently rolling native mixed-grass prairie. The climate was continental and semiarid, characterized by strong winds and high evaporation rates. The plant community was dominated by western wheatgrass (*Pascopyrum suthii*), needle-and-thread (*Stipa comata*), blue grama (*Bouteloua gracilis*), and spike moss (*Selaginella densa*). Low shrubs (*Sarcobatus vermiculatus*, *Artemisia cana*, *Ceratoides lanata*) were widespread but sparse and trees largely absent.

Methods

Territory mapping

I measured territory size using two methods, depending on bird species. For Grasshopper and Baird's sparrows, I used the flush-mapping technique (Wiens 1969), a technique specifically designed for secretive grassland birds that display from the ground or low perches. This method is thought to give practical estimates of territory size, at least for that day and time-of-season (Reed 1985). In this study, I opportunistically located a singing male that was then approached and flushed, with its initial position, flight path, and landing position recorded using Global Positioning System (GPS). This procedure was repeated until a minimum of 10 consecutive flushes were mapped; the individual was not visited again that year.

Sprague's Pipits required a different technique since they extensively display by singing from the air throughout the breeding period (Robbins 1998). Here, positions were estimated by standing directly beneath the singing male, marking the approximate ground position using GPS. Again, a minimum of 10 positions were obtained for each territory, with special attention to delineating the outer area of display.

For all species, mapping was conducted throughout daylight hours, using territorial behavior, primarily singing and countersinging displays, as well as agonistic behaviors, particularly chasing. When the individual male being mapped went out of sight and sound, song playback was then used to call the individual back into the central territory area until 10 unique positions were recorded. Positions for all techniques were marked using a @Garmin GPSmap76CSx, which provided an optimal accuracy of ± 5 m.

Analysis

Universal Transverse Mercator (UTM) coordinates were recorded for each position. Territory positions were mapped, and total area and periphery were calculated using ArcInfo GIS software (Environmental Systems Research Institute 2007*), using minimum convex polygons with Hawth's tool extension in ArcMap (Environmental Systems Research Institute 2007*).

Statistical analyses were conducted using SPSS v. 17.0 (SPSS 2008). Territory estimates were summarized by bird species, (Sprague's Pipit, Grasshopper and Baird's sparrows), month (June vs. July) and year (2007, 2008 and 2009). Effects and their interaction were tested using univariate analysis of variance, treating each factor as fixed. Simple differences in means and proportional reduction in error terms (R^2) were employed as measures of strength. Individual territories were treated as independent sample units, within and among months and years; species, month and year were treated as between-subject factors. *Post hoc* comparisons were conducted using the Bonferroni test (SPSS 2008). Significance level for all statistical tests was set at an α -level of 0.10.

Results

Across all species, months and years, mean Type A territory size was estimated at 0.43 ha (SE = 0.03, $n = 129$; Table 1). Values ranged from a low of 0.10 ha (Baird's Sparrow) to a high of 2.10 ha (Sprague's Pipit). Across all years, mean territory size varied little among bird species (Mean_{range} = 0.03 ha, $P = 0.879$). There was even less variation between June and July, suggesting little, if any, dependence on nest phase (mean_{diff} = 0.01 ha, $P = 0.867$). In contrast, there was variation in territory size among years ($P = 0.034$), that did not interact with species ($R^2 = 0.02$, $P = 0.603$; Figure 1). Mean territory size in 2008 (mean = 0.54 ha, $n = 28$) was significantly greater ($P = 0.030$) than in 2007 (0.35 ha, $n = 54$; Table 1).

Discussion

Territorial behavior may serve to partition available habitat and resources, although this relationship can vary with species, season, year, and with other factors (Fratwell and Lucas 1970). Territorial behavior also serves to space out the birds and minimize (but not prevent) direct competition for food, particularly where

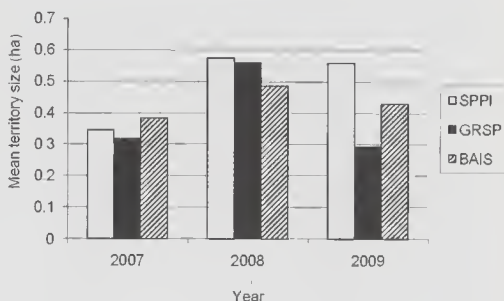


FIGURE 1. Annual variation in Type A breeding territory (Nice 1941) sizes for three grassland species: SPPI = Sprague's Pipit, GRSP = Grasshopper Sparrow, and BAIS = Baird's Sparrow during June and July of 2007–2009 in north-central Montana. Within-year estimates were similar across species most years.

foraging time and space and food availability are reduced (Tryon and MacLean 1980). Birds may not be trying to maximize the number of individuals in an area, but occupying, or attempting to occupy, areas that maximize their reproductive fitness (Fratwell and Lucas 1970).

In this study, territory size estimates were all remarkably similar among species, but not across years. Given the standardized methodology used here, these two findings suggest that the natural factors that determine territory size vary annually and appear to be affecting these three grassland bird species in a similar manner. This could be related to differences in vegetation structure and/or site quality (perhaps as a function of weather) or less likely, variation in population density. Although somewhat taxonomically distinct, the species studied here occupy generally similar ecological niches with regards to foraging substrates, as well as nest-site characteristics and breeding phenology (Dieni and Jones 2003; Jones et al. 2010). Clearly these annual factors could have been causing the notable increase in mean territory size between 2007 and 2008 documented here.

Conversely, I found that mean territory size did not vary with time-of-season. Territory measurements were taken well after the spring arrival of each species (Jones et al. 2010), eliminating the effect of increasing population pressure on territory size due to more arrivals. All three of these species were found to have single frequency peaks in clutch initiation dates during 1997–2007, suggesting a tendency here towards single broods per season (Jones et al. 2010). Therefore, territories defended in July should primarily represent the later stages of breeding and this is what would be expected in Type A territorial defense.

Territory size estimates for the species studied here are generally smaller than that reported in the literature, although relatively few studies have been conducted for either Sprague's Pipits (Robbins and Dale 1999) or

TABLE 1. Territory size statistics for three species of mixed-grass prairie songbirds at Bowdoin National Wildlife Refuge, Montana. Mean territory size did not vary significantly with species or month, but did vary ($P = 0.034$) between 2007 and 2008.

| Factor | Mean ha (SE) | SD | Minimum | Maximum | <i>n</i> |
|---------------------|--------------|------|---------|---------|----------|
| Species | | | | | |
| Sprague's Pipit | 0.45 (0.05) | 0.35 | 0.15 | 2.10 | 41 |
| Grasshopper Sparrow | 0.43 (0.07) | 0.36 | 0.16 | 1.87 | 26 |
| Baird's Sparrow | 0.42 (0.03) | 0.24 | 0.10 | 1.18 | 62 |
| Month | | | | | |
| June | 0.41 (0.03) | 0.22 | 0.10 | 1.13 | 41 |
| July | 0.40 (0.04) | 0.31 | 0.11 | 2.10 | 60 |
| Year | | | | | |
| 2007 | 0.35 (0.03) | 0.19 | 0.10 | 1.13 | 54 |
| 2008 | 0.54 (0.07) | 0.37 | 0.19 | 1.87 | 28 |
| 2009 | 0.46 (0.05) | 0.34 | 0.11 | 2.10 | 47 |

Baird's Sparrows (Green et al. 2002). Davis and Fisher (2009) reported a mean territory size of 2.5 ha (SD = 0.5, $n = 30$) for breeding Sprague's Pipits in Saskatchewan, which exceeds my estimate for this species. Measurement error might explain at least some of the difference but details are unavailable (Davis and Fisher 2009). Robbins (1998) measured dimensions of Sprague's Pipits flight display area, and found that singing displays were limited to a relatively small area (61 m × 55 m, $n = 3$), calculated here roughly to be a mean area = 0.33 ha, which was similar to my estimates, particularly in 2007.

Territory sizes in Grasshopper Sparrows varied across their geographic range, from 0.81 ha (Pennsylvania; $n = 22$) to 1.38 ha (Michigan; $n = 6$) (Vickery 1996). Smaller average territories were reported from 0.19 ha (w. Pennsylvania; $n = 20$) to 0.32 ha (W. Virginia) (Vickery 1996). In a grassland study in Wisconsin, Wiens (1969) reported an average territory size of 0.85 ha (range = 0.32–1.74 ha; $n = 73$). Territories from Bowdoin NWR were small, averaging 0.43 ha (range: 0.16–1.87 ha; $n = 26$), although they were generally within the territory sizes reported for Grasshopper Sparrows. Territory size in Wisconsin (Wiens 1969) changed during the year, decreasing as the breeding season progressed, which was not observed in this study.

In Baird's Sparrow, at Lostwood NWR, North Dakota, territories on plots burned 2 or 4 times between the late 1970s and 1993 ranged from 0.80–2.25 ha ($n = 30$; Winter 1999). This range is larger than in this study, even for 2008 (0.21–0.85 ha). Breeding territory sizes were larger early in the breeding season in North Dakota (Green et al. 2002), which was not the case in this study.

Since the effort here was standardized, temporal comparisons within-species seem valid. However, comparisons between bird species may be suspect in absolute terms. Although flush-mapping method likely gave fairly accurate results for territory size of the two sparrow species studied here, the passive mapping method

employed here for Sprague's Pipit likely underestimated territory size for this species. While measurement errors could account for the observed differences, territory sizes can vary with population density, within individuals, and with nesting phenology. Territory sizes also vary at different portions of the species ranges, within different micro-habitats and with habitat quality (DeGraaf 1989).

Type A territoriality is widely prevalent among bird species; it often has regulation implications that are critical for the conservation of populations and are important in the evolution of interspecific interactions (Rappole et al. 1977). Anich et al. (2009) used radio-telemetry to conclude that mapping accurate locations of singing birds provided reasonable estimates of the primary (Type A) use area, which I measured here, but did not provide accurate estimates of the home range. However, the dynamic, fluctuating nature of bird territoriality can complicate the interpretation of mapping data, and that may make comparisons between studies challenging.

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First Occurrence of Chain Pickerel (*Esox niger*) in Ontario: Possible Range Expansion from New York Waters of Eastern Lake Ontario

JAMES A. HOYLE¹ and COLIN LAKE¹

¹ Ontario Ministry of Natural Resources, Glenora Fisheries Station, 41 Hatchery Lane, Picton, Ontario K0K 2T0 Canada
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In this paper, we document the first Chain Pickerel (*Esox niger*) collected in Ontario and the first on the northwestern side of the St. Lawrence River in Canada. The fish was caught by a local commercial fisherman in April 2008. Since 2008, five additional specimens have been caught and are also documented here: three in 2009 and two more through spring 2010. All individuals were mature adults in robust condition. The appearance of Chain Pickerel in the Ontario waters of eastern Lake Ontario and the upper St. Lawrence River may signal an expansion in the range of this species from New York state waters.

Key Words: *Esox niger*, Chain Pickerel, range expansion, Ontario, Lake Ontario, St. Lawrence River.

The Chain Pickerel (*Esox niger*) is a small to medium-sized member of the pike family (Esocidae). The species prefers warm water, usually inhabits sluggish streams and heavily vegetated lakes, and is a top predator in the fish community (Scott and Crossman 1973). Its native range is primarily the Atlantic coastal plain on the east side of the Allegheny-Appalachian Mountains in the eastern United States. Introductions and range expansions have resulted in a distribution that now extends west of the Allegheny-Appalachian Mountains (Coffie 1998).

The Canadian distribution of the Chain Pickerel includes Quebec (south of the St. Lawrence River and east of Montreal), southern New Brunswick, and Nova Scotia. Its status is Not at Risk in Canada (COSEWIC 1997*; Coffie 1998). The species is not native to New Brunswick or Nova Scotia, and its native status in Quebec seems uncertain (Coffie 1998). Previous reports of Chain Pickerel in Canadian waters of Lake Ontario are considered by Scott and Crossman (1973); and Coffie (1998) to be in error. The historical observation in question was made in 1908, and no confirmed observations of this species have been documented until now. In this paper, we document the first occurrence of Chain Pickerel in Canadian waters of eastern Lake Ontario and the upper St. Lawrence River.

Chronology and Locations of Occurrences

The following chronology documents the occurrences of six Chain Pickerel captured between 25 April 2008 and 10 May 2010 and submitted to the Glenora Fisheries Station of the Ontario Ministry of Natural Resources in Picton, Ontario. Detailed capture, biological and morphometric, and meristic information for these fish is reported in Table 1. Six additional anecdotal reports (fish not physically examined by the authors) are also noted (Table 2). These occurrences represent the first documented Chain Pickerel records in the province of Ontario.

Fish 1

On 25 April 2008, a commercial fisher caught an "unusual pike" while fishing for Yellow Perch (*Perca flavescens*) with gill net gear (57-mm mesh size) near the mouth of Parrotts Bay in the lower Bay of Quinte, Lake Ontario (Figure 1). The fish was submitted (frozen) to the Glenora Fisheries Station on 28 April 2008. The golden, chain-like markings on the flanks of the fish (Figure 2) suggested that the fish was a Chain Pickerel, and this was confirmed by submandibular pore count of 8 (4 on each side), branchiostegal ray counts of 6 + 8 (total 14, ceratohyal + epihyal) on the left side and 6 + 9 (15) on the right side, and prominent vertical subocular bars (Holm et al. 2009). Upper and lower halves of both cheeks and opercula were fully scaled.

The fish appeared to have a fresh Sea Lamprey (*Petromyzon marinus*) wound (skin not broken, diameter of wound 18–20 mm) on the right side just above the pelvic fin. The first fish was not examined internally, but eggs running freely from the body after partial thawing indicated that it was a mature female. These eggs were counted ($n = 724$) and weighed (4.48 g), and an estimate of fecundity thus determined (Table 1). Also caught in the same gill net were Yellow Perch, White Sucker (*Catostomus commersoni*), Northern Pike (*Esox lucius*), Rock Bass (*Ambloplites rupestris*), Longnose Gar (*Lepisosteus osseus*), and Walleye (*Sander vitreus*). This was the first Chain Pickerel observed at the Glenora Fisheries Station, which has been monitoring the local fish community and fisheries since the 1950s.

Fish 2

On 16 September 2009, a single Chain Pickerel was caught near Wolfe Island during a routine fish community index gill netting survey in the Thousand Islands area of the upper St. Lawrence River. This survey has been conducted biennially by Ontario Ministry of Natural Resources staff since 1987. The fish was caught

TABLE 1. Vital statistics for six Chain Pickerel (*Esox niger*) from Canadian waters of the eastern Lake Ontario/upper St. Lawrence River region. The first two fish were subsequently delivered to the Royal Ontario Museum (ROM catalogue numbers indicated). All fish were mature; the degree of gonad development is indicated. Capture locations are illustrated in Figure 1.

| | Fish | | | | | |
|---|-------------------|-------------------------------|-----------------------|-----------------------|-------------------|-------------------|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Source | commercial fisher | Ministry of Natural Resources | commercial fisher | commercial fisher | commercial fisher | commercial fisher |
| Gear | gill net | gill net | hoop net | hoop net | hoop net | hoop net |
| Latitude | 44.208 | 44.234 | 44.198 | 44.198 | 44.187 | 44.187 |
| Longitude | -76.698 | -76.283 | -76.368 | -76.368 | -76.625 | -76.625 |
| Date of capture | 25 April 2008 | 16 September 2009 | 2-12 April 2009 | 2-12 April 2009 | 30 April 2010 | 10 May 2010 |
| Date sampled | 28 April 2008 | 14 October 2009 | 10 March 2010 | 10 March 2010 | 4 May 2010 | 14 May 2010 |
| ROM catalogue no. | 86559 | 86560 | n/a | n/a | n/a | n/a |
| Total length (mm) | 454 | 581 | 571 | 594 | 579 | 564 |
| Fork length (mm) | 420 | 536 | 527 | 553 | 534 | 521 |
| Round weight (before processing or removal of any part) (g) | 762 | 1465 | 1233 | 1169 | 1243 | 1138 |
| Sex | female | male | male | male | male | male |
| State of maturity | ripe and running | gonad developing | gonad fully developed | gonad fully developed | gonad spent | gonad spent |
| Fecundity (eggs g ⁻¹) | 162 | - | - | - | - | - |
| Submandibular pores | | | | | | |
| Left | 4 | 5 | 4 | 4 | 4 | 4 |
| Right | 4 | 4 | 4 | 4 | 4 | 4 |
| Branchiostegal rays | | | | | | |
| Left | 6,8 | 6,9 | 5,9 | 6,8 | 6,9 | 6,8 |
| Right | 6,9 | 6,9 | 5,9 | 5,8 | 6,9 | 5,9 |

TABLE 2. Anecdotal reports of captures of Chain Pickerel (*Esox niger*). Note that a photograph was provided with reports iii and vi. Round weights are approximate.

| | Report | | | | | |
|---|-------------------|-------------------|-------------------|-------------------|-------------------|--------------|
| | i | ii | iii | iv* | v | vi |
| Source | commercial fisher | commercial fisher | commercial fisher | commercial fisher | commercial fisher | angler |
| Gear | hoop net | hoop net | hoop net | hoop net | hoop net | rod and reel |
| Latitude | 44.187 | 44.156 | 44.091 | 44.286 | 44.200 | 43.987 |
| Longitude | -76.625 | -76.898 | -77.306 | -76.265 | -76.345 | -77.002 |
| Date of capture | Spring 2009 | March 2010 | 21 March 2010 | March/April 2010 | 3 May 2010 | 19 June 2010 |
| Photograph provided | no | no | yes | no | no | yes |
| Round weight (before processing or removal of any part) (g) | 1200 | 1200 | 1200 | <75 | 675 | 1200 |
| Number of fish | 1 | 1 | 1 | 4-6 | 1 | 1 |

* Note: Fisher reported a total of 4-6 fish caught in the leader (1 ¼ inch mesh) of a hoop net in late March and early April.

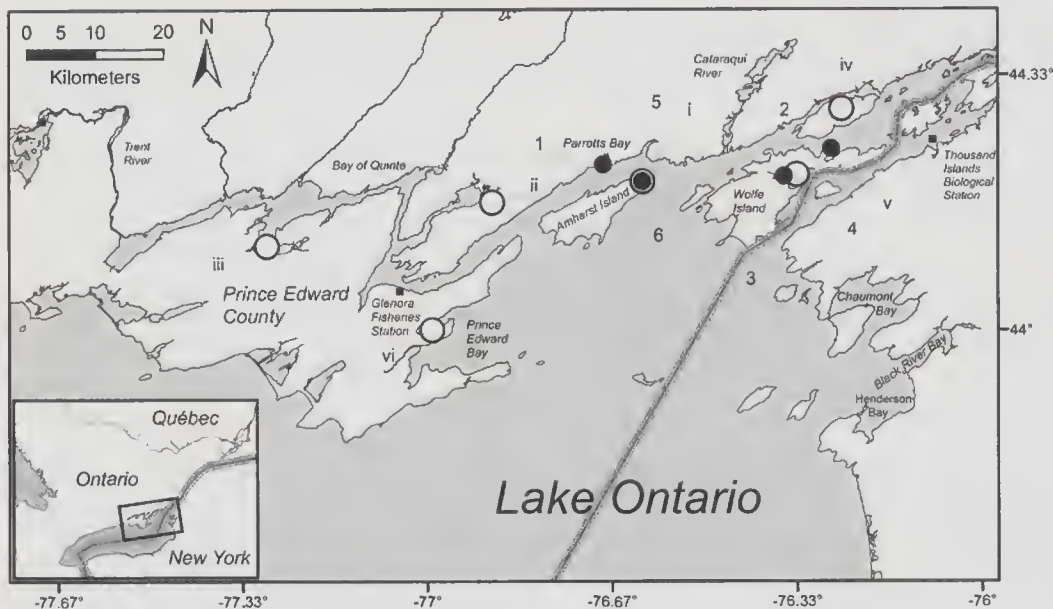


FIGURE 1. Map of eastern Lake Ontario and the upper St. Lawrence River showing occurrences of Chain Pickerel (*Esox niger*) (1 = confirmed, i = anecdotal), as described in tables 1 and 2. Note that anecdotal occurrences iii and vi included a photograph. The Glenora Fisheries Station (Ontario Ministry of Natural Resources) and the Thousand Islands Biological Station (State University of New York College of Environmental Science and Forestry) are also shown.

in the 102-mm mesh panel of a gang of gill net consisting of 10 mesh sizes ranging from 38 to 152 mm (approximately 13-mm intervals). Also caught in the same gill net gang were Yellow Perch, Brown Bullhead (*Ameiurus nebulosus*), Rock Bass, White Sucker, Northern Pike, and Largemouth Bass (*Micropterus salmoides*). The net was located in water 4.8 m deep, and the water temperature and secchi depth readings were 20.4°C and 5.0 m, respectively.

Fish 3 and 4

On 9 March 2010, two Chain Pickerel that had been kept frozen for approximately one year since their original capture some time between 2 and 12 April 2009 were turned in by a local commercial fisher. The two fish had reportedly been caught on a single day, but it is not known whether they were caught in the same hoop net. The fish were submitted to staff at the Glenora Fisheries Station after a presentation by JAH alerted commercial fishers to the presence of Chain Pickerel in the area. Also caught during this same time period were Yellow Perch, Black Crappie (*Pomoxis nigromaculatus*), Northern Pike, sunfish (likely Pumpkinseed, *Lepomis gibbosus*), and White Perch (*Morone americana*).

Fish 5 and 6

These two Chain Pickerel were caught at the east end of Amherst Island by a local commercial fisher, the first on 30 April and the second on 10 May 2010.

The fish were caught on different dates but in the same hoop net set at the same location. Also caught with these Chain Pickerel were Brown Bullhead, American Eel (*Anguilla rostrata*), and redhorse (*Moxostoma* spp.).

Other possible occurrences

Anecdotal reports of additional Chain Pickerel have also been received: one in 2009 and five in 2010. Two of these reports included photographs of the fish. One of these reports involved the capture of multiple fish (a total of 4–6) over several weeks, while the remaining five reports involved single fish (Table 2). Three occurrences were from the same general area as the six fish documented above. The other three were distributed more widely to the west and north (Prince Edward Bay and Bay of Quinte, Lake Ontario) of the original occurrences.

Five of these six possible occurrences were reported taken by commercial hoop net fishers and one was reported taken by angling (Table 2). With the exception of the 4–6 small individuals (report number IV in Table 2), the size range of the fish was similar to the sizes of the six fish documented above (Table 1). Identification of juvenile esocids based on general appearance can be difficult because the colour pattern of juveniles is different from that of adults of the same species. The colour pattern of the juvenile Chain Pickerel is similar to the juvenile Northern Pike, but differs in having fully scaled gill covers and fewer than 10

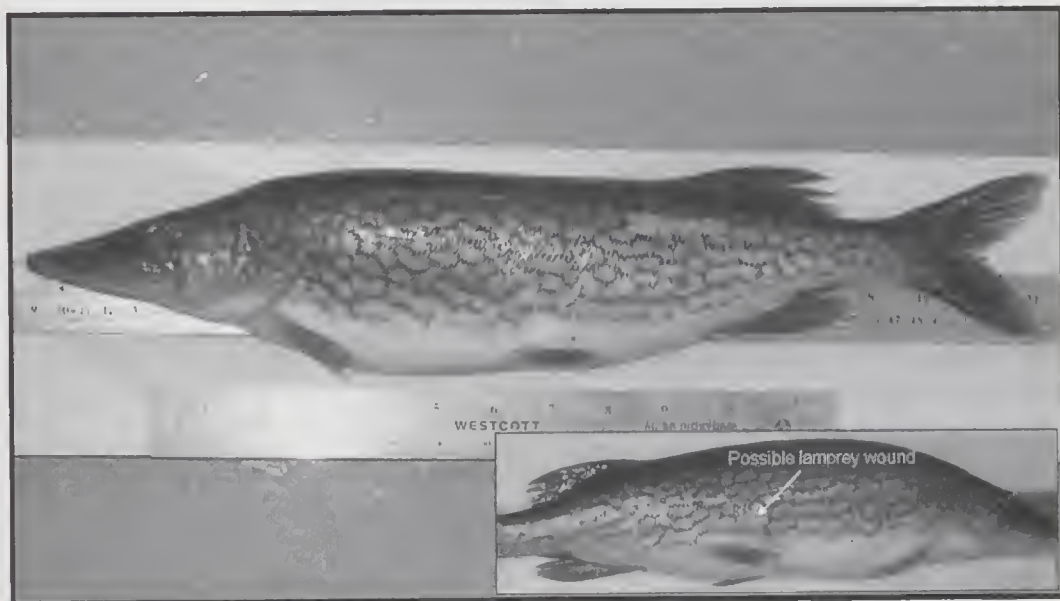


FIGURE 2. Photograph of the first documented Chain Pickerel (*Esox niger*) in the province of Ontario, caught on 25 April 2008 near Parrotts Bay, Lake Ontario (see Fish 1 in Table 1). Inset photo shows possible Sea Lamprey wound on the right side of the fish.

pores on the underside of the lower jaw. The juvenile Chain Pickerel differs from the juvenile Grass Pickerel (*Esox americanus vermiculatus*) and the juvenile Redfin Pickerel (*E. a. americanus*) in having 14–17 rays in each gill membrane (Holm et al. 2009). Although it is tempting to conclude that Chain Pickerel are now successfully reproducing in the area, additional confirmed observations of juvenile fish are required.

Discussion

Where did these Chain Pickerel come from? Coffie (1998) suggested that Chain Pickerel could potentially make their way west, from the Eastern Townships of Quebec, up the St. Lawrence River to Lake Ontario. Although Chain Pickerel records are common in the Eastern Townships, intensive fish surveys in the lower St. Lawrence River during the 1970s, 1990s, and 2000s revealed only two Chain Pickerel, possibly misidentified, in the St. Lawrence River proper, both below Montreal.

It seems very unlikely that a natural movement of the Chain Pickerel from the lower St. Lawrence River to the international sector has occurred to date (Pierre Dumont, Ministère des Ressources naturelles et de la Faune du Québec, personal communication, 7 February 2011). Furthermore, extensive commercial and government index fishing throughout the Ontario waters of the St. Lawrence River did not reveal any Chain Pickerel prior to the present work (Ontario Ministry of Natural Resources, unpublished data). Similarly, exten-

sive and long-term sampling by the New York State Department of Environmental Conservation and by the State University of New York (SUNY) College of Environmental Science and Forestry (Thousand Islands Biological Station) targeting adult and young-of-the-year esocids in New York waters of the upper St. Lawrence River has not yet shown any evidence of Chain Pickerel on the south side of the river to date (Farrell et al. 2007; New York State Department of Environmental Conservation 2010*; J. Farrell, SUNY College of Environmental Science and Forestry, personal communication, 3 February 2011).

In contrast, in the nearby New York waters of eastern Lake Ontario, Chain Pickerel abundance has increased in some areas (i.e., Chaumont Bay, Black River Bay, and Henderson Bay). Chain Pickerel have likely dispersed to these eastern Lake Ontario embayments from the upper reaches of the Black River basin, where the species is common (R. Klindt, New York State Department of Environmental Conservation, personal communication, 31 July 2010). Chain Pickerel are also common in Oneida Lake in the Finger Lakes area of New York State, and movement via the Oneida and Oswego rivers to southeastern Lake Ontario is also plausible (J. R. Jackson, Cornell University Biological Field Station, personal communication, 8 February 2011).

Given the present documented distribution of Chain Pickerel in Ontario waters, it seems most likely that the origin of this new Canadian population is the New

York waters of eastern Lake Ontario. Genetics studies to investigate this hypothesized origin and to examine the degree of hybridization (e.g., with Northern Pike) would be beneficial (see Crossman and Buss 1965; Casselman et al. 1986).

Three other members of the esocid family are native to this area of Lake Ontario. Two, the Muskellunge (*Esox masquinongy*) and Northern Pike, are larger bodied than the Chain Pickerel, and one, the Grass Pickerel, has a smaller body than the Chain Pickerel. All are specialized top predators in the fish community. Northern Pike have shown long-term trends of decline in the Thousand Islands area of the upper St. Lawrence River (Ontario Ministry of Natural Resources 2010*) and New York waters of eastern Lake Ontario (New York State Department of Environmental Conservation 2010*). The upper St. Lawrence River Muskellunge population experienced significant die-offs in 2005 and 2006 related to viral hemorrhagic septicemia (VHS) (ScienceDaily 2007*). These events may have opened niche space for the invading Chain Pickerel. The Grass Pickerel also appears to be expanding its distribution and abundance (J. Farrell, SUNY College of Environmental Science and Forestry, personal communication, 3 February 2011).

The establishment of the Chain Pickerel in this area could have an impact on the other esocids and other piscivores in the fish community that have similar habitat requirements, such as Largemouth Bass. Ecosystem changes to eastern Lake Ontario (especially the Bay of Quinte) following the arrival of zebra and quagga mussels (*Dreissena* spp.), such as clearer water, more aquatic vegetation, and increased abundance of near-shore prey fish species (e.g., Pumpkinseed Sunfish and Bluegill Sunfish, *Lepomis macrochirus*), may favour these ambush, sight-feeding piscivores (Hoyle et al. *in press*).

The appearance of Chain Pickerel in the eastern Lake Ontario and upper St. Lawrence River region may signal a northwestern expansion of the species' range. Mandrak (1989) concluded that Chain Pickerel would invade Ontario from the south under a climate warming scenario. Indeed, Casselman (2002) reported a significant increase in water temperatures in eastern Lake Ontario and the Bay of Quinte over the last 50 years. The Chain Pickerel is adapted to warm water and heavily vegetated, nearshore habitats. For this reason, the St. Lawrence River and the vast open waters of Lake Ontario may represent somewhat of a physical barrier to the expansion of the Chain Pickerel from the south. Having now bridged this barrier, the species appears to be dispersing rather quickly in Ontario waters and it may now be relatively uninhibited in continuing its expansion north into Ontario via the Cataraqui River-Rideau Canal and Trent-Severn waterways, east down the St. Lawrence River, and west around Prince Edward County toward north-central Lake Ontario. Dispersal further west along the north

shore of Lake Ontario may be more difficult because that shoreline is largely devoid of warm, vegetated waters. Presumably, continued range expansion to the north would eventually be limited by water temperature regime. Climate warming in this region of southern Ontario would potentially favour the persistence of Chain Pickerel at the northern edge of its expanded range.

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ADDENDUM

Since the acceptance of this paper the following eight additional Chain Pickerel records have been documented. All fish were caught by commercial fishers in hoop net gear.

TABLE 1. Chain pickerel caught in Ontario, 2011.

| | Fish | | | | | | | |
|-------------------|-----------|-----------|-----------|----------|----------|-----------|-----------|-----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Latitude | 43.951 | 44.200 | 43.969 | 44.187 | 44.218 | 44.187 | 44.187 | 44.187 |
| Longitude | -77.296 | -76.345 | -77.001 | -76.625 | -76.546 | -76.625 | -76.625 | -76.625 |
| Date of capture | 16-Sep-10 | 14-Apr-11 | 27-Apr-11 | 2-May-11 | 7-May-11 | 13-May-11 | 13-May-11 | 13-May-11 |
| Total length (mm) | 575 | 636 | 435 | 535 | 615 | 647 | 625 | 506 |
| Fork length (mm) | 548 | 591 | 407 | 511 | 574 | 598 | 584 | 467 |
| Round weight (g) | 1381 | 2023 | 573 | 1357 | 1640 | 2009 | 1568 | 936 |
| Sex | F | F | M | F | M | M | F | M |

Tardigrades of Fish Creek Provincial Park, Alberta, Canada: A Preliminary Survey

GARY T. GROTHMAN

Natural and Mathematical Sciences Area, St. Mary's University College, Calgary, Alberta T2X 1Z4 Canada; email: gary.grothman@stmu.ab.ca

Grothman, Gary T. 2011. Tardigrades of Fish Creek Provincial Park, Alberta, Canada: a preliminary survey. *Canadian Field-Naturalist* 125(1): 22–26.

Tardigrades are cosmopolitan animals with a patchy distribution record, largely due to the limited collection history for this phylum rather than actual rarity. Most Canadian records are from near coastal areas, with a few notable exceptions, most recently one study of tardigrades in central Alberta. The present study reports the occurrence of 12 species or species groups in Fish Creek Provincial Park in southern Alberta. Eight of these taxa are new records for Alberta, and two (*Diphyscon (Diphyscon) granifer* and *Echiniscus granulatus*) are new records for Canada.

Key Words: Tardigrada, survey, meiofauna, Alberta.

Tardigrades (phylum Tardigrada), also commonly known as water bears, are microscopic invertebrates (normally < 800 μm) (Kinchin 1994) found in ecosystems from the Arctic and the Antarctic to the tropics, on sandy beaches, the ocean bottom, in shallow ponds, and, most famously, in mosses (Kinchin 1994; McInnes 1994). While all tardigrades in their active state are dependent on a film of water and so may be considered aquatic, for convenience those from non-submerged habitats may be described as terrestrial (Ramazzotti and Maucci 1983).

Their most widely recognized characteristic is remarkable resilience, including an ability to survive long periods without water by entering an anhydrobiotic stage in which they crumple down to resemble a speck of dust, surviving for up to 10 years in this desiccated state before being rehydrated and resuming normal life (Jönsson and Bertolani 2001; Bertolani et al. 2004). They have been shown to resist extremes of heat (Doyère 1842; Rahm 1921) and cold (Becquerel 1950; Hcngherr et al. 2009), radiation (May et al. 1964), high pressure, and vacuum (Seki and Toyoshima 1998)—indeed, they are the only animals so far to have been deliberately exposed to the vacuum and radiation of space, which they survived (Jönsson et al. 2008).

Fish Creek Provincial Park (50°55'N, 114°3'W) is a natural area in Calgary, Alberta, at an elevation of approximately 1048 m (Figure 1). The area has long, dry, cold but highly variable winters and short, moderately warm summers; the yearly mean temperature is 4.1°C and the mean annual precipitation is 412.6 mm (National Climate Data and Information Archive 2010*). At 1348 ha, Fish Creek Provincial Park is one of Canada's largest urban parks, and it is almost entirely enclosed within the city (Friends of Fish Creek 2010*).

Fish Creek Provincial Park is at the northwestern edge of the Prairie ecozone, and it contains grasslands, Trembling Aspen (*Populus tremuloides*) woods, ripari-

an forest, White Spruce (*Picea glauca*) forest, and natural and engineered wetlands (Robertson 1991; Friends of Fish Creek 2010*). Trembling Aspens tend to grow at the edge of floodplain terraces, along the tops of north-facing slopes, and in ravines, while riparian vegetation is dominated by Balsam Poplars (*Populus balsamifera*) and willows (*Salix* spp.) (Pinel 1980). White Spruce are located on north-facing slopes and floodplains between the Trembling Aspen and riparian vegetation in the western end of the park (Pinel 1980). Grasslands occur on the floodplain and drier south-facing slopes (Pinel 1980).

Only one previous survey of terrestrial tardigrades has been carried out in Alberta (Boeckner and Proctor 2005). Fish Creek Provincial Park is an ideal location in which to begin a more widespread survey. It not only includes a good mixture of ecosystem types, but it also contains both natural and disturbed areas appropriate for longitudinal studies of anthropogenic impacts on tardigrades. Relatively few studies of the colonization of newly altered environments by tardigrades have been performed (Uhía and Briones 2002; Hohberg 2006), so the colonization of the engineered wetlands recently completed in the Park to treat stormwater runoff from the surrounding communities will be of particular interest (Friends of Fish Creek 2009*). In their cryptobiotic state, tardigrades are easily dispersed by passive transport (Nelson et al. 2009); therefore, terrestrial tardigrades should be fairly early colonizers of disturbed areas, particularly areas with erratic periods of moisture and temperature. Truly aquatic tardigrades, which lack a desiccated "tun" stage with its presumed wind-dispersal capacity, are likely to be less easily dispersed (Nelson et al. 2009).

There is a general need for wider surveys of the distribution of this phylum; the majority of the more than 1000 species described have been found in only one region, or even in only a single sampling site (McInnes



FIGURE 1. Fish Creek Provincial Park, Calgary, Alberta, Canada (Alberta Tourism, Parks and Recreation, Canmore)

1994; Pilato and Binda 2001). This is likely due as much to the patchiness of tardigrade surveys as to any patchiness in tardigrade distribution.

Previous studies that concentrated on or included Canadian tardigrades are usefully summarized in Bateman and Collins (2001), updated by Boeckner et al. (2006). Since the preparation of these two lists, two additional studies have been published (Boeckner and Proctor 2005; Collins 2010). The majority of work has been performed on so-called terrestrial tardigrades, which inhabit mostly moss, lichen, and leaf litter, with only one study, of mountain lakes, including tardigrades of permanent water bodies (Anderson and de Henau 1980).

Methods

In total, 73 samples were collected, and GPS coordinates and location descriptions were recorded. The sampling and processing procedure of Nelson et al. (2009) was used. Samples of dry moss (~250 mL), lichen (~1 mL), and leaf litter (~250 mL) were collected by hand and stored up to one year, but normally less than two weeks, in paper bags in a sealed specimen cabinet. This procedure will have selected against species with little capacity for anhydrobiotic survival.

Samples of aquatic sediment (~125 mL) were collected in jars and processed within six hours.

Dry samples were soaked in bottled water (Culligan) for 16–24 hours, agitated, and filtered through stacked sieves (1.4 mm, 75 μ m, and in some cases 45 μ m). The 75 μ m and 45 μ m sieves were backwashed, with the collected material immediately fixed in boiling 95% reagent alcohol. In cases of heavy burden with inorganic matter, a modification of the procedure of Hallas (1975) was followed: samples were allowed to settle for 5 minutes, the precipitate was re-suspended in 50% sucrose and centrifuged for 5 minutes at 1200 \times g, and then the supernatant was re-filtered through the finest sieve and collected by backwashing with 80% alcohol. Aquatic samples were briefly stirred and allowed to settle to remove the most dense sediment, and then the liquid was decanted and filtered as above.

Samples were examined with a stereomicroscope at 30 \times , and specimens were mounted in polyvinyl alcohol (Bioquip 6371A) for observation with a Leica DME compound microscope using brightfield and phase contrast. Specimens were observed immediately in order to record perishable characters such as colour and eyespots, then the specimens allowed to decolourize for two weeks and were re-observed for internal

TABLE 1. Number of tardigrades, by species in each substrate, recovered from Fish Creek Provincial Park. Abbreviations used: cf. = provisional identification to species; gr. = group of closely related species; sp. = unidentified species of subgenus.

| | Substrate | | |
|--|------------|-----------|-------------|
| | Moss | Lichen | Leaf litter |
| Number of samples that contained tardigrades (total number of samples in parentheses) | 14 (29) | 9 (12) | 7 (14) |
| <i>Diphasco</i> (<i>Adropion</i>) cf. <i>prorsirostre</i> | | 2 | |
| <i>Diphasco</i> (<i>Diphasco</i>) <i>granifer</i> | | | 3 |
| <i>Diphasco</i> (<i>D</i>) <i>pingue</i> gr. | 4 | | |
| <i>Diphasco</i> (<i>D</i>) sp. | | 1 | |
| <i>Echiniscus granulatus</i> | 1 | | |
| <i>Hypsibius convergens</i> | | | 4 |
| <i>Isohypsibius lunulatus</i> | 25 | | |
| <i>Isohypsibius</i> cf. <i>prostomus</i> | 40 | | |
| <i>Isohypsibius tuberculatus</i> gr. | | | 2 |
| <i>Macrobiotus</i> cf. <i>harmsworthi</i> | 11 | 1 | |
| <i>Milnesium tardigradum</i> gr. | 10 | 16 | 4 |
| <i>Paramacrobiotus</i> cf. <i>richtersi</i> | 8 | | 5 |
| <i>Ranzottius oberhaeuseri</i> gr. | 47 | 47 | 3 |
| Unidentified to this level | 141 | 7 | 22 |

morphology. Permanent mounts of all specimens are stored at St. Mary's University College and are available for review.

Identification of specimens was based primarily on the keys of Ramazzotti and Maucci (1983); Dastyh (1988); Nelson et al. (2009); Pilato and Binda (2010). Taxonomy and nomenclature were confirmed with the most recent checklists (Guidetti and Bertolani 2005; Degma and Guidetti 2007; Degma et al. 2010*).

Results

Tardigrades were extracted from fewer than half (33 of 73) of the samples examined. Of 409 tardigrades extracted, 234 could be identified to species or species-group level. As many tardigrades can be identified to species only by differences in egg morphology and few eggs were recovered from these samples, many of the specimens are identified only to subgenus or to a group of closely related species (Table 1). There were a minimum of 1 to a maximum of 5 species (mean 1.7) per positive sample. No tardigrades were found in 11 aquatic samples from engineered ponds, while 3 of 7 samples from Fish Creek or a natural pond yielded only a total of 5 specimens in such poor condition that they could not be readily identified (one *Isohypsibius* sp., two Hypsibiidae, and two other Eutardigrada).

Two species, *Diphasco* (subgenus *Diphasco*) *granifer* (Figure 2) and *Echiniscus granulatus* (Figure 3), are new records for Canada (Bateman and Collins 2001; Boeckner et al. 2006). *Echiniscus granulatus* is a widespread species found in several geographic regions (McInnes 1994), and both species have previously been recovered in North America (McInnes 1994; Bartels and Nelson 2007). *Diphasco* is a new genus for Alberta, represented here by both subgenera *Diphasco* (*D. granifer* and *D. pingue* gr.) and *Adropion* (*D. cf. prorsirostre*). *Isohypsibius lunulatus*, *I. cf.*

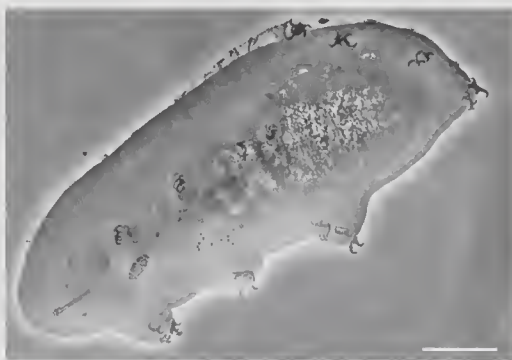


FIGURE 2. *Diphasco* (*Diphasco*) *granifer* beginning to shed (note duplicated claws and cuticle pulling away). Phase contrast. Scale bar = 50 μ m.

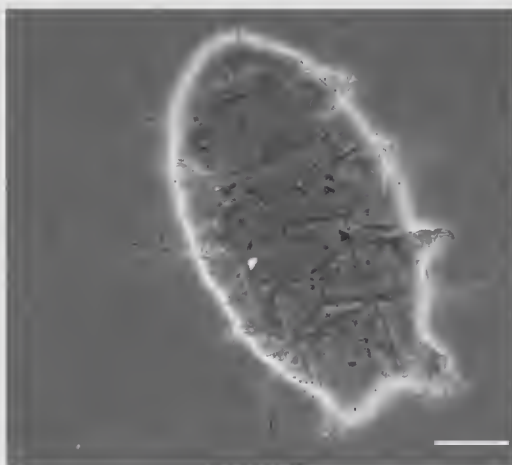


FIGURE 3. *Echiniscus granulatus*. Phase contrast. Scale bar = 50 μ m.

prosotomus, and *Macrobotus* cf. *harmsworthi* have not previously been recorded in Alberta.

Nine of 12 lichen samples contained tardigrades, principally of the *Ramazzottius oberhaeuseri* group (47 individuals) and the *Milnesium tardigradum* group (16). Tardigrades were recovered from half of moss and litter samples (14 of 29 and 7 of 14, respectively). In moss, the *Ramazzottius oberhaeuseri* group (47) was most abundant, followed by *Isohypsibius* cf. *prosotomus* (40) and *Isohypsibius lunulatus* (25).

Discussion

In the absence of eggs, it was not possible to identify the collected *Ramazzottius oberhaeuseri* gr. specimens to species, but close observation suggests the presence of at least three distinct species, based on cuticular coloration and sculpture. Differences in morphology in the macroplacoids and cuticle also suggest that the specimens identified as *Macrobotus* cf. *harmsworthi* and *Paramacrobotus* cf. *richtersi* (listed in Boeckner et al. (2006) by its former nomenclature, *Macrobotus richtersi*) may include multiple closely related species. Further collection and morphometric analysis should permit a more precise determination. *Milnesium*, long considered a monospecific genus, now has 14 new species described in the last two decades (Degma et al. 2010*). It is represented here by the species-group *Milnesium tardigradum* gr.

Of the examined substrates, lichen was most likely to harbour tardigrades, primarily *Ramazzottius oberhaeuseri* gr. and *Milnesium tardigradum* gr., but leaf litter had the most diverse assemblages, with a mean of 2.1 species per positive sample compared to 1.6 for lichen. The two most diverse samples, with 5 and 4 species, were both from leaf litter. This may reflect the diverse nature of leaf litter itself, which can be considered a vertical set of different microhabitats with shallow soil at the bottom. It would be worthwhile in future studies to differentiate leaf litter by the dominant type of vegetation. Trembling Aspen and White Spruce, for example, are expected to produce litter differing in numerous ways. On the other hand, moss yielded the greatest numbers of tardigrades: 20.5 per positive sample versus 8.2 for lichen and 6.1 for leaf litter.

Sample sizes were too small to make strong statements as to species distribution at present, particularly as samples from different substrates were not standardized for mass, but these figures agree generally with previous work, which has shown greater abundance and species diversity in moss and leaf litter than in lichen (Miller et al. 1996; Avdonina 2006; Bartels and Nelson 2007).

Overall, the number of tardigrades recovered was not particularly high, and many samples contained no tardigrades at all. Certainly, yields were considerably lower than those of Boeckner and Proctor (2005), who sampled moss on Black Cat Mountain in central Alber-

ta. It is possible that the more urban nature of Fish Creek Provincial Park contributes to this discrepancy; it is recognized that tardigrade distribution is sensitive to, and a possible biomarker for, air quality (Moly de Peluffo et al. 2006). Fish Creek Provincial Park is a long, narrow park confined to the valley around Fish Creek. Since the Park is largely surrounded by subdivisions and is crossed by two major highways, air quality may be a factor limiting tardigrade distribution.

As expected, no tardigrades were recovered from the water of the recently created wetlands; repeat sampling in future years will be necessary to track colonization of these new environments as well as to make comparisons with similar natural wetlands in the region. It will be interesting to compare these results with observations from a wider area in southern Alberta. Based on reports of seasonality in freshwater and terrestrial tardigrades (several summarized in Kinchin 1994), it would also be useful to look for seasonal variation in tardigrade distribution while monitoring changes in the population of Fish Creek Provincial Park.

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Home Range, Movements, and Habitat Utilization of Striped Skunk (*Mephitis mephitis*) in Scarborough, Ontario, Canada: Disease Management Implications

RICK ROSATTE^{1,2}, PAULA KELLY³ and MIKE POWER⁴

Ontario Ministry of Natural Resources, Wildlife Research and Development Section, Trent University, 2140 East Bank Drive, Peterborough, Ontario K9J 7B8 Canada

¹Corresponding author (e-mail: rick.rosatte@ontario.ca; telephone 705-755-2280)

²385 Arbor Pine Drive, Ortonville, Michigan, 48462 USA

⁴8 Tuch Drive, Keswick, Ontario L4P 3P1 Canada

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A total of 28 Striped Skunks (*Mephitis mephitis*) were fitted with radio-transmitters and their movements were monitored in Scarborough (Toronto), Ontario, in 1986 and 1987. Mean annual home range size for combined sex and age classes of Striped Skunks was 0.9 km² (SD = 1.4) (range = 0.1–5.0 km²). Home ranges were smaller during winter (\bar{x} = 0.04 km², SD = 0.05) than during fall (\bar{x} = 0.67 km², SD = 1.09) (P = 0.055) but not different from ranges during spring (\bar{x} = 0.25 km², SD = 0.31) or summer (\bar{x} = 0.27 km², SD = 0.43). Nightly movements ranged between 0.1 km and 3.0 km and were greatest during October. Skunks were located more often in field habitats (56% of observations) than in residential (23%), field/industrial (10%), or industrial (8%) habitats. Ecological data on Striped Skunks were used in the design of rabies control tactics for use in urban areas in Ontario, Canada.

Key Words: Striped Skunk, *Mephitis mephitis*, home range, movements, Scarborough, Toronto, Ontario.

Striped Skunks (*Mephitis mephitis*) have been a primary vector of rabies in rural habitats of Ontario since the 1960s (Johnston and Beauregard 1969; Rosatte 1988). The disease was also prevalent in Striped Skunks in large urban centres of Ontario, including metropolitan Toronto (Rosatte et al. 1992). In view of this, it was imperative that ecological data be collected on urban Striped Skunks to assist in the design of effective wildlife rabies control programs. A radio-telemetry study was initiated in Scarborough (Toronto), Ontario, during July 1986, to study the movements and ecology of Striped Skunks. Those data were used in the design of rabies control programs targeting urban areas of Ontario. This paper reports on our findings during that study in 1986 and 1987.

Study Area

The study area consisted of an urban complex of 60 km² in Scarborough, Ontario, Canada, centred on 43°42'N, 79°26'W (the eastern part of metropolitan Toronto). The human population density at the time of the study (circa 1986) was estimated at approximately 4200 people/km². The landscape of the study area was a mosaic of habitat classes {see Rosatte (1986) and Rosatte et al. (1987) for a complete description and habitat maps}. The urban complex was intersected by the Rouge River system {see Rosatte et al. (1992) for a map of river systems}.

Methods

Between July and November 1986, 28 Striped Skunks were live-captured with Tomahawk #105, 106, or 108 cage traps (Tomahawk, Wisconsin) baited with sardines, in a 60 km² area of Scarborough, Ontario. Traps were covered with a sheet of plastic to prevent the researcher from being sprayed. Skunks were then immobilized with ketamine hydrochloride (20–30 mg/kg) via hand-held syringe or using a drug-pole containing a syringe, needle, and plunger mechanism, were vaccinated with an intramuscular injection (1 mL) of Imrab inactivated rabies vaccine (Merial Inc., Athens, Georgia) and DPAL (disptemper, parvovirus, adenovirus, leptosporosis), were fitted with a VHF radio-collar or implantable transmitter (148–152 Mhz, Lotek Engineering, Newmarket, Ontario, or Holohil Systems, Woodlawn, Ontario), and were released at the point of capture. Some juvenile Striped Skunks were handled without drugs using a net or bag. Striped Skunks were classed as adult male, adult female, juvenile male, or juvenile female.

Of the 28 Striped Skunks, 10 were adults (6 males, 4 females); they were fitted with radio-collars. The remaining 18 Striped Skunks (10 juvenile females, 7 juvenile males, and 1 adult male) were captured (same area) and immobilized, and transmitters (22.9 g, 7.5 cm long, 2 cm diameter) (Lotek, Newmarket, Ontario) were implanted in the peritoneal cavity, as detailed by Rosat-

te and Kelly-Ward (1988). Five of the implants malfunctioned during the course of the study and were replaced by radio-collars.

Striped Skunks were located with Lotek SRX 400 receivers and Yagi antennae (Lotek Engineering, Newmarket, Ontario) from 25 July 1986 to 1 July 1987. Some Striped Skunks were monitored continually on some nights of each month during the study, while others were located just once per day. During nightly tracking, Striped Skunks were located every 15–60 minutes from dusk to dawn, the frequency of locations depending on how many animals were being monitored. Locations (called “fixes”) were calculated by the intersection of two or three compass bearings from the observer to the Striped Skunk’s location, which was plotted on topographical maps. Striped Skunks were also located during the day at their den sites, and in some cases active animals were observed and their locations noted. As the distance from the observer to the animals was small (<100 m), any errors associated with triangulation were negligible. The type of habitat in which the Striped Skunks were located was also recorded. Habitats were classed as field, industrial, groomed grass, forested park, commercial, or residential. On some occasions, skunks were located on the border of field and industrial habitats. If this occurred, the habitat was classed as field/industrial although it was impossible to calculate the percentage of the area that was deemed to be field/industrial.

Home ranges using a Minimum Convex Polygon estimator were calculated using Home Range Tools for ArcGIS® software (Rodgers et al. 2005). An estimate is provided for annual and seasonal ranges of Striped Skunks using the total number of locations. At least 30 fixes were required for annual range analysis and 15 fixes for seasonal range analysis. This was determined by examining the data to estimate when additional fixes did not affect home range size. Seasonal home ranges included spring (March–May), summer (June–August), fall (September–November), and winter (December–February). Dispersal was arbitrarily defined as a movement of ≥ 1 km from the natal or summer home range. To determine the potential for Striped Skunks to spread infectious diseases, the maximum distance across annual home ranges was calculated using a line measurement tool (display travel) in Home Range Tools, ArcMap version 9.2, an option in ArcGIS®. The cumulative distance travelled by Striped Skunks on a nightly basis was also calculated using the display travel function.

Data were analyzed using Statistica 6.0 software. A main effects ANOVA was used to determine whether there were differences in age (adults vs. juveniles) or sex (males vs. females) in annual and seasonal home range size, whether there were differences in the maximum distances across home ranges, and whether there were differences in habitat utilization (Zar 1999). A one-way ANOVA was used to examine individual sex

TABLE 1. Mean (SD) annual and seasonal home ranges (km²) of Striped Skunks, *Mephititis mephitis*, radio-tracked in Scarborough, Ontario, during the period July 1986 to July 1987.¹

| | Adult female | Adult male | Juvenile female | Juvenile male | Adults | Juveniles | Females | Males |
|--------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Annual | 0.3 (0.1) n = 4 | 0.5 (0.3) n = 3 | 1.0 (0.5) n = 6 | 2.0 (1.5) n = 3 | 0.4 (0.1) n = 7 | 1.3 (0.6) n = 9 | 0.7 (0.3) n = 10 | 1.2 (0.8) n = 6 |
| Spring | 0.1 (0.06) n = 4 | 0.4 (0.3) n = 2 | 0.3 (0.2) n = 4 | 0.2 (0.17) n = 2 | 0.3 (0.2) n = 6 | 0.3 (0.2) n = 6 | 0.2 (0.1) n = 8 | 0.3 (0.2) n = 4 |
| Summer | 0.1 (0.1) n = 2 | 0.3 (0.03) n = 2 | 0.3 (0.03) n = 6 | 0.5 (0.2) n = 4 | 0.2 (0.1) n = 4 | 0.4 (0.3) n = 10 | 0.3 (0.2) n = 8 | 0.4 (0.1) n = 6 |
| Fall | 0.3 (0.1) n = 3 | 0.2 (0.08) n = 6 | 0.9 (0.4) n = 6 | 0.5 (0.3) n = 5 | 0.3 (0.1) n = 9 | 0.8 (0.4) n = 11 | 0.6 (0.3) n = 9 | 0.4 (0.1) n = 11 |
| Winter | 0.04 (0.01) n = 4 | 0.02 (0.01) n = 3 | 0.05 (0.03) n = 4 | 0.01 (0.01) n = 2 | 0.04 (0.01) n = 7 | 0.01 (0.01) n = 6 | 0.03 (0.01) n = 8 | 0.02 (0.01) n = 5 |

¹Means are weighted means; SD = standard deviation; n = sample size; Spring = March–May, Summer = June–August, Fall = September–November, Winter = December–February.

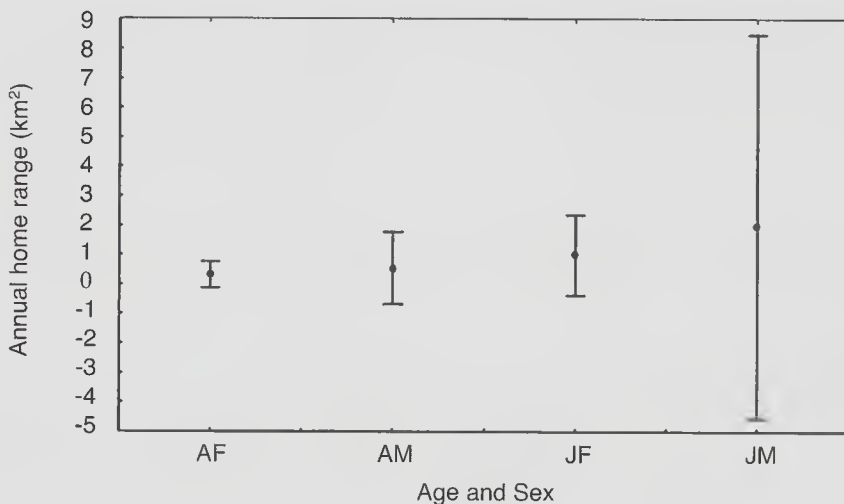


FIGURE 1. Mean annual home range size (95% confidence interval) for 16 Striped Skunks, *Mephitis mephitis*, radio-tracked in Scarborough, Ontario, during the period July 1986 to July 1987 (AM = adult male; AF = adult female; JM = juvenile male; JF = juvenile female; mean = weighted mean).

and age differences in home range size for each season as well as to detect differences in nightly movements of Striped Skunks on a monthly basis (only for March to November, as Striped Skunks denned during the winter (December to February)) (Zar 1999). As there were unequal numbers of home range values for different age and sex classes, the ANOVA calculated the weighted mean home range size (Zar 1999). If differences were found with the one-way ANOVA, a post hoc analysis was done using a Tukey test (Zar 1999). Since the data were not normally distributed (Zar 1999), a Friedman ANOVA comparing multiple variables by ranks was used to determine whether there were differences in habitat utilization (pooled data).

Results

Only partial data were supplied by 12 of the 28 Striped Skunks that were fitted with radio-collars or had transmitters implanted during 1986: 1 slipped its radio-collar, 6 died, and 5 of the radio-transmitters malfunctioned before the end of the study. Consequently, data from only 16 of the 28 animals (4 adult females, 3 adult males, six juvenile females, and 3 juvenile males) were used for annual home range and movement calculations. However, data from between 12 and 20 Striped Skunks were used for seasonal home range estimations, and data from all 28 Striped Skunks were used for habitat utilization calculations.

Home range

Area of annual home ranges: A total of 4624 locations were acquired during 1986 and 1987 on the 16 Striped Skunks that were used for annual home

range analysis. The mean number of locational fixes per Striped Skunk was 289 (SD = 141.5). Annual home range size for juvenile Striped Skunks (\bar{x} = 1.3 km², SD = 0.6 km²) was not significantly different from annual ranges for adult Striped Skunks (\bar{x} = 0.4 km², SD = 0.1 km²) (F = 2.02, P = 0.18) (Table 1) during the study. We could not detect any differences between the annual home range sizes of males and females (F = 0.52, P = 0.48) (Table 1). There were also no detectable differences in annual ranges among individual sex and age classes (F = 0.9, P = 0.47) (Figure 1). Mean annual home range size for combined sex/age classes of Striped Skunks was 0.9 km² (SD = 1.4, range = 0.1–5.0 km²).

Area of seasonal home ranges: A total of 4968 locational fixes were used for seasonal home range analysis. The number of Striped Skunks per seasonal analysis ranged from 12 to 20 (Table 2). The mean number of locational fixes per Striped Skunk ranged from 47.6 to 111.6 (Table 2). No differences were detected in seasonal home range size based on age (F = 1.33, P = 0.37) or sex (F = 1.56, P = 0.32) (Table 1). In addition, no differences in seasonal home range size were detected according to individual sex and age classes (F = 0.87, P = 0.6) (Table 1). When the data were pooled, there was a marginally insignificant difference in seasonal home range size (F = 2.54, P = 0.066). Post hoc analysis indicated that home ranges were smaller during winter (\bar{x} = 0.04 km², SD = 0.05) than during fall (\bar{x} = 0.67 km², SD = 1.09) (P = 0.055) but were not different from ranges during spring (\bar{x} = 0.25 km², SD = 0.31) or summer (\bar{x} = 0.27 km², SD = 0.43).

TABLE 2. The number of locational fixes used during home range analyses of Striped Skunks, *Mephitis mephitis*, radio-tracked in Scarborough, Ontario, during the period July 1986 to July 1987.

| Season | Number of Striped Skunks used in the analysis | Total number of fixes | Mean (SD) number of fixes ¹ |
|--------|---|-----------------------|--|
| Annual | 16 | 4624 | 289 (141.5) |
| Spring | 12 | 1008 | 99.0 (84.5) |
| Summer | 14 | 667 | 47.6 (27.6) |
| Fall | 20 | 2232 | 111.6 (72.8) |
| Winter | 13 | 1061 | 81.6 (25.5) |

¹SD = standard deviationTABLE 3. Mean nightly movements of 16 Striped Skunks, *Mephitis mephitis*, radio-tracked in Scarborough, Ontario, during the period July 1986 to July 1987.¹

| Month | Number of tracking nights | Mean number of movements/night (km) | Standard deviation | Minimum distance travelled/night (km) | Maximum distance travelled/night (km) |
|----------------|---------------------------|-------------------------------------|--------------------|---------------------------------------|---------------------------------------|
| August 1986 | 10 | 0.5 | 0.3 | 0.2 | 0.9 |
| September 1986 | 25 | 0.8 | 0.6 | 0.1 | 2.5 |
| October 1986 | 34 | 0.9 | 0.6 | 0.3 | 3.0 |
| November 1986 | 28 | 0.3 | 0.3 | 0.1 | 2.1 |
| March 1987 | 19 | 0.2 | 0.2 | 0.1 | 0.6 |
| April 1987 | 7 | 0.4 | 0.2 | 0.1 | 0.7 |
| May 1987 | 21 | 0.7 | 0.6 | 0.1 | 1.8 |
| June 1987 | 8 | 0.9 | 0.3 | 0.5 | 1.4 |

¹Although Striped Skunks were radio-tracked during the winter, movements were minimal (due to denning) and are not presented in this table. As the study began in late July 1986 and ended in early July 1987, no movement data were available for July.

Distance across home ranges: No differences in distances across ranges were noted based on age of the 16 Striped Skunks used in this analysis (adults vs. juveniles) ($F = 2.45$, $P = 0.14$) or sex (males vs. females) ($F = 0.83$, $P = 0.38$). Differences in distances across ranges were not found on an individual age/sex basis. Means distances across home ranges were as follows: adult females 0.9 km (SD = 0.2, $n = 4$), adult males 1.4 km (SD = 0.3, $n = 4$), juvenile females 1.7 km (SD = 0.4, $n = 5$), and juvenile males 2.0 km (SD = 1.0, $n = 3$) ($F = 0.92$, $P = 0.46$) (Figure 2). Distances ranged from 0.7 km (home ranges of adult females) to 4.1 km (distances of juvenile males).

Movements

Nightly movements/month: A total of 16 different Striped Skunks (see Table 1 for age and sex) were tracked for a cumulative total of 152 nights between July 1986 and June 1987. As Striped Skunks denned during the winter from early December to early March and did not move any appreciable distance during that time, nightly movement data were analyzed on a comparative basis for the period August to November 1986 and the period March to June 1987 only (although Striped Skunks were radio-tracked during the intervening winter). As Striped Skunks were born in April, were not fully mobile until the summer, and denned during the winter, we compared nightly movements of

juveniles and adults from August to November 1986 only.

We could not detect any differences in nightly movements of juveniles vs. adults from August to November 1986 ($F = 0.084$, $P = 0.98$). When the data were pooled, a significant difference was detected in the cumulative distance travelled per night on a monthly basis ($F = 6.40$, $P = 0.0001$). Post hoc testing revealed that nightly movement of Striped Skunks was significantly greater during September and October than during March and November (not including the winter months, December to February) ($P = 0.0001$) (Table 3). Nightly cumulative distance travelled ranged from a minimum of 0.1 km to a maximum of 3.0 km/night (Table 3).

Winter movements: Striped Skunks generally did not move once they had entered their winter den. However, on eight occasions, Striped Skunks were documented moving < 0.1 km from the den during the period from 13 January to 9 February 1987. These movements were likely related to breeding activities. Movement (< 0.15 km) was also noted on three occasions from 24 to 27 February 1987. This was related to Striped Skunks changing dens.

Dispersal: Of the 16 Striped Skunks that were used for annual home range analysis, only three were known

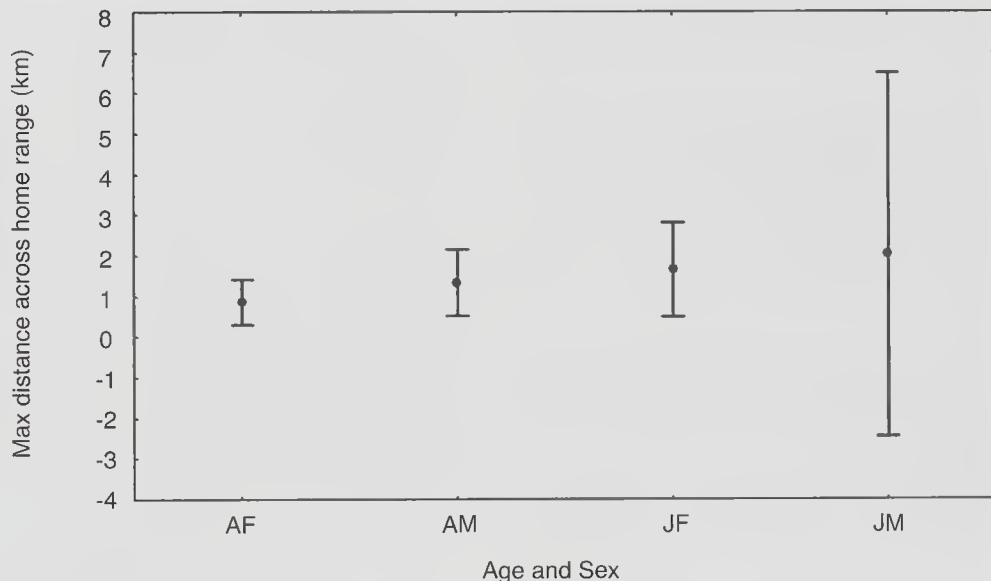


FIGURE 2. The mean (95% confidence interval) of the maximum distance (km) across the annual home range of 16 Striped Skunks, *Mephitis mephitis*, radio-tracked in Scarborough, Ontario, during the period July 1986 to July 1987 (AM = adult male; AF = adult female; JM = juvenile male; JF = juvenile female; mean = weighted mean).

to have dispersed greater than 1 km from their natal range during the study period—a juvenile female Striped Skunk dispersed 2.1 km on 19 September 1986, another juvenile female dispersed 1.1 km on 17 September, and a juvenile male dispersed 3.1 km on 16 September.

Winter denning period: Data were available for 14 of the Striped Skunks during the entire winter denning period. Striped Skunks entered their winter dens between 4 and 11 December 1986 and left the dens in the spring between 4 and 15 March 1987. Eighty-six percent (12/14) of winter dens were in ground burrows. The other dens were under a building and a shed.

Communal denning: During radio-tracking studies, Striped Skunks were noted as occupying winter dens with other Striped Skunks on eight occasions. On six of those occasions, two Striped Skunks (an adult female and an adult male; an adult female and a juvenile female; a juvenile female and a juvenile male; an adult female and an adult male; a juvenile female and an adult male; and two juvenile females) were found to be sharing a ground burrow den. On two occasions, three Striped Skunks were found to be in the same ground burrow den (an adult male, an adult female, and a juvenile female; and two adult females and a juvenile female).

Possible evidence of breeding activities: During our radio-tracking studies, we found evidence of

Striped Skunk movements that were probably related to breeding activities. On 13 January 1987, an adult male moved about 0.1 km to a den in a ground burrow. An adult female that had occupied a different ground burrow den with at least two other radio-collared females during December 1986 moved to the same ground burrow den on 13 January 1987. Another female, a juvenile, also moved to the same den in mid-January. The three Striped Skunks shared the same den for two weeks, from 13 to 28 January 1987, until the adult male left the shared or communal den on 29 January and moved to another ground burrow about 100 m away. Both females moved back to their original ground burrow dens on 24 February.

Habitat utilization

Over the course of the study, the 28 Striped Skunks were located in specific habitats on 4973 occasions. The habitat composition of the study area included 57% residential, 17% industrial, 9% fields, 7% forested park, 6% groomed grass, and 4% commercial areas. Striped Skunks were located in field habitats during 56% of the observations (2795/4973) and in residential habitats during 23% (1162/4973) of the observations. Ten percent (496/4973) of skunk locations occurred on the border of fields and industrial habitats which were identified as field/industrial in terms of classification. Industrial habitats accounted for only 8% (415/4973) of the observations. Locations in groomed grass, forested park, and commercial habitats ac-

counted for a combined total of only 2% (105/4973) of the observations, so those data were deleted from the analysis.

We could not detect any differences in habitat utilization based on the sex and age of Striped Skunks ($F = 1.318$, $P = 0.29$). When the data (all observations) were pooled, Striped Skunks were located in field habitats more frequently than in residential, field/industrial, or industrial habitats (in that order) (ANOVA chi square = 30.2, $P < 0.0001$). Fields accounted for only 9% of the study area.

Mortality

Six mortalities were confirmed during the study. Four were due to predation, most likely dogs, and two were due to infections likely associated with the implantable transmitters.

Discussion

Home range size and movements of Striped Skunks in this study were comparable to findings from studies in other urban areas, including Toronto (Rosatte et al. 1991), Niagara Falls (Rosatte et al. 2010), San Francisco (Boydston 2005), and Chicago (Gehrt 2004). This is likely due to the fact that urban habitats provide an ample supply of food and shelter in confined spaces, more so than in rural landscapes. In addition, Striped Skunks are by nature a fairly sedentary animal compared to other urban species, such as Coyotes (*Canis latrans*), Red Foxes (*Vulpes vulpes*), and Raccoons (*Procyon lotor*) (Gehrt and Riley 2010; Hadidian et al. 2010; Rosatte et al. 2010; Soulsbury et al. 2010).

Small home ranges and movements are an advantage when disease control strategies in urban environments are being planned. If an animal is less mobile, containment areas can be smaller and are less costly to implement, and the disease can be controlled much more quickly (Rosatte et al. 1997). However, as noted in this study, some juvenile Striped Skunks may disperse in mid- to late September. In view of this, rabies control strategies should be implemented prior to the period of dispersal to avoid juvenile Striped Skunks disseminating the disease.

Seasonal home ranges for Striped Skunks in this study were smallest during the winter months. This is due to the fact that Ontario has relatively severe winters that limit food availability for Striped Skunks in urban areas (Ontario Ministry of Natural Resources 1997). As a result, Striped Skunks den, often communally, from early December to early March in order to conserve energy. However, they may leave the winter den for mating in mid- to late January (Rosatte and Lariviere 2003). Communal denning by Striped Skunks, combined with the fact that Striped Skunks breed in communal dens (males being polygamous), contributes to the spread of diseases such as rabies (Rosatte and Lariviere 2003; Rosatte et al. 2007a). However, as Striped Skunks are in their dens during

much of the winter in northern climates such as Ontario, control of diseases such as rabies is not feasible during that period of time (early December to early March).

Generally, Striped Skunks remained in winter dens, usually ground burrows, from early December to early March during this study. This is a wise strategy for Striped Skunks, as temperatures often dip below freezing during the winter and limit the availability of food (such as insects) in areas such as metropolitan Toronto (http://climate.weatheroffice.gc.ca/climateData/hourlydata_e.html?timeframe=1&Prov=ON&StationID=5097&hlyRange=1953-01-01%2011-06-12&Year=1987&Month=1&Day=11). However, movements to other dens were noted in mid-January during this study. We assumed that movements of males and females to different dens during mid-winter was due to breeding activities, i.e., seeking mates. The temperature on 13 January 1987, when the male and female Striped Skunks moved to the same den, was -1°C (http://climate.weatheroffice.gc.ca/climateData/hourlydata_e.html?timeframe=1&Prov=ON&StationID=5097&hlyRange=1953-01-01%2011-06-12&Month=1&Day=13&Year=1987&cmdB1=Go). From an energy conservation perspective, it does not make sense for a Striped Skunk to spend energy moving to another den when the temperature is cold unless the movement is associated with breeding.

Telemetry data in this study revealed extensive use of field and residential habitats by Striped Skunks. This is interesting, as fields accounted for only 9% of the study area. Rosatte et al. (1991) also found high use of fields by Striped Skunks during a live-trapping program in Toronto, Ontario. As Striped Skunks feed primarily on grubs and insects, such as beetles, grasshoppers, and crickets, it makes sense for Striped Skunks to spend much of their time foraging in field areas and residential yards and gardens (Rosatte and Lariviere 2003; Rosatte et al. 2010). Fields also provide areas where soils, vegetation, and drainage are conducive to the construction of ground burrows for denning. Residential yards also provide structures such as sheds, stairs, decks, and garages under which Striped Skunks may construct winter and maternal dens. Given the high use of fields and residential areas by Striped Skunks, rabies control tactics targeting Striped Skunks in urban areas should focus on those habitats (Rosatte et al. 1992, 1997, 2007a).

This study provided information on the ecology of Striped Skunks in urban areas in Ontario. The Ontario Ministry of Natural Resources (OMNR) used vector ecological data from this study, as well as others, to design effective tactics for the control of rabies in Ontario. As a result, the arctic variant of rabies was eliminated from metropolitan Toronto by 1996 (Rosatte et al. 1992, 2007b) and the raccoon variant of rabies was eliminated in eastern Ontario by 2005 (Rosatte et al. 2001, 2009).

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Recent Expansion of *Spiranthes cernua* (Orchidaceae) into Northern Ontario due to Climate Change?

PAUL M. CATLING¹ and MICHAEL J. OLDHAM²

¹Agriculture and Agri-Food Canada, Environmental Health, Biodiversity, Saunders Building, Central Experimental Farm, Ottawa, Ontario K1A 0C6 Canada; e-mail: catlingp@agr.gc.ca

²Ontario Natural Heritage Information Centre (NHIC), Ontario Ministry of Natural Resources, 300 Water Street, 2nd Floor, North Tower, P.O. Box 7000, Peterborough, Ontario K9J 8M5 Canada; e-mail: michael.oldham@ontario.ca

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The expansion northward since 1980 of the native orchid Nodding Ladies'-tresses (*Spiranthes cernua*) in Ontario is described and assessed with respect to the possibility of the expansion being a recent response to climate change. Based on evidence of the extent of the orchid's distribution from prior botanical surveys, it is considered to be a recent arrival in a previously unoccupied area of northern Ontario. Second-order polynomial regression revealed a significant increase in mean yearly temperature of 1 Celsius degree in parts of northern Ontario since 1980. Based on close association with limits of yearly temperature, this is considered sufficient to explain the expansion, and the individual extensions of range fit well into the anticipated newly available territory. Based on a consideration of the location of extensions with respect to plant hardiness zones, the landscape that has become available since 1980 is 160 000 km², in a band approximately 200 km wide across the southern part of northern Ontario. Assuming further temperature increases, this band is expected to expand to a width of approximately 300 km by 2040, providing 360 000 km² of newly available landscape over six decades. *Spiranthes cernua* produces thousands of seeds per flower by adventitious embryony, allowing single individuals to establish populations through long-distance wind dispersal with no reliance on pollination. *Spiranthes cernua* is therefore well adapted to quickly colonize new territory that becomes available through climate warming.

Key Words: *Spiranthes cernua*, Nodding Ladies'-tresses, orchid, range extensions, climate change, Ontario, Canada.

As a result of both field reconnaissance and a survey of major collections (Canadian Museum of Nature (CAN), Agriculture and Agri-Food Canada (DAO), Royal Ontario Museum (TRT), and Erindale College, University of Toronto (TRTE)) (acronyms follow Holmgren 2005*), we noticed that a conspicuous native orchid species, Nodding Ladies'-tresses (*Spiranthes cernua* (L.) Rich.), had extended its range northward into cooler regions of Ontario beyond the range limit indicated in a synthesis of geographic distributions up to 1980 (Whiting and Catling 1986). The objective of the present work is to assess the evidence for recent northward expansion since 1980, to determine the likelihood of this being due to climate change, and to project current and future potential distributions.

Methods

Assessment of range extensions

We obtained additional information on recent expansion of *Spiranthes cernua* from label data from recently collected herbarium specimens at the herbarium of Algoma University College, CAN, DAO, Royal Botanical Gardens (HAM), Ontario Ministry of Natural Resources (NHIC), Queen's University (QK), TRT, TRTE, University of Western Ontario (UWO), and University of Waterloo (WAT). We also gathered information from databases and field botanists, and we conducted field surveys in the region of interest. The number of specimens collected/observed was insufficient

to allow any statistical tests of significance to be applied or to indicate periods of spread using proportion curves (e.g., Delisle et al. 2003). The interpretation of these range extensions is subject to the bias related to variation in sampling effort that applies to all collections, but interpretation taking this bias into account is possible, as described below.

To obtain a general view of distribution using a dot distribution map (Figure 1), we consulted the following sources: Whiting and Catling (1986) for Ontario distribution up to 1980; Smith (1993) and Homoya (1993) for the states of Minnesota and Indiana (respectively); Case (1987) for the rest of the western Great Lakes region; Barkcr et al. (1977) for the area west of the Great Lakes; Angelo and Boufford (2010*) for New England; Welby and Werier (2010*) for New York; and Rhoads and Klein (1993) for Pennsylvania. For the Quebec distribution, the map in Catling (1980) was employed. The distribution was obtained by positioning of the grey dots on a base map using map overlays from photographs of maps in the preceding texts using Arcmap 9.3.

After the distributions and range extensions had been established and mapped, we considered the possibility that the plant had been overlooked in its newly discovered areas of occurrence. Since *Spiranthes cernua* is conspicuous as a result of white inflorescences 3 cm wide and up to 10 cm long and it grows in open habitats such as roadsides and shorelines, we believe

that it is unlikely that it was overlooked in botanical surveys that were done in the region of new occurrence. *Spiranthes cernua* blooms in late summer and fall, but botanical surveys are frequently carried out during this period so as to include many late-blooming species. Thus the late blooming time is not considered a factor that would lead to the species being overlooked.

Assessment of climate change

The northward extensions are assessed with respect to the possibility that they represent a recent response to climate change. The basic question has two components: (1) has the climate changed and (2) has it changed enough over three decades to enable a change in distributional limit?

(1) The extent to which climate has changed in the region of concern in northern Ontario was considered with regard to historical data on mean yearly temperature, which is closely associated with plant distribution limits in the province. The mean yearly temperature may be only a surrogate for an actually influential array of climatic phenomena, including frost-free period, snow cover, winter temperature, and growing degree days. It is, however, not a concern with regard to the present application, because a change in mean yearly temperature can still reliably suggest a trend.

Data on mean yearly temperature were obtained from Environment Canada (2010*). Three stations in the general region of the extensions—North Bay, Timmins, and Kenora—were used to determine trend, since these had a continuous record spanning many decades. Data for Timmins and Kenora were available for the period 1940–2010, and data for North Bay were available for the period 1960–2010. A second-order polynomial regression was used to obtain a reasonable line fit to the data. This method was used because the value of the highest order term was significant or nearly significant at the 95% level and the *R*-squared values indicating amount of variation explained by the fit were higher than for lower order models.

A significant relationship between year and temperature was obtained with an analysis of variance (ANOVA). The two dashed lines closest to the regression line on the plots indicate the 95% confidence limits for mean response at a given value of *X*, and the furthest pair of dashed lines indicates the range within which 95% of observations would occur for predictions. All of the statistical procedures and plots utilized Statgraphics Centurion 15 software (Statpoint 2005*).

(2) Has the climate changed enough over three decades to enable a change in distributional limit? A number of authors have noted that the distributional limits of plants in Ontario are correlated with climatic conditions (e.g., Cody 1982; Reid 1985). The mean yearly temperature isotherm of 7.8°C (Brown et al. 1980), for example, corresponds well with the irregular northern limit of the Carolinian zone in southern Ontario, as established by W. S. Fox and J. H. Soper, based on the northern limits of 54 plant species (e.g., Soper 1962). Yearly temperature isotherms for northern

Ontario (Chapman and Thomas 1968) also correspond approximately to plant distribution limits (personal observation, PMC). The correspondence is nearly exact with regard to a particular irregular isotherm over hundreds of kilometres where the difference between the isotherms is 1–2 Celsius degrees. Since landscape conditions are similar on each side of many of these limiting lines, it is strongly implied that it is climate rather than substrate which is the salient factor. Thus a change of 1–2 Celsius degrees appears to be sufficient for distribution to assume a new isotherm limit.

Since the position of isotherms on the landscape is controlled by major landscape features, the value of the lines may change with time but the lines may remain in more or less the same position on the landscape. If an isotherm assumes a new and higher value, the associated distributional limit of an organism should be able to move to the new isotherm limit so that potential new range can be delineated by expansion to the next limiting line. The area between the old limiting isotherm and the new limiting isotherm is the “new territory,” and this can be inferred on maps of isotherms when the amount of warming is known. Although substrate features may play a role in distributions, in the present case the entire region under consideration is the Canadian Shield with essentially similar landscape throughout. For climate change to be an explanation for northward expansion, we consider a minimum requirement to be a significant relationship between temperature and year with an increase in 1 Celsius degree since 1980. If the extensions fit nicely into the anticipated new territory associated with such an increase, then the possibility of climate warming playing a role is further supported.

Determination of current potential distribution and future distribution

To indicate current potential distribution, we anticipated full occupation of hardiness zones (Agriculture and Agri-Food Canada 2010*) presently occupied by northward range extensions since 1980. Hardiness zones, which are based on an assessment of plant response to climate and an assessment of climate data, were updated in 2000 to reflect recent changes in Canadian climate and to develop a more objective approach to climate mapping (McKenney et al. 2001). This version of the hardiness zones was used throughout. Mean maximum temperature of the coldest month and frost-free days are the most important correlates of hardiness, but mean yearly temperature, length of growing season, and many other factors are also highly correlated.

A future potential distribution area was determined based on a projected temperature increase of 1 or 2 Celsius degrees between 2011 and 2040 (using a higher greenhouse gas scenario) (Colombo et al. 2007*) and the correspondence between hardiness zones (Agriculture and Agri-Food Canada 2010*) and mean yearly temperature.

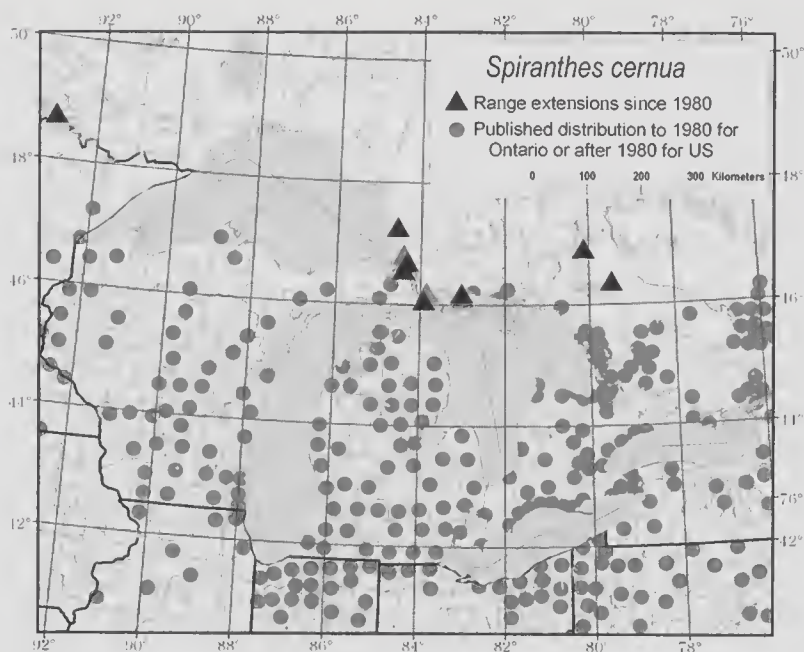


FIGURE 1. Distribution of *Spiranthes cernua* (Nodding Ladies'-tresses) in the north-central part of its range, showing northward range extensions in Ontario since 1980 (triangles). Black triangles indicate collections and grey triangles indicate sight records. Either kind of triangles are centered over one or more location and/or sight records of the plant. The positioning of the grey dots was achieved with map overlays from texts listed in Methods.

Results and Discussion

Documentation of extensions

The first record of *Spiranthes cernua* for the Lake Superior drainage in Ontario was made by Larry Johnson on 10 September 1994 in Algoma District, Lake Superior Provincial Park, at the south end of Kenny Lake, 47.28°N, -84.56°W (photo, DAO). It was also found here subsequently on 10 September 2005 by M. J. Oldham and W. D. Bakowsky (32205, DAO). Other range extensions for Algoma District include extensive peatland on the east side of Highway 17, south of Goulais River, 46.71°N, -84.34°W, 12 August 2001, M. J. Oldham and W. D. Bakowsky 26664 (DAO, MICH); the north side of Highway 17, ca. 1 km east of Pancake River bridge, 46.96°N, -84.64°W, 10 September 2003, W. D. Bakowsky and M. J. Oldham 2003-134 (DAO); Sault Ste. Marie, gravel pit on the west side of Maki Road, northwest outskirts of town, 46.57°N, -84.42°W, 10 September 2005, M. J. Oldham and W. D. Bakowsky 32214 (DAO); Fort St. Joseph National Historic Site, between Rains Point and La Pointe, south shore of St. Joseph Island, North Channel of Lake Huron, southeast of Sault Ste. Marie, 46.07°N, -83.93°W, 11 September 2005, M. J. Oldham and W. D. Bakowsky 32249 (DAO). In addition, there are several sight records by M. J. Oldham and W. D. Bakowsky for western Algoma District (Lake Superior beach, ca. 3 km south of the mouth of

Goulais River, near the mouth of Cranberry Creek, north of Sault Ste. Marie, 46.70°N, -84.43°W, 2 September 2005; St. Joseph Island, 46.21°N, -83.86°W, 11 September 2005; South Point of Mississagi Island, North Channel, on the east shore, 7 km south of the mouth of the Mississagi River, 46.11°N, -83.01°W, 29 August 2006; Haviland Bay, Lake Superior, north of Sault Ste. Marie, 46.82°N, -84.41°W, 28 August 2010). *Spiranthes cernua* has now been found in at least nine sites at the southeast corner of Lake Superior in Algoma District (Figure 1) west and north of the range mapped in Whiting and Catling (1986).

Two records in 2010 from north of North Bay in Nipissing District are also range extensions: the west side of Lake Temagami on Gull Lake portage trail, 46.92°N, -80.13°W, August 2010, D. Adams (photo, DAO); north of North Bay on Highway 11, 46.40°N, -79.47°W, P. M. Catling and B. Kostiuk s.n. (DAO).

One of the most interesting range extensions is in northwestern Ontario (Figure 1), where *Spiranthes cernua* was found on the east arm of Rainy Lake by A. Harris and R. Foster (Harris et al. 2002*). The species is apparently not present near the Canadian border in northern Minnesota (Smith 1993) or in adjacent Manitoba (Ames et al. 2005). The Rainy Lake location approximately 200 km northwest of the nearest location in Minnesota shown by Smith (1993) is the first for northwestern Ontario.

Previous botanical survey work

The area of the east shore of Lake Superior has been extensively studied by Claude Garton, with specimens deposited at Lakehead University (LKHD), but this shoreline has attracted the attention of many botanists, including in particular those based at the Canadian Museum of Nature (CAN) (Hosie 1938; Given and Soper 1981; Soper et al. 1989). Two large parks occur on the eastern shore of the Lake Superior region, Pukaskwa National Park of Canada and Lake Superior Provincial Park, both of which have had botanical surveys conducted in them which did not reveal *Spiranthes cernua* (e.g., Garton 1978*; Ontario Ministry of Natural Resources 1985*; White 1988*; Brunton 1991*). Despite at least three earlier botanical surveys and lists (Ontario Ministry of Natural Resources 1985*; White 1988*; Brunton 1991*), *Spiranthes cernua* was not found in the Lake Superior drainage in Ontario until 1994, when it was found in Lake Superior Provincial Park. The level of botanical work here makes it seem very unlikely that the species was overlooked previously. Most likely it was simply not present.

With respect to northwestern Ontario, Rainy River District has received much less attention than eastern Lake Superior, but there have been inventories of Quetico Provincial Park (Walshe 1980; Ahlgren and Ahlgren 1989*; Scott 2009), and botanists such as Claude Garton (LKHD) have collected in the area. Recent botanical inventory work (since 1990) has also been undertaken in Rainy River District by several botanists (W. D. Bakowsky, S. R. Brinker, R. Foster, A. Harris, M. J. Oldham, P. Scott), resulting in surveys of over 100 sites and the collection of >1000 vascular plant specimens and >5000 sight records. Consequently, it again seems unlikely that *Spiranthes cernua* was overlooked.

With regard to the Temagami area, W. R. Watson conducted an extensive botanical survey of the Temagami Forest Reserve in the early 1920s (specimens at TRT), and this was a region that botanists examined en route to other areas in the north, such as the Clay Belt, that were under study (Baldwin 1958, 1962). Thus the Temagami area is considered to be relatively well known botanically, making the absence of collections of *Spiranthes cernua* there (until recently) also likely due to absence of the plant.

There is one final way of obtaining an indication of the extent of prior botanical survey work in the area of these extensions and that is to check a map showing collections of plants in the region of the extensions that occur in the same habitat as the putatively spreading species. Hooded Ladies'-tresses (*Spiranthes romanzoffiana* Cham.) often occurs in the same habitats as *Spiranthes cernua*. *Spiranthes romanzoffiana* was found prior to 1980 throughout the region of the *Spiranthes cernua* extensions (Whiting and Catling 1986), indicating that botanists had visited habitats in the region

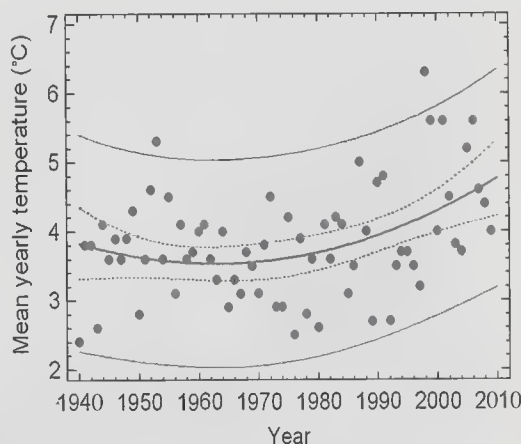


FIGURE 2. Mean annual temperature from 1960 to 2010 at North Bay, Ontario, with fitted second-order polynomial regression.

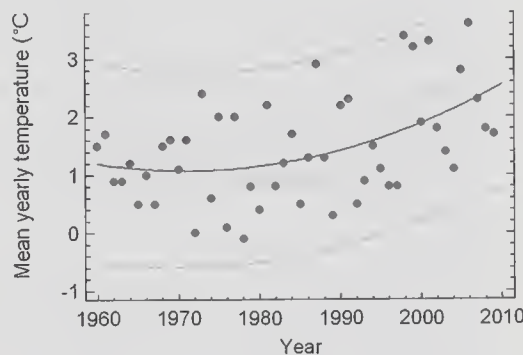


FIGURE 3. Mean annual temperature from 1940 to 2010 at Timmins, Ontario, with fitted second-order polynomial regression.

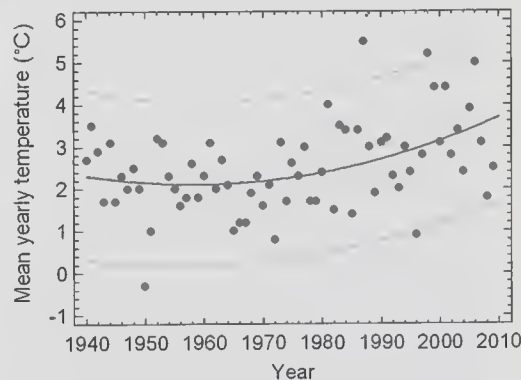


FIGURE 4. Mean annual temperature from 1940 to 2010 at Kenora, Ontario, with fitted second-order polynomial regression.

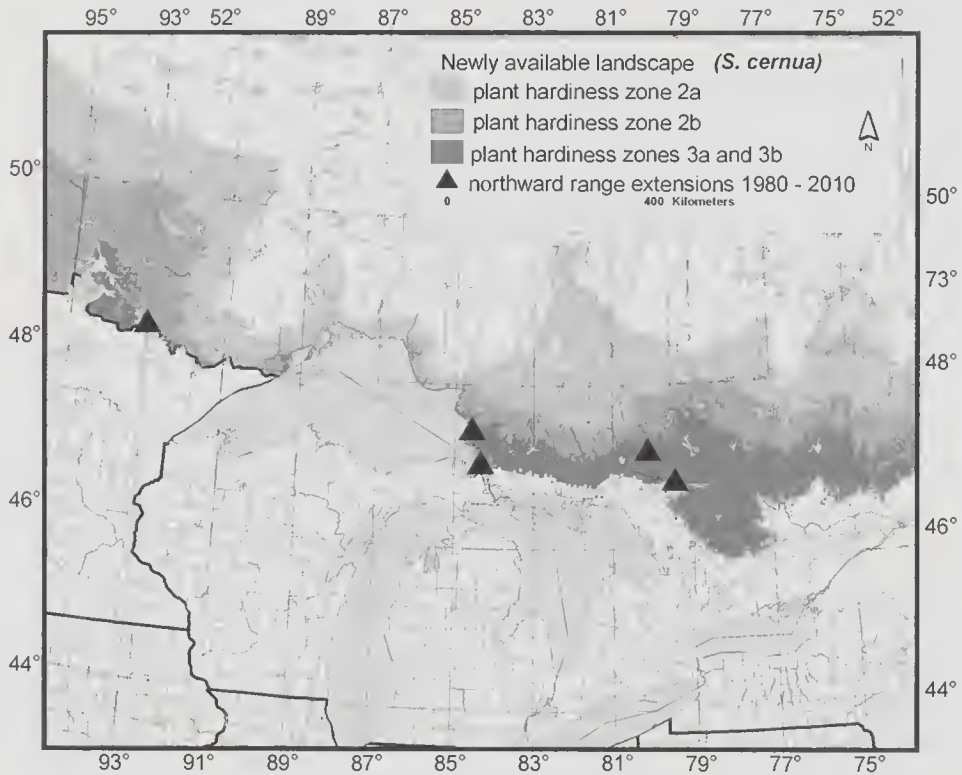


FIGURE 5. Plant hardiness zones (2000 version) 2a (above, – light shading), 2b (middle, – medium shading), and 3a and 3b (combined below, – dark shading) and northward range extensions of *Spiranthes cernua* since 1980 (triangles). Based on the locations of the extensions and the general similarity of the landscape throughout these regions, the current potential distribution of *Spiranthes cernua* extends to the limit of the current zone 3 (a and b). These hardiness zones indicate the landscape that has become available to the species between 1980 and 2010, apparently as a result of climate warming of 1 Celsius degree over that period. By 2040, current zone 2a is expected to be at least partially occupied.

and had found a very similar plant but did not find *Spiranthes cernua*. The same can be found by examining maps of Loesel's Twayblade (*Liparis loeselii* (L.) Rieh.) and Tall Northern Green Orchid (*Platanthera aquilonis* Sheviak; = *P. hyperborea* (L.) Lindl.). The evidence thus is strongly in favour of regarding these new occurrences as genuine indications of range extension since 1980.

Has the climate changed enough to explain the extensions?

The polynomial regressions for mean yearly temperature at North Bay, Timmins, and Kenora show a similar trend toward increase by approximately 1 Celsius degree since 1980 (Figures 2, 3, and 4). For North Bay, the *P* value for the analysis of variance (ANOVA) is 0.0019, indicating a significant relationship between year and temperature, and the *R*-squared value indicates that the fitted model explains 17.11% of the variability in mean annual temperature. Similarly, for Timmins and Kenora, the *P* values for ANOVA were 0.0029 and 0.0011, respectively, and the *R*-squared val-

ues were 22.04% and 18.47%, respectively. In all cases, the Durbin-Watson statistic was not significant, indicating absence of serial autocorrelation. Thus climate has changed enough for climate warming to be a factor.

Since older climate data for parts of southern Ontario show lower temperatures throughout the 20th century, the second-order fits are adequate for the present purpose, even though they suggest higher temperatures around 1940; however, the second-order fits cannot be used to extrapolate either forward or backward.

Do the extensions fit well into an anticipated newly available territory?

Prior to 1980, *Spiranthes cernua* generally reached its northern limit in a region indicated as 4.4–5.6°C mean annual temperature (Chapman and Thomas 1968; Brown et al. 1980) or 4–5°C (Watson and MacIver 1995*). Now *Spiranthes cernua* exists within a region that was indicated on these older maps as 2–3°C. The newly available territory extends north to Kenora in the west and north to Timiskaming in the east and

includes the general region of Temagami. The extensions fit well into an anticipated new territory that has become available due to an increase of 1 Celsius degree in mean yearly temperature since 1980.

Current distribution and potential future distribution

The landscape (zones 3a, 3b, and 2b), newly available since 1980, is 160 000 km², in a band approximately 200 km wide across the southern part of northern Ontario that became available over three decades (Figure 5). Based on further temperature increases of 1–2 Celsius degrees, using a higher greenhouse gas scenario (Colombo et al. 2007*), this band is expected to expand to a width of approximately 300 km by the year 2040, including zone 2a, and provide 360 000 km² of newly available landscape over six decades.

Conclusions

The distribution of *Spiranthes cernua* appears to have expanded northward since 1980, based on 15 records within previously unoccupied regions of northern Ontario where the flora has been well documented. The change in climate reflected by the increase of 1 Celsius degree in mean yearly temperature over the past three decades is widespread in northern Ontario within the regions of the extensions and is considered sufficient to explain them. *Spiranthes cernua* produces thousands of very light, wind-dispersed seeds from a single blossom by adventitious embryony so that single individuals are capable of high seed production in situations lacking pollinators; *Spiranthes cernua* can therefore rapidly produce large populations in new areas (Catling 1980, 1982, 1983). However, the use of this species as a bioindicator must take into account the potential for fluctuation in the fraction of plants that flower from year to year. Response to climate change may be occurring more rapidly than anticipated, and the response to it by some organisms may be well underway. Large areas appear to have already become available to species occurring on the southern edge of the boreal shield ecozone, and by 2040 the northern limits of quick response species in this region may have expanded 300 km north of their 1980 position.

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Migrant Common Eider, *Somateria mollissima*, Collisions with Power Transmission Lines and Shortwave Communication Towers on the Tantramar Marsh in Southeastern New Brunswick

COLIN M. MACKINNON¹ and ANDREW C. KENNEDY¹

¹Canadian Wildlife Service, Environment Canada, P. O. Box 6227, Sackville, New Brunswick E4L 1G6 Canada

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Between 1971 and 2009, 85 dead, injured, or grounded Common Eiders, *Somateria mollissima*, were recorded on the Tantramar Marsh in southeastern New Brunswick, apparently the result of collisions with power transmission lines and shortwave communication towers. Of 82 location observations, 53 (65%) were near a series of power transmission lines and 21 (26%) were in the vicinity of shortwave communication towers. Of the 85 birds observed, 43 (51%) were found dead, 18 (21%) were found alive on the ground with undetermined injuries, 5 (6%) were found alive with broken wings, and 9 birds (11%) were found alive with no obvious external injuries and were released in water. A further 10 live birds (12%) were observed on small bodies of water and appeared unable to fly. Occurrences appear to be predominantly during fall migration, with most sightings recorded between 9 October and 21 December (99%, $n = 73$). The effects of cumulative mortality on Common Eiders should be considered if further infrastructure within the Tantramar Marsh or infrastructure involving other known overland routes used by Common Eiders during migration is proposed.

Key Words: Common Eider, *Somateria mollissima*, Tantramar Marsh, Chignecto Isthmus, New Brunswick, power transmission lines, shortwave towers, communication towers, fall migration, bird strikes.

Introduction

Along the East Coast of North America, Common Eiders are legally harvested as well as being the most abundant species of seaduck. Breeding populations have been recently estimated to be 18 000 pair in Labrador, 3 000 in Newfoundland and 18 000 – 22 000 in New Brunswick and Nova Scotia (Canadian Wildlife Service Waterfowl Committee 2010). During fall migration, the *Somateria mollissima dresseri* subspecies is known to cross the narrow isthmus, including the Tantramar Marsh, between New Brunswick and Nova Scotia for wintering areas to the south (Goudie et al. 2000) (Figure 1).

The Tantramar Marsh (67 km²), including the Tantramar River and Aulac River drainages, is situated in south-eastern New Brunswick, near the town of Sackville, and immediately west-northwest of the Missaguash Marsh which separates New Brunswick from Nova Scotia (45°55'N, 64°18'W). Located at the head of Cumberland Basin, which is at the north-eastern extremity of the Bay of Fundy, the Tantramar Marsh consist predominantly of agricultural lands that have been reclaimed from the sea by a series of dykes, a tide control gate, and an *aboiteau* (a wooden sluice underneath a dyke used to maintain drainage) (Figure 2).

These tidal barriers protect not only agricultural land but also important transportation and communication infrastructure (the Trans-Canada Highway, a Canadian National Railway line, Radio Canada International



FIGURE 1. Location of the Tantramar Marsh (Chignecto Isthmus) situated on the border between New Brunswick and Nova Scotia; Baie Verte (Northumberland Strait) to the northeast and Cumberland Basin (Bay of Fundy) to the southwest. Note the "Wolf Island", Labrador banding location for the Common Eider found on the Tantramar Marsh (see text for details).

station, and three major power transmission lines). This area also constitutes part of the Chignecto Isthmus, where, at the narrowest point, the Northumberland Strait (Baie Verte) to the north and the Bay of Fundy (Cumberland Basin) to the south are separated by a land mass only ~24 km wide (see MacKinnon and Kennedy 2009). The Tantramar Marsh, situated between these two larger bodies of tidal waters, is the site of overland migration by Common Eiders.

Observations of Common Eiders crossing over land at certain locations within the Maritimes (New Brunswick, Nova Scotia, and Prince Edward Island) are not new (Tufts 1961; Boyer 1966; MacKinnon et al. 1991*; Goudie et al. 2000; Bond et al. 2007; Nature New Brunswick 2008). More specifically, Erskine and Smith (1986) went into much greater detail in their review of the status and movements of Common Eider ducks within the Maritimes, with particular reference to the birds' northward movements from the Bay of Fundy to the Northumberland Strait. Gauthier et al. (1976) noted that this less common option of overland migration by Common Eiders likely represents an added risk compared to following the Nova Scotia coastline offshore.

This paper summarizes observations of downed, injured, or dead Common Eiders on the Tantramar Marsh. We have assembled records from a number of observers and compared the locations in those records, along with our own detailed observations, with the location of anthropogenic structures within the boundaries of the study area. Although it is known that dead Common Eiders are frequently encountered on the isthmus, we seek to determine when this is most likely to occur and what is causing the mortality.

Study Area

The Tantramar Marsh consist of a wide-open expanse of un-forested, flat grasslands (agricultural hay and pasture lands) bordered by gently rising uplands to the west (town of Sackville, New Brunswick) and a narrow finger of land known locally as the Aulac Ridge to the east. In the late 19th and early 20th centuries, this farmland was dotted with hundreds of "marsh barns," reflective of a highly valuable hay crop; few of these structures survive today (MacKinnon 2000). The northern extremity of the marsh is bordered by a matrix of spruce (*Picea*)-fringed sphagnum bogs, lakes, and wooded swamps with gently rising ground farther inland. The southern flank bounds the curving north shore of Cumberland Basin (Figure 2). Across the southern edge of this area (from roughly east to west) lies the Trans-Canada Highway as well as the main Canadian National Railway line connecting Canada's eastern seaboard to destinations west. The High Marsh Road (Jolicure Road) runs parallel to, and 4.5 km north of, the Trans-Canada Highway. This secondary road connects Upper Sackville to the village of Jolicure and eventually merges with Route No. 16.

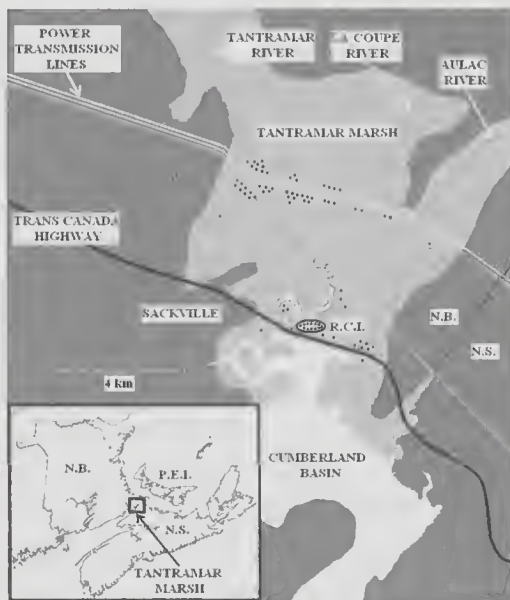


FIGURE 2. Locations of salient features of the Tantramar Marsh, New Brunswick. Note the locations of the power transmission lines as well as the Radio Canada International (RCI) facility immediately east of the Tantramar River. Baie Verte is situated 14 km to the northeast of the map. The "High Marsh Road" runs parallel and immediately south of the double row of power transmission lines. Approximate locations of downed Common Eiders are represented by black dots ($n = 82$).

Immediately north of the Trans-Canada Highway and centered within the Tantramar Marsh, is a small (~50 ha) area of elevated land known as Coles Island, site of the Radio Canada International station. This communications facility began operation in 1943; shortwave service followed in 1945 (Figure 3). The Radio Canada International operation is predominantly a large "curtain array" consisting of numerous support cables with a grid of wires strung between 13 metal-framed towers. These towers are arranged in a semicircle extending horizontally for approximately 1200 m. The tallest towers in the middle of the array reach a maximum height of 131 m. With a broadcast power reaching 500 000 watts, the Radio Canada International station can broadcast shortwave communications to all corners of the globe.

There is a series of three power transmission corridors that cross the Tantramar Marshes. Each corridor contains a series of parallel high-voltage transmission cables. These consist of a single 345 kV line running from Memramcook, New Brunswick, to Onslow, Nova Scotia, and two additional lines (138 kV each) that connect Memramcook to Maccan and Springhill, Nova Scotia. These lines enter the marsh in close proximity to one another, along the western boundary of the



FIGURE 3. Radio Canada International station situated on Coles Island within the Tantramar Marsh near Sackville, New Brunswick. There is a complex matrix of wires/guy lines between the towers. The tallest feature is 131 m. Photo: C. MacKinnon.

Tantramar, about 1 km northwest of the High Marsh Road. At a point 200 m north of the covered bridge that crosses the Tantramar River, these lines split (Figure 4). Two sets of parallel lines (one with metal lattice support towers and one with wooden poles) run across the marsh, west to east, just north of the High Marsh Road. The third set of lines, supported by both metal and wooden towers, runs diagonally across the marsh from the northwest to the southeast.

Methods

All Common Eiders recorded in this study were "downed" (found on the ground or water) within the Tantramar Marsh; the observer, date, and location were recorded when either a live duck or a carcass was found. Similar observations were collected by a number of volunteers. The authors kept more detailed records throughout all of 2008 and 2009. We attempted to record unit of effort, but the sporadic nature of the observations, as well as inaccessibility of portions of the study area, made direct comparisons difficult.

Locations of reported killed/injured/downed Common Eiders were recorded using the Universal Transverse Mercator (UTM) military grid reference on the National Topographic Map Series, Amherst 21H/16 (1:50 000 scale). The locations of these records were then compared to the locations of the three power transmission lines and the Radio Canada International tower array within the study area.

Results and Discussion

Common Eiders are reluctant to fly overland (Gauthier et al. 1976). However, the narrowness of the Chignecto Isthmus and resulting short flight distance (~24 km) between the Bay of Fundy and the Northumberland Strait provides these birds with a much shorter alternative than the approximately 2 200 km coastal route, including Cape Breton, around Nova Scotia (Erskine and Smith 1986; MacKinnon et al. 1991*; Bond et al. 2007). Such observations are not new: in 1973, W. B. Hughson reported seeing flocks ranging from 32 to 175 birds (at altitudes between 32 and 137 m) on 1, 2, 4, and 9 October 1973. These birds were flying in a southwesterly direction over the Tantramar National Wildlife Area; located along the northern periphery of the Tantramar Marsh. On 4 October, Hughson estimated that over 1000 birds passed overhead between 16:15 and 19:35 (Hughson 1973*).

It has been suggested that overland migration by Common Eiders increases the risk that they will not complete the journey. Some of this risk may include losing direction while crossing overland and becoming exhausted due to inclement weather and unpredictable storms, as well as the chance of striking ground-based objects (Gauthier et al. 1976). Such accidents may be natural, such as an encounter with trees over a height of land, but accidents may also involve collisions with anthropogenic structures. Regardless of cause, it is generally assumed that once a Common Eider is on



FIGURE 4. Intersection of three transmission lines north of the covered bridge on the High Marsh Road (Jolicure Road), Tantramar Marsh, New Brunswick, the site of numerous Common Eider collisions. Photo: A. Kennedy.

the ground away from open water, it may be difficult for it to regain flight. Furthermore, once grounded, these birds make easy prey for a variety of predators and often, based on the numbers of predated carcasses we observed, have little chance of survival.

We presumed that Common Eiders found on the ground within the treeless study area had flown into anthropogenic structures, such as nearby power transmission lines and communication towers. There are numerous records of such occurrences throughout the greater Chignecto Isthmus (see Nature New Brunswick 2008), although, in general, most observations are anecdotal and the details of the incidents are not always clear.

Locations of Common Eiders recovered on the Tantramar Marsh

Of the 82 detailed location records, 53 (65%) Common Eiders were found along the 6.0-km-long section of road and adjacent power transmission corridor that cross the upper part of the Tantramar Marsh (generally from the covered bridge over the Tantramar River to the bridge over the La Coupe River). An additional 21 (26%) were recovered under, or in close proximity to, the Radio Canada International towers at Coles Island, while the remaining 8 (10%) were recovered from other locations within the study area (Figure 1).

Timing of Common Eider collisions

Of 74 observations of Common Eiders with known dates of occurrence, all but one (3 July 2007) occurred

between 9 October and 21 December. There were more occurrences in October ($n = 35$, 47%) than in November ($n = 22$, 30%) or December ($n = 16$, 22%). There have been a few reports of dead birds found in the April–May period, but these reports have been mostly wing remnants that, in all likelihood, were from incidents that had occurred late the previous fall, the carcasses being covered by snow and protected from scavengers over the winter months.

Condition of recovered Common Eiders

Of the 85 birds observed, 43 (51%) were found dead, 18 (21%) were alive but were found on the ground with undetermined injuries, 5 (6%) were found alive with broken wings, and 9 birds (11%) were found alive with no obvious external injuries and were released in water. A further 10 live birds (12%) were observed on small bodies of water and appeared unable to fly.

Incident observations and weather conditions

C. M. M. and A. C. K. made detailed observations during 2008 and 2009. We recorded 17 and 25 observations of Common Eiders, respectively. In 2008, these observations were all single records, with the exception of 4 birds recorded on 25 October. These 4 birds likely collided with the Radio Canada International towers during the night or early morning hours of 24/25 October; weather conditions may have been a contributing factor. Throughout the evening of 24 October 2008, the temperature dropped from 7.8°C at 18:00 to 4.3°C at midnight. Wind speed throughout the evening was a

relatively constant 7–9 km/h from the south. The temperature had dropped to -1.1°C by 03:00 and was still below freezing (-0.8°C) at 07:00 on 25 October. Wind speed remained very light, still predominantly from the south, at 6–9 km/h during this same period (Environment Canada* 2008).

It may be noteworthy that the night of 24/25 October had the heaviest frost of the fall up to that date. Relative humidity ranged from 94 to 97% in the early morning hours, vehicle windows were lightly covered with ice, and the ground was covered with a heavy frost. The moon was full on 14 October and a new moon followed on 28 October. This means there would have been relatively little if any natural light on the night of 24/25 October. The Tantramar is known to have frequent and transient pockets of fog that would not be recorded by nearby weather stations. There could have been some ground fog on 24/25 October, but we have no record or indication that there was. It would appear that a combination of a dark, relatively still night, clear air, and possibly scant light reflecting on frozen ground culminated in more than one bird, likely from a larger flock, or flocks, hitting obstacles and being brought to ground at a variety of locations.

Of the 25 observations in 2009, three groups of birds (12 birds on 9 October, 5 birds on 12 November, and 4 birds on 19 December) were recorded, in addition to observations of individual birds. For the largest event, a number of people reported dead or injured/downed Common Eiders scattered in the study area on 9 October. The early morning hours were calm with light winds (~ 10 km/h) out of the north-northwest. Temperature was $\sim 7^{\circ}\text{C}$ with 94% relative humidity. At sunrise, most of the Tantramar was blanketed with patches of low-lying fog. As the remains of dead Common Eiders were being quickly scavenged by Common Ravens (*Corvus corax*) and American Crows (*Corvus brachyrhynchos*), the Common Eiders must have collided with the transmission lines earlier that same day during foggy conditions. Of the 12 birds, 8 (66.6%) were found near the power transmission lines, one (8.3%) was found near the Radio Canada International towers, and 3 (25%) were observed away from adjacent structures.

Band recovery

We do not have detailed information on where the Common Eiders that cross the isthmus originate. Of particular interest was a single banded bird recovered on 20 October 2009 by Chris Novak (Sackville, 392 Main Street, Sackville, New Brunswick E4L 3H6), who provided the following observations: "I found a banded eider in the ditch with a severely broken wing and emaciated. I assume it clipped the power lines along Folkins Drive ($45^{\circ}55'04''\text{N}$, $64^{\circ}20'12''\text{W}$) as the broken wing is the only injury I can visually notice". That bird, number 1307-50171, was banded by Katherine Mehl on 18 August 2007 as an after hatch year

male on Wolf Island, Table Bay, Newfoundland and Labrador, 76 km northeast of Cartwright, Labrador (Randy Hicks, Wildlife Technician, Canadian Wildlife Service, Environment Canada, Box 6227, 17 Waterfowl Lane, Sackville, New Brunswick E4L 1G6) (Figure 1).

Conclusion

The fall migration of Common Eiders across the Tantramar Marsh and the likelihood of the birds colliding with anthropogenic structures impose a flight risk to these birds. Most recoveries of downed, injured, or dead Common Eiders have been attributed to collisions either with power transmission lines or with the array of lines and towers associated with the Radio Canada International station at Coles Island. These accidents may be more frequent during times of bad weather and poor visibility. The total number of Common Eiders that cross the isthmus in the fall and the impact of these losses on subpopulations are lacking. Modification of the existing features to lessen the risk may not be possible; however, the effects of cumulative mortality on the Common Eider should be considered if further infrastructure within the Tantramar Marsh or infrastructure involving other known overland migratory routes of the Common Eider is proposed.

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Some Observations on the Pollination of Round-Leaf Orchid, *Galearis (Amerorchis) rotundifolia*, Near Jasper, Alberta

PAUL M. CATLING¹ and BRENDA KOSTIUK¹

¹170 Sanford Avenue, Ottawa K2C 0E9 Canada; e-mail: catlingp@agr.gc.ca

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On June 16 and 17, 2010, data were collected on pollination in a population of *Galearis rotundifolia* at the confluence of the Maligne and Athabasca Rivers north of Jasper, Alberta. The primary pollinator was the bee *Osmia proxima* and this species was also the most frequent visitor. While most flies were visitors, four species, *Eriozona (Megasyrphus) laxus*, *Eristalis (Eoseristalis) hirta*, *Eristalis (Eoseristalis) rupium*, and *Eupeodes (Lapposyrphus) lapponicus* also served as pollinators. It is estimated that 25–44% or more of flowers were pollinated in the previous year, a relatively high percentage that supports the “advertisement model” for evolution of food deception in orchids. The pollinating bee or fly lands on the lip and probes the spur which is approximately the same length or longer than the tongue. In the process of pushing into the flower and backing out, the sticky contents of a bursicle are either discharged by the backward movement of a flap or by forward pressure. Either of these actions may release adhesive fluid which fixes the viscidia onto the front of the insect’s head. The gradual bending forward of the caudicles reduces likelihood of pollination of consecutively visited flowers with pollen from those recently visited flowers on the same plant (geitonogamous pollination) and thus promotes outcrossing.

Key Words: Round-Leaf Orchid, *Galearis rotundifolia*, pollination, bee, *Osmia proxima*, fly, *Eriozona (Megasyrphus) laxus*, *Eristalis (Eoseristalis) hirta*, *Eristalis (Eoseristalis) rupium*, *Eupeodes (Lapposyrphus) lapponicus*, deceptive pollination, geitonogamous pollination, fecundity, Jasper, Alberta.

The pollinators and general pollination mechanisms of many North American orchids are known (Catling & Catling 1991, van der Cingel 2001), but nothing has been recorded of the pollination of the Round-Leaf Orchid, *Galearis (Amerorchis) rotundifolia* (Banks ex Pursh) R. M. Bateman (Figure 1, St. Hilaire 2002; Handley and Heidel 2005). This attractive species (see Luer 1975 and Reddoch and Reddoch 1997 for illustrations and a description of the plant) has a widespread distribution in northern North America extending from Newfoundland to Alaska and south to the Great Lakes region (Sheviak and Catling 2002). It is uncommon over much of the southern and particularly the southeastern parts of this range (personal observation, St. Hilaire 2002, Handley and Heidel 2005). Here it often occurs in isolated colonies of often less than a few dozen plants in cool, calcareous swampy woods and fens (e.g., Reddoch and Reddoch 1997). In contrast, it is frequent in much of the northern boreal forest and western cordillera where substrates range from acid to alkaline and from pure organic peat to coarse sand. The largest populations occur in open conifer woodland along rivers and creeks in the Rocky Mountains (personal observation). Large and concentrated populations are often valuable for studying pollination since they attract pollinator attention and thus increase the likelihood of observing pollinations. On June 16 and 17, 2010, a large population of *Galearis rotundifolia* at the confluence of the Maligne and Athabasca Rivers north of Jasper, Alberta had reached peak flower and

the weather was appropriate for observations of pollination. Here we provide information on the pollination of that population.

Methods

Study Area

The study area was located on the north side of the Maligne River at its confluence with the Athabasca River (52.9346°N, -118.0342°W). The vegetation is open White Spruce (*Picea glauca* (Moench) Voss) woodland with scattered shrubs of Bearberry (*Arctostaphylos uva-ursi* (L.) Spreng.), American Silver-Berry (*Elaeagnus commutata* Bernh. ex Rydb.), Shrubby Cinquefoil (*Dasiphora fruticosa* (L.) Rydb. ssp. *floribunda* (Pursh) Kartesz), Russett Buffalo-Berry (*Shepherdia canadensis* (L.) Nutt.) and birches (*Betula* spp.). Among the dominant herbaceous plants were strawberries (*Fragaria virginiana* Duchn. ssp. *glauca* (S. Wats.) Staudt) and Hair-Like Sedge (*Carex capillaris* L.). The orchids occurred in the open and among shrubs. The area was much richer in plant species, had less ground moss than surrounding woodland, and appeared to be subject to periodic short duration flooding in spring.

Pollination observations

We watched a 10 m² patch of 306 flowering stems of *G. rotundifolia* from 10:00 AM until 6:00 PM on 16 and 17 July 2010 and visited adjacent patches of hundreds within 20 m. The weather was mostly sunny

on both days with morning temperatures of 10°C becoming 18-20°C by noon and reaching 24°C by 2-3 PM and cooling quickly after 6 PM to 15°C.

With a 40 cm diameter hoop insect net, we made an attempt to capture all insects seen to visit two or more flowers. "Pollinators" are here defined as insects consecutively visiting two or more flowers and carrying pollinia of *G. rotundifolia*. "Visitors" include (a) insects landing on two or more consecutive flowers and not carrying pollinia, (b) landing on two or more consecutive flowers but not captured and (c) landing on a flower once. Bee pollinators were identified by Dr. Cory Sheffield and Dr. Laurence Packer, both of York University using Sandhouse (1939) and Mitchell (1962) and are contained in the collection of Dr. Laurence Packer at York and also in the Canadian National Collection (CNC) in Ottawa. Flies were identified by Dr. Jeff Skevington using Stubbs & Falk (1983) and Van Veen (2004) and vouchers (35756-35763) are contained in CNC. Lepidoptera were identified by the authors using Layberry et al. (1998) with vouchers also in CNC.

Pollination success

To obtain an idea of the success of pollination in this patch of 306 flowering stems (in 2010), we counted the number of persisting dehiscent capsules on dried inflorescences of the previous year. Although flowers that are not pollinated may disappear within a few to several weeks, the capsules that ripen remain intact as brown and dried material until well into the following summer. Based on the number of ripened ovaries and the number of inflorescences, we were able to calculate the % of flowers that ripened capsules assuming that the number of stems in the patch had not changed substantially since 2009.

Pollination mechanism

Based on observations of bees and manipulation of 15 fresh flowers with a needle the apparent pollination mechanism is discussed. Despite the difficulty of observation and the lack of a large sample, these suggestions may be useful in serving as a basis for future study.

Results

Pollinators

Except for flies, there was no general activity of potential pollinators until after noon when bees and some butterflies were seen. The first insects visiting the flowers were Syrphid flies but these were only resting. At 1:00 PM, the first consecutive bee and fly visitors were observed (Table 1) and these were observed on average every 10-15 minutes until 4:00 PM both days after which there was no visitation to flowers. At 4:00 PM temperatures dropped and there was no direct sun on the site.

The primary pollinator was the bee, *Osmia proxima* Cresson (Table 1), and this species was also the most

TABLE 1. Pollinators and visitors of flowers of *Galearis rotundifolia* near Jasper, Alberta.

| Species | Number |
|--|--------|
| Pollinators (captured, visiting two successive flowers and carrying pollinia) | |
| Hymenoptera, <i>Osmia proxima</i> | 8 |
| Diptera, <i>Eristalis hirta</i> | 2 |
| Diptera, <i>Eristalis rupium</i> | 1 |
| Diptera, <i>Eupeodes lapponicus</i> | 1 |
| Visitors (captured, visiting two successive flowers, not carrying pollinia) | |
| Hymenoptera, <i>Osmia proxima</i> | 2 |
| Diptera, <i>Eristalis hirta</i> | 2 |
| Hymenoptera, small bee | 2 |
| Visitors (not captured, two flowers) | |
| Hymenoptera, cf. <i>Osmia proxima</i> | 10 |
| Diptera, cf. <i>Eristalis</i> sp. | 5 |
| Diptera, Syrphidae | 5 |
| Hymenoptera, small bee | 3 |
| Diptera, Bombyliidae | 2 |
| Visitors (not captured, single flower) | |
| Diptera, Syrphidae | 13 |
| Hymenoptera, cf. <i>Osmia proxima</i> | 6 |
| Hymenoptera, small bee | 4 |
| Diptera, other | 4 |
| Diptera, Bombyliidae | 3 |
| Diptera, cf. <i>Eristalis</i> sp. | 3 |
| Lepidoptera, <i>Papilio glaucus</i> | 1 |
| Lepidoptera, <i>Glaucopsyche lygdamus</i> | 1 |
| Lepidoptera, <i>Erynnis persius</i> | 1 |

frequent visitor. While most flies were visitors, four species, *Eriozona (Megasyrphus) laxus* Osten Sacken, *Eristalis (Eoseristalis) hirta* Loew, *Eristalis (Eoseristalis) rupium* Fabricius, *Eupeodes (Lapposyrphus) lapponicus* (Zetterstedt) also served as pollinators. All of these pollinators carried the pollinaria on the lower part of the front of the head between the eyes (Figures 2 and 3) and they were also frequent visitors (Table 1).

Lepidoptera, *Erynnis persius* Scudder ssp. *borealis* (Cary), *Glaucopsyche lygdamus* Doubleday, and *Papilio glaucus* Linnaeus visited the flowers rarely (Table 1) but were common in the immediate area. No scales of butterflies were present on pollinated flowers suggesting that Lepidoptera had not been the pollinators. The commonest butterfly, *G. lygdamus*, flew over orchid patches without stopping and was mostly attracted to flowers of *Hedysaum alpinum* Linnaeus, possibly for egg-laying.

Bumblebees (*Bombus melanopygus* Nylander) were frequent on an adjacent (3 m away) flowering patch of *Elaeagnus commutata* (20 captured in ½ hour and 20 others seen) but were not seen on the orchids despite their relatively high numbers on the adjacent plants. Bumblebees were also seen pollinating *Dryas drummondii* Richards. ex Hook. on the river gravel 50 m away. *Papilio glaucus* was also a frequent pollinator



FIGURE 1. Flower of Round-Leaf Orchid (*Galearis rotundifolia*) photographed near the confluence of the Maligne and Athabasca Rivers, on 17 June 2010. Photo by P. M. Catling.

of the adjacent patches of *Elaeagnus commutata*, but was only seen once on a flower of *G. rotundifolia*. Smaller bees (smaller than *O. proxima*) were scarce in the *Elaeagnus commutata* shrubs and among the orchids but visited *Fragaria virginiana* ssp. *glauca* frequently.

Pollination success

At least 433 fruits were produced in 2009 and at least 174 stems were involved in this production. Using the 2010 average of 5.6 flowers per spike, then the total number of flowers in 2009 was 974.4. Thus 44.44%, i.e., 433 of 974.4 of flowers produced fruit. If there had been 306 stems (the 2010 figure) in 2009, then 25.21% of the flowers would have produced fruit.

Pollination mechanism

The pollination system is apparently similar to that of related species in the genus *Orchis* (*Galearis* differing from *Orchis* principally in the lack of tuberoids). Pollination of species of *Orchis* has been extensively studied over a long period (Darwin 1888, Nilsson 1983), and is characterized by food-deceptive flowers lacking fragrance or nectar. In *G. rotundifolia*, as

in many European *Orchis* species, the dorsal sepal and two lateral petals form a hood at the top of the flower (Figures 1 and 4). This restricts access to the column and spur so that an insect's head faces the stigmatic surface. The three-lobed lip (labellum) forms a sloping landing platform and the spreading lateral sepals may also assist in landing on the flower. The tubular spur is oriented in a slightly downcurved position with respect to the centre of the lip (Figure 4). The column, within the hood, is immediately above the spur. The central part of the column is surmounted by what is usually interpreted as an anther derived from a single stamen (Jacquemyn et al. 2009) with two pollinaria, one in each half of the anther (Figure 5). The club-shaped pollinarium (Figure 6), approximately 1.5 mm in length, includes an upper part with a number of masses of pollen (massulae) that are attached by threads to a central axis, thus allowing a gradual discharge of pollen to consecutive flowers (Johnson & Nilsson 1999). The massulae are attached by the caudicle to the sticky viscidium (disc). The viscidia are adjacent and contained in the fleshy and more or less purse-like bursicle which is situated on the rostellar



FIGURE 2. The Megachilid bee, *Osmia proxima* in lateral (below) and dorsal (above) view. The specimen was seen to visit two *G. rotundifolia* flowers consecutively and carries 9 pollinaria (p) of the orchid on the clypeus, indicating at least 5 flower visits of which at least four could have resulted in pollination. The mouthparts to 4 mm long are below the pollinaria including palps and a curled tongue (glossa) that can extend to the base of the spur when the head is fitted into the mouth of the spur. Photos by P. M. Catling.

part of the column which projects downwards into the mouth of the spur (Figures 4 and 5). The bursicle contains a sticky liquid which prevents the disc from drying out until the whole pollinium is removed by an insect visiting the flower. The bursicle may be ruptured or pushed backward as an insect, attracted by floral shape and colour at least, presses the lower front of its head, usually the clypeus, against it trying to

reach the bottom of the spur. It appears that the viscidia of *Galearis rotundifolia* are often removed together but in some species of *Orchis* with similar structure one may be removed after which the flap of the bursicle returns to its original position, thus preventing the viscidium that has not been removed from drying out (Jacquemyn et al. 2009). The fluid dries out quickly (within 1 minute in a few tests), and affixes the polli-



FIGURE 3. The Syrphid fly (*Eristalis* sp. with two pollinaria (p) attached to the side of the face (prefrons). The beak-like proboscis to the left of the pollinaria is less than 2 mm long and cannot reach the base of the spur. Photo by P. M. Catling.

narria to the clypeus. A forward rotation of each pollinarium resulting from a bending of the base of the caudicle was observed over the period of approx. 60 seconds, but this elapsed time was not verified with a significant sample of flowers. The rotation brings the pollinaria into a position where they contact the stigmatic surface, instead of the base of the anther sacs, of the next flower visited.

Discussion

Pollinators

It seems likely based on studies of related species of *Orchis* and *Dactylorhiza* in Europe, that *Galearis rotundifolia* would be pollinated by bees and flies. These are the pollinators of *Orchis purpurea* Huds. which has superficially similar flowers (Jacquemyn and Brys 2010). The similar *Dactylorhiza sambucina* (L.) Soó and *Orchis mascula* L. in southern Baltic island of Stora Karlsö are pollinated by a single solitary bee species and the pollinaria are similarly attached on the front of the head below and between the eyes (Pettersson and Nilsson 1983).

The principal pollinator of *G. rotundifolia*, *Osmia proxima* is found throughout a large area of North America (Mitchell 1962). It has been reported on a variety of flowers with differing floral morphology including *Balsamorhiza*, *Houstonia*, *Penstemon*, *Rubus* and *Trifolium* (Mitchell 1962; Tepedino et al. 1999; Cane 2005). Unlike some of these plants, which have numerous pollinators, it appears that *G. rotundifolia* may be narrowly adapted to *Osmia proxima* and possibly other bees of similar size. *Osmia proxima* nests in holes in wood and hollow stems (Cane et al. 2007), and does not have extraordinary requirements making it a reliable pollinator. The tongue of *Osmia prox-*

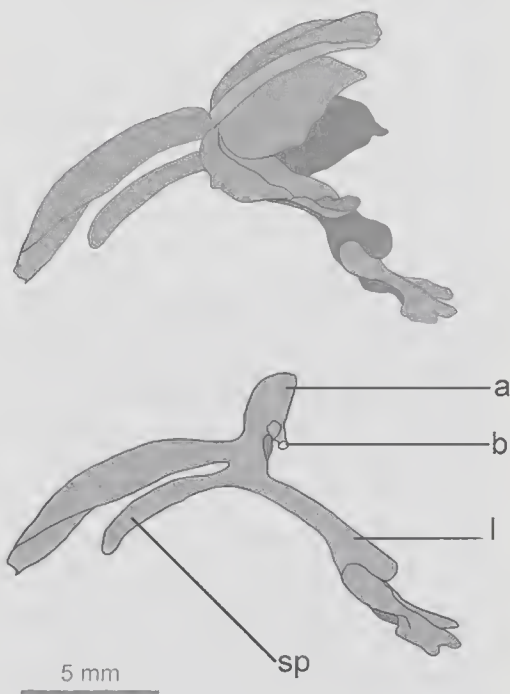


FIGURE 4. Camera lucida drawings of a flower of *Galearis rotundifolia* from Jasper, Alberta, in lateral view with all floral parts (above) and with the dorsal sepal and lateral petals (hood or galea) removed (below). In the lower drawing, the anther (a), bursicle (b), lip (l) and spur (sp) are identified. Drawings by P. M. Catling.

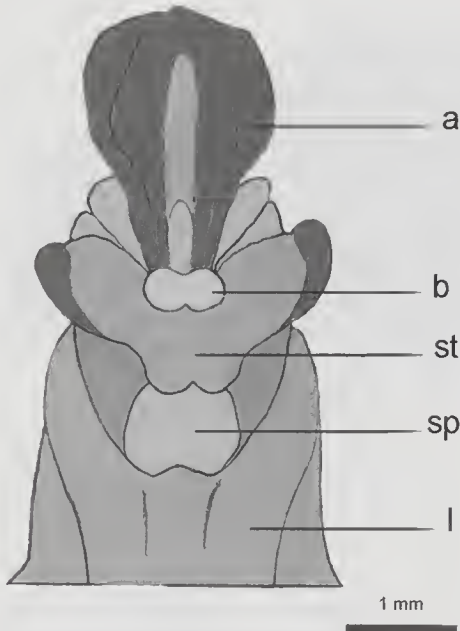


FIGURE 5. Camera lucida drawing of a column of *Galearis rotundifolia* from Jasper, Alberta, viewed from the lower front and showing the anther (a), the bursicle (b), the stigmatic surface (st), the entrance to the spur (sp), and the basal portion of the lip (l). Drawings by P. M. Catling.

ima can be extended to 5–6 mm from the head and it appears to be able to reach the base of the spur, unlike the fly pollinators. The extent to which this is relevant is unclear considering the reported lack of a reward.

The lack of visitation by *Bombus* species in this study, despite their general abundance in the area, might be attributed to the fact that these bees can quickly learn deceptive flowers and *G. rotundifolia* is a case of food deception, like most related *Orchis* species (Dafni 1987). Van der Cingel (2001) suggested, without a source, that flowers of *G. rotundifolia* are both nectar-free and scentless and Reddoch and Reddoch (1997) also suggest that there is no fragrance, but this requires more study. Our observations near Jasper are not conclusive on this point, but some flowers at least were lacking nectar, which could have been due to general lack of nectar or its removal by visiting insects.

Pollination success

In estimating the percentage of flowers developing fruit, there are assumptions such as the presence of similar numbers of plants and flowers in consecutive years, which are not reasonable for many orchid populations and for some in this group because fruit set

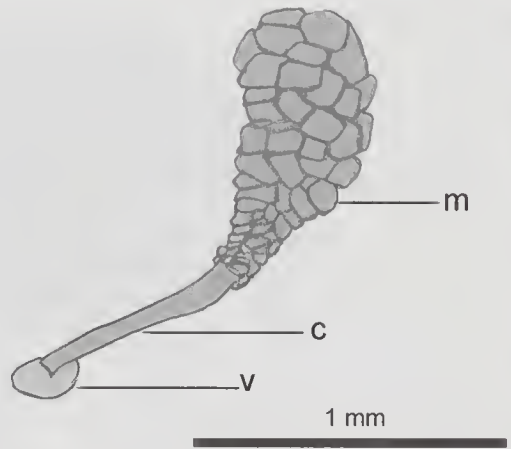


FIGURE 6. Camera lucida drawing of a pollinarium of *Galearis rotundifolia* from Jasper, Alberta, showing the packets of pollen (massulae – m), the caudicle (c) and the viscidium (v). Drawing by P. M. Catling.

has been shown to vary considerably between years (e.g., Jacquemyn and Brys 2010). If the population had been larger in 2009 and if stems without pollinated flowers are less likely to persist, this would have brought the percentage down, but on the other hand, the opposite seems more likely since the number of stems seems to be increasing vegetatively each year and stems with more persisting parts seem more likely to be dislodged by high wind, etc. Thus it seems appropriate to either stay with the range 25–44% of flowers or anticipate a slightly higher value.

These are relatively high numbers for a deceptive orchid. In eastern North America, *Galearis rotundifolia* and *Calypso bulbosa* often have less than 1% of plants in a population produce any seed, regardless of population size, but in some geographic regions and particularly in the western cordillera the percentage of plants setting viable seed may be much higher (personal observations, Catling & Catling 1991), likely due to generally larger population sizes in the west since a strong positive relationship exists between population size and fruit production (Jacquemyn et al. 2007).

Regardless of geographic variability, fecundity at the study site seems abnormally high considering similar and related species. For example, in a population of *Orchis purpurea*, in Belgium, 5–20% of flowers set fruit over 5 years (Jacquemyn and Brys 2010) and in parts of western Europe the fruit set for this species averaged 5.5%. In *Orchis mascula* in UK, the proportion of flowers setting fruit varied between 20.5% and 55.5% in recently coppiced woodland and between 8.8% and 13.2% in undisturbed woodland (Jacquemyn et al. 2009).

In *Orchis mascula* in Sweden, fruit production per individual was 3–20% and approx. half of the individuals in any population did not set any fruit (Nilsson 1983). In *Dactylorhiza sambucina* (L.) Soö on the southern Baltic island of Stora Karlsö, 0–8% (mostly 2%) of the flowers on an inflorescence produced fruit. The percentage is higher for *Orchis spitzelii* Sauter ex Koch in southern Sweden, where 8 to 60% of the flowers on a plant produced fruit (Fritz 1990).

Fruit set and lifetime fitness of orchids are usually pollen (pollinator) limited (Calvo and Horvitz 1990, Johnson and Nilsson 1999) so that the idea of lacking nectar and decreasing reward would seem to be a problem. However, the values of deception are easily underestimated. It may serve as an outcrossing advantage because lack of reward promotes visitation of fewer flowers in an inflorescence, or a clonal patch, thus favoring outbreeding at the expense of inbreeding (Dressler 1981). This explanation has limitations because inbreeding is already reduced by the amount of time required for the caudicle to bend into a position appropriate for pollination and this is generally too slow to allow pollination of consecutive flowers on the same spike. A more plausible value of deception is based on experiments with *Orchis*, where Johnson and Nilsson (1999) suggested that the selective value of food deception is that savings in nectar production are invested in advertising display which attracts increased numbers of pollinators. *Galearis rotundifolia* often forms large conspicuous patches as a result of its stoloniferous habit (personal observation) so that nectar production savings may be easily invested in number of stems in a clonal patch. Based on the extent of effective pollination in the study population, the level of advertising may have reduced the effect of pollinator limitation, thus supporting the advertisement hypothesis.

Pollination mechanism

The mass of sticky fluid in the bursicle and the fact that both pollinaria are removed at the same time may be an adaptation to attachment to the hairy surface of bees which would require more adhesive than that needed to attach to the smooth surface of a proboscis or a compound eye. The excess fluid and simultaneous removal of adjacent pollinaria is also characteristic of pollination of *Galearis spectabilis* (personal observation) unlike the situation in many species of *Platanthera* (Catling & Catling 1991). Similarities to related European species of *Orchis* and *Dactylorhiza* are noted above.

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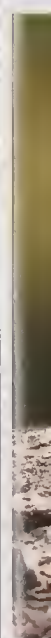
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Notes

Eastern Chipmunk, *Tamias striatus*, Attack on a Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, at Cooks Lake, Halifax County, Nova Scotia, Canada

DARRELL ABOLIT¹ and JOHN GILHEN²

¹ 1051 Cooks Brook Road, Cooks Brook, Nova Scotia B0N 1K0 Canada

² Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6 Canada

Abolit, Darrell, and John Gilhen. 2011. Eastern Chipmunk, *Tamias striatus*, attack on a Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, at Cooks Lake, Halifax County, Nova Scotia, Canada. *Canadian Field-Naturalist* 125(1): 55–57.

Sciurids are often seen eating carrion on roads but are rarely seen attacking live prey. We report a rare incident of an Eastern Chipmunk, *Tamias striatus*, attacking (but not eating) a Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, at Cooks Lake, Halifax County, Nova Scotia, Canada, on 29 September 2009 at 1315 h.

Key Words: Eastern Chipmunk, *Tamias striatus*, Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, attack, predation, Cooks Lake, Halifax County, Nova Scotia.

There are five species of tree squirrels and chipmunks native to Nova Scotia (Scott and Hebda 2004): the Eastern Chipmunk (*Tamias striatus*), the Eastern Gray Squirrel (*Sciurus carolinensis*), the Red Squirrel (*Tamiasciurus hudsonicus*), the Northern Flying Squirrel (*Glaucomys sabrinus*), and the Southern Flying

Squirrel (*Glaucomys volans*). Sciurids are often seen eating carrion on roads but are rarely seen attacking live prey (Callahan 1993). Callahan (1993) defines predation by sciurids as the killing and eating of active vertebrates, including conspecifics or other relatively large, mobile prey, by free-living animals. Callahan



FIGURE 1. Eastern Chipmunk (*Tamias striatus*) grasping a Maritime Garter Snake (*Thamnophis sirtalis pallidulus*) behind the head at Cooks Lake, Halifax County, Nova Scotia, on 29 September 2009 at 1315 h.



FIGURE 2. Eastern Chipmunk (*Tamias striatus*) biting a Maritime Garter Snake (*Thamnophis sirtalis pallidulus*) along its trunk at Cooks Lake, Halifax County, Nova Scotia, on 29 September 2009 at 1315 h.

(1993) states that predation excludes killing that appears unrelated to feeding.

D. A. was working on a winter's wood supply in his backyard at Cooks Lake, Cooks Brook area, Halifax County, Nova Scotia (45°00'22.38"N, 63°15'54.49"W), on 29 September 2009 when, at 1315 h, he observed an Eastern Chipmunk with a Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, hanging limp in its mouth. The Eastern Chipmunk brought the Maritime Garter Snake out of the wood pile, grasped it behind the head with its front paws, and obviously bit into its head. D. A. photographed the Eastern Chipmunk with the Maritime Garter Snake in its grasp (Figure 1). The Eastern Chipmunk seemed relaxed as it rested on a piece of firewood, continually biting the Maritime Garter Snake throughout the trunk length (Figure 2). The episode lasted approximately five minutes. The Eastern Chipmunk did not eat the Maritime Garter Snake but left it draped over the firewood and continued foraging in the backyard. The Maritime Garter Snake disappeared from the firewood site overnight. We do not know if the Maritime Garter Snake was alive or fresh dead when the Eastern Chipmunk attacked it.

The Eastern Chipmunk is a small ground-dwelling sciurid of deciduous and mixed forest. This diurnal sciurid will also climb up on shrubs or bushes and even higher while foraging. It is also at home in disturbed habitat such as backyards and gardens. Its diet is varied and includes mostly seeds, fruits, and nuts as well as green vegetation. In summer it eats a host of wild

fruit and berries; in the autumn it switches to nuts (Cameron 1956; Peterson 1966; MacClintock 1970; Banfield 1974; Reid 2006). Its diet also includes slugs, worms, frogs, and salamanders (Banfield 1974). Eastern Chipmunks have been reported killing, but not eating, Northern Redbelly Snakes (*Storeria o. occipitamaculata*) and Garter Snakes (*Thamnophis sirtalis*) (Banfield 1974). Eastern Chipmunks are known to attack other vertebrates such as young birds and bird eggs, but such prey accounts for only a small part of their diet (MacClintock 1970).

Snakes are known predators of Eastern Chipmunks (MacClintock 1970) and the young of other small mammals. There is one report of Maritime Garter Snakes preying on young Meadow Voles (*Microtus pennsylvanicus*) on Little Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia (Gilhen 1984). A mature female Maritime Garter Snake in captivity will eat live young (pinkies and fuzzies) of domesticated House Mice (*Mus musculus*). In June 1956 or 1957 an adult Maritime Garter Snake was observed attacking a young Snowshoe Hare (*Lepus americanus*), at Merrymakedge area, Kejimikujik National Park and Historic Site (personal communication, David Coldwell, 28 February 2011). An adult Maritime Garter Snake would probably be a threat to young Eastern Chipmunks in a ground nest. This example of an Eastern Chipmunk attacking a Maritime Garter Snake at Cooks Lake is possibly more of a defensive behaviour than one of foraging for food.

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Andrew Hebda, Curator of Zoology, Nova Scotia Museum of Natural Science, made useful comments on the manuscript.

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Two Amelanistic Eastern Red-backed Salamanders (*Plethodon cinereus*) from Eastern Canada

JEAN-DAVID MOORE¹ and JOHN GILHEN²

¹Forêt Québec, Direction de la recherche forestière, 2700, rue Einstein, Ste-Foy, Québec G1P 3W8 Canada

²Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6 Canada

Moore, Jean-David, and John Gilhen. 2011. Two amelanistic Eastern Red-backed Salamanders (*Plethodon cinereus*) from eastern Canada. *Canadian Field-Naturalist* 125(1): 58–60.

Three colour morphs of the Eastern Red-backed Salamander, *Plethodon cinereus*, are known in eastern Canada: red-backed, lead-backed, and erythristic. Anomalies, including two albino and four leucistic individuals, are also known from eastern Canada. We report the first salamander individuals exhibiting amelanism, which is a lack of black skin pigment, but with black eyes, one from Quebec and one from Nova Scotia, Canada.

Key Words: Amelanistic, Eastern Red-backed Salamander, *Plethodon cinereus*, deciduous forest, Quebec, coniferous forest, Nova Scotia, Canada.

The Eastern Red-backed Salamander, *Plethodon cinereus*, is probably the most abundant salamander in eastern North America (Conant and Collins 1998). Three colour morphs of this species are known in eastern Canada. The two most common are the grey-black with a reddish dorsal stripe (red-backed morph) and the grey-black without a dorsal stripe (lead-backed morph). The erythristic morph (all red) is apparently rare, at least in eastern Canada (Bleakney 1958; Cook 1967; Gorham 1970; Cook 1984; Gilhen 1984; MacCulloch 2002; Desroches and Rodrigue 2004). Anomalies, including albino and leucistic individuals, are known from populations in eastern Canada. The albino individuals, one from Nova Scotia (personal communication, J. Gilhen) and one from Quebec (personal communication, J.-F. Desroches), are pinkish white with pink eyes. The leucistic individuals, two from Nova Scotia (personal communication, J. Gilhen), one from New Brunswick (personal communication, G. Jongsma) and one from Ontario (Rye 1991), vary from pinkish white to milky white with black eyes.

We report the first salamander individuals exhibiting amelanism, one from Quebec and one from Nova Scotia, Canada. Amelanism (also known as amelanosis) is a pigmentation abnormality characterized by the lack of skin pigments called melanins, which are responsible for black, brown, and yellow colours, but with black eyes. Amelanistic specimens are pale in colour, although they may have some colour, especially red or pink, owing to the presence of other pigments.

Study Area

The Quebec specimen was captured 50 km north-west of Quebec City, in the Lake Clair watershed, Quebec (46°57'N, 71°40'W), at an elevation of 270 to 390 m. The habitat consists of mostly uneven-aged deciduous woods with small patches of conifers. The deciduous area is composed of Sugar Maple (*Acer saccharum*), Yellow Birch (*Betula alleghaniensis*), and American

Beech (*Fagus grandifolia*). The coniferous patches are principally Balsam Fir (*Abies balsamea*) with some Red Spruce (*Picea rubens*). Additional details on the habitat are described in Moore and Wyman (2010).

The Nova Scotia specimen was captured on Route #212 (Station 10), in the Goffs area of the Salmon River watershed, Halifax County, Nova Scotia (44°53.841'N, 63°26.857'W), at an elevation of about 230 m. The habitat consists mostly of clear-cut coniferous forest on the southeastern side of the highway. This salamander was migrating to the northwestern side, which is maturing coniferous forest composed mostly of White Spruce (*Picea glauca*), Balsam Fir, and Tamarack (*Larix laricina*). The ditches on both sides of the highway were wet, with sphagnum (*Sphagnum* sp.) and some Broadleaf Cattail (*Typha latifolia*) and banked by Speckled Alder (*Alnus incona*), seedling conifers, and Red Maples (*Acer rubrum*).

Methods

Snout-vent length of the Quebec specimen was measured in the field using a dial calliper. Salamanders were weighed with a 10 g Pesola® spring scale. No attempt was made to determine the gender of the animal, but the presence of eggs was noted. Following examination and photographing, it was released on site. The Nova Scotia specimen was also measured using a dial calliper. It was weighed using SARTORIUS Model 2256 Top-loading Balance. Sex was determined by dissection. The salamander was photographed one day after capture.

In the descriptions that follow, we use Smith (1975) to identify colours, and the identification number is included with the first mention in text.

Specimens

Quebec

The first specimen, an adult female (Figure 1), was 80.15 mm in total length, 41.8 mm in snout-vent



FIGURE 1. Adult amelanistic Eastern Red-backed Salamander, *Plethodon cinereus*, observed and photographed by Jean-David Moore on 13 October 2005, Lake Clair watershed, 50 km northwest of Quebec City, Quebec, Canada.

length, and weighed 1.15 g. It was found on 13 October 2005 by J-DM during a study of *Plethodon cinereus* (Moore and Wyman 2010).

The back of the Quebec individual was a heavy dappling of Peach Red (94) (Smithe 1975) on Pratt's Gray (88), with Peach Red becoming infrequent on white on the posterior of the tail. The sides of the trunk were pinkish white with some Peach Red spotting, and the sides of the tail were cream white.

The legs were Pratt's Gray with a dappling of Peach Red and Medium Plumbeous (87), the front legs being slightly darker than the back legs. The underside was transparent Pratt's Gray, exposing a Mauve (75) blood vessel anteriorly. The underside of the tail was slightly darker than the sides. The eyes were approaching Jet Black (89).

Nova Scotia

The second specimen, also an adult female (Figure 2), was 58.0 mm in total length, 33.0 mm in snout-vent length, and weighed 0.8 g. It was collected at night on wet highway on 11 June 2009 by JG. This specimen was deposited in the Nova Scotia Museum of Natural History (NSM55494), Halifax.

The back of this individual was a dappling Peach Red on Pratt's Gray, with small Pratt's Gray skin spots on the posterior trunk. The Peach Red became infrequent on Pratt's Gray on the posterior tail. The sides were a dappling of Peach Red on Pratt's Gray with a



FIGURE 2. Adult amelanistic Eastern Red-backed Salamander, *Plethodon cinereus*, collected by John Gilhen on 11 June 2009, Route #212, at Goffs (Station 10), Halifax County, Nova Scotia, Canada.

small amount of Medium Plumbous posteriorly. The legs were Pratt's Gray with a dappling of Peach Red and Medium Plumbous, the front legs being slightly darker than the back legs. The underside was transparent Pratt's Gray exposing a Mauve blood vessel on the anterior trunk. The eyes were approaching Jet Black.

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Additional Data and Perspectives on Interspecific Aggression in the Common Loon, *Gavia immer*

MARTIN L. MORTON¹ and MARIA E. PEREYRA¹

¹ Department of Biological Sciences, University of Tulsa, Tulsa, Oklahoma 74104 United States; e-mail: marty-morton@utulsa.edu

Morton, Martin L., and Maria E. Pereyra. 2011. Additional data and perspectives on interspecific aggression in the Common Loon, *Gavia immer*. *Canadian Field-Naturalist* 125(1): 61–62.

We witnessed the killing of a female Redhead (*Aythya Americana*) by a male Common Loon (*Gavia immer*). The wound was delivered into the abdomen from below, and death occurred because of a torn, hemorrhaging liver. This same Common Loon also threatened a female Ring-necked Duck (*Aythya collaris*) with ducklings. We hypothesize that interspecific aggression by loons might be energetically costly but is sometimes adaptive because it deters predators.

Key Words: Common Loon, *Gavia immer*, Redhead, *Aythya americana*, aggression, interspecific fatalities, British Columbia.

Common Loons (*Gavia immer*) are known for being highly aggressive during the breeding season, and fights between males for territories are often fatal (McIntyre and Barr 1997; Piper et al. 2008). This combative behavior is sometimes directed toward other species as well, especially waterfowl, and, as with conspecifics, can also lead to the death of attacked individuals (Sperry 1987; Kirkham and Johnson 1988). Herein we describe the killing of an adult female Redhead (*Aythya americana*) and harassment of a Ring-necked Duck (*A. collaris*) brood by a male Common Loon on a lake in northern British Columbia and discuss possible reasons for this kind of behavior.

Our observations took place from a small bluff on the western shore of an elongate, unnamed lake, without islands, about 2 km in length and 40 ha in size. The lake is fed and drained by Fourth of July Creek and lies within a glaciated canyon about 28 km north-east of Atlin, British Columbia, at 59°47'N, 133°28'W. The site is located next to the northeastern end of Steamboat Mountain (not to be confused with the more well-known Steamboat Mountain west of Fort Nelson).

Since 1998, we have stopped our vehicle on this bluff, where the lake is about 200 m wide, a few times each summer to watch waterbirds, usually ducks and gulls totaling a dozen or more in number, floating or swimming within easy view. When we arrived at 14:30 on 24 June 2010, however, the lake's surface seemed devoid of waterbirds. This was the first time we had ever seen the lake without waterbirds. After a few minutes, though, we began hearing a male Common Loon making tremolo calls about 200 m up the lake (north) from us. This was the also the first time we have heard a male making this call. Using 10 × 40 binoculars, we were able to locate the loon and were watching when it rose up and made a wing-flapping display. About 15 minutes later, three Redheads, a male and two females, flew in from the north and landed about 80 m across the water from us. We shifted to observing them as they slowly swam southward into a light wind (~ 15 km/hr) and began to separate, with one female lagging 10 m or so behind the other two ducks. By

chance, we were both focused on the lagging female when the water suddenly erupted beneath her, and the Common Loon emerged to full height with the duck grasped in his bill. During the next 3–5 seconds, using feet and wings, he maintained this erect posture at the surface as he shook the duck violently from side to side. He then dropped her and she began flapping and kicking before righting herself to face her attacker with neck extended and head held low to the water in what we took to be a threatening or defensive posture. Meanwhile, the loon watched her intently from a distance of 3–4 m but did not move toward her or touch her again. After a couple of minutes, the female's head began to droop and as it became submerged she rolled over completely once, again flapping and kicking, then became motionless with head underwater. She was dead. The loon watched for about 5 min more as the body drifted with the wind then swam over to a position about 30 m from the eastern shore. The other two Redheads had flown off when the attack began and we did not see them again.

Eventually the female's body drifted ashore, enabling us to recover it and to perform an autopsy. Only a small spot of blood was visible on the ventral plumage, but once the skin was removed a ragged hole 1–2 cm in diameter in the abdominal wall 1 cm distal to the tip of the sternum was revealed. Within the abdomen, we found large blood clots which obviously came from the liver because it was torn into pieces whereas the other internal organs were undamaged.

We returned to the same viewing site at 14:50 on 15 July. A male Common Loon, which we assumed to be the same individual as we had observed on 24 June, was present and very close to where we had last seen him over near the eastern shore, and once again there were no other birds on the water. This changed shortly, when a female Ring-necked Duck emerged from marshy shoreline vegetation about 40 m from the loon and, trailed by five young about one-third grown, began swimming northward along the water's edge. When a dead, recumbent tree was encountered they did not swim out and around it; rather, they clambered through

the branches or beneath them and remained close to the shoreline. All the while, the loon was facing them and watching. He then dipped his head underwater for a few seconds, then lifted it up and dove. The hen immediately turned toward the shore, only a meter or so away, and, along with her brood, swam with wings flapping to it then ran up and across a grassy area into a thicket of willows. Seconds later the loon surfaced where they had been, but did not follow onto the land. During the additional 20 minutes that we watched, he moved very little and the ducks did not reappear. We did not notice any female Common Loons during either of our visits, but there was about 150 m of shoreline marsh where the duckling-loon interaction occurred that may have been suitable habitat for loon nesting.

The majority of recorded attacks by loons on waterfowl have involved harassment and sometimes killing of ducklings and goslings (Sperry 1987; Kirkham and Johnson 1988). The body size, strength, and bill shape of loons makes them dangerous to even larger individuals, as shown by two records of fatal attacks on adult Canada Geese (*Branta canadensis*) that were defending nests, one by an Arctic Loon (*G. arctica*; Jones and Obbard 1970) and another by a Common Loon (Sperry 1987). Although puncture wounds, possibly attributable to loons, have been found in dead floating ducks (Munro 1939), there are only a few eyewitness accounts of fatal attacks by loons on adult waterfowl. We suggest that this is because adult waterfowl are quite aware that loons are dangerous and are usually careful to avoid them. In the fatal encounter we witnessed, however, the Common Loon was able to approach from behind and below the Redhead without her detecting it.

Ultimate explanations for fighting behavior among conspecifics so intense that severe injury or death may occur usually invoke the importance of future reproductive success (Enquist and Leimar 1990; Kemp 2006). More difficult to understand is why such a high level of aggression by male loons is also aimed at heterospecifics. At least four explanations have been advanced. These involve predation for food, competition for food, sexual selection, and non-discriminatory attacks devoid of fitness benefit. But loons do not eat the waterfowl they kill, overlapping use of food resources seldom occurs, and females do not appear to observe fighting males. By default, this leaves the tentative conclusion that loon attacks on waterfowl are examples of aberrant or non-adaptive behavior (Kirkham and Johnson 1988). As pointed out by Sperry (1987), however, encounters between loons and other waterbirds may be more frequent than is commonly recognized, especially on small lakes. Our observations support this hypothesis because our small lake was apparently swept free of gulls and ducks by a resident male Common Loon, and he attacked at once when any reappeared.

We assume that a significant expenditure of time and energy is required for such intense patrolling activity,

which occurs even through the night (Paruk 2008), and that this activity may not be an example of misdirected territorial behavior, as described by Murray (1971). We propose instead that, unlike many passerine birds (Veen et al. 2000; Fitzsimons 2006), loons do not innately discriminate among territorial intruders as to their depredation potential. Still, in some circumstances, their willingness to attack all intruders might prevent a predation event—an adaptive outcome. For example, small islands are often used as nesting sites by Common Loons, probably because this decreases exposure to mammalian predators (McIntyre 1994; McIntyre and Barr 1997). Nevertheless, island and floating nests are sometimes depredated (McIntyre and Mathisen 1977). This means of course that any mammal involved must swim to and from the island and, while in the water, expose itself to attack by a guarding male loon.

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Two Vascular Plants New to Nova Scotia: Yellow Glandweed (*Parentucellia viscosa* (L.) Caruel) and Whorled Loosestrife (*Lysimachia quadrifolia* L.)

MICHAEL MACDONALD¹ AND BILL FREEDMAN²

¹ 55 Ridge Valley Road, Halifax, Nova Scotia, B3P 2E4 Canada; e-mail: Michael.MacDonald@Stantec.com

² Department of Biology, Dalhousie University, Halifax, Nova Scotia, B3H 4J1 Canada; e-mail: bill.freedman@dal.ca

MacDonald, Michael, and Bill Freedman. 2011. Two vascular plants new to Nova Scotia: Yellow Glandweed (*Parentucellia viscosa* (L.) Caruel) and Whorled Loosestrife (*Lysimachia quadrifolia* L.). *Canadian Field-Naturalist* 125(1): 63–64.

Yellow Glandweed (*Parentucellia viscosa* (L.) Caruel), found near Yarmouth, and Whorled Loosestrife (*Lysimachia quadrifolia* L.), found near Halifax, are reported as new to Nova Scotia. The former is also new to the Atlantic coast of North America.

Key Words: Yellow Glandweed, *Parentucellia viscosa*, Whorled Loosestrife, *Lysimachia quadrifolia*, new record, Nova Scotia, Maritime Provinces.

Yellow Glandweed (*Parentucellia viscosa* (L.) Caruel), also known as Yellow Gumweed and as Red Bartsia, is an herbaceous, hemiparasitic annual in the family Scrophulariaceae (USDA, 2010a*). It is native to Mediterranean and western regions of Europe, usually occurring in coastal habitats, and has been introduced as an alien species to various countries. It is now known to occur in Australia, Canada (British Columbia), Chile, New Zealand, and the United States (Arkansas, California, Hawaii, Louisiana, Mississippi, Oklahoma, Oregon, Texas, and Washington). With opposite toothed and pinnately veined leaves, *Parentucellia* is reminiscent of *Rhinanthus*, but is glandular hairy and without inflated calyces. We report this species for the first time from the Atlantic Coast of North America, having discovered one small population near Cape Forchu, Yarmouth County, Nova Scotia (43.81728N; -66.14847W; 16 July 2010, *MacDonald and Freedman*, NSPM, photos DAO and Atlantic Conservation Data Centre). It was first observed in flat roadside habitat within about 20 m of the ocean on the northwest side of Route 304, occurring in open rocky cobble in a weedy community between a fishing shack and piles of stored lobster traps. Listed in order of decreasing abundance, the most prominent associated plants were *Trifolium aureum*, *Plantago maritima*, *Festuca rubra*, *Agrostis stolonifera*, *Ligusticum scoticum*, *Ambrosia artemisiifolia*, and *Odontites vernus* ssp. *serotinus*. We searched other potential habitat in the vicinity, both north and south of the population over several km along Route 304, but found no others. There were about 300 individual plants in the discovered population, mostly occurring in an area of about 40 m², with a few local outliers of as much as 10 m. The source of this adventive population of *P. viscosa* is not known, but the species is not grown as an ornamental and so was likely introduced accidentally.

Whorled loosestrife (*Lysimachia quadrifolia* L.) is a perennial forb in the family Primulaceae. It is native

to and widely distributed in eastern North America (Cholewa 2009; USDA 2010b), being known from 26 states as well as New Brunswick (Hines 2000), Ontario, and Quebec. We report this plant for the first time from Nova Scotia, from two locations: (a) Point Pleasant Park, Halifax, Halifax County (44.63°N; -63.57°W, 10 June 2010, *MacDonald and Freedman*, NSPM, photos DAO and Atlantic Conservation Data Centre); and (b) along the north side of Highway 103, west of exit 5, Halifax County (44.71°N; -63.91°W, 10 July 2010, *MacDonald and Freedman*, NSPM, photo DAO and Atlantic Conservation Data Centre). The Point Pleasant population was in an open well-drained trail edge in shrubby habitat dominated by *Diervilla lonicera*, with about 25 stems of *L. quadrifolia* present. The Highway 103 population was in a mesic habitat fringing a wetland beside Little Indian Lake, in an open, gently sloping roadside with mixed gravel and humus amid various herbs and low shrubs, with 200–400 stems of *L. quadrifolia* occurring in an area of about 5 m x 4 m. It seems likely that these adventive populations established by seed carried in mud by vehicles from established populations elsewhere in eastern North America. The nearest of the few New Brunswick occurrences (Hines 2000) are approximately 200 km NNW of the new Nova Scotia localities.

Acknowledgements

Sean Blaney of the Atlantic Canada Conservation Center (ACCCDC) confirmed that these species were not previously known from Nova Scotia. Paul Catling of the National Herbarium, Agriculture Canada, Ottawa, commented on a draft of the manuscript. Specimens of both species have been deposited with the Nova Scotia Museum of Natural History, and colour images and copies of the specimen labels were sent to the ACCDC and the National Herbarium.

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North American Deer Mouse, *Peromyscus maniculatus*, Consuming a Parasitizing Botfly Larva, Diptera: Cuterebridae

FRANCES E. C. STEWART

Department of Integrative Biology, University of Guelph, 50 Stone Road East, Guelph, Ontario N1G 2W1 Canada; email: fstewart@uoguelph.ca

Stewart, Frances E. C. 2011. North American Deer Mouse, *Peromyscus maniculatus*, consuming a parasitizing botfly larva, Diptera: Cuterebridae. *Canadian Field-Naturalist* 125(1): 65–66.

During a laboratory study in Algonquin Provincial Park, Ontario, Canada, I videotaped a female North American Deer Mouse, *Peromyscus maniculatus gracilis*, consuming a botfly larva, Family Cuterebridae, that had just emerged from her chest. Although botfly parasitism has been widely studied in several species of small mammals, there are no prior reports of the host consuming the emerged botfly parasite.

Key Words: North American Deer Mouse, *Peromyscus maniculatus*, botfly, Cuterebridae, parasitism, nest defense.

The diet of the North American Deer Mouse (here after deer mouse), *Peromyscus maniculatus gracilis* (Wagner 1845), can vary depending on its location, season, and in some cases interspecific competition with the White-footed Mouse, *P. leucopus* (Wolff et al. 1985; Falls et al. 2007). However, the deer mouse is primarily known to be an opportunist, obtaining nutrition from an array of sources such as arthropods, fruit, nuts, green vegetation, and carrion (Hamilton 1941; Schieck and Millar 1985; Wolff et al. 1985). Despite this wide variety, I found no reference to deer mice consuming botfly larvae and, more specifically, their own parasites.

Botflies, are found throughout the geographical distribution of the deer mouse. They are known to parasitize many species of small mammals, however, one of their typical hosts is *Peromyscus* and parasitism may be as high as 70% in a given year (Dunway et al. 1967; Slansky 2007). While botfly parasitism is common among small mammal populations in Algonquin Provincial Park (personal observation), there is no documented case of botfly consumption by their mammalian host. In this paper, I describe one instance of a female deer mouse eating a botfly larva three hours after the larva began to emerge. To my knowledge, this is the first recorded observation of a small mammal consuming a botfly larva, and the first recorded observation of a small mammal consuming its own endoparasite.

Observations

In August 2010, wild *P. maniculatus* were housed in a laboratory setting at the Algonquin Wildlife Research Station in Algonquin Provincial Park, central Ontario, Canada (45°37'N, 78°21'W) as part of a pilot study quantifying maternal care in this species. Throughout this study, pregnant female deer mice were trapped using Sherman live-traps and housed in a laboratory holding facility prior to parturition. Females gave birth within several days of capture and the mother and pups were videotaped for seven days post partum.



FIGURE 1. A still photo obtained from video footage of a female deer mouse consuming a recently emerged parasitizing botfly larva directly above her nest containing four pups, Algonquin Provincial Park, August 9, 2010. Although of inadequate resolution, the relative size of botfly larva to deer mouse as well as the stance the female assumes while eating the botfly larva are adequately portrayed in this figure.

This particular observation was made post-parturition on a study female that gave birth on 3 August 2010 at 5 pm. Only one individual in the study was infected with a botfly parasite, thus comparison among individuals was not possible. The parasitized female had a botfly developing in her upper left chest prior to capture. On the morning of the sixth day of postpartum observations (9 August) the botfly larva had partially emerged. By evening, the botfly larva was no longer visible in the cage; the only evidence of its existence was the wound left on the mother's chest from where it had emerged. Upon review of the day's video footage it was evident that the female had consumed the botfly larva. The video record showed the botfly

larva beginning to emerge on 9 August at 9:51 am. The botfly larva fully emerged from the female at 13:04 hr and fell to the cage floor directly beside her nest, which contained four pups (six days old). The larva measured approximately 1.5 cm in length, 1 cm in diameter and was in its third instar. The female did not react to the larva for approximately 22 minutes, at which time she picked it up. The female instantly positioned herself above her nest and held the botfly larva with both paws. She began to eat the botfly at 13:26 hr and finished at 13:32 hr, continuously turning the larva clockwise with her right paw.

Discussion

This appears to be the first documented report of a deer mouse eating a parasitic botfly larva. Although, owing to its consumption, I am unable to identify the larva to species, it is likely that the larva belonged to either *Cuterebra fontinella* or *C. americana* due to species distribution and host-species preference (Catts 1982). In Algonquin, botfly parasitism fluctuates seasonally with most infestations occurring between late July and October (Slansky and Kenyon 2002) and *Peromyscus* individuals can have between zero and three botflies at any point (personal observation). Several studies have investigated the behavioural effects of botfly parasitism and have determined that botflies generally have little effect on *Peromyscus* compared to atypical hosts, such as non-native rodents, lagomorphs, and Carnivora, which experience physiological and behavioural changes resulting in decreased activity, food intake, and reproductive success (Slansky 2007). Nonetheless, individuals can be adversely affected by botfly parasitism, and a smaller dispersal distance from the natal nest was noted in the offspring of parasitized individuals (Wolf and Batzli 2001; Jaffe et al. 2005). I offer this account of a female deer mouse eating a parasitizing botfly as the first account of a mechanism by which deer mice may mitigate the effects of botfly parasitism.

Researchers studying foraging, diet, and nutrition of deer mice rely primarily on stomach content analysis techniques to determine dietary composition (Millar et al. 1990). Although this method is relatively effective at determining nutritional composition and digestibility, it does not provide insight into the behavioural mechanisms by which individuals obtain their food. For example, through gut analysis, it has been known for almost 70 years that deer mice consume arthropods (Hamilton 1941; Wolff et al. 1985), some of which may be botflies. However, the incentive behind this mechanism of prey acquisition remains to be investigated.

Due to this observation occurring in a laboratory setting, I am unable to determine whether this behaviour occurs in free-ranging individuals. However, I foresee two reasons that are not mutually exclusive for a lactating female deer mouse to consume a botfly larva in the vicinity of her nest; (1) she consumes the botfly

as a source of nutrition, or (2) she consumes the botfly larva to prevent pupation in the direct vicinity of her pups. Unlike this laboratory situation, wild mice do not have access to food *ad libitum* and are likely to consume high nutrient foods when available. However, botfly infestations have also been observed in nest-bound infant rodents, who were deleteriously affected due to their small size and high-energy demand for growth (Slansky and Kenyon 2002). Therefore, either of the above-mentioned mechanisms may account for this female consuming the botfly in the direct vicinity of her nest and additional research is required to determine the incentives and to assess the generality of this strategy for mitigating parasitism in small mammals.

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Wolves, *Canis lupus*, Carry and Cache the Collars of Radio-collared White-tailed Deer, *Odocoileus virginianus*, they Killed

MICHAEL E. NELSON^{1,2} and L. DAVID MECH^{1,3}

¹ U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711-37th Street, SE, Jamestown, North Dakota 58401 USA

² Mailing address: 7332 Tracy Road, Duluth, Minnesota N 55803 USA; e-mail: Michael_nelson@usgs.gov

³ Mailing address: The Raptor Center, 1920 Fitch Avenue, University of Minnesota, St. Paul, Minnesota 55108 USA

Nelson, Michael E., and L. David Mech. 2011. Wolves, *Canis lupus*, carry and cache the collars of radio-collared White-tailed Deer, *Odocoileus virginianus*, they killed. *Canadian Field-Naturalist* 125(1): 67–68.

Wolves (*Canis lupus*) in northeastern Minnesota cached six radio-collars (four in winter, two in spring-summer) of 202 radio-collared White-tailed Deer (*Odocoileus virginianus*) they killed or consumed from 1975 to 2010. A Wolf bedded on top of one collar cached in snow. We found one collar each at a Wolf den and Wolf rendezvous site, 2.5 km and 0.5 km respectively, from each deer's previous locations.

Key Words: Wolf, *Canis lupus*, White-tailed Deer, *Odocoileus virginianus*, caching, radio-collars, den, homesite, Minnesota.

Wolves (*Canis lupus*) cache food in summer when they travel alone or in small groups (Murie 1944, Cowan 1947, Magoun 1976; Mech and Adams 1999). Caching stores excess food, protects it from scavengers and maggots, and provides a buffer during periods of prey scarcity (Mech 1970). However, caching by free-ranging Wolves has not been reported during winter (Peterson and Cuicci 2003). This is not surprising because much of the Wolf literature is based on forest-dwelling Wolves that have primarily been observed from small aircraft during winter, conditions that have precluded detailed observations of caching. Wolves do return to old kills in winter and conceivably may uncover caches made earlier (Mech 1966).

In a long-term radio-telemetry study of White-tailed Deer (*Odocoileus virginianus*) preyed upon by Wolves in northeastern Minnesota (48°N, 91°W; Nelson and Mech 1986), retrieving the collars of radio-collared deer killed by Wolves revealed that Wolves cached radio-collars. Aerially locating deer 1-3 days/week and retrieving radio-collars of killed deer within 24 hours of discovery presented an unbiased method to document caching in winter, as well as during other seasons.

Of 202 radio-collared deer killed and/or consumed by Wolves during 1975-2010, Wolves cached the collars of six (3%) deer, one each in January, April, August and November, and two in March. Wolves buried four collars in 25-76 cm of snow and two in soil covered by duff and leaf litter. The collar was still attached to the neck and head of research animals for two collars buried in snow, and one of those was beneath a Wolf bed. We found one collar 200 m from the kill site and another in a Wolf summer homesite 500 m from the deer's location just before being killed, although the kill site was not found. Of the remaining 196 radio-collared deer, Wolves in April and May (0-15 cm snow) carried and dropped two collars 300 and 400 m from kill sites. We found a third collar dropped at a Wolf den the first week in April, 2.5 km from the deer's previous

26 January-March locations, and like the previous homesite observation, the kill site was unknown.

Our observations document that Wolves make caches during winter and confirm that Wolves will bed on top of their caches, behavior reported for the Red Fox (*Vulpes vulpes*, Mech 1967) but only suspected for Wolves (Mech 1970).

Presumably caching a radio-collar must be far less frequent than caching food because a collar has no nutritional value. As a nonfood item, it is unclear why Wolves would cache a radio-collar, although, deer hair, blood, scent, and bone-like rigidity of the collar could conceivably play a role in eliciting caching behavior. However, well-fed captive Wolves carry away and cache nonfood objects belonging to their caretakers (Schmidt, International Wolf Center, personal communication). Carrying a radio-collar for considerable distances appears similar to this behavior, which suggests that aspects of caching behavior may be more complex than simply a response to nutritional pressures. Awareness of and attraction to physical objects may be a deep-seated trait in the genome. Hiestand (1989) found that Wolves spontaneously oriented to physical objects in fewer experimental trials than dogs (*Canis familiaris*), a finding corroborated by observations of captive Wolves (Fentress 1967, 1992; MacDonald 1980, Zimen 1981). The selective breeding of dogs for retrieving objects for humans is evidence that possession of objects plays a role in canid social behavior. Because Wolves are the progenitors of dogs, the propensity for this trait must have its origins in the Wolf genome.

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The Brown Morph of the Northern Ringneck Snake, *Diadophis punctatus edwardsii*, on Big Tancook Island, Mahone Bay, Nova Scotia

JOHN GILHEN

Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6 Canada; e-mail: gilhenja@gov.ns.ca

Gilhen, John. 2011. The brown morph of the Northern Ringneck Snake, *Diadophis punctatus edwardsii*, on Big Tancook Island, Mahone Bay, Nova Scotia. *Canadian Field-Naturalist* 125(1): 69–71.

I describe a brown morph of the Northern Ringneck Snakes (*Diadophis punctatus edwardsii*) that occurs in a population on Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia, Canada.

Key Words: Brown morph, Northern Ringneck Snake, *Diadophis punctatus edwardsii*, Big Tancook Island, Mahone Bay, Nova Scotia.

The Northern Ringneck Snake, *Diadophis punctatus edwardsii*, is a small, slender, nocturnal, woodland snake. The most commonly observed dorsal colour is black to slate-grey. This rear-fanged but harmless snake was known to the Mi'kmaq People in Nova Scotia as "the worst snake, Um-taa-kum (k)", (phonetic, from Harry Piers Museum Number 5321, Gilhen 2000).

In Nova Scotia the Northern Ringneck Snake is common in the Atlantic Interior, Theme Region 400 (Davis and Browne 1997). It is most commonly observed in southwestern mainland of Nova Scotia, and less commonly observed in the northeastern mainland. Only four localities are known on Cape Breton Island (Figure 1). Big Tancook Island is a coastal drumlin situated at the mouth of Mahone Bay: 44°27'00"N, 64°10'00"W. There are exposed slate rock areas, particularly along the shore. A gravel road on the island stretches from southeast to northwest giving residence access to the ferry. Although fishing is an important industry, many residents take pride in their extensive lawns and gardens. This extensive edge habitat, with lots of loose slate rock and wood debris, adjacent to the coniferous forest provides cover for three species of snake which are common on the island: Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, Eastern Smooth Green Snake, *Opheodrys vernalis*, and Northern Ringneck Snake.

The colour of the Ringneck Snake, *Diadophis punctatus*, varies over the range of the species in North America. Ernst and Ernst (2003) described the species as a complex of 12 subspecies and give the general dorsal colour as an "olive, greenish grey, blue black, or black snake with a dark head and a cream, yellow or orange neck band". However, Conant (1958) gives the dorsal colour of the Northern Ringneck Snake, the subspecies native to Nova Scotia and Canada, as bluish black, bluish gray, slate, or brownish, with a golden collar.

Most published accounts for Canadian populations of the Northern Ringneck Snake agree that this snake is basically bluish-slate gray to black in colour on the back, with a yellowish or yellowish-orange neck band

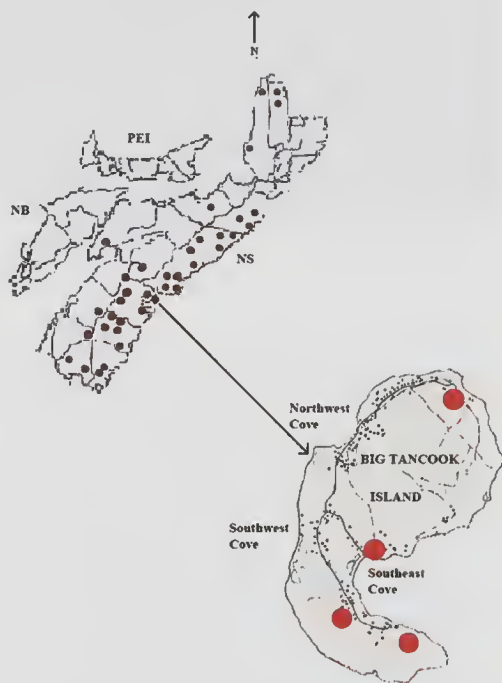


FIGURE 1. Distribution of the Northern Ringneck Snake, *Diadophis punctatus edwardsii*, in Nova Scotia.

(Cook 1984 [Canada], Logier 1958 [Ontario], Desroches and Rodrique 2004 [Quebec], Gorham 1970 [New Brunswick]).

In Nova Scotia the dorsal colour of hatchling Northern Ringneck Snakes is black on the back of the head, trunk and tail. Juveniles can be slightly lighter grey-black. Most observations of adults in Nova Scotia are of a black or bluish slate-grey snake with a yellowish-orange collar (Martin 1969; Gilhen 1970, 1984).

I first became aware that brown individuals represented a distinct brown morph in Nova Scotia, and not



FIGURE 2. Two brown and one bluish slate-grey Northern Ringneck Snakes (*Diadophis punctatus edwardsii*) from Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia.

an anomaly, while reviewing Harry Piers' Accession Books 1899 to 1939 (Gilhen 2000). Two of the nine specimens (22%) he catalogued were brownish above. He described one Northern Ringneck Snake (NSM 3410), from Tufts Cove, Dartmouth, Halifax County, Nova Scotia, collected 22 August 1909 by Lancelot A. Purcell as "Above, brownish-black (clove brown), paler on the sides..." A second brownish individual (NSM 3591) collected at Point Pleasant Park, peninsular Halifax, Halifax County, Nova Scotia, on 12 August 1910, by Ralph McDonald and Robert Walsh was described as "Above grayish hair-brown (perhaps more like dark mouse-gray); dark (clove brown) on top of head. The colour of the back passes into bluish-gray (light French-gray) on one or two rows of scales above the belly." I have observed the brown variations described by Piers in Nova Scotia. The shade and brightness depends on the light and time before or after the skin is shed. Fresh shed individuals appear glossy and iridescent, particularly on the lower sides. Piers referred to the glossy lower sides as "slight bronzy and bluish play of colours in some lights".

In 1969, during a study of the variation of Northern Ringneck Snakes at McCabe Lake, Halifax County, Nova Scotia, the author observed that the dorsal colour of two adults (8%) was a cinnamon-brown colour anteriorly, gradually changing to bluish slate-grey posteriorly. In 2005 he also noticed that on Big Tancook Island, Mahone Bay, Nova Scotia, that approximately 50%, were brown anteriorly (Figure 2). Based on

Smithe (1974) the cinnamon-brown colour, observed on two individuals at McCabe Lake and those of the Big Tancook Island population, would vary from Antique Brown (Color 37) to Cinnamon (39) depending on light and time before or after shedding. On 10 June 2010 several freshly shed individuals observed on Big Tancook Island were noted to be a bright orange-brown on the back of the head, trunk and tail (Figure 3) and varied from Tawny (Color 38) to Cinnamon-Rufous (40) depending on light.

The individual dorsal scales of the brown adult Northern Ringneck Snakes from McCabe Lake and Big Tancook Island are black in ground colour with numerous bluish-grey and brown spots. The brown spots are more plentiful anteriorly and overwhelm the grey spots, thus giving these snakes a brownish appearance anteriorly. At about mid-trunk length the proportion of grey spots gradually increase so that the dorsal colour of the individual changes from brown to bluish slate-grey.

Although the ventral colour of Northern Ringneck Snakes in Nova Scotia can vary from yellowish-orange, orange to reddish-orange, on Big Tancook Island the bluish slate-grey individuals are yellowish-orange while brown individuals tend to be a darker orange. Also, on Big Tancook Island mid-ventral spotting is extensive and extremely variable, as found on the mainland at McCabe Lake (Gilhen 1969, 1984)

The Northern Ringneck Snakes in Figure 2 were retained as voucher specimens and deposited in the



FIGURE 3. One brown morph of the Northern Ringneck Snake, *Diadophis punctatus edwardsii*, from Big Tancook Island, Mahone Bay, Lunenburg County, Nova Scotia.

Nova Scotia Museum of Natural History, Halifax (NSM55555) as well as a series of colour photographs of the Big Tancook Island snakes.

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A Brief Survey of Mycophagy in Ruffed Grouse, *Bonasa umbellus*, from Northwestern Ontario

JOEY B. TANNEY¹ and LEONARD J. HUTCHISON¹

¹ Faculty of Natural Resources Management, Lakehead University, 955 Oliver Road, Thunder Bay, Ontario P7B 5E1 Canada; e-mail: jtanney@lakeheadu.ca.

Tanney, Joey B., and Leonard J. Hutchison. 2011. A brief survey of mycophagy in Ruffed Grouse, *Bonasa umbellus*, from northwestern Ontario. *Canadian Field-Naturalist* 125(1): 72–73.

There are few published observations regarding the phenomenon of mycophagy in birds, the Ruffed Grouse being no exception. Twenty hunter-killed Ruffed Grouse crops were acquired in the Thunder Bay District from 22 September to 18 October, 2010, and examined for the presence of consumed fungal tissue. Four crops were found to contain intact remains of fruiting bodies. Based on cystidia and spore morphological characters, the specimens recovered were found to belong to three genera: *Lactarius*, *Russula*, and *Melanoleuca*. The results of this brief survey suggest the possible importance of mycophagy in the seasonal diet of the Ruffed Grouse, and indicate the need for further investigation.

Key Words: Ruffed Grouse, *Bonasa umbellus*, mushrooms, *Lactarius*, *Russula*, *Melanoleuca*, Ontario.

The Ruffed Grouse (*Bonasa umbellus* L.) is one of the most important game birds across its North American range (Rusch et al. 2000; Fearer and Stauffer 2003). Consequently, many studies have investigated the seasonal variation and composition of the Ruffed Grouse diet in various localities (e.g., Gilfillan and Bezdek 1944; Korschgen 1966; King 1969; Stafford and Dimmick 1979; Norman and Kirkpatrick 1984; Servello and Kirkpatrick 1989; Sedinger 1997). A noticeable gap in the literature is the lack of information pertaining to the use of fungal fruiting bodies by the Ruffed Grouse, most attention being paid to the consumption of plant material including herbaceous plants, berries, and reproductive buds. The few publications which include nominal observations of mycophagy in Ruffed Grouse ultimately ignore the possible significance of fungi in their diet.

Brown (1946) reported gilled mushrooms (Agaricales) in 5 (2.6%) out of a total 188 crops obtained in Maine during a fall season. Based on a survey of 34 crops and gizzards collected in Maine in October, Kitams (1943) found that fungi composed 2.4% of the total food groups observed. In a similar study, 1 (2.0%) out of 49 crops collected in interior Alaska during the fall contained Basidiomycete mushrooms (McGowan 1973). Conversely, Stewart (1956) found that gilled mushrooms were consumed in fair quantities by Ruffed Grouse chicks in the late summer. These occurrences of mycophagy in the summer and fall seasons offer evidence of the possible importance of mushrooms as a seasonal food. However, none of these studies actually identified the mushrooms to genus found in the digestive tracts, contributing to the ambiguity surrounding fruiting body selection by Ruffed Grouse.

From 22 September to 18 October, 2010, twenty hunter-killed Ruffed Grouse crops were acquired in the Thunder Bay District (northwestern Ontario) and examined for the presence of consumed fungal tissue. Four crops (20%) were found to contain intact remains

TABLE 1. Fruiting bodies collected from Ruffed Grouse crops in the Thunder Bay District of northwestern Ontario.

| Genus | Incidence (# crops) | Date Collected |
|----------------------|---------------------|----------------|
| <i>Lactarius</i> | 1 | 01/10/2010 |
| <i>Melanoleuca</i> | 1 | 22/09/2010 |
| <i>Russula</i> sp. 1 | 1 | 08/10/2010 |
| <i>Russula</i> sp. 2 | 1 | 14/10/2010 |

of fruiting bodies, which were subsequently collected and preserved in vials containing 70% ethanol. Gill tissue was mounted in various dyes, including Melzer's reagent, Phloxine B (1% aqueous solution), and lactophenol cotton blue, to facilitate identification based on spore and fruiting body morphology. Specimens were viewed with a Nikon Eclipse E400 phase contrast compound light microscope and measurements were made on material mounted in Phloxine B.

The four fruiting bodies recovered belonged to three genera (Table 1). Identification to species was not possible based on the available tissue or microscopic characters alone; however, the two *Russula* specimens were represented by two distinct species. Members of the Russulaceae were distinguished by amyloid reticulate or wart ornamented basidiospores and cystidial morphology (Kränzlin 2005). The *Lactarius* specimen bore numerous lactiferous hyphae in the hymenium. Cystidial morphology and verrucose ornamentation on amyloid basidiospores aided in the identification of the *Melanoleuca* specimen (Gillman and Miller 1977).

Fungal material found in crops consisted of hymenia or gill tissue, with very little pileus or stipe tissue observed. This suggests the preferential feeding on gills rather than the consumption of entire fruiting bodies. The hymenium may be the most nutritious portion of the fruiting body due to the presence of relatively nitrogen-rich spores. Picking at the gills may also be easier than attempting to break whole caps for consumption.

Despite the small sample size and inherent limitations involved with investigating diet composition based on crop analyses, which only represent recent feedings, it is evident that Ruffed Grouse in northwestern Ontario utilize fungi as a source of food in the fall season. When leafy plant tissue and berries become scarce in the fall, mushrooms may offer a high carbohydrate and protein source in a diet which is being replaced with lower-energy, fibrous foods (e.g., Lundgren 2009).

Reports of avian mycophagy are relatively scarce (Simpson 1998; Simpson 2000). Although this may reflect the actual rarity of this phenomenon, it could possibly be attributed to a lack of expertise in identifying fungi by researchers. Being able to recognize fungal tissue in gut contents and collaborating with mycologists may assist in the elucidation of mycophagy in birds, which may be more common than previously thought. We believe this note represents the first work identifying fungal genera consumed by Ruffed Grouse. Further work should include a larger sample size, longer sample period and the use of molecular techniques to more precisely identify the fungal diet composition. Investigating the effect of digestive tract passage on spore viability may also provide insight on the role of birds as possible spore dispersal vectors.

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The Warty Dory, *Alloctytus verrucosus* New to the Fish Fauna of Canada

COREY J. MORRIS¹, BRIAN W. COAD², and GARY FISHER³

¹ Department of Fisheries and Oceans Canada, P.O. Box 5667, St. John's, Newfoundland and Labrador A1C 5X1 Canada

² Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, Ontario, K1P 6P4 Canada

³ P.O. Box 92, Port Rexton, Newfoundland and Labrador A0C 2H0 Canada

Morris, Corey J., Brian W. Coad, and Gary Fisher. 2011. The Warty Dory, *Alloctytus verrucosus*, new to the fish fauna of Canada. *Canadian Field-Naturalist* 125(1): 74–75.

In April 2010, a Warty Dory, *Alloctytus verrucosus* (Gilchrist, 1906), was captured during commercial fishing activities in the Labrador Sea. This is the first record for Canada and the northwest Atlantic Ocean.

Key Words: Warty Dory, *Alloctytus verrucosus*, deep-sea fish, range extension, Labrador Sea, Canada.

A Warty Dory, *Alloctytus verrucosus* (Gilchrist, 1906), was captured in April 2010 during commercial fishing activities descending to 1250 m depth, in the Labrador Sea east of Hamilton Bank (53°33.31'N, 52°11.29'W) (Figure 1). This is the first record of its capture in Canadian waters and the northwest Atlantic Ocean as Scott and Scott (1988) and Coad et al. (1995) do not record it. The Warty Dory is a member of the Oreosomatidae family of fishes, found typically throughout the southern hemisphere but also in the Gulf of Mexico and rarely in Europe (Karrer in Smith and Heemstra 1986; James et al. 1988; FAO Fisheries Department 1994; Gomon et al. 1994; Heemstra in Carpenter 2002). It is the second most northerly specimen on record after one caught off western Scotland at 58°40'N, 9°00'W (du Buit and Quéro 1993).

This species is edible and has an estimated life span up to 140 years. It occurs in large shoals on continental slopes and, as a bathypelagic species, this specimen may have been caught as the trawl was retrieved.

Data provided by Fisheries and Oceans Canada, from 60 observations recorded between 1931 and 2010 within a 75 km radius of the capture site at depths between 1000 and 1500 meters, indicate that the temperature and salinity were stable year round at 3.5°C and 34.91 psu, with standard deviations of 0.2 and 0.06 respectively.

The fish was caught during commercial Turbot (Greenland Halibut, *Reinhardtius hippoglossoides*) fishing operations using a bottom trawl. Crew member Gary Fisher, with more than 30 years of fishing experience, did not recognize the unusual fish and preserved it for identification. The frozen specimen was brought to the Northwest Atlantic Fisheries Centre, St. John's, Newfoundland and Labrador, for identification. The specimen is preserved in the Canadian Museum of Nature, Ottawa under CMNFI 2010-0034.

The specimen (Figure 2) is 25.4 cm in length (with the caudal peduncle and caudal fin lost, these parts estimated from illustrations to be about 28% of length, giving an approximate total length of about 35.5 cm). Literature records give 42.5 cm TL and 2.0 kg as maxima.



FIGURE 1. Distribution of the Warty Dory in the Labrador Sea at 53°33.31'N, 52°11.29'W.

The specimen is identified by having such generic characters as a predorsal profile not rising sharply before the dorsal fin, the pelvic fin origin at mid-belly with 6-7 soft rays and a spine not reaching the anal fin origin, and irregular rows of enlarged scales on the belly between the pectoral and pelvic fins. Species characters include strongly ctenoid scales, two rows of enlarged, horizontal belly scales, and distribution in respect to related species.

The fish has the following meristics and morphometry which agree with literature descriptions: Dorsal



FIGURE 2. Warty Dory, *Allocyttus verrucosus*, ca. 35.5 cm. CMNFI 2010-0034.

fin spines 7 (5-8 in literature), dorsal fin soft rays 25 (28-33; but the specimen is damaged at the end of the fin and the count is incomplete), anal fin spines 3 (2-3), anal fin soft rays 29 (26-31), pectoral fin branched rays 18 (17-21), pelvic fin branched rays 6 (6-7), total gill rakers 25 (24-28), and lateral line scales not countable because lost caudally (83-91).

The body is deep and compressed, rhomboidal in shape, with the predorsal profile straight to slightly convex, and not rising sharply to the dorsal fin. The operculum has bony ridges. The eye is large (45.2 mm bony orbit, longer than both the snout and the postorbital distance), the protrusible mouth is large and oblique, the upper jaw is longer than the snout, and jaws bear small conical teeth. Scales are firmly attached and ctenoid, and are also found on the cheek. The bases of the soft dorsal and anal fins bear slightly enlarged scales, with strong ctenii. Two irregular, horizontal rows of enlarged scales lie on the belly between the pectoral and pelvic fin levels, the lower row extending back to the anal fin level. The upper row has 3 obvious enlarged scales and the lower row 10 scales. The lateral line is wavy at mid-body and is arched anteriorly over the pectoral fin and opercular region. It is interrupted over the anterior anal fin level, beginning again 4 scale rows lower down on the mid-line of the body. The first dorsal fin spine is short with the second spine the longest. Overall colour is brown with black gill membranes, gill cavity and peritoneum. Fin membranes are black and fin rays light. Scales are paler in their centre with margins darker.

Range extensions for deep-sea fishes are not unexpected as fishery operations move into deeper waters not extensively sampled by research vessels. Deeper waters have fairly stable temperature and salinity lev-

els which facilitate world-wide distributions. The most dramatic evidence of this was the recent discovery of a Patagonian Toothfish (*Dissostichus eleginoides*, a member of the mainly Antarctic Notothenioidae) found off Greenland (Møller et al. 2003). Commercial fishing operations can make valuable contributions to our knowledge of Canadian fish biodiversity and fishery crews are encouraged to preserve unusual specimens for study and deposition in a museum.

Acknowledgements

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A Tribute to Hubert ("Hue") Norman MacKenzie, 1922–2009

DANIEL F. BRUNTON

216 Lincoln Heights Road, Ottawa, Ontario K2B 8A8 Canada; e-mail: bruntonconsulting@rogers.com

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Gentlemanly ... that would probably be the most common summation offered by those of us who were privileged to work with Hubert ("Hue") MacKenzie (Figure 1) during his years with the Ottawa Field-Naturalists' Club (OFNC). Hue served the OFNC in many capacities, including an exceptionally busy four-year period as President in the late 1960s. It is probably fair to say that he entered into his association with the OFNC simply as a budding naturalist keen on improving his knowledge of birds and plants (especially orchids). While he certainly achieved that, within short order his involvement and commitment evolved into that of an important official within the organization and a leader of its awakening conservation consciousness.

Hue was born in Vancouver, British Columbia, on 2 April 1922 and was raised in that area. He attended Burnaby High School until 1940 and provided World War II service in the Canadian Army (1942–1946). He moved to Ottawa in 1949 to join the federal civil service where he met and married Ottawa Valley resident Elva Maitland. In the early 1950s they moved back to western Canada where Hue studied at the University of British Columbia while Elva worked as a school teacher. It was in this time that they became keenly interested in both the study of natural history and in travel, activities they kept up throughout their marriage (Brenda Wilson, personal communication). They returned to Ottawa about 1960 both in response to a desire to return to Elva's geographic roots and to further Hue's career as a statistician. He worked with Supply and Services Canada and its predecessors for the rest of his professional career, retiring as Chief of Section in 1980. Although fellow statistician and future OFNC President Frank Pope knew Hue during their overlapping careers in "Stats Can", neither was aware of the other's natural history interests (Frank Pope, personal communication).

Hue and Elva joined the Ottawa Field-Naturalists in May 1962 to further enhance and develop the skills and interests they had developed in British Columbia. Although interested in birds in a general way since childhood, Hue became seriously interested in birding at this time (Coope 2002). The timing of their involvement was fortuitous for the OFNC. This was just as the Club was to feel the first wave of environmental awareness that was sweeping the western world in that decade and major changes in the organization were

afoot (Brunton 2004). Within short order his involved and steady approach to Club matters was apparent and he and Elva became fixtures at Club events (especially birding field trips). Soon thereafter (December 1963), Hue was elected a member of Council and began a long period of contribution to the organizational and administrative needs of the OFNC. This included terms as Vice-president (1965–1966) and President (1966–1969). One of the unglamorous but very important of these initiatives was chairing a special Council committee to revise and update the OFNC constitution in 1967 along with Ted Mosquin, Victor Solman, and Rowley Frith.

It is probably fair to say that he came to the development of conservation awareness gradually during this period. It was likely through the MacKenzies' field investigations for birds and native orchids that Hue became increasingly ecologically aware and conservation oriented. Working with a group led by orchid specialist Edward Greenwood (Reddoch and Reddoch 2002) he became active in efforts to protect important populations of locally uncommon species as the decade wore on. He was very involved, for example, in the effort to protect the large population of Pink Ladyslipper (*Cypripedium acaule*) in the National Capital Greenbelt lands north of Corkstown Road in Nepean (now western Ottawa) in 1967 (LAC OFNC, 6 June 1967).

Hue also served as OFNC representative to the founding meeting of the Canadian Environmental Council (LAC OFNC, 17 September 1969). Although agreeable to and involved with relatively low-key, "bureaucratic" conservation initiatives in the National Capital Greenbelt and elsewhere in the mid-1960s (LAC OFNC, 1 March 1968), he was not convinced that the OFNC should join the conservation activist movement that was sweeping the continent in that decade. He spoke against such an activist approach, for instance, in regards to the increasingly urgent conservation needs of Gatineau Park (LAC OFNC, 6 December 1966).

That perspective evolved in the late 1960s and by the early 1970s, however, Hue could (and would) be both stubborn and impatient in his promotion and encouragement of the growth of conservation awareness within and beyond the Club. In October 1970, for example, he worked directly with Regional Municipal-



FIGURE 1: Hue MacKenzie (17 May 2006) (courtesy of Jo Ann MacKenzie)

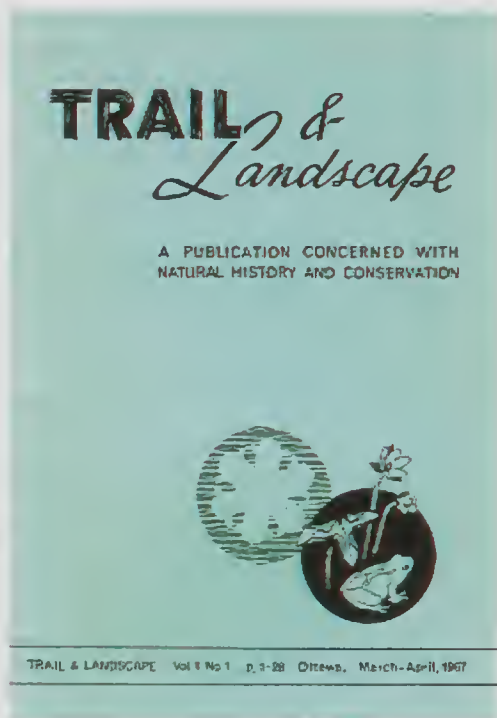


FIGURE 2: First issue of *Trail & Landscape*.

ity of Ottawa-Carleton officials in refining the boundaries of a system of conservation areas originating from a submission by the OFNC Conservation Committee (LAC OFNC, 8 October 1970).

MacKenzie was founding chair of the Natural Areas Committee in 1970, overseeing the establishment of the Terms of Reference for the group. It is from this that the present-day Conservation Committee arose. His actions in the late 1960s and 1970s, along with those of fellow activists Sheila Thomson, Ted Mosquin, Anne and Gary Hanes, Donald Smith and a number of others cleared substantial, early portions of the Club's conservation pathway. Within a few years the dynamic OFNC conservation group had become the primary independent conservation interest in western Quebec and eastern Ontario. It remained the most important and persuasive voice for citizen conservation action in this area for at least two decades (arguably, excluding the important Gatineau Park issue which was also being addressed by an new, exclusively conservation-oriented organization).

Perhaps the most notable single OFNC achievement during MacKenzie's term as OFNC President, however, was the launching of *Trail & Landscape* (T&L) as the replacement for the chatty but largely unsubstantial *OFNC Newsletter* (Figure 2). The need for a regularly produced, science based and informative regional

publication was huge. The proposal for the creation of such a publication was made by Ted Mosquin at MacKenzie's first OFNC Council meeting as President (LAC OFNC, 5 January 1967). While Mosquin, Sheila Thomson and inaugural T&L editor Anne Hanes provided the ideas and creative spark for the publication, MacKenzie's Council provided the administrative and logistical support to make it happen.

The launch of T&L that year was immediately reflected in a surge in OFNC membership. Club membership had increased steadily through the post-war period but it rose exponentially with the complimentary encouragements of a continent-wide awakening to natural history and to conservation matters. T&L offered the regional voice for such concerns (Brunton 2004). Over 40 years later T&L remains an important reference source – an ecological corporate memory for the Ottawa Valley, as it were – into which new, significant contributions continue to be added.

The OFNC reached its Centennial in 1979, an important milestone for what was already Canada's largest and oldest regional natural history organization. MacKenzie was not the designer of Centennial celebration plans, some of which were initiated in the 1960s. From the mid-1970s onward, however, Hue was the primary coordinator of the numerous elements that made up that undertaking. OFNC Centennial projects

included special publications such as the second edition of John Macoun's long out-of-print autobiography (Macoun 1979) and the remarkable, scholarly index to the predecessors of the *Canadian Field Naturalist* (Gillett 1980). There were also special celebratory assemblies, Centennial excursions, historical explorations and various other tributes acknowledging the contributions of Canada's oldest and largest regional natural history organization.

It was a mammoth task to co-ordinate this all-volunteer effort. As Centennial Committee Chairman Hue actively and successfully directed activities up to and well after the year in question. He stayed on as Centennial Committee chairman until 1981 when everything was wrapped up.

Hue's interest in orchids was spurred on by Ed Greenwood's 1966 establishment of the Native Orchid Location Survey initiative in the Ottawa District. Soon expanded to national coverage, this initiative accumulated data on the location and size of thousands of orchid populations across Canada (Reddoch and Reddoch 2002). Working with fellow enthusiasts such as Greenwood and Joyce and Allen Reddoch, Hue and Elva made major contributions of original data. They submitted hundreds if not thousands of observations, making significant distributional discoveries in the process (e.g., MacKenzie and Greenwood 1969). Hue served as National Coordinator for the program from 1969 through 1974.

Following the end of his marriage to Elva in the 1970s, Hue married fellow birder and active OFNC member Jo Ann Murray. The two became a fixture of the Canadian birding scene (especially on the West Coast) for another thirty years. They moved to Burnaby, British Columbia in 1983, subsequently taking up residence in Surrey in 1985.

In retirement in western Canada Hue remained active both in natural history investigation and in the development of supporting organizations both at home (Vancouver Natural History Society, White Rock and Surrey Naturalists, etc.) and abroad. He was a founding member of the British Columbia Field Ornithologists in 1991. Hue was co-ordinator for the White Rock Christmas Bird Count for many years (he participated in over 75 Christmas Counts) and co-ordinated a 1985-1986 Spotted Owl survey in southern British Columbia (Coope 2002).

As well as bird conservation issues such as habitat protection, rare species management and population surveys, the MacKenzies were keenly interested in the recreational aspects of birds ("listing"). They accumulated some of the largest of Canadian life list totals, both topping 510 species by the early 2000s. Their birding focus became increasingly international in later years, with birding excursions to over 20 countries. At the time of his death Hue's world "life list" stood at an impressive 4433 species (Jo Ann MacKenzie, personal communication). With a particular inter-

est in Southeast Asia, he was especially active with the International Taiwan Birding Association.

Hue MacKenzie was awarded an OFNC Honorary Membership in 1983 in recognition of his critical role with the Club Centennial organization and for his important pioneering contribution to the conservation agenda of the OFNC. The award recognized how pivotal he was in developing a more hands-on approach within this essentially conservative organization. Many prominent member of the day (himself included initially) had argued that bold conservation action had no role in organizations like the OFNC. Hue's quiet persuasion won the day (mostly) and the Ottawa Valley is better for it.

Hue died in Surrey, British Columbia on 4 November 2009 of an asbestos-related cancer that may have been triggered many years before, in his late teens or early 20s, when he worked one summer in contact with the material on a ship. He is survived by his wife Jo Ann (Murray) MacKenzie and step-daughters Linda Murray and Carol Murray, all British Columbia residents.

Hue MacKenzie's contribution to Club affairs is wonderfully summed up by a line in his Honorary Membership citation, "... it is difficult to point to a major Club activity over the past two decades that has not profited from the 'The MacKenzie Touch'" (Gummer 1983). Hue was "... an inspiration to a whole generation of new Ottawa area naturalists" (Brunton 2004), this author included, and an energizing and encouraging voice to many of us in those rapidly changing times.

Acknowledgements

My thanks for discussions and input about Hue MacKenzie and his times from former OFNC Presidents Sheila Thomson, Frank Pope, Ted Mosquin and Roger Foxall. *Canadian Field-Naturalist* Editor Francis Cook, former *Trail & Landscape* editor Joyce Reddoch and zoologist Martin McNicholl also provided valuable insights and information. Brenda Wilson of Ottawa, Ontario also provided valuable background on her cousin Elva (Maitland) MacKenzie (deceased 13 May 2008) and on Hue MacKenzie's early Ottawa years. Finally, my thanks to Jo Ann MacKenzie who offered much useful information, especially in regards to his post-Ottawa years, and kindly consented to the use of the photo of Hue.

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Book Reviews

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

ZOOLOGY

Bats

By Phil Richardson. 2011. A Firefly Book. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 128 pages. \$19.95 CAD. Paper.

Phil Richardson is to be congratulated for producing an informative and easy-to-read book about bats. The density of information is high and the level of accuracy is good. There is a wide range of illustrations introducing the bats. The sampling of bats is world-wide, but the focus is more European than North American.

The Table of Contents is simplified, making it easy for the reader to orient within the book. The index is thorough and helpful. The reader can learn about echolocation and behaviour, reproduction and diversity. There also is information about bat houses and conservation of bats. But the book is short (128 pages) and the depth of treatment of any subject is relatively brief.

There are places where the book could be more helpful. For example, many people are interested in "bat detectors", instruments that allow them to eavesdrop on the biosonar calls of bats. The topic is covered, but details are not provided either of suppliers or of the types of bat detectors available. But, with internet access, a reader can probably find a bat detector to buy.

While the book contains many illustrations, there is considerable variation in quality; many are disappointing. The photograph on the cover is an example: a good shot of a flying bat, but not really showing the animal to advantage. It is useful to be able to see the bat's face, and not when it is squinting. This having been said, my favourite picture is the one of a lesser long-eared bat on page 88.

The book presents an outdated classification of bats. The suborders Megachiroptera and Microchiroptera (vulgarized as microbats and megabats) are no longer current. There is no mention of the family Miniopteridae, although there is a photograph of a bent-winged bat (that belongs to this family). A book published in 2011 should have presented changes in our views of the classification of bats that have been in effect for

at least five years. It is astonishing that a leaf-nosed bat from South and Central America, would be called a "vesper bat" (page 36).

In my opinion, the main drawback of the book is the absence of information about bats and disease. On page 87 there is one reference to the potential for blood-feeding vampire bats to spread rabies. There is no mention of Ebola, Hendra virus, SARS, or histoplasmosis – all diseases associated with bats. There are no details about how bat biologists can protect themselves against rabies or histoplasmosis. "Public health" does not appear in the table of contents or in the index. The photograph on page 117 of a young person holding a bat but not wearing gloves will be jarring to many people concerned about the hazards associated with handling bats.

I am sure that many bat biologists will appreciate the treatment of conservation and the introduction to the diversity of bats. Alerting the reader to the ravages of White Nose Syndrome in the American northeast is timely, but there is no mention of bats being killed at turbines at "wind farms". Many bat biologists would have expected information about bats and diseases that can affect people. It is difficult to give a public talk about bats and not mention rabies or histoplasmosis. One could not make a presentation about bats at a school without alerting the students to the reality that bats bite in self defence and you do not want to be bitten by one.

Bats are utterly fascinating and Richardson's book is a good starter ... but the reader needs to approach it with caution because there are some things that the reader should know and will not find in the book.

BROCK FENTON

Emeritus Professor of Biology, The University of Western Ontario, London, Ontario N6A 5B7 Canada.

Keeping the Bees: Why All Bees Are at Risk and What We Can Do to Save Them

By Laurence Packer. 2010. HarperCollins Publishers Ltd., 2 Bloor Street East, 20th Floor, Toronto, Ontario M4W 1A8. 273 pages. \$17.99 CAD Paper.

Keeping the Bees is a must-read for any naturalist interested in insects and/or concerned about the current pollinator crisis. Written by York University (Toronto) mellitologist (entomologist who specializes in bees) and biology professor Laurence Packer, this book is both a celebration of the diversity and fascinating lives of bees, and a rallying cry to save them from further species loss. I was hooked from the beginning.

Divided into 13 chapters, the book covers a wide range of topics, including bee evolution, bee biodiversity, bee identification, bee research, bees and food, bee life and drama (social and solitary), bee reproduction and genetics, misconceptions about bees, threats to bee survival, and ways we can help bees survive. Each chapter starts with a story from the author's life as a researcher and teacher, adding personal, passionate, and often humorous touches to the book. Photographs, appendices, sources (references and other information) and a detailed index complete the package.

The first chapter – a particularly compelling one which depicts a world without bees – makes the case for the rest of the book. Packer points out that bees are at a higher risk of extinction than most other organisms, and that without bees, the world as we know it today would be very different – far fewer wildflowers, and a substantially diminished, and more expensive, food supply. Packer also reveals the sheer numbers of bees – more bee species than birds and reptiles combined, more bee and wasp species than plants – and stresses that we don't know enough about ecological interdependencies to grasp the extent to which Earth's organisms depend, directly or indirectly, on the pollination services of bees.

In other chapters, the author portrays the fascinating lives of bees. He sets straight, for example, popular myths about bees, revealing that certain widespread associations made with bees – complex social lives, hard work, honey – are a combination found in less than 1% of bee species! In fact, most bees live solitary lives, some bees are actually lazy, less than 5% of bees make honey, and many bees are not capable of stinging, all of which makes the bee world much more diverse and interesting than widely believed.

Yet this diversity also makes it difficult to differentiate between bees and other bee-like insects. Not only that, closely related bees are tricky to distinguish, as the author reveals through a painful experience where he is stung by a bee he mistakes for a stingless species.

Bee identification aside, the diversity is captivating. There are, of course, honey bees and bumblebees, as

well as leaf-cutter bees, orchard bees, vulture bees, cellophane bees, cuckoo bees, robber bees, and more. Along with this variety goes a diversity of appearances, feeding strategies and breeding and nesting practices, which Packer describes in gleeful detail.

Sadly, this diversity is declining alarmingly, as sections throughout the book, and Chapter 11 ("What Are We Doing to the Bees?") in particular, reveal. Yet humans have not always, as the author points out, had a negative impact on wild bees. Throughout most of our history, he writes, we have had a mutually beneficial relationship, with many past land management practices creating suitable habitat for bees.

Which brings us to Chapter 13 ("Help the Bees"), the chapter which outlines things we can do to help preserve bees, many of which are small steps we can take no matter where we live, most of which we can do in our backyards. In a previous chapter, Packer had pointed out that urban areas, as well as low-input agricultural lands, often provide complex habitat that can be good for bees.

"If you want to find an ecologically complex single square kilometre," he writes, "you would be hard-pressed to improve upon an old city's downtown neighbourhoods, assuming that the inhabitants are more interested in gardening than they are in covering their property in concrete. Every backyard shows the signs of different planting preferences, and the overall results may be spectacularly diverse" (p. 152).

Statements like that raised expectations for a comprehensive and fact-filled "you can help" chapter. But I was disappointed to find only 11 pages devoted to that topic. The "Sources" section admittedly provides more information, but not as much as I had hoped, considering the critical nature of the issue. Fortunately, there is lots of great material available from a wide variety of credible organisations on the internet, as I have discovered in the meantime.

Despite this little shortcoming, *Keeping the Bees* is an important book with an urgent and impassioned message – to take immediate action in support of bees, for their survival, and ours. These small animals are so fascinating and diverse, and vitally important to life on this planet. We, as naturalists interested in and concerned about the natural world, can take very concrete and simple steps we to make the lives of bees easier. The least we can do is read a book like *Keeping the Bees*, and recommend it to others.

RENATE SANDER-REGIER

3, 11th Line, Bristol, QC, Canada

Bird Color Mysteries Explained

By Geoffrey E. Hill. 2010. National Geographic Society, 1145 17th Street N.W., Washington, D.C. 20036-4688. 255 pages. \$27.50 USD Cloth.

When I have been leading a trip that involved a bus ride I have filled in some of the travel time with an introduction to bird colour. Such an understanding I believe enhances the experience of watching birds. My explanations tend to be basic and in non-scientific terms.

Professor Geoffrey Hill has written an in depth explanation of the colouration of birds. This book is intended for bird watchers and the author uses plain, rather than scientific, language. When a technical term is unavoidable, Professor Hill explains its meaning and use. This makes the text easy to read and understandable for anyone with a fair comprehension of English.

The author explains the way we humans perceive colours and the differences in this perception by birds. He shows how colour is measured scientifically and how we can interpret the resultant graphs for our response against a bird's. He discusses the nature of "colour" as hue, saturation and brightness and how this affects the way we see bird feathers.

Professor Hill goes through the different pigments used by birds. He give details on the origin of the melanins, carotins and more rare pigments. He puts into plain words the methods used by birds to build and combine these pigments to reach the colour they need. In doing so he reveals why some birds can have colour variations in normal populations. For example, the House Finch is typically orange-red, but can have orange or yellow morphs.

He next talks about feather structure and its influence on colour. The blue of Blue Jays and parrots are formed by light reflecting off the microscopic sub-structures of the feather components. The author explains why the hue varies with the angle of the light in some birds and in others remain consistent. By mixing reflected blue light and yellow pigment we see green feathers.

The next chapter is a little more complex because it deals with DNA, genes and inheritance. The author carefully shows how genetic inheritance controls the

colours of birds. If you are not used to the terms you may need to read this more slowly. Our knowledge is far from complete and the influence of environmental factors needs much more research. While food can contribute to bright colour in healthy birds [the pink in flamingos from the carotene in shrimp] it is less clear what happens when birds are stressed by disease etc.

The science behind the mechanics of colour in feathers has been relatively easy to resolve. The reason why birds are coloured and how they use their vibrant [or dowdy] plumage is much more difficult to define. The author sifts through research to answer whether aggression, sex, territory, camouflage or all of the above is the reason for colour use. This gets very confusing because, whereas as a particular combination of colour characteristics work as an attractant in one species it does not seem to apply to a different, but similar, plumaged bird. The results are therefore complicated and this is clearly an avenue for extended research.

Hill uses inserted boxes to amplify special points or key research. These are very helpful, but I always find this technique irritating. I never know whether to read past them and preserve the flow of the text, or to stop and read the box. In this case I used a combination of reading on and then going back to the previous box.

The author uses analogies with common place materials to explain the scientific phenomena evolved. These are so well done that the principles and results became very clear. This is one of the best and most enjoyable books I have read in a long while. Even a person who has never read scientific text before will understand most of this book on first reading. It is a book that needs to be read by every birder and by many who are naturalists. It will help the avid birders make correct identifications and will raise everybody's enjoyment of wildlife.

ROY JOHN

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

The Crossley ID Guide: Eastern Birds

By Richard Crossley. 2011. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 544 pages. \$35.00 USD Cloth.

In 1934 Roger Tory Peterson [RTP] published his "Guide to the Birds." This was the first bird book where the illustrations were meant as a true field guide, rather than delightful pieces of art. Peterson's paintings, while beautiful, were simplified to make the key characteristics more obvious. He sold out this first printing of 2,000 copies in one week, and became a dynamo who

did more to promote wildlife than any other person.

In the years that followed others produced new guides that contained incremental improvements. RTP's work covered only the east of North America, so whole continent guides appeared. More illustrations of different plumages and then recognizable sub-species were added. An increasing list of rarities were

included, first as appendices then in the body of the text. Better, more accurate illustrations with more and more detail became the standard.

I was never a fan of photos. They show a bird in one pose, one light, one plumage and one state of health. A good artist can smooth out all the individual variations to produce a "typical" looking bird. In the last few years some guides have used computer-manipulated photos that do what the artist does to create a useable illustration.

Crossley's guide has good range maps and clear text, often with a hint of humour. But do not buy this book for the writing; buy it for the photographs. The author has taken a typical habitat photo as background and super-imposed multiple images of a single species. By careful positioning he has produced a remarkable three dimensional image. It is not totally true to life because I might see a large flock of Snow Buntings, but I never expect to see a flock of Barn Owls. The result is more like looking at a museum diorama of perfectly mounted specimens.

Each species occupies from a quarter to a full page. The ones on a full page tend to be the more common species, at least in some part of the continent. Some very common birds, however, are relegated to less than a page. The abundant Glaucus-winged Gull gets only one third of a page, whereas the rare Kirtland's Warbler covers half a page. Each page is normally "pure" – that is only one species is shown. In a few cases some bird [and even the odd human] has sneaked into the background. I rather like the partially-hidden Green Jay behind the Plain Chacalacas. If you look there are adults, juveniles, males and females, winter and summer plumages as appropriate. And you must look carefully. I saw six birds the first time I glimpsed the Willow Flycatcher page, the second time I realized there were eight birds shown and the third time I found nine.

Indeed many species are depicted disappearing into the background, just as they do in real life.

Many times you will hear experienced birders say this looks like a good spot for a particular species. By recognizing key habitat conditions you can calculate what birds might be expected. Knowing what to look for is a huge help in being prepared to identify whatever flits into view. Crossley's new style photographs give an excellent insight into habitat. Time and again I found myself thinking that I had seen that species in those surroundings.

I normally suggest novice birders stick to RTP's classic for the first two years. Its simplified illustrations and lack of confusing plumages make it easier for a new birder to get started. After some experience a person can move on to the more detailed and modern of guides. In future I will be recommending birders buy two guides; the 500 gm [1 lb] RTP guide to carry with them in the field and the 1600 gm [3lb 8 oz] Crossley guide to have in the car. If, for no other reason, this is the best book to learn a bird's habitat requirements – an important part of bird finding and identification. This guide also provides a method of comparing various plumages to birds seen in the field.

Did I find any errors? There were a few things I noted, but they were so insignificant that they are not worth mentioning. Enjoy this book for its positive aspects.

This innovative new guide is a must buy for all birders. The three-dimensional effect alone is worth the price as it really takes you back in to the field. The photo-edited bird illustrations are as good as artists renderings. Do not wait for your birthday, buy it and use it now.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5

Handbook of the Birds of the World. Volume 15. Weavers to New World Warblers

By Josep del Hoyo, Andrew Elliott, and David A. Christie (Editors). 2008. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 879 pages. €215 EUR Cloth.

It is amazing to think what an epic began when I bought Volume I Handbook of the Birds of the World [1992]. Now, 19 years later, I have Volume 15 – the penultimate tome. Only one more volume to come in 2012 [covering Tanagers, Cardinals, Buntings and Blackbirds]. This issue, Volume 15, deals with Weavers, Wydahs and Indigobirds, Waxbills, Vireos, Finches, Hawaiian Honeycreepers, Olive Warbler and New World Warblers. As usual the format, the artwork and photographs are excellent.

Weavers are the bright, colourful sparrow-sized birds that build large colonial nests. Some of the species have given me problems in the past as, many are yellow bodied with black faces. While it is easy to see the dif-

ferences between species in illustrations, I have found it much trickier in the field. The other confusion I have had is separating wydahs from widowbirds. Bird lists from trip reports and other sources often use these names interchangeably. Now there is one reference that put these species into a clear perspective. The high quality photographs allow the reader to compare the artwork to a real bird.

Waxbills are familiar birds in the pet trade, providing aviculturist with a large number and variety of colourful animals. They have rounded heads and large dark eyes, which makes them look cute. When I plan a trip to another country I usually visit a couple of pet stores to study their collection of birds. Typically

there are several cages of birds from the waxbill family. Their names, firetail, parrotfinch and firefinch, evoke their arresting colours, and HBW 15 has page after beautifully-painted page of these little birds.

In this company the poor vireos look dowdy. Most of the 52 species are small greeny-grey birds that give many birders identification problems. Fortunately the Finches are another large group of colourful, entertaining birds. I have rarely been in a locality where I did not see at least one pretty, little finch species. While many cause excitement amongst birders in one locality, it is not because the bird is rare, but because they wander from other localities. Redpolls, crossbills, chaffinches and rosy finches can all cause hearts to flutter in some parts of the world.

The chapter on Hawaiian Honeycreepers is rather sad. All of these species are colourful, mostly red or yellow, and with interesting profiles. Of the 40 or so original species 16 to 19 are extinct, a poor reflection on human stewardship of those lovely islands. The photos and plates evoke the magic of the Pacific and somewhat offset "the relationship [being] ... one of tragedy."

The enigmatic Olive Warbler has bounced around genera and now sits as a single species in *Peucedramus*. The taxonomist dilemma notwithstanding, it is an attractive bird sought after by visitors to the southern United States and Mexico.

The final group are the misnamed New World Warblers. [I prefer the Canadian French *Paruline* – Yellow-rumped Paruline even *Parula Paruline* sounds fine to me]. In summer plumage at least, this is another collection of attractively-coloured birds. The "warblers" have many ardent fans in North America and I am certain these people will be pleased by HBW 15's coverage.

In addition to the excellent illustrations there is an equally excellent text. I was amused to find that even HBW has some complications with taxonomists, and

this has resulted in extra half-plate. The descriptions plainly show the differences in eastern and western populations of Warbling Vireos, the stronger colouration of the green morph Pine Siskins [sometimes confused with "Vagrant" Eurasian Siskins in North America], the separation of indigo birds in Africa and the hard-to-separate redpolls. The polymorphic Red-billed Quail has three full illustrations and an extra the male heads while the text expertly covers its wide variability. The status, conservation and distribution is dealt with generically in the introductory passages and specifically for each species. For example, the now, widespread distribution of the Common Waxbill is referenced, but only the native range is shown on the map.

The Foreword was an essay on the Conservation of the World's Birds. It is a well researched, informative and thoroughly illustrated by charts and graphs. It gives any reader a clear, if depressing, overview of the status of all birds. Naturally the author concentrates on species at risk, but there is sufficient data to show where all the bird populations are headed. While many issues will be known to avid birders I am sure we can all learn something new. I did; I did not realise people were poisoning vulture so these birds did not give away their poaching activities. However, I think the essay's real value is how it focusses all the individual problems [loss of albatross to long-lining, tropical forest destruction for soya beans, the impact of cats etc.] into a coherent whole.

Overall this is another superb addition to this vast reference work. I repeatedly go back to older editions to resolve numerous issues and this volume will join those ranks. This is a book for every serious birder and researcher.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario, K1J 6K5

Natural History. The Ultimate Visual Guide to Everything on Earth

By Becky Alexander. 2010. Smithsonian/Dorling Kindersley, Tourmaline Editions Inc., 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7. 648 pages. \$55.00 CAD Cloth.

Some time ago I loaned one of my favourite books [The Natural History of Europe. By Harry Garms. 1967. Paul Hamlyn Ltd., London.] to a friend. It is an old, illustrated guide to the birds, mammals, reptiles, plants etc. While this may, as a collection of allsorts, not be a book for the purist, but I have found it very useful on my trips to Europe. The species illustrated are the commoner ones; those you are most likely to see on a short trip.

Natural History claims to be the ultimate visual guide to everything on earth – a profound claim! Will this do the same thing for the world as my old book does for Europe? The book covers rocks, plants, animals and the species in between. In 648 pages it cannot go into

great detail, but only achieve an understanding of the basics. So how well does it do?

It does it very well. The book is logically and clearly organized into rocks, minerals, fossils and the domains, kingdoms, phyla or divisions, classes, orders, and families of the living world. As in every DK book I have read, the illustrations are beautiful; whether this is an Amoeba or a Bird of Paradise. From about five to a dozen species are shown on each page. They are photographs, stripped of the background and placed on the white page. This is a good way to show the species characteristics. It is illuminating to see in this way those species we do not normally see well [fish, worms and parasites].

A good example is the molluscan class of Cephalopods. Twenty-one species are shown; covering the nautilus, cuttlefish, squids and octopi. A double page is given over to the Common Octopus so that individual characteristics [skin, beak, suckers, etc.] can be explained. The species are selected to show the diversity of forms, colours and life styles. Similarly there are 48 species of turtles, with a double page spread on the Aldabran Giant Tortoise. Examples have been chosen from around the world; from the cute 13 cm Spotted Turtle to the 1.2 m Galapagos Tortoise. The authors show that even the turtles simply designed shell can vary from smooth to knobby, soft to hard, patterned or plain.

Plants get a similar coverage. The orchids are represented by 27 species that cover most of the major genera. Curiously the Phalaenopsis [the second most important pot flower in US commerce] are represented by a man-made hybrid rather than a wild species such as *P. equestris* or *amabilis*. Even more surprising is the great Cattleyas are missing. The double page is given to *Dinema polybulbon* [1831; This species is more usually referred to by the 1788 *Epidendrum polybulbon* – a delightful miniature [mine has just flowered].

So you can find pages on albatross to kinglets, blue whales to shrews and liverworts to spruces. There is a little of everything; bacteria, algae, ferns, trees, fungi, sea life, worms, spiders, crustaceans, insects, fish and frogs. To help the reader the top edges of the seven sections are colour coded. Oddly the plant page corners are tinged purple, not green.

Essential Ornithology

By Graham Scott. 2010. Oxford University Press, 198 Madison Avenue, New York, New York 10016. 172 + x pages. \$55.00 USD Paper.

This is an excellent overview of ornithology, academically sound yet also attractive for amateurs. Graham Scott is an English scientist, the author of the well-received *Essential Animal Behaviour* (2005). In *Essential Ornithology* he presents a concise yet comprehensive overview of birds and their biology in a format that is both attractive and innovative.

The book is very well thought out and well organized. The seven chapter titles provide a succinct summary of its contents: "Evolution of birds," "Feathers and flight," "Movement: migration and navigation," "Eggs, nests and chicks," "Reproduction," "Foraging and avoiding predators," and "Populations, communities, and conservation."

Each chapter begins with an interesting or unique quotation, dating from the 18th century through to 2005, and throughout the book Scott reinforces his general arguments with interesting specifics. Key points are highlighted and key references are also provided in the margin. Also in the margin are 9 "Concepts" and 26 "Flight Paths", which provide quick cross-references

To claim to be the ultimate visual guide to everything on earth is rather sweeping. Any reader will quickly pick out the deficiencies and disparities. There is no mention of enigmatic stalagmites or beautiful sand roses. Nor do pearls of any kind appear in these pages. When a genus is included it may get disproportionate coverage. Only 0.5 percent of willows are pictured, yet the popular penguins get 70 percent coverage. Lichens, while there are good examples of each type, are only on two pages. If they included all the North American lichens alone the book would grow by over 100 pages. The flowering plants show a bias towards the temperate zones. Few Arctic plants are included and the tropical trees tend to disappear into the woodwork [pun!]. Another characteristic I find irritating is the way the publisher has mixed illustration sizes. For example, the 2 cm Gold Beetle is depicted three times the size of the 7.6 cm Stag beetle and the 3.2 m Atlantic Sailfish is eclipsed by the 6 cm Mandarin fish.

These comments notwithstanding, I think this is a great book to buy, particularly for a family. It is easy to get a broad perspective of the natural world and the format and layout make it simple to use. It is a super reference volume that I will use time and again; I am sure it will grow on me. Perhaps I should paraphrase the sub-title to "The wonderful visual guide to the diversity of life on earth."

ROY JOHN

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

to entries elsewhere in this book. The book is further enhanced by 29 superb colour photographs, 69 helpful black-and-white figures, 23 box inserts of text (up to two pages long) and one 4-page table of bird Orders and Families.

It is a sign of the times that the journals which Scott cited most often were *Nature*, *Animal Behaviour*, *Proceedings of the Royal Society: Biology*, and *Science*, with 14, 11, 10 and 10 articles cited, respectively. Of the 44 journal titles cited, only 10 were standard ornithological journals and each was cited only once or twice; Scott's choices highlight the obvious but worrisome (to me) trend toward the ever-diminishing importance of specialized ornithological journals.

The book contains few of the editing errors inevitable in a work of this kind. The Journal volume number or the year of publication is wrong on pages 58 or 109, 83, 100, 103, and 110; *petechina* and *bee* are misspellings on pages 54 and 98, respectively; and an author's name is spelled both correctly and incorrectly (Stark and Starck) on page 91.

All in all, this is a delightful book. It is recommended as an introduction to ornithology for new recruits to birding, as an appropriate refresher overview for serious bird students, and as a basic text for a half-class in ornithology.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

BOTANY

North American Native Orchid Conservation – Preservation, Propagation, and Restoration

By Jyotsna Sharma (Editor). 2009. Conference Proceedings of the Native Orchid Conference, Inc., Green Bay, Wisconsin, June 12–16, 2009. Native Orchid Conference, Inc., P.O. Box 29010, Greensboro, North Carolina 27429-9010. 131 pages, plus CD. \$24.95 USD Soft cover.

As noted in the preface by Clifton (Kip) Knudson (Native Orchid Conference Conservation Committee Chair), the 2009 Native Orchid Conference (NOC) annual meeting held on June 12–16 at the University of Wisconsin campus at Green Bay, Wisconsin, focused on actions to meet the goals of the NOC mission: “to foster the study, conservation, and enjoyment of the native orchids of the United States and Canada.” The major goal was to provide information that would assist native orchid habitat conservation. The articles are organized into five sections: conservation, preservation, restoration, propagation, and experimental studies. Sixteen (more than half) of the 21 articles in this proceedings feature conservation, restoration and preservation. There is a welcome focus throughout much of this document on practical conservation effort. The work presented is scientifically sound and the 131 – page publication is well designed and well produced. Editor Jyotsna Sharma and production manager Clifton Knudson are to be complemented on an excellent job. With a wealth of information for a very reasonable price, the Native Orchid Conference Inc. has taken a major step toward the achievement of their stated goals.

The “**Orchid Conservation**” section includes five articles. The first paper entitled “The role of systematics in orchid conservation,” provides some useful information on the ways that systematics can assist in setting orchid conservation priorities. For example newly discovered species have often been overlooked due to their rarity and are likely to require protection. The article entitled “Orchid conservation and the IUCN red list: *Platanthera praeclara*, a case study” provides a very helpful overview of global status ranking. The method of establishing a protection framework based on representation in different ecological regions is notable and has been applied to crop relatives. Related to this subject of global assessment are assessments done to support listings under the US and Canadian Endangered Species Acts which use similar criteria and function in the same way to provide a basis for protection and recovery programs. It is particularly interesting that in the example, the global and national assessment teams co-operated together in developing an assessment.

The paper entitled “Ethics of plant rescue: what’s in it for the plant?,” covers a difficult subject with caution and common sense. The author notes that “... plants that are removed to a garden cannot be considered as rescued because they cease to be a part of a reproducing population in a natural plant community.” Moving plants is a last resort and moving plants to gardens is generally to be discouraged as long as conservation is the objective. This subject area is related to the idea of the use of transplanting as a conservation tool. Transplanting is best not considered as a conservation tool unless it is based on expert knowledge and follow up and is accompanied by a strong commitment. There is no guarantee of success. It often fails and has been frequently used as a “quick fix” for habitat destruction with disastrous results. Not surprisingly some expert organizations, such as the Canadian Botanical Association, have discouraged the use of simple transplanting as a reliable solution to the destruction of a natural habitat; “The Canadian Botanical Association is strongly opposed to the idea that transplanting is a reliable method of conserving rare species” (<http://www.cba-abc.ca/pospaper.htm>, see also Fahselt 1988, 2004, 2006, 2007 and references in Catling 2008). Protecting and managing a natural habitat is more likely to be successful than transplanting because conditions can often be maintained more easily than they can be duplicated (despite our occasional accidental production of great orchid habitat). There is a place for gardens and transplanting in education and recovery, but the limitations and the context needs to be better understood and guidelines, including concepts presented in this article, need to be developed. “Orchid Conservation for the 22nd century” provides a valuable overview of the elements of orchid conservation efforts and suggests both integrated orchid conservation and flexibility. The following and last article in this section, “Orchid food webs,” extends the idea of integrated orchid conservation through consideration of orchid food webs. A more thorough understanding of the ecological network that supports a population of orchids has great potential to improve conservation efforts.

The “**Orchid preservation**” section is particularly valuable in providing help with the basic ground

work of conservation. "Using a community support network to preserve native orchid habitat" outlines the roles and actions that are needed for successful preservation. This will be really useful to people engaged in direct conservation efforts. "Challenges and strategies ..." has a background in the Chicago region, where orchid habitats have been very extensively destroyed. In fact Illinois is in the forefront of both losses and current efforts to protect what remains. In the state, 25% of orchids are gone and another 25% are at risk. The discussion of difficulties is distressing but the achievements are uplifting. The article entitled "Wisconsin State Natural Areas: a place for every orchid" has to do with the states remarkable "State Natural Areas Program" (<http://www.dnr.state.wi.us/org/land/er/sna/>) which protects 90 % of the states rare plants in 609 sites encompassing 330,000 acres. This is a good example of the potential to learn a lot about what is happening outside and apply it at home.

The four following articles on Carney Fen State Natural Area in Michigan are excellent. This detailed and specific approach is the basic stuff of orchid (and other) conservation. The whole subject of looking after the world requires less preaching and more getting on with the job. One has to do both to be a real conservationist. The first article in this series is about the creation of "State Natural Areas." These are the highest quality remnants of Michigan's native ecosystems. These places provide a standard against which management actions in other areas can be compared, and they are also biological warehouses holding the materials necessary for restoration elsewhere. In part II Kip Knudson provides the basic information on how Carney Fen was protected by legal dedication by state statute. The Natural Areas nomination process was an education for the committee of orchid enthusiasts formed under the sponsorship of the Chapee Rapids Audubon Society. They soon learned that an ecosystem approach would be necessary to protect the site. What were the five important lessons learned during the creation of Carney Fen Natural Area? The answer could apply to the successful creation of many protected areas. Part III outlines the geologic history and provides an explanation for the unusual plants and species richness in the fen area. Part IV outlines some of the recent history of the area. For a long time the large population of Ram's Head Lady's-slipper was a secret known only to a select group who perceived the main threat as poaching, but when they returned for the annual pilgrimage one year, part of the site had become a dump. Of course this led to an expanded view of the threats! Fortunately there was still a lot to protect. A final article in this section entitled "The Ridges Sanctuary, Orchid Hot Spot - 45 years of change" outlines the decline in orchid populations, but the continuation of protected habitat as part of a local initiative established in 1937.

The section entitled "Orchid Restoration" was of special interest. Having watched woodland orchids come and go from numerous pine plantations in Ontario, I was very interested to read about "53 years of succession in a Wisconsin Scots Pine (*Pinus sylvestris*) plantation." As is commonly the case the orchid populations reached a peak and then declined as succession proceeded. A number of articles have drawn attention to the fact that Scots Pine has a capacity to be invasive and to destroy valuable natural open habitats, especially meadows, prairies and sand barrens (e.g., Catling & Carbyn 2005; Catling & King 2008). To avoid contributing to this problem, pine plantations should be comprised of native species, which appear to be just as beneficial for orchids. The good news here is that a natural forest community succeeded the plantation.

The next article in this section features conservation efforts in the coastal plain and mountain bog communities of Georgia. Here the Atlanta Botanical Garden has developed an exemplary protective network in cooperation with the Georgia Plant Conservation Alliance. If this kind of leadership of *in situ* protection by botanical gardens and local groups could be extended throughout North America, we would be in a much improved position with regard to protecting rare and endangered plants. The article makes a strong point for education and suggests that despite huge losses there is some good news.

The article entitled "Transplanting a rare orchid" describes an admirable effort to maintain the Small White Lady's-slipper in Nebraska. Although it is my view that something should be done to protect any threatened wild orchids, I also believe that transplanting is a last resort because there is no guarantee of success. It is always best to make a very substantial effort to protect the existing habitat of a rare plant. Our understanding of habitat is often incomplete, but developers prefer to think that we are all outstanding gardeners and can grow anything anywhere. Occasionally someone says, "if they can grow somewhere else, why are they not there already?" Since orchids are well equipped to find the places where they can survive (with the largest numbers of the smallest seeds in the plant kingdom), the reason that they are not already present could be because the habitat is not appropriate. The concept of transplanting does assume a great deal (including knowledge and gardening capabilities that few people have). It is also complicated to evaluate and the criteria should include local increase, ample seed production and colonization of new habitat. I am aware of many more failed transplantation attempts with orchids than successes. In this case in Nebraska the transplanting effort is not a failure and to a degree may be regarded as a success. This article does inspire thought on the subject! See above for more thoughts on transplanting.

The "Orchid Propagation" section includes 3 articles. "Orchid Seed Germination" is one of the most concise and informative articles that I have seen on the subject. Following is an article on the micropropagation of the spectacular and rare (rarer than tigers) *Cypripedium kentuckiense*. This species is subject to poaching so that propagation can play an important role in conservation and this article provides some useful information. The propagation section concludes with an article on Yellow Lady's-Slippers. Here the many questions about the variation in this group are reviewed but of particular interest is the discussion of variability of in plants from a single seedpod. On the accompanying CD there are color photos which help to evaluate the color variation in siblings.

The symposium volume concludes with a section entitled "Experimental Studies" which includes 2 articles. The article entitled "Visitor impact and sustainability" may give the impression that low levels of foot traffic can have a negative impact on orchids, but the article is mostly about impact on orchid habitat rather impacts on orchids. To the extent that orchids are considered, a beneficial effect is demonstrated. A positive effect of moderate trampling on orchids has been suggested (Catling 1996, p. 18) as a result of orchids being relatively more abundant in the area of light trampling near to a bare path than in the more distant area further away. Many species of native North American orchids benefit from a degree of ground disturbance. Orchid enthusiasts and photographers may be having a positive impact much of the time and may be to some extent be substituting for recently lost ecological processes. The second article concerning the pollination biology of *Epipactis gigantea* is a field study that includes much valuable information from breeding experiments. The plants produce more seeds through outbreeding, but are capable of both self-pollination and asexual seed production. This species attracts fly pollinators that are parasites of aphids and the flies lay eggs on the flowers. The article is a valuable contribution to the pollination biology of North American orchids, but it also contains information that is needed for conservation purposes.

Clearly there is a lot packed into this symposium volume. Is it what you need? Information generally available on orchid conservation ranges from hundreds of articles in journals to special issues of regular journals (Kull et al. 2006), books (Dixon et al. 2003) and to regular worldwide scientific meetings such as the International Orchid Conservation Congresses (2001, in Perth, Western Australia; 2004 in Sarasota, Florida; 2007 in San José, Costa Rica; and 2011 in Czech Republic – <http://www.iocc4.cz/index.php?m=home>). Certain organizations including both international such as Orchid Conservation International – <http://www.orchidconservation.org/main/about-oci.html> and local such as Native Orchid Conservation Inc. – <http://www.nativeorchid.org/about.htm> are committed to the

goal of orchid conservation. Many orchid and naturalist's clubs also provide information on orchid conservation. Yes, there is a lot of information available on the subject, but "North American Native Orchid Conservation ..." is a very useful package. – especially for an introduction. More importantly it largely originates from the people that actually do the job on the ground and consequently it may have much more impact among the real practitioners than many other attempts to cover the subject. The information is well presented and accurate, and most aspects of orchid conservation are included. I missed the conference so the proceedings were important to me. The CD included valuable material that extended the text. As well as material that was just interesting such as images from Kauth's presentations and photos taken at the conference and on the conference field trips, the CD included conference documents and links and a couple of very nice videos one featuring Great Lakes Orchids. I was very impressed. This publication is a valuable source and background for anyone interested in orchid conservation. It deserves prizes and awards. Thanks to all those involved.

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PAUL M. CATLING

Agriculture and Agri-Food Canada, Environmental Health, Biodiversity, Saunders Building, Central Experimental Farm, Ottawa, Ontario K1A 0C6.

Coastal Wetland Ecosystem *Spartina* Salt Marsh and Its Management in China

By Guan Daoming, 2009. China Ocean Press, 8 Dahuisi Road, Beijing, 100081, P. R. China. 167 pages. ¥65 RMB Yuan.

Coastal wetlands are very ecologically important and vulnerable, located in the transition zone between land and sea. They have both upland and aquatic characteristics, and thus, they often have a richer flora and fauna than other environments, and are tidally influenced. A salt marsh is characterized by being frequently or continuously flooded by relatively shallow, high salinity water, and dominated by halophytic or salt tolerant herbaceous plants. Salt marshes are believed to be one of the most biologically productive habitats on the planet, rivalling tropical rainforests. However, plant species diversity is relatively low, since the flora must be tolerant of salt, complete or partial submersion, and anoxic mud substrate. The ecological features of salt marshes are dependent on precisely coordinated cycles of tides or immersion and exposure, sediment deposition, and erosion. Many of the salt marsh plants are usually not grazed at all by higher animals, but die off and decompose, to become food for microorganisms, which in turn become food for fish and, in turn, birds. Salt marshes can export nutrients to coastal waters, slow erosion along the shoreline and buffer stormy seas. They also help to filter pollutants before they enter oceans and estuaries, either by settling of sediments or by microbial and plant removal of nutrients and other substances. They serve as depositories for a large amount of organic matter, and are full of decomposition products, which feeds a broad food chain of organisms, from bacteria to mammals. Salt marshes provide tremendous ecological benefits, as well as economic, social, and cultural values to the large region.

China has a coastline of roughly 18,000 km, which extends from the Bohai Gulf to the tropical waters of the South China Sea. The Chinese coastal salt marshes serve as fuel stops for waterfowl on the migratory road between Siberia and Australia. The estimated total area of coastal salt marshes and mudflats in China is about 2.2 million hectares. Whereas, in the recent decades, salt marshes in many areas have been subjected to numerous human stresses, especially the alternation for agricultural or residential purposes, and also have undergone changes in species composition, including the colonization of invasive species. Degraded salt marshes have a reduced capacity to assimilate pollutants, buffer storm damage, support native biota, to provide opportunities for human use and enjoyment, to respond to sea level rise and so on. Hopefully the present growing interest in protecting and restoring salt marshes is not too late. We are sure that once the eco-

logical processes of salt marsh ecosystem have been better understood, more sound and practical management and restoration efforts can be suggested and used to preserve these valuable marshes and put them back to healthy state.

In North America, the most common salt marsh plants are glassworts (*Salicornia* spp.) and the cordgrass (*Spartina* spp.), which have worldwide distribution. They are often the first plants to take hold in a mudflat and begin its ecological succession into a salt marsh. However, in China, *Spartina* grasses are introduced species. Since introduction, *Spartina* grasses not only have played important and positive roles in shoreline protection, erosion prevention, silt promotion and land formation, but also have produced some negative impacts. In 2003, the State Environmental Protection Administration of China released its first list of alien invasive species, in which *Spartina* grasses as the only coast salt marsh plant species was listed. However, the severeness of the so called negative impacts of *Spartina* grasses have long been argued.

To show the comprehensive information of *Spartina* species and provide reference or guidance for management of *Spartina* salt marsh ecosystem, the book Coastal wetland ecosystem *Spartina* salt marsh and its management in China was recently published. The main contents of the book is Chapter 1 The ecological and biological characteristics of *Spartina* species; Chapter 2 The composition and biodiversity of *Spartina* salt marsh ecosystem; Chapter 3 The nutrient cycling and energy flow of *Spartina* salt marsh ecosystem; Chapter 4 Impacts of *Spartina* species on coastal wetland ecosystems; Chapter 5 The comprehensive utilization of *Spartina* species; Chapter 6 The distribution of *Spartina* species in the coastal wetlands of China; Chapter 7 Management strategies of *Spartina* species.

The book is well written with few errors. It can serve as reference for persons who are engaged in botany, wetland ecology, environmental science, shoreline protection and restoration.

LI DEZHI¹ AND QIN AILI²

¹Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N), Shanghai, China, 200062.

²Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd, Songjiang, Shanghai, China, 201600.

ENVIRONMENT

Sustainability: A Biological Perspective

By Stephen Morse. 2010. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013. 261 pages. \$45.00 USD Paper.

Sustainability: A biological perspective is an efficient and effective overview of the concept of sustainability. Intended, as the author writes in the first chapter, as an introduction to the topic, as well as a spur to engagement, the book covers not only theories underlying sustainability, but also how those theories are translated into practice.

Morse approaches the topic of sustainability from two main angles: production and consumption. Chapters two to four explore sustainability related to three particular areas of production: agriculture, fisheries, and industry. Chapter five discusses social and economic dimensions of sustainability, while chapter six focuses on consumption. And the final chapter wraps things up with a discussion of sustainability science and the importance of taking an interdisciplinary perspective. Tools such as modelling and sustainability indicators, and approaches such as stakeholder participation and evidence-based policy, are also introduced and discussed.

Despite the biological promise of the title – its main attraction for me – the book did not deliver much in the way of biological interest. It did not even offer a discussion of biodiversity, much less a chapter as I had hoped. This was a major disappointment.

Sustainability: A biological perspective is a dense book, packed full of information, diagrams, equations, graphs, and tables – and not a single photograph that I can remember! The target readership is obviously students in various physical or environmental sciences, and their professors – or natural scientists at large, and other readers with an interest in understanding sustainability from different perspectives, and with the time to read a densely written and organized book. It does offer a long list of detailed reference.

While the book may be suitable to that target readership, I am not certain how much appeal it would hold for the passionate naturalists among us.

RENATE SANDER-REGIER

3, 11th Line, Bristol, Quebec

Wired Wilderness: Technologies of Tracking and the Making of Modern Wildlife

By Etienne Benson. 2010. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218. 251 pages. \$55.00 USD Hardcover.

Benson has produced a much needed historical introduction into the world of radio-telemetry technology. In today's biological research, radio-tagging wildlife seems to be common place. These tags can incorporate global positioning system technology, satellite tracking, or traditional radio-telemetry techniques. Little does anyone know that these technological advances had a tumultuous beginning, with plenty of political wrangling, sprinkled with environmental activism and public disapproval.

The book is divided into six parts: an introduction, four chapters, and a conclusion. Supplementary sections are also included: an abbreviations section, notes, essay on sources, and an index. The chapters are the crux of the book; they provide case histories on the use of radio-telemetry on wildlife, detailing the behind-the-scenes political drama that nearly ended much of the radio-telemetry work at the time. Focus animals include the grizzly bear (*Ursus arctos*), tiger (*Panthera tigris*), and orca (*Orcinus orca*). In the beginning, however, such high profile animals were not tagged, more accessible species were used, such as ruffed grouse (*Bonasa umbellus*), raccoons (*Procyon lotor*), and rabbits (*Sylvilagus* spp.). These early trials fine-tuned the

technology where advancements in a durable unit capable of withstanding the natural landscape were made.

The impetus to explore this type of technology was sparked with the launch of Sputnik. In 1957, Russia was the first to launch a satellite into outer space, much to the embarrassment of the United States. Biologists began to think that if Russia can send a dog into space and radio-telemeter back to earth basic physiological data, then certainly animals on earth can be tagged in a similar fashion, feeding data into a laboratory.

However, not all researchers were enthusiastic with the radio-telemetry technology. Olaus Murie, for example, did not want radio-tagged grizzly bears in National Parks and Refuges. He felt that the refuges should be devoted to "basic scientific research, with the least possible equipment. It should be for the kind of scientific study based on thinking, based purely on close observation, trying to understand the relations among various animal forms and the changing environment" (p. 61). Others felt that the radio-tags themselves had significant negative effects on wildlife. Francis L. Kellogg, the outgoing president of the US-controlled portion of the WWF, had this to say about radio-collaring tigers in Nepal and India: "To what degree, I pondered, does the

radio collar affect the shy wild animal that carries it? Or the vehicles and aircraft that can so unerringly home in on its most secret lair? And the darting process, what of that? What lasting effect can shooting and drugging of a wild animal have?" (p. 119). Other radio-telemetry research projects brought public outcry and lawsuits from environmental groups. The final chapter of the book, "The Regulatory Leviathan," focuses entirely on the tagging of cetaceans, especially orcas. These lawsuits and protests made scientific research of marine mammals nearly impossible at times. With radio-telemetry technology being so heavily criticized, other non-invasive techniques were being developed, including camera trapping and the analysis of DNA in faeces and hair. These techniques had the potential to "make life easier for the animal and are often better received by landowners and wildlife departments" (p. 138). Benson explores these trials and tribulations in great detail through the book.

When I studied San Joaquin kit foxes (*Vulpes macrotis*) and non-native red foxes (*V. vulpes*) for my thesis work in Kern County, California, one of the first tools I used was radio-telemetry (see Clark et al. 2005). My thesis work was possible due to the hard work and perseverance of the many radio-telemetry pioneers mentioned in this book. All of the researchers today that use these sorts of technological tools owe a great deal to people like Dwain W. Warner, William H. Marshall, William Cochran, Donald Siniff, John and

Frank Craighead, David L. Mech, William E. Evans, and Katherine Ralls, among many others mentioned in the book. But, the technology is not out of the woods yet. Even today, researchers are discovering that radio-tagging wildlife is having a significant effect on their behavioural patterns (see Wilson 2011 and Saraux et al. 2011). Nonetheless, one of the subtle themes explored in the book is the idea that the radio-tagging of a few animals, even if there are risks, such as death, will benefit the population as a whole. These benefits include the basic ecological understanding of the species; mapping migratory patterns, especially for birds and marine mammals; and collecting home range data, physiological data, and other life-requiring variables necessary for the conservation of wildlife.

Benson chronicles these pioneering studies in a readable and enjoyable fashion. The book is a must read for anyone interested in radio-telemetry technology or is involved in current radio-telemetry research.

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HOWARD O. CLARK, JR.

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

NEW TITLES

Prepared by Roy John

† Available for review * Assigned

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

ZOOLOGY

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* **Birds of Canada.** By Tyler Hoar, Ken De Smet, Wayne Campbell, and Gregory Kennedy. 2010. Lone Pine Publishing, 10145 – 81 Avenue, Edmonton, Alberta T6E 1W9. 528 pages. \$39.95 CAD Cloth.

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* **Decline and Recovery of the Island Fox – A Case Study for Population Recovery.** By Timothy J. Coonan, Catherin A. Schwemm, David K. Garcelon. 2010. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473. \$59.00 Cloth.

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CAROLYN CALLAGHAN
Editor, *The Canadian Field-Naturalist*

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Copy Editor: Elizabeth Morton

Business Manager: Frank Pope, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2

Journal Manager: Jay Fitzsimmons: subscriptions@canadianfieldnaturalist.ca or via postal address above.

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COVER: R. Rosatte. Photograph of a Cougar (*Puma concolor*) track. See pages 116-125 in this issue.

The Canadian Field-Naturalist

Volume 125, Number 2

The Recent Spread and Potential Distribution of *Phragmites australis* subsp. *australis* in CanadaPAUL M. CATLING¹ and GISÈLE MITROW

Biodiversity, Environmental Health, Agriculture and Agri-Food Canada, Saunders Building, Central Experimental Farm, Ottawa, Ottawa K1A 0C6 Canada

¹ Corresponding author (email: catlingp@agr.gc.ca)Catling, Paul M., and Gisèle Mitrow. 2011. The recent spread and potential distribution of *Phragmites australis* subsp. *australis* in Canada. *Canadian Field-Naturalist* 125: 95–104.

To provide information on geographic occurrence, rate of spread, and potential distribution of European Common Reed, *Phragmites australis* subsp. *australis*, in Canada, we measured 1740 herbarium specimens from 21 collections across Canada, entered the information into a database, and mapped and analyzed these records. The European subspecies *australis* was first documented in Canada 100 years before it was recognized as an alien invader. It was not until the invading plants had entered a phase of rapid local increase after 1990 that they attracted sufficient attention that a comparison of the invasive and non-invasive plants was made. By 2001, two different races had been distinguished, and soon after they were separated as different subspecies. The first Canadian collection of the alien subsp. *australis* was made in southwestern Nova Scotia in 1910. By the 1920s, it occurred in southern Nova Scotia, along the St. Lawrence River near Quebec City and at Montreal. The first southwestern Ontario specimen was collected in 1948. Thus by 1950 subsp. *australis* was known from only four relatively small areas of Canada based on 22 collections. At this same time, the native race, subsp. *americanus*, had a widespread distribution in Canada represented by 325 collections. This strongly supported the comparable and limited distribution of subsp. *australis* at the time. By 1970, subsp. *australis* had spread locally but was still found only in southwestern Nova Scotia, in the St. Lawrence River valley, and in southwestern Ontario. By 1990, subsp. *australis* had become much more frequent in the St. Lawrence River valley and in southwestern Ontario, and it had extended westward into eastern Ontario. By 2010, it had spread throughout much of southern Ontario and southern Quebec, and it had a more extensive distribution in Atlantic Canada, but the biggest change was its spread into western Canada. It appeared in northern Ontario, northwestern Ontario, southern Manitoba, and interior southern British Columbia. The rate of spread is increasing and within a decade or two, based on the extent of appropriate plant hardiness zones currently occupied, it is expected to become abundant in the prairie provinces and across most of southern Canada.

Key Words: European Common Reed, *Phragmites australis* subsp. *australis*, *Phragmites australis* subsp. *americanus*, invasive alien, weed, spread, potential distribution, biodiversity, Canada, prairies, prairie provinces, plant hardiness zones.

Information on the geographic occurrence of invasive species is essential for the protection of native biodiversity. The Convention on Biological Diversity (United Nations 1992*) calls for “the eradication of those alien species which threaten ecosystems, habitats or species.” The Canadian Biodiversity Strategy (Biodiversity Convention Office 1995, article 1.81) recommends that ways to identify and monitor alien organisms be developed and implemented, that priorities be determined, and that databases that will help predict the spread of these organisms be developed and analyzed. A related goal of Agriculture and Agri-Food Canada is to minimize risks to native biodiversity from exotic organisms (Agriculture and Agri-Food Canada Environment Bureau 1997). The global strategy for plant conservation adopted by the conference

of the parties to the Convention on Biological Diversity in 2002 included among its outcome targets for 2010 “management plans in place for at least 100 major alien species that threaten plants, plant communities and associated habitats and ecosystems.” This target has yet to be properly evaluated (Secretariat of the Convention on Biological Diversity 2009), but clearly the European subspecies of Common Reed (*Phragmites australis* (Cav.) Trin. ex Steud. var. *australis*) is a major alien species. It is currently ranked as the foremost invasive plant threat to native biodiversity in Canada that is lacking a comprehensive management plan (Catling 2005*). It is rapidly spreading in Canada, and geographic information is urgently needed.

As a result of confusion with the native *P. australis* subsp. *americanus* Saltonstall, P. M. Peterson & Soreng

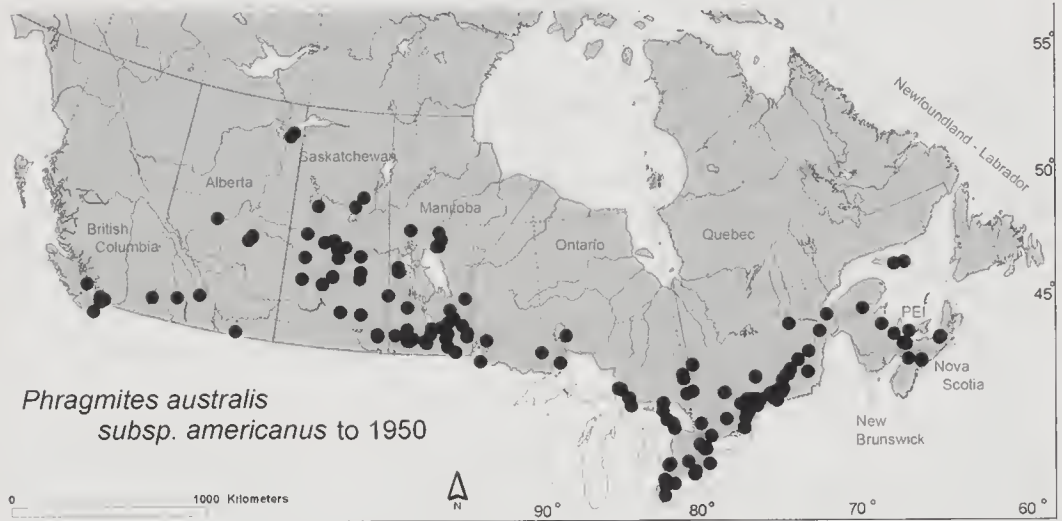


FIGURE 1. Distribution of the native *Phragmites australis* subsp. *americanus* in Canada up to 1950, showing the widespread distribution anticipated for a native taxon. Specimens examined from the following herbaria: ACAD, ALTA, CAN, DAO, MMMN, MT, MTMG, NSPM, QFA, QUÉ, SASK, TRT, TRTE, UBC, UNB, UPEI, UWO, V, WAT, and WIN.

(a native plant of fens, bogs and rivershores), subsp. *australis* was not included among the invasive species covered by White *et al.* (1993). Possible "invasive biotypes" were alluded to in 2001 (Small and Catling 2001), and the status and identification of native and introduced races were clarified for Canada in 2003 (Catling *et al.* 2003). Also, by 2003, the presence of non-native genotypes had been well established (Saltonstall 2002, 2003). The two subspecies, then treated as races, were only briefly alluded to by Mal and Narine (2004) based on Catling *et al.* (2003). In 2004, the widespread native North American race was described as the distinct subspecies *americanus* (Saltonstall *et al.* 2004). The identification of the introduced *Phragmites australis* subsp. *australis* was clarified by Catling (2007*) and Catling *et al.* (2007).

In eastern Canada, the invasive alien subsp. *australis* is having major impacts (Mitrow and Catling 2009*); it is displacing native vegetation in rich salt marshes in the estuary of the St. Lawrence River (personal observation); it has become the most significant threat to native vegetation in the St. Lawrence River area (Lavoie *et al.* 2003); it is replacing native wetland vegetation in Long Point Biosphere Reserve on the Lake Erie shore of Ontario (Wilcox *et al.* 2003); it is eliminating the habitat of the endangered Eastern Prairie Fringed Orchid (*Platanthera leucophaea*) (COSEWIC 2003) and other native prairie plant species at risk in the Lake St. Clair marshes (personal observation); it is displacing the rich biodiversity of shoreline fens on Lake Huron (Bickerton 2007*); and it is invading cereal crops in parts of eastern Ontario and southern Que-

bec (personal observation). Recent studies have described the characteristics that enable it to achieve these kinds of environmental damage especially with regard to outcompeting *Typha* in wetlands (Bellavance and Brisson 2010). It was first reported (i.e., not recorded indirectly as a misidentified specimen) in western Canada in 2003 (Martin 2003*; Schueler *et al.* 2003*) and first in Atlantic Canada in 2004 (Catling *et al.* 2004*). Using a well-supported assessment protocol (Morse *et al.* 2004), it was ranked as the top priority invasive alien plant in Canada in 2005 (Catling and Mitrow 2005; Catling 2005*).

A useful map of mostly invasive *Phragmites* in Canada, based on a recent extensive survey (Schueler 2002*), provided a valuable benchmark but did not distinguish subspecies, since it was generated prior to the work that enabled convenient identification. The synthesis of biological information on *Phragmites australis sensu lato* in North America for the "Biology of Canadian Weeds" series also preceded the taxonomic understanding of two separate entities. Consequently, Mal and Narine (2004) produced a map of the Canadian distribution that did not distinguish between subspecies. Maps of the two subspecies are available online via a searchable database with geographic querying capability (Catling 2007*; Catling and Mitrow 2009a*). Although this was a useful step, the data on which the maps are based has not been subject to analysis aimed at documenting rate of spread. Potential distribution in Canada was discussed by Catling and Mitrow (2009b*), but no detailed mapping was provided. The present work responds to the needs outlined above by pro-



FIGURE 2. Distribution of the alien *Phragmites australis* subsp. *australis* in Canada up to 1950, showing the limited distribution anticipated for an introduced taxon, here largely limited to urban areas of introduction. Specimens examined from the following herbaria: ACAD, ALTA, CAN, DAO, MMMN, MT, MTMG, NSPM, QFA, QUE, SASK, TRT, TRTE, UBC, UNB, UPEI, UWO, V, WAT, and WIN.

viding an analysis of geographic information relating to the status, spread, and current and potential distribution of *Phragmites australis* subsp. *australis*.

Methods

Herbarium specimens were measured and identified, and the label data were recorded and mapped in order to provide information on geographic occurrence. Herbaria at the following institutions supplied specimens: Acadia University (ACAD), the University of Alberta (ALTA), the Canadian Museum of Nature (CAN), Agriculture and Agri-Food Canada (DAO), the Eastern Ontario Biodiversity Museum (EOBM, now in DAO), Carleton University (CCO, now in DAO), the Manitoba Museum (MMMN), the Université de Montréal (MT), Macdonald Campus of McGill University (MTMG), the Nova Scotia Museum of Natural History (NSPM), Université Laval (QFA), the Herbarium du Québec Ministère des Ressources naturelles et de la Faune du Québec (provincial herbarium, Quebec ministry of natural resources and wildlife) (QUE), the University of Saskatchewan (SASK), the Royal Ontario Museum (TRT), Erindale College of the University of Toronto (TRTE), the University of Calgary (UAC), the University of British Columbia (UBC), the University of New Brunswick (UNB), the University of Prince Edward Island (UPEI), the University of Western Ontario (UWO), the Royal British Columbia Museum (V), the University of Waterloo (WAT), and the University of Winnipeg (WIN) (acronyms from

Thiers 2011*). These 21 collections differ in their regional representation but collectively represent all of Canada. The collection information was organized into a database of 1740 records. Most of the specimen data used are readily available at <http://www.cbif.gc.ca/> (see Catling 2007*; Catling and Mitrow 2009a*).

Of the specimens in the database, only 728 could be used because only these specimens could be identified to subspecies with a high level of confidence. For Figure 1, 156 plants with prominent reddish-purple basal stem internodes and 169 plants lacking lower stems but with lower glumes over 4.4 mm were plotted. For Figures 2 to 5, 413 plants were considered: 248 with yellow lower stem internodes and 165 without lower stems but with lower glumes less than 3.8 mm long.

These decisions exclude plants with intermediate stem colours and intermediate lower glume lengths and correspond to recent identification keys separating the two subspecies (Catling *et al.* 2007). The colour of the lower stem internodes is considered the most reliable character in both fresh and dried material. Most of the 1012 excluded specimens had immature inflorescences or were lacking basal parts. Only 3% of the exclusions were the result of intermediacy of internode colour. On the basis of intermediate lower glume lengths alone, 30.5% of specimens fulfilled the exclusion criteria for intermediacy. The intermediates were not obviously hybrids and were considered to represent extremes.



FIGURE 3. Distribution of the alien *Phragmites australis* subsp. *australis* in Canada up to 1970. Specimens examined from the following herbaria: ACAD, ALTA, CAN, DAO, MMMN, MT, MTMG, NSPM, QFA, QUE, SASK, TRT, TRTE, UBC, UNB, UPEI, UWO, V, WAT, and WIN.

The identification key used was as follows:

- 1a. Lower stem internodes yellowish or yellowish-brown; lower glumes 2.6–4.2 (4.8) mm long; ligule of middle leaf excluding fringe usually 0.1–0.4 mm high subsp. *australis* (introduced)
- 1b. Lower stem internodes reddish-purple; lower glumes 3.8–7.0 mm long; ligule of middle leaf excluding fringe usually 0.4–0.9 mm high . . . subsp. *americanus* (native)

Variation in sampling effort over time can lead to biases in interpreting periods of invasiveness. These biases can be overcome to some extent by a comparison with the rate at which similar native and exotic taxa have been collected (Deslile *et al.* 2003). Here we compare the distribution of the native subsp. *americanus* up to 1950 to that of the introduced subsp. *australis* by the same date to help establish the invasive period of the latter. Arrival in a particular region may have been in advance of the date of the first collection, and at any particular time an invasive species may be more widespread at the time than collections indicate. Using collections to represent distributions, especially of invading species, is only an approximation, but it is also an indication of what is definitely known with a background of proof. It has worked relatively well because field botanists are distributed

across Canada and have increased in number over the last century.

With regard to predicting the potential area of distribution in Canada of the introduced subsp. *australis*, we used the simple yet useful approach of anticipating full occupation across Canada of hardiness zones (Agriculture and Agri-Food Canada 2010*, United States Department of Agriculture 2011*) currently occupied by subspecies *australis* in the east. Hardiness zones, which are based on both assessments of plant response to climate and climate data, have been updated to reflect recent changes in Canadian climate and to develop a more objective approach to climate mapping (McKenney *et al.* 2001). Mean maximum temperature of the coldest month and the number of frost-free days are the most important correlates of hardiness. Using the hardiness zones projection, potential range is based on occurrences and climatic tolerances of genotypes already present. The potential range assumes the ability to spread (see below) and it assumes that substrate requirements will be met. Although substrate may determine the level of impact in local areas, it is not likely to restrict broad scale distribution because calcium-rich alkaline soils are widespread or continuous across much of Canada and regions without such soils are connected due to the use of de-icing salt on roads which serve as the major invasion pathway (Catling and Carbyn 2006; Lelong *et al.* 2007; Jodoin *et al.* 2008; Brisson *et al.* 2010).

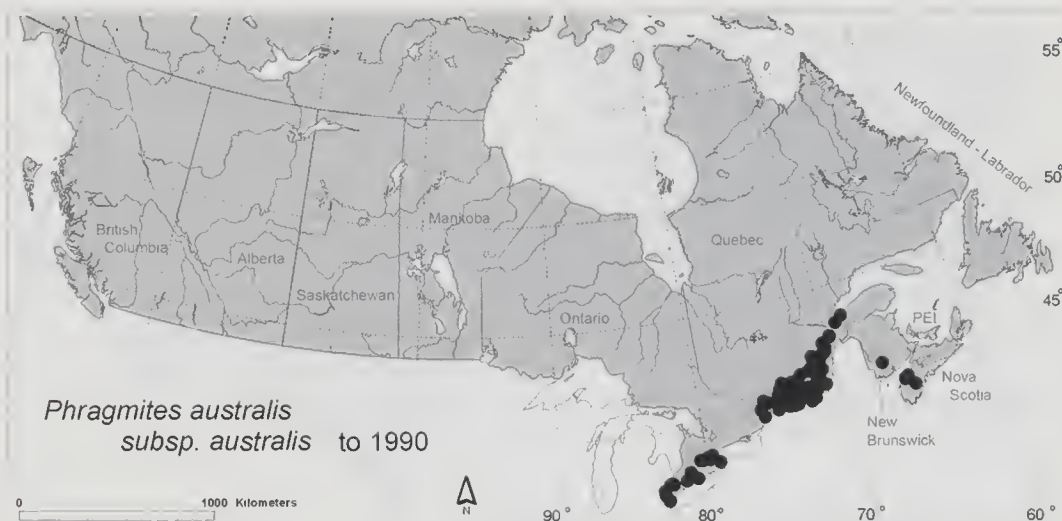


FIGURE 4. Distribution of the alien *Phragmites australis* subsp. *australis* in Canada up to 1990. Specimens examined from the following herbaria: ACAD, ALTA, CAN, DAO, MMMN, MT, MTMG, NSPM, QFA, QUE, SASK, TRT, TRTE, UBC, UNB, UPEI, UWO, V, WAT, and WIN.

Results

Arrival and initial spread to 1950

The native and very similar *P. australis* subsp. *americanus* was first collected in Canada in Montreal in 1820 (approximately 45.56326°N, 73.66830°W, 1820, *Holmes s.n.*, MT). By 1910, there were 39 collections. Based on 317 collections, its distribution in North America had been established as being widespread by 1950 (Figure 1). The Canada-wide distribution has been filled and slightly extended since that time, but the changes are not substantial (personal observation).

The first Canadian record of *P. australis* subsp. *australis* is from Annapolis Royal in southwestern Nova Scotia (44.73937°N, 65.51820°W, 1 September 1910, *J. Macoun 82089*, CAN 34069). By 1950, it had a distinctly introduced distribution pattern, being known from only four locations, three of which were seaports (Figure 2). The number of collections before 1950 was only 22. This number of collections and distribution pattern (Figure 2), compared to that of the native subsp. (Figure 1), strongly support the concept of subsp. *australis* being an alien taxon with a very limited distribution in Canada for a long period. Unlike the situation with the native subsp. *americanus*, the range of the introduced subsp. *australis* has been substantially extended since then.

Following the early collections, subsp. *australis* was subsequently found many times at Annapolis Royal by a series of collectors (Catling *et al.* 2004*) (e.g., 30 August 1921, *M.L. Fernald and B. Long 23296*,

ACAD, CAN 34067, MT). In that town it is currently known as “elephant grass,” and it is believed to have been introduced with straw on trains carrying elephants and other circus animals in the early 1900s (Catling *et al.* 2004*). Of course, it may also have originated in packing material or hay on ships arriving from Europe. It was also collected early at Bridgetown, Nova Scotia (44.83670°N, 65.28681°W, 14 September 1928, *H.G. Perry and M.V. Roscoe 13820, 13954, 13957*, ACAD, MTMG 25805, NSPM).

The first specimen of subsp. *australis* from the St. Lawrence River downstream from Quebec City was collected at L'Islet (46.87733°N, 71.11144°W, August 1916, *Frère Marie-Victorin s.n.*, CAN 332090). The first record from the Montreal region was from Thérèse-de-Blainville (approximately 45.68330°N, 73.78330°W, September 1929, *S. Lauzon 39*, MT).

The first known occurrence of subsp. *australis* from southwestern Ontario was on Walpole Island, Lake St. Clair (approximately 42.52917°N, 82.47851°W, 8 August 1948, *R.W. Neal 786*, DAO 25225).

1970

By 1970, subsp. *australis* had spread locally but was still known from only the three regions: southwestern Nova Scotia, the St. Lawrence River valley, and southwestern Ontario. However, it had become more continuously distributed in the St. Lawrence River valley, with collections between Quebec City and Montreal on the south shore of the St. Lawrence River, suggesting spread along roads (e.g., Black Lake, 46.04111°N,

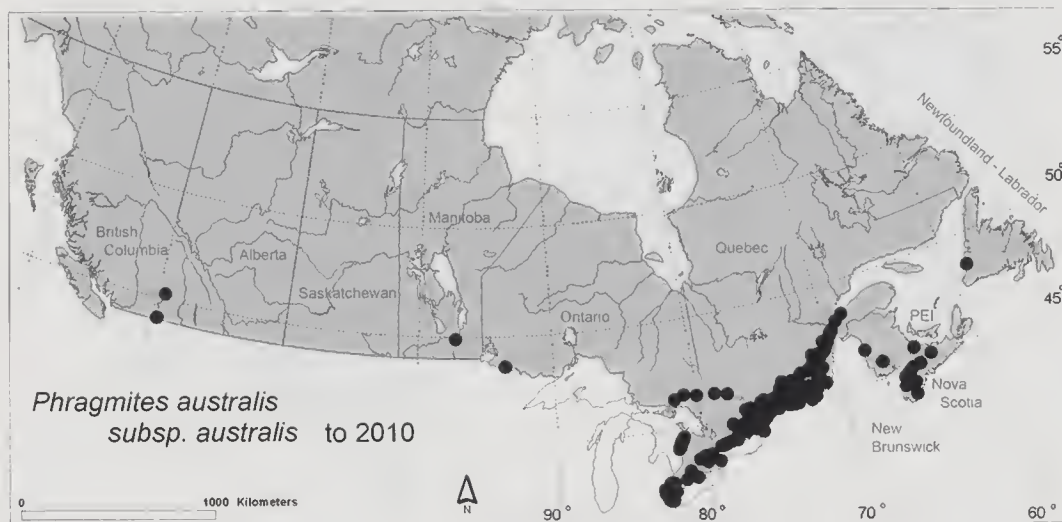


FIGURE 5. Distribution of the alien *Phragmites australis* subsp. *australis* in Canada up to 2010. Specimens examined from the following herbaria: ACAD, ALTA, CAN, DAO, MMMN, MT, MTMG, NSPM, QFA, QUE, SASK, TRT, TRTE, UBC, UNB, UPEI, UWO, V, WAT, and WIN.

71.361944°W, 12 July 1965, *G. Deshaies, P. Forest, V. Blais 10397*, MT). Over this 20-year period, it had also become distributed throughout much of the Carolinian zone of southwestern Ontario (Figure 3).

1990

By 1990, subsp. *australis* had become frequent and abundant in the St. Lawrence River valley and had recently appeared in the lower Ottawa River valley (Catling and Carbyn 2006), where it was first collected near Manotick (west side of Highway 16, 45.18614°N, 75.72348°W, 8 September 1976, *A. Hanes s.n.*, DAO 153254). Its known range had extended northeast in the St. Lawrence River valley to Rimouski (48.45000°N, 68.50000°W, 25 August 1987, *E. Côté 47*, MT). In Nova Scotia, it was still confined to the southwestern part of the province, but it was found for the first time in New Brunswick (2 miles south of Beaver Dam, 45.77212°N, 66.68840°W, 21 May 1981, *H. Hinds 4181*, MTMG 117304, UNB 36992). It had also developed a more continuous distribution in the Carolinian zone of southwestern Ontario by this time (Figure 4).

2010

Between 1991 and 2010 (Figure 5), there were two major changes. Firstly, there were substantial increases in the distribution at the local level. The St. Lawrence and southwestern Ontario regions of occurrence of subsp. *australis* were joined as a result of expansion along highways. Likewise, distributions became more continuous in the Maritimes (Catling *et al.* 2004*).

Secondly, a number of populations were found far outside the traditional areas of occurrence. For example, subsp. *australis* invaded the Lake Huron coast-

line (Bickerton 2007*) and was found north in Ontario as far as Sudbury (e.g., on the side of Highway 17, 67 km west of Coniston, near Wabagishi Road, 46.33298°N, 81.56477°W, 4 August 2004, *P. M. Catling s.n.*, DAO 795731). Most important were long-distance disjunctions (within the Canadian range) to Newfoundland and Labrador, northwestern Ontario, Manitoba, and British Columbia. The Newfoundland and Labrador record is from insular Newfoundland in Stephenville (48.55000°N, 58.58330°W, 1 August 1991, *R. Day s.n.*, DAO 595274). The first record in northwestern Ontario is from Fort Frances (bank of Highway 11 on the west side of Fort Frances, 48.60461°N, 93.45773°W, 1 August 2004, *P. M. Catling and B. Kostiuik s.n.*, DAO 795730). It was predicted that subsp. *australis* would spread to the prairie provinces (Catling and Mitrow 2009b*). So quickly did the prediction come true that publication of the first Manitoba collection (Snyder 2009*) (Winnipeg, Fort Garry area, west side of Route 90, north of Route 155, 49.88444°N, 97.14639°W, 15 October 2009, *E. Snyder s.n.*, DAO 845029) accompanied the note predicting it in the same issue of Botanical Electronic News. Records from British Columbia were also reported during this period (Schueler *et al.* 2003*; Martin 2003*; Okanagan River, protected area east of the Okanagan Highway and west of the Osoyoos Indian Reserve, 25 September 2000, *F. W. Schueler*, DAO 793302; and edge of small *Typha latifolia* wetland in semi-urban setting near the head of the Vernon arm of Okanagan Lake, 50.25248°N, 119.34725°W, December 2003, *M. Martin s.n.*, DAO 793085).

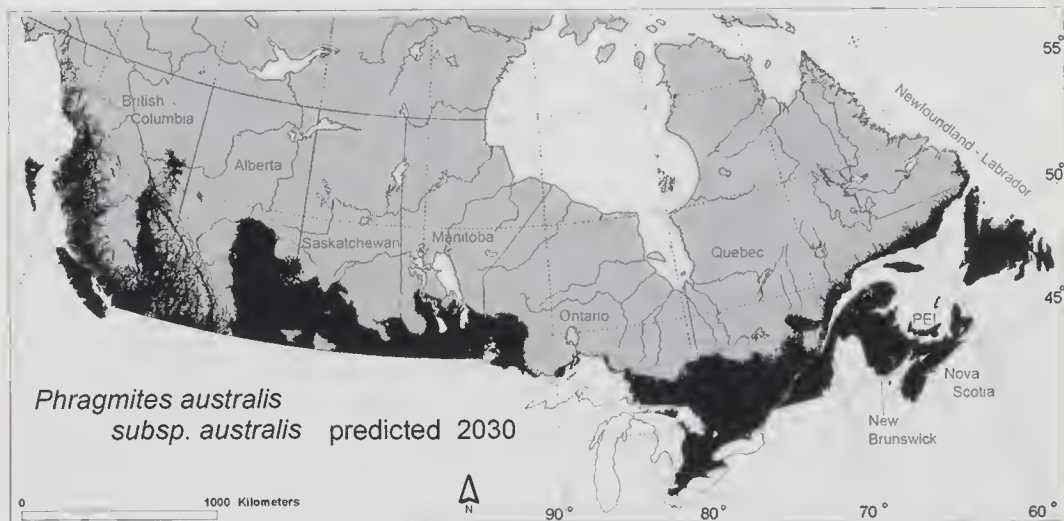


FIGURE 6. Predicted distribution of the alien *Phragmites australis* subsp. *australis* in Canada in 2030. The black areas on the map above represent the predicted range of European Common Reed in Canada within two decades based on the extent in Canada of plant hardiness zones currently occupied by subsp. *australis* in eastern Canada and taking into consideration both substrate and the past rate of spread. Note extensive anticipated occurrence in the prairie provinces. Since the rate of spread is increasing and the climate over much of Canada is getting warmer, the distribution of European Common Reed may extend north of the black areas over the shorter period of a single decade. The 2030 projection is a minimal area projection.

Rate and patterns of spread

The alien subsp. *australis* was introduced relatively early, but it wasn't until after 1970 and mostly over the past few decades that it invaded large parts of Canada (Figures 2 to 5). Initially most of the increase was within small local regions. Next there was expansion and consolidation of these regions, followed by major spread and long-distance dispersal.

Estimating potential distribution

The collections occurred within a range of plant hardiness zones extending from 2b in the north to 6a in the south, and the area of occurrence extends to zone 8a in adjacent regions of the United States. Based on the occurrence of these zones across Canada, an extensive distribution for subsp. *australis* across Canada can be anticipated (Figure 6).

Discussion

The rate of recent spread suggested by collections corresponds to sudden appearance in a region noted by various authors (Bickerton 2007*; Catling and Carbyn 2007; Wilcox *et al.* 2003), followed by increasing local abundance over a period of several years. Its invasion of the Ottawa district began as recently as the 1970s (Catling and Carbyn 2007). Schueler (2002*) noted that he noticed *Phragmites*, through the 1980s and 1990s, in places and abundances it seemed not to have occupied in the 1970s. Lelong *et al.* (2007) reported that, starting in 1970, a complete shift occurred in Quebec

over the next two decades from dominance of subsp. *americanus* to dominance of subsp. *australis*.

Although Delisle *et al.* (2003) did not distinguish races or subspecies, using proportion curves they identified a period of expansion in Quebec beginning in the 1960s at the time of major highway construction in the province. Many authors noticed that expansion was associated with roads (Gervais *et al.* 1993; Schueler 2002*; Catling and Carbyn 2007; Lelong *et al.* 2007; Jodoin *et al.* 2008; Brisson *et al.* 2010). Catling and Carbyn (2007) suggested that dispersal of rhizomes along roads (Figure 7) is the major mechanism of dispersal, although plants may also reproduce by seed in some, but not all, circumstances (Gervais *et al.* 1993; Belzile *et al.* 2009). The rhizomes extend onto gravel shoulders and are broken and transported by construction equipment (Figure 7), including graders, ploughs, and mowers. They are also spread in the treads of many kinds of vehicles and have been transported on the undersides of vehicles in caked mud.

Although the hardiness zones are relatively current (McKenney *et al.* 2001), the extent of these zones in Canada gives a minimal potential range (Figure 6) because climate warming is not taken into account. Since the effect is expected to be greatest in western Canada (Johnston *et al.* 2009*, Natural Resources Canada 2011*), we may anticipate occurrences north of the limit shown in the prairie region where substrates are conducive to spread.



FIGURE 7. An excavator working along a highway in southwestern Quebec, where it is being used to deepen a roadside ditch. The excavated substrate containing rhizomes of *Phragmites australis* subsp. *australis* will be transported to a landfill, and rhizomes with shoots can be seen lodged in the tracks. The vehicle will likely introduce rhizomes to the next work site. Photo by P.M. Catling in southwestern Quebec in 2005.

It appears that subsp. *australis* arrived 100 years ago but did not spread much over the subsequent 60 years (Figures 2 and 3). It then became much more abundant and moved substantially into new territory after 1970. The initial lag period may be a consequence of initial rarity, but it also reflects much less opportunity for spread due to the more limited road network in the past. The pattern of initially slow and then exponentially increasing rate of spread has been documented in other high-priority invasive plants in Canada, such as Glossy Buckthorn (*Frangula alnus* P. Mill., previously *Rhamnus frangula*), which presents a very similar pattern (Catling and Porebski 1994). Much greater local abundance and longer distance expansion of subsp. *australis* occurred after 1990 (Figure 4). It took only two decades to move into and become abundant in eastern Ontario and other regions (see above). As it increases in abundance in source areas and as satellite populations are established, the rate of spread is likely to increase. Based on rate of spread in the east, it seems likely that it will extend abundantly into parts of the prairie provinces over the next decade. Increasing numbers of roads and traffic will contribute to the increasing rate of increase. Spread of plants along roads can be very rapid (Reznicek and Catling 1987), and roads are increasingly identified as a major factor in the spread of invasive species (Christen and Matlack 2009). Other factors such as increasing numbers of biotypes coming into contact may also play a role in providing the raw material for local adaptation (Culley and Hardiman 2007; Belzile *et al.* 2009).

The potential environmental damage associated with *Phragmites australis* subsp. *australis* is very substantial, since the prairie wetlands are host to a large native biodiversity that includes waterfowl of great economic importance. Substantial costs to agriculture may occur as a result of the invasion of irrigation systems in the western prairie region and of wild rice in the east. Sport fishing may be affected by a general decline in biodiversity in parts of southern and northwestern Ontario. Of course, the future is difficult to predict, but, based on what we have seen of its impacts in the east, it will be desirable to keep subsp. *australis* out of the Canadian prairies as long and as completely as possible.

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Some Wild Canadian Orchids Benefit from Woodland Hiking Trails – and the Implications

PAUL M. CATLING and BRENDA KOSTIUK

170 Sanford Avenue, Ottawa, Ontario K2C 0E9 Canada; email: catlingp@agr.gc.ca

Catling, P. M. and B. Kostiuk. 2011. Some wild Canadian orchids benefit from woodland hiking trails – and the implications. *Canadian Field-Naturalist* 125(2): 105–115.

To clarify the impact that trails have on orchids we compared the occurrence of orchids on the lightly trampled edges of bare trails, with the occurrence of orchids in the surrounding woodland and noted the degree of disturbance. A two-way mixed analysis of variance, using six trails from across Canada, indicated that location by distance strata interaction was lacking. Orchid densities were consistently higher within a few meters of the bare portion of a trail than further away. The width of the disturbance gradient for two well-used trails in parks in Bruce County, Ontario, was determined with regression to be within 1 m from the edge of the bare portion of the trail. *Calypso bulbosa* var. *americana* on trails in Alberta, *Epipactis helleborine* and *Goodyera oblongifolia* on trails in Ontario, *Goodyera repens* on trails in Northwest Territories and all native orchids (cumulatively) on trails on Flowerpot Island, Ontario demonstrated consistent and significant increased abundance within the trail disturbance gradients in comparison to their occurrence in the surrounding forest. More flowering plants of *Goodyera oblongifolia* and mature capsules of *Epipactis helleborine* occurred in the trail disturbance gradient than beyond suggesting a beneficial impact on fecundity. The disturbance gradient effect likely includes light trampling which reduces competition, compacts soil, and exposes mineral soil. The effect also includes increased light and microclimate differences near to the path. Landscape managers should recognize that in some situations orchids may benefit greatly from trails and that trails may be better considered as a benefit than as a problem.

Key Words: *Calypso bulbosa* var. *americana*, *Epipactis helleborine*, *Goodyera oblongifolia*, *Goodyera repens*, disturbance, trails, paths, conservation, management, rare plants, Ontario, Alberta, Northwest Territories, Canada.

Although there is an extensive literature on the impacts of trails on vascular plants (e.g., Liddle 1975; Jordan 2000; Ferguson et al. 2010), and it includes a few useful articles concerning the minimization of conflicts between recreational uses of trails and conservation on trails (Cole 1993), very few studies have emphasized the beneficial effects of trails (Bratton 1985; Sinclair and Catling 2000). However, it is widely known that there is a disturbance gradient and zonation of plants extending from the bare portion of a trail into the surrounding woodland and it is also known that the trail flora includes characteristic woodland species that increase in abundance near the trail (Dale and Weaver 1974; Bright 1986; Benninger-Truax et al. 1992; Ferguson et al. 2010). Trails may also increase native biodiversity (Roovers et al. 2005) and act as dispersal corridors for some species (Benninger-Truax et al. 1992).

Many native Canadian orchids are associated with disturbed situations, including trails (Catling 1996, page 18), but there is little information on the trail effect. In one of the few quantitative studies, Bratton (1985) found that populations of *Galearis spectabilis* (L.) Raf. (Showy Orchis) were denser close to trails. Other studies have shown that trampling in orchid habitat increases soil compaction and decreases the abundance of fungivorous nematodes (Light and MacConaill 2007, 2008, 2009). How this affects orchids remains unclear, although a beneficial effect of trails was suggested in one of these studies (Light and MacConaill

2009). Despite the lack of specific information, it should not be surprising that some orchids benefit from trail-related disturbances, since this has been documented for a number of plants including rare species (e.g., Sinclair and Catling 2000).

An understanding of the disturbance effects of trails on terrestrial orchids would also be relevant to conservation and management. Natural areas are frequently maintained for both conservation and recreational purposes. Both of these objectives require sensible decisions. In a few instances the closure of a trail to prevent orchids from being trampled has failed to take into account the fact that the orchids might not have been there in the first place without the trail (personal observation). There are numerous instances of populations of rare plants in high traffic areas that declined or disappeared as soon as the population was protected from disturbance with a fence (personal observation). Recreation – specifically the use of trails – is economically important, valued at \$56 million annually in the US (compared to \$66 million in wildlife viewing and \$13 million in hunting, (Frantz 2007*; Kelley 2006*). Recreation is also part of the human experience of nature, which helps to develop a protective attitude. Thus it is undesirable to restrict human traffic, from both a recreational and a conservation perspective, unless it is necessary to preserve a species or population.

We suspect that trails used by humans often lead to an increase in biodiversity and contribute to the pro-

TABLE 1. Locations, species recorded, near and far trail distances compared, number of trail sections for counts, and the length of the sections for 6 trails used in a study of orchids on trails.

| Location/Species | Latitude | Longitude | Near trail distance (m) | Far trail distance (m) | No. of sections/section length (m) |
|--|----------|-----------|-------------------------|------------------------|------------------------------------|
| Alberta, Waterton Park, Carthew Trail / <i>Calypso bulbosa</i> var. <i>americana</i> | 49.0542 | -113.9237 | 0-1 | +1-3 | 15/100 |
| Northwest Territories, Fort Smith, Queen Elizabeth Park Trail/ <i>Goodyera repens</i> | 60.02441 | -111.9097 | 0-0.5 | +0.05-1 | 20/10 |
| Ontario, Flowerpot Island, Bruce Peninsula National Park, Marl and Loop Trails/ All orchids (Table 2) and <i>Goodyera oblongifolia</i> | 45.2990 | -81.6224 | 0-1 | +1-2 | 10/100 |
| Ontario, Bruce Peninsula, Bruce Peninsula National Park, Burnt Point Loop Trail/ <i>Goodyera oblongifolia</i> | 45.2624 | -81.6400 | 0-1 | +1-2 | 13/100 |
| Ontario, Stony Swamp, Jack Pine Trail, Ontario/ <i>Epipactis helleborine</i> | 45.2935 | -75.8154 | 0-1 | +1-2 | 12/100 |
| Ontario, Marlborough Forest, Rideau Trail, Ontario/All orchids | 45.0706 | -75.8328 | 0-1.5 | 4-7 m | 11/100 |

tection of rare and attractive plants, despite occasional trampled plants. Here we analyze data concerning the presence of orchids along trails to further explore this hypothesis.

Methods

Study areas and sampling procedures

In all cases the substrate of trails studied was natural. Trails created with wood chips, planks, or the crushed stone used for patios, were not included. Sites were chosen by convenience and on the basis of the presence of relatively large numbers of one or more species of orchids that would allow quantitative data to be collected. The data were gathered in such a way as to facilitate comparison of frequencies near a trail, i.e., within the disturbance gradient (usually < 1.5 m), and far from a trail (> 1.5 m). Near and far areas surveyed were either of similar size or the areas far from the trail were larger (Table 1). Distances were always measured from the edge of the bare portion of the trail. The homogeneity of vegetation before paths were created is assumed. This is not an unreasonable assumption and it is accounted for by a sufficient number of sample regions along a path through an essentially homogeneous landscape that includes similar substrates and slopes. In all cases the orchid plants were flowering or fruiting at the time of the surveys (indicated below) and all were conspicuous and readily identified. The several study areas were selected to demonstrate the widespread occurrence of the phenomenon. Locations of trails studied are indicated in Figure 1 and given in Table 1.

1. *Alberta, Waterton Lakes National Park of Canada.* The Carthew-Alderson Trail in Waterton Lakes National Park of Canada passes through Lodgepole Pine (*Pinus contorta* var. *latifolia*) – Engelmann's Spruce (*Picea engelmannii*) forest. This trail is cut out of a steep mountain slope with a gradual to steep bank on one side and descending slope on the other. The disturbed part of the trail on the bank side is characteristically 1 meter wide and the slope varies from 5 – 10° beside the bare portion of the trail rising to a slope of 80 – 90° at a distance of 1 m. Most orchid plants occur in the region of the lower slope where occasional trampling occurs and where some mineral substrate is often exposed. Sampling, on 25 June 2010, involved 15 consecutive sections of 100 m each with data on occurrence of *Calypso bulbosa* (L.) Oakes var. *americana* (R.Br.) Luer (Fairy Slipper) on the slope side of the trail, either within 1 m of the edge of the bare portion of the trail, or between +1 and 3 m from the edge of the trail. This trail had 40 hikers during the four hour period that we were there and thousands probably use it annually.

2. *Northwest Territories, Queen Elizabeth Territorial Park.* The trail from a parking lot and camping area to a high bank overlooking the Slave River in Queen Elizabeth Territorial Park, was surveyed on 3 July 2010. *Goodyera repens* (L.) R. Br. (Dwarf Rattlesnake-plantain) was the only orchid present. The trail goes through mature Jack Pine (*Pinus banksiana*) – White Spruce (*Picea glauca*) forest. The number of plants of *Goodyera repens* was recorded both 0 – 0.5 m and +0.5 – 1.0 m from the edge of the bare portion of the trail in 20 consecutive sections of 10 m each. Thus

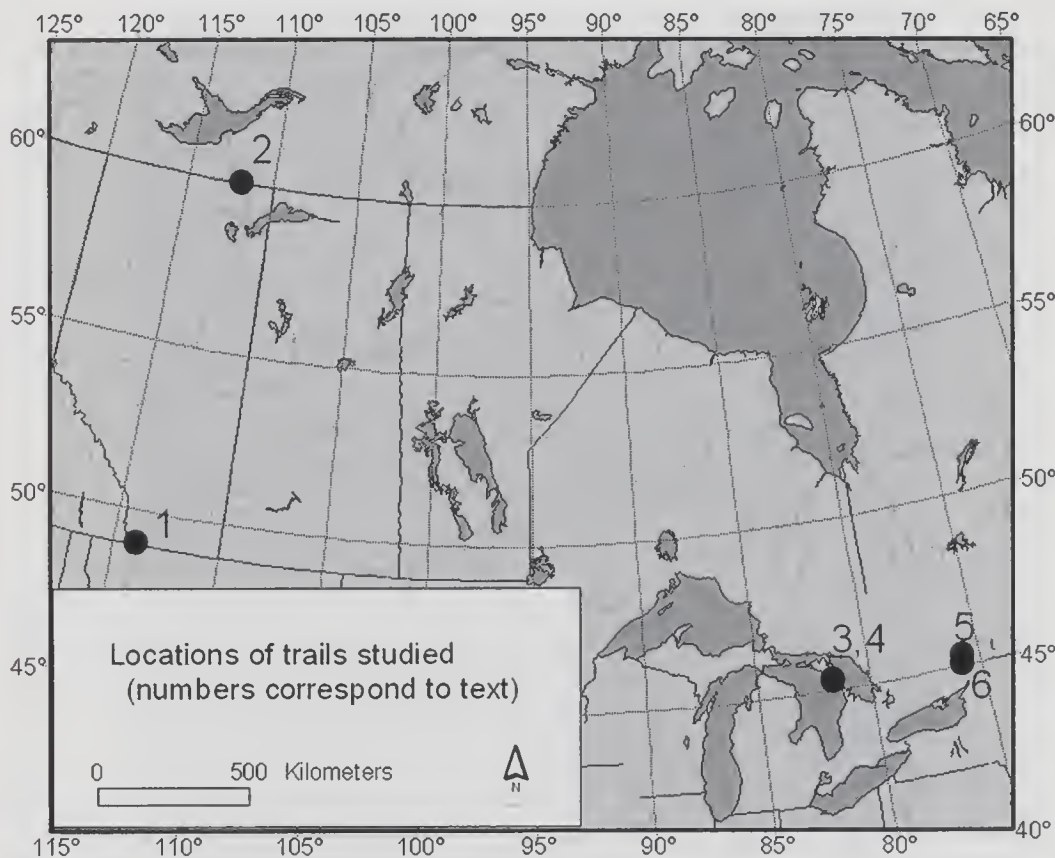


FIGURE 1. Locations of trails studied (dots). The numbers of the dots correspond to the numbers in the text.

areas compared were 100 m². The bare portion of the trail was 1 m wide. Local residents suggested that on most days during July and August, 100 people use this trail each day.

3. *Ontario, Fathom Five National Marine Park of Canada.* The Marl Pond Trail and the interior portion of the Loop Trail on Flowerpot Island are located in Fathom Five National Marine Park of Canada, off Tobermory in Georgian Bay of Lake Huron. The trails traverse woodland of Eastern White Cedar (*Thuja occidentalis*), Trembling Aspen (*Populus tremuloides*), Balsam Fir (*Abies balsamea*), and Sugar Maple (*Acer saccharum*). The most frequent orchid here was *Goodyera oblongifolia* (Menzies' Rattlesnake Plantain). At this site the data collected on 1 August 2010 included distance from the edge of the bare portion of the path up to 2 m distant for all native orchids on either side of 10 sections of each trail, the sections each being continuous and 100 m long. The data were also divided for comparison as 0 – 1 m and +1 – 2 m from the edge of the bare portion of the trail. The trail is undu-

lating with a bare portion 0.5 – 1 m wide. Most of the Marl Pond Trail (Figure 2) was surveyed excepting the last few hundred m through open rock scree but much of the dry, rugged central plateau portion of the interior part of the Loop Trail was omitted due to scarcity of orchids and narrowness of trail due to boulders and large rocks. One hundred and twenty-five people passed us on the Loop Trail within 2 hours, mostly in groups and often with children. During the high point of the season in July and August, we suspect that at least a few hundred people use this trail each day.

4. *Ontario, Bruce Peninsula National Park of Canada.* The entire length of the south side of the Burnt Point Loop Trail in Bruce Peninsula National Park of Canada, in Ontario, was surveyed on 2 August 2010. The trail traverses woodland of Eastern White Cedar, Trembling Aspen, and Balsam Fir. Here data were collected from the bare portion up to 2 m distant for all native orchids on either side of 13 consecutive sections of the trail, the sections each being continuous and each 100 m long. The trail is undulating with a bare

portion 0.5 – 1 m wide. Increasingly exposed rocks and roots have resulted in expansion of trail width to 2 m in some areas. Sixty-five people passed us on this trail late on a rainy afternoon. The annual use in spring, summer and fall is estimated as thousands.

5. *Ontario, Ottawa, Stony Swamp, Jack Pine Trail.* *Epipactis helleborine* (L.) Crantz (Broadleaf Helleborine) was surveyed along 12 consecutive sections of trail, each 100 m long. The trail passes through Jack Pine-Sugar Maple forest over sandstone. In each section the number of plants 0 – 1 m and +1 – 2 m from the trampled edge of the trail was recorded. The trail has a central bare portion at least 1 m wide and is used by thousands of people each year. Data was collected on 27 August 2010.

6. *Ontario, Marlborough Forest, Rideau Trail.* The hiking trail passes through Eastern White Cedar, Balsam Fir and White Spruce forest on shallow soil over limestone. Orchids here included *Cypripedium arietinum* R. Br. (Ram's-head Lady's-slipper), *Cypripedium parviflorum* var. *pubescens* (Greater Yellow Lady's-Slipper), *Epipactis helleborine* (L.) Crantz, *Platanthera aquilonis* Sheviak (Northern Green Orchid), *Platanthera hookeri* (Torrey) Lindley (Hooker's Orchid) and *Spiranthes lacera* (Raf.) Raf. (Northern Slender Ladies-tresses). The trail is more open than the surrounding forest and tends to be invaded by young growth of the forest trees. This undergrowth is cut and is then usually dumped between 1 and 3 m off the trail thus creating a complicating factor (smothering of vegetation with organic matter) for comparisons involving the adjacent far trail area. As a result orchids were recorded here within 1.5 m of the bare trail edge on either side of the trail and this was compared with records from the 3 m wide track through the woods parallel to the trail but 4 m removed on the west side. The comparison involved 11 sections of one hundred m each and the data were gathered on 29 August 2010. The trail had experienced little recent use, evidently due to flooding of large sections. At this site *Maianthemum stellatum* (L.) Link. (False Solomon's Seal) was distinguished from non-flowering plants of *Cypripedium arietinum* by the more pubescent and non-winged stems and curving and sheathing leaves of the latter.

Data Analysis

We used the data collected (as described above and see Table 1) to perform four related analyses:

(1) Overall trail effect

We used all data on orchids along six trail segments to examine the effect of trail proximity. This was done by fitting a two way mixed ANOVA, with stratum (near, far) as a fixed factor, and location as a random factor, to the $\log_{10} + 1$ transformed counts for each trail section. The transformation was necessary to stabilize the variance, and the 1 is added because $\log_{10}(0)$ is undefined, and some sections had counts of zero.

(2) The trailside gradient

In the case of the two trails (Fathom Five and Bruce Peninsula) data were available on actual distances of all recorded plants from the edge of the bare portion of the trail out to a distance of 2 m. This not only provided a means of determining the extent of the trail effect on orchids, it also provided an evaluation of the probable width of the disturbance gradient. Regression along with correlation and analysis of variance (ANOVA) was used to determine the significance of the relationship. The shape and formula of the best fit regression line helped to define the distance at which abundance of orchids changed. The analysis was performed using the number of orchids in 20 consecutive 10 cm sections up to 200 cm from the bare edge of the trail.

(3) Pairwise and independent comparisons

Much of the analysis here involves instances based on adjacent occurrence (near to the trail and far from the trail) along consecutive sections of trail. Near is defined as 0 to 1.5 m or less (as indicated – Table 1) and far is defined as more than 0.5 or more commonly more than 1 or 1.5 m. These distances are generally supported by the gradient analysis described above. However, the limits of the distances for the comparison to trailside areas were generally decided upon based on observation of what appeared to be a likely limit for the gradient based on changes in vegetation.

Since sections of trail within and outside a given distance share certain landscape features and have an extensive common boundary, they might be regarded as paired samples. On the other hand the near and far trail samples are actually not from the same source and are, to a large extent, independent. As a result of these paired and independent aspects, the data were analyzed both ways – as paired samples using the Paired t-test, the Sign Test and the Wilcoxon Signed Rank Test and as independent samples using the Mann-Whitney Wilcoxon test comparing medians and the Kolmogorov-Smirnov Test comparing distributions.

The Paired t-test, employing differences between pairs of observations, compares means and assumes normality considered as acceptable within limits of ± 2 for both skewness and kurtosis. All other tests are non-parametric. The Sign Test and the Wilcoxon Signed Rank Test compare medians. Of the two the Wilcoxon, using ranks, explains more of the data (Sokal and Rolf 1995). The Kolmogorov-Smirnov Test has the advantage of providing a different perspective in comparing distributions to some extent independent of mean and variance, but the Mann-Whitney Wilcoxon test which compares ranks in the combined data is considered the best suited to the present data (Sokal and Rolf 1995). For all tests the significance was defined as less than 0.05.

The amount and consistency of difference in numbers of orchids within and outside the disturbance gra-



FIGURE 2. *Goodyera oblongifolia* (arrows) on the edge of the bare portion of the Marl Pond Trail on Flowerpot Island Flowerpot Island, Georgian Bay, Lake Huron, in Fathom Five National Marine Park of Canada, Ontario.

dient of consecutive trail sections were illustrated using simple plots with line graphs. The graphs were considered appropriate because the distributions are continuous distances from the start of the trail showing the pattern of corresponding differences encountered as one proceeds. All of the statistical procedures and plots utilized Statgraphics Centurion 15 software (Statpoint 2005*).

(4) Effect on fecundity

For *Epipactis helleborine* and *Goodyera oblongifolia*, numbers and proportions of capsules and flowering plants respectively near and far from the trail were tabulated. In the case of *Goodyera oblongifolia*, flowering condition was related to distance with analy-

sis of variance and regression using the 10 consecutive components of distance from the bare trail edge.

Results

(1) Overall trail effect

Counts varied substantially among strata ($F = 104.7$, $df = 1, 150$, $p < 0.001$) and locations ($F = 19.9$, $df = 5, 150$, $p < 0.001$) with no evidence of a location by strata interaction ($F = 0.93$, $df = 5, 150$, $p = 0.46$) and no evidence of significant spatial autocorrelation within trails among adjacent sections. Orchid densities were, on average, higher in close proximity, a result that appears to be consistent across the range of locations investigated (Figure 3).

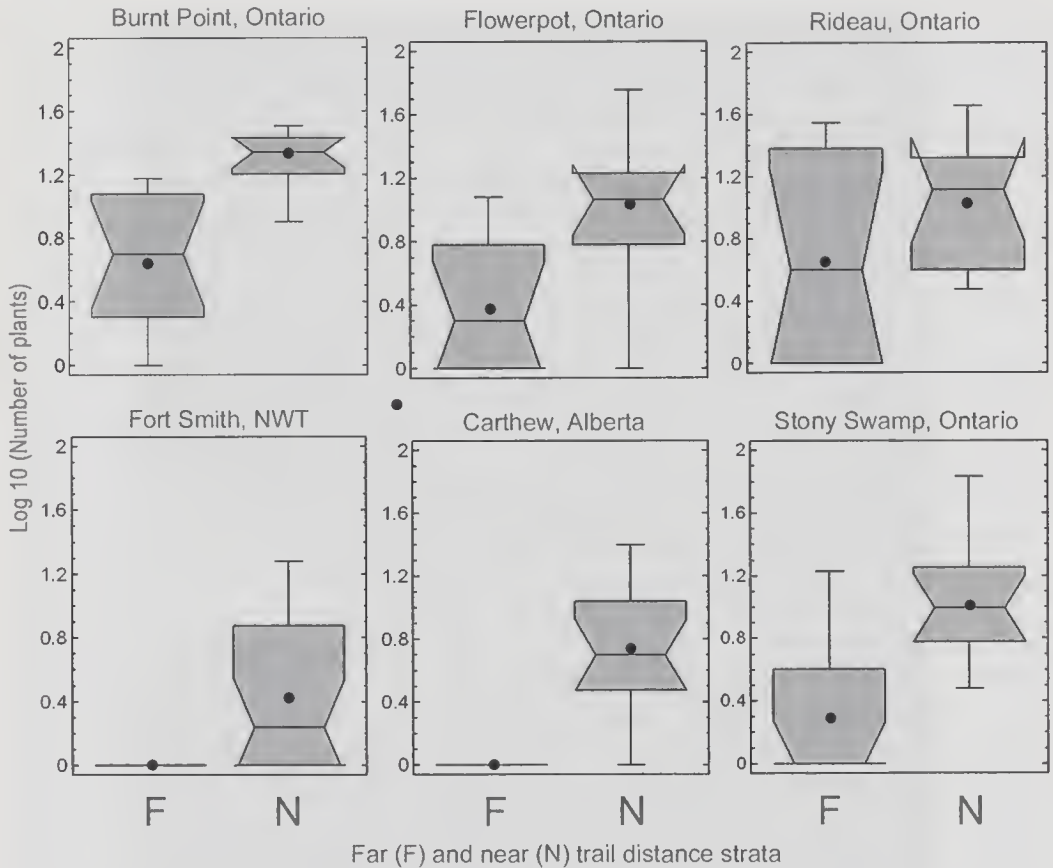


FIGURE 3. Box-and-whisker plots showing \log_{10} (number of orchid plants) for far (F) and near (N) distance strata of six woodland trails. The boxes represent the middle half of the data. Vertical lines through the boxes indicate the range of values. Horizontal lines at the notch in the boxes are medians. The dot shows the location of the sample mean.

(2) The trailside gradient

The best fit for the regression line derived from the data on number of plants of all native orchids with respect to distance from the bare portion of the trails on Flowerpot Island (Figure 4) is the reciprocal- X model with Number of plants = $-3.17474 + 74.6288/\text{number of consecutive } 10 \text{ cm distance}$ ($r\text{-squared} = 95.75\%$). Clearly the number of plants declines with increasing distance from the bare portion of the path and there is a major change in slope at a distance of 0.2 m and at 0.4 m distance indicating a major change in the gradient at this point. The correlation coefficient is -0.98753 indicating a strong relationship which is highly significant (ANOVA $F = 405.74$, $P = 0.0000$).

A similar result was obtained for the regression line derived from the data on number of plants of *Goodyera oblongifolia* on the Burnt Point Trail (Bruce Peninsula National Park) over distance from the bare portion of the trail (Figure 5). In this case the exponential model provided the best fit with Number of plants = $\exp(4.37993 - 0.148863 \times \text{number of consecutive$

TABLE 2. Numbers of eight species of orchids including *Calypso bulbosa americana*, *Corallorhiza maculata*, *Corallorhiza trifida*, *Goodyera oblongifolia*, *Goodyera repens*, *Piperia unalascensis*, *Platanthera aquilonis*, and *Platanthera hookeri* recorded along the Marl Pond and Loop trails on Flowerpot Island, Fathom Five National Marine Park, at a distance of either 0-1 m from the trampled edge or 1-2 m from the trampled edge on 1 August 2010.

| Species | 0-1 m from edge | 1-2 m from edge |
|--|--------------------|--------------------|
| <i>Calypso bulbosa</i> var. <i>americana</i> | 2 | 0 |
| <i>Corallorhiza maculata</i> | 4 | 0 |
| <i>Corallorhiza trifida</i> | 2 | 0 |
| <i>Goodyera oblongifolia</i> | 150 | 27 |
| <i>Goodyera repens</i> | 5 | 2 |
| <i>Piperia unalascensis</i> | 2 | 0 |
| <i>Platanthera aquilonis</i> | 4 | 0 |
| <i>Platanthera hookeri</i> | 3 | 0 |
| Totals | 172 | 29 |

TABLE 3. Two sample comparison significance tests for data on orchids adjacent to and distant from trails in various locations. Paired tests include t-Test, Sign Test and Wilcoxon Signed Rank Test and independent tests include Mann-Whitney Wilcoxon Test and Kolmogorov-Smirnov Test (K-S). S = standard skewness for the two-sample comparison. K = standard kurtosis for the two sample comparison. See Methods for details on data collection for each of the 8 sites. K-S = Kolmogorov-Smirnov Test.

| Species/ Location | S | K | t-test | Sign Test | Signed Rank Test | Mann- Whitney | K-S |
|---|------|------|----------|--------------|---------------------|------------------|----------|
| <i>Calypso bulbosa</i> var. <i>americana</i> Carthew-Alderson Trail, Waterton Lakes National Park, Alberta | 2.08 | 0.84 | 0.001235 | 0.000874 | 0.001645 | 0.000015 | 0.000004 |
| <i>Goodyera repens</i> Queen Elizabeth Territorial Park, Northwest Territories, Fort Smith | 2.55 | 1.22 | 0.002275 | 0.001154 | 0.000865 | 0.000062 | 0.000001 |
| All native orchids Flowerpot Island, Fathom Five National Marine Park, Ontario | 2.34 | 1.65 | 0.035934 | 0.004426 | 0.005889 | 0.004256 | 0.003323 |
| <i>Goodyera oblongifolia</i> Flowerpot Island, Fathom Five National Marine Park, Ontario | 2.27 | 1.43 | 0.078000 | 0.288843 | 0.042062 | 0.056411 | 0.164215 |
| <i>Goodyera oblongifolia</i> Burnt Point Trail, Bruce Peninsula National Park, Ontario | 4.1 | 6.6 | 0.008596 | 0.005545 | 0.002098 | 0.000103 | 0.000181 |
| <i>Epipactis helleborine</i> Jack Pine Trail, Stony Swamp Conservation Area, National Capital Commission, Ontario | 3.27 | 4.53 | 0.008149 | 0.001496 | 0.002449 | 0.002116 | 0.009655 |
| <i>Epipactis helleborine</i> Capsules, Jack Pine Trail, Stony Swamp Conservation Area, National Capital Commission, All orchids, Rideau Trail, Marlborough Forest, Ottawa, Ontario | 3.73 | 5.56 | 0.058629 | 0.015861 | 0.011278 | 0.045296 | 0.033702 |
| | 1.21 | 1.52 | 0.112476 | 0.227799 | 0.074646 | 0.113084 | 0.075807 |

10 cm distance (r -squared = 74.20%). Again the number of plants declines with increasing distance from the bare portion of the trail but the major change in slope is at a distance of 1 m. These results were also significant with the correlation coefficient = -0.861398 indicating a moderately strong relationship and ANOVA $F=51.77$, $P=0.0000$.

(3) Pairwise and Independent comparisons

In the study situations, *Calypso bulbosa*, *Epipactis helleborine*, *Goodyera oblongifolia*, *Goodyera repens* and all native orchids (cumulatively) on the two Flowerpot Island trails (Table 2) demonstrated consistent (Figures 2, 6-13) and significant (Table 3) increased abundance close to trails in comparison with the number of orchids farther from trails in the surrounding forest. Along a section of the Rideau Trail in eastern Ontario, orchids (Table 4) were more abundant near the trail but the effect was not significant (Table 3).

TABLE 4. Numbers of six species of orchids including *Cypripedium arietinum*, *Cypripedium parviflorum*, *Epipactis helleborine*, *Platanthera aquilonis*, *Platanthera hookeri* and *Spiranthes lacera* recorded along a trail (1.5 m from the trampled portion) and along a woodland track parallel to the Rideau Trail in the Marlborough Forest, eastern Ontario.

| Species | Beside trail (1-1.5 m) | Off trail (4-7m) |
|---|---------------------------|---------------------|
| <i>Cypripedium arietinum</i> | 42 | 62 |
| <i>Cypripedium parviflorum</i> var. <i>pubescens</i> | 36 | 21 |
| <i>Epipactis helleborine</i> | 37 | 21 |
| <i>Platanthera aquilonis</i> | 2 | 0 |
| <i>Platanthera hookeri</i> | 1 | 4 |
| <i>Spiranthes lacera</i> | 0 | 1 |
| Totals | 118 | 109 |

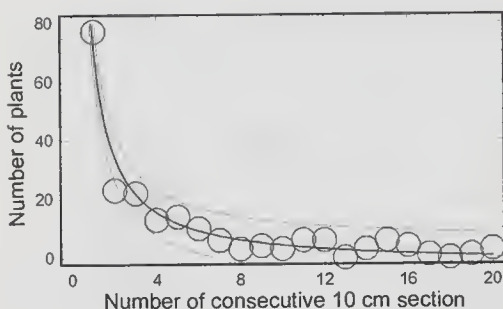


FIGURE 4. Regression line derived from the data on number of plants of all orchids with respect to distance from the bare portion of the Flowerpot Island trails (Bruce Peninsula National Park, Ontario). The best fit line is the reciprocal $-X$ model with Number of plants = $-3.17474 + 74.6288/\text{number of consecutive } 10 \text{ cm distances}$. The outer lines are the 95% prediction intervals for new observations. The inner lines are the 95% confidence intervals for the mean of many observations.

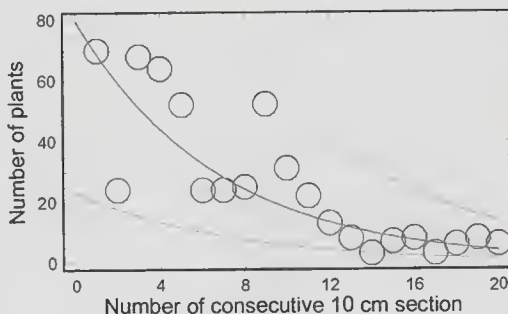


FIGURE 5. Regression line derived from the data on number of plants of *Goodyera oblongifolia* with respect to distance from the bare portion of the Burnt Point Loop Trail near Tobermory, in Bruce Peninsula National Park of Canada, Ontario, 2 August 2010. The best fit line is the exponential model with number of plants = $\exp(4.37993 - 0.148863 \times \text{number of consecutive } 10\text{-cm distances})$. The outer lines are the 95% prediction intervals for new observations. The inner lines are the 95% confidence intervals for the mean of many observations.

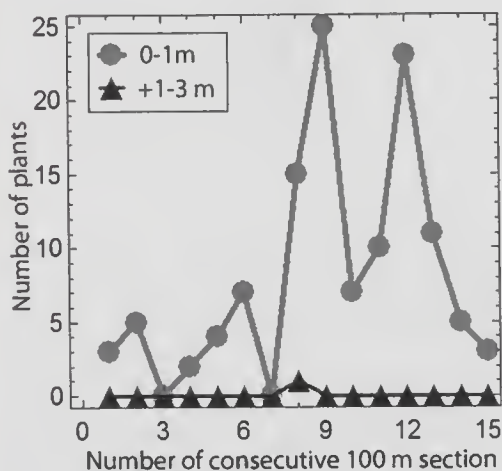


FIGURE 6. Plot of number of plants of *Calypso bulbosa* within 1 m of the trampled section of trail (dots) or 1–3 m off the trail (triangles) along 15 consecutive sections of 100 m each of the Carthew-Alderson Trail in Waterton Lakes National Park of Canada, Alberta, 25 June 2010.

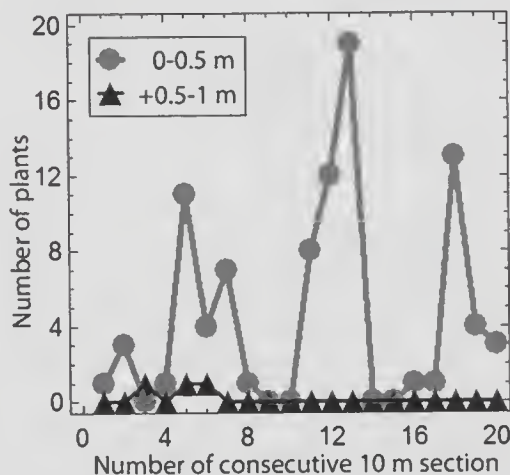


FIGURE 7. Plot of number of plants of *Goodyera repens* in Queen Elizabeth Territorial Park, Northwest Territories, 0–0.5 m (dots) or 0.5–1.0 m (triangles) from the trampled portion of the trail in 20 consecutive sections of 10 m each, 3 July 2010.

The standard skewness and standard kurtosis values do exceed the desirable limits for the paired t -test, but they do not necessarily invalidate the results.

(4) Effect on fecundity

Although there were three times as many flowering plants of *Goodyera oblongifolia* within 1 m of the Burnt Point Loop trail (Bruce Peninsula National Park) as there were beyond 1 m (105 plants versus 34), a significantly higher proportion of the plants further

from the edge of the trail were flowering (ANOVA $F = 12.18$, $P = 0.0005$). Likewise for the two Flowerpot Island trails (Fathom Five National Marine Park) there were more than twice as many flowering plants within 1 m of the bare portion of the trail as there were beyond 1 m (50 plants versus 21). However, a significantly higher proportion of the plants further from the trail edge were flowering (ANOVA $F = 44.91$, $P = 0.0000$). With respect to capsules of *Epipactis*

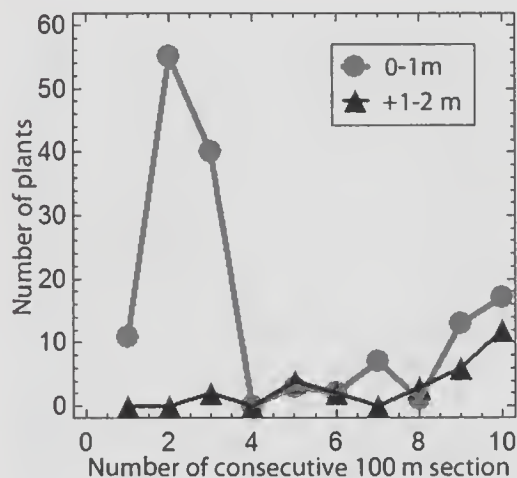


FIGURE 8. Plot of number of plants of *Goodyera oblongifolia* either 0–1 m (dots) or 1–2 m (triangles) from the bare portion of the trails in 10 consecutive sections of 100 m each on Flowerpot Island, Georgian Bay, Lake Huron, in Fathom Five National Marine Park of Canada, Ontario, 1 August 2010.

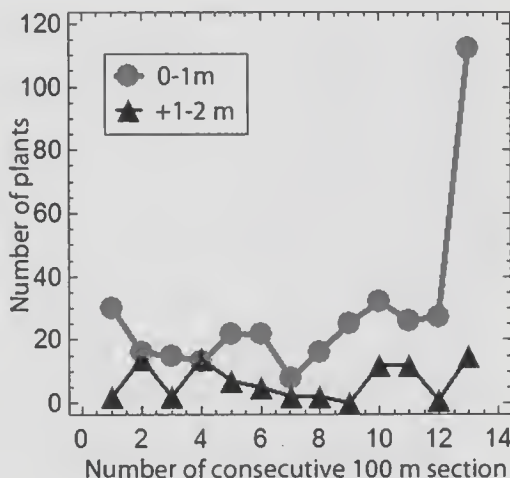


FIGURE 9. Plot of number of plants of *Goodyera oblongifolia* either 0–1 m (dots) or 1–2 m (triangles) from the bare portion of the trail in 20 consecutive sections of 100 m each, Burnt Point Loop Trail, Bruce Peninsula National Park of Canada, Ontario, 2 August 2010.

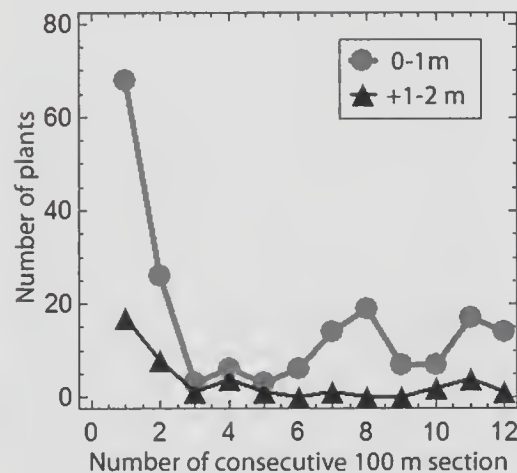


FIGURE 10. Plot of number of plants of *Epipactis helleborine* either 0–1 m (dots) or 1–2 m (triangles) from the bare portion of the trail along 12 consecutive sections of 100 m each, Jack Pine Trail in Ottawa (Stony Swamp Conservation Area, National Capital Commission) on 27 August 2010.

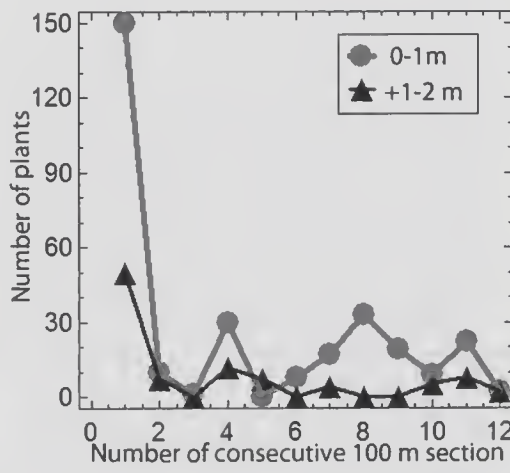


FIGURE 11. Plot of number of capsules on plants of *Epipactis helleborine* either 0–1 m (dots) or 1–2 m (triangles) from the bare portion of the trail along 12 consecutive sections of 100 m each, Jack Pine Trail in Ottawa (Stony Swamp Conservation Area, National Capital Commission) on 27 August 2010.

helleborine, more capsules developed near to the bare part of the trail than further from it (Figure 11).

Discussion

(1 and 2) Overall trail effect and the trailside gradient

Although not all trails conform to a rule (authors, personal observation), a beneficial effect of trails on

orchids can be demonstrated from data collected across Canada. That there is a significant beneficial effect and that it occurs over a distance of less than 1.5 m from the bare portion of a woodland trail is not surprising in light of: (1) the general tendency for terrestrial orchids to respond positively to disturbance; and (2) the literature indicating a zonation of species and suggesting

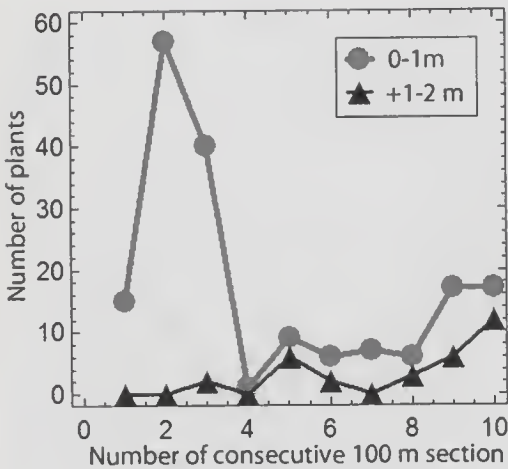


FIGURE 12. Plot of number of native orchids either 0–1 m (dots) or 1–2 m (triangles) from the bare portion of the trails in 10 consecutive sections of 100 m each, Flowerpot Island, Georgian Bay, Lake Huron, in Fathom Five National Marine Park of Canada, Ontario, 1 August 2010.

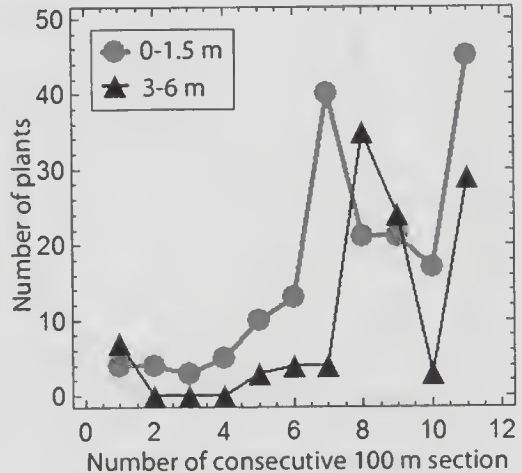


FIGURE 13. Plot of number of native orchid plants either 0–1.5 m from the bare portion of the trail on either side of the trail (dots) or along a parallel line through the woodland 3 m wide (triangles) and 4 m from the bare edge of the trail in 11 trail sections, Rideau Trail (Marlborough Forest, City of Ottawa), eastern Ontario, 29 August 2010.

a trailside disturbance gradient of varying width (Bates 1935; Liddle 1975, 1997; Bright 1986; Benninger-Truax et al. 1992; Jordan 2000; Ferguson et al. 2010).

(3) Pairwise and Independent comparisons

There are few previous data for the specific sites studied to compare with the results of the present study. Although the trampling study in Waterton Lakes National Park (Douglas et al. 1975*) was very comprehensive, there was no clear trend in the orchids present and this study was of too short a duration (one year) to indicate beneficial effects and it was designed only to elucidate short-term negative impacts. Much of the general literature has also assumed only negative effects and the experimental design has been developed to quantify negative impact. Although some studies noted previously (Dale and Weaver 1974; Bright 1986; Benninger-Truax et al. 1992; Ferguson et al. 2010) indicated a beneficial effect on some species, demonstration of a beneficial effect on orchids remains unique to Bratton (1985). Here that phenomenon is extended across Canada and to three native and one introduced species.

(4) Effect on fecundity

Light trampling beside the bare portion of a trail would be expected to damage plants and thus lead to reduced flowering and fruit production. Although proportionately less flower or fruit production occurred near the trail in the case of *Goodyera oblongifolia* and *Epipactis helleborine* respectively, this effect was not sufficient to reduce fecundity adjacent to the trail with

respect to the adjacent forest because of the much larger number of plants adjacent to the trail. In the case of *Cypripedium acaule* Ait. (Pink Lady's-slipper) studied by Bratton (1985), there was no indication of an effect on density, but there was significantly reduced flowering near to the trail. This was attributed primarily to poaching.

Mechanisms of the trail effect

Many studies have documented a zonation from the bare portion of a trail into the surrounding habitat (Bates 1935; Liddle 1975, 1997; Benninger-Truax et al. 1992; Jordan 2000) and attributed it to light trampling reducing competition, compacting the soil, and exposing mineral soil, and to increased light and microclimate differences near to the path. During our surveys of the study trails, people were often seen stepping off the bare part of the trail to let others pass, or stepping off the edge of the trail accidentally or walking on both edges of the bare portion of the trail when walking two or three abreast. This is observed to kill some plants thus reducing competition for others that do survive and it results in a number of effects that are outlined above. The disturbance gradient becomes a clearly distinctive habitat to which some species are adapted. For example, on the Northwest Territories trail studied, the edges of the bare portion of the trail had more species of graminoid plants, much fewer species of moss, some bare soil and rare or restricted species such as *Botrychium lunaria* (L.) Sw. (Common Moonwort).

Management Implications

Protection with fences may be appropriate in many cases, such as alpine vegetation growing on mountain-top lookouts (Willard and Marr 1971), and restricted access may be necessary in order to reduce poaching (Bratton 1985) but disturbance along trails may also be beneficial. There is a general tendency to consider trails only as problematic (e.g., Cole 1993; Jordan 2000). This has led to restrictions including fences, trail closures and signs requiring people not to step off trails. The result of these restrictions can be reduced populations of rare plants, reduced experience of nature by people leading to less interest in conservation, and reduced income from recreation. A trail may be a problem, but it may not. Trails are not only good for people; they are sometimes (perhaps often) also good for rare plants, and particularly for some orchids, the most popular of native plants and a useful group of environmental indicators. A complaint about a trailside orchid plant knocked over by a hiker, should take into account the fact that the hikers may be the reason that the plant was there in the first place and that overall, hikers may often significantly improve orchid habitat.

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Evidence Confirms the Presence of Cougars (*Puma concolor*) in Ontario, Canada

RICK ROSATTE

Ontario Ministry of Natural Resources, Wildlife Research and Development Section, Trent University, DNA Building, 2140 East Bank Drive, Peterborough, Ontario K9J 7B8 Canada; email: rick.rosatte@ontario.ca

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A study was initiated to collect and collate evidence to resolve the long-standing question of whether free-ranging Cougars (*Puma concolor*) exist on the Ontario landscape. A total of 497 pieces of evidence confirmed that Cougars were present in Ontario during the period 1991 to 2010. That evidence included 21 pieces of class 1 evidence (scat, hair, DNA, tracks, photographs of a Cougar), 13 class 2 sightings (by qualified observers such as biologists), and 463 class 3 sightings (credible sightings by unqualified observers). The evidence presented in this paper indicates the presence in Ontario of free-ranging Cougars of unknown origin.

Key Words: Cougar, *Puma concolor*, mountain lion, puma, endangered, Ontario.

The Cougar (*Puma concolor*, formerly *Felis concolor*) (Wozencraft 1993), also known as the puma or mountain lion, is native to North, Central, and South America (Wilson and Reeder 1993; Pierce and Bleich 2003; Bolgiano and Roberts 2005; Wilson and Reeder 2005). In North America, the distribution of Cougars has been reduced to a third of their historical range due primarily to mortality resulting from conflict with humans (Pierce and Bleich 2003). By the 1940s, native Cougars had apparently been extirpated from eastern North America, where the historical range was considered to be east of a line from the Red River in central Manitoba to the western boundary of Louisiana (roughly east of the 100th meridian) (Bolgiano et al. 2000). The U.S. Fish and Wildlife Service recently (March 2011) concluded that the Eastern Cougar (*Puma concolor couguar*) is extinct (McCullough 2011*). However, Cougars in Ontario, Canada, are currently classed as endangered provincially (Species at Risk 2010a*).

Evidence indicating the presence of Cougars in eastern North America has been accumulating during the last three decades. In the United States, the growing number of sightings prompted officials to place *Felis concolor couguar* on the 1973 endangered species list (Bolgiano and Roberts 2005). From 1976 to 2000, evidence (scat, tracks, videos, sightings, carcasses) corroborating the presence of Cougars was collected in 11 northeastern states and provinces from New Brunswick to Missouri (West Virginia, Missouri, Illinois, New Brunswick, Vermont, Maine, Ontario, Virginia, Maryland, North Carolina, and Massachusetts) (Gerson 1988; Stoeck 1995; Bolgiano et al. 2000). Evidence has subsequently been found in an additional 7 jurisdictions (Minnesota, Iowa, Arkansas, Ohio, Michigan, Manitoba, and Quebec) (Heist et al. 2001; Clark et al. 2002; Johnson 2002; Parks Canada 2004; Reichling 2004; Bolgiano and Roberts 2005; Parks

Canada 2006; Swanson and Rusz 2006). In Ontario, Gerson (1988) documented 189 probable Cougar sightings between 1935 and 1983. Since most of these sightings could not be verified, the question as to whether free-ranging Cougars occur on the landscape was still unanswered. The current study was initiated to gather additional evidence to resolve the issue and to confirm the existence of Cougars on the current Ontario landscape.

Study Area and Methods

In 2006, a Cougar research network led by the author was established in Ontario. The network consisted of 89 biologists and wildlife technicians, primarily from the Ontario Ministry of Natural Resources (OMNR). The purpose of the network was to compile reports of Cougar sightings received by OMNR offices, to gather physical evidence with which to corroborate credible observations, where possible, and to collaborate on the design and implementation of an Ontario Cougar research program. Collaborators in the project included the OMNR Wildlife Research and Development Section, OMNR district staff, the Ontario Puma Foundation, and the Natural Resources DNA Profiling and Forensic Centre at Trent University. To gain experience in tracking, capturing, and handling Cougars and in identifying Cougar sign, tracks, and scat through instruction by some of North America's renowned Cougar biologists, I attended Cougar workshops in New Mexico and Montana during 2008 and 2009.

Collaborators from across Ontario were asked to forward credible (believable based on evidence) Cougar sighting data and other evidence (tracks, photographs, scat, tissue samples) to me for evaluation. Sightings that were determined not to be Cougars (either by me or by the primary investigator) were excluded from the analysis. Although data were primarily from the

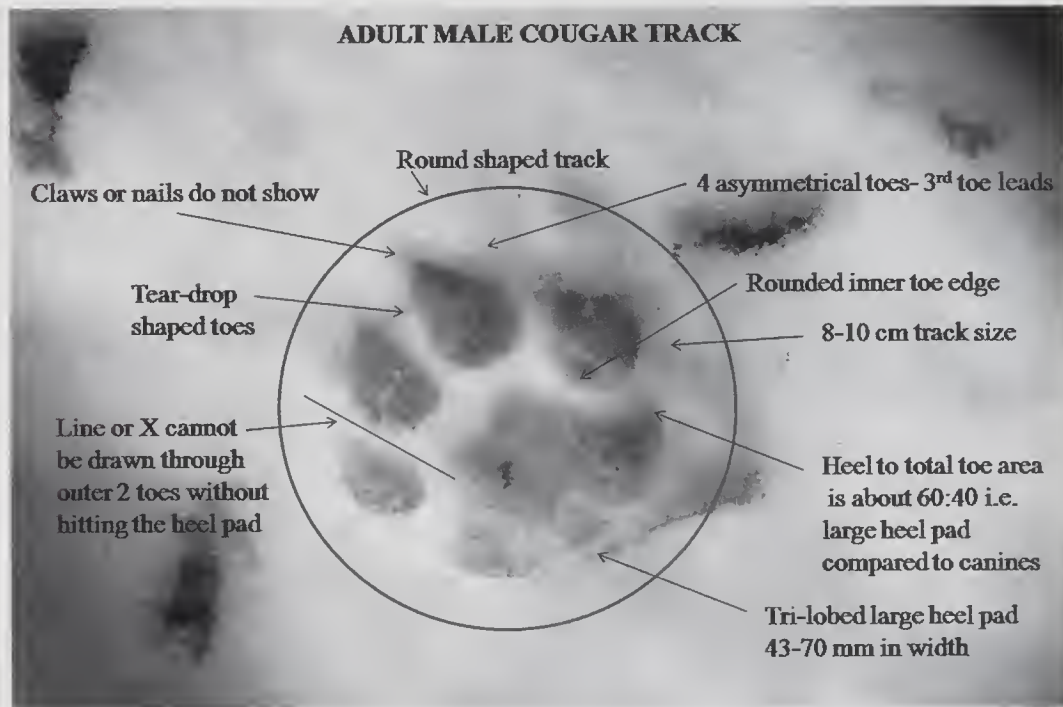


FIGURE 1. Photograph of a Cougar (*Puma concolor*) track showing key identifying features. Photo by Rick Rosatte.

present study (2006 to 2010), data collected by OMNR district staff during the period 1991 to 2005 were also examined. Physical evidence of Cougar presence was collected using standardized data collection protocols (Cardoza and Langlois 2002). Tracks were identified using the characteristics shown in Figure 1 and Shaw et al. (2007).

Credible sightings and physical evidence were classed in one of three categories according to Clark et al. (2002). Class 1 evidence included 1) Cougar DNA extracted from tissue, 2) hair determined to be Cougar through a comparison with reference samples known to be Cougar, 3) Cougar scat, 4) a photograph of a Cougar, or 5) tracks confirmed through expert analysis to be those of a Cougar. Photographs of tracks thought to be made by a Cougar were confirmed by at least two and up to four different tracking experts and Cougar biologists from across North America.

Class 2 evidence included sightings by a qualified observer such as a professional biologist or OMNR staff member (e.g., technician) with an extensive biological background that included mammalian identification.

Class 3 evidence included sightings that were reported by an unqualified observer but that, based on evidence or descriptions of the animal, I deemed credible. Sightings that were identified by the observer as "black Cougars" or "black panthers" were not included, as there are no records of a black phase of Cougar occur-

ring in North America (Texas Parks and Wildlife 2011*). Credible black Cougar sightings were assumed to be exotic cats, such as a melanistic Jaguar (*Panthera onca*) or a melanistic Leopard (*Panthera pardus*) (Figure 2).

Whenever possible, I interviewed in person the individuals who reported Cougar sightings. They were asked to describe the animal according to colour, body size, and length of tail, and they were asked to provide the distance from the animal, the length of the observation, and the date and location of the sighting. They were also asked to select the animal that most closely resembled the animal they reported seeing from a series of photographs of mammals native to Ontario, e.g., Red Fox (*Vulpes vulpes*), Wolf (*Canis lupus*), Coyote (*Canis latrans*), Cougar, American Black Bear (*Ursus americanus*), Canada Lynx (*Lynx canadensis*), Bobcat (*Lynx rufus*), White-tailed Deer (*Odocoileus virginianus*), Fisher (*Martes pennanti*), and Common Raccoon (*Procyon lotor*), as well as exotic species, e.g., Jaguar and Leopard. If the description matched a Cougar and the observer selected the Cougar from the photographs, the sighting was deemed credible.

In an attempt to capture a photograph of a Cougar, trail cameras were installed by OMNR staff in the vicinity of credible Cougar sightings across Ontario during the period 2008 to 2010. Cameras were left in place for several months. The details of that study, including methods, are outlined in a manuscript that



FIGURE 2. Photograph of a melanistic Jaguar (*Panthera onca*) taken by a trail camera near Guelph, Ontario, in April 2010.

has been submitted to the Canadian Field-Naturalist for possible publication.

For the purposes of reporting evidence, the province was divided into four regions—northwestern Ontario (NWO), northeastern Ontario (NEO), southwestern Ontario (SWO), and southeastern Ontario (SEO). The northwestern region approximated an area bounded by Red Lake, Geraldton, Sault Ste. Marie, and Thunder Bay (Figure 3). The northeastern region included the approximate area within the perimeter defined by Long Lac, Cochrane, North Bay, and Blind River. The southwestern region included the perimeter defined by Toronto, Windsor, Owen Sound, and Barrie. The southeastern region included the area within the perimeter defined by Parry Sound, Oshawa, Cornwall, and Pembroke. The northwestern and northeastern regions are in the Boreal Forest and Great Lakes-St. Lawrence Forest regions. The southwestern region is



FIGURE 3. Location of class 1 and class 2 evidence of Cougars in Ontario during the period 1991 to 2010. 1 = class 1 evidence (scat and DNA); 2 = class 2 evidence (sightings by a professional biologist). Locations are approximate.



FIGURE 4. Photograph of a Cougar track near Sioux Narrows, Ontario, March 2007. A trapper and a member of the public both observed the Cougar. Photo by Robert Horley.

in the Deciduous Forest and Great Lakes-St. Lawrence Forest regions, and the southeastern region is primarily in the Great Lakes-St. Lawrence Forest region (Species at Risk 2010b*).

Between 2006 and 2010, I gave presentations to naturalist groups, hunting and trapping organizations, and OMNR district staff in order to increase awareness and knowledge of Cougar presence in Ontario. I also assisted OMNR district and policy staff in designing Cougar response protocols and Cougar fact sheets, and I designed Cougar sighting data sheets, Cougar track identification sheets, and a Cougar sighting database for use during this study.

Results

The present study confirms the presence of Cougar in Ontario. A total of 497 pieces of evidence collected between 1991 and 2010 were evaluated. This included 21 pieces of class 1 evidence collected during the

period 1998 to 2010 (Table 1; Figure 3). Sixty-seven percent of that evidence was collected during the period 2006 to 2010 (the time of this study), with the remainder being collected during the period 1998 to 2005.

Class 1 evidence included 15 tracks in different areas of Ontario confirmed as Cougar (Figure 4); hair samples from the Sudbury area (northeastern region) that were morphologically identical to Cougar hair (J. Fortier, personal communication); DNA from one Cougar scat from the Wainfleet area (southwestern region) (A. Yagi, personal communication; Harris 2007); one scat from the Kenora area (northwestern region) confirmed as Cougar by thin layer chromatography (L. Anderson, personal communication); one photograph from the Orillia area (southeastern region) confirmed to be consistent with a Cougar (Figure 5); one infrared image from the Sunderland area (southeastern region) that was consistent with the morpho-



FIGURE 5. Photograph of a Cougar in the Orillia area near Coldwater, Ontario, in March 2007. S. Kenn of the Ontario Puma Foundation did an on-site investigation and determined that the photograph was authentic. Photo by Bill Robson.

logical features of a Cougar; and one photograph of a Cougar from the Gowganda area (northeastern region) that was confirmed to be consistent with a Cougar.

There were 13 class 2 sightings made by biologists across Ontario during the period 1994 to 2010 (Figure 3). Fifty-four percent of those occurred during the period 2006 to 2010 and the remainder occurred during the period 1994 to 2005.

There were also 463 class 3 sightings that were recorded across Ontario during the period 1991 to 2010 (Table 1). Eighty-two percent of those occurred

during the period 2006 to 2010 with the remainder occurring during the period 1991 to 2005.

A total of 52 credible "black Cougar" sightings were reported in Ontario during the period 1991 to 2010: one in the northwestern region, 15 in the northeastern region, 9 in the southwestern region, and 27 in the southeastern region (Figure 2). These were not classed, as there are no records of black Cougars occurring in North America. They were assumed to be escaped exotic animals (Texas Parks and Wildlife 2011*).

TABLE 1. Pieces of evidence, by class and region, that confirm the presence of Cougars in Ontario, Canada, during the period 1991 to 2010.

| Evidence | Region | | | | All of Ontario |
|----------|--------------|--------------|--------------|--------------|----------------|
| | Northwestern | Northeastern | Southwestern | Southeastern | |
| Class 1 | 7 | 3 | 3 | 8 | 21 |
| Class 2 | 2 | 2 | 0 | 9 | 13 |
| Class 3 | 5 | 116 | 64 | 278 | 463 |
| Total | 14 | 121 | 67 | 295 | 497 |

Class 1 = evidence such as DNA or hair from Cougars, Cougar scat, photographs of Cougars, or photographs of Cougar tracks; class 2 = credible sighting by a qualified observer such as a biologist; class 3 = credible sighting by an unqualified observer. Class 1 and class 2 evidence is from 1994 to 2010. Class 3 evidence is from 1991 to 2010; however, 81% of the sightings were made during the period 2006 to 2010.



FIGURE 6. Photograph of a Fisher, which is sometimes misidentified as a black Cougar. Photo by Rick Rosatte.

Trail cameras were set up across Ontario by OMNR staff to attempt to detect Cougar presence. More than 17 000 camera-nights were accumulated between 1 April 2008 and 31 December 2010. No definitive photographs of a Cougar were acquired during the study; however, one infrared image from a trail camera was assessed to be morphologically similar to a Cougar. Based on the number of photographs of animals taken by the trail cameras (154 736), the probability of taking a photograph of a Cougar on a trail camera in Ontario during the period 2006 to 2010 was close to zero.

Discussion

In a previous study, 318 Cougar sightings (189 of which were probable) reported in Ontario between 1935 and 1983 received subsequent evaluation by OMNR staff (Gerson 1988). Evidence from those sightings plus evidence from Minnesota and Manitoba suggested that Ontario might support a resident Cougar population (Gerson 1988). The number of credible Cougar sightings in Ontario increased from 28 during

the period 1950–1959 to 103 during the period 1980–1983 (Gerson 1988). In addition, the Ontario Puma Foundation received notice of more than 500 possible Cougar sightings provincially between 2002 and 2006 (S. Kenn, personal communication). This trend suggests an increasing presence of Cougars in Ontario and was one of the reasons the current study was initiated. In addition, the Gerson (1988) study relied on sightings, whereas the current study also sought to find physical evidence of Cougars in Ontario. The current study confirms the presence of Cougars in Ontario, primarily based on class 1 and class 2 evidence. However, it is acknowledged that although class 3 sightings were deemed credible (based on animal descriptions), there is always the possibility that some may have been misidentifications, especially if the animal in question was a Canada Lynx or a Bobcat.

As the diet of Cougars consists primarily of ungulates, in particular Mule Deer and White-tailed Deer (Hornocker and Negri 2009), there is certainly a sufficiently large prey base for Cougars in Ontario, which



FIGURE 7. Photograph of a treed Cougar west of Great Falls, Montana, taken in February 2009. Photo by Rick Rosatte.

has a White-tailed Deer population estimated to be between 400 000 and 500 000 (Bellhouse and Rosatte 2005).

As Cougars are habitat generalists, most areas of Ontario could support Cougars (Hauck 2000). The evidence from this study provides proof that Cougars exist on the landscape in Ontario; however, it does not indicate the origin of these animals. Possible sources of Cougars in Ontario include 1) escaped or released captive animals (or their offspring), 2) animals that have dispersed into Ontario from areas supporting free-ranging Cougar populations or their offspring, 3) remnants of a native free-ranging Cougar population in Ontario, and 4) a genetic mix of these sources of animals. In view of the high human population density and isolation of southern Ontario by the Great Lakes, it seems plausible that the source of Cougars in southern Ontario may be escaped captive animals. As northern Ontario is in closer proximity to source populations of Cougars than the southern part of the province, at least some of the source animals for northern Ontario could be immigrants from the west.

It is unknown how many Cougars there are in captivity in Ontario, but it is likely several hundred. It is reasonable to assume that at least some of those may

have escaped or been released into the wild (Bolgiano and Roberts 2005). It would also be plausible to assume that some Cougars immigrated into Ontario. The eastward expansion of Cougars is clearly evident, with the presence of Cougars having been documented by photographs in Minnesota (2009), Indiana (2009 to 2010), Wisconsin (2009 to 2010), and Michigan (2010) (The Cougar Network 2011*). Cougar sighting evidence (1879 to 1975) and two Cougar carcasses (one shot and one trapped in 2004), as well as three photographs of Cougars (2006 to 2008), have proven that Cougars are present in Manitoba (Nero and Wrigley 1977; Watkins 2005; The Manitoba Mountain Lion Wildcat Watch 2011*). If Cougars have expanded their range from western North America, it is possible that Cougars have immigrated into Ontario from the western U.S. states and western Canadian provinces (Cougars are capable of moving 50 km/night, with home ranges of 150 to 700 km²; Hornocker and Negri 2009). In fact, one radio-collared Cougar was documented moving 960 km from South Dakota to Saskatchewan before it was shot in 2008. Another Cougar from the same South Dakota study travelled 1060 km to Oklahoma (Hornocker and Negri 2009). Another radio-collared Cougar from South Dakota travelled >800 km

to northwestern Minnesota (Hornocker and Negri 2009; The Cougar Network 2011*). Potential travel corridors for Cougars immigrating into Ontario include the Sault Ste. Marie area (from Michigan), the Kenora area (from Manitoba), the Quebec border area, and the Thousand Islands Ontario/New York border area (dispersal via the Appalachians). Cougars have been sighted and physical evidence of Cougars has been found recently in all of those areas (Bolgiano and Roberts 2005).

In my opinion, the majority of Cougars currently in Ontario are most likely a genetic mixture of escaped/released captives (or their offspring), immigrants (or their offspring), and/or native animals. Cougars appear to have been present in Ontario between the 1930s and the 1980s (Gerson 1988). In view of this, at least some native Cougars in Ontario may have survived the decimation of eastern Cougar populations in the late 1800s. This would be feasible, given the size of Ontario (area of >1 million km²) and the remoteness of the province, especially in the north. However, the presence of Cougars in Ontario between the 1930s and the 1980s may also have been the result of immigration from the west or escaped/released captive animals (Bolgiano and Roberts 2005).

More class 3 Cougar sightings were reported by the public in some areas of Ontario (e.g., North Bay to Cochrane, Sudbury to Sault Ste. Marie, Belleville/Brockville to Ottawa, Bancroft to Madoc, Peterborough to Lindsay and Port Perry, and Aurora to Orillia) than in other areas. This is likely more a reflection of the reporting system than of Cougar density. Due to a variety of factors (e.g., work load, high staff turnover, low human population density, reluctance on the part of the public to report Cougar sightings in some areas, poor road access in northern Ontario), detailed records of Cougar sightings were not available for all areas of the province. Some areas had fewer reported credible Cougar sightings, but that does not mean that Cougars are not present on the landscape in those areas. Explanations could include sightings that were not reported at all, sightings that were reported but not tabulated, or sightings that were recorded but not made available for analysis.

Conversely, a significant number of sightings in an area do not necessarily mean that Cougar density is high in that area. Cougars are generally solitary (other than during breeding and adult females with young) and they range widely and travel extensively; therefore, multiple sightings in an area could be of the same Cougar. A rash of sightings in an area has also been attributed to an increased awareness of Cougars by the media.

During this study, a total of 52 credible "black Cougar" sightings were reported in Ontario. In my opinion, they were in all likelihood escaped exotic animals, most likely melanistic Leopards or melanistic Jaguars (Figure 2), or another species such as a Fisher

(Figure 6) or a small American Black Bear. I could not find any records or published literature documenting the capture, killing, or photographing of black Cougars in North America (Texas Parks and Wildlife 2011*). However, a few black Cougars were found in South America during the 1700s (Buffon 1772–1809). Given this, it is highly unlikely there are any melanistic Cougars in Ontario.

It is difficult to discern whether increasing evidence from sightings is indicative of an expanding or increasing free-ranging population of Cougars in Ontario. For example, the media can have a great impact on the frequency of reports from the public of possible Cougar sightings (Cougar Management Guidelines Working Group 2005). On Saturday, 19 June 2010, one Ontario newspaper published an article on Cougar research in Ontario by the Ontario Ministry of Natural Resources. On Monday, 21 June 2010, 48 media outlets (television, radio, newspaper) covered the same story. This resulted in numerous (>20) members of the public phoning OMNR and the Ontario Puma Foundation on the day of the story to report that they had observed a Cougar that day. Many of those sightings were misidentifications, with reporting being stimulated by the media coverage.

Because of their reclusive and secretive habits, Cougars are very difficult to find, even in areas that support considerable populations (Hornocker and Negri 2009). For example, in February 2009, I attended a Cougar workshop in Montana. As part of the course, the instructor led the group into the mountains and tracked Cougars using two trained tracking dogs. It took the group four days of snowshoeing to intersect the trails of just three Cougars—and only one of the Cougars was treed and photographed (Figure 7). Also in support of the view that Cougars are difficult to detect, trail cameras have been used with limited success to detect Cougar presence in areas supporting low to moderate densities of Cougars. In one study in Alberta and Saskatchewan, only two Cougars were photographed by trail cameras (Bacon 2010). In another study, in California, only three Cougars were captured on cameras (Casey 2008). In our trail camera study, there was only one photo that was judged to be a Cougar, based on morphological features on an infrared photo, despite thousands of trail camera-nights across the province. Given the low probability of capturing a photograph of a Cougar in areas supporting low to moderate densities of Cougars, trail cameras are probably not a good tool to use to detect Cougar presence in Ontario. It also suggests that Cougars exist at low densities in the province.

While this study provided evidence of Cougar existence in Ontario, it did not determine the subspecies of Cougar currently present in the province. In the early 1900s, 32 distinct subspecies of *Puma concolor* were identified in North and South America, based on geographic and morphometric criteria (Young and Gold-

man 1946; Culver et al. 2000; Culver 2004, 2005). Recent molecular evidence suggests 6 subspecies, with only one for North America (*Puma concolor cougar*) (Culver et al. 2000; Culver 2005). One reason to initiate genetic studies on Cougars in Ontario would be to determine their geographic origin (i.e., are they South American genotype Cougars from the pet trade?). However, the results would likely be inconclusive. If the Cougar sample was found to be a North American genotype (which was the case with the DNA from the Cougar in Wainfleet, Ontario; Brad White, personal communication), the animal could be an escaped or released captive, a descendant of such, an immigrant from another area, or an animal descended from native stock. Indeed, it could have ancestors from all three of the aforementioned sources. If DNA analysis showed that the Cougar was wholly or partially derived from a "Latin American subspecies," then one would suspect that it or its ancestors were former captives, i.e., escaped or released captive Cougars. If one agrees with Culver (2005) that there is only one subspecies of Cougar in North America, then it does not really matter whether a specific Cougar is a "captive" North American genotype or a "wild" free-ranging genotype, in terms of managing this species in Ontario. What is important is that there are "free-ranging" North American genotype Cougars in Ontario that have originated from an unknown combination of released, escaped, native, or dispersing animals.

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Seasonal Moulting in Deer Mice (*Peromyscus maniculatus*) in the Rocky Mountains, Alberta

CRISIA A. TABACARU,^{1,3} JOHN S. MILLAR,¹ and FREDERICK J. LONGSTAFFE²

¹ Department of Biology, The University of Western Ontario, London, Ontario, Canada

² Department of Earth Sciences, The University of Western Ontario, London, Ontario, Canada

³ Current address: Department of Renewable Resources, University of Alberta, Edmonton, Alberta T6G 2E3 Canada; email: tabacaru@ualberta.ca

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We recorded seasonal moulting in North American Deer Mice (*Peromyscus maniculatus*) in the Kananaskis River valley, Alberta, Canada, to test the hypothesis that moulting is restricted to the times of year that do not overlap with other high-energy demands, such as reproduction (spring and summer), or with low nutrient availability (winter). Although a seasonal trend showing a peak in moulting in the post-breeding period provided support for our prediction, a low level of continuous moulting did occur throughout the year.

Key Words: North American Deer Mouse, *Peromyscus maniculatus*, moult, seasonal, Kananaskis, Alberta.

Thermoregulation is understood to be the main adaptive function of hair (Ling 1970; Viro and Koskela 1978; Johnson 1984), with the degree of insulation dependent on length and density (Johnson 1984). Hair wears over time, and insulation must be adjusted and/or replaced seasonally (Viro and Koskela 1978; Johnson 1984). In many mammals, hair density increases during winter, allowing more heat retention, and decreases during the summer, allowing more heat loss (Sealander 1951; Johnson 1984). Seasonal colour changes may also occur and are assumed to provide both camouflage and temperature regulation, where light-coloured hair absorbs less heat than dark-coloured hair (Severaid 1945). High-energy expenditure is required for moulting and thus it does not generally coincide with other high-energy demands such as reproduction (Negus 1958) and does not occur at times of insufficient food supply (Stodart 1965; Ling 1970).

Two main types of moult occur in most mammals: maturational (juvenile to adult) and seasonal regeneration. The maturational moult is most obvious, as it commonly includes a colour change. It has been studied in many small mammals, such as Southern Red-backed Voles (*Myodes gapperi*, formerly *Clethrionomys gapperi*; Sare et al. 2005), California Voles (*Microtus californicus*; Ecke and Kinney 1956), and North American Deer Mice (*Peromyscus maniculatus*; Collins 1923). Seasonal regeneration moult in adults, however, has not been studied extensively in any small mammal, and the literature is contradictory in some cases. For example, Osgood (1909) described two moults in Black-eared Mice (*Peromyscus melanotis*), but Collins (1923) suggested continuous moulting with one tentative peak in October and November in Deer Mice from California.

Here, we present data on seasonal moulting in Deer Mice from a northern population to test the hypothesis

that moulting is restricted to the times of year that do not overlap with other high-energy demands, such as reproduction (spring and summer), or with low nutrient availability (winter). We expected to find moulting exclusively in the fall, a time of low energy expenditure.

Methods

We collected Deer Mice from three riparian habitats: Porcupine Creek (~1440 m above sea level), Wasootch Creek (~1440 m above sea level), and Evan-Thomas Creek (~1650 m above sea level), all tributaries of the Kananaskis River near Kananaskis Village in the foothills of the Rocky Mountains west of Calgary, Alberta (51°N, 115°W) between June 2007 and August 2008. We used 30–60 Little Critter live mammal traps (Rogers Manufacturing Co., West Kelowna, British Columbia) per site per month, depending on trap success at different times of the year. Traps were insulated with cotton bedding and baited with a mixture of oats and sunflower seeds. They were set at approximately 1830 h and checked at approximately 0630 h. Trapping continued until 10–12 male Deer Mice were caught in each trapping session. We focussed on males in order to avoid depleting the population over the long term, but females were captured opportunistically when abundant.

Captured individuals were taken to the laboratory, where they were euthanized using isoflurane and dissected immediately. Prior to dissection, they were sexed, weighed, and aged, where grey pelage (any amount) indicated juveniles and brown indicated adults. Females were recorded as pregnant, lactating, or non-breeding, and males were recorded as scrotal or non-scrotal. Mass of both testes of males (± 0.001 g) was also recorded as a more precise measure of reproductive status. In

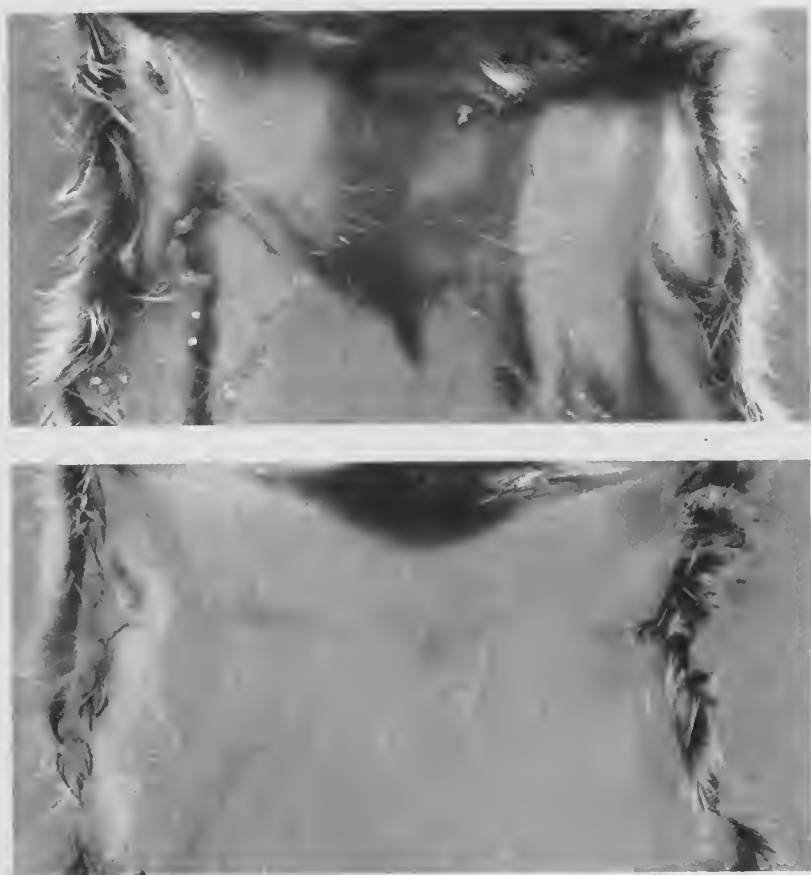


FIGURE 1. Example of moult pigmentation on the undersides of two Deer Mouse (*Peromyscus maniculatus*) pelts.

other species of mice (e.g., Taiwan Field Mouse, *Apodemus semotus*), spermatogenesis and the mass of reproductive organs have been shown to be correlated (Lee et al. 2001).

We used pigmentation on the underside of the skin to follow waves of new hair growth (Stodart 1965). The skin of each individual was cut along a mid-ventral line, removed, and spread to dry. We then photographed the pigment on the underside of the skin, which showed distinct dark patches in areas of new hair growth (Figure 1). Digital photos of the skins were analyzed for percentage of pigmentation (area of pigmented skin as a percentage of total area) using ArcMap software (ESRI, Redlands, California). We did not examine any pigmentation on the limbs or tail, and any individual with <5% pigmentation was classified as not moulting because small patches of pigmented skin are often associated with wounds that are healing (Viro and Koskela 1978). We sorted skins by month and biological season (breeding season = June to August; post-breeding period = September and October; winter

period = November to March; and pre-breeding period = April and May).

We conducted all statistical analyses using SPSS (version 16.0). The data were checked for normality of residuals and homogeneity of variances (Levene's test), and all proportions were arc-sine transformed. Monthly and seasonal analysis of degree of moult within moulting individuals was done using analysis of variance (ANOVA). When the homogeneity of variances was not improved by transformations, we used Welch's ANOVA (Welch 1951) to confirm results. The relationships between proportion of moulting individuals and testes mass and the relationships between degree of moult within moulting individuals and testes mass were analysed using linear regression.

Results

We captured 92 adult male Deer Mice; 46 juvenile males and 14 adult females were also captured opportunistically. Samples were collected every month between June 2007 and August 2008, except December

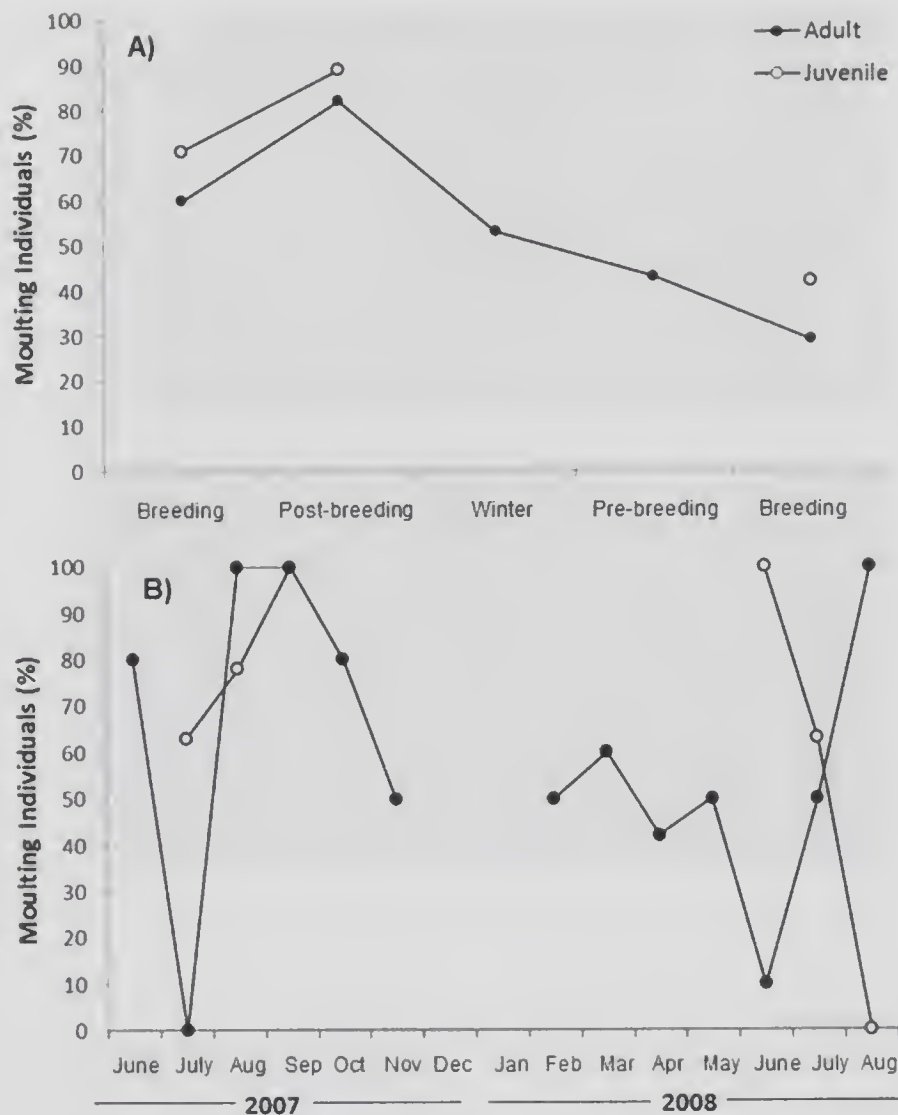


FIGURE 2. Percentage of moulting male Deer Mice (*Peromyscus maniculatus*) by A) biological season, and B) month. Biological seasons were defined as follows: breeding season 2007 = June–August; post-breeding period 2007 = September and October; winter 2007–2008 = November–March; pre-breeding period 2008 = April and May; and breeding season 2008 = June–August.

2007 (due to extreme cold) and January 2008 (due to large snowfalls).

The proportion of moulting males peaked in August and September 2007 and August 2008, and it decreased over the fall, winter, and spring months, reaching a minimum in June 2008 (Figure 2). The proportion of moulting juveniles that had been born in 2007 increased over the summer and peaked in September 2007. Among biological seasons (Figure 2), the pro-

portion of moulting individuals peaked during the post-breeding period and was at a minimum during the breeding season of 2008, both for adult-only samples and for juveniles born in 2007. The 2008 breeding season had a lower proportion of moulting individuals than the 2007 breeding season.

The trend in degree of moult among moulting individuals (amount of pigmentation) was similar to the proportion of moulting individuals, both monthly and

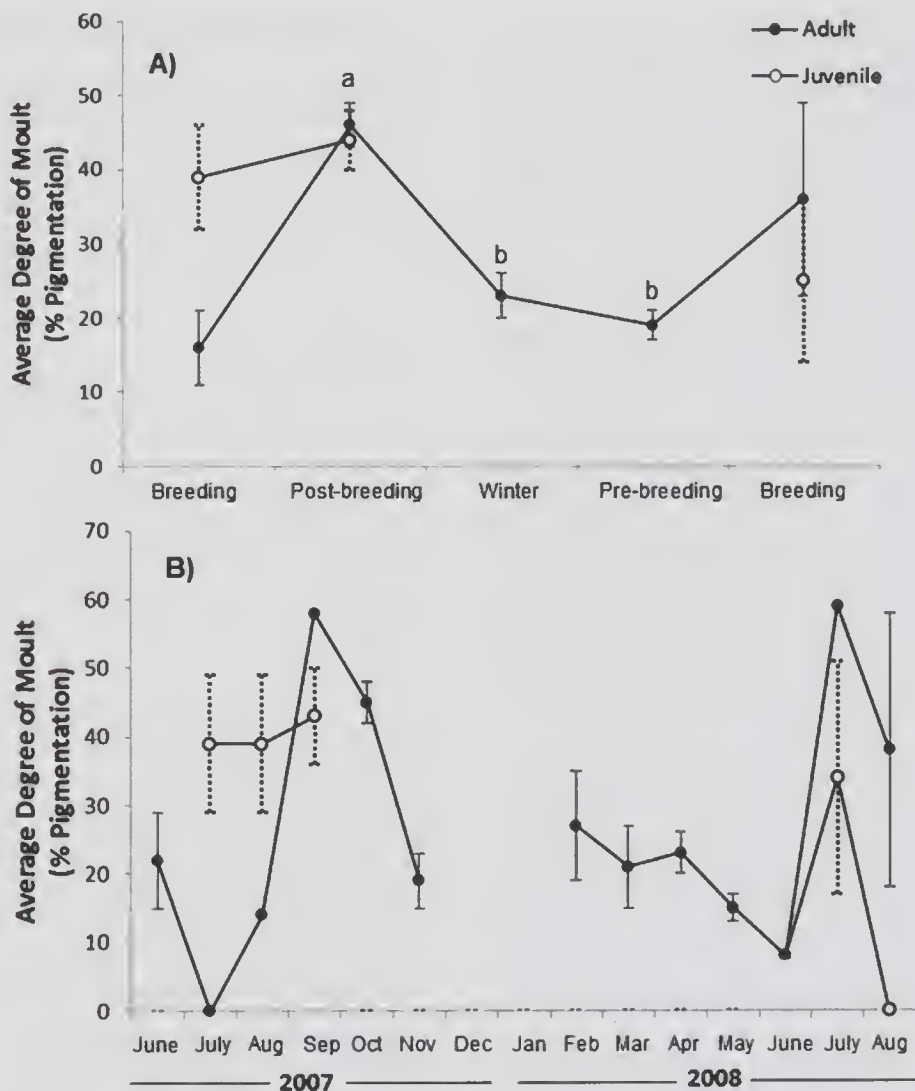


FIGURE 3. Average degree of moult (\pm SE) by A) biological season, and B) month, among moulting male Deer Mice (*Peromyscus maniculatus*). Biological seasons were defined as follows: breeding season 2007 = June–August; post-breeding period 2007 = September and October; winter 2007–2008 = November–March; pre-breeding period 2008 = April and May; and breeding season 2008 = June–August.

seasonally (Figure 3). Although we excluded 6 of 14 months from monthly statistical analysis and the two breeding seasons from seasonal analysis (because of low sample sizes of adult males and a low proportion of moulting individuals, respectively), we were still able to detect an effect of season. Degree of moult within moulting adult males differed among months ($F_{6,35} = 4.47$, $P = 0.002$) and biological seasons ($F_{2,34} = 15.57$, $P < 0.001$; Figure 3). The degree of moult among moulting adult males decreased with in-

creasing testes mass ($R^2 = 0.11$, $F_{1,45} = 5.35$, $P = 0.026$), but there was no relationship between testes mass and the proportion of moulting individuals by month ($R^2 = 0.10$, $F_{1,12} = 1.15$, $P = 0.306$).

Adult females were captured in November 2007, June 2008, and July 2008. None of the six females sampled in November and only two of eight females sampled in June and July were moulting, indicating a low rate of moult in summer.

Discussion

Although a seasonal trend showing a peak in the post-breeding period occurred in adult males, some continuous moulting also occurred throughout the year. Our data agree with Collins (1923), who described continuous moulting in Deer Mice in California. But, unlike Collins (1923), we found a distinct post-breeding peak, providing some support for the assumption that moulting should occur during the non-breeding season, when energy demands are low. However, the constraints appear relative rather than absolute.

Viro and Koskela (1978) found a similar moulting peak in post-breeding Eurasian Harvest Mice (*Micromys minutus*) in a northern environment in Finland. Other species of the genus *Peromyscus*, however, appear to have two seasonal moults per year, e.g., *P. melanotis* in Mexico (Osgood 1909) and *P. boylii* (Brush Mouse) in Missouri (Brown 1963). These warmer and more temperate environments may provide an earlier surge of resources that permits a spring moult that is not evident in more northern species. At our study site in the Rocky Mountains of Alberta, vegetation begins to grow as late as mid-May and begins dormancy as early as mid-August. This short growing season probably does not provide sufficient time for two moulting events per year for small mammals in addition to reproduction.

Testes mass, a proxy for reproductive activity, showed a negative relationship with degree of moult, also supporting the prediction of little overlap between these two energetically costly events. A similar relationship between testes mass and moulting was observed in Eastern Cottontails (*Sylvilagus floridanus*; Spinner 1940). Therefore, although we found that moulting did occur during the breeding season, the degree of moult varied with breeding status: adult male Deer Mice putting energy into enlarged testes moulted less frequently and to a lesser degree than non-breeding male Deer Mice.

These data also help to explain the discrepancy in moulting events between the breeding seasons of 2007 and 2008. Breeding, as defined by scrotal males, began quite early in 2008 (some time in March) and ended early (some time in August), while in 2007 it ended in September. The early onset of breeding in 2008 most likely permitted an earlier onset of moulting toward the end of the season, whereas the still active reproductive status of the Deer Mice in August 2007 probably caused them to postpone moulting.

Juvenile male Deer Mice showed a similar trend to adults during the breeding season, although they were moulting more intensely (more area of the skin was pigmented) than adults—a sign of the post-juvenile moult. By October, most samples were young-of-the-year adults. The occurrence of a moulting peak during the post-breeding period within this cohort suggests

that they undergo two successive moulting events before winter. This is especially true of those born early.

In general, moulting occurred at a low level throughout the year, with a more intense post-breeding peak evident in the fall. This indicates that the energetic cost of hair replacement may be low enough that a low level of moulting can be sustained even during the most resource-poor times, but the energetic cost may be high enough to drive the majority of individuals to moult at times of low energy demand and high resource abundance.

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Influence of Wind and Humidity on Foraging Behavior of Olfactory Mesopredators

REBEKAH E. RUZICKA¹ and MICHAEL R. CONOVER¹

¹Department of Wildland Resources, Utah State University, Logan, Utah 84322-5230 USA

Ruzicka, Rebekah E., and Michael R. Conover. 2011. Influence of wind and humidity on foraging behavior of olfactory mesopredators. *Canadian Field-Naturalist* 125(2): 132–139.

Many mammalian predators rely on scents to locate prey and weather conditions that affect an odor plume (i.e., scents suspended in air) or depositional odor (i.e., scents laid on the ground) should affect predator foraging behavior. We predicted that wind speed, wind direction, and humidity would influence the foraging behavior of olfactory mesopredators. We tested these predictions by conducting spotlight surveys for foraging Red Foxes (*Vulpes vulpes*), Striped Skunks (*Mephitis mephitis*), and Raccoons (*Procyon lotor*) along the dike surrounding Willard Bay Reservoir in Willard, Utah, from August 2008 to August 2009. We recorded predator species, locations, numbers, and weather conditions at the time each predator was observed. While humidity had no effect on foraging, wind speed and direction were significant predictors of a predator's nightly foraging activity, with most predators observed when wind speeds were 2 to 4 m/s and winds were blowing perpendicularly over the dike rather than parallel to the dike. Wind speed and direction also influenced where predators foraged on the dike, with predators being more likely to forage on the windward side of the dike when wind speeds were high enough to cause turbulence. We detected differences among predator species in their response to wind speed: Raccoons were more active than Striped Skunks and Red Foxes when the wind was calm and blowing parallel to the dike. Overall, our results indicate that these predator species alter their foraging behavior based on wind speed and wind direction. By foraging when winds were light and blowing perpendicularly over the dike, predators could likely enhance their ability to locate food using olfaction.

Key Words: Striped Skunk, *Mephitis mephitis*, Raccoon, *Procyon lotor*, Red Fox, *Vulpes vulpes*, mesopredator, olfaction, olfactory predator, Utah.

Foraging behavior of predators is a function of the predators themselves, their prey, and environmental conditions at the time of foraging (Schmidt 1999). Olfactory predators such as Raccoons (*Procyon lotor*), Red Foxes (*Vulpes vulpes*), and Striped Skunks (*Mephitis mephitis*) may employ all five senses to detect and locate prey, but they rely primarily on their acute sense of smell when conditions are favorable for its use (Conover 2007). For example, Raccoons are known to grope and probe with their forefeet to locate food underwater, but they generally detect prey using olfactory cues (Bowman and Harris 1980; McClearn 1992).

Although many studies have examined the effects of vegetation and prey distribution on predator behavior (Bowman and Harris 1980; Schmidt 1999), few studies have examined the effects of weather. We are aware of two studies that investigated the effects of weather on olfactory predator foraging. Jolly and Jolly (1992) found that wind direction affected the search time it took for captive Dingoes (*Canis lupus dingo*) to locate meat baits. Shivik (2002) found that search time of domestic dogs (*Canis lupus familiaris*) increased as circular standard deviation of wind direction increased.

Weather conditions that have an impact on odor plumes (i.e., scents suspended in the air) and depositional odors (i.e., scents laid on the ground or vegetation)

should affect predator foraging behavior. These weather conditions include temperature, cloud cover, humidity, wind speed, and wind turbulence. High temperatures and direct sunlight destroy odorants and decrease the scent available for a predator to detect, while low temperatures and humidity counteract these effects and keep odors viable (Gutzwiller 1990). Heavy rain or snow washes away or obscures depositional odor trails (Whelan et al. 1994). High wind velocities, turbulence, and shifting wind direction can dilute an odor plume beyond a predator's ability to detect it (Shivik 2002; Conover 2007; Borgo 2008). Moderate wind velocities, laminar flow, and constant wind direction result in a long, linear plume that can extend some distance downwind of the odor source. Predators are more likely to come into contact with an odor plume of this shape than a plume that is spherical and limited to the immediate vicinity of the odor source by lack of wind (Conover 2007; Borgo 2008). High wind speeds create turbulence and cause odor plumes to disintegrate. Hence, moderate wind speeds should create optimal conditions for predators to use olfaction to locate prey. Habitat features also influence odor plumes. Optimal habitat for the use of olfaction is where the upper surface of the ground or vegetation is smooth; surface features that protrude into the air, such as shelterbelts and

dikes, create areas of turbulence on their leeward side (Conover 2007).

We hypothesized a priori that more predators would be foraging when 1) it was humid, 2) wind speeds were between 1 and 3 m/s, and 3) the wind was blowing at right angles to the dike (across the dike) because such conditions are conducive to the use of olfaction to locate food (Conover 2007). The objective of this study was to test these predictions by observing olfactory mesopredators in their nightly foraging on Willard Bay Reservoir Dike in Willard, Utah. We also predicted that these predators would avoid foraging on the leeward side of the dike when wind velocities were high because this area would experience enough air turbulence to break up odor plumes.

Methods

Study area

This study took place at Willard Bay State Park and Reservoir (41°37'N, 112°08'W) in northern Utah, USA. The state park is located approximately 5 km south of the Bear River Migratory Bird Refuge at an elevation of 1287 m and is bordered on the east by Interstate 15 and on the west by the Great Salt Lake. The Arthur V. Watkins Dike runs approximately 11 km and separates the freshwater of Willard Bay from the Great Salt Lake (Figure 1). The reservoir side of the dike extends laterally 20 m and is lined with riprap consisting of boulders 0.5 to 3.0 m in diameter. The dry side of the dike, opposite Willard Bay Reservoir, also extends laterally approximately 20 m; it is earthen and covered with vegetation. The dike is approximately 15 m high, 11 m wide at the top, and 40 to 50 m wide at the base. The road on top of the dike is approximately 10 m wide and runs the length of the dike. The swath of land between the dike and the Great Salt Lake varies from 70 to 135 m in width, depending on the level of the Great Salt Lake. A row of tamarisk (*Tamarix* spp.) is present at approximately 70 m from the dry side of the dike and runs intermittently along most of the dike.

The vegetation on the top of the dike and on the slope of the dry side of the dike was dominated by Cheatgrass (*Bromus tectorum*), Crested Wheatgrass (*Agropyron cristatum*), and various bluegrass species (*Poa* spp.). The most common forbs on the dike were Dyer's Woad (*Isatis tinctoria*), Flixweed (*Descurainia sophia*), Red-stem Filaree (*Erodium cicutarium*), and Field Bindweed (*Convolvulus arvensis*). At the base of the slope, there is a 5-m-wide section of riprap constructed of boulders 0.5 to 1 m in diameter. Beyond the riprap, there was a 5-m-wide area of patchy grasses and forbs intermixed with stands of Common Reed (*Phragmites australis*) that extended the entire length of the dike. Off the dike on the dry side, there is a dirt road approximately 30 to 40 m in width that people use to access the dike for fishing. The most common forbs and grasses off dike were Cheatgrass, Inland Saltgrass (*Distichlis spicata*), Rabbitfoot Grass (*Polypogon mon-*

speliensis), Poison Hemlock (*Conium maculatum*), Dyer's Woad, Virginia Glasswort (*Salicornia virginica*), Matted Sandmat (*Chamaesyce serpens*), and knotweed (*Polygonum* spp.).

Field methods

We used a 1 000 000 candlepower spotlight from a truck driven at 15 km/h on top of the dike to observe predators located on top or on either side of the dike. The observer in the back of the truck scanned both sides of the dike, while the driver watched for predators on the road. Both observers scanned ahead in an effort to detect animals before they moved. Any animal that was obviously fleeing before it was sighted was excluded from the analysis. If a group of predators was observed, such as a family group of Raccoons, we counted this as one observation. Red Foxes, Striped Skunks, and Raccoons are secretive and nocturnal, and they make use of shelters or dens when not active. Therefore, we assumed predators were foraging when observed, unless it was obvious they were not (e.g., a litter of young Red Foxes in front of a den or a Raccoon in a tree cavity).

Our starting location on the dike, going either north or south, was randomly determined for each observation period (i.e., each night of spotlighting). Our observations began at 0.5 to 1 hour after sunset and continued until the entire dike had been surveyed (usually 2 to 3 hours). We made observations between 20 August 2008 and 18 August 2009. No observations were made between mid-February and the end of March 2009, when winter weather made the dike impassable. Observations were made weekly from 20 August 2008 to mid-February 2009, weekly between the end of March and the beginning of May 2009, and twice weekly from the beginning of May to 18 August 2009.

To investigate the influence of wind speed and direction on where predators were foraging, we divided the dike into three sections, based on its orientation (Figure 1). Section 1 is oriented northeast/southwest, section 2 is oriented north/south, and 3 is oriented east/west. We classified the dike's cross-sectional terrain into one of four categories: reservoir side, top of the dike, slope of the dike on the dry side, or off of the dike on the dry side (Figure 1). When a predator was spotted, the truck was stopped at right angles to where the predator was first seen. We recorded the predator species, the section of the dike, the type of terrain in which the predator was located, and the distance in meters between the road and the predator's location using a Nikon Prostaff 550 range finder (Nikon Incorporated, Melville, New York). We then measured the direction of the wind using a compass and the wind speed (m/s) using a Kestrel 2000 weather meter (Nielsen-Kellerman, Boothwyn, Pennsylvania). We took four measurements of the wind speed at 15-second intervals at a height of 2 m above the ground at the top of the dike. We recorded the high, low, and mean wind speeds during this 1-minute period.

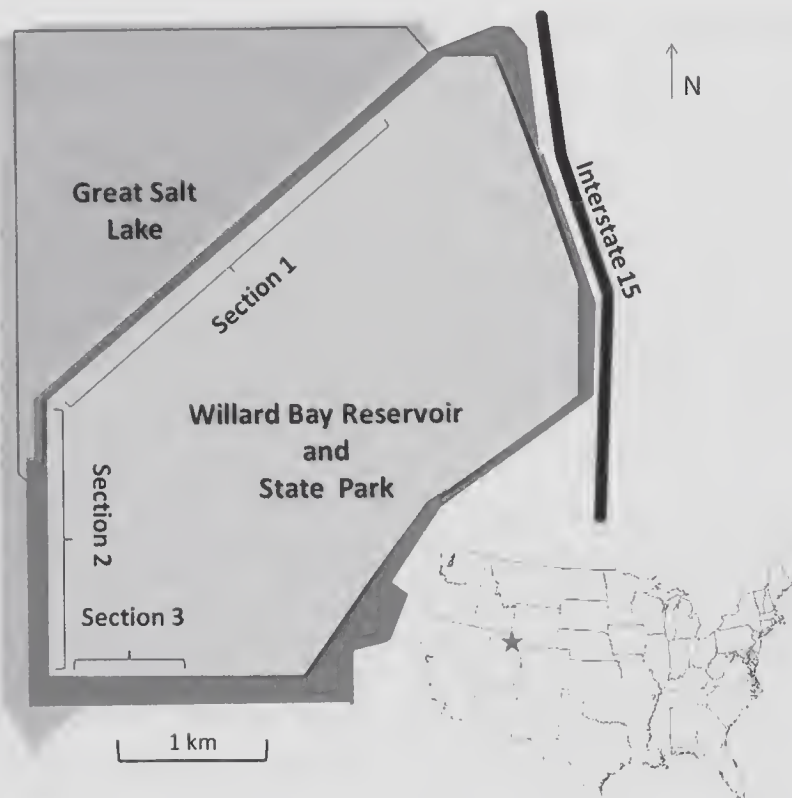


FIGURE 1. Overview of Willard Bay State Park and Reservoir, Utah, USA, showing sections of the Arthur V. Watkins Dike, where we conducted predator spotlighting surveys.

We selected 5 to 10 random locations along the dike using a random number chart to determine distances from the start. We measured wind speed and wind direction at these locations to capture their variation throughout the spotlighting run. We recorded relative humidity using a Kestrel 2000 weather meter. Precipitation was not a factor in our analysis because surveys were conducted only when it was not raining or snowing (due to poor visibility created by those conditions).

Data analysis

We used four different regression analyses to determine the effect of wind speed, the orientation of the wind relative to the dike, and humidity on the number, location, and species of predators we observed. We conducted a multiple linear regression in SAS (PROC REG, Version 9.2, SAS Institute, Cary, North Carolina) to model the number of predators observed as a function of wind speed, wind orientation, and humidity. We determined mean wind speed of each night spotlighting by averaging all wind measurements taken from the dike that night, including both predator observations and random points. Mean wind orientation for each night was calculated using the CIRCSTATS pack-

age in Program R (Version 2.9.2, R Foundation for Statistical Computing, Vienna, Austria). To include wind orientation as a continuous circular variable in the linear regression, we first converted it to radians and then calculated cosine and sine of the variable (Zar 1984). It was necessary to include both sine and cosine of wind orientation to describe accurately wind direction in the model. Therefore, we retained both variables if one was significant for all models that contained wind orientation.

Each spotlighting event was considered an independent sample, although the observations were collected in a sequential manner. To account for autocorrelation of the response, we introduced a time variable, where one unit of time was one night of spotlighting. Quadratic terms of both wind speed and time were introduced to account for systematic variation in the residuals. Wind and time variables were also centered so that the scale among the variables would be similar for easier interpretation of diagnostics. For this and all other tests, we considered results to be significant when $P < 0.05$.

Two multinomial logistic regressions were used to model the dike section and terrain category where a

predator was observed as a function of wind speed, the orientation of the wind relative to the dike, humidity, species, and time (PROC LOGISTIC, SAS). The objective of this analysis was to determine whether predators changed their foraging location in response to weather conditions. Our operating hypothesis was that turbulence caused by air flowing at an angle to the dike would make foraging conditions poor in one area of the dike and predators would therefore choose to forage in another section or in another terrain category. In both regressions, we also included the interaction between wind speed and orientation. We did this to account for the fact that, at low wind speeds, the direction the wind is blowing relative to the dike is not likely to have an impact on predator foraging behavior because there will be very little turbulence. Thus, at low wind speeds, foraging conditions would be similar on all sections regardless of the direction the wind was blowing.

Predator species was included in these models to account for differences in habitat use among the species. For example, Raccoons often forage near water and would therefore be more likely to be observed on the reservoir side of the dike, regardless of the weather conditions. As species was a categorical variable, we used odds ratios calculated in SAS using PROC LOGISTIC to detail the relationship between predictor and response. We assumed that when the odds ratio confidence interval included 1.0, events were equally likely to occur. A multinomial logistic regression requires that one level of the response be designated the reference level to which the other levels of the response will be compared. Therefore, we arbitrarily chose section 1 and off the dike on the dry side to be the reference level.

For all regression analyses, we used a step-wise backward selection to identify the final model. We first ran the global model and then eliminated variables one at a time, based on their individual significance. In each case, terms with the highest P values were eliminated first, and the model was re-run following each elimination.

Results

We observed a total of 180 predators during 40 nights of spotlighting from 20 August 2008 to 18 August 2009: 87 Raccoons, 50 Red Foxes, and 43 Striped Skunks. During the sampling period, 61 nights of spotlighting were possible, however we only sampled on 40 occasions due to interference from weather. The number of predators to observed decreased over the winter and then increased in late July and August of 2009 (Figure 2). After accounting for these seasonal changes in predator numbers, we found that most predators were observed at intermediate wind speeds (between 2 and 4 m/s) and when winds were blowing from the northwest. Overall, the model, including the time vari-

ables, was highly significant ($F_{6,32} = 20.89, P < 0.001$) with an adjusted $r^2 = 0.76$. Individually, the time variables were also highly significant (time: $t_1 = -5.41, P < 0.001$; time squared: $t_1 = 5.29, P < 0.001$). The wind factors (wind speed squared, wind speed, and sine of wind orientation) were all significant predictors of the number of predator observations per night (wind speed squared: $t_1 = -2.91, P = 0.006$; wind speed: $t_1 = 2.49, P = 0.018$; sine of wind orientation: $t_1 = 2.52, P = 0.017$). Cosine of wind orientation was non-significant (cosine of wind orientation: $t_1 = -0.27, P = 0.79$); however, we retained this variable in the model to preserve interpretation of wind orientation.

We observed an interactive effect of wind speed and orientation on predator location (Figure 3). This interactive effect was manifested in the significance of the three-way interaction among sine of wind orientation, cosine of wind orientation, and wind speed ($\chi^2_2 = 8.8, P = 0.01$) in the logistic regression describing dike section. The max-rescaled r^2 for this model was 0.22, and the percentage correctly classified was 72%. Humidity, time, and species were all non-significant predictors of the section of dike where a predator was observed (humidity: $\chi^2_2 = 2.06, P = 0.35$; time: $\chi^2_2 = 0.90, P = 0.64$; species: $\chi^2_4 = 3.50, P = 0.48$).

Species of predators differed in their use of terrain types. Raccoons were 28 times more likely to be observed on the bay side than on the reference level (off-dike dry side) than Striped Skunks (95% CI = 3.5 – 231). Raccoons were 50 times more likely to be observed on the bay side than on the reference level (off-dike dry side) than Red Foxes (95% CI = 6 – 333). Raccoons were also 4.5 times more likely than Red Foxes to be observed on the dike than on the off-dike dry side (95% CI = 1.4 – 15).

Odds ratios for Red Foxes versus Striped Skunks indicated that they were equally likely to be seen on the bay side (0.58 [95% CI = 0.03 – 9.9]), on the dike (0.48 [95% CI = 0.1 – 1.8]), or on the slope of the dike on the dry side (0.58 [95% CI = 0.2 – 2.3]) when compared to the off-dike dry side. Raccoons were also equally likely as Striped Skunks to be seen on the dike (2.2 [95% CI = 0.7 – 7.0]) and the slope of the dike on the dry side (0.95 [95% CI = 0.2 – 3.8]), as well as Red Foxes on the slope of the dike on the dry side (1.6 [95% CI = 0.4 – 6.3]). Overall, in the terrain regression, species was the only significant predictor of terrain type where a predator was observed ($\chi^2_6 = 26.1, P < 0.001$). All other variables were non-significant: wind speed ($\chi^2_3 = 2.37, P = 0.49$), wind orientation (sine: $\chi^2_3 = 4.03, P = 0.26$; cosine: $\chi^2_3 = 7.76, P = 0.051$), temperature ($\chi^2_3 = 1.99, P = 0.57$), humidity ($\chi^2_3 = 0.95, P = 0.81$), and time ($\chi^2_3 = 5.2, P = 0.16$). The three-way interaction among wind speed, cosine wind orientation, and sine wind orientation was also non-significant in the terrain model ($\chi^2_2 = 1.76, P = 0.62$).

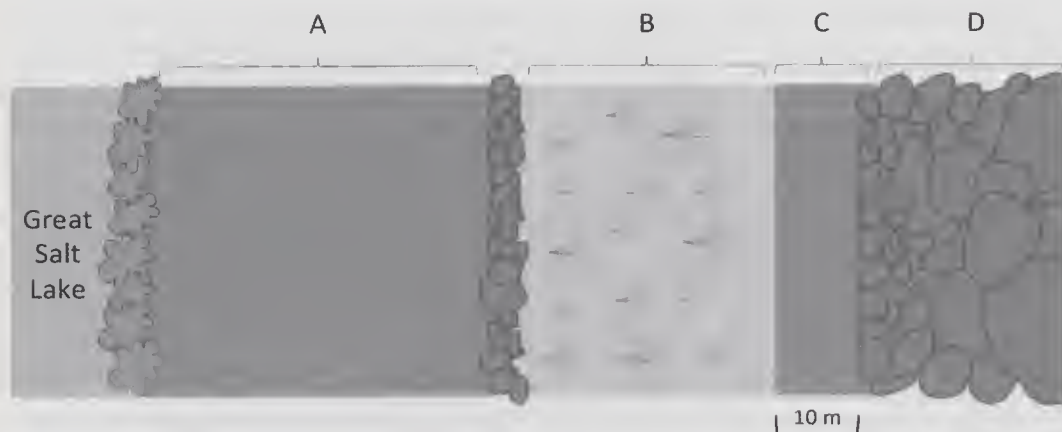


FIGURE 2. Cutout of Arthur V. Watkins Dike at Willard Bay State Park and Reservoir, Utah, USA, showing terrain types: A) off-dike on the dry side, B) slope of the dike on the dry side, C) top of the dike, and D) reservoir side.

Discussion

We did not conduct surveys when it was snowing, raining, or there was fog because poor visibility would have influenced our ability to locate predators. We do not believe that our ability to locate predators varied with wind speed, the orientation of the wind relative to the dike, or humidity. It is possible that at low wind speeds predators would have been able to hear our vehicle approaching from a greater distance and flee the area before we were able to observe them. However, this area is regularly driven by people fishing and other people using the dike. It is likely that predators are conditioned to the noise of vehicles and would have no reason to flee, because this area is not hunted.

We were unable to estimate how our ability to detect predators varied across species. We believe that our detection probability was the highest for Red Foxes. Red Foxes are larger than Striped Skunks and Raccoons and are easily visible in all terrains. Their behavior also increased their visibility, as they would often freeze and look at the spotlight before running. Raccoons tended to freeze and look at the spotlight as well, and their medium size made them easy to detect. On the reservoir side of the dike, the large rocks and crevices make it possible for Raccoons to hide, and it is likely that there were more Raccoons present there than we observed. Given this, Raccoon use of the reservoir side of the dike may have been even greater than what we recorded. Striped Skunks did not tend to look at the spotlight, and they were probably underrepresented in the survey. However, these discrepancies in predator counts had minimal effect on our results. We were not interested in estimating the predator population, only in comparing changes in predator behavior with varying wind conditions.

One limitation of our study is that it was an observational study, and many factors besides weather may have influenced the predators we observed. We also

assumed that most predators were foraging when we observed them at night but some undoubtedly were searching for mates or patrolling their territories. In spite of all this extraneous "noise" surrounding our findings, the results still demonstrate that wind speed and the orientation of the wind relative to the dike affected how many, where, and which predators were observed. Together with time variables, these weather factors explained >75% of the variation in the number of predators observed per night.

Effect of wind speed and the orientation of the wind relative to the dike on predator numbers

We observed the most predators when wind speeds were moderate (2 to 4 m/s); we saw few predators at low or high wind speeds. These results support our a priori prediction that optimal foraging conditions for olfactory predators should occur at wind speeds between 1 and 3 m/s. When there is little or no wind, odor plumes are small and localized, and this decreases the probability that predators will be able to detect a prey's odor unless they are very close to it. Predators also have difficulty using olfaction to locate prey when the wind speed becomes fast enough to create turbulence, because turbulence causes odor plumes to disintegrate (Conover 2007). An alternate hypothesis is that olfactory predators avoid foraging when the conditions are windy because the wind increases ambient noise levels, making it more difficult to hear their prey or an approaching predator. However, this hypothesis also predicts that the number of foraging predators should peak when there is no wind, but we found that predator numbers peaked at moderate wind speeds.

For wind orientation, most predators were observed when winds came from the northwest and flowed at right angles to section 1 of the dike, so that the dry side of the dike was on the windward side. This would give predators a large area to forage in (i.e., the dry side of sections 1 and 2), where their efforts would not be

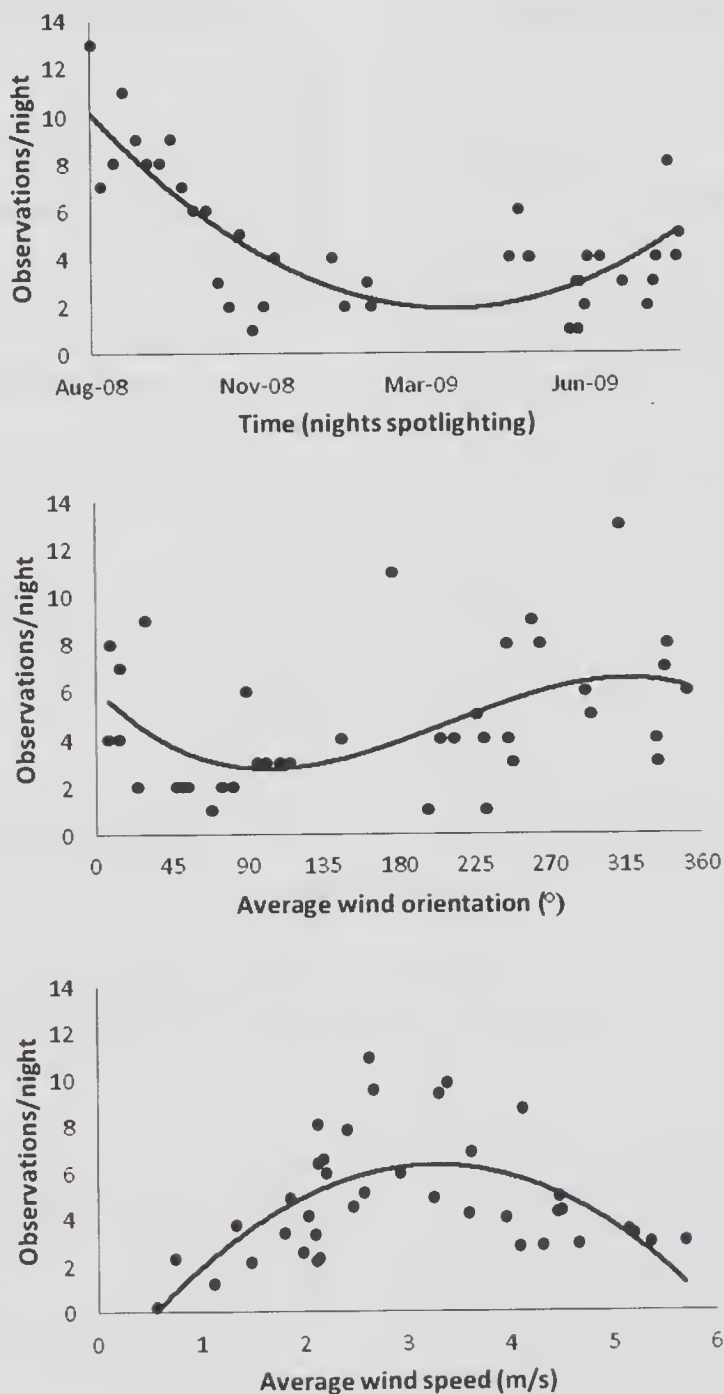


FIGURE 3. Number of olfactory predators observed (•) during nocturnal spotlighting over time (where one unit of time represents one night of spotlighting), average orientation of the wind relative to the dike per night, with 0° and 360° being North, and average wind speed per night (m/s). Predicted values (—) were obtained from a multiple linear regression of the number of predators observed per night on time, orientation of the wind relative to the dike, and wind speed. Data were collected during spotlighting surveys from August 2008 through August 2009 at Willard Bay State Park and Reservoir, Utah.

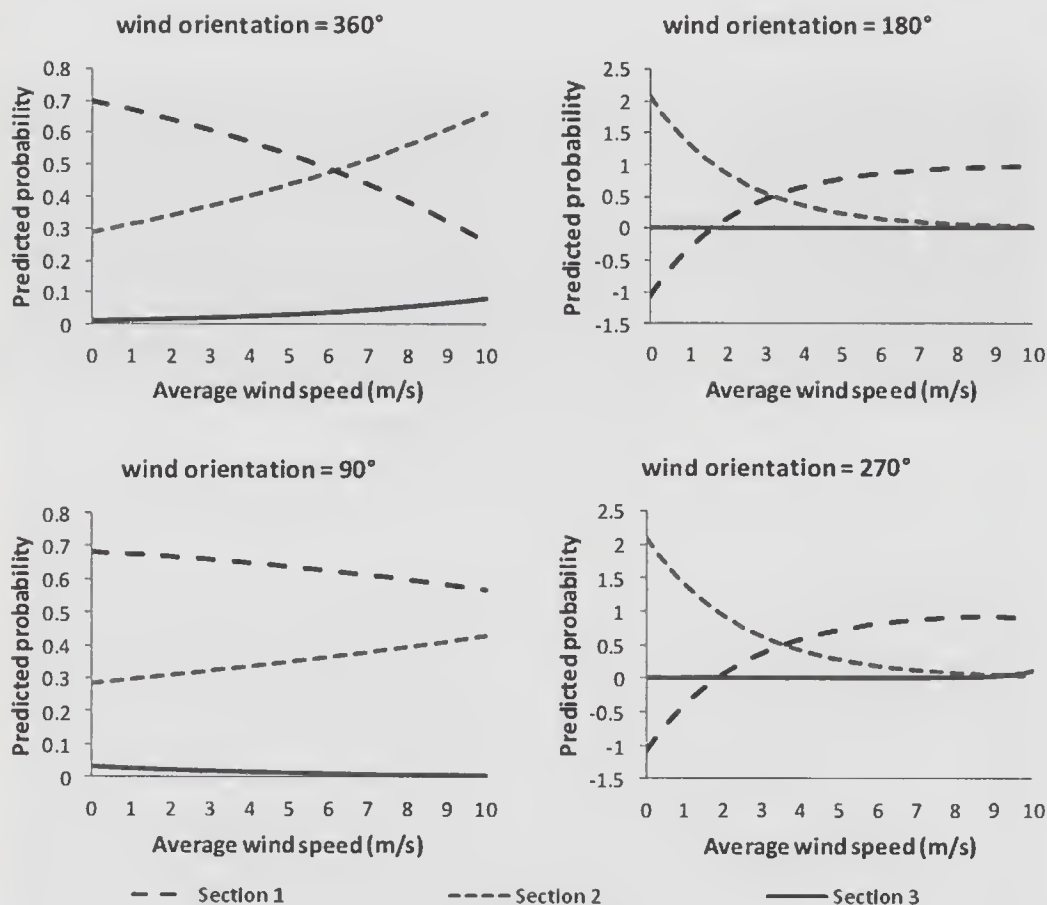


FIGURE 4. Predicted probabilities of observing a predator calculated from a multinomial logistic regression where the section of dike (1, 2, or 3) a predator was observed on was modeled as a function of the orientation of the wind relative to the dike and the wind speed. Predicted probabilities are shown across all wind speeds for four values of wind direction: North (0°), East (90°), South (180°), and West (270°). Data were collected during spotlighting surveys from August 2008 through August 2009 at Willard Bay State Park and Reservoir, Utah.

impeded by turbulence caused by the dike because these areas were on the windward side of the dike.

Seasonal variation in predator numbers

From August 2008 to June 2009, the number of predators we saw decreased, with a small increase in July and August 2009. Several factors could be responsible for this pattern, including seasonal variation in predator activity. Striped Skunks and Raccoons often become inactive for days or weeks during the winter (Dustin et al. 1997; Huxoll et al. 1998). Seasonal changes in predator populations may also have contributed to this pattern. Utah's cold temperatures and deep snow during winter kill many predators. There also was an outbreak of sarcoptic mange in the Salt Lake Valley during the course of the study (Ron Merrill, United States Department of Agriculture/Animal

and Plant Health Inspection Service (APHIS)/Wildlife Services, personal communication), and this could have contributed to increased predator mortality (Lindström et al. 1994). The increase in the number of predators in July and August likely reflects juvenile predators beginning to forage.

Effect of wind speed and the orientation of the wind relative to the dike on predator locations

Wind speed and the orientation of the wind relative to the dike had an interactive effect on the locations where we observed predators. We hypothesized that the mechanism driving predator location in response to wind speed and orientation would be the orientation of the wind relative to the dike and wind turbulence patterns that result from the dike-to-wind angle. This turbulence does not occur below a certain wind speed

(Conover 2007). Therefore, it is likely that, at low wind speeds, orientation of either the dike or wind matters less than at high wind speeds. Section 1 was the most probable location to observe a predator at low wind speeds when the wind was blowing from the north or east. However, our model broke down at low wind speeds for south and west winds, predicting probabilities less than one and greater than zero for sections 2 and 3. We did not find this surprising, given the small sample size for these wind directions. We conclude from our data that there is an interaction between wind speed and wind orientation (given the significance of the term) that affects the section of dike where predators forage, but it is impossible to determine the intricacies of the effect with our data set.

Raccoons were the most commonly observed predator on the dike. Several attributes of Raccoon behavior and of Willard Bay likely combined to draw Raccoons to the area. Raccoons often forage along the edge of water bodies because they are adept at using their front paws to grasp items in shallow water such as mollusks, crayfish, and other invertebrates and will even catch fish (McClearn 1992). Raccoons generally choose these aquatic animals if they are available, and Raccoons spend a disproportionate amount of time in wetland habitat compared to upland habitat (Fritzell 1978). Likewise, we found that Raccoons were 28 times more likely than Striped Skunks and 50 times more likely than Red Foxes to be observed on the reservoir side of the dike.

We detected no differences between Red Foxes and Striped Skunks in their use of the terrain. Both species were more likely to be seen on the dry side of the dike than were Raccoons. Striped Skunks and Red Foxes commonly employ a wide-area search strategy for food (Crabtree et al. 1989; Jędrzejewski and Jędrzejewski 1992), and the dry side of the dike was more suited to their hunting methods. Neither species is known to prefer aquatic prey. Red Foxes and Striped Skunks typically avoid entering water (Sargeant et al. 1984; Lokemoen and Woodward 1993), and Red Foxes prefer open habitats for foraging (Jędrzejewski and Jędrzejewski 1992).

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Interpretations of Polar Bear (*Ursus maritimus*) Tracks by Inuit Hunters: Inter-rater Reliability and Inferences Concerning Accuracy

P. B. Y. WONG^{1,2,3}, P. VAN COEVERDEN DE GROOT¹, C. FEKKEN⁴, H. SMITH⁵, M. PAGÈS^{6,7} and P. T. BOAG¹

¹ Department of Biology, Queen's University, 99 University Avenue, Kingston, Ontario K7L 3N6 Canada

² Department of Ecology and Evolutionary Biology, University of Toronto, 25 Willcocks Street, Toronto, Ontario M5S 3B2 Canada

³ Department of Natural History, Royal Ontario Museum, 100 Queens Park, Toronto, Ontario M5S 2C6 Canada

⁴ Department of Psychology, Queen's University, 99 University Avenue, Kingston, Ontario K7L 3N6 Canada

⁵ Faculty of Education, Queen's University, 511 Union Street, Kingston, Ontario K7M 5R7 Canada

⁶ Centre de Biologie pour la Gestion des Populations (Unité mixte de recherche 022 Institut national de la recherche agronomique (INRA)-Institut de recherche pour le développement (IRD)-Centre de coopération internationale en recherche agronomique pour le développement (CIRAD)-Montpellier SupAgro), Campus International de Baillarguet, CS 30016, Montpellier-sur-Lez cedex 34988 France

⁷ Laboratoire de génétique des microorganismes, Université de Liège, Institut de Botanique, 4000 Liège, Belgium

P. B. Y. Wong, P. Van Coeverden de Groot, C. Fekken, H. Smith, M. Pagès, and P. T. Boag. 2011. Interpretations of Polar Bear (*Ursus maritimus*) tracks by Inuit hunters: inter-rater reliability and inferences concerning accuracy. *Canadian Field-Naturalist* 125(2): 140–153.

Due to their tracking experience in pursuing Polar Bears (*Ursus maritimus*), Inuit hunters could provide non-invasive estimates of Polar Bear characteristics from tracks, and Polar Bear monitoring programs could benefit from Inuit input. We determined i) inter-rater reliability of estimates of the sex, age, and size of Polar Bears, and estimates of the age of tracks made by a group of nine Inuit hunters who interpreted 78 tracks; ii) we made preliminary comparisons of sex and size estimates with conventional (scientific) estimates; iii) we catalogued the Polar Bear hunting experience and track interpretation techniques of nine Inuit hunters; and iv) we explored relationships between hunting experience and the ability to interpret tracks. The group of Inuit hunters made reliable and consistent estimates of Polar Bear sex, age, and size, as well as estimates of age of track (after data from one participant was excluded). Although our comparisons are based on small samples, our findings suggest that Inuit hunters may be accurate in estimating the sex of Polar Bears (74.42% agreement with genetic determinations) and the size of Polar Bears from their tracks. Our data indicate shared tracking techniques used by hunters may explain high agreement in making specific estimates, while individual hunting experience and particular methods used to interpret tracks may lead to inter-rater reliability and accuracy in interpreting tracks.

Key Words: Polar Bear, *Ursus maritimus*, tracking, traditional knowledge, interviews, population characteristics, non-invasive population monitoring, Nunavut.

Uncertainty in range-wide responses by the Polar Bear (*Ursus maritimus*) to changes in sea ice conditions (Aars et al. 2006*; Freeman and Wenzel 2006; Dyck et al. 2007; Stirling et al. 2008) can affect contemporary estimates of sizes and dynamics of Polar Bear populations (Taylor et al. 2005; Aars et al. 2006*; Taylor et al. 2006; Dowsley 2007). Canadian Polar Bears are monitored in accordance with the 1973 Agreement on the Conservation of Polar Bears (Aars et al. 2006*; Freeman and Wenzel 2006; Stirling and Parkinson 2006) using "sound conservation practices based on the best available scientific data" (Canada et al. 1973*).

Polar Bear dynamics are mainly estimated through analyses of population viability using data from aerial capture-mark-recapture (CMR) surveys (Taylor et al. 2005; Taylor et al. 2006), which are expensive (Dowsley 2009), infrequent (Government of Nunavut 2005*; Taylor et al. 2006), and sometimes do not have the full support of local communities (Tyrell 2006; Clark et al. 2008; Shannon and Freeman 2009). The lack of

accurate information on Polar Bear population dynamics can have regional consequences, ranging from erratic harvest quotas for resident Inuit (Taylor et al. 2008; Dowsley 2009) to incorrect projection of responses by Polar Bear populations to climate change and the aggravation of differences of opinion between scientific and Inuit communities (Clark et al. 2008; Dowsley 2009). A first step to a more affordable and wide-spread monitoring program may be more frequent, less invasive estimates of Polar Bear activity involving local Inuit.

The integration of local knowledge/expertise into valid scientific Polar Bear monitoring methods is a laudable goal (Agreement between the Inuit of the Nunavut settlement area and Her Majesty the Queen in right of Canada 1993*; Government of the Northwest Territories 1993*; Usher 2000), but it has proven to be elusive. Information that Inuit hunters can provide, for example, numbers, age, or sex classes of Polar Bears or location of sightings (Stirling and Parkinson 2006), has not been integrated into a rigorous repeatable

method, fuelling international criticisms of changes in quotas based on data provided by Inuit hunters (these data are considered non-scientific information) (Aars et al. 2006*). With their expert knowledge of Polar Bear morphology and behaviour (Freeman and Wenzel 2006), Inuit hunters may be the first to notice major changes in Polar Bear population dynamics (Derocher et al. 2004). They regularly predict when and where Polar Bears are likely to be at certain times of the year, and they may be able to provide valid estimates of the sex, age, and size of specific Polar Bears from their tracks. As a first step toward the inclusion of estimates from tracks into any Polar Bear activity survey, such data should be evaluated for inter-rater reliability (defined here as consistency or repeatability of estimates among individual hunters) and accuracy (the extent to which estimates are close to scientifically derived values).

Polar Bear tracks exhibit cues that are used by observers, Inuit or otherwise, to generate estimates of the sex, age, and size of the animal that made them, according to some decision rules. However, there are many sources of error in estimates made by observers, for example, lack of ability, experience, and attention, as well as fatigue. One strategy for estimating error is to assess the degree of agreement in estimates generated by multiple judges, for example, using inter-rater reliability statistics such as Ebel's intraclass correlation coefficient (Ebel 1951; Bartko and Carpenter 1976; Shrout and Fleiss 1979). Although mathematically similar to the more widely known Cronbach's coefficient alpha (Cronbach 1951; Cortina 1993; Peterson 1994; Santos 1999; Gliem and Gliem 2003*), Ebel's intraclass correlation coefficient provides an index of agreement among multiple judges (in this case, Inuit observers), while Cronbach's alpha provides an index of agreement among items (different sets of tracks). In this regard, the intraclass correlation coefficient has been used to evaluate the reliability of multiple raters in reviewing quality assessments (i.e., Kilic and Cakan 2007) and health care-related assessments (i.e., Schneider et al. 2004; Riffenburgh and Johnstone 2009; Ramachandran et al. 2011).

Beyond confirming that judges make decisions that are in agreement is demonstrating that judgments are valid or accurate relative to an external criterion. Accuracy in identifying the sex of Polar Bears from tracks can be evaluated by comparing an identification made from tracks with genetic sex determination using associated non-invasively collected tissue. Accuracy in estimating of the age of Polar Bears from tracks relies on genetically identifying animals caught in a previous aerial capture-mark-recapture study and determining their ages from tooth wear patterns (Calvert and Ramsay 1998). Inferences concerning accuracy in estimating the size of Polar Bears may be drawn by comparing the size estimate with measurements of the length of the stride from the same tracks (Heglund 1974).

However, it is likely that stride length will provide more repeatable estimates of animal size in any monitoring program.

Our understanding of Inuit information about Polar Bears derived from tracks will be enhanced by considering the history and personal experience of hunters. Identifying which characteristics distinguish the most reliable and accurate hunters may also help provide subsequent recruitment criteria for Inuit hunter participation in track-based Polar Bear surveys. Preliminary assessments of the reliability of three active Inuit hunters and three elders (identified by other participants and community members) in 2007 and three active hunters and four non-Inuit in 2008 indicate that active, experienced hunters are generally more reliable observers of tracks (unpublished data).

Building on this work, we report i) inter-rater reliability of a larger group of Inuit hunters in estimating Polar Bear characteristics from tracks; ii) preliminary comparisons of Inuit hunter estimates of the sex and size of Polar Bears with external track estimates; iii) the techniques that Inuit hunters use to interpret tracks; and iv) criteria such as hunting background and tracking experience that contribute to higher inter-rater reliability and accuracy of estimates.

Methods

We randomly assigned a number (1 to 9) and distributed instructions to nine Inuit from the communities of Gjoa Haven, Taloyoak, and Cambridge Bay in Nunavut, Canada. Participants 1 to 7 identified themselves as active hunters (Inuit who presently hunt Polar Bears when provided with the opportunity), and participants 8 and 9 were elders (older community members who no longer actively hunt). Participant 1 translated all of the verbal responses of participants 8 and 9; for this reason, we collected all data from participants 8 and 9 after we had collected the data from participant 1. Participants 1 and 3 had participated in at least one of the earlier field seasons (Wong 2010*). Additional hunters were contacted through the hunters and trappers organizations in their respective communities.

Participant 1, followed by the other participants, located Polar Bear tracks via snowmobile in M'Clintock Channel between and around Cape Sydney (69°N, 97°W) and Gateshead Island (70°N, 100°W) from 11 to 15 May 2009. Sampling occurred on straight-line transects between Cape Sydney and Gateshead Island and randomly chosen transects around Gateshead Island to avoid re-sampling the tracks of individual Polar Bears. For each track, each participant provided an estimate of the sex, age in years, and nose-to-tail size in feet of the Polar Bear that had made the track, along with the age of the track in days. Participants provided their estimates without discussion with the other participants in the same order at all tracks observed. In order to minimize random guessing, we

included "I don't know" as a possible response (Yu 2001*).

Inter-rater assessment of estimates made by hunters of sex, age, and size of Polar Bears and estimates of age of track

We used group agreement, individual differences, and changes in group variability over time to determine the inter-rater reliability of the interpretations of tracks across tracks interpreted by all participants. Following MacLennan (1993), we calculated the intraclass correlation coefficient (Ebel 1951) for the group of hunters and the adjusted item-total Pearson product-moment correlation coefficients (r) for each participant (Gliem and Gliem 2003*) using SPSS (SPSS Inc.) for estimates of Polar Bear sex, age, and size, and estimates of age of track across tracks. We also determined the mean adjusted item-total r for the group by z_r -transforming the adjusted item-total r values for each participant, computing the arithmetic mean, and back-transforming mean z_r values (Silver and Dunlap 1987).

We tested for consistent differences among hunter estimates with a chi-square (χ^2) analysis of sex ratios; a one-way analysis of variance (ANOVA) for each of the age and size of Polar Bears and the age of track variables; and a post-hoc Tukey-Kramer Honestly Significant Difference (HSD) test for the age and size of Polar Bears and age of track variables (JMP version 9.0) (JMP 2009). To determine whether group variability decreased over time, we numbered tracks in the order they were interpreted and we tested the relation between track and coefficients of variation in the estimates of age and size of Polar Bears and estimates of the age of track using linear regression.

Comparisons of sex estimates with genetic determinations and comparisons of size estimates with stride measurements

To provide inferences concerning the accuracy of the estimates of sex and size of Polar Bears made by the participants, we made comparisons with respective "scientific" estimates of sex and stride length. Track data were collected alongside an ongoing study from 2007 to 2009 to genetically sex Polar Bears using non-invasive sampling stations, which consisted of a square barbed-wire fence surrounding a pole baited with seal meat (Van Coeverden de Groot et al. 2010*). These stations were erected between Cape Sydney and Gateshead Island no more than three days prior to track data collection along the same transect used to locate tracks. Samples of hair from Polar Bears that were attracted to these stations were collected between 11 and 15 May 2009 for genetic sexing and genotyping (Van Coeverden de Groot et al. 2010*) at the same time as we documented associated track interpretations made by participants (above). We also collected hair samples on an *ad hoc* basis along tracks where interpretations were made. We supplemented these data with paired track interpretations and hair

samples collected in this area from 1 to 14 May 2008 and around Cape Sydney from 2 to 18 May 2007 (Figure 1).

Only hair samples that were associated with a single track (thus a single individual) were included in subsequent analyses; these associations were either obviously apparent or confirmed by participant 1. The resulting data set was composed of hair samples from 2009 associated with estimates by participants 1 to 9; samples from 2008 associated with estimates by participant 3 and one previous hunter participant from Taloyoak (participant A); and samples from 2007 associated with estimates by participants 1, 2, and A and two previous participating hunters from Gjoa Haven (participants B and C). We stored all hair samples frozen in cryovials.

Genetic sex determination of hair samples relied on a polymerase chain reaction (PCR) duplex amplification of the ZFX/ZFY and SRY markers (Pagès et al. 2009), which we first evaluated on 10 tissue samples of known sex (six females and four males). Because a faint SRY-like band was observed for some females, the initial method was modified. PCR amplicons were digested overnight at 37°C by the restriction enzyme BclI (BioLabs), which cuts ZFY into two fragments (106 bp and 37 bp) but not ZFX. This procedure was designed using the software NEBcutter V2.0 (BioLabs). Digestions were carried out in 20 μ L reaction volumes containing 5 units of BclI enzyme (BioLabs) and 0.2 μ L of BSA (supplied with the enzyme, 10 mg/mL). Digested amplicons were then analyzed using a microchip electrophoresis system (MultiNA, Shimadzu; and Agilent 2100 Bioanalyzer, Agilent).

A three-band profile corresponded to a male (144 bp ZFX, 115 bp SRY, 106 bp ZFY) (the 37 bp ZFY was too short to be visualized), and a one-band profile corresponded to a female (144 bp ZFX), even though a two-band profile could be observed (144 bp ZFX, faint 115 bp SRY band, but no ZFY band). The refined procedure allowed us to circumvent the amplification of false SRY in females (probably due to SOX gene family amplification), regularly observed in mammalian sexing procedures (Taberlet et al. 1993; Kohn et al. 1995; Durnin et al. 2007).

The new method was tested on 22 DNA extracts obtained from non-invasive samples (15 hair and 7 feces) of individuals of known sex (16 males and 6 females). Four of these samples failed to amplify. Reliable and accurate sex determinations were obtained for the remaining 18 samples. The sex was then determined for 33 study samples. Between one and three independent PCR attempts were carried out and analyzed to determine sex by consensus among the different attempts. In cases where multiple hair samples were associated with a single set of tracks, genetic sex determination for the sampled Polar Bear was made by consensus. We calculated the percentage of agreement for pairs of estimates of the sex of Polar Bears

made from tracks and genetic determinations from 2007 to 2009 for each hunter and across all hunters, and then, using a binomial test, we evaluated whether percentage agreement was significantly different from random guessing (50%).

In the absence of data relating stride length to body length in Polar Bears, we compared hunter estimates of size directly with stride measurements. Some participants mentioned during interviews that stride length is a useful indicator of body size, and we assumed stride length was correlated with true body size (Heglund 1974). By random assignment, in 2009 participants 4, 5, and 6 walked along each track and selected by group consensus consecutive footprints left by walking Polar Bears on flat terrain considered to be suitable for measurement. After providing their other estimates, these participants recorded a minimum of six measurements of the distance from the front edge of the left-hind footprint in one group of tracks to the front edge of the corresponding footprint in the following group at each suitable track. We compared the means of stride distances with corresponding estimates of Polar Bear size by calculating Pearson's product-moment correlation coefficients (r) for all 2009 participants.

Semi-structured interviews for hunting and track interpretation techniques and experience

We obtained permission to conduct interviews from the Nunavut Research Institute, Queen's University, and the Gjoa Haven Hunters and Trappers Organization, along with oral and written consent from each participant. Between 1 April and 11 May 2009, we conducted semi-structured interviews according to participant availability and convenience. The interviews, which occurred alone with the participant (except when a translator was required), ranged from 5 to 12 min depending on mutual comprehension and the amount of information.

All interviews were conducted following Huntington (1998, 2000). Directive questions (i.e., name, age, community) preceded general questions concerning tracking methods, with follow-up questions to allow hunters to explain their own understanding and thoughts or to clarify information (Huntington 1998, 2000; Rapley 2001). We audiotaped and transcribed all interviews, with the exception of the interview with participant 5, whose responses were mainly recorded by hand due to a malfunctioning battery in the recorder.

To provide further contextual information, we documented non-verbal cues in a journal and verbal styles through audio-recording, and we quoted each participant's experiences and reflections in his own words (Baxter and Eyles 1997; Huntington 2000; Rapley 2001). These details included data such as the participants' apparent increased comfort in answering interview questions when they were not being audiotaped. We then grouped all transcribed interviews and relevant

data pertaining to track interpretation methods based on our interpretations (Burnard 1991) and used quotations and other information that best represented these groupings.

Participant background and hunting experience and inter-rater reliability and accuracy in interpreting tracks

To make a preliminary description of the relationship between the background of the participants and their ability to interpret tracks, we calculated pair-wise Spearman's rank correlation coefficients (ρ) between adjusted item-total r (for each of the sex, age, and size of Polar Bears and the age of track), the percentage agreement of sex estimates with genetic sex determinations, and r for size estimates with stride measurements and each participant's background and tracking experience.

We organized background and hunting experience using five criteria: continuous data on age and education and categorized data on frequency of guiding, preferences for hunting alone, and the ability to interpret tracks from observing few footprints. We divided frequency of guiding Polar Bear hunts into three categories ("never guides," "sometimes guides," and "often guides"); preferences for hunting alone versus hunting with a group into two categories; and the methods used to interpret tracks from observing footprints into three categories ("observing a whole track," "sometimes observing a whole track, sometimes a single footprint," and "observing only a single footprint"). We did not have the above participant background information for participant 5.

Results

The group of hunters encountered 99 tracks in total in 2009 (Figure 1). All nine participants observed 43 tracks between Cape Sydney and Gateshead Island, 25 tracks north of Gateshead Island, and 17 tracks south of Gateshead Island; participants 1 and 9 also observed 14 tracks north of Gateshead Island. All participants estimated the sex, age, and size of the Polar Bear that had made the track and the age of the track for the same set of 78 tracks. None reported "I don't know."

Inter-rater reliability of estimates of sex, age, and size, and age of track

Preliminary data analysis based on box plots revealed outlying data points that skewed the distribution of age of track estimates. Since outliers were associated with participant 5, we report inter-rater reliability assessments with and without data from participant 5 to examine his effect on inter-rater reliability. Based on interclass correlation coefficients (ICC), the group of nine participants was reliable in estimating sex, age, and size but was not reliable in estimating age of track (Table 1). Specifically, the ICC for sex, age, and size

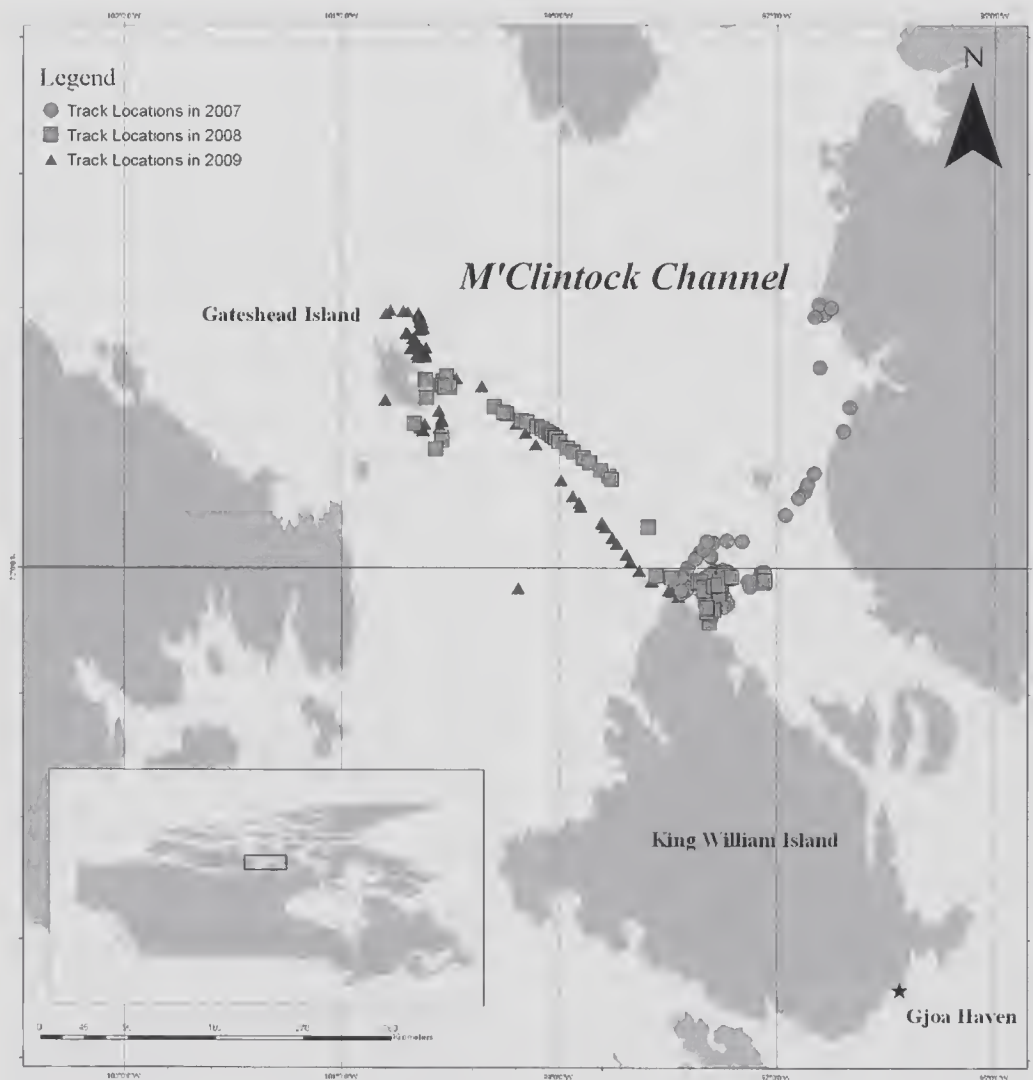


FIGURE 1. Track locations over ice in M'Clintock Channel, Nunavut, Canada, from 2007 to 2009. A total of 19 tracks were interpreted by three hunters and three elders in 2007, and a total of 27 tracks were interpreted by three hunters and four non-Inuit in 2008. In 2009 (the current study), a total of 99 tracks were encountered between Cape Sydney and Gateshead Island between 11 and 15 May. Of these 99 tracks, 78 were interpreted by all nine participants, who estimated the sex, age, and size of the Polar Bears that made them and the age of the track.

estimates exceeded 0.7, often used as the benchmark for a measurement to be considered reliable according to similar statistics (Clark and Watson 1995; Santos 1999; Streiner 2006).

When the estimates made by participant 5 are excluded, the age of track estimates are also reliable and the inter-rater reliability of estimates of sex, age, and size do not change appreciably. Based on adjusted item-total correlations between estimates made by each participant and group estimates, participants were generally consistent in making estimates of all four

variables (mean adjusted item-total $r > 0.40$; Gliem and Gliem 2003*). When the estimates made by participant 5 are excluded, there is little change in consistency in the sex, age, and size estimates, although correlations of individual age of track estimates with group age of track estimates are generally higher.

Sex ratio estimates differed significantly among the nine participants ($\chi^2 = 20.20$, $df = 8$, $P = 0.0096$). Mean age estimates were also significantly different (one-way ANOVA, $df = 8$, $r^2 = 0.40$, $F = 58.95$, $P < 0.05$), with a post-hoc Tukey-Kramer HSD test

TABLE 1. Intraclass correlation coefficients (ICC) (Ebel 1951), mean adjusted item-total correlations (r), and individual participant adjusted item-total r for estimates of sex, age, and size of Polar Bears and estimates of age of track for the complete group of 9 participants and for 8 participants (excluding participant 5), made in M'Clintock Channel, Nunavut, from 11 to 15 May 2009.

| | Adjusted item-total Pearson product-moment correlation coefficient (r) | | | | | | | |
|------|--|--------------------------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|
| | Polar Bear | | | | | | | |
| | Sex | | Age | | Size | | Age of track | |
| | All 9 participants | Participants 1-4 and 6-9 | All 9 participants | Participants 1-4 and 6-9 | All 9 participants | Participants 1-4 and 6-9 | All 9 participants | Participants 1-4 and 6-9 |
| ICC | 0.74 | 0.77 | 0.74 () | 0.77 | 0.91 | 0.92 | 0.35 | 0.85 |
| 1 | 0.37 | 0.35 | 0.58 | 0.54 | 0.69 | 0.70 | 0.47 | 0.63 |
| 2 | 0.60 | 0.60 | 0.55 | 0.54 | 0.84 | 0.75 | 0.47 | 0.68 |
| 3 | 0.62 | 0.65 | 0.63 | 0.64 | 0.74 | 0.76 | 0.36 | 0.62 |
| 4 | 0.41 | 0.44 | 0.50 | 0.54 | 0.69 | 0.71 | 0.40 | 0.70 |
| 5 | 0.11 | | 0.53 | | 0.52 | | 0.49 | |
| 6 | 0.62 | 0.61 | 0.57 | 0.56 | 0.63 | 0.64 | 0.55 | 0.67 |
| 7 | 0.33 | 0.35 | 0.81 | 0.79 | 0.82 | 0.82 | 0.64 | 0.76 |
| 8 | 0.16 | 0.19 | 0.76 | 0.73 | 0.73 | 0.69 | 0.33 | 0.27 |
| 9 | 0.64 | 0.62 | 0.63 | 0.62 | 0.78 | 0.76 | 0.44 | 0.55 |
| Mean | 0.45 | 0.49 | 0.63 | 0.63 | 0.73 | 0.74 | 0.47 | 0.63 |

indicating participants 3, 4, and 8 differed the most ($P < 0.05$). Mean size estimates (one-way ANOVA, $df = 8$, $r^2 = 0.15$, $F = 15.60$, $P < 0.05$) and age of track estimates with participant 5 (one-way ANOVA, $df = 8$, $r^2 = 0.07$, $F = 6.45$, $P < 0.05$) and without participant 5 (one-way ANOVA, $df = 7$, $r^2 = 0.07$, $F = 6.37$, $P < 0.05$) also differed significantly. Post-hoc Tukey-Kramer HSD tests indicated that participants 4, 5, and 8 differed the most in the mean estimates of size ($P < 0.05$); when participant 5 was excluded, participant 9 differed the most in the mean age of track estimates ($P < 0.05$). Relations between coefficients of variation in age of Polar Bears ($r^2 = 1.19 \times 10^{-5}$, $df = 76$, $P = 0.98$), size ($r^2 = 0.0025$, $df = 76$, $P = 0.66$), and age of track estimates, with participant 5 ($r^2 = 0.037$, $df = 76$, $P = 0.09$) and without participant 5 ($r^2 = 0.0037$, $df = 76$, $P = 0.59$), and the sequence of track observations over the study were not significant.

Comparisons of sex estimates with external determinations and comparisons of size estimates with stride measurements

We collected a total of 23 hair samples identified with sex along ten tracks in 2007, a total of 8 samples along two tracks in 2008, and a total of 22 samples along seven tracks in 2009 (Table 2); multiple hair samples were collected along 11 of these tracks. Of the total 53 hair samples, 25 samples (associated with five tracks in 2007, one track in 2008, and five tracks in 2009) were sexed in the lab and used for subsequent comparisons with hunter estimates of sex from tracks. Two samples were ambiguously sexed and 6 samples were not sexed due to repeated PCR failure, which we ascribe to too little DNA in the hair samples. Many of the samples that we failed to sex

were part of a collection of samples associated with single tracks. This meant that a genetic sex determination could still be made for these tracks using other hair samples.

All hair samples were collected from Polar Bear sampling stations except for three samples that were collected along one isolated track in 2007. No hair samples were collected along multiple sets of tracks (i.e., tracks easily identifiable as females with associated cub were excluded). All participants from 2007 (participants 1 to 9), 2008 (participants 3 and A), and 2009 (participants 1, 2, A, B, and C) provided sex estimates with a mean agreement of 74.42% with the associated genetic sex determination (Table 2). These results were significantly different from a random guess frequency of 50% ($n = 41$, $P = 0.0010$).

Participants 4, 5, and 6 recorded sets of six stride measurements along each of nine tracks interpreted by all participants (2009). The time and effort required to make consistent measurements (i.e., following tracks to locate areas where the animal was walking and the left hind pad of a footprint was distinct) limited our sample, as we preferentially allocated our sampling effort to achieving a larger data set of track interpretations. In light of this limitation ($n = 9$ tracks, Table 3), estimates of animal size and measurements of stride length made by participants 1, 2 and 7 were significantly correlated. All other participant correlations were not statistically significant; however, they overwhelmingly represented a large effect size (Cohen 1992).

Semi-structured interviews to gather participant background, hunting experience, and techniques

Participants varied in terms of background and experience (Table 4); in particular, participants 1 and

TABLE 2. Percentage agreement between individual participant's estimates of the sex of Polar Bears from tracks and associated genetic sex determinations from hair collected along tracks from 2007 to 2009. The number of unique tracks with associated tissue samples used for the percentage agreement calculation for each participant is shown. The number of participants who provided sex estimates varied from 2007 to 2009. In some cases, there was more than one tissue sample associated with a track; in those cases, the consensus determination of the sex for all associated samples was used (see text for details).

Samples from 2009 were made in M'Clintock Channel between and around Cape Sydney and Gateshead Island, Nunavut, from 11 to 15 May 2009 by all nine participants. Samples from 2008 were associated with estimates by participant 3 and participant A (from Taloyoak) in M'Clintock Channel between and around Cape Sydney and Gateshead Island, 1 to 14 May 2008. Samples from 2007 were associated with estimates by participants 1, 2, and A and participants B and C (two hunters from Gjoa Haven) around Cape Sydney, 2 to 18 May 2007.

| Participant | No. of track-tissue pairs | Percentage agreement |
|----------------------|---------------------------|----------------------|
| 1 ^{a, b} | 7 | 71.43 |
| 2 ^{a, b, c} | 2 | 100.00 |
| 3 ^{a, b, c} | 7 | 71.43 |
| 4 ^a | 3 | 66.67 |
| 5 ^a | 3 | 100.00 |
| 6 ^a | 3 | 66.67 |
| 7 ^{a, b} | 3 | 66.67 |
| 8 ^d | 3 | 66.67 |
| 9 ^d | 5 | 40.00 |
| A ^a | 3 | 100.00 |
| B ^{a, b, c} | 2 | 100.00 |
| C ^d | 2 | 100.00 |
| Weighted mean | | 74.42 |

^a Participants who actively hunt.

^b Participants who guide Polar Bear hunts professionally.

^c Participants who identified themselves as Canadian Rangers.

^d Participants identified by other participants as elders.

3 were well-known professional hunters and guides; participants 2 and 3 were certified Canadian Rangers (Canada 2010*) who were also recognized as professional hunters; and participant 7 had guided Polar Bear denning surveys as well as Polar Bear hunts. On the other hand, criteria used to interpret tracks were held in common among the participants (Table 5). Sex estimates were generally made by observing footprint orientation, size, and shape. Participants indicated that male footprints were more oriented inwards, toward the centre of the track, than female footprints. Participant 2 indicated after his interview that adult male footprints are "turned in" because their shoulder muscles are more developed and the footprints of young males and females are less "turned in." Participants also indicated that footprints made by males are larger than those of females (participant 2, 5 May 2009):

TABLE 3. Pearson correlation coefficients (r) of estimates of the size (length) of Polar Bears and mean measurements of six Polar Bear stride lengths across nine tracks for all nine participants, made in M'Clintock Channel, Nunavut, from 11 to 15 May 2009.

| Participant | r | P |
|-------------|------|-------|
| 1 | 0.67 | 0.05* |
| 2 | 0.78 | 0.01* |
| 3 | 0.54 | 0.13 |
| 4 | 0.63 | 0.07 |
| 5 | 0.65 | 0.06 |
| 6 | 0.31 | 0.41 |
| 7 | 0.69 | 0.04* |
| 8 | 0.01 | 0.98 |
| 9 | 0.56 | 0.12 |

*Significant correlation at an alpha level of 0.05.

"And the female track and male track is different. And he said it's a different—those toes are narrow—and males are wider." (Participant 1 translating for participant 9, 12 May 2009)

Participant 1 observed accompanying tracks to identify sex as well as age:

"...Female only by herself is...5, 6 years old. Something like that...and a young male too. Same thing." (Participant 1, 10 May 2009)

Age estimates were generally dependent on footprint size or shape or on the estimated sex of the Polar Bear. All participants indicated footprint or track size differed with the age of the animal, where older Polar Bears make larger tracks. Participant 3 estimated age by inferring the weight of the animal from the depth of the track in the snow:

"...By the tracks...you can kind of tell from how big the track is... maybe the weight of the bear...depends on the snow I guess. How deep it is...." (Participant 3, 10 May 2009)

Some participants mentioned footprint shape as a cue to estimating age, with similarities between the tracks of young males and females:

"...grown up bears...tracks or footprints are more round." (Participant 2, 5 May 2009)

"...Young males'... prints are a little bit—almost same size as a female but they're more narrow." (Participant 2, 5 May 2009)

All participants examined the size of footprints to estimate the size of Polar Bears, and all participants observed weather and snow conditions or hardness and softness of prints to estimate the age of a track. Participants generally associated soft footprints with fresh tracks and hard footprints with old tracks:

"On a nice day, you can tell it's not too long ago. Even when there's drifting snow you can test it with your

TABLE 4. Summary of participants' responses to interview questions, 1 April to 11 May 2009.

| Participant | Age * | Highest education level * | Place of birth | Frequency guiding hunts * | Prefers to hunt alone | Learned how to hunt from | Reasons for hunting |
|-------------|---------|---------------------------|----------------|---------------------------|-----------------------|--|-----------------------------------|
| 1 | 63 | Grade 5 | mainland | often | yes | hunters | food fur money food |
| 2 | 50 | Grade 6 | community | occasional | yes | elders father brother grandfather | food enjoyment |
| 3 | 51 | Grade 5 | community | often | yes | elders father grandfather uncle | food enjoyment |
| 4 | 32 | Grade 7 | city | infrequent | yes | elders | food no data |
| 5 | no data | no data | no data | never | no data | hunters | food enjoyment |
| 6 | 23 | Grade 9 | city | never | no | participant 7 | food enjoyment |
| 7 | 35 | Grade 9 | community | often | yes | elders hunters father | food fur money enjoyment |
| 8 | 71 | never attended school | mainland | infrequent | no | hunters father | food |
| 9 | 67 | never attended school | mainland | infrequent | no | hunters stepfather | food |

* Variables compared with criteria for biases in estimates and ability to interpret tracks.

TABLE 5. Summary of criteria used by various hunters to estimate the sex, age, and size of Polar Bears from tracks and to estimate the age of tracks, based on interviews conducted between 1 April and 11 May 2009.

| Variable | Participant | | | | | | | | |
|---------------------|-------------------------------|-------------------|-------------------------|-------------------|----------------|------------|------------|-------------------|------------|
| | 1 | 2 | 3 | 4 | 5 ^a | 6 | 7 | 8 | 9 |
| Polar Bear | | | | | | | | | |
| Sex | OF, AT ^b | OF, FS | no data | OF, FS, FSh | no data | OF, FSh | OF, FSh | OF, FS, FSh | FS, FSh |
| Age | FS, ES, AT ^b | FS, FSh, ES | FSh, SD ^b | FS, ES | no data | FS | FS | FS | FS |
| Size | FS | FS | FS | FS | FS | FS | FS | FS | FS |
| Age of track | W, Sn | W, Sn | W, Sn | W | W, Sn | Sn | W, Sn | W, Sn | W, Sn |
| Method ^c | S | S | S, M | M | no data | M | M | S | S, M |

OF = orientation of footprints

FS = footprint size

FSh = footprint shape

AT = accompanying tracks (i.e., male or cub tracks associated with a female)

ES = estimated sex

SD = snow depth

W = weather conditions

Sn = snow conditions

^a Data based on notes recorded in P. Wong's journal during the interview and her recollection.

^b Cues not mentioned by other participants.

^c Whether hunters interpreted one or two footprints (S) or looked at a number of footprints (a track, M). These data were subsequently included in comparisons of tracking experience and inter-rater reliability and accuracy.

TABLE 6. Pair-wise Spearman's rank correlation coefficients (ρ) of participant characteristics and inter-rater reliability and accuracy of their estimates.

| | Participant | | | | |
|--|----------------------|------------------|------------------------|--|--|
| | Frequency of guiding | Age ^a | Education ^a | Frequency of accompanying hunters preferred ^a | Ability to interpret tracks from few footprints ^a |
| Adjusted item-total r | | | | | |
| Polar Bear | | | | | |
| Sex | 0.06 | -0.12 | -0.11 | 0.17 | -0.19 |
| Age | 0.45 | 0.48 | -0.25 | 0.17 | 0.06 |
| Size | 0.50 | 0.31 | -0.17 | -0.28 | 0.32 |
| Age of track | 0.15 | -0.60 | 0.74 ^b | -0.17 | -0.38 |
| Agreement of sex estimates with genetic determinations | 0.22 | -0.14 | 0.22 | -0.58 | -0.51 |
| Correlations of size estimates with stride length | 0.50 | -0.24 | 0.35 | -0.73 ^b | 0.06 |

^a Data not available for participant 5.

^b Significance at the alpha level of 0.05.

hand, see if the footprints are hard or soft. Harder means longer and...soft means just a few hours ago or something." (Participant 2, 5 May 2009)

Comparisons of participant background and hunting experience with ability to interpret tracks

Exploratory analyses relating the characteristics of participants to indices of their inter-rater reliability and accuracy in interpreting tracks (Table 6) must be interpreted with caution; reported background and experience may not necessarily lead to reliable or accurate estimates and vice versa. Individual differences in inter-rater reliability and comparisons with external determinations were statistically defined; for example, inter-rater reliability in estimating sex was defined as the adjusted item-total correlation between a participant and all other participants for sex estimates. Moreover, the sample size for these analyses was small (nine participants), so it may be more appropriate to consider correlations that demonstrate at least a moderate effect size of .50 or greater (Cohen 1992).

More reported experience as a hunting guide was positively correlated with reliable estimates of size and experience as a hunting guide was positively correlated with more size estimates that were correlated with external determinations. Older participants were more reliable in estimating the age of Polar Bears but were less reliable in estimating the age of tracks. More educated participants showed greater inter-rater reliability in estimating the age of tracks. Preferring to hunt with other hunters was associated with estimating sex and size in lower agreement and lower correlation with external determinations, respectively. Claiming to be able to gain information from relatively few tracks was associated with lower agreement of sex estimates with genetic determinations.

Discussion

Inter-rater reliability of Inuit hunters in estimating Polar Bear characteristics from tracks

This research provides promising findings regarding the potential value of information provided by Inuit hunters, particularly their estimates of Polar Bear features given only Polar Bear tracks to observe. A group of nine Inuit hunters generally agreed in their estimates of sex, age, and sex of Polar Bears. Moreover, over time, there was no change in group variability in estimating these characteristics. For a small number of tracks, Inuit hunters' sex estimates were in higher agreement with genetic determinations than with random guessing. Overall, these findings, along with variation among hunter estimates, were enriched by relating hunters' self-reported background and hunting experience to inter-rater reliability and the correlations of their estimates with scientific determinations. As might be anticipated, more hunting experience and confidence were associated with greater degrees of inter-rater reliability and comparability with externally determined identifications.

We expected that a group of hunters with shared knowledge and experience in tracking would show high agreement. However, our group was reliable in estimating the age of tracks only after the data from one participant (5) were excluded. Low inter-rater reliability can result from random guessing (Yu 2001*); to increase inter-rater reliability, participants must be re-examined for their experience or removed from subsequent surveys (Peterson 1994; Santos 1999). Alternatively, low inter-rater reliability in estimating the age of tracks suggests the effect of track degradation and substrate should be investigated. Although collective information about tracks through group discussion can be highly accurate (Stander et al. 1997),

TABLE 7. Comparisons of track interpretation techniques used by Inuit hunters and published scientific data on Polar Bears.

| Inuit track interpretation technique | Scientifically reported categorical difference |
|---|---|
| Larger track sizes of males versus females <ul style="list-style-type: none"> • orientation of footprints toward centre of track in males due to larger "shoulder" muscles; • similarity between female tracks and young male tracks. | Extended growth period in males results in greater body length and mass in adult males than in females of similar age (Derocher and Wiig 2002; Derocher et al. 2005); average footprint width of 22 cm in adult males and 16 cm in adult females (Amstrup et al. 2006). |
| Using snow or weather conditions to determine age of track. | Track degradation or age of track increases with recent snow fall (Amstrup et al. 2006), wind, ice overflow, and melt-out (Hayward et al. 2002). |
| Using the presence of accompanying tracks to estimate sex and age of Polar Bear. | Accompanying tracks indicate maturity, births, and disappearance of young (Jewell et al. 2001). |
| Using inferences of body weight from depth of tracks in the snow to estimate the age of the Polar Bear. | Body mass and age are correlated in Polar Bears (Derocher et al. 2005). |

our study shows high inter-rater reliability of estimates made by a group of hunters, suggesting hunters may be able to reliably interpret tracks alone.

Preliminary comparisons of estimates of Polar Bear sex and size from tracks with external determinations

Our data suggest that Inuit made estimates in agreement with genetic determinations 74% of the time. Although this value may be criticized due to the small sample size of track interpretations with associated tissue, it is the only instance of comparing Inuit interpretations of tracks with external validity criteria. We recognize that tracks may vary in probability of accurate identification, for example, easily identifiable tracks belonging to females and their associated cubs and large tracks likely belonging to adult males are easier to interpret. Although easily identifiable tracks were excluded from our analyses, a larger sample of track and tissue pairs (excluding easily identifiable tracks) will be required to provide inferences concerning the accuracy of Inuit estimates of the sex of adult Polar Bears.

Genetic sexing of Polar Bear hair is still a relatively new procedure (Pagès et al. 2009), and optimizing techniques for feces and blood will provide genetic determinations from additional pairs of tracks and tissue for validation (Van Cocverden de Groot et al. 2010*). Work to genotype non-invasive tissue associated with previously captured (Taylor et al. 2006) and aged (Calvert and Ramsay 1998) Polar Bears to compare with estimates of age made by hunters from tracks is also warranted, given the high inter-rater reliability of the Inuit estimates reported herein. Calibrations of body size and stride length in zoo animals or "rogue" Polar Bears detained in Churchill (Tyrell 2006) will be required to establish a robust relationship between animal size and stride length in Polar Bears for further comparison with estimates made from tracks. At a minimum, all sampling efforts (both wild and known Polar Bears) should include measurements

taken along tracks made in similar snow substrate that minimizes variability in gait patterns (i.e., walking versus galloping). Distinguishing among Polar Bears of similar age and sex (identity) awaits additional data such as the optimization of multivariate analyses of digital images of Polar Bear tracks (Alibhai and Jewell, personal communication; Jewell et al. 2001; Alibhai et al. 2008), and will be required for a valid estimate of Polar Bear abundance (Hayward et al. 2002; Silveira et al. 2003).

At the outset, a number of limitations were associated with a survey of animal tracks based exclusively on interpretations of tracks made by hunters. Gathering track data requires high densities of individual animals (Smallwood and Fitzhugh 1995) and minimal variance in individual travel distances (Stephens et al. 2006). Animals must be mobile in order to be counted (Becker et al. 1998); otherwise, a failure to detect tracks will not necessarily indicate absence (Gese 2001; Crooks et al. 2008). In addition to physical geography (Gompper et al. 2006; Houser et al. 2009), weather and snow conditions can affect track detectability (Jewell et al. 2001; Hayward et al. 2002; Silveira et al. 2003; Alibhai et al. 2008), thus further supporting the need to evaluate the effect of substrate on interpretations made by Inuit hunters.

Against these concerns, our data indicate Inuit have the potential to provide information on more than simply presence or absence of specific Polar Bears in an area. Coupled with genetic data from remote sampling stations (Harris 2010*), this information could provide preliminary estimates of contemporary Polar Bear activity that are currently unavailable for most populations. Before this information is included, however, evaluations of accuracy in estimating Polar Bear age and size and the age of tracks need to be completed. It is important to note that there are no data on individual and inter-rater reliability and accuracy in hunter estimates of sex, age, and size for any target animal species (but see Stander et al. 1997). Once

these evaluations have been completed, the challenge will be to integrate Inuit track data into a valid Polar Bear activity survey with genetic data from non-invasive samples (Harris 2010*) and potentially digital images from tracks.

Polar Bear population characteristics estimated from tracks alone could provide repeatable objective data (Smallwood and Fitzhugh 1995; Stander et al. 1997; Gusset and Burgener 2005). However, the margins of error in ongoing capture-mark-recapture surveys continue to be smaller. This means that capture-mark-recapture surveys result in more accurate harvest quotas that would presumably minimize over- or under-harvesting. At this stage, the track data discussed here should supplement rather than replace capture-mark-recapture data, especially when capture-mark-recapture surveys or direct visualization of animals is difficult (Beier and Cunningham 1996; Jewell et al. 2001).

Tracks alone can be used to detect the presence or absence of individual Polar Bears (Balme et al. 2009); behavioural activity such as births, disappearance of young, maturity, and maternity (Jewell et al. 2001); and, more importantly, large changes in population activity over large areas (Balme et al. 2009) and time (Kendall et al. 1992; Hayward et al. 2002; Melville and Bothma 2006; Balme et al. 2009) with high statistical power in detecting decreases in abundance (Beier and Cunningham 1996). These data could, in conjunction with modelling techniques associated with capture-mark-recapture surveys, inform managers when another survey is required to re-evaluate harvest quotas. It is important to note that data derived from tracks will require independent estimates of population parameters, such as those provided through genetic analyses or capture-mark-recapture, to be applied to management (Herzog et al. 2007).

Hunting and tracking experience as indicators of inter-rater reliability and potential accuracy in interpreting tracks

Hunters indicated that they acquired their tracking skills through interactions with a similar group of people (elders, other hunters, and family members). Although the small sample size limited statistical comparisons between information from interviews and estimates made by participants, our qualitative interpretations suggest inter-rater reliability of hunters in interpreting tracks may be explained by their shared track interpretation techniques. Many of the shared skills reported by Inuit can be directly linked to Polar Bear characteristics identified in conventional scientific studies (Table 7). We anticipate that optimizing multivariate analyses of digital track images will provide morphometric data against which these shared criteria (Table 5) can be directly compared. On the other hand, some hunters (participants 1 and 3) identified unique track interpretation techniques, perhaps acquired as a function of their extensive tracking experience

or their involvement in other scientific research projects (in 2007 and 2008). These few, context-rich cases can identify particular track interpretation techniques that might be taught to a larger group (Maxwell 2004; Flyvbjerg 2006) should their techniques be arguably better for interpreting tracks.

The qualitative data also explore individual differences in Inuit estimates of Polar Bear characteristics from tracks. Participant 3 is an experienced hunter, and the wider range in his age estimates may accurately reflect the true range in Polar Bear age, which has been estimated to be up to 20 years in female Polar Bears (Ramsay and Stirling 1988). Likewise, participants 4 and 5 showed the greatest differences in estimates from the rest of the hunters (in addition to participant 5 lowering the effect on inter-rater reliability); this difference may be ascribed to their less frequent participation in Polar Bear hunts. Participant 8 (an elder) also showed differences in his estimates as well as lower agreement with other hunters and external determinations; this difference may be explained by his general lack of active hunting. Participants 1, 2, and 7 (all experienced professional guides) gave estimates of animal size most correlated with stride length. The hunters whose size estimates correlated the least with stride length were again the elder (participant 8) and a young hunter (participant 6). Overall, our study suggests Inuit from any community who show levels of expertise comparable to the most reliable and likely accurate hunters reported here (see above) could provide useful non-invasive estimates of Polar Bear characteristics from tracks for any population.

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Notes

Records of Melanistic American Red Squirrels (*Tamiasciurus hudsonicus*) from Nova Scotia

HOWARD M. HUYNH^{1,2*}, BERNARD L. BURKE³, and DONALD F. MCALPINE²

¹ Department of Biology, Acadia University, Wolfville, Nova Scotia B4P 2R6 Canada

² New Brunswick Museum, 277 Douglas Avenue, Saint John, New Brunswick E2K 1E5 Canada

³ 21 Micmac Boulevard, Dartmouth, Nova Scotia B3A 4N3 Canada

*Corresponding author; email: howard.huynh@ttu.edu

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Though melanism has been observed in several species of North American sciurids, the occurrence of this phenotype is relatively rare in American Red Squirrels (*Tamiasciurus hudsonicus*). We provide the first detailed accounts of melanistic Red Squirrels observed in Nova Scotia, Canada.

Key Words: American Red Squirrel, *Tamiasciurus hudsonicus*, Melanism, Nova Scotia.

Melanism in mammals refers to black or very dark brown pelage (Caro 2005), and is a relatively uncommon phenotype observed in most species of mammals (Guthrie 1967). While most populations exhibit gradual intraspecific colour variation across their geographic range, there are some populations that show discontinuous variation (Caro 2005), with melanistic (melanic) individuals occurring at high frequency (Guthrie 1967). For example, some populations of Eastern Gray Squirrel (*Sciurus carolinensis*) (hereafter Gray Squirrel) in northern latitudes are comprised almost entirely of melanistic individuals (Banfield 1974; Hall 1981; Thorington and Ferrell 2006).

Melanism has been reported in other North American sciurids [e.g., Eastern Fox Squirrel (*Sciurus niger*) (Kiltie 1989); Arctic Ground Squirrel (*Spermophilus parryi*) (Guthrie 1967); Eastern Chipmunk (*Tamias striatus*), Yellow-Bellied Marmot (*Marmota flaviventris*), Black-Tailed Prairie Dog (*Cynomys ludovicianus*), Thirteen-Lined Ground Squirrel (*Spermophilus tridecemlineatus*) (Thorington and Ferrell 2006)]. Melanistic American Red Squirrels (hereafter Red Squirrel), *Tamiasciurus hudsonicus*, are rarely encountered in the wild (Allen 1898; Layne 1954; Benton 1958; Steele 1998) considering the high abundance of this species over its large geographic range (Young, 1999). In this paper, we report the first records of melanistic Red Squirrels from Nova Scotia, Canada.

On March 6, 2010, the first author observed a melanistic adult Red Squirrel in Kentville Ravine, Nova Scotia (45°07'69"N, 64°49'44"W), foraging near a stand of White Spruce (*Picea glauca*). Though melanistic Gray Squirrels are known to occur in the Annapolis Valley of Nova Scotia (Huynh et al. 2010), the body size of this animal was too small to be that

of a typical adult Gray Squirrel. The presence of other external characters – i.e., hair tufts protruding from the top of the pinnae (more accentuated in winter pelage; Steele 1998; Whitaker and Hamilton 1998) and smaller, flatter tail (Steele 1998) – also confirmed that this animal was a Red Squirrel.

On March 22, 2010, the second author observed and photographed a young adult melanistic Red Squirrel (Figures 1A and B) in Upper Nine Mile River, Nova Scotia (Fraser Road; 44°69'41"N, 63°59'00"W). The animal was foraging near a stand of White Spruce. Another melanistic Red Squirrel was also observed by the second author in the Upper Nine Mile River region (Ess Road; 44°69'41"N, 63°59'00"W) on January 12, 2008, but it is uncertain whether these 2 sightings are of the same individual.

An earlier record of a melanistic Red Squirrel in Nova Scotia was brought to our attention by Fred Scott (Acadia Wildlife Museum) and Mark Elderkin (Nova Scotia Department of Natural Resources). A young subadult melanistic Red Squirrel was collected from Melanson Kings Co., Nova Scotia, by Ivan M. Levy (owner and operator of the S. G. Levy and Sons Ltd. sawmill) on June 11, 1983 and deposited in the mammal collection at the Acadia Wildlife Museum (Catalogue Number MA 1847; Figure 2). This voucher was one of several melanistic young individuals observed from the same litter (M. Elderkin, personal communication). Recorded external measurements from the attached tag for this specimen are as follows: total length = 225.0 mm; tail length = 110.0 mm; hindfoot length = 40.0 mm; ear length = 19.0 mm; mass = 47.8 g.

Although Banfield (1974) stated that melanism is "occasionally seen" in Red Squirrels, he did not cite any references that supported this claim. Upon review



FIGURE 1A & B. A young adult, melanistic American Red Squirrel (*Tamiasciurus hudsonicus*) observed foraging in Upper Nine Mile River, Nova Scotia. Photos by Rita Viau (A) and Bernard Burke (B).



FIGURE 2. A subadult melanistic American Red Squirrel (*Tamiasciurus hudsonicus*) collected from Melanson Kings Co., Nova Scotia deposited in the mammal collection at the Acadia Wildlife Museum (Catalogue Number MA 1847). Photo by Howard Huynh.

of the scientific literature, the paucity of relevant sightings and reports seems to suggest that melanism is actually a rare phenotype in Red Squirrels. Layne (1954) stated that "abnormal color variants are uncommon in the red squirrel" and that "melanic specimens are rare." Likewise, Woods (1980) commented that "melanistic Red Squirrels are rarely encountered." Steele (1998), although citing a few reports of melanistic Red Squirrels, noted that pelage aberrations of any kind are relatively rare in this species. Benton (1958), who reported 4 melanistic Red Squirrels (presumably all from the same litter) from New York, also commented that melanistic Red Squirrels are "apparently rare." To our knowledge, no melanistic Red Squirrels have ever been reported from Nova Scotia, making the observations reported here the first records for the province. Interestingly, Adams (1873), who apparently made a special effort to record information on melanism (and albinism) in eastern Canadian wildlife, noted that a population comprised entirely of melanistic Red Squirrels was found on the south coast of New Brunswick. The information was provided to Adams by George Boardman, a well-known ornithologist and naturalist in the region (McAlpine 1994), but nothing in Adams (1873) suggests that Boardman observed melanistic Red Squirrels himself. Unfortunately, the precise location of the observation provided by Boardman was not recorded and no subsequent comments or information on this population have since been published (Layne 1954). None of the more recent discussions of the mammal fauna of Maritime Canada (e.g., Rand

1933, Smith 1940, Cameron 1958, Peterson 1966, Squires 1968, and Dilworth 1984) report melanism in the Red Squirrel, attesting further to the rarity of melanistic individuals of this species in this region.

Various hypotheses have been put forth in an attempt to explain the adaptive significance of melanism in sciurids. Though some experiments have shown that melanistic Gray Squirrels experience advantageous thermoregulation in cold environments (e.g., Innes and Lavigne 1979; Ducharme et al. 1989), the hypothesis of melanism conferring selective advantage in northern, colder environments has not been addressed in Red Squirrels. Considering that Red Squirrels have low thermal insulative capacity due to their small body size (Irving et al. 1955), restrict their activities to sub-nivean space during cold temperatures (Pruitt and Lucier 1958), and remain relatively inactive in winter (Banfield 1974), melanism may not contribute significantly to beneficial thermoregulation in this species. Mengel and Jenkinson (1971) suggested that melanism in a Red Squirrel taken from Yukon, Canada, may be attributed to fire melanism – i.e., dark individuals residing on a dark substrate, the latter resulting from burning of landscapes by fire (Guthrie 1967). However, the frequency of fire acting as a natural disturbance event in Nova Scotia forests is low due to fire suppression practices (Davis and Browne 1996). Hence, it is likely that melanism is not an adaptive polymorphism for Red Squirrels in Nova Scotia in response to fire disturbance regime. Regardless, the rarity of melanism in the Red Squirrel generally suggests that

it is not an adaptive polymorphism in this species, and that any hypothesized selective advantages associated with this phenotype (e.g., thermoregulation, camouflage, disease resistance) to Red Squirrels in Nova Scotia or elsewhere has yet to be determined.

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Wolf, *Canis lupus*, Pup Mortality: Interspecific Predation or Non-Parental Infanticide?

A. DAVID M. LATHAM^{1,2} and STAN BOUTIN

Department of Biological Sciences, CW405, Biological Sciences Building, University of Alberta, Edmonton, Alberta T6G 2E9, Canada

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¹Present address: Landcare Research, Gerald Street, P.O. Box 40, Lincoln 7640, Canterbury, New Zealand

²Corresponding author: email: ADM.Latham@yahoo.co.nz

A breeding male Gray Wolf, *Canis lupus*, equipped with a GPS collar was documented going to the den site of another Gray Wolf pack. This trip was coincident with an attack on the den of the other pack and the occurrence of a dead and partially consumed Gray Wolf pup at the same location. We present two possible explanations—interspecific predation and non-parental infanticide—to account for this observation. Because the Gray Wolf with the GPS collar and his mate were first-time breeders and were attempting to establish a territory space of their own, we speculate that, based on the available evidence, this observation most likely represents a case of non-parental infanticide that fits the predictions of the resource competition hypothesis.

Key Words: Gray Wolf, *Canis lupus*, interspecific predation, non-parental infanticide, resource competition hypothesis, Alberta.

Intraguild predation and competition can result in the killing of individuals from species within the same guild, whereas intraspecific competition can result in the killing of individuals within the same species. The large carnivore guild in northeastern Alberta consists of Gray Wolves (*Canis lupus*), Coyotes (*C. latrans*), and American Black Bears (*Ursus americanus*). Although Gray Wolves have been shown to be competitively dominant over Coyotes and American Black Bears, there have been a few reports of interactions in which American Black Bears have chased or killed Gray Wolves (Ballard et al. 2003). Intraspecific competition or intraspecific strife can be an important source of mortality within a population, and for Gray Wolves it has been shown to be one of the commonest sources of mortality outside of human exploited Gray Wolf populations (Mech and Boitani 2003). Although many deaths occur as a result of disputes between packs at territorial boundaries, disputes can also occur within a pack's territory (Mech and Boitani 2003).

The aim of this note was to document a trip by a breeding male Gray Wolf to the den site of another Gray Wolf pack and the occurrence of a dead and partially consumed Gray Wolf pup at the same location. We present two possible explanations—interspecific predation and non-parental infanticide—to account for the pup's mortality.

Study Area and Methods

Between January 2006 and January 2008, we conducted a radio-tracking study on a Gray Wolf population near the town of Wabasca-Desmarais (55°57'N, 113°49'W) in northeastern Alberta. During this period, we deployed 20 very high frequency (VHF) radio-collars and 12 remote downloadable global positioning system (GPS) collars (Lotek Wireless, Aurora, Ontario,

Canada) on Gray Wolves from 11 packs. GPS collars were programmed to provide a location every 2 hours, whereas telemetry flights were flown 3 or 4 times per month (Latham 2009). We subsequently investigated the clusters of locations (i.e., locations in close temporal and spatial proximity; Anderson and Lindzey 2003) retrieved from the GPS collars to investigate kill sites and to collect Gray Wolf scats (i.e., to assess food habits).

Results

The Calling Lake pack consisted of a first-time breeding pair (Wolves 8 and 31) and their litter of six pups (Latham 2009). On 22 June 2007, we investigated a GPS cluster generated by the breeding male from the Calling Lake pack (Wolf 31). Wolf 31 generated this cluster just outside the northwestern boundary of his territory on 25 and 26 May 2007 and he subsequently returned to his den site. The approximate round-trip distance from Wolf 31's den to the cluster and back to his den was 70 km. Wolf 31 did not go to this location at any other time during our study. To our knowledge, his mate (Wolf 8), who was equipped with a VHF radio-collar, did not accompany Wolf 31 to this location, because data from telemetry flights placed her at (or near) her den throughout the month of May.

Examination of the site associated with the GPS cluster revealed a recently used Gray Wolf den belonging to a pack unknown to us. The den was approximately 22 km in a direct line from the den site of the Calling Lake pack. The southeast-facing entrance of the den had been dug under the roots of a White Spruce (*Picea glauca*) stump situated beside a stream. Closer examination of the site revealed extensive digging on the western side of the den that appeared to be an attempt to gain access to the denning chamber. Claw

marks on the tree roots where the digging occurred were more recent than those at the den's entrance, and they appeared to be those of a large mammalian carnivore. Based on the size of the claw marks on the tree roots, they were most likely Gray Wolf or possibly American Black Bear.

Further investigation of the site revealed the partially consumed carcass of a Gray Wolf pup estimated to be 4 to 5 weeks old on the grass outside the den. The carcass consisted of the upper and lower jaw bones (including the nose), the lower portion of the legs (including the feet), and the hide. The leg bones and skull had been completely sheared by a predator's teeth. The carcass was filled with maggots and had begun to decay. In addition to the Gray Wolf pup carcass, the skulls and fur of two Beavers (*Castor canadensis*) were found at the site.

The area surrounding the den site was further examined for evidence of potential predators/scavengers, particularly American Black Bear, Coyote, Red Fox (*Vulpes vulpes*), and Common Raven (*Corvus corax*); however, the only sign (tracks, scat, and hair) of predators that was evident in the area was that of Gray Wolf.

Interspecific predation?

We suggest two explanations to account for the destroyed and vacated den and the dead and partially consumed Gray Wolf pup at this site. First, a sympatric predator such as an American Black Bear, a Coyote, or a Red Fox could have found the den site, destroyed it as it attempted to gain access to one or more pups that were hiding, and killed and eaten the pup that we found (i.e., interspecific predation). However, while there have been a few accounts of mature American Black Bears chasing off (or in one instance killing) lone wolves (Joslin 1966; Rogers and Mech 1981; Fremmerlid and Latham 2009), we are unaware of any instances where these species have attacked a Gray Wolf den or killed Gray Wolf pups. Furthermore, although these opportunistic predators may be capable of attacking and killing Gray Wolf pups, they have been shown to be the loser in competitive interactions with Gray Wolves, particularly in a pack (e.g., Carbyn 1982; Peterson 1995; Ballard et al. 2003). We therefore argue that Gray Wolf dens are dangerous places for these species to forage and that these predators should be expected to avoid the dens of Gray Wolves. In addition, we found no evidence of tracks, hair, or scat belonging to any of these species in the vicinity of the den site. Consequently, while interspecific predation remains a possible explanation for our observation, we believe that evidence for this explanation is lacking. Similarly, we observed no evidence of Common Ravens scavenging at the site, and Common Ravens are unlikely to shear through leg bones. Thus, scavenging by Common Ravens did not influence our conclusions.

It is also possible that the pup died of unknown causes and was scavenged by its parents, by its litter mates, by Wolf 31, or by an alternative predator species. The primary piece of evidence that suggests that this is not the case is the apparent digging to gain access to the den. Within the denning chamber, there were numerous small spaces associated with the tangle of tree roots where a pup could hide from predators. It appears likely that the comparatively recent digging that exposed the denning chamber was an attempt by a predator to gain access to one or more hiding pups, not a dead pup. Furthermore, if the pup was scavenged rather than killed, it appears illogical that the parents would destroy their own den to gain access to the dead pup. Finally, we argue that it was unlikely that the pup was scavenged by its litter mates because this would not account for the destruction of the den, nor do we believe it possible that litter mates 4 to 5 weeks old would be capable of shearing through the femur and skull of a dead sibling (Packard 2003).

Non-parental infanticide?

GPS data and subsequent field investigations have been used to help infer all manner of results from predator-prey research in recent years (e.g., Anderson and Lindzey 2003; Demma et al. 2007; Webb et al. 2008), and we believe a more parsimonious explanation for our observation is that the trip by Wolf 31 to the unknown pack's den site resulted in the den being attacked and (at least) one pup being killed (i.e., non-parental infanticide) (Hrdy 1979; Ebensperger 1998). The most important evidence to support this claim is the fact that GPS data placed Wolf 31 at the den site for two days (non-maternal wolves frequently leave their den for two or more days at this time of year) where the pup was killed at approximately the same time as the pup died. In addition, the estimated age of the pup supports Wolf 31 being responsible for its death. Assuming an average birth date of mid- to late April for Gray Wolves in Alberta (Latham 2009; Webb 2009), the estimated age of the pup at the time of death (4 to 5 weeks) matches the dates when Wolf 31 was documented at the den (25 and 26 May).

Discussion

Non-parental infanticide has been reported from a wide variety of animal taxa (Ebensperger 1998), including the family Canidae. For example, it has been documented from captive populations of Dingoes (*Canis lupus dingo*) (Corbett 1988), Indian Wolves (*C. lupus pallipes*) (McLeod 1990), and Wolves (*C. lupus* ssp., Altmann 1974 in Packard 2003; Altmann 1987 in Packard 2003). In all cases, females were responsible. Furthermore, non-parental infanticide has been reported in wild Coyotes (Camenzind 1978), African Wild Dogs (*Lycaon pictus*) (van Lawick 1973), and Red Foxes (Vergara 2001). Females are believed to have been responsible in the two former cases, whilst

the sex in the latter was unknown. Non-parental infanticide has not previously been documented in wild Gray Wolves; consequently, our observation represents the first possible account of non-parental infanticide by a wild male Gray Wolf.

Most explanations of non-parental infanticide suggest some adaptive benefit to the perpetrator (Hrdy 1979; Pierotti 1991). In our opinion, the resource competition hypothesis, which suggests that infanticide may eliminate competition for the animal responsible, or its offspring, to limited physical resources such as food, nesting sites, or space (Rudran 1973; Hrdy 1979), provides the most plausible explanation for the current possible case of non-parental infanticide.

This hypothesis makes two predictions: infanticide is expected to be more prevalent (1) under conditions when resources are more limited and (2) when population densities are high (Butynski 1982). Gray Wolf densities in this region of northeastern Alberta have increased substantially over the last 15 years; however, there has also been a substantial increase in the availability of prey (Latham et al. 2011). Despite the apparent contradiction, it should be emphasized that Wolf 31 and his mate, Wolf 8, were young wolves attempting to carve out a territory of their own in a space that had become available after the demise of the pack that formerly occupied that space (Latham 2009). There were likely other Gray Wolves (floaters or neighbouring packs) also attempting to claim this available space (Mech and Boitani 2003). Consequently, Wolf 31's behaviour may have been an attempt to eliminate current or future competition for limited physical resources (prey and territory space) within an area that he and his mate were trying to establish as their own.

Given our knowledge of territoriality in Gray Wolves (see Mech and Boitani 2003), it is not surprising that non-parental infanticide is not a commonly observed phenomenon in wild Gray Wolf populations. Gray Wolves put considerable effort into territory defence, particularly during the breeding season (Peters and Mech 1975). Consequently, instances of a Gray Wolf going to a neighbouring pack's den site are probably rare. However, where space for a territory has become available (such as in the current example), non-parental infanticide may be less of a rarity as competing Gray Wolf packs or floaters vie to establish an exclusive territory. Because Gray Wolf pups are easier to kill than adults, one would expect that, during such boundary disputes, a Gray Wolf from a competing pack would target pups rather than adults in an attempt to reduce future competition.

Although the current example of non-parental infanticide has been inferred from GPS data and subsequent field investigation, we believe that available evidence from the site and the predictions associated with the resource competition hypothesis support a non-parental infanticide scenario. Current technology, such as GPS collars with downloadable data, in combination with

timely field investigations, may help to clarify the importance and role of non-parental infanticide in territorial animals (such as Gray Wolves) where little information currently exists.

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Killing and Caching of an Adult White-tailed Deer, *Odocoileus virginianus*, by a Single Gray Wolf, *Canis lupus*

MICHAEL E. NELSON

U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711-37th Street Southeast, Jamestown, North Dakota 58401 USA; mailing address: 7332 Tracy Road, Duluth, Minnesota 55803 USA; email: meklnelson2@gmail.com

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A single Gray Wolf (*Canis lupus*) killed an adult male White-tailed Deer (*Odocoileus virginianus*) and cached the intact carcass in 76 cm of snow. The carcass was revisited and entirely consumed between four and seven days later. This is the first recorded observation of a Gray Wolf caching an entire adult deer.

Key Words: Gray Wolf, *Canis lupus*, White-tailed Deer, *Odocoileus virginianus*, caching, surplus killing.

When killing ungulates during winter, Gray Wolves (*Canis lupus*) typically remain near kill sites until the prey is entirely eaten (Mech 1970). The exception to this is "surplus killing," when escape by prey is impeded by features of the landscape and Gray Wolves kill more than they can immediately consume (Mech et al. 1971; Carbyn 1983; Miller et al. 1985; Boyd et al. 1994; DelGiudice 1998). Throughout the year, meat and other prey parts that are not immediately consumed are cached underground or beneath snow (Mech 1970; Adams et al. 1995; Nelson and Mech 2011). Herein, I report the caching of an intact adult male White-tailed Deer (*Odocoileus virginianus*) killed by a single Gray Wolf during a winter of extreme snow depths.

Study Area and Methods

The event occurred during a long-term study of White-tailed Deer in northwestern Lake County in the Superior National Forest in northeastern Minnesota (48°N, 91°W, Nelson and Mech 1981, 2006). Topography is flat, dominated by lakes and rivers (Heinselman, 1996). Forests are primarily deciduous-coniferous mixtures of Aspen (*Populus tremuloides*), Jack pine (*Pinus banksiana*), and Spruce (*Picea* spp.) (Heinselman, 1996). Temperatures and weekly snow depths during February when the observation occurred average -13°C (Heinselman, 1996) and 46 cm (Nelson unpublished 1975–2010) respectively. Gray wolf (*Canis lupus*) predation is the primary cause of winter deer mortality (Nelson and Mech 1986). The White-tailed Deer in this observation was captured in a Clover trap, radio-collared, and followed 2–3 times per week by aerial radio-tracking (Nelson and Mech, 1981, 2006).

Results

An 8.5-year-old radio-collared male White-tailed Deer died between 2 and 5 February 1996. On 8 February I found the carcass completely buried intact, covered with ~10 cm of snow. The snow depth was 76 cm, requiring snowshoes for human travel. A deep, narrow trail led to the kill site, which became apparent only after my snowshoes contacted compacted snow cov-

ering the White-tailed Deer and the radio-collar's signal confirmed that the collar must be underneath the snow. Snow mixed with a few broken dead twigs had been raked over the carcass from a radius of ~1 m. I cleared the compacted snow by hand to expose the White-tailed Deer, being careful not to disturb the hair or other evidence related to cause of death.

There was a single large carnivore track present, but the track details and other tracks were masked by the fluffy snow from the sides of the deep trail created by the chase. The chase must have taken place within the confines of the single deep trail because there was no other trail or track sign on either side of it. The carcass was cached in the trail next to two dead conifers ~8 cm in diameter, presumably at the site of death because there was no drag path away from the pursuit trail. The legs were angled down below the body, with the hooves buried deep in the snow, which covered the legs completely. I removed the snow from the head and neck first and found a few drops of blood on the throat and the snow beneath it. I removed the remaining snow from the carcass and found no further evidence of external trauma (i.e., tooth punctures, gashes, hair loss).

I necropsied the White-tailed Deer on site. The White-tailed Deer weighed 89 kg, the same weight as when it was radio-collared two years earlier. He had no remaining back, heart, kidney, or omental fat, but I collected a section of femur marrow fat for dry weight measurement of fat content (Neiland 1970), later measured at 50%. Bone marrow is the last site of depletion of stored fat, and it was at a level indicating poor nutritional condition as a result of nearly complete catabolism of all body fat (Verme and Ullrey 1984; DelGiudice 1998). Dissection of the neck showed subcutaneous haemorrhaging and contusions at the puncture sites. Two holes 40 mm apart on one side of the throat matched an open cut 35 mm long on the opposite side of the throat, measurements that match the distance between the canines from a cleaned Gray Wolf skull from within the study area. Death appeared to have resulted from the throat-hold.

I left the carcass uncovered at the site on 8 February. An unknown number of days later multiple Gray Wolves returned and consumed the carcass. Depending on when the White-tailed Deer was killed, it was not consumed until 4–7 days later. It is unknown if the same Gray Wolf that killed the White-tailed Deer returned to feed on it.

Strangulation by Gray Wolves with no obvious evidence of trauma was also the cause of death of an intact adult male American Elk (*Cervus elaphus*) I examined in Yellowstone National Park, Wyoming, in March 1997. The Elk was in poor condition at the end of a severe winter, as evidenced by lack of internal fat deposits and visibly low levels of fat in the femur marrow.

Discussion

All the evidence indicates that a single Gray Wolf grabbed the White-tailed Deer's throat and strangled it. In snow depths < 50 cm, White-tailed deer can plant their legs on firm ground and they are able to run, bound, jump over objects, and turn acutely, and, when cornered, can strike attacking predators with their hooves and antlers (Mech 1970; Nelson and Mech 1985, 1993). I have even observed a White-tailed Deer standing and facing off against three Gray Wolves that surrounded it but were hesitant to approach it and finally left it alone (Nelson and Mech 1994). It follows that, when impeded by deeper snow, as in this case, a White-tailed Deer most likely loses all the aforementioned defenses, enabling a single Gray Wolf to kill it. However, direct observation of a kill under these conditions has not been reported.

Later in the winter of 1996, three more radio-collared White-tailed Deer were killed by Gray Wolves and not immediately or completely consumed. The first, which was killed in March, when snow depths reached 90 cm, also had bite marks on its throat. In April, when snow depths had receded to 70 cm, Gray Wolves killed two more radio-collared White-tailed Deer; one was 10% eaten and the other was uneaten when examined. The uneaten White-tailed Deer was killed 1 km from the cached White-tailed Deer in this account.

Concurrently, southwest of my study area, Gray wolves also underutilized their kills (DeGiudice 1998), just as Gray Wolves did in my study area in 1969 when snow depths exceeded 80 cm (Mech et al. 1971). However, neither study reported evidence of caching, although DeGiudice (1998) reported deer killed by Bobcats (*Lynx rufus*) which are present in my study area along with similar-sized Canada Lynxes (*Lynx canadensis*). Both species kill ungulates by bites to the throat and both cache parts of their prey (Bergerud 1971, Labisky and Boulay 1998). Although rare in my study area, a Canada Lynx previously killed a radio-collared White-tailed Deer by gripping the throat (unpublished). The distance between the canines in the Canada Lynx is ~ 25 mm, roughly 60% that of the dis-

tance in the Gray Wolf which excludes a Canada Lynx and a Bobcat as the predator that killed the White-tailed Deer in this observation.

Similar to my observation, one of my pilots recounted an aerial observation he made years earlier of a lone wolf bedded on top of a deer the wolf had killed approximately an hour prior to the observation. He first observed the wolf feeding on a deer it had just killed on a frozen snow-covered lake. The pilot made a return flight over the kill hours later, and the wolf was bedded on top of a mostly snow-covered deer. Although the observation was not made from the ground, it suggests that the bedded wolf had covered much of the deer with snow.

Nelson and Mech (2011) reported a wolf burying a White-tailed Deer's head and neck with the radio-collar still attached under the snow and then bedding on top of it. Adams et al. (1995) reported the caching of an intact Caribou (*Rangifer tarandus*) calf in snow, and Schultz (2010) observed an intact fresh White-tailed Deer foetus cached in snow and scent-marked with urine by wolves.

This observation is the first record of a Gray Wolf caching an entire adult deer. However, it is unknown if such caching is unique to the deep snow which already surrounded the deer's legs and which may have enabled the Gray Wolf to cover the rest of the body more easily.

Acknowledgements

This research was supported by the U.S. Geological Survey, U.S. Forest Service, Northern Research Station, and the Special Projects Foundation. I also acknowledge volunteer wildlife technicians who assisted in live capture of White-tailed Deer and who helped retrieve radio-collars. I also thank the pilots of the U.S. Forest Service for skilful and safe flying and specifically pilot Douglas Bohman for his observation. I followed the American Society of Mammalogists Guidelines (Animal Care and Use Committee) for animal handling and care in conducting research.

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Book Reviews

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

ZOOLOGY

Birds of the Aleutian Islands

By D. Gibson and G. V. Byrd. 2007. Alaska, Series in Ornithology No. 1. The Nuttall Ornithological Club & The American Ornithologist's Union, 5405 Villa View Drive, Farmington, New Mexico 87402 USA. 351 pages. \$47.50 USD.

The overly enthusiastic book jacket reads: "*Most significant book ever published on Alaskan birds*". And, "*The volume represents the first in a series of avian monographs published jointly by Nuttall Ornithological Club – the oldest natural history society in North America, and the American Ornithologists' Union – the largest ornithological society in the world*".

Well, one would wish they could do better than this book then. The main problem with this publication is less its accuracy on the birds of the fascinating Aleutians, but its message: which basically is NONE. The book just represents a classic old school of ornithology which entirely lacks a reality check. There is for instance no hint about Global Climate Change (with Alaska being one of the prime places to see this), nor a real hint about the massive impact of fisheries (the Aleutian Island chain having one of the largest fisheries in the world; thus, and as elsewhere in the world, bycatch, discard and overfishing issues must be huge), or a relevant mentioning of chronic oil pollution, contamination, ghost nets, plastic debris, invasive plants and cumulative impacts for instance. Naturalists pick such details up within an eyeblink. They know for many decades that (sea-) birds reflect the habitat. But simply leaving these environmental factors out is all but 'objective science' or meaningful ornithology. Although any of these topics are found in the scientific, public and even ornithological and taxonomic literature for over 20 years by now, the authors and their book just try to look to the other side. The magnitude of the human footprint even in remote areas such as the Aleutian Islands can already be seen by the 600 (!) Raven sightings reported during winter on Unalaska. If Ornithologists want to be taken seriously, and provide best professional advice (as hinted here in this book and approved by AOU etc.), in the year 2007 and beyond, we cannot afford to fully ignore globally applicable, well worked-out ecological ideas, and simply retreat on the notion of: 'feathers and plumages' and compiled opportunistic sightings. This just makes for a job half-done: counting the deck chairs on the Titanic. And so the book and its single chapter with four appendices suffers from this mindless type of descriptive shotgun ornithology. It's definitely not sci-

ence (e.g., no hypothesis got asked by the authors, no wider context, methods and ethics questions got raised in the classroom). It's easy to show for instance that basically ALL the density estimates in this book can be ignored for true abundances (e.g., detectability and survey effort problems are virtually not addressed to this very day in almost any pelagic bird work in the Aleutians; same is true for any relevant research design to obtain better estimates). Data presented in this book were simply uncritically pooled, museum-style, from various survey methods and protocols during more than 35 years (standard methods such as mist-netting, point counts or mark-capture-recapture are not mentioned). Consequently, the inference on 'habitat use' must be dubious (e.g., in Tables 8, 9 and 10; for details on such topics see for instance various papers in THE AUK on that very issue). Due to the above, and also as a disappointment to managers, this book fails also on its trend and population estimates; it further leaves endangered and candidate species basically untreated. In other words: the Aleutian Islands National Wildlife Refuge established in 1913, and a designated International Biosphere reserve in 1972 by the U.S. Department of State, lacks relevant and ecologically meaningful avian pelagic inventory data to this very day. This book makes it clear and these details are rather surprising and when considering that Alaska has over 20 wildlife-related statisticians (one of the highest concentrations anywhere in the U.S., and likely in the world) ready to help as needed, and that the Aleutians are a global oil spill and traffic hotspot for many decades.

The opening pages of this book give a nice overview on the discovery history of the region. But if I were an Aleutian native, I would be rather offended by this publication because the native view and culture – for over 10,000 years in existence is virtually ignored. Equally ignored is an advanced Ecosystem view, e.g., food items, energy flow, processes and habitat (the authors base this mostly on a 30 years old publication by Kessel 1979).

The Aleutian avifauna currently comprises of 299 species and subspecies, of which 272 species and 28 subspecies are discussed in this book. Some readers

might argue about *Motacilla* and the subspecies taxonomy. The phylogenetic sequence and scientific and English names follow the Check-list of North American Birds (AOU 1998), but NOT ITIS (Integrated Taxonomic Information System www.itis.org) and as widely used by the U.S. Federal Government and carrying a global mandate (museums and refuges should at least refer to this scheme). The perplexing Aleutian Cormorant (taxonomic) history is covered nicely though, and likely among the best sources on this topic anywhere.

As expected from the authors, this book is strong on the story of invasive rats and foxes, and their almost endless eradication efforts on the Aleutians. However, in this book, we never really learn about the hopelessness of such work and its underlying core reasons (re-occurring 'rat spills', as well as invasive species, are basically a function of a mis-managed global economy, and can re-occur at any time, setting such eradication programs back to square one and adding to the true and huge costs of globalization that not well accounted).

The Aleutian climate section of this book is outdated, carrying references from 1973 etc. What will be equally surprising to most readers though is that El Niño and Regime Shifts are not really mentioned, neither. This book gives us the impression that predominantly it tried to compile bird records from the 40s, 50s, and 60s, and that it was written in the 80s. And therefore, this publication is really strong in its narrow compilation of historical records, but basically does not read well. This is because its core consists of nothing but plain species list compilations. Much arm-waiving can be found there to explain them, and the text is full of citing exceptions and outliers (a strength of this book). Because these records were mostly collected and published opportunistically, their interpretive value is rather limited, and the authors made no attempt in helping the reader with what it all really means (in several occasions the authors comment on dubious observations). The reported Bird Banding Records I find patchy. Helpful records such as from Citizen Science (http://depts.washington.edu/coasst/find_a_beach.html), OBIS-Seamap (<http://seamap.env.duke.edu>), ORNIS (<http://www.specifysoftware.org/Informatics/informaticsornis>). Beringian Seabird Colony Catalogue (http://gcmd.nasa.gov/records/GCMD_seamap270.html), Offshore Survey work (<http://www.absc.usgs.gov/research/NPPSD/index.htm>); just think of the Fisheries and Offshore Oil & Gas Impact, as well as the Fisheries Observer projects alone) are bluntly missing. It is unclear whether Dave Sibley's sightings, as well as observations made by other competent observers and birders were included. In the text and appendix the authors make a nice hint to the huge underlying University of Alaska Museum Collection (8,000 specimens collected from 1827 to 2000), but its digital online version, ARCTOS (<http://arctos.database.museum/home.cfm>), does not get mentioned. Instead, authors

refer to a dead-end PDF (Checklist of Alaskan birds at www.uaf.edu/museum/bird/products/checklist.pdf). The provided overview and Gazetteer of the Aleutian Islands is already easily outcompeted by the Wikipedia reference (http://en.wikipedia.org/wiki/Category:Islands_of_Alaska) on Alaskan Islands, globally available free of charge. The authors make reference to field data they compiled, and which must be on file somewhere with the Museum (an apparent major data source. It would be nice though to have this precious information readily available for a global audience, e.g., online in ORNIS). This matters especially in times of massive development of the region by offshore oil and gas and nearby mining.

Unfortunately, the book also carries relatively little Russian information (with the Kommandeurs Island being a natural part of the Aleutians and actually one of the best studied islands in Russia overall, with observations starting 1930s onwards. Updated citations from Russia are also missing). *In lieu* of the overarching Beringia ecosystem, and considering that the Aleutians link for centuries international markets such as China, Japan and India with the Americas, such a lack of information must be seen as a lost opportunity. From all colonial powers, the Russians, (and some English and Spanish) were there first, after all, and kept precious naturalist notes.

For the over 150 islands of the Aleutian Chain, the species sections of the Gyrfalcon, Yellow-billed Loon, Spectacled Guillemot, or for the eider duck species, for instance, show clearly how incomplete the records of this book are. Judged from similar reports elsewhere (e.g., Bay of Fundy), I believe the few reported South Polar Skua sightings in the Aleutians are underestimates.

Imprecise wording issues occur throughout the book, and no real consistent terminology is found. For instance, what is really the biological difference between a hypothetical and an accidental occurrence, and where to draw the line and when considering that all sorts of sightings from various data protocols were simply merged? I am unclear what authors exactly mean when they refer to 'Amurland', or breeding, migration and wintertime, and non-breeders (Table 3 is helpful though).

I like Table 5 (timing of earliest egg laying) and the 32 photos (photo 6 made bird history showing thousands of shearwaters etc., off Akutan Island). I was not able to spot relevant typos and errors in the text. But some of the observer and institutional abbreviations I could not find explained, and I have not understood why in several instances some coordinates actually lack the latitude!

As can be expected for a treatise of a major island chain like here, readers will learn some details about island biogeography, e.g., island hopping, dispersal, ptarmigans (a classic topic for the Aleutians) and subspecies. But this book is not really informative on

endemic genetics, and not on the global context of the Aleutian Islands, e.g., species reservoirs.

Obviously, this book can be used to describe some very relevant aspects of ornithological, Alaskan and environmental history, but the virtual absence of key words and textbook concepts such as Conservation, Adaptive Management and Sustainability must simply be perceived as 'tragic'. It leaves a clear political profile and statement. The compiled literature cited I find informative, but sometimes rather selective (e.g., milestone publications by T. Gaston and I. Jones, D. Klein and A. Springer are missing).

Overall, I think this book does fill a gap, but not a huge one (and unfortunately not a digital one), nor one that helps managers to manage seabirds better or to conserve them for the global village. Keep in mind: Pebble Mine (one of the largest Copper Mines) is expected to affect parts of the Aleutians, and Bristol Bay is forecasted by NMFS to be a major supplier of offshore oil & gas in the U.S. Further, Arctic Shipping

will run by the Aleutians! These are all global, not only Alaskan or American topics. Including future study needs for the Aleutians would have been nice, too. So if this volume is the "*Most significant book ever published on Alaskan birds*" one should be rather scared. Instead, I find that this book represents the end of an era. It stands out as a symbol of a wrongly understood, ignorant ornithology, wildlife and environmental science for Alaska and beyond, but politically supported for decades by our all tax dollars, that ignores the real needs of the living and non-living world harming the future of the globe and its citizens. Instead, relevant progress and the provision of leadership is still immediately required for a meaningful Ornithology and Resource Management. Naturalists are urgently asked to help and improve the current situation.

FALK HUETTMANN PHD, ASSOCIATE PROFESSOR
EWHALE lab, Institute of Arctic Biology, Biology & Wildlife
Department, University of Alaska-Fairbanks, Fairbanks,
Alaska 99775 USA

The Stokes Field Guide to the Birds of North America

By Donald W. Stokes and Lillian Q. Stokes. 2010. Little, Brown and Company, New York, New York. 792 pages. \$24.99 USD.

Donald and Lillian Stokes have carved themselves a special niche in the bird field guide world; they specialize in producing field guides that use photos of birds rather than drawings, such as the Sibley guide (2000). The Stokes guide, however, is not just a bunch of bird photos; it's a carefully designed guide that will aid birders in the field regardless of experience level.

The Stokes guide has an informative introduction, with sections on how to use the guide, key to the species accounts, how to interpret the range maps, and basic bird exterior anatomy. The species accounts make up the bulk of the book. The accounts are grouped in colour-coded sections; as you flip through the coded page bottom, the group names appear: "Curlew", "Flycatcher", "Thrasher", "Falcon", and so forth. It's a very handy feature.

The introduction states that the range maps are the most up-to-date, when compared to other guides, and include the American Birding Association's rarity rating code for each species and known wild hybrids. The scientific names and common name conventions are up-to-date and reflect recent taxonomic revisions.

The 854 species accounts are laid out to aid the birder in the field, with the photographs and range maps all on the same pages. The accounts contain all the information needed when in the field, such as the shape of the bird, various seasonal morph and age descriptions, subspecies information, hybrids, what the bird looks like in flight, the habitat it occupies, differences between males and females, and what the voice sounds like. Included with the guide is a CD that has more than 600 songs and sounds of 150 birds. A headphone

symbol at the end of the account informs the reader that the bird's voice is included in the CD.

The more than 3,400 photographs are all in colour (except for some of the Ivory-billed Woodpecker [*Campephilus principalis*] photos which are black-and-white; one is colourized) with the birds facing to the right. I was sceptical when I first encountered the Stokes guide series several years ago (I had the *Stokes Field Guide to Birds: Western Region* [1996] that I bought in 1997), wondering how someone could identify a bird using photos alone, since photos are only snapshots in time, reflecting age, feather patterns, and general condition at the moment the photo was taken. Certainly, a generalized image was needed that illustrated what the typical bird in the field should look like, as purported by the Peterson bird guide (2008). However, as I examined the photos selected for the Stokes Guide, I was impressed with the quality of the photos used to represent the birds a wildlife observer may encounter in the field. In most cases, several photos are included, such as the juvenile form, summer and winter forms, males and females, and for some birds, the 1st, 2nd, and 3rd year forms. Each photo even has a state abbreviation next to it noting where the bird was photographed, aiding in regional differences. However, some photos are not as good as they could be, such as the photo of the Black Swift (*Cypseloides niger*), page 413. No feather details can be discerned and it is basically a black silhouette. However, when I showed the photo to another biologist, he mentioned that because this species is such a rapid flier, the key identification feature needed is the general shape, i.e., the

slightly notched tail and finely pointed wings. Keeping these comments in mind, the photo indeed adequately includes these points and I would guess an observer could identify a Black Swift if using this guide in the field. I am sure photographing such a fast flying bird is a challenge as well.

Other features in the guide include a glossary, key to state, province, and international location codes, and an index. Folded in the front cover is a quick alphabetical index. For some bird groups that are difficult to identify and tell apart, such as the gulls, a special identification tip section is included (i.e., page 289).

Overall *The Stokes Field Guide to the Birds of North America* will serve well the naturalist and wildlife observer that prefers photos over drawings. The Guide is said to be the most up-to-date guide currently available and includes all the latest high-interest rarities

(back cover). This alone makes it a worthwhile volume to have. Dimension-wise, it is not a small guide (22 × 15 × 5 cm), but smaller than some (i.e., Sibley 2000; 25 × 16 × 4 cm), and is rather heavy (1.36 kg), however do not let size hold you back on picking up a copy; it is a very useful guide and with bird watching as popular as ever, it is a good guide to have in your wildlife library.

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HOWARD O. CLARK, JR.

H. T. Harvey & Associates, 7815 North Palm Avenue, Suite 310, Fresno, California, USA

Manual of Central American Diptera, Volumes 1 and 2

Edited by B. V. Brown, A. Borkent, J. M. Cumming, D. M. Wood, N. E. Woodley, and M. A. Zumbado. 2009 and 2010. NRC Research Press, Ottawa, Ontario, Canada. Volume 1, 714 pages, \$95 CAD. Volume 2, 748 pages, \$95 CAD.

Like the common housefly, the newly published *Manual of Central American Diptera* (MCAD) is a curious beast that is best understood when put in context. Rather than being the product of spontaneous generation, this two-volume set is the culmination of a decade of writing, illustrating, and editing on the part of six editors and dozens of chapter authors. The current manual is the latest contribution to a long-term international collaboration on the part of dipterists. A three-volume *Manual of Nearctic Diptera* was published in 1981-1989 and *Contributions to a Manual of Palaearctic Diptera* was published in four volumes in 1997-2000. A multi-volume *Afrotropical manual* is in progress, with publication likely by 2020. The current work keeps in the spirit and format of these previous and future works.

But why so much organized and concerted effort on flies of Central America? Firstly, flies are a hyperdiverse group of organisms. The currently described 153,000 species in Diptera represent about 10% of all described animal species. Despite this, most species of flies have yet to be formally described. As a comparison, there are as many described species in a single family of flies (Tachinidae) as there are in all of the Class Aves. And Tachinidae is not even the most speciose family in Diptera. Flies are found in every region of the world, in every microhabitat, and in every ecological niche. The tropical regions, especially the Neotropics, are the center of diversity for many families of flies. Central America holds many undescribed species, genera, and possibly even families of flies.

Before delving headlong into cataloguing the diversity of flies in Central America, the MCAD first out-

lines the context of flies within the natural and human worlds. An introductory chapter outlines the geographical focus of the manual on the seven nations of Central America, plus the southern and coastal parts of Mexico. This opening chapter, by head editor Brian Brown of the Natural History Museum of Los Angeles County, also lays out the format of the following chapters and emphasizes the ecological importance of flies. Tips for collecting and studying flies in the wild are also offered. The next chapters are on morphological terminology, natural history, economic importance, and phylogeny of flies. These chapters provide an excellent overview of the diversity of forms, lifestyles, and impacts of the fly families that make up the rest of the manual. The morphology chapter, especially, is of high value, as it provides not only a unified system of morphological naming, but also detailed illustrations of structures. I find myself referring back to these illustrations and descriptions often when reading other chapters.

The next two chapters of the manual showcase both the utility of the MCAD and also the incredible effort that went into its production. Chapters six and seven are dichotomous keys to all 105 of the fly families of Central America as adults and larvae, respectively. It is here that the myriad of illustrations within the MCAD become abundantly clear. The reason for the high quality and quantity of illustrations highlighting and explaining every small fly part imaginable is the decision to re-purpose many of the illustrations used in the *Manual of Nearctic Diptera*. These illustrations, painstakingly originally produced, need only new labels to be useful in the current work. Where

the original drawings are not sufficient, many new drawings are included. Also included in the first volume are full-colour photographs of every fly family. The photographs were supplied by Prof. Steve Marshall of the University of Guelph and are of the high quality that entomologists and photophiles have come to expect from him.

While the introductory chapters, family keys, and illustrations are more than enough reason to invest in the MCAD, they are not enough to fill two 700+ page volumes. The remainder of volume one and all of volume two are filled with individual chapters on each of the fly families found in Central America. Each of these chapters contains a short, diagnostic description of the morphology of the family and background on the biology, economic importance, classification, and potential identification challenges within the family. Also included in each chapter are dichotomous keys to each genus found in Central America, and yet more high-quality illustrations. Some of these chapters are admittedly works in progress as the diversity

of some groups has only begun to be studied. Other families are well-studied or less diverse and these chapters could serve as complete guides to the entire Neotropical region.

With the MCAD in hand (or more likely in a backpack considering the size of the two volumes), one could provide themselves an identification and background information for any one of thousands of genera of flies they may encounter in Central America. Those not planning a trip to this part of the world may enjoy simply surveying the diversity of form and lifestyle represented by this broad group of unique creatures. What is certain, though, is that 1400 pages may be sufficient to provide a little context for those buzzing little "moscas" of Central America, but it is not enough space to truly capture the beauty and wonder found in the world of Diptera.

JOEL F. GIBSON

Department of Biology, Carleton University, Ottawa, Ontario

Godwits: Long-haul Champions, New Zealand to the World – One Bird's Voyage

By K. Woodley. 2009. A Raupo Book, published by Penguin Books, Penguin Group (NZ), 67 Apollo Drive, Rosedale, Auckland 0632, New Zealand www.penguin.co.nz 240 pages, approximately \$50 NZD.

This prominent book from New Zealand naturalists comes as a mixed bag: it's truly an elaborate international Bar-tailed Godwit monograph of relevance for North America and for the East Asian Australasian (EAA) flyway, but it does not achieve on the conservation side at all.

Of course, the 239 pages greatly impress by their minute detail, through the thoroughness of the text, with the great effort invested by the author, and indeed through its fascinating photos (once again, many brilliant shorebird master pieces from J. van de Kam, from the author and from many international naturalists can be enjoyed). The text makes for a reading in bird physiology, describes literally every feather of the godwit, and is full of global shorebird gospel (specific terminology like radius, ulna, humerus, keratin, moult patterns etc. are also found throughout, but it usually lacks the statistical basics to make sense of the information provided). Myself, I am not a big fan of equaling avian body fat with airplane fuel, of hyping up evolutionary traits, and elaborate on scientific ivory-tower questions and statements like 'do birds sleep while on non-stop migration' or "*A wing area reduction of 10 per cent will increase the minimum turning radius by 11.1 per cent*". The 16 lavishly illustrated book chapters deal with virtually all aspects of Bar-tailed Godwits and shorebirds along the huge EAA flyway and beyond. Readers will find that the author chooses his sources and words extremely carefully and strategically (as shown for instance in the frequent use of terms like 'may', 'could', 'potentially', risk, threat, serious). The

chapters explain to the naturalist all details of 'being godwit', 'being waderologist', how to capture birds, how to count them, what it means to participate in the infamous cannon-netting operations, and finally, how to run satellite telemetry (the real clue of this authoritative monograph). The earlier investigations tracking godwits into the Yellow Sea and at the Yalu Jiang reserve (where the huge shorebird concentrations were hardly known to even the local staff prior to this effort!) makes for a shorebird classic, and so do the shore bird counting, leg flagging and inventory training sessions in China held by Australian and New Zealand shorebird enthusiasts. Ultimately, this book culminates with 'E7', the celebrated international Bar-tailed Godwit media star who now allows for many people to have a career and a living by flying for them a round-trip migration New Zealand Yellow Sea Alaska, and which was followed via the internet and Google maps in-time through the use of satellite telemetry (presumably supported by American tax money).

Throughout the book, one will find many wise citations made by naturalists and ornithologists. I really like the opening chapters of this publication, and the nice descriptive Alaskan breeding ground chapter from the Old Chevak camp (godwit crèches are reported. But it's of peculiar note that Woodley does not elaborate whether his birds engage in Extra Pair Copulations (EPCs)). Further, I like the many environmental and shorebird history facts presented, e.g., for the Yellow Sea and for the entire New Zealand and British context. The author makes clear that godwits and shore-

birds are still hunted virtually anywhere on the entire flyway (this includes New Zealand and Australia, as well as a rampant harvest in international Ramsar sites). The author further states that many airports are placed right into shorebird habitat (e.g., in Anchorage, Vancouver, San Francisco). Almost funny is the reported statement made by a New Zealand politician that "*The birds migrate to Siberia and provide food for Communists*", and thus that they should be hunted. Further counterproductive comments appear by the actions of the New Zealand Acclimatization Society. Fascinating are the details provided through the interview with G. Turbott (who also wrote the Foreword for this book) about New Zealand and its shorebirds in the 1950s. Whereas, the 'future outlook' chapter mentions many conservation keywords, but it really "has no teeth" (=no beak). The fact that these godwits migrate routinely over 11,000 km each way gets quickly over sensationalised in the text (while for instance Red-necked Stints, tiny shorebirds of the same flyway and flying equally long distances from Tasmania to Wrangel Island, are not mentioned by the author, nor is the earlier telemetry and survey work in Russian Far East and Japan really given credit. As typically found in western publications, meaningful citations from the Russian Far East, a major part of the EEA flyway, are unfortunately missing).

Like many members of the public that are not familiar with the genetic discussion, Woodley fell in the trap to believe that the scientific DNA taxonomic analysis would easily 'resolve' avian taxonomy, and should lead conservation decisions (whereas instead, being habitat-centric would be much more meaningful). Basic general ecology, wildlife management and statistics literature got ignored. But the author leaves us with no doubt that Australia lacks (!) relevant protection efforts for godwits, and Woodley further documented many times that the New Zealand government either missed the boat regarding a meaningful shorebird and habitat godwit protection, or prefers to be entirely absent from flyway conservation meetings, or favours other (industrial) goals in its actions paid with tax money (these facts match a pattern we see elsewhere too, e.g., in southern hemisphere fisheries, forestry, agriculture, invasive species, seabird research and Asian protection of biodiversity).

Unfortunately, this book still celebrates an outdated single-species and overall population approach, and shows no vision or lead for an efficient shorebird and ecosystem management, e.g., calling for institutional reforms, use of science-based pro-active decision-making, and how naturalists can contribute in a meaningful way. No calls for truly protected areas, e.g., relevant mudflats or flyways, are made neither. And so, where this detailed book ultimately fails us, in my view, is in its ethics and relevant conservation achievement. The author and his team try to imply otherwise though. But already the serious environmental issues

such as avian disease, wholesale watershed destructions, ocean sewage and algae blooms, as well as local extinctions, oil spills and climate change are just mentioned in passing. The Yellow Sea chapter makes for a very nice read, but it is widely naïve in its conservation view (e.g., that one would still be able to manage the Asian situation and 'western style', while instead we are already faced with massive losses and write-offs and on a global scale, and certainly in New Zealand and Australia); it hardly is criticizing China's environmental policies and the many known violations of its internationally agreed-upon migratory bird legislations (e.g., signed with the U.S., as well as with Australia in the China-Australian Migratory Bird Agreement (CAMBA), and with the international community). Where are the lawyers, environmental advocates, big NGOs and shorebird conservationists here? But China is obviously one of the main trading partners, also floating Australian mines and public income, directly affecting New Zealand also). The godwit flyway is obviously dealing with some of the biggest and most influential economies in the world: U.S., China, Korea, Japan, Russia, as well as the Australian Arc of Instability and Destruction (e.g., Timor, Fiji, Bougainville). All of these topics so crucial to godwits are not well dealt with in this book. And equally serious, the retreat of the melting permafrost in the tundra as well as sea level rise (an issue publicly known for over a decade) is virtually left untouched by the author. Whereas, it's sure that areas like the Yukon-Kuskokwim Delta (in terms of biomass being among the richest in the world, and a godwit breeding ground where the author and his colleagues spent much time and pages on) will be directly affected. Same is true for the New Zealand and Australian godwit wintering coasts, its diminishing mangroves and ecological watershed services. Also, at the home front in New Zealand and Australia, and other than just 'counting', these shorebird enthusiasts and their organizations did virtually nothing to stop large-scale coastal and watershed destruction. The excessive use of Australian and New Zealand beaches by cars, ATVs, tourists, locals, dogs, as well as real estate development remains widely unmentioned. But at least when the industrial developments in Alaska's Bristol Bay (e.g., the huge Pebble Mine and offshore oil & gas drilling) nearby the breeding and stop-over grounds receive no mentioning at all, the informed reader will start to get really annoyed and understand that here just a one-sided and limited bird profile gets presented. But the story really gets worse in the Saemangeum case of South Korea's Yellow Sea (where 30% of the tidal area has already disappeared; a tragic topic the author writes about in several chapters, but does not much beyond that). It appears as if the author and his shorebird team spent great efforts there counting migratory shorebirds before and during the controversial sea wall construction seasons at this MAJOR migration hotspot for most shorebirds along the fly-

way. But if one thinks it honestly through, it was clear right from the start that the habitat destruction in Saemangeum was NOT to be stopped by just 'counting shorebirds', and while just talking about it. And thus, it basically was a done deal, and the counting exercises did not stop but eventually rather confirmed the destruction and with the intimate knowledge of virtually all major shorebird communities in Australia, New Zealand, England and beyond (e.g., in the U.S. The big conservation NGOs like BirdLife International, Wetlands International and WWF did basically not achieve a thing in Saemangeum). Knowing that the 'shorebird activists' themselves were right at the front line of this incredible destruction event and saw it all coming, all what they did was "count shorebirds", and mostly for non-peer-reviewed journal publications without impact or audience even, and all done just after the fact (=funeral science: just confirming the dead). Wildlife management can do much better. This has certainly not been objective science, lacks latest statistical methods as well, and thus is not really good science, nor a good global citizenship, nor best professional practice, nor pro-active management and pre-cautionary (as mandated by IUCN and officially approved by New Zealand and Australia). It just makes for a very poor conservation science practice, if at all. Being non-political is a political statement indeed (in the text, the author instead still spends great detail elaborating on uncertainties in population trends, that naturalist shorebird counting data would be used by science and management, and even, that the *baueri* subspecies of godwits already declined by 30%, and so does the population at the infamous Farewell Spit in New Zealand!). What is all that narrow shorebird effort good for if knowingly we just count the deckchairs on the Titanic? And how ethical is that approach, and who promotes it and why? And why should we celebrate extinct birds in greatly illustrated books, instead of just maintaining them in nature? Other ethical issues got quietly ignored, and when knowing that using mist nets, banding/leg flags and cannon netting tends to regularly result into (some) bird deaths. Also, when gear and telemetry implants are used birds can die early, and if they ever survive the migration even (as with the apparent and assumed cases of the many try-out birds that lead to E7 and its colourful data points on a Google Earth map). The fact that a veterinarian from the U.S. is cited to cover for proper animal treatment in New Zealand cannot deny this fact, or might make it worse (e.g., that anaesthetics would generally have no effect on little bird brains, behaviour and migration). Science what for, and by whom? And what political scheme and party do these New Zealand naturalists here truly support in their actions? The text is otherwise not short in blaming hunters for birds with crippled legs (the 'sick army' that occurs after each hunting season).

But the author and his team are not alone in such approaches to conservation that ignores basic ethics

questions and the root causes of extinction. It just tries to present a profile of so-called objective science (while in Australia, New Zealand and with the USGS hardly any universities are even involved in this project and in EAA shorebird flyway research). Playing god, playing with birds, and as an anthropological and cultural phenomenon? It even receives uncritical support with some researchers in Holland, UK and elsewhere, supporting such concepts into the academic arena. Similar stands to conservation have actually been taken by a wide culture of ornithologists, by big NGOs and by some naturalists in the western world; and some even herald it as good bird management (but on what performance metrics and achievements is that based on?). In reality, and fully in line with the many criticisms made by Rosales (2008); Bandura (2007); Stiglitz (2006); Schweder (2001) and others, this approach had lead by now to a global bankruptcy and crisis, and certainly for shorebirds (c. 65% of North American shorebirds alone are declining). The conservation model of this book and its naturalists has shown itself as nothing but enforcing 'business as usual': a global habitat destruction towards the extinction process. And these engaged naturalists are the first ones to see and to know it during the shorebird counts; but why do they not speak up and do something about it? Perhaps a hint for such value system is found in the British birding origin, in the U.S fear of good advocacy and environmental stewardship, or with the former profession of these shorebird naturalists (e.g., retired employees of mining companies and industry, metallurgists etc.). Other explanations might come with the intimate project involvement of big and affluent governments, and which are often directly tied to big (oil & energy) money. Showing funding transparency would help to resolve this question (no funding details are provided in this book). The presented satellite telemetry work on godwits is certainly not done and funded by naturalists but by the USGS and the Anchorage office (located in a state which receives largest chunks of its budget directly from oil revenues and their companies). It is clear that research designs and animal care permits would run differently when universities and their students and Institutional Animal Care and Use Committee (IACUC) would have gotten involved and be in the driver seat. The great shorebird data mentioned by the naturalist author and collected by publicly paid USGS employees and others for over 30 years are not made available to the global audience (at least conceptually, the Freedom of Information Act should probably apply here). Whereas, an Arctic project like this and linking both poles (!) would have made for a great showcase in the International Polar Year (IPY) 2007/8, with eBIRD (www.ebird.org) data, in GBIF (www.gbif.org) and in movebank (www.movebank.org). What a great opportunity to serve the global public and data needs for better decision-making, but the project participants simply did not choose to participate in such

efforts for the benefit for mankind, instead just serving their own interests!

In conclusion, one way or another, this otherwise great book includes some environmental science scandal. Great achievements might not always come cheap or for free, but only the ethics, and the declining bird populations and habitats will judge our efforts eventually and how well we finally achieved as naturalists, as governments and otherwise. At least for the next few years, it is clear that Asia, global warming and the massive global human population increase will easily run over New Zealand, Australia and North America, and as well run virtually over all of our birds, habitats and wilderness. With most governments, big NGOs and professional societies failing us already for years

in regards to pro-active globally sustainable leadership, it's left on us naturalists to keep as many pieces of nature as we still can. There is no time left anymore. But as the lacking conservation progress by these shore-bird naturalists shows us, and with G2 and the Pacific Free trade zone in the full making, we must be very scared indeed and be prepared for E7 just being an environmental write off and that it simply was just a wasted 'flash in the pan' but without a sustainable future.

FALK HUETTMANN PHD, ASSOCIATE PROFESSOR
EWHALE lab, Biology & Wildlife Department, Institute of
Arctic Biologym, University of Alaska, Fairbanks Alaska
99775 USA

Life in a Shell: A Physiologist's View of a Turtle

By Donald C. Jackson. 2011. Harvard University Press. 79 Garden Street, Cambridge, Massachusetts 02138 USA. 178 pages. \$29.95 USD.

Instantly recognizable because of their distinctive shells, turtles are nonetheless taken for granted. People rarely consider the questions inherent in living inside a bony shell. How can turtles breathe since they can't expand their ribcage? And how can they survive an entire winter under water without breathing?

Such questions have fascinated Donald Jackson for many years. Jackson, now a professor emeritus at Brown University, has studied the physiology of turtles since the late 1960s. Unlike many turtle biologists, Jackson did not begin with a passion for turtles. He began his research career studying temperature regulation in exercising dogs. An interest in anerobic metabolism led to an experiment using turtles to measure total metabolic rate and so began Jackson's ongoing studies in turtle physiology.

Jackson's book is divided into eight chapters, each focusing on a different topic: a general introduction to turtles, buoyancy, breathing, studies on sea turtles at Tortuguero in Costa Rica, overwintering without breathing, surviving without oxygen, the heart, and metabolic rate. Although this is a slender volume, Jackson tackles some very technical issues. The explanations are general clear, with plenty of examples and comparisons to humans. And the book is filled with fascinating insights. For example, turtles breathe differently than mammals. Turtles do not breathe contin-

uously, like we do, but intermittently. A turtle takes a few breaths, holds its breath and then repeats the cycle. This pattern holds true even when turtles are on land. Turtles, of course, are renowned for holding their breaths long periods of time. Most humans can hold their breath for a minute or two, but according to Jackson, the world record is an amazing 11 minutes, 35 seconds. Of course, even 11 minutes is trivial compared with the six months a turtle may spend under water during hibernation. Turtles are "cold blooded" so in winter, resting on the bottom of a wetland, their body temperature is just slightly above freezing. This can reduce their heart rate to as little as one beat every 10 minutes, however, even at this reduced rate oxygen would be all consumed in less than a day. So how do turtles survive the winter? Either through oxygen uptake from the water, or, in some species, anaerobic metabolism.

This is certainly a book about physiology, more than turtles. With an emphasis on partial pressures of oxygen, regulation of blood pH, metabolic depression, and lactate sequestration this book is not for the reader just casually interested in turtles. It will be of primary interest to physiologists and dedicated turtle biologists.

DAVID SEBURN

Seburn Ecological Services, 2710 Clarendon Street, Ottawa,
Ontario K2B 7S5 Canada

BOTANY

A Field Guide to Alpine Flowers of the Pacific Northwest

By Phillipa Hudson. 2011. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia, V0N 2H0 Canada. Eight fold 9-inch by 36-inch plasticized sheet. \$7.95 CAD.

A Field Guide to Gemstones of the Pacific Northwest

By Rick Hudson. 2011. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia, V0N 2H0 Canada. Eight fold 9-inch by 36-inch plasticized sheet. \$7.95 CAD.

The flower guide covers 110 flowers and two fruits of the principle, cute alpine wildflowers. Each photo is 1.75 by 1.5 inches [4.5 by 4 cm] and shows an individual flower or flowerhead. They are arranged by colour from purple through pink, red, yellow, orange to white and green. As the photos are close up there is little portrayal of the leaves or the general shape of the plant. The text has the English and scientific names, the plant's height and its distribution. While this guide does not have the depth of information of a full book on flowers, it is very compact and light. It will be most useful for visitors and backpackers.

The gemstone guide covers about two dozen rocks with most pictures about 5 to 10 cm square. These often show the uncut and cut stones ready to be mounted. The text is necessarily brief and gives only limited information on where to find these gems. Given the limited space I was surprised to read some of the information [origin of the word crystal or ecosystem restoration] as it seemed superfluous. I would have preferred more details on how to find these interesting items. Again this mini guide will be valuable to hikers.

ROY JOHN

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

Wetlands of the Hudson Bay Lowlands: An Ontario Review

By John Riley. 2011. Nature Conservancy of Canada and the Ontario Ministry of Natural Resources, 36 Eglinton Avenue West, Suite 400, Toronto, Ontario M4R 1A1 Canada. 156 pages. NCC: <http://www.natureconservancy.ca>; OMNR: <http://www.mnr.gov.on.ca/en/Business/FarNorth>.

The Hudson Bay Lowlands are the longest marine wetlands in the world and cover an area larger than Great Britain. Because of the harsh living conditions and swampy nature of the area there are few people. The lowlands are shared with Manitoba and Quebec, and the area came to prominence with the construction of the La Grand River hydroelectric project in the 1970s and 1980s. These flooded large areas resulted in the release of mercury that had major impacts on the wildlife [including humans]. Similar developments could have major consequences for the Ontario wetlands.

This book is a scientific report of the results of field investigations along the Ontario coast of Hudson and James Bay. Written by John L. Riley, Chief of Science of the Nature Conservancy of Canada and the author of *Flora of the Hudson Bay Lowland and its post-glacial origins* [on the National Research Council Canada's website put in the title, not the impossibly-long URL]. The current work is an inventory and mapping of the region's plant biodiversity. Its primary purpose is land use planning to enable authorities to identify areas for protection and potential sustainable economic development. The report covers the geology, climate and biology of this remote area. Using defined sampling methods the author establishes wetland variability and succession, environmental variability and wetland types

and characteristics. Appendices add further information on the wetlands and vegetation.

This is a book for scientists and very serious amateurs. For example, all the species are identified by their scientific name only. Those who have the background will find this work to be a great resource that contributes significantly to our knowledge base of Northern Ontario. It identifies all the wetland types and gives their critical physical and chemical characteristics. There is good coverage of the vegetation which includes mosses, grasses as well as higher plants. There is little information on animal life and, oddly, the author only uses their common names.

The report is well illustrated by numerous air and ground photos, supplemented by close ups of flowers and seeds. There are several excellent maps and many graphs and charts. These additions and the well organized text make this an easy report to use.

The only other comment I have is the author's incorrect use of the word parameter in a report that is otherwise so precise.

This report is a valuable and important addition to an under-researched area of Canada. I hope it will be used by those making decisions on development in this sensitive region. I doubt if many politicians will understand its information, but they should listen to the

scientists who advise them. Personally I was delighted to read it, as I will be visiting James Bay this summer, and I extracted much useful material.

ROY JOHN

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

Field Guide to the Seaweeds of Alaska

By Mandy R. Lindeberg and Sandra C. Lindstrom, 2010. Alaska Sea Grant College Program, University of Alaska Fairbanks. iv + 188 pages, \$30.00 USD.

If you are a student or professional involved in coastal marine science in Alaska, or a naturalist who is resident or visiting coastal Alaska, then this field guide is for you. This book by a world authority on the seaweeds of western North America (Lindstrom) and another professional who is clearly an excellent photographer (Lindeberg) is an important addition to the shelves of anyone concerned with seaweeds on the temperate coasts of western North America. The authors have produced an excellent field guide; indeed, this is the best that I have come across.

Seaweeds are inherently a difficult assemblage of organisms to deal with. They are phylogenetically disparate, and come in a range of sizes from the microscopic to dozens of meters. Their morphology is highly variable both within and among species, and it can take considerable experience to distinguish many of the forms. From a wider perspective, creating a first class field guide is a complex business. It must be accessible for the tyro, and useful for the experienced. It should be large enough for substantial information, and yet not so bulky as to deter you from carrying it with you. It needs to be up to date for the experts, and yet with a comfort level that comes from familiarity with the names and organisms.

Overall, Lindeberg and Lindstrom have overcome these challenges, and the compromises they have made are reasonable. The images are mostly excellent, the text is highly informative without being overwhelming, and it is organized such that critical information is immediately accessible. With its ring binding the volume opens flat, and the book will easily fit into a pack, even if too large for a pocket. The authors have found (or made up) common names for every species they cover, and the guide has visual and descriptive tools for arriving at species names. These are easy to use and a suitable alternative for many who may be intimidated by dichotomous keys. The introductory material covering background information on taxonomy and ecology is useful, and I only wish that the

authors had included a general summary of the seaweed flora of Alaska as a whole, and the proportions of species in each of the major assemblages that are treated in the guide.

While the photographs and thumbnails are both attractive and useful, the authors have produced a website (www.seaweedsomalaska.com) that mirrors the field guide and has additional photographs of many species. While the reproduction in the field guide is generally excellent, many of the photographs are stunning on the computer screen. The website then links to AlgaeBase, the most authoritative website for algae, where formal descriptions and taxonomic/nomenclatural information are available. Such links turn this 'simple' field guide into a major learning tool. But while these web tools provide a connection to the larger world of algae, the authors miss out by not connecting directly to a more comprehensive floristic list, or formal keys for the region. There are many algal groups where only a single species might be represented in the guide (e.g., *Ceramium*, *Polysiphonia*, many groups of filamentous red algae). While I would not expect this guide to treat all of the species, it would be helpful to let the reader know that there are additional species for naturalists, especially ones with access to a microscope, to look for in each of these groups. This would be great information to add to the book's website.

There is a growing interest in the collection and use of seaweeds as natural foods. As the authors point out in their introduction, many seaweeds are good to eat. However, the authors don't elaborate on this in a way that would make the uninitiated actually try some algae while on the shore, or tempt them to take home some Laver for drying or cooking. The authors do include a reference to one of several guides to cooking with seaweeds, but perhaps this is an aspect to be developed in the next edition, or on the website.

DAVID GARBARY

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

OTHER

Biodiversity Conservation in Central Asia: On the Example of Turkmenistan

By E. Rustamov and A. Rustamov. 2007 Nagao Natural Environmental Foundation, Shitaya, Taito-ku, Tokyo, Japan http://www.nagaofoundation.or.jp/index_e.php

This nice book of 204 pages offers us an overview of biodiversity, habitat and conservation for a region that either is hardly known or widely ignored: Turkmenistan in Central Asia. This publication carries no ISBN number, but the three sections (Introduction, The Animals Values and Functions in Nature and Human's Life, Strictly Protected Areas in Turkmenistan) consist of 22 chapters with great and authoritative information. Naturalists with an interest in global biodiversity, desert and mountain ecology, Caspian Sea and Central Asia will have a feast because Turkmenistan covers a wide variety of over 20,000 species, consisting of 718 vertebrate species (half of them are birds; and 110 are mammals), including many reptiles as well as over 8,000 insects. Species of the high-altitude belt (1500m till 2900m) are also described. The twelve page bibliography of Turkmenistan, Russian, and English references will get appreciated by the western audience (precious literature comes from the 1930s, 1950s and 1980s). The fascinating photo section of over 60 pages must be emphasized; it greatly achieves in the promotion of Turkmenistan and its protected areas, its biodiversity and habitats. Maps and an ecological desert food web scheme are also presented. The eight state reserves are presented in detail (History; Location, Relief, Climate; Vegetation; Fauna, Fishes, Amphibians and Reptiles; Mammals; Birds; Resume): Repetek, Khazar, Badkhyz, Kopetdag, Syunt-Khasardag, Kaplankyr, Amu-Dariya, and Koitendag. All of these 'strictly' protected areas are either widely known in Asia and beyond, or carry very peculiar habitat and biodiversity features. But taken together, they only cover 1.6% of the nation, and therefore the additional 24 temporarily protected areas are also mentioned. Already the Badkhyz state reserve is a world heritage site, and has a long science tradition (e.g., with investigators such as I. A. Linchevsky, V. I. Lipsky, A. G. Bannikov, G. P. Dementiev). This reserve alone holds 50% of Turkmenistan's red data book species. The author shows us that the birds of the Kopetdag are well studied and described, and that Khazan was set up in the 1930s for the protection of wintering birds in the Caspian Sea region. The Amudar'ya state reserve was especially established for the bukhara deer and the tugai forest vegetation (which is characterized by two popular species and over 25 other plant species). Turkmenistan's famous black and white saxaul forests are mentioned in detail, and so are the Piedmont and Turan Plains, and the Karyluk Caves. Archeologists probably also want to check out Koitendag's Plateau of Dinosaurs (famous for its fossilized footprints and artefacts). Ancient plant imprints such as giant grass *Aundo*, *Sevoika* and tree

ferns can be found also. Turkmenistan's Jujube Grove of Koitendag is the largest one in Central Asia. Other fascinating landscape features described by the author are for instance the Eroilanduz Depression and the Barkhans (Sand sea).

The author makes clear that UNDP and The World Bank shaped much of the modern conservation landscape in Turkmenistan. Turkmenistan is an IUCN member, holding the 1978 meeting XIV General Assembly in Ashgabat. Turkmenistan also joined six summits to address the Aral Sea problem (together with Kazakhstan, Uzbekistan, Tajikistan and Kyrgyzstan). Further, this country ratified the Convention on Biological Diversity, and later signed agreements in support of the Frame Convention on Climate Change, the Vienna Convention and the Montreal Protocol (re. Ozon), and agreements on the protection of the Caspian Sea environment and others. But the authors make clear that Turkmenistan has not yet signed CITES, nor even Ramsar and the Bonn Convention on Migratory Species (CMS).

The author divides the nature protection history of Turkmenistan into three periods: Initial protection of individual natural objects and territories, first attempts at a complex approach to the protection of natural resources and creation of legal basis (the Role of USSR was particularly strong in 1970s and 1980s), and the period from the 1980s until now (which gets characterized by the author as a series of dramatic and fatal anthropogenic impacts, and with a deleterious effect on the country's economy and human health).

If species disappear from Turkmenistan they are usually gone in central Asia also. To avoid this situation, the creation of a red data book was made possible by the Turkmen Society for Nature Conservation, Ministry of Forestry, Academy of Sciences of Turkmenistan, National Institute of Deserts, Fauna and Flora of Turkmenistan, and the Turkmenistan Ministry of Nature Protection. The first edition was published 1985 and the current second 1999 edition of this book consists of 107 species, including 29 new species (23 species got excluded due to extinction or status change). Most of the endangered species in Turkmenistan are reptiles, and many avian red data species are eagles. It becomes quickly clear though that this red data book is a huge underestimate and does not halt the extinction, nor that it really follows a pre-cautionary approach (as the IUCN demands).

Other interesting Central Asian environmental history can be found in this book with the Wild Ass. In 1880 huge populations were being described for this 'donkey' by several naturalists. But the populations got

seriously destroyed afterwards. During 1941-45 it was at the verge of extinction (a path already followed by the Przewalski's Horse in Mongolia). A re-introduction and strong conservation efforts, e.g., in Badkhyz, brought the species back to low population levels. In passing, the authors mention another Central Asian feature of landscape history, the Aral Sea rescue.

This publication is also very helpful in that the Rustamovs provide as many quantitative estimates as possible. They extrapolate that 350 million lizards live in the Karakum desert, and that 100 million Horsfield's terrapin tortoises occur. Further, the prey items of many discussed species are usually mentioned.

The reader learns in this book about Turkmenistan's stunning landscape and habitat features, but also about massive population declines, extinctions and habitat loss. This information reads like a giant biodiversity funeral, and the author leaves us with no doubt that unbalanced economic growth is responsible. An epitaph is in order. The sections on strictly protected areas in Turkmenistan make it clear that they are all but strictly protected, e.g., as can be seen in the extensive economic development that occurred in Kopetdag. Pistachio woods usually can get over 300 years old, but many of these open woodlands got widely destroyed by man. Ploughing, impacts of the Karakum Canal, and problems through cotton plantations further contribute to such problems. The development and use of clay in deserts threatens many snake species. The hyrcanian tiger existed in Turkmenistan till the 1930s, but now is extinct. Due to the vast and ongoing habitat degradation of leopard habitats they are now also found at the verge of extinction. The caracal is almost endangered. Overcutting and overgrazing from the 1920s onwards lead to huge destruction of habitat. Goitred gazelles are in wide decline (from 100,000 individuals down to now less than just 8,000). Saiga antelopes suffered dramatic declines due to traditional (Chinese) medicine demand. The Persian gazelle became very rare in just a few decades. Argali (initially over 8,000 in 1980s) and Bezoar goats (over 6,000) in central Kopetdag are now less than 2,000 animals. Bat populations are dramatically depleted. The Turanian Tiger, Cheetah and Red Deer are already extinct species. The famous Houbara Bustard is rare now in Turkmenistan. Large pheasant declines are also reported and these are due to loss of the tugai vegetation, excessive use of pesticides and illegal hunting. From 300 known black francolins the populations are now down to 50. Of the 25,000 white-tailed eagles known to occur in the 1930s, now only 150 are counted. Shelducks declined from thousands to hundreds. White-headed ducks (40,000 birds were counted in 1937) make now for a rare species in Turkmenistan. The lizard desert monitor (an animal of 1.5 m in size) is also in steep decline (in the mid 1980s over 19,000 were counted, but they are now rare). The Badkhyz state reserve holds about

46 species of mammals, but the Caspian Tiger, Cheetah, Bukhar Deer, Bezoar Ibex and Asiatic Ibex were exterminated in historical times.

Intense commercial fishery also occurred in the natural lakes and water reservoirs of this desert country. Over 75% of all fish were caught by the 1970s and 1980s. Overfishing is reported for species like sabrefish, bream, pike perch, aral barbell and asp. Compared to the 1970s, nowadays the catch is eight-times smaller. Noteworthy is that not even the unique Caspian Seal is included in the red data book.

The authors state that the very existence of human society is inseparable from nature; hence, a close connection is found between nature use and protection. But they state that currently, we are running a technological self-destruction. Regardless of the large biodiversity loss, Turkmenistan has a long track record of (sustainable) nature use. Koitendag for instance is home to oil, rubber and gum-bearing, tanning, dyeing, medical and decorative plants. In Turkmenistan, walnut, almond and pistachio species are important for the national nut production. Turkmenistan's fur harvest consisted of up to 90% fox. Nutria farms got started already in the 1930s, and this species escaped and got introduced; a similar situation is found with black musk rats. The common myna penetrated the territory already in the middle of the last century, making for an avian range expansion of a synanthropic species. During WW2 Turkmenistan exported a large amount of marsh frogs; also, a large amount of tortoise meat got canned. Turkmenistan further engages in the harvest and farming of poisonous snakes. The explicit use of poisonous snakes started 50 years ago. Venom-based medicines are used worldwide for the treatment of rheumatism, radulitis and polyarthritis. And thus, snake venom is ranked in Turkmenistan higher than gold. Four venomous snakes occur: Blunt-nosed Viper, Saw-scaled viper, Cobra and Copperhead.

The first Turkmenistan studies that aimed at the establishment of strictly protected areas were carried out in 1922. And thus, this book banks a lot on the great work that was done on Nature Conservation in the 1930s. Dr Laptev's surveys from this period present the global audience with a historic baseline of a wilderness area. Already at that time the acamedician V. I. Vernadetsky found that the rapid human technological developments put a geological pressure to the biosphere. And D. N. Kashkarov also stated in 1930 "... we must save our productive forces and natural resources from destructive use and extermination. It's a matter of natural importance". The urgent need for Wild Ass protection was already recognized by M. P. Rozanov in 1937. The authors elaborate on contributions made by famous investigators such as V. A. Paletsky, V. A. Dubyansky and E. A. Klyushkin. V. I. Vernadetsky, a prominent philosopher and environmentalist, is reported on several times. The legendary scientist N.

J. Vavilov considered Sumbar Valley as the origin of many of the world's cultivated plants. As many others, S. V. Veisov worked on Turkmenistan's nature for over 40 years. Botanist M. G. Poppov worked most of his life in the juniper woodlands. The publication of 'The Nature of Central Kopetdag' from 1986 makes for a central reference in this book and beyond.

Due to this strong earlier research base, the author can present in depth on many endemic species such as the big and small Amudarya shovelnose fishes, Blind Loach (a newly described species), Black-tailed Toad Agama, Maghor, Corsac Fox, Striped Hyena, Wild Boar, Porcupine, Bukhar Argali, Tien Sien Brown Bear, Tolai Hare, hedgehogs, Long-clawed Ground Squirrel, jerboas, Marbled Teal, Purple Swamp Hen, Saxaul Sparrow, shrikes, chats, larks, pipits, flycatchers, wheat-ears, Saxaul Jay, sandgrouse, Dalmatian and Great White Pelicans, Eurasian Spoonbill, wintering Coot, Golden Eagle, Egyptian Vulture, Black Vulture and over 30 falciformes. Some birds are described that even winter in the desert. Flamingos occur in several smaller colonies in adjacent Kazakhstan, and c. 15,000 individuals are wintering in the Khazar state reserve. Other great presented information deals with wild sugar cane, the licorice plant, black widow spiders, leishmania disease transmitted by great gerbils, and the 10 month hibernation of tortoises in Badkhyz. Seasonal Caspian Sea level change and rise is reported by up to a 1m. We further learn that the *mandragora turcomanica* (Mandrake) plant species is of paramount scientific value, but only 500 (!) plants are left in the Syunt-Khasardag state reserve. The few typos in this book can easily be forgiven.

By now, most mammals retreated into protected or less accessible mountain areas. As a consistent message from this book we learn that Turkmenistan's reserves are way too small (Badkhyz should be enlarged by at least 20%; and IUCN requires to protect at least 10% of any national area). Authors demand that better laws are needed for Turkmenistan, e.g., the Nature Conservation Law from 1991: virtually all of the hunt-

ing regulations need improvement; and rare and endangered animals and plants should be entirely protected. The introduction and acclimatization of alien species, e.g., fish, must be stopped (legally and on the ground). The Bolshoy Balkan mountains need to be protected; the cheetah in Badkhyz should be restored, and the Karlyk Caves need efficient protection from tourists. Currently, the nature reserves just have a peculiar marginal distribution, being located at the outer edges of Turkmenistan, and are designed without modern strategic conservation planning. For Sumbar valley, the world's genetic center of cultivated plants, it took four decades til protection. Now, much hope is placed on the UNDP project on "Improvement of the managing system of protected areas in Turkmenistan" (2003-2006). The authors also put hope on the GEF project of sustainable development of the Khazar state reserve for Caspian Sea. Important Bird Areas (IBA/ Birdlife International) and the ECONET project are mentioned as additional beacons of hope.

Taxonomic names of this book are unfortunately not expressed in www.itis.org for globally standardized names, known governmental failures are not presented in depth, climate change is virtually left unmentioned, and the huge and further increasing Chinese and Indian demands on Turkmenistan are hardly discussed. However, this book simply makes for the biodiversity milestone publication for this region and shows how much decline and destruction the globe is currently going through during post-communism. We are unsure what the future will bring exactly, but with an increase in human population, with more Chinese and Indian influence, as well as with climate change on the steep rise it can hardly look good for Turkmenistan. Central Asia and the global ecological services relying on this region.

FALK HUETTMANN PHD, ASSOCIATE PROFESSOR
EWHALE lab, Institute of Arctic Biology, Biology & Wildlife
Department, University of Alaska-Fairbanks, Alaska 99775
USA; E-mail: fhuettmann@alaska.edu

NEW TITLES

Prepared by Roy John

† Available for review * Assigned

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

ZOOLOGY

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BOTANY

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OTHER

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News and Comment

Northeast Natural History Conference 2012

The 12th Northeast Natural History Conference (NENHC) hosted by The Association of Northeastern Biologists to be held 15-19 April 2012 at the OnCenter Convention Center in Syracuse, New York. This is a 3 day conference which promises to be the largest forum for researchers, natural resource managers, students, and naturalists to present current information on the varied

aspects of applied field biology (freshwater, marine, and terrestrial) and natural history for the Northeastern United States and adjacent Canada. Registration is currently open. Deadline for abstract submissions is February 15, 2012 and early registration deadline is March 1, 2012. More information is available at www.eaglehill.us/NENHC_2012/NENHC2012.

American Society of Mammalogists Annual Meeting 2012

The 92nd annual meeting of the American Society of Mammalogists to be held 22-26 June 2012 at the Peppermill Resort, Spa & Casino in Reno, Nevada. Registration is currently open. Deadlines for abstract submis-

sions is April 15th, 2012 and registration is June 15th, 2012 (after this date, a \$50 fee will apply). More information is available at www.mammalsociety.org.

Northeast Partners in Amphibian and Reptile Conservation Annual Meeting 2012

The 13th annual meeting of the Northeast Partners in Amphibian and Reptile Conservation (NEPARC) to be held 24-26 July 2012 at the Highland Center Lodge in Crawford Notch, New Hampshire. Deadline for sub-

mission of abstracts for oral presentations is February 10, 2012 and for poster abstracts, June 15, 2012. More information is available at www.northeastparc.org.

World Congress of Herpetology 7

The 7th World Congress of Herpetology (WCH) to be held 8-14 August 2012 at the University of British Columbia and the University of Victoria, in Vancouver, British Columbia. Registration is currently open. Dead-

line for submission of abstracts and early registrations is February 29, 2012. More information is available at www.worldcongressofherpetology.org.

North American Ornithological Conference 2012

The 5th North American Ornithological Conference (NAOC-V) to be held 14-18 August, 2012 at the University of British Columbia campus in Vancouver, British Columbia. Deadline for regular abstract sub-

missions is February 29, 2012 and early registration is May 15 2012. More information is available at www.naoc-v2012.com.

Dr. J (John) Wilson Eedy 1944–2003

Dr. J. Wilson Eedy, a scientist and humanitarian, died suddenly in Nigeria on June 23rd, 2003. J. Wilson Eedy was born in Stratford, Ontario September 30th 1944. He married Edith in 1967 and had a son and a daughter.

Wilson's professional career followed a path, which in hindsight reflected his evolution as a humanitarian. He received his B.Sc. from the University of Western Ontario in Zoology in 1967, followed by an M.Sc. under Dr. Ogilvie in 1969 (his thesis was entitled "The factors affecting the thermal preferences of house mice

and Mongolian gerbils"). He received a doctorate in 1973 from Carleton University (his thesis subject was "Seasonal and geographic variations in the thermoregulatory behaviour of two species of *Peromyscus*") under Dr. Don Smith. Dr. Eedy joined NRC for one year as a post doctoral fellow working with the Water Subcommittee and Arctic Panel, National Research Council of Canada, Ottawa and authored a report on the "Environmental cause and effect phenomena relating to technical development in the Canadian Arctic."

Much of his later work involved travels in the Canadian Arctic.

He joined Beak Consultants Limited in October 1973, where he was one of the nine principals, and became a major contributor to many Environmental Impact Statements (EISs) for large industrial projects. Many of these projects were in the north, including the Mackenzie Valley pipeline, the Dempster Highway, and many proposed mines and hydroelectric schemes.

Wilson's role initially was the terrestrial wildlife and wildlife habitat. This quickly became fused with the botanical assessments. At the same time, the issues associated with the socioeconomic impacts of development began to be included in assessments. This was a new area of investigation and Wilson developed a strong interest and expertise. He enjoyed the process of meeting with people and sharing his expertise. As much of his work was in the north, Wilson had a great deal of contact with First Nation's people. In a sense, Wilson was a pioneer in applying environmental science to mega-projects within the new environmental assessment legislation. When Geographic Information Systems (GIS) emerged as a tool, Wilson saw the value it could bring, and subsequently how it could help developing countries build a framework for the future. This meant Wilson could examine the broad scale issues and translate them into terms that would benefit individuals.

Wilson was appointed book review editor of the *Canadian Field-Naturalist* on 12 July 1975 and served until his untimely death on the 23 June 2003. As well as editing all reviews, he prepared a list of new titles for virtually every issue covering zoology, botany, environment and miscellaneous. In the 1980s he added a category "young naturalists" to the new titles section, and produced annual book-review editor's report. Wilson also spent many years on the Ecological and Environmental Advisory Committee (EEAC) for the Regional Municipality of Halton.

Wilson was very hard working and immensely productive, and could be relied on to get the job done on time. He would churn out well-written reports three times faster than his colleagues. Wilson had a terrific

sense for new projects and business prospects – an ideal combination in a consultant. He applied this intensity to other areas of his life too. He relished finding out about other people's cultures. Without restraint he would try local foods, a perilous venture for one in his condition and something that would exasperate his colleagues.

Not surprisingly, when Wilson had the opportunity to combine his many talents to help a developing nation, he took it. In 1995, along with Drs. Greg Wickware and Festus Akindunni, he joined with some Nigerians to create a geomatics company that would employ Nigerians, working for Nigerians to better life in Nigeria. He was intrigued by Nigeria and it became his second home; a place he literally adopted. He often wore the flamboyant traditional costume. He saw a way that he could make a real difference for the people of Nigeria, but this was not without personal risk.

Wilson had been diagnosed as diabetic at 11 years old. This disease is unfortunate for someone who has chosen to wander the remote places of our planet. There was always a danger Wilson would be far out on the tundra or deep in the jungle when he needed help. Despite this risk, he persisted with his objectives in Canada and Nigeria. Indeed Nigeria was not the best place to follow the food and exercise regime required to keep this condition under control. He became ill on several occasions, but passionately continued to work in Nigeria for four to six months every year. Sadly, this strain eventually took its toll.

Wilson's work went beyond his founding of Geomatics Nigeria and building a skilled team of local people. He was involved in a variety of projects, including a GIS Space Agency conference, many forestry and park planning projects, and the African Healthcare Telematics Conference in 2000, which was in response to the HIV/AIDS problem pervading Africa. He and his wife personally supported a family with eight children, all of whom received post-secondary education.

This dynamic man will be missed by his many friends around the world.

ROY JOHN

Errata *The Canadian Field-Naturalist* 125(1): 53

In "Some Observations on the Pollination of Round-Leaf Orchid, *Galearis* (*Amerorchis*) *rotundifolia*, Near Jasper, Alberta", in the acknowledgements on page 53, last line "Ms. Joyce Reddoch" should be "Dr. Joyce Reddoch" and "Dr. Allen Reddoch" should be "Dr. Allan Reddoch".

The Ottawa Field-Naturalists' Club Awards for 2010, Presented April 2011

KEN ALLISON, IRWIN BRODO, JULIA CIPRIANI, CHRISTINE HANRAHAN AND ELEANOR ZURBRIGG

On April 16th, 2011 members and friends of the Ottawa Field-Naturalists' Club gathered at the Club's Annual Soirée at St. Basil's Church in Ottawa. Awards were given to members and non-members who distinguished themselves by accomplishments in the field of natural history and conservation, or by extraordinary

activity within the Club. In particular, long time service to the Club's publications, lifetime study of birds and their songs, forest stewardship efforts and teaching of natural history to youth are all in evidence among this year's winners. The following citations for those who received an award were read to the members and guests assembled for the event.

Ronald E. Bedford – Honorary Member

After 32 years of committed service to the Ottawa Field-Naturalists' Club's (OFNC) Publications Committee, Ron Bedford has stepped down as Chair. His humour, steady hand, sharp eye, sound judgement and grasp of the committee's function will be missed.

The Publications Committee is responsible for the policies and production of the Club's two quarterly publications, *The Canadian Field-Naturalist* and *Trail & Landscape*, along with special issues of these publications.

The dominant quarterly publication is *The Canadian Field-Naturalist* (CFN), a scientific journal recognized internationally, has been the major project for the Club for over one hundred and twenty-five years. In overseeing the CFN, Ron worked closely with Francis Cook, its long-standing editor, and the late Bill Cody, business manager. Issues of editorial policy and publication format were addressed. The latest challenge has been to produce an online version of the journal.

Ron played an important role in establishing the OFNC Publication Policy in the early 1980s. As one member described it, the policy was as important as it was contentious at the time. The policy stands today essentially as it was developed almost 30 years ago.

Ron's calm, thoughtful, professional input throughout was a huge help in keeping the participants focused and getting the job done. The core elements of the policy are intact and still serve the OFNC and its publications very well in their contribution to the larger community in Ottawa and across Canada. This is a testament to the success of Ron's contributions.

As Committee Chair, Ron supported and encouraged the acceptance of numerous special contributions proposed and subsequently published in the CFN. Among them are Irwin Brodo's "Lichens of the Ottawa Region, Second Edition"; Joyce and Allan Reddoch's "The Orchids in the Ottawa District"; John L. Cranmer-Byng's "A Life with Birds: A Biography of Percy Algernon Taverner 1875-1947"; and Alexander Burnett's "A Passion for Wildlife: A History of the Canadian Wildlife Service".

Ron is also a keen bird watcher and often goes on the Club bus trip to Point Pelee. With his wife Trudy, he led many nature walks in the eastern part of the city.

For his commitment and stewardship, the Club is proud to offer an Honorary Membership to Ron Bedford.

Daniel F. Brunton – Honorary Member

Ask anyone in the Ottawa region to name a prominent and respected naturalist, and if they know of anyone that might fit that description, they are most likely to name Dan Brunton. He is the expert that is most frequently consulted by the local media in matters of natural history, and municipal and regional departments in the Ottawa region often call on his help and opinion for environmental issues.

All this is not surprising if one looks at Dan's remarkable achievements over the past 40 years. Although counting himself as principally a botanist and birder, he has publications on moles, wolves, turtles and salamanders as well. His major scientific work has dealt with quillworts (*Isoetes*) and ferns in general, usually co-authored with Donald Britton of Guelph University. This

has resulted in more than 30 peer-reviewed publications including the description of over 15 new North American taxa. Dan, however, is an expert general botanist with a broad knowledge of plants of every kind. He also has a long list of publications on birds, most of them in *Trail & Landscape*, *The Canadian Field-Naturalist* (CFN) or *Blue Jay*.

Dan was born and raised in Ottawa and spent his formative years first with a passion for astronomy, and then birding, often in the company of folks like Ron Pittaway, Monty Brigham, Joe Dafoe and Ken Ross. He received his university degree in Geography and Botany from Carleton University in 1973. Dan worked for several years as a park naturalist, especially in Algonquin Park, and he has always been very active

in that park and its biota. Dan also worked in Alberta at the Kananaskis Provincial Park, helping to develop their interpretation program.

Dan Brunton has operated a private consulting firm (Brunton Consulting Services) since the 1970s, doing environmental assessments, botanical or biological surveys, or providing expertise to governmental agencies. He has naturally become very much interested in conservation matters and has served the community well in this regard. Dan received the Ottawa Field-Naturalists' Club's 2003 Conservation Award for his work in establishing a Riverkeeper program in Ottawa. The Transportation Association of Canada awarded him their 1999 Environmental Achievement Award, and, in 1992, he received the Canada 125 Medal from the Canadian Government for his contributions to natural features protection and conservation in the National Capital Region. Dan received the Club's Anne Hanes Natural History Award in 1988 for his book, *Nature and Natural Areas in Canada's Capital*.

Michael D. Cadman – Honorary Member

Mike Cadman is a Songbird Biologist with the Ontario Region of the Canadian Wildlife Service (CWS), Environment Canada.

Mike has been studying birds for most of his life, and earned his MSc from the University of Toronto for research on American Oystercatchers. Mike is best known as the coordinator and lead editor of both the first and second versions of the *Atlas of the Breeding Birds of Ontario*, published in 1987 and 2007, respectively. These were both major projects, involving five years of field work by many hundreds of volunteers, covering the entire province. The 2007 Atlas is the largest and most comprehensive wildlife study in Ontario's history. Having the two atlases 20 years apart allows scientists to compare the two datasets and track changes in bird distribution and abundance.

In addition to the two atlas projects, Mike has been involved in many bird monitoring programs in Ontario. These have included the Forest Bird Monitoring Program and the Eastern Loggerhead Shrike Recovery

Francis R. Cook – Member of the Year

The OFNC Member of the Year Award recognizes the member judged to have contributed the most to the Club in the previous year. Francis Cook is the 2010 Member of the Year for his exceptional effort to bring *The Canadian Field-Naturalist* (CFN) up to date.

Francis Cook was Editor of the CFN from 1962 to 1967 and served as an Associate Editor (herpetology) for several years thereafter. In 1981 he returned as Editor of the CFN. During this past thirty-year span he has maintained the CFN as the most scientifically important and visible aspect of the Club. This has been

The Ottawa Field-Naturalists' Club (OFNC) has benefited tremendously from Dan's interest and activity in Club affairs ever since he joined in 1967. He has served on numerous committees and chaired many including the Awards Committee (see his interesting article in *Trail & Landscape* 21(5): 236-243, 1987), and was President of the Club from 1982-1983. He received the George McGee Service Award for 1985. Dan contributed dozens of articles to *Trail & Landscape* and, in 2004, prepared a detailed and fascinating history of the Club in *The Canadian Field-Naturalist* (vol. 118: 1-34). In fact, Dan provides a unique contribution to the OFNC as the Club historian, and he shares this knowledge freely.

For his achievements as a knowledgeable naturalist, accomplished botanist and birder, important environmentalist, outstanding service to the Club, and spokesperson for natural history in the National Capital Region, the Club is proud to offer Honorary Membership to Daniel F. Brunton.

Team. He also initiated and coordinated the Ontario Rare Breeding Bird Program which resulted in the publication of Ontario Birds at Risk. He helped develop Bird Studies Canada's Marsh Monitoring Program. He coordinates Wildlife Watchers, which encourages volunteer participation in wildlife monitoring projects, and he organizes the Guelph Christmas Bird Count.

Mike also contributes to the conservation of birds and their habitats by serving with organizations such as the Society of Canadian Ornithologists, Birds Studies Canada, Environment Canada's national landbird committee and the Ontario Partners in Flight Working Group. In the past, he has chaired National Recovery Teams for Eastern Loggerhead Shrike, Acadian Flycatcher, Hooded Warbler, and Henslow's Sparrow.

The Ottawa Field-Naturalists' Club would like to recognize Mike's significant contributions to the understanding of birds, bird distributions, and habitat requirements by making him an Honorary Member.

marked by his receiving during this period three external awards for his and the journal's excellence.

It is, however, for his recent effort to bring the CFN back on schedule that Francis Cook is being recognized as Member of the Year for 2010. For various reasons, during recent years the publication schedule slipped badly. Looking ahead to retirement with the completion of the 2010 Volume 124, and with the intention of the OFNC to begin an online edition of the CFN in 2011 under a new Editor, Francis undertook the demanding task of completing the outstanding issues.

This meant producing seven issues within about ten months. Volume 123(2) appeared in November 2010 (the fourth issue to be published in 2010), from which he determined that he could expedite matters by preparing the remaining six in tandem rather than sequentially. Of these, Volume 123(3) appeared in February 2011 and Volume 123(4) in mid-March; the remaining

four issues are targeted to appear this Spring. This constitutes a production level never attempted before, let alone achieved in the 130 year history of the journal.

For these reasons, and in recognition of these unique achievements, it is our pleasure to present Francis Cook with the Member of the Year Award for 2010.

Barbara Gaertner and Diane Kitching – George McGee Service Award

The George McGee Service Award is given in recognition of members who have contributed significantly to the smooth running of the Club over several years.

Barbara Gaertner and Diane Kitching are excellent choices for this award, recognizing their years of hard work, reliability and dedication as volunteer leaders for the Macoun Field Club. This is the nature club for youngsters in grades 4 through 12 that is sponsored by the OFNC and the Canadian Museum of Nature. Barbara's and Diane's contributions, supporting and assisting Rob Lee, have been critical to the success of the club and its operations.

Over the years, Barbara and Diane have shared some responsibilities and alternated others. Both attend most of the young naturalists' indoor meetings, give talks at the indoor meetings, come on nearly all the field trips and sometimes lead a sub-group, deal with parents when new youth come in, act as the contact person for new members, make sure all members are properly registered, and find speakers for the indoor meetings. They have represented the Macoun Field Club at public venues such as the Wildlife Festival display at Billings Bridge. Both have been, and Diane currently is, the Macoun Field Club representative on the OFNC Council. They also have their own study trees and write

about them for the *Little Bear* – the annual publication – thereby encouraging the young naturalists to do the same. Coincidentally, both of their study trees were later killed by lightning. Barbara and Diane have become better naturalists after all these years as leaders for the Macoun Field Club and are very valuable people to the group.

Barbara proofreads the Macoun web page, goes on camping trips, prints out a customized trip list of youth attending field trips, and takes field notes on field trips to the Study Area.

Diane is the contact person for calls from parents wanting field trip information (every two weeks), and she makes carpooling arrangements and ensures kids are properly dressed. And even if Diane didn't go on a camping trip, she would supply the now famous cream of chicken soup! For a time, Diane produced the monthly newsletter when there was no young person to do this. She also provides art supplies for drawing workshops.

Barbara and Diane have provided very valuable service to the Macoun Field Club, and therefore to the Ottawa Field-Naturalists' Club, and we are pleased to recognize this service through the 2010 George McGee Service Award.

Limerick Forest Advisory Committee, Friends of Limerick Forest, Grenville Land Stewardship Council, and the United Counties of Leeds and Grenville – Conservation Award (Non-member)

The Conservation Award for a non-member is given in recognition of an outstanding contribution by a non-member in the cause of natural history conservation in the Ottawa Valley, with particular emphasis on activities within the Ottawa District.

The 2010 award recognizes the work of four groups who have worked together successfully to ensure ecologically sustainable stewardship for the Limerick Forest. These four are the Grenville Land Stewardship Council, the Limerick Forest Advisory Committee, the Friends of Limerick Forest and the United Counties of Leeds and Grenville.

The Limerick Forest is a large, 5,782 hectare tract in the United Counties of Leeds and Grenville (UCLG). It contains provincially significant wetlands and is home to several species of at risk flora and fauna. In 2001, the Grenville Land Stewardship Council (GLSC) (which has recently been incorporated into the new Leeds and Grenville Stewardship Council) set up the Limerick Forest Advisory Committee (LFAC). LFAC

and the Stewardship Council worked closely with the UCLG during the transition of responsibility for the forest from the province to the county. At this time, there were no permanent staff to oversee the forest.

The LFAC, an entirely volunteer run organization, proved invaluable. Members dedicated countless hours to preparing a Long Range Strategic Plan and Terms of Reference to guide forest management in an ecologically sustainable direction. They also chaired sub-committees (including an ecology sub-committee), performed on-the-ground work (clearing trails, removing garbage, etc.), supervised volunteer days, monitored invasive species, and undertook wildlife enhancement projects. The feeling was, and is, that Limerick is very much a community forest. Therefore, recreational opportunities were promoted, and parking areas, picnic sites and trails were developed or repaired, and the forest headquarters were fixed up. Detailed maps of the forest were also prepared. Open houses were well attended. Participants enjoyed guided walks, displays,

horse-drawn wagon rides, and barbecues. Brochures about Limerick were later produced, and a website was set up, all with the aim of promoting the forest as a community resource to be used wisely, cherished, and protected.

The UCLG hired a consultant to prepare a Twenty-year Forest Management Plan, which a sub-committee of LFAC reviewed and offered comments on. Such collaboration is typical of the cooperative efforts that characterize the relationship between volunteers and the United Counties of Leeds and Grenville.

More recently, the LFAC was dissolved, to be replaced by the Friends of Limerick Forest. Many of the

same long-serving volunteers are active on this new committee, which carries on the tradition of committed volunteer work and cooperation with the UCLG to enhance and maintain Limerick Forest.

The work performed by volunteers, the County and the Grenville Land Stewardship Council is remarkable. It is truly thanks to all of them that the Limerick Forest today is a fine example of what an ecologically sustainable forest can and should be. For all these reasons and more, these four organizations are worthy recipients of the Conservation Award (Non-member) for 2010. Congratulations!

Monty Brigham – Anne Hanes Natural History Award

The Anne Hanes Natural History Award recognizes excellence in natural history research by an amateur. This year the award goes to Monty Brigham for his work over many decades recording the sounds of Canadian bird species.

Monty is one of Canada's foremost experts on audio recording and identification of bird sounds. His recordings are widely recognized for their quality and quantity. He has recorded the songs and calls of over 300 Canadian bird species. He has published a number of collections of Canadian nature sounds, starting with "Songs of the Seasons", produced in 1979 to help commemorate the OFNC's centennial year. He has also prepared "Peelee Spring" (1980) and "Algonquin Park" (1981) and "Natural Sounds of Ontario: Birds, Frogs and Mammals" (2003). In the early 1990's he produced

"Bird Sounds of Canada", a set of six CD's designed to complement "Birds of Canada".

At present, many of Monty's recordings are available online as he has been a major contributor of sound recordings to Dendroica, an interactive website with vocalizations and images of birds from Canada, USA, and Mexico. This website is sponsored by Environment Canada and the United States Geological Survey, among others.

For his outstanding contribution to our knowledge of bird, mammal and amphibian vocalizations in Eastern Ontario and across Canada, the Ottawa Field-Naturalists' Club is very pleased to present Monty Brigham with the Anne Hanes Natural History Award for 2010.

MacSkimming Outdoor Education Centre – Mary Stuart Education Award

In these days of trimmed School Board budgets and cancelled enhancement programs in our schools, it is reassuring to know that there are places like the MacSkimming Outdoor Education Centre. This facility, funded and staffed by the Ottawa-Carleton District School Board, has provided Ottawa school children from Kindergarten to Grade 12 with quality education in natural history and outdoor skills since 1967. There are four permanent staff teachers who run outdoor classes. About 23,000 students visit the Centre each year, spending anywhere from a few hours to four days, learning about nature.

Although the Centre is a low-profile affair, their work has not gone unnoticed. It recently received the prestigious Award for Excellence in Environmental Education from the Canadian Network for Environmental Education and Communication (EECOM). They noted that many former students say that their lives were changed by their experiences at the Centre, either by encouraging them to choose a career in environmental related fields, or simply by showing them

how to become a more environmentally responsible citizen.

The MacSkimming Outdoor Centre is located in Cumberland, on 425 acres of forests, fields and wetlands, with boardwalks to take the students close to the action. In 1969, 254 acres of this property were designated as the Beckett's Creek Migratory Bird Sanctuary by Environment Canada. The children learn about the weather, how to identify trees, what's living in the water, plants and soils, animals in the forest and their interactions, and much more. Among the goals of the program are: increasing knowledge about nature and natural processes, increasing environmental literacy, getting comfortable in the outdoors and simply enjoying the joys of the natural world.

For their many years of exceptional service in teaching natural history to Ottawa area children, the OFNC is proud to present the MacSkimming Outdoor Education Centre and its Site Program Administrator, Kevin Wallace, with the Mary Stuart Education Award for 2010.

Editor's Report for Volume 124 (2010)

Mailing dates for issues in volume 124:

- (1) 19 April 2011;
- (2) 25 May 2011;
- (3) 25 July 2011;
- (4) 18 August 2011

A summary of distribution of memberships in the Ottawa Field-Naturalists' Club and subscribers to *The Canadian Field-Naturalist* for 2010 is given in Table 1. The number of articles and notes in Volume 124 is summarized in Table 2 by topic; totals for Book Reviews and New Titles are given in Table 3, and the distribution of content by page totals per issue in Table 4. Manuscripts [excluding book reviews, notices, and reports] submitted to *The Canadian Field-Naturalist* totalled 56 in 2010 all of which were processed to various stages during the year; 21 of these were accepted for 2010 issues along with 23 first submitted in 2009, two first submitted in 2002, and one each in 2004 and 2005, all revised in 2010.

The journal was printed once again at Gilmore Printers, Ottawa, and thanks are due Chuck Graham for overseeing production and printing. As they have for many years now, Elizabeth Morton proofed and edited manuscripts, Wendy Cotie typeset galleys and corrections for page proofs, and prepared pdfs, Roy John requested books for review, selected reviewers, edited submitted reviews, and prepared the new titles listings. Sandra Garland, the webmaster for the Ottawa Field-Naturalists' Club, posted tables of contents and abstracts and some full pdfs on the OFNC website pending development and completion of the new *Canadian Field-Naturalist* web site by Jay Fitzsimmons. Leslie Cody again prepared the Index with proof-reading by Frank Pope who carried out all other duties of the Business Manager as well as serving as Club Treasurer. Jim Ward continued to mail invoices and reprints as Assistant Treasurer until he handed his duties on to Jay Fitzsimmons. My gratitude is due to all on this effective team.

The following reviewed papers submitted in 2010 (with number of manuscripts reviewed in parentheses if more than one).

Associate Editors: R. Anderson, Canadian Museum of Nature, Ottawa, Ontario; W. B. Ballard, Texas Tech University, Lubbock, Texas (13); C. D. Bird, Erskine, Alberta (9); R. R. Campbell, St. Albert, Ontario; P. M. Catling, Agriculture and Agri-Food Canada, Ottawa, Ontario (6); B. W. Coad, Canadian Museum of Nature, Ottawa, Ontario (2); A. J. Erskine, Sackville, New Brunswick (7); D. F. McAlpine, New Brunswick Museum, Saint John, New Brunswick (2); D. W. Nagorsen, Mammalia Biological Consulting, Victoria, British Columbia (7);

Others: L. G. Adams, USGS-Alaska Science, Anchorage, Alaska; R. Alvo, Ottawa, Ontario; K. B. Aubry, USDA Forest Service, Pacific Northwest Research Station, Olympia, Washington; M. Barret, Edmonton, Alberta; J. Bart, Snake River Field Station, USGS Forest and Rangeland Ecosystem Science Center, Boise, Idaho; M. Bechard, Boise State University, Idaho; R. Bedford, Ottawa, Ontario; S. Blaney, Atlantic Canada Conservation Data Centre, Sackville, New Brunswick; M. Boeckner, Meritus University, New Brunswick; R. Brooks, University of Guelph, Ontario; M. Boeckner, Meritus University, New Brunswick; D. Brunton, Ottawa, Ontario; L. Carbyn, Canadian Wildlife Service, Edmonton, Alberta; C. Cariappa, Texas Tech University, Lubbock, Texas; T. E. Chubbs, Department of National Defence, Happy Valley-Goose Bay, Labrador; D. Cluff, Environment and Natural Resources of the Northwest Territories, Yellowknife, Northwest Territories (2); M. Collins, Memorial University of Newfoundland, St. Johns; J. Cosgrove, Royal British Columbia, Museum, Victoria, British Columbia; S. Davis, Canadian Wildlife Service, Regina, Saskatchewan; S. DeStefano, University of Massachusetts, Amherst; J. DeVault, U.S. Department of Agriculture, Sandusky, Ohio; H. Dodds, Ontario Veterinary College, University of Guelph, Ontario; C. Edge, University of New Brunswick, Fredericton; P. Ewins, World Wildlife Fund Canada, Toronto, Ontario; R. Erickson, Texas Tech University, Lubbock, Texas; A. Ferguson, Texas Tech University, Lubbock, Texas;

TABLE 1. The 2010 circulation of *The Canadian Field-Naturalist* (2009 in parenthesis). Compiled by Frank Pope from the mailing list for 124(4).

| | Canada | USA | Other | Total |
|---------------------|-----------|-----------|---------|------------|
| Memberships | | | | |
| Family & individual | 453 (517) | 18 (21) | 2 (2) | 473 (510) |
| Subscriptions | | | | |
| Individual | 90 (95) | 35 (37) | 3 (3) | 128 (132) |
| Institutional | 135 (142) | 194 (196) | 26 (28) | 355 (366) |
| Total | 678 (754) | 247 (251) | 31 (33) | 956 (1028) |

TABLE 2. Number of research and observation articles and notes published in *The Canadian Field-Naturalist*, Volume 124 (2010), by major field of study.

| Subject | Articles | Notes | Total |
|-------------------------|----------|-------|-------|
| Mammals | 7 | 7 | 14 |
| Birds | 6 | 3 | 9 |
| Amphibians and reptiles | 4 | 1 | 5 |
| Fish | 2 | 1 | 3 |
| Plants | 5 | 2 | 7 |
| Other | 2 | 1 | 3 |
| Total | 26 | 15 | 41 |

TABLE 3. Number of reviews and new titles published in the Book Review section of *The Canadian Field-Naturalist*, Volume 124, by topic.

| | Reviews | New Titles |
|---------------|---------|------------|
| Zoology | 15 | 33 |
| Botany | 3 | 10 |
| Environment | 7 | 9 |
| Miscellaneous | 2 | 4 |
| Electronic | 2 | 0 |
| Total | 29 | 56 |

P. Frame, University of Alberta, Edmonton, Alberta; J.-M. Gagnon, Canadian Museum of Nature, Ottawa, Ontario; V. Geist, Port Alberni, British Columbia; J. Gilhen, Nova Scotia Museum of Natural History, Halifax, Nova Scotia (3); G. Gillespie, Fisheries and Oceans Pacific Biological Station, Nanaimo, British Columbia; L. Gillespie, Canadian Museum of Nature, Ottawa, Ontario; A. Giordano, Texas Tech University, Lubbock, Texas; J. M. Green, Memorial University of Newfoundland, St. John's; P. Gregory, University of Victoria, British Columbia; D. Gummer, Western and Northern Service, Centre, Parks Canada, Calgary Alberta; G. T. Hvenegaard, University of Alberta, Augustana Campus, Camrose, Alberta; D. Hebert, Creston, British Columbia; T. Herman, Acadia University, Wolfville, Nova Scotia; E. Holm, Royal Ontario Museum, Toronto, Ontario; D. Holt, Texas Tech University, Lubbock, Texas; T. S. Jung, Yukon Department of Environment, Whitehorse, Yukon Territory; C. Krebs, University of British Columbia, Vancouver; C. Kukal, Texas Tech University, Lubbock, Texas; R. Leach, Northern Alberta Institute of Technology, Edmonton; M. Mallory, Canadian Wildlife Service, Iqaluit, Nunavut; N. Mandrak, Fisheries and Oceans Canada, Burlington, Ontario; T. Meier, Denali National Park and Preserve, Alaska; A. Mercier, Memorial University, St. John's, Newfoundland and Labrador; D. F. Murray, University of Alaska Museum, University of Alaska Fairbanks; R. MacCulloch, Royal Ontario Museum, Toronto (3); D. Mech, U.S. Geological Survey, and The Raptor Center, University of Minnesota,

TABLE 4. Number of pages per section published in *The Canadian Field-Naturalist*, Volume 124 (2010), by issue.

| | Issue | | | | Total |
|-------------------------------|-------|-----|-----|-----|-------|
| | 1 | 2 | 3 | 4 | |
| Articles | 53 | 80 | 57 | 17 | 207 |
| Notes | 7 | 4 | 22 | 0 | 33 |
| Book Reviews* | 10 | 13 | 11 | 0 | 34 |
| News and Comment, Notice** | 1 | 3 | 10 | 15 | 29 |
| Tributes | 26 | 0 | 0 | 69 | 95 |
| Index | — | — | — | 15 | 15 |
| Advice to Contributors | 1 | 0 | 0 | 0 | 1 |
| Total | 98 | 100 | 100 | 116 | 414 |

* Total pages for book review section include both reviews and new titles listings.

** Includes CFN Editor's report in number 2, Minutes of the OFNC Annual Business Meeting in number 3, and OFNC Awards and review article in number 4.

St. Paul, Minnesota (7); D. Naughton, Canadian Museum of Nature, Ottawa, Ontario; R. Newell, E. C. Smith Herbarium, Acadia University, Wolfville, Nova Scotia; E. Nol, Trent University, Peterborough, Ontario; J. Oakleaf, U.S. Fish and Wildlife Service, Albuquerque, New Mexico; M. Panasci, Texas Tech University, Lubbock, Texas; K. G. Poole, Aurora Wildlife Research, Nelson, British Columbia; F. Pope, Ottawa, Ontario. H. Proctor, University of Alberta, Edmonton, Alberta; G. Proulx, Alpha Research & Management Ltd., Sherwood Park, Alberta; M. Pybus, Alberta Fish and Wildlife Division, Edmonton; J. Reddoch, Ottawa, Ontario (3); C. Renaud, Canadian Museum of Nature, Ottawa, Ontario; E. M. Rominger, New Mexico Department of Game and Fish, Santa Fe, New Mexico; B. Samuel, Texas Tech University, Lubbock, Texas; J. Sanderson, Small Cat Conservation Alliance, Tucson, Arizona (2); J.-P. L. Savard, Canadian Wildlife Service, Ste. Foy, Quebec; F. W. Schueler, Bishops Mills Natural History Centre, Ontario (4); C. Sheviak, New York State Museum at Albany (2); J. Skevington, Agriculture Canada, Ottawa, Ontario; P. Taylor, Acadia University, Wolfville, Nova Scotia; R. P. Thiel, Department of Natural Resources, Sandhills Wildlife Area, Babcock, Wisconsin; R. Thompson, Arizona Game and Fish Department, Phoenix; R. Weir, Artemis Wildlife Consulting, Armstrong, British Columbia; J. Whitaker Jr., Indiana State University, Terre Haute, Indiana; K. S. White, Alaska Department of Fish and Game, Douglas, Alaska; W. Wishart (retired) Alberta Fish and Wildlife, Edmonton; M. Zinck Munro, Nova Scotia Museum, Halifax, Nova Scotia.

Since 1962, I am indebted above all to my wife Joyce who so successfully managed the difficult role of living with and encouraging an editor. In two terms as Editor (1962-1966; 1981-2010) I have edited a total of 19,479 journal pages in 137 issues in 34 ¼ years [a record for *The Canadian Field-Naturalist*, surpass-

ing Harold Senn's 13 ¼ years, but not for a Canadian natural history journal, as Victor-A. Huard was editor of *Le Naturalist canadien* for 36 years; 1894-1929]. My thanks to present and past Presidents and Councils of the Ottawa Field-Naturalists' Club, especially to Chairman Ron Bedford and the Publications Committee (1981-2010) of the OFNC for support. The Canadian Museum of Nature (and its predecessor the National Museum of Canada) provided space and facilities during my tenure there as curator and researcher (1960-1993) and afterwards in retirement as emeritus and associate, most recently at the museum's Natural Heritage Building, Gatineau (Aylmer), Quebec. Thanks to the Associate Editors, and the many individual reviewers and the authors who submitted original articles, notes, reviews, and cover photos over the years,

thus making the journal possible. The past contributions of these and others in production are acknowledged individually annually in my previous Editor's Reports (1982-2009) or in individual articles in *The Canadian Field-Naturalist*. Special thanks to the Ottawa Field-Naturalists' Club for the opportunity to edit their journal for so long, and to my initial editing predecessor and mentor, Bob Hamilton, and the editors between my two terms, Theodore Mosquin and Lorraine Smith, who are mainly responsible for the journal in its present form. I am indebted to the incoming Editor, Dr. Carolyn Callaghan, for making my transition out of the post both smooth and cordial.

FRANCIS R. COOK
Past Editor

The Canadian Field-Naturalist — Instructions for Authors

Aim and Scope

The Canadian Field-Naturalist (CFN; ISSN: 0008-3550) publishes peer-reviewed scientific papers on natural history relevant to Canada. Relevance to Canada usually means the species studied must inhabit Canada, even if the research itself occurred outside Canada. e.g., U.S.-based research on a species whose range extends into Canada, or research in Asia on a species introduced into Canada. Natural history comprises organism-scale biological research in diverse fields including behaviour, ecology, conservation, and taxonomy, among others. We publish research on any taxa, from microbes to large-bodied mammals. We encourage manuscript submissions from professional and amateur naturalists. Our journal has been published continuously since 1879 by the non-profit group The Ottawa Field-Naturalists' Club, making it one of the longest-running ecological journals in North America.

Manuscript Types

Articles. Articles report original research and are at least five pages long in printed form. There are no upper-boundary restrictions on the number of pages or references for articles (maximum abstract length: 250 words). Articles are peer-reviewed.

Notes. Like articles, Notes report original natural history research. Notes only differ in being shorter (maximum abstract length: 100 words; maximum page length in final printed form: 4 pages, or approximately 2000 words). Many Notes report novel observations of animal behaviour, diet choice, or range extensions of species. Notes are peer-reviewed.

Book Reviews. We publish many reviews of books of interest to naturalists, from all over the world (i.e., not necessarily related to Canadian species). Each issue includes a list of new book titles received by our Book Reviews Editor with notation on books available for review, although we are open to suggestions of reviews for other titles. All book reviews and inquiries related to book reviews should be sent to our Book Review Editor, Roy John (r.john@rogers.com). Book reviews are edited by Roy John, but are not considered peer-reviewed.

Tributes. Tributes are descriptions of recently-deceased exemplary naturalists who contributed to our understanding of Canadian nature. Please inquire with our Editor-in-Chief, Dr. Carolyn Callaghan, before writing a Tribute. Tributes are not peer-reviewed.

News, Opinions and Reports. Short news items, commentary, or reports of interest to naturalist readers. They are not peer-reviewed, and are normally contributed by our Editor-in-Chief. News item suggestions should be directed to our Editor-in-Chief, Dr. Carolyn Callaghan (editor@canadianfieldnaturalist.ca). Commentary may be similar to articles in format or it may be just a series of paragraphs.

Editorials, Club Reports. These items are contributed by our editors and Ottawa Field-Naturalists' Club personnel, and are not open to submission by others.

Manuscript Guidelines

Manuscripts are to be submitted to the Editor-in-Chief by email (editor@canadianfieldnaturalist.ca) or post, written in the journal style. Authors should consult a recent issue of CFN to understand journal format. A sample issue is available for free online at www.ofnc.ca/cfn/122-1/subscribers-index.php.

Legal issues, ethical conduct

The research reported must be original. Manuscripts cannot have been published, or be under consideration for publication, in part or in entirety in any other publication media including journal, newsletter, book, report, either online or in print. The author(s) is/are expected to confirm that a manuscript submitted for consideration for publication in the Canadian Field-Naturalist has not already been published elsewhere, and will not be published elsewhere unless rejected by the Canadian Field-Naturalist. Published means distributed or otherwise made available in print, either in hard copy or online and with or without peer review.

All co-authors must have read and approved the submitted version of the manuscript. If institutional or contract approval for the publication of data is required, authors should have obtained it prior to manuscript submission. Authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, or minerals. Animal care should comply with relevant institutions' guidelines and be considered ethical by peers. A cover letter, indicating compliance with the preceding points must accompany the manuscript submission when appropriate.

Language

Manuscripts can be submitted in English or French. Manuscripts are permitted, but not required, to include abstracts and keywords in both languages. Canadian spelling of the English language is required on manuscripts submitted in English. A contemporary reference for formal Canadian spelling is the *Canadian Oxford Dictionary*.

Font, page format, file type

Font should be 12-point Times New Roman. Manuscripts should be double-spaced throughout including references with margins 2.5 cm (1 inch) wide. Pages should be numbered sequentially, and lines should be numbered continuously. The file should be saved as .doc (Microsoft Word 2003) file format.

Nomenclature and units of measurement

Species' common names (when available) and scientific names should both be used at least once in the manuscript. Initial letters of species common names should be capitalized. Authorities' names (e.g., "Kuhl" in *Castor canadensis* Kuhl) should be omitted from scientific names unless the manuscript has taxonomic relevance or in the first reference to a featured species. Units of measurement should follow standard metric SI units.

Vouchers, location information, GenBank

All voucher material should include the name and location of the collection and the specimens' catalog numbers. All collections or observations of species should include latitude and longitude in decimal degrees at two decimal points or finer depending on the sensitivity of the information. All genetic sequences should be accompanied by GenBank accession numbers.

Title page

Include the title, a running title (maximum of 35 characters), the list of authors, and the type of submission the manuscript should be considered. For each author provide their

affiliation with postal address (home address is fine for unaffiliated amateurs) and e-mail address. Indicate which author is the corresponding author, and provide their phone number in addition to postal and e-mail address.

Abstract page

The second page of the manuscript (for Articles and Notes) should include the abstract and a list of key words (4-10 key-words).

Manuscript sections

Articles should typically contain the following sections listed as bolded, 16-point font headings, initial caps only: Introduction, Methods, Results, and Discussion. Alternative headings are permitted. Second-level subheadings are permitted and should be italicized in 12-point font. Notes' headings, if any, are at the authors' discretion. Both Articles and Notes should also include Acknowledgements, Documents Cited, and Literature Cited. Acknowledgements should list authors' funding sources and thank people who contributed significantly to the study. Documents and Literature Cited are described below.

Citation format

Below are example citations in CFN style. When more than one document is cited in a citation, sort them chronologically, and alphabetically within the same year, separated by semicolons.

Single author: "... fishers in Maine (Coulter 1966)."

Two authors: "... been observed (MacKinnon and Kennedy 2009)"

Three or more authors: "... diet composition (Arthur *et al.* 1989)."

Multiple documents cited: "... birds and tardigrades are very different (Tufts 1961; Nelson *et al.* 2009)."

References (Documents Cited and Literature Cited)

Cited references should be listed under the headings of Documents Cited (for reports of limited circulation and web documents) and Literature Cited (for journal articles, books, book sections, and theses). All references should have hanging indents. Web documents' citations should include their website address and the date they were accessed. Journal names should be written in full. Below are example references in CFN format.

Documents Cited

Environment Canada. 2008. National Climate Data and Information Archive, Environment Canada. Accessed 5 November 2008. www.climate.weatheroffice.gc.ca.

Friends of Fish Creek Provincial Park Society. 2009. Water quality monitoring report 2009. Accessed 20 March 2011. <http://wsow.brbc.ab.ca/reports/FishCreekStudy2.pdf>.

Stevens, V. 1995. Wildlife diversity in British Columbia: distribution and habitat use of amphibians, reptiles, birds, and mammals in Biogeoclimatic Zones. Working Paper 04. B.C. Ministry of Forest Research Program, and Ministry of Environment, Lands, and Parks' Habitat Protection Branch, Victoria, British Columbia, Canada. 288 pages.

Literature Cited

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Box 35069, Westgate PO
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Canada

Contact Information

CFN website:
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Ottawa Field-Naturalists' Club (our publisher) website:
www.ofnc.ca

Editor-in-Chief: Dr. Carolyn Callaghan
editor@canadianfieldnaturalist.ca

Assistant Editor: Trina Rytwinski
canadianfieldnaturalistae@gmail.com

Book Review Editor: Roy John
r.john@rogers.com

Journal Manager: Jay Fitzsimmons
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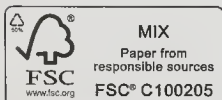
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Business Manager: Frank Pope, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2

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COVER: The dead body of a white-nose syndrome infected bat (*Myotis* sp.) in Berryton Cave, New Brunswick, overcome by co-occurring fungi (probably *Mortierella* sp.). Photo by Donald F. McAlpine, New Brunswick Museum. See article by McAlpine, Vanderwolf, Forbes, and Malloch, pages 257–260.

Presence of Mammals in Ontario, Canada, Verified by Trail Camera Photographs Between 2008 and 2010

RICK ROSATTE¹

¹Ontario Ministry of Natural Resources, Wildlife Research and Development Section, Trent University, DNA Building, 2140 East Bank Drive, Peterborough, Ontario K9J 7B8 Canada; email: rick.rosatte@ontario.ca

Rosatte, Rick. 2011. Presence of mammals in Ontario, Canada, verified by trail camera photographs between 2008 and 2010. *Canadian Field-Naturalist* 125(3): 193–199.

Trail cameras were used to determine the presence of medium to large-sized wild mammals in Ontario between 2008 and 2010. A total of 27 different species of mammals across the province were photographed during 17308 trail-camera-nights. Presence indices (photographs per trail-camera-night) for the areas sampled in southern Ontario were highest for the following species: White-tailed Deer (*Odocoileus virginianus*), Raccoon (*Procyon lotor*), Coyote (*Canis latrans*), Eastern Gray Squirrel (*Sciurus carolinensis*), and Red Squirrel (*Tamiasciurus hudsonicus*). Presence indices for the areas sampled in northern Ontario were highest for White-tailed Deer, American Black Bear (*Ursus americanus*), Moose (*Alces alces*), Snowshoe Hare (*Lepus americanus*), and Red Squirrel. Trail camera photographs depicted extensive use of snowmobile trails by wildlife in southern Ontario.

Key Words: diversity, mammals, trail cameras, White-tailed Deer, *Odocoileus virginianus*, Raccoon, *Procyon lotor*, Coyote, *Canis latrans*, Eastern Gray Squirrel, *Sciurus carolinensis*, Red Squirrel, *Tamiasciurus hudsonicus*, American Black Bear, *Ursus americanus*, Moose, *Alces alces*, Snowshoe Hare, *Lepus americanus*, Ontario.

Rarely does one have the opportunity to photograph secretive wildlife species in their natural habitat, other than species that have become habituated to humans. However, trail cameras triggered by movement or by body heat that take high-quality photographs have increased the probability of capturing a photograph of most wildlife species (Sanderson and Trolle 2005; Kelly et al. 2008; O'Connell et al. 2011).

Many books and manuscripts have been published regarding the distribution and abundance of mammals in North America, including Ontario (Whitaker 1996; Feldhamer et al. 2003). However, very few studies have been published that document the actual presence of mammalian species in Ontario (Dobbyn 1994; Eder 2002). This study provides photographic evidence of the presence of medium to large-sized mammals in Ontario using trail cameras maintained by government biologists and technicians.

Study Area and Methods

A study was initiated in 2008 to determine the presence of Cougars (*Puma concolor*) on the Ontario landscape, as described in Rosatte (2011). Cameras were placed at the locations of credible Cougar sightings throughout the province. A secondary objective of the study was to evaluate the presence of other medium to large-sized mammalian species in Ontario

in the vicinity of Cougar sightings. Trail cameras (RECONYX RC60, Cuddeback infrared and flash, Wildview, and Moultrie infrared) were set up across Ontario from Red Lake in the northwest to Kapuskasing in the northeast to Grand Bend in the southwest and Brockville in the southeastern part of the province. For the purposes of analysis, northern Ontario was considered to be the area north of the French River (approximately 46°00' north latitude). Northern Ontario includes both the Boreal Forest and the Great Lakes-St. Lawrence Forest regions (Ontario Ministry of Natural Resources 2011*). The area of southern Ontario where the trail camera study took place is primarily eastern mixed forest in the Great Lakes-St. Lawrence Forest region and the Deciduous Forest region (Ontario Ministry of Natural Resources 2011*). Trail cameras in the north were located near Atikokan, Blind River, Chapleau, Kapuskasing, Kenora, Nakina, Nipigon, North Bay, Red Lake, Sault Ste. Marie, and Timmins. In the south, trail cameras were located near Bancroft, Belleville, Bobcaygeon, Brighton, Brockville, Campbellford, Frankford, Lindsay, Midhurst, Minden, Norwood, Omcree, Orangeville, Parry Sound, Pefferlaw, Peterborough, Samia, Uxbridge, Whitney, Wingham, and Woodville.

Generally, cameras operated year round and were checked every one to two months, with batteries and



FIGURE 1A. Photograph of American Black Bears on a snowmobile trail near Sunderland, southern Ontario, September 26, 2008. Photo by R. Rosatte.

memory cards being replaced at that time. The memory cards were viewed using the trail camera or via a computer, photographs of mammals were verified to species by biologists and wildlife technicians, and the data (date the photograph was taken, location of the camera, and species) were tabulated in Microsoft Excel spreadsheets. I received the data files annually during the study. Where multiple photographs of the same animal had been taken in succession (e.g., the RECONYX cameras took five photographs in 5 sec), the animal was counted only once. However, if multiple animals of the same species were captured in a single photograph, the total number of animals present was counted.

Each camera operated on a 24-h basis which was considered to be one trail-camera-night. The data from all cameras were pooled, as initial testing of the cameras indicated there was little difference among cameras with respect to their ability to photograph medium to large-sized animals within 7 to 10 m of the camera. Since the dataset was limited to date, location, and species, analyses were restricted to presence/absence and a crude estimate of density in terms of animals/trail-camera-night. The data were standardized to provide presence indices by dividing the number of photographs per species by the number of trail-camera-nights. The locations of the photographed mammals were plotted and compared to range and distribution maps in Dobbyn (1994), Whitaker (1996), and Feldhamer et al. (2003) to determine whether the locations were within the species' present ranges as indicated on the published maps.

Results

A total of 56 cameras recorded 154736 photographs during 17308 trail-camera-nights in Ontario from April 1, 2008, to March 31, 2010. About 96% of the photographs were either false triggers caused by the movement of vegetation on windy days or multiple photographs of the same animal that had remained within the range of a camera for several minutes, resulting in several hundred photographs being taken of the same individual.

In total, 27 species of wild mammals were photographed by the trail cameras: White-tailed Deer (*Odocoileus virginianus*), Raccoon (*Procyon lotor*), Coyote (*Canis latrans*), Eastern Gray Squirrel (*Sciurus carolinensis*), American Black Bear (*Ursus americanus*), Red Squirrel (*Tamiasciurus hudsonicus*), European Hare (*Lepus europaeus*), Snowshoe Hare (*Lepus americanus*), Red Fox (*Vulpes vulpes*), Moose (*Alces alces*), Gray Wolf (*Canis lupus*), Canada Lynx (*Lynx canadensis*), North American Elk (*Cervus elaphus*), Striped Skunk (*Mephitis mephitis*), Northern Flying Squirrel (*Glaucousys sabrinus*), Eastern Cottontail (*Sylvilagus floridanus*), North American Porcupine (*Erethizon dorsatus*), Virginia Opossum (*Didelphis virginiana*), Fisher (*Martes pennanti*), American Marten (*Martes americana*), Muskrat (*Ondatra zibethicus*), American Mink (*Neovison vison*), Wolverine (*Gulo gulo*), American Beaver (*Castor canadensis*), Woodchuck (*Marmota monax*), Ermine (*Mustela erminea*), and Bobcat (*Lynx rufus*) (Figures 1a to 1g). All locations fell within the published distribution ranges for each species, with the exception of the loca-



FIGURE 1B. Photograph of a male White-tailed Deer in the Peterborough area, southern Ontario, September 9, 2010. Photo by Rick Rosatte.



FIGURE 1C. Photograph of a Coyote in the Lindsay area, southern Ontario, January 6, 2010. Photo by Rick Rosatte.



FIGURE 1D. Photograph of a European Hare in the Cannington area, southern Ontario, December 20, 2009. Photo by Rick Rosatte.

tions of the North American Elk, which was restored to northern Ontario during 2000 and 2001, as described by Rosatte et al. (2007).

The presence indices (photographs per trail-camera-night) for the areas of southern Ontario that were sampled were highest for the following species: White-tailed Deer, Raccoon, Coyote, Eastern Gray Squirrel, and Red Squirrel (Table 1). Presence indices for the areas sampled in northern Ontario were highest for

White-tailed Deer, American Black Bear, Moose, Snowshoe Hare, and Red Squirrel (Table 2).

There was also extensive use of snowmobile trails by wildlife in southern Ontario during all seasons, 2008 to 2010. A total of 4465 trail-camera-nights in the Lindsay, Ontario, area resulted in 85760 photographs showing 15 species of wildlife using the trails as travel corridors. Species photographed using snowmobile trails included Coyote ($n = 574$), Raccoon

TABLE 1. Number of photographs and number of photographs per trail-camera-night of mammals in northern Ontario taken between April 1, 2008, and March 31, 2010.¹

| | Species ¹ | | | | | | | | | | | | | | | |
|--|----------------------|---------------------|-------|----------------|--------------|-----------|-------------|--------------|---------|--------|---------|--------------------------|---------|--------------------|-----------------|--------|
| | White-tailed Deer | American Black Bear | Moose | Snow-shoe Hare | Red Squirrel | Gray Wolf | Canada Lynx | American Elk | Red Fox | Coyote | Muskrat | Northern Flying Squirrel | Raccoon | Eastern Cottontail | American Marten | Fisher |
| Number of photographs | 403 | 304 | 188 | 167 | 81 | 79 | 74 | 74 | 50 | 21 | 18 | 18 | 12 | 11 | 9 | 6 |
| Number of photographs/trail-camera-night | 0.08 | 0.06 | 0.04 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.009 | 0.004 | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 | 0.001 |

¹Total trail-camera-nights = 17308; trail-camera-nights for northern Ontario = 5289.

TABLE 2. Number of photographs and number of photographs per trail-camera-night of mammals in southern Ontario taken between April 1, 2008, and March 31, 2010.¹

| | Species ² | | | | | | | | | | | | | | | |
|--|----------------------|---------|--------|-----------------------|--------------|---------|--------------------------|---------------|---------------|---------------------|--------|------------------|--------------------------|--------------------|-------|--------|
| | White-tailed Deer | Raccoon | Coyote | Eastern Gray Squirrel | Red Squirrel | Red Fox | Northern Flying Squirrel | Striped Skunk | European Hare | American Black Bear | Fisher | Virginia Opossum | North American Porcupine | Eastern Cottontail | Moose | Ermine |
| Number of photographs | 1454 | 929 | 904 | 781 | 264 | 150 | 73 | 61 | 56 | 35 | 34 | 18 | 17 | 17 | 7 | 3 |
| Number of photographs/trail-camera-night | 0.12 | 0.08 | 0.08 | 0.07 | 0.02 | 0.01 | 0.006 | 0.005 | 0.005 | 0.003 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.0003 |

¹Total trail-camera-nights = 17308; trail-camera-nights for southern Ontario = 12019.

²Four or five different White-tailed Deer, Coyotes, or Raccoons were found in single photographs taken by trail cameras in southern Ontario.



FIGURE 1E. Photograph of a Fisher in the Sunderland area, southern Ontario, August 23, 2009. Photo by Rick Rosatte.



FIGURE 1F. Photograph of a Canada Lynx in the Red Lake area, northern Ontario, September 1, 2009. Photo by Kim Austen.

($n = 481$), White-tailed Deer ($n = 183$), Red Fox ($n = 72$), Striped Skunk ($n = 39$), American Black Bear ($n = 38$), European Hare ($n = 23$), Eastern Gray Squirrel ($n = 23$), and Fisher ($n = 10$) (Figure 2). Six other species that were photographed using snowmobile trails are noted in Figure 2.

Discussion

In the past, researchers have used photographs acquired by cameras set up on trails to estimate the abundance and relative density of certain mammalian species (Kelly et al. 2008; Negroes et al. 2010). However, in those studies, individual animals were identified in the photographs and were used to estimate animal density. Even though camera study locations were separated by several animal home ranges, individual animals could not be identified in this study because of the large volume of photographs. In addition, some species do not have significant variation in attributes, such as fur coloration or markings that would allow individuals in photographs to be differentiated. Since individual animals in this study could not be identified with any certainty, an indicator of presence in terms of animals per trail-camera-night was the only practical approach. It was not possible, given the limitations of the dataset, to examine other aspects of Ontario mammalian ecology, such as temporal behaviour patterns.

A significant number of photographs of White-tailed Deer, Raccoons, and Coyotes were acquired in southern Ontario; however, one should not infer from these data that these three species exist in high densities. Nevertheless, one can infer a significant presence of those species based on the sheer magnitude of the photographs. In some instances during this study, there were four or five different individuals of the same species in a single photograph at several camera locations spaced several home ranges apart in southern Ontario (e.g., this was true for White-tailed Deer, Raccoons, and Coyotes). This is indicative of a significant presence



FIGURE 1G. Photograph of a Wolverine in the Red Lake area, northern Ontario, July 8, 2009. Photo by Kim Austen.

on the landscape. At the other end of the spectrum, species that were seldom photographed in this study do not necessarily exist at low densities in the province. This could merely be a function of the fact that cameras may not have been placed in the habitats preferred by those species.

The trail cameras photographed about 31% of the wild mammalian species that are thought to be present in Ontario. There are 86 species of mammals in Ontario (Dobbyn 1994), and about 38% of those are small mammals, such as mice, moles, voles, shrews, and bats, which would not be expected to trigger the trail cameras due to their small body size. In addition, there was no possibility that another 11% of the mammalian species in Ontario would be photographed, as cameras were not placed in their ranges. Polar Bears (*Ursus maritimus*), seals, and whales fall into this category. Some of the other species present in Ontario that were not photographed include American Badger (*Taxidea taxus*) (which is a species at risk), Cari-

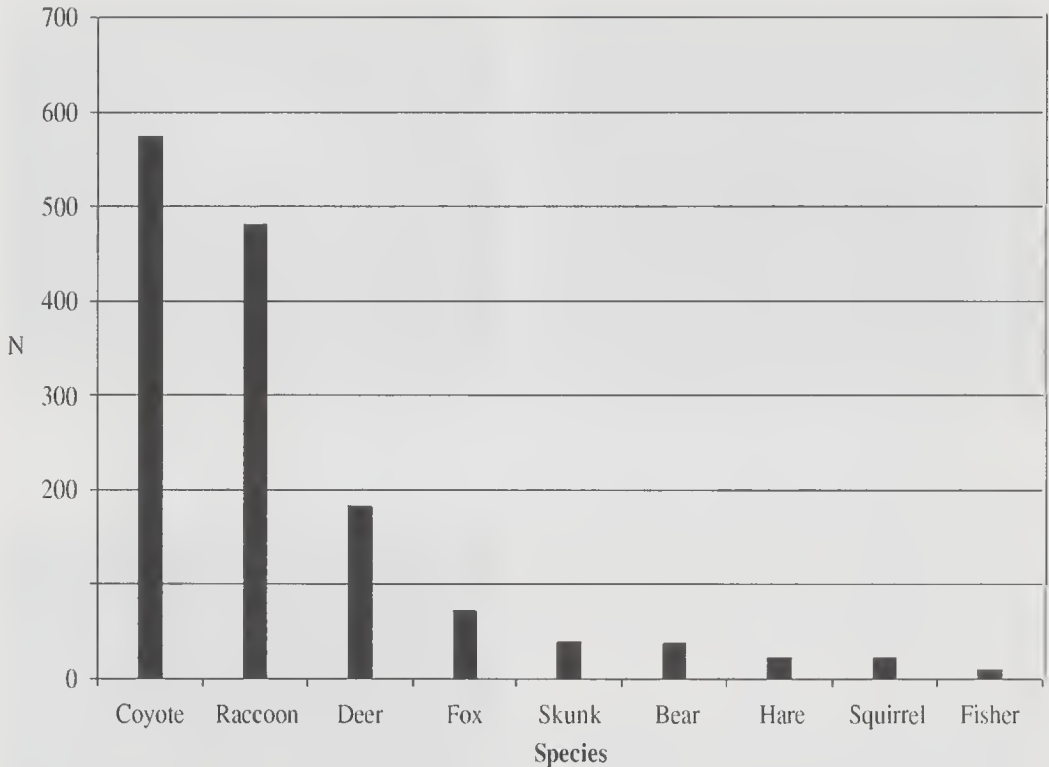


FIGURE 2. Number of photographs of mammals taken by trail cameras on snowmobile trails in southern Ontario between April 1, 2008, and December 31, 2010.¹

¹ Other mammals included Eastern Cottontail ($n = 8$), North American Porcupine ($n = 7$), Virginia Opossum ($n = 7$), Red Squirrel ($n = 1$), American Mink ($n = 1$), and Woodchuck ($n = 1$). Deer = White-tailed Deer, fox = Red Fox, skunk = Striped Skunk, bear = American Black Bear, hare = European Hare, squirrel = Eastern Gray Squirrel. N = number of photographs of each species.

bou (*Rangifer tarandus*), and Arctic Fox (*Vulpes lagopus*), because few or no cameras were placed within their ranges. No photographs of the North American River Otter (*Lontra canadensis*) were acquired because cameras were not set up in aquatic habitats, and no photographs of the Eastern Chipmunk (*Tamias striatus*) were acquired because it would likely be too small to trigger the cameras.

The presence indices (animals per trail-camera-night) do not reflect actual density of animals but rather provide an indication of the presence of these species on the Ontario landscape. The presence and range of mammals in Ontario are affected by many factors, including climatic conditions, habitat (including forest type), land-use (e.g., agriculture), food availability, predation, and disease. For example, Virginia Opossums were photographed in southern Ontario only. This species is a recent immigrant to southern Ontario. The Virginia Opossum is not very hardy and

it has not yet adapted to severe winters, so it would not be expected to be present in northern Ontario. Another example is Raccoons and Striped Skunks, which do well in the agricultural and urban regions of southern Ontario. However, the boreal forest of northern Ontario is generally unsuitable habitat for Raccoons and Striped Skunks, and densities of these species are low in the north (Rosatte 2000; Rosatte and Larivière 2003; Rosatte et al. 2010).

Trail cameras proved to be a valuable and non-invasive wildlife research tool for recording the presence of medium and large-sized animals in Ontario. Cameras were able to operate year round in temperatures colder than -20°C when batteries and memory cards were changed every one to two months. Trail cameras with appropriate experimental designs are currently being used in Ontario for such diverse projects as estimating the density of North American Elk in northern Ontario, determining their calving sites in the

southern part of the province, and determining the presence of an endangered species, *Puma concolor* (Rosatte et al. 2007; Rosatte, 2011).

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Effects of Feral Horses on Vegetation of Sable Island, Nova Scotia

BILL FREEDMAN^{1,2}, PAUL M. CATLING³, and ZOE LUCAS⁴

¹Department of Biology, Dalhousie University, Halifax, Nova Scotia B3H 4J1 Canada

²Corresponding author (email: bill.freedman@dal.ca)

³Biosystematics Research Institute, Central Experimental Farm, Agriculture Canada, Ottawa, Ontario K1A 0C6 Canada; email: catlingp@agr.gc.ca

⁴Sable Island Green Horse Society, P.O. Box 64, Halifax CRO, Halifax, Nova Scotia B3J 2L4 Canada; email: zoelucas@greenhorsesociety.com

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To provide necessary information for the management of biodiversity on Sable Island, Nova Scotia, we studied the effects of feral horses on vegetation using exclosures and ancillary observations. Nine plant communities inside and outside of six exclosures were compared using various vegetation parameters and Mann-Whitney tests to evaluate the significance of differences. The most important findings were as follows: (1) effects of horses were greatest in the Marram (*Ammophila breviligulata*) grassland and much less in the communities that were not dominated by Marram Grass; (2) effects on Marram grassland varied substantially among sites; (3) the cover of standing litter of herbaceous plants was on average of 9.3 times greater inside exclosures in grassland habitats; (4) the cover of living foliage was usually higher inside exclosures, but not all differences were significant; (5) species richness and species diversity were not substantially affected; (6) the average cover of Marram Grass, the most abundant plant and a key sand binder on the island, was greater inside exclosures in six of seven study sites, significantly so in three of them; and (7) there were inconsistent differences in cover of other species at different sites. Wetland habitats cover a relatively small portion of Sable Island, but they support much of the plant biodiversity. There is evidence of strong but variable effects of horses on wetland vegetation. "Horse lawns" are littoral habitats dominated by *Agrostis stolonifera* (Carpet Bentgrass) and other low-growing plants. The lawn habitats represent less than 1% of the island's vegetation, and their presence is believed to be due to grazing and trampling by horses.

Key Words: Sable Island, feral (wild) horses, *Equus caballus*, vegetation, *Ammophila breviligulata*, Marram Grass, grazing, exclosures, standing litter, erosion, trampling, environmental impact, Nova Scotia.

Sable Island is located in the open Atlantic Ocean about 150 km east of the land mass of Nova Scotia, Canada. The island is an important location for the conservation of Canadian biodiversity. It supports several endemic taxa, including the *princeps* subspecies of the Savannah Sparrow (the Ipswich Sparrow) (*Paserculus sandwichensis princeps* Maynard) and several plants and invertebrates (Howden et al. 1970; Catling et al. 1984; Wright 1989). There are additional species of plants and animals on the island that are otherwise rare in Nova Scotia and/or Canada, as well as regionally important breeding populations of the Gray Seal (*Halichoerus grypus* (Fabricius)), the Harbor Seal (*Phoca vitulina* Linnaeus), and seabirds. Particularly well known is a population of wild horses (*Equus caballus* Linnaeus). Although it was established from feral animals, this herd is genetically distinct from 15 other horse breeds in eastern Canada and 5 Spanish ones, and it is therefore of conservation interest (Plante et al. 2007).

In view of these biodiversity values, substantial losses of vegetated terrain and freshwater ponds caused by erosion are serious threats to the conservation of the natural heritage of Sable Island. This concern has been heightened as a result of predictions of rising sea levels and an increasing frequency of severe storms in the North Atlantic. These could potentially reduce the veg-

etated area of the island. Moreover, in October 2011, it was announced that Sable Island would be protected as a national park reserve. Conservation of its natural and cultural heritage will be key aspects of its management plan.

A number of non-native mammals as well as many alien plants have been introduced onto Sable Island (Catling et al. 1984; Wright 1989). Cattle (*Bos taurus* Linnaeus) were introduced around 1550 as food for shipwrecked mariners. In the mid-17th century there may have been as many as 800 free-ranging cattle, but they were eliminated by a commercial harvest and have not been present for at least two centuries (Nova Scotia Museum of Natural History 2001*). Horses were introduced onto the island in the mid-18th century and pigs (*Sus scrofa* Linnaeus) and sheep (*Ovis aries* Linnaeus) were released in 1801, but these latter species did not become established or were soon eliminated by hunting. Today, feral horses are the only terrestrial mammals on Sable Island (Welsh 1975*; Christie 1995). These animals are descended from the mid-18th century introduction, supplemented by sporadic releases of a few additional animals in the 1800s and early 1900s with the intent of "improving" the breeding stock.

Trampling and feeding activities of introduced large mammals have influenced the vegetation of Sable Island, and feral horses continue to exert an effect. In

addition, native vegetation was disturbed during a period of subsistence and market gardening and other activities by the personnel of several life-saving stations (Catling et al. 1984). More recently, only small numbers of people have been resident on Sable Island (typically fewer than 10), limited to personnel engaged in atmospheric and ecological research and monitoring, in addition to maintaining an emergency-response capability.

During several decades prior to 1961, some horses were removed from the island for use on the mainland as working or riding animals. The intensity of this exploitation depended on the interest of the island superintendent of the time; under some superintendents, there was extensive live-harvesting on an annual basis, while others allowed only minor interventions. Since 1961, however, the horses have been protected from harassment or culling under provisions in the Sable Island Regulations made under the Canada Shipping Act (currently, the Canada Shipping Act, 2001). Their legal protection arose as a result of a controversial plan in 1960 to remove all horses from Sable Island because of damage they were presumed to be causing to its habitats as well as popular conceptions about harsh living conditions for the animals. Some people still advocate for a cull of these animals, based on concerns that this alien population might be damaging habitat, or due to unease about suffering the animals are believed to experience from injuries, illness, or other aspects of their wild circumstances. Recently, the horse population of Sable Island has ranged in late-summer abundance from about 250 to 450 animals (including foals) (estimates based on annual direct counts) (Z. Lucas, unpublished data).

Despite the ongoing controversy, there has been only one published study that focused on the effects of feral horses on habitats of Sable Island (Welsh 1975*). That work was based on observational studies of horse feeding and of seasonal forage biomass. Welsh (1975*) concluded that the most important effects were caused by localized trampling and destabilization of vegetation rather than by overgrazing of forage.

In North America, grazing by wild horses has been shown to reduce the richness of plant species in some situations (Beever and Brussard 2000; Beever et al. 2008) but not in others (Detling 1998), with the differences likely due to both ecosystem vulnerability and varying intensities of grazing pressure. Assateague Island on the Atlantic coast of Maryland has dune habitats comparable to those of Sable Island, and there are contrasting reports of the effects of feral horses there. Eline and Keiper (1979) reported little effect on dune vegetation, whereas De Stoppelaire et al. (2002*) suggested that "unless the size of the feral horse population is reduced, grazing will continue to foster unnaturally high rates of dune erosion."

In the present study we compare the abundance and community structure of vegetation inside and outside fenced areas established to exclude horses from the vicinity of buildings and equipment. The exclosures

enabled us to examine the influences of horses, mainly grazing and trampling, on dominant plant species of the major terrestrial community types of Sable Island. This work is supplemented by additional observations of habitat changes associated with horse activity outside the exclosures. The objective is to provide information required for the management of biodiversity on Sable Island.

Study Area

Sable Island is essentially a crescent-shaped, emergent sandbar in the open ocean, with its long axis oriented east to west. It is about 47 km in length and has an area of 32.3 km², of which 15.5 km² is vegetated (Catling et al. 1984; Freedman 2001*). The mean annual temperature of Sable Island is 7.6°C (SD 1.5), and the annual precipitation is 146 cm (92% wet, 8% snow) (Environment Canada 2011*). All terrain on the island is susceptible to the erosion and deposition of sand, with non-vegetated habitat being especially vulnerable to these processes and mature shrub-heath habitat the least susceptible. The dynamics of sand erosion and deposition are related to the relative exposure of habitats, particularly during wind- and rain-storms.

Catling et al. (1984) described the most prominent terrestrial plant communities on Sable Island as follows: grassland dominated by Marram Grass (American Beachgrass) (*Ammophila breviligulata* Fern.), often with abundant Beach Pea (*Lathyrus japonicus* Willd. var. *maritimus* (L.) Kartesz & Gandhi), Seaside Goldenrod (*Solidago sempervirens* L.), and Common Yarrow (*Achillea millefolium* L. var. *occidentalis* DC.); mature heath dominated by Northern Bayberry (*Morella* (*Myrica*) *pensylvanica* (Mirbel) Kartesz), Lowbush Blueberry (*Vaccinium angustifolium* Ait.), Black Crowberry (*Eupetrum nigrum* L.), Creeping Juniper (*Juniperus horizontalis* Moench), Common Juniper (*J. communis* L. var. *megistocarpa* Fern. & St. John), and Virginia Rose (*Rosa virginiana* P. Mill. var. *virginiana*); and an intermediate type, referred to as Marram-heath transitional.

Methods

Exclosures

We studied the three plant communities (Marram grassland, mature heath, and Marram-heath transitional) in a total of nine stands in six exclosures. These fenced areas have been constructed at various times to prevent horses from utilizing habitat in the proximity of buildings, wind turbines, or arrays of scientific equipment used to monitor atmospheric conditions. The locations of the exclosures are indicated with coordinates in Table 1 and are clearly defined on the landscape by the fences, buildings, or other structures indicated in their names. Of the two wind turbine sites, b is the more westerly. At Main Station, the grassland site was at the northwest corner of the compound, the mesic heath on the west side, and the drier heath on the south-

TABLE 1. Nine sampling sites with horse enclosures on Sable Island, showing the site acronym and name, age (number of years horses have been excluded), area, and dominant vegetation.

| Site and name | Age (years) | Area (ha) | Coordinates (°N, °W) | Vegetation |
|-------------------------|-------------|-----------|----------------------|-------------------------|
| East Light BIO (EL-BIO) | >20 | 1.38 | 43.959733, 59.833233 | Marram grassland |
| Main Station (MS) | >20 | 5.80 | 43.930966, 60.008766 | |
| Grassland (MSgr) | >20 | na | 43.933900, 60.006905 | Marram grassland |
| Mesic heath (MSmh) | >20 | na | 43.933606, 60.007543 | Marram-heath transition |
| Drier heath (MSdh) | >20 | na | 43.931912, 60.006120 | mature heath |
| West Light BIO (WL-BIO) | 10 | 0.19 | 43.932066, 60.023566 | Marram grassland |
| Nova Scotia Camp (NSC) | 30 | 0.14 | 43.934183, 60.047333 | Marram grassland |
| Maritime Tel (MTT) | 20 | 0.05 | 43.931866, 60.020450 | Marram grassland |
| Wind Turbine (a) (WTa) | 4 | 0.14 | 43.929883, 60.002300 | Marram-heath transition |
| Wind Turbine (b) (WTb) | 4 | 0.21 | 43.929900, 60.003566 | Marram-heath transition |

east side. The enclosures are constructed of wooden or steel posts and steel-mesh fencing. They vary in size, shape, and age (Table 1).

Horses occasionally enter some enclosures, and small numbers of Gray Seals may enter when they roam inland parts of the island during their breeding season (December through February). However, such entries are occasional (i.e., for short periods, no more than several times a year), and so are considered to be of minor importance with regard to analysis and interpretation of our field data. In addition, terns nest in or near several enclosures, in particular East Light-BIO (Bedford Institute of Oceanography, Department of Fisheries and Oceans), which has recently supported about 500 nests inside and fewer outside. The largest enclosure is at Main Station, with an area of 5.8 ha. It supports three major terrestrial plant communities, which were sampled separately. The other enclosures are smaller, and each supports only a single community. The enclosure at the Maritime Telegraph and Telephone Company (Maritime Tel and Tel, now Aliant) site and the enclosure at the Nova Scotia Camp have relatively small areas of vegetated habitat and much of the space is occupied by buildings, so we report summary data for the cover values for these enclosures rather than by species.

Vegetation sampling at enclosures

Vegetation was sampled in mid-August 2009, using quadrats of 1 m² located at regular distances (usually at intervals of 10 m, but less for the smallest enclosures) along transects that ran parallel to the enclosure fences, one quadrat on the inside and one on the outside. At each sampling point, a quadrat was sampled 3 m inside the fence and a paired set of quadrat was sampled 3 m outside. The 3-m distance was chosen to reduce effects of local trampling in the immediate external proximity of fences, which are often used as pathways and scratching places by horses and are not typical of the ambient habitat condition. For smaller enclosures, 10 quadrats were used; for larger ones, 20 quadrats were used. Within each quadrat, the percentage foliage cover was visually estimated for each species, as were

the standing litter of herbaceous plants (graminoids plus forbs) and the total litter (including litter lying on the ground). The cover estimates accounted for foliage overlap, so the total cover in densely vegetated quadrats could exceed 100%.

Data analysis

For each paired quadrats (inside and outside each enclosure) and for each habitat type within Main Station, the average cover and standard error were calculated for each species, the sum of all species, standing litter of herbaceous species, and total litter. Non-parametric Mann-Whitney tests were used to compare the statistical significance of differences of the most abundant species inside and outside the enclosures. Quadrats inside and outside were also compared in terms of species richness and diversity (the latter indicated by the Shannon-Wiener index, $H = -\sum p_i \log p_i$, with p_i approximated by the relative cover of each species).

Additional observations

Observations were also made in 2008 and 2009 in relation to other habitat changes associated with feral horses.

Horse lawns: These are smaller-scale vegetational features that are commonly observed around the edge of freshwater ponds outside enclosures, a habitat where horses often spend time feeding. The vegetation is low-growing almost to the degree of being two-dimensional, and is dominated by grasses. A selection of three sites was sampled beside ponds at the east end of the island, each using 10 quadrats of 1 m² each placed along a transect, supplemented by photography.

Trampling: Well-worn paths established by the observed repeated passage of horses are common in all plant communities, at scratching posts, and where animals dig to access groundwater for drinking. Vegetation of these microhabitats was documented by notes and photography.

Feeding in ponds: During the summer and autumn, horses in areas with freshwater and brackish ponds are often seen feeding on aquatic macrophytes. General observations were made of this feeding and of the apparent effects on vegetation.

TABLE 2. Comparison of vegetation inside and outside horse exclosures. Cover data are in percentage and are the mean \pm standard error (SE), with the number of quadrats (n) indicated. Species richness is the number of species present, and diversity is the Shannon–Wiener index (H'). Significant differences in cover between samples outside exclosures and samples inside exclosures are marked as follows: * = $P < 0.05$, ** = $P < 0.01$, and *** = $P < 0.001$.

| Habitat | Site | (n) | | Cover (%) | | Species diversity | Site-level species richness |
|------------------|--------|-------|---------|-----------------|-----------------|-------------------|-----------------------------|
| | | | | Live | Standing litter | | |
| Marram Grassland | EL–BIO | 20 | Outside | 63 \pm 6 | 7 \pm 1 | 2.14 | 20 |
| | | 20 | Inside | 115 \pm 12*** | 91 \pm 11*** | 1.66 | 19 |
| | MSgr | 10 | Outside | 75 \pm 14 | 19 \pm 5 | 1.88 | 15 |
| | | 10 | Inside | 68 \pm 13 | 132 \pm 22*** | 1.96 | 15 |
| | WL–BIO | 20 | Outside | 54 \pm 5 | 4 \pm 1 | 1.90 | 17 |
| | | 20 | Inside | 95 \pm 21* | 26 \pm 4*** | 1.56 | 17 |
| | NSC | 10 | Outside | 40 \pm 8 | 4 \pm 2 | 2.00 | 13 |
| | | 10 | Inside | 79 \pm 6** | 75 \pm 7*** | 2.18 | 16 |
| | MTT | 10 | Outside | 43 \pm 5 | 14 \pm 4 | 1.90 | 17 |
| | | 10 | Inside | 62 \pm 6 | 122 \pm 20** | 1.38 | 14 |
| Marram–heath | WTa | 10 | Outside | 60 \pm 12 | 5 \pm 1 | 1.84 | 20 |
| | | 10 | Inside | 71 \pm 9 | 32 \pm 12*** | 2.07 | 21 |
| | WTb | 10 | Outside | 87 \pm 15 | 4 \pm 1 | 2.15 | 25 |
| | | 10 | Inside | 74 \pm 9 | 31 \pm 10** | 2.05 | 21 |
| | MSmh | 10 | Outside | 72 \pm 7 | 17 \pm 2 | 2.43 | 29 |
| | | 10 | Inside | 72 \pm 5 | 48 \pm 18* | 2.52 | 23 |
| Mature heath | MSdh | 20 | Outside | 77 \pm 6 | 1 \pm 0 | 2.08 | 27 |
| | | 20 | Inside | 107 \pm 5* | 18 \pm 5** | 2.13 | 27 |

Results

Effects on major plant communities

With respect to the cover of both live foliage and litter (Table 2) and effects on individual species (Table 3), the effects of horses were greatest in the Marram grassland and much less in the communities not dominated by Marram Grass, based on 5 Marram and 4 non-Marram sites. However, effects on Marram grasslands varied substantially between sites.

Effects on plant cover

The cover of standing litter of herbaceous plants was consistently significantly higher inside than outside exclosures. This was due to the presence of a larger amount of litter of non-eaten graminoids and forbs within the fenced areas. There was also a tendency for plant communities to have a larger cover of living foliage inside the exclosures, but only some of the differences were significant (Table 2). Overall, in the Marram grassland habitats, the cover of standing litter inside the exclosures was on average 9.3 times the cover outside exclosures (Figure 1). In the Marram–heath community, the cover of standing litter inside the exclosures was on average 4.6 times the cover outside exclosures, and in the mature heath the cover of standing litter inside the exclosure was on average 18 times the cover outside the exclosure (although the absolute amount was relatively small in this habitat).

Effects on species richness and diversity

Differences in both species richness and species diversity were small and inconsistent among the study sites (Table 2). For grassland sites, the species diversity

averaged 1.96 outside and 1.75 inside, while richness was 16 in both. For Marram–heath transition sites, species diversity averaged 2.14 outside and 2.21 inside, while richness was 25 and 22, respectively. For the one site of mature heath, species diversity and richness were similar inside and outside the exclosure (Table 2).

Effects on particular species

The average cover data for 47 vascular species inside and outside exclosures are indicated in Appendix 1. While these data provide a useful perspective, more important are the significance results for differences within a species (Table 3). Of 57 instances where there were sufficient data for a statistical test, 10 were significant.

Anemophila breviligulata is the most abundant plant on Sable Island, the principal sand-binding agent, and the key forage species for horses in terms of biomass consumed and time spent feeding (Welsh 1975*). The average cover of Marram Grass was less outside the three Marram grassland exclosures, significantly so in two of them (Table 3). The average cover of Marram Grass was less outside two of the three Marram–heaths sampled, but the differences were not significant. Marram Grass had significantly less cover outside the single heath exclosure than inside.

The only other instances of major vegetation dominance (Appendix 1) being substantially affected were as follows: there was significantly less cover of *Poa pratensis* L. (Kentucky Bluegrass) and *Solidago sempervirens* L. on the outside of one grassland exclosure than on the inside, and there was significantly more cover of *Juncus balticus* Willd. var. *littoralis* Engelm.

TABLE 3. Significance values from Mann-Whitney (Wilcoxon) tests comparing cover of vascular plant species inside and outside exclosures at nine sites. A dash (-) means that there was no occurrence or the frequency was less than 50% for sites with 20 quadrats or at least 25% for sites with 40 quadrats. Significant differences ($P < 0.05$) are indicated in bold. Within significant differences, the underlining indicates more cover inside than outside exclosures; no underlining indicates more cover outside than inside exclosures.

| Species | Marram grasslands | | | Marram-heath transition | | | Mature heath |
|---|-------------------|--------|---------------|-------------------------|--------|--------|---------------|
| | EL-BIO | MSGr | WL-BIO | WTa | WTb | MSmh | MSdh |
| <i>Achillea millefolium</i> | 0.0000 | 0.593 | 0.3468 | - | - | - | - |
| <i>Agrostis stolonifera</i> | - | - | - | - | - | - | - |
| <i>Ammophila breviligulata</i> | 0.0019 | 0.2676 | 0.0000 | 0.3532 | 0.3586 | 0.9086 | 0.0192 |
| <i>Anaphalis margaritacea</i> | - | - | - | 0.8081 | 0.5409 | - | 0.0026 |
| <i>Anthoxanthum odoratum</i> | - | - | - | - | - | - | - |
| <i>Arenaria lateriflora</i> | 0.0005 | - | - | - | - | - | 0.0056 |
| <i>Aronia prunifolia</i> | - | - | - | - | - | 0.3375 | - |
| <i>Symphytotriclum novi-belgii</i> | - | - | 0.1656 | - | - | 0.0908 | 0.1501 |
| <i>Carex silicea</i> | - | - | - | - | - | - | - |
| <i>Cerastium fontanum</i> var. <i>vulgatum</i> | 0.4375 | - | - | - | - | - | - |
| <i>Cladina rangiferina</i> | - | - | - | - | - | - | - |
| <i>Calystegia sepium</i> | - | - | - | - | - | - | - |
| <i>Danthonia spicata</i> | - | - | - | - | - | - | - |
| <i>Deschampsia flexuosa</i> | - | - | - | - | - | - | - |
| <i>Empetrum nigrum</i> | - | - | - | - | - | 0.5616 | 0.2368 |
| <i>Festuca rubra</i> | 0.0744 | - | 0.6341 | 0.6155 | 0.5627 | 0.6369 | 0.8935 |
| <i>Fragaria virginiana</i> | 0.0032 | - | - | 0.7006 | 0.0783 | 0.8182 | 0.0656 |
| <i>Hieracium scabrum</i> | - | - | - | - | - | - | - |
| <i>Ilex verticillata</i> | - | - | - | - | - | - | - |
| <i>Juncus balticus</i> | - | - | 0.0000 | - | - | - | - |
| <i>Juniperus communis</i> | - | - | - | - | - | - | - |
| <i>Juniperus horizontalis</i> | - | - | - | - | 0.5674 | - | 0.8048 |
| <i>Lalryrus japonicus</i> | - | 0.2102 | - | - | - | - | - |
| <i>Leontodon autumnalis</i> | - | - | - | - | - | - | - |
| <i>Linaria vulgaris</i> | - | - | - | - | - | - | - |
| <i>Linnaea borealis</i> | - | - | - | - | - | - | - |
| <i>Luzula multiflora</i> | - | - | - | - | - | - | - |
| <i>Maianthemum stellatum</i> | - | - | - | - | - | 0.1463 | 0.8657 |
| <i>Mitchella repens</i> | - | - | - | - | - | - | - |
| <i>Morella pensylvanica</i> | - | - | - | 0.6756 | 0.2093 | 0.7019 | 0.3274 |
| <i>Oenothera parviflora</i> | - | - | - | - | - | - | - |
| <i>Poa annua</i> | - | - | - | - | - | - | - |
| <i>Poa pratensis</i> | - | - | 0.0006 | - | - | - | - |
| <i>Plantago lanceolata</i> | - | - | - | - | - | - | - |
| <i>Rhinanthus crista-galli</i> | 0.1474 | - | - | - | - | - | - |
| <i>Rosa virginiana</i> | 0.0637 | - | 0.3279 | - | 0.7578 | 0.0838 | 0.0191 |
| <i>Rubus arcuans</i> | - | - | - | - | - | - | - |
| <i>Rumex acetosella</i> | 0.0478 | - | - | 0.9672 | - | - | - |
| <i>Solidago rugosa</i> | - | - | - | - | - | - | - |
| <i>Solidago sempervirens</i> | 0.0109 | - | 0.3975 | 0.1925 | - | - | - |
| <i>Spartina pectinata</i> | - | - | - | - | - | - | - |
| <i>Stellaria graminea</i> | - | - | - | - | - | - | - |
| <i>Thalictrum pubescens</i> | - | - | - | - | - | - | - |
| <i>Trientalis borealis</i> | - | - | - | - | - | - | 0.0604 |
| <i>Trifolium repens</i> | - | - | - | - | - | - | - |
| <i>Vaccinium angustifolium</i> | - | - | - | - | - | - | 0.4722 |
| <i>Vaccinium macrocarpon</i> | - | - | - | - | - | - | - |
| <i>Viburnum nudum</i> | - | - | - | - | - | - | - |

EL-BIO = East Light BIO; MSGr = Main Station grassland; WL-BIO = West Light BIO; WTa = Wind Turbine (a); WTb = Wind Turbine (b); MSmh = Main Station mesic heath; MSdh = Main Station drier heath. See Table 1 for description of sites.



FIGURE 1. Marram-dominated grassland outside a horse enclosure at East Light BIO (to the left of the enclosure fence) and inside (to the right of the enclosure fence). The key difference is in the amount of standing dead biomass of Marram Grass and other forbs inside the enclosure. Photo: Freedman, July, 2009.

(Baltic Rush) on the outside of another grassland enclosure than on the inside. The dominant species of heathlands were not affected significantly at the single heathland enclosure.

Among the less dominant species, there was significantly more cover of *Moehringia (Arenaria) lateriflora* (L.) Fenzl. (Blunt-leaf Grove-sandwort) inside two enclosures than outside. Several other instances of significant effect were as follows: there was significantly more cover of *Rosa virginiana* and the annual alien *Rumex acetosella* L. (Common Sheep Sorrel) on the outside of enclosures than on the inside (Table 3), and at some sites there was significantly more cover of *Anaphalis margaritacea* (L.) Benth. (Common Pearly-everlasting) and *Fragaria virginiana* Duchesne (Virginia Strawberry)—both of which provide abundant nectar and pollen for insect pollinators on the island—outside enclosures. Both *Anaphalis margaritacea* and *Fragaria virginiana* may be promoted by horse activity.

Additional observations

Horse lawns: The sandy shoreline of ponds on Sable Island is mostly gently sloping, and during the grow-

ing season this littoral habitat progressively drains to a mesic-hydric condition. The pond-edge habitats often have a lawn-like community that is apparently produced by horses as a result of frequent close cropping and trampling (Figure 2). These "horse lawns" are dominated by alien species, particularly *Agrostis stolonifera* L. (Carpet Bentgrass) (Table 4). The horse lawns have a low, almost two-dimensional structure, in that they are dominated by prostrate graminoids and forbs no more than a few centimetres tall, and they are maintained in that condition by frequent grazing. Some members of this community are capable of growing much taller but are maintained in a prostrate condition by close cropping, and they may even flower and set seed in that low growth form. The horse lawns support relatively high species richness but low heterogeneity due to the single dominant. Although the horse-lawn habitats cover a small part of Sable Island (less than 1% of its area), they are disproportionately well used by horses. In places less intensively affected by horses, pond margins support nutrient-poor communities dominated by a sparse cover of graminoids, hydric and mesic forbs, and *Vaccinium macrocarpon* Aiton. (Cranberry).

Trampling by horses: Horses wander extensively over Sable Island and utilize all of its terrestrial area, although they spend disproportionately more time in habitats with abundant forage, such as Marram grassland. The horses tend to utilize an extensive network of paths, which are well trampled and support greatly diminished or no vegetation over a width of typically 20–50 cm (Figure 3). There are also sparsely vegetated areas of trampled habitat, typically of 1–10 m², in the immediate vicinity of erect features that horses use for scratching, including posts, fences, and the blown-out edges of vegetated dunes. In addition, there are no ponds over about half of the length of the island, particularly in the eastern end. In those areas, horses dig in low places to expose fresh groundwater for drinking, and those waterholes have numerous radial trails leading to them. Overall, the horse trails cover an estimated 1–2% of the vegetated area of Sable Island. A minor amount of wind erosion is associated with the many horse trails, and increased sand deposition may be apparent in adjacent areas.

Feeding in ponds: Horses feed in all of the approximately 35 freshwater ponds during the summer, when the biomass of aquatic macrophytes is relatively large (Figure 4). They eat a variety of aquatic and wetland plants. Species of pondweeds, especially *Stuckenia* (*Potamogeton*) *pectinata* (L.) Boerner (Broadleaf Pondweed) and *Potamogeton pusillus* L. ssp. *tenuissimus* (Mert. & Koeh) Haynes and C.B. Hellquist (Small Pondweed), appeared to be eaten more frequently than other macrophytes during our late-summer surveys in 2008 and 2009. Also eaten were (alphabetically by genus): *Lysimachia terrestris* (L.) Britton, Sterns & Poggenb. (Bog Loosestrife), *Nuphar lutea* (L.) Sm. ssp. *variegata* (Dur.) E. O. Beal (Variegated Yellow Pond-lily), *Polygonum hydropiperoides* Michx. (Swamp Smartweed), *Potamogeton perfoliatus* L. (Claspingleaf Pondweed), and *Schoenoplectus* (*Scirpus*) *americanus* (Pers.) Volk. ex Schinz & R. Keller (American Bulrush). As well as loss of vegetation cover and likely a selective removal of certain species, aquatic habitats that are used by horses for feeding may experience considerable disturbance caused by trampling and defecation. Ponds less visited by horses appear to have more of the rarer wetland species of the island.

Manure and urine: Horse manure is widespread on Sable Island, being present even in non-vegetated sandy plains, although it is most abundant in habitats that are well used for grazing, such as Marram grassland. The manure occurs mostly as sporadic defecations by animals as they move about, as well as larger mounds known as “stud piles” that are created by stallions in their social interactions, such as to demarcate territory and defend a herd of mares (Welsh 1975*; Beaver 2003).

Although the widespread occurrence of partly digested and composted manure was not directly studied by us, it undoubtedly has an influence on nutrient cycling



FIGURE 2. Horse lawns are decumbent, almost two-dimensional communities beside ponds that are created by close-cropping and trampling by feeding horses. Photo: Freedman, July, 2009.

in terrestrial and freshwater habitats, and manure may stimulate the overall productivity of vegetation. In the absence of horses, dead forage accumulates as standing litter, which we observed inside all of the enclosure plots. Although the litter eventually decomposes, it may do so more slowly than manure. In this sense, horses may increase the rates of decomposition and nutrient cycling on Sable Island, and these processes may enhance the productivity of affected vegetation.

Discussion

The largest and most consistent effect of horse grazing that we observed on vegetation of the major terrestrial communities of Sable Island was a decrease in the biomass of standing litter in all habitats and a decrease in live Marram Grass in grassland. Various other studies of wild horses have found that, at high population levels, they may degrade their habitat by trampling and overgrazing.

Several studies have been made at Assateague Island National Seashore, a sandy barrier island in Maryland. De Stoppelaire et al. (2002*, 2004) and Seliskar (2003) examined as many as 17 enclosure plots and found that non-grazed habitat had more plant cover, taller grasses, larger biomass, and greater frequency of flowering of *Ammophila breviligulata* and *Spartina patens* (Ait.) Muhl. (Marshhay Cordgrass), the principal foods of the feral horses. Also working on enclosures on Assateague Island, Sturm (2007*) found that horses reduced the

TABLE 4. Community composition of three horse lawns. Cover data are in percentage and are the mean \pm SE (10 quadrats per site).

| Species | Horse lawn | | |
|--|---------------|---------------|---------------|
| | 1 | 2 | 3 |
| <i>Achillea millefolium</i> | 0 | <0.1 | 0 |
| <i>Agalinis neoscotica</i> | <0.1 | 0 | 0 |
| <i>Agrostis stolonifera</i> | 106 \pm 14 | 67 \pm 12 | 77 \pm 10 |
| <i>Anthoxanthum odoratum</i> | 0 | <0.1 | 0 |
| bryophytes | 0 | 2.0 \pm 1.2 | 7.1 \pm 3.2 |
| <i>Centunculus minimus</i> | 3.4 \pm 1.5 | 3.8 \pm 3.1 | 6.3 \pm 3.3 |
| <i>Cerastium fontanum</i> var. <i>vulgatum</i> | 0 | <0.1 | 0 |
| <i>Eleocharis</i> sp. | <0.1 | 0 | 0.1 \pm 0.1 |
| <i>Hypericum boreale</i> | 0.3 \pm 0.2 | 0.1 \pm 0.1 | 0.1 \pm 0.0 |
| <i>Juncus articulatus</i> | 0.4 \pm 0.2 | 0 | 0 |
| <i>Juncus balticus</i> | <0.1 | <0.1 | 0 |
| <i>Juncus bufonius</i> | 0.1 \pm 0.1 | <0.1 | 0 |
| <i>Juncus canadensis</i> | 0.1 \pm 0.1 | 0 | <0.1 |
| <i>Leontodon autumnalis</i> | <0.1 | 0.2 \pm 0.2 | <0.1 |
| <i>Lycopus uniflorus</i> | 0 | 0 | 0.8 \pm 0.8 |
| <i>Lysinachia terrestris</i> | 0 | 0 | <0.1 |
| <i>Panicum dichotomiflorum</i> | 0.2 \pm 0.2 | 0 | <0.1 |
| <i>Plantago lanceolata</i> | <0.1 | 1.1 \pm 1.0 | 0 |
| <i>Plantago major</i> | 0 | 0.1 \pm 0.1 | 0 |
| <i>Poa annua</i> | 3.6 \pm 2.6 | 3.8 \pm 1.6 | 1.6 \pm 1.0 |
| <i>Polygonum hydropiper</i> | 0.3 \pm 0.3 | <0.1 | <0.1 |
| <i>Ranunculus flammula</i> | 0 | 0 | <0.1 |
| <i>Ranunculus repens</i> | 0.2 \pm 0.2 | 0 | 0 |
| <i>Rumex acetosella</i> | 0 | <0.1 | 0 |
| <i>Sagina procumbens</i> | <0.1 | 1.6 \pm 1.0 | <0.1 |
| <i>Schoenoplectus americanus</i> | 0.4 \pm 0.3 | 0.5 \pm 0.5 | 0.1 \pm 0.1 |
| <i>Solidago sempervirens</i> | 0 | <0.1 | 0 |
| <i>Sphagnum</i> sp. | 0 | 0 | 0.5 \pm 0.3 |
| <i>Taraxacum officinale</i> | 0 | <0.1 | 0 |
| <i>Trifolium repens</i> | 2.3 \pm 1.6 | 5.0 \pm 1.7 | 0 |
| <i>Vaccinium macrocarpon</i> | 0 | <0.1 | 0 |
| <i>Viola lanceolata</i> | 0 | <0.1 | 0.3 \pm 0.2 |
| Total cover | 117 \pm 42 | 86 \pm 26 | 94 \pm 25 |
| Species richness | 18 | 22 | 17 |
| Species diversity (<i>H</i>) | 0.7 | 1.3 | 1.1 |

abundance of forage species and the species richness, evenness, and diversity of their communities. On a barrier island at Cape Lookout National Seashore, North Carolina, Barber (2001) found that grazing by horses and cattle resulted in grasslands that are relatively short-statured and of sparse cover compared with habitat protected by fencing. De Bonte et al. (1999) examined a coastal dune system in the Netherlands, and they found that areas newly grazed by horses and cows had a reduced abundance of palatable species and an increase in the abundance of less-palatable ones, although there was an overall increase in species richness.

Studies have also been made in inland habitats, where wild horses maintain much larger and wider-ranging populations than on coastal islands. Beaver and Brussard (2000) used exclosures to study the effects of feral horses on montane vegetation in Nevada, and they found greater plant cover, height, and species richness where grazing had been prevented. In a larger-scale study of 19 montane sites across nine mountain ranges in the Great Basin of the southwestern U.S.,

Beaver et al. (2003, 2008) found greater plant cover and species richness at sites from which wild horses had been removed, especially of species that the animals prefer as forage. Studies at the Sheldon National Wildlife Refuge in Nevada found a greatly increased biomass of forage species in exclosure plots for wild horses and burros (*Equus africanus asinus* Linnacus), as well as a rapid recovery of vegetation after these animals were removed from the greater habitat (U.S. Fish and Wildlife Service 2010*). Abella (2008) reviewed the effects of wild burros on vegetation in the Mohave Desert of the southwestern U.S. and found that forage grasses were 3 to 9 times more abundant inside exclosures that excluded large herbivores (of which burros were the most abundant).

Our observation of "horse lawns" is comparable to reports of lawn-like habitats elsewhere created by close cropping by feral sheep, such as the "biotic grasslands" on the island of Hirta off northwestern Scotland (Gwynne et al. 1974). We have also observed coastal lawn-like habitats created by sheep on islands off Nova



FIGURE 3. A path through mature heath created by frequent passage of horses. Photo: Freedman, July, 2009.



FIGURE 4. Horses feeding in a freshwater pond. Horses cause disturbance by trampling, removing forage, and defecating. Photo: Freedman, July, 2009.

Scotia where the terrain is rocky drumlin with a natural cover mostly of conifer forest and heath, rather than sandy grasslands as on Sable Island (unpublished observations).

Our most important observations with respect to exclosures were as follows: (1) effects of horses were greatest in the Marram grassland and much less in the communities not dominated by Marram Grass; (2) effects on Marram grassland varied substantially between sites; (3) there was a larger accumulation of standing litter of herbaceous plants inside all horse exclosures; (4) a higher cover of living foliage occurred inside of most exclosures, although not all differences were significant; (5) there were no substantial effects on species richness and diversity; (6) the cover of *Ammophila breviligulata*, the most abundant plant and the key forage species for horses, was greater inside six of the seven exclosure habitats, significantly so in three of them, two of which were in Marram grassland; and (7) there were inconsistent differences in the cover of other species at different sites. Although wetland habitats did not occur in the exclosures, there is evidence of a strong but variable effect on these habitats caused by feeding and trampling by horses.

Because of the unique biodiversity values of Sable Island and the fact that it is to become a national park, there is a need for information to guide its stewardship. The Canada National Parks Act states that the "maintenance or restoration of ecological integrity, through the protection of natural resources and natural processes, shall be the first priority of the Minister when considering all aspects of the management of parks." The Canada National Parks Act defines ecological integrity as follows: "ecological integrity means, with respect to a park, a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes."

In this context, the horses of Sable Island, being a feral population of an alien large mammal, might be viewed as posing a challenge to the ecological integrity of the island. However, managing the presence or abundance of the wild horses of Sable Island would be highly controversial. In any event, such a judgment would need to be informed by reliable information about the ecological effects of these animals.

In fact, it is likely that horses and other non-native biota have caused substantial changes to Sable Island since they were introduced several centuries ago, as have disturbances associated with other anthropogenic influences, such as the cultivation of food crops and the passage of vehicles over sensitive terrain. These various influences have undoubtedly contributed to the destabilization of dunes, leading to increased erosion and blowouts and effects on the species composition, relative abundance, and productivity of plant communities. There are no studies of the earlier changes, al-

though relevant comments were made about vegetation damage by large mammals in some historical journals (Catling et al. 1984). It seems, however, that ecological changes caused by horses on Sable Island have stabilized in recent decades, during which time their abundance has ranged from about 250 to 450 animals.

To provide a more complete understanding of the effects of horses on the vegetation of Sable Island, we recommend monitoring of the existing exclosures over the long term and perhaps the installation of additional exclosures in key habitats, as well as focused studies of the effects of horses on freshwater wetlands, which support much of the rarer biodiversity of the island.

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APPENDIX 1 (continued). Comparison of plant species inside and outside horse enclosures. Cover data are in percentage and are the mean \pm SE.

| Species | East Light BIO | | Wind turbine (a) | | Wind turbine (b) | | Main Station grassland | | Main Station mesic heath | | Main Station drier heath | | West Light BIO | |
|--------------------------------|----------------|---------------|------------------|---------------|------------------|---------------|------------------------|-----------------|--------------------------|---------------|--------------------------|----------------|----------------|---------------|
| | outside | inside | outside | inside | outside | inside | outside | inside | outside | inside | outside | inside | outside | inside |
| <i>Solidago sempervirens</i> | 0.8 \pm 0.3 | 7.3 \pm 2.2 | 1.3 \pm 0.6 | 3.3 \pm 1.2 | 0.3 \pm 0.2 | 0.4 \pm 0.2 | 3.8 \pm 2.3 | 1.6 \pm 1.1 | 0.1 \pm 0.1 | 0.0 | <0.1 | <0.1 | 8.6 \pm 2.2 | 6.6 \pm 1.8 |
| <i>Spartina pectinata</i> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 \pm 0.5 |
| <i>Stellaria graminea</i> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | <0.1 | <0.1 | 0.0 | 0.0 | 0.0 | 0.0 | <0.1 |
| <i>Thalictrum pubescens</i> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 \pm 0.9 | 1.0 \pm 1.1 | <0.1 | 0.4 \pm 0.3 | 0.0 | 0.0 |
| <i>Trifolium borealis</i> | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 \pm 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | <0.1 | 0.4 \pm 0.2 | 0.0 | 0.0 |
| <i>Trifolium repens</i> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | <0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| <i>Vaccinium angustifolium</i> | 4.8 \pm 2.8 | 0.4 \pm 0.3 | 0.2 \pm 0.2 | 0.8 \pm 0.7 | 16.1 \pm 7.1 | 1.0 \pm 0.8 | 0.2 \pm 0.2 | 0.0 | 2.8 \pm 1.0 | 3.8 \pm 1.5 | 22.8 \pm 5.2 | 29.8 \pm 6.7 | 0.0 | 0.0 |
| <i>Vaccinium macrocarpon</i> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 \pm 0.3 | 0.0 | 0.0 | 0.0 |
| <i>Viburnum nudum</i> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 \pm 2.6 | 15.0 \pm 10.6 | 15.5 \pm 9.7 | 1.5 \pm 0.8 | 6.2 \pm 4.0 | 0.0 | 0.0 | 0.0 |

Major Threats Facing Terrestrial Mammals in Canada

ISTVÁN IMRE^{1,3} and DARREN DERBOWKA²

¹Department of Biology, Algoma University, 1520 Queen Street East, Sault Ste. Marie, Ontario P6A 2G4 Canada

²Ontario Forest Research Institute, Ontario Ministry of Natural Resources, 1235 Queen Street East, Sault Ste. Marie, Ontario P6A 2E5 Canada

³Corresponding author; (tel.: 705-949-2301 ext. 4341; fax: 705-949-6583; email: istvan.imre@algomau.ca)

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Largely due to influences related to dramatic human population growth, threats to many species are on the rise globally. An examination of mammals assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determined the major threats facing terrestrial mammal populations in Canada. Significant threats were associated with habitat loss and overall mortality caused directly by humans. Carnivores and rodents differed substantially in mortality caused directly by humans and loss of food resources. Large mammals were more affected by climate change than small mammals.

Key Words: terrestrial mammals, threats, Committee on the Status of Endangered Wildlife in Canada, COSEWIC, Species at Risk Act, species at risk, habitat loss, habitat fragmentation, loss of food, Canada.

Mammals are among the best known and recognizable groups of animals on the planet, and they are more readily studied than other organisms. People's attitudes toward other mammals have changed significantly since historical times. Local people predominantly used mammals for food or various artifacts (e.g., Robinson and Redford 1991), and mammals often formed an important component of culture or religion (Cuarón 2008).

Increasing global human populations have been associated with extensive habitat disturbance related to changes in land cover, agriculture, rampant resource extraction, and extensive fragmentation of the remaining forests. Habitat loss and modification are considered among the leading threats to all species globally, including mammals (Primack 2006). Mammalian species diversity, abundance, and total and mean biomass tend to decrease with increasing human disturbance of the landscape (Chiarello 2008; Laurance et al. 2008; Lopes and Ferrari 2008). In addition to the indirect negative effect of human activities through habitat disturbance, humans in many poor areas of the world rely to an ever increasing extent on hunting and poaching of mammals for food or trade. For example, the multibillion-dollar trade in bushmeat, i.e., the meat of terrestrial wild animals (including primates), hunted and killed for subsistence (food) or for commercial purposes, is an important contribution to the economy of the developing world, and hunting for bushmeat is considered one of the most important threats to the survival of tropical vertebrates, including mammals (Brashares et al. 2004). Similarly, poaching has been shown to reduce substantially the abundance of mammal populations in high demand (Wright et al. 2001).

There are now more than 45 000 animal species of concern listed on the Red List of the International

Union for Conservation of Nature (International Union for Conservation of Nature 2011). Largely due to influences related to dramatic growth in the human population, threats to many species are on the rise globally. Currently, it is estimated that 1.6% of the world's mammal species have become extinct since the year 1600 (Primack 2006), a period associated with the advent of the industrial revolution and marked increases in global human populations. The analysis of 114 countries done by McKee et al. (2003) revealed that the number of species classified by the IUCN as threatened (i.e., critically endangered, endangered, or vulnerable) in the average nation would rise roughly 14% by the year 2050 as a direct result of human population growth alone, further indicating the trend in species extinctions is expected to continue into the future.

While the IUCN is the watchdog of the status of wildlife populations worldwide, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is responsible for monitoring species at risk of extinction in Canada. In 2003, the Canadian government passed the Species at Risk Act (SARA), which provides the legal means through which species assessed by COSEWIC are afforded protection and targeted for recovery. By examining the species in the COSEWIC database and the information on the Species at Risk Public Registry, we investigated the types of threats facing terrestrial mammal populations in Canada and determined which categories of threat were posing the most substantial risk to these animals. Further, to determine whether types of threats facing different groups of animals differ, we compared carnivores and rodents and large-bodied mammals with small-bodied mammals. Finally, we evaluated the conservation measures implemented under the Species at Risk Act in Canada to see whether they are likely to address the negative trends noted in Canadian mammals at risk.

Materials and Methods

To determine the types of threats facing terrestrial mammals in Canada, we retrieved data from the COSEWIC database (http://www.cosewic.gc.ca/eng/sct5/index_e.cfm). Using the search engine provided, we obtained a list of species assessments that included extirpated, endangered, threatened, and special concern. All status categories were defined by COSEWIC. The extirpated designation is given to a species that no longer exists in the wild in Canada but that occurs elsewhere. Endangered species face the immediate threat of extirpation or extinction within Canada. Threatened species include those organisms that can be expected to become endangered if limiting factors are not mitigated. Lastly, species of special concern include species that may become threatened or endangered because of a combination of biological characteristics and identified threats. Mammals that are extinct or extirpated were not included in this study, as current threats to extant mammals were desired rather than historical factors.

After the list had been compiled, we obtained specific threat data for each species from the Species at Risk Public Registry (http://www.sararegistry.gc.ca/default_e.cfm), which describes the threats currently affecting each species. Broad categories of threat were designated, as identified in each of the website's threat descriptions. A frequency distribution table of species by threat category was generated using a designation of 1 to indicate impact by a particular threat category or left blank to indicate no impact. A species could be affected by a particular threat category only once, even if multiple threats described were identified within the same category.

We used the designatable units (*sensu* Green 2005) as specified on the Species at Risk Public Registry. It is important to note that these units can be certain populations of a species or a subspecies, but will be referred to as "species" in this study. For example, four different populations of the Woodland Caribou (*Rangifer tarandus caribou*) are listed as designatable units, with different levels of endangerment: the Northern Mountain population is of special concern, the Boreal and Southern Mountain populations are threatened, and the Atlantic-Gaspésie population is endangered.

Threat data were collected from species assessment reports prepared by COSEWIC as well as the shorter species accounts provided on the Species at Risk Public Registry. The data collection and analyses were limited to actual and imminent threats. For example, the Plains Bison is not currently affected by disease, but the likelihood of Plains Bison contracting tuberculosis, brucellosis, or anthrax from nearby domestic cattle herds is very high; therefore, disease was included as an imminent threat for this species. Species with no current threats or imminent threats were not included in the analysis. For example, the Spotted Bat (*Eudernia maculatum*) was removed from our list because

there is no strong evidence supporting the threats in its species account.

A total of 11 categories of threat were identified as affecting mammals at risk assessed by COSEWIC in Canada: 1) habitat alteration or loss, 2) direct human-caused mortality, 3) habitat fragmentation, 4) predation, 5) loss of food resources, 6) climate change, 7) small population size, 8) invasive species, 9) disease, 10) hybridization, and 11) northern extent of range. Included under Habitat alteration or loss were such threats as urban development, agriculture, deforestation, and human population growth that have reduced the overall land base available for habitat and/or have altered the system in such a manner that it is no longer suitable for species habitation. Direct human-caused mortality involved threats such as hunting, trapping, motor vehicle collisions, and targeted exterminations. Habitat fragmentation was included as its own threat category because of its frequent appearance in species accounts. Habitat fragmentation represents a very specific circumstance of habitat alteration where habitat has been increasingly divided into smaller and smaller units. The Predation category of threat included pressures from naturally established predator-prey relationships that may have been exacerbated by other human-induced impacts. Threats under Loss of food resources are the result of the loss of prey organisms and plants. This threat affects both carnivores/omnivores and herbivores, and these losses may be a direct result of impacts caused by humans. Threats from Climate change were broadly inclusive and not well defined in species accounts, but generally were expected to contribute to habitat alteration. Threats under Small population size stemmed from loss of genetic variability, demographic variation, and magnitude of natural catastrophes. Invasive species threatened mammals by directly competing for resources or by preying directly upon them. Disease was reported as a native threat that could exacerbate species decline. Hybridization included interbreeding with related species, resulting in reduced vigour and introgression. Lastly, Northern extent of range was reported as a threat to those species with populations struggling at their northernmost tolerance limits.

The taxonomic order was also identified for each species, along with the average adult body mass. Body mass data were collected from the COSEWIC assessment reports or the species accounts on the Species at Risk Public Registry or from Banfield (1977). Where differences in average body mass were reported by sex, mass was determined by averaging the mass of adult males and females.

Collected frequency data were summarized to show the overall proportion of impacts that each threat category posed for mammal species at risk in Canada. Total frequency data were also summarized to show the percentage of all species that was reported as being affected by each threat category. Frequency data were likewise summarized for large mammals (>10.0 kg)

and small mammals (<10.0 kg) and for mammals in the orders Carnivora and Rodentia. Body size threshold was selected based on clustering of the data.

We compared the proportion of affected carnivores and rodents and large and small mammals, respectively, for any given threat category using 2×2 contingency tables. On several occasions, more than 20% of the categories contained frequencies less than about five; therefore, in addition to the χ^2 analyses, we also computed Yate's correction for continuity as well as Fisher's exact test (Quinn and Keough 2002). The latter two tests supported the findings of the regular χ^2 test in all instances; hence we reported only the results of the χ^2 tests. The value of α was set at 0.05.

Results

In Canada, there are 32 terrestrial mammal species and subspecies at risk (including the Spotted Bat) assessed by COSEWIC. Excluding the Spotted Bat, there were 10 endangered, 9 threatened, and 12 species of special concern (Table 1). The order Carnivora had the most species in this study, with 11. Artiodactyla was second with 8 species, followed by Rodentia with 7, Soricomorpha with 3, and Chiroptera and Lagomorpha with 1 each (Table 1). A total of 13 large-bodied mammal species (>10 kg) and 18 small-bodied animals (<10 kg) were examined in this study, with average body weights (SD) of 231.8 kg (SD 239.9) and 1.44 kg (SD 2.09), respectively (Table 1).

On average, 2.7 categories of threat (SD 1.1) affected each of the identified terrestrial mammal species at risk. Threats in the Habitat loss category affected 84% of species (Figure 1). Direct human-caused mortality ranked second, with 58% of species experiencing this threat type (Figure 1).

Several differences in the frequency of reported threats to species in Carnivora and Rodentia appeared to be substantial upon visual inspection (Figure 2). Direct human-caused mortality affected a significantly higher proportion ($\chi^2 = 10.57$, $df = 1$, $P = 0.001$) of carnivores (91%) than rodents (14%) in Canada. Furthermore, a large proportion of carnivores (55%) were threatened by Loss of food resources but no rodents were reported as being affected by this threat type ($\chi^2 = 5.73$, $df = 1$, $P = 0.017$). Differences in the other threat categories were not significant (data not shown).

Some differences in reported threat frequencies also appeared in the comparison of large-bodied and small-bodied mammals (Figure 3). Climate change affected a significantly larger proportion ($\chi^2 = 6.36$, $df = 1$, $P = 0.012$) of large-bodied mammals (31%) than small-bodied mammals (0%). Differences in the other threat categories were not significant (data not shown).

Discussion

Data from the International Union for Conservation of Nature, which examines 245 countries for the number of critically endangered, endangered, or vulnerable species, showed that Canada had more mam-

mal species in these categories than 69% of examined nations worldwide (table 5, International Union for Conservation of Nature 2011). Interestingly, this placed Canada at par with several third world nations, such as Guinea Bissau, Mali, Mozambique, Namibia and Niger. However, it is likely that different levels and quality of documentation in different countries may influence these data. In comparison with large developed countries with conservation data of similar quality to those from Canada, like Australia (55 mammals) and the United States (37 mammals), Canada had a markedly lower number of critically endangered, endangered, or vulnerable mammals (12) (table 5, International Union for Conservation of Nature 2011). In addition, it is important to note that there are substantial differences among these countries in population density and overall area.

McKinney (2002) observed that human population size increases with land area and is strongly correlated with the proportion of species classified by the IUCN as threatened (i.e., critically endangered, endangered, or vulnerable) among nations. It is reasonable to expect that both habitat loss and direct human-caused mortality would also rise with increasing population density, both of which represented the most significant reported threats to mammals at risk in this paper. In another study examining 114 continental nations, approximately 88% of the variation in the number of mammal and bird species at risk was explained by human population density and species richness variables (McKee et al. 2003). Population extinctions have been linked to population density and the associated impacts of agriculture, hunting, and grazing, particularly in Southeast Asia, where more than half of its examined land base had lost 75% to 100% of its mammal species (Ceballos and Ehrlich 2002). Habitat loss and fragmentation are also significant threats to mammals in Brazil, which boasts the world's largest diversity of known mammals, with 530 described species (Costa et al. 2005).

Canada is one of the last places on Earth with large wilderness areas and a small average human population density, yet the number of species classified by the IUCN as threatened (i.e., critically endangered, endangered, or vulnerable) continues to rise. Kerr and Deguise (2004) measured habitat loss within the ranges of 243 terrestrial species (including mammals) assessed by COSEWIC as endangered, threatened, or special concern across Canada and found that less than 50% of the species' ranges was still natural habitat; no detectable natural habitat remained for 16 of the 243 species. In addition, the authors found that habitat loss explained most of the variation in the number of endangered species per ecozone in Canada and concluded that habitat loss within a species' range is likely to be the most important factor that prevents its recovery (Kerr and Deguise 2004).

TABLE 1. Terrestrial mammals at risk assessed by the Committee on the Status of Endangered Species in Canada, including common and scientific names, order; COSEWIC status category, average adult body weight, and occurrence in Canada.

| Scientific name | Order | Status | Average adult mass (kg) | Canadian occurrence |
|--|--------------|-----------------|-------------------------|--|
| Peary Caribou | Artiodactyla | Endangered | 85.00 | NT, NU |
| Woodland Caribou (Atlantic-Gaspésie population) | Artiodactyla | Endangered | 157.50 | QC |
| Plains Bison | Artiodactyla | Threatened | 700.00 | BC, AB, SK, MB |
| Wood Bison | Artiodactyla | Threatened | 700.00 | YT, NT, BC, AB |
| Woodland Caribou (Boreal population) | Artiodactyla | Threatened | 157.50 | NT, BC, AB, SK, MB, ON, QC, NL |
| Woodland Caribou (Southern Mountain population) | Artiodactyla | Threatened | 157.50 | BC, AB |
| Barren-ground Caribou (Dolphin and Union population) | Artiodactyla | Special concern | 95.35 | NT, NU |
| Woodland Caribou, Northern Mountain population | Artiodactyla | Special concern | 157.50 | YT, NT, BC |
| American Badger <i>jaxsonii</i> subspecies | Carnivora | Endangered | 6.15 | ON |
| American Badger <i>jeffersonii</i> subspecies | Carnivora | Endangered | 6.15 | BC |
| Wolverine (Eastern population) | Carnivora | Endangered | 12.70 | QC, NL |
| American Marten (Newfoundland population) | Carnivora | Threatened | 0.83 | NL |
| Ermine <i>haidarum</i> subspecies | Carnivora | Threatened | 0.07 | BC |
| Grey Fox | Carnivora | Threatened | 4.05 | MB, ON |
| Swift Fox | Carnivora | Threatened | 1.95 | AB, SK |
| Eastern Wolf | Carnivora | Special concern | 27.50 | ON, QC |
| Grizzly Bear (Northwestern population) | Carnivora | Special concern | 300.00 | YT, NT, NU, BC, AB |
| Polar Bear | Carnivora | Special concern | 450.00 | YT, NT, NU, MB, ON, QC, NL, Arctic Ocean |
| Wolverine (Western population) | Carnivora | Special concern | 12.70 | YT, NT, NU, BC, AB, SK, MB, ON |
| Pallid Bat | Chiroptera | Threatened | 0.03 | BC |
| Nuttall's Cottontail <i>nuttallii</i> subspecies | Lagomorpha | Special concern | 0.80 | BC |
| Ord's Kangaroo Rat | Rodentia | Endangered | 0.07 | AB, SK |
| Vancouver Island Marmot | Rodentia | Endangered | 3.50 | BC |
| Western Harvest Mouse <i>drychei</i> subspecies | Rodentia | Endangered | 0.01 | AB |
| Black-tailed Prairie Dog | Rodentia | Special concern | 1.25 | SK |
| Mountain Beaver | Rodentia | Special concern | 0.81 | BC |
| Western Harvest Mouse <i>megalotis</i> subspecies | Rodentia | Special concern | 0.01 | BC |
| Woodland Vole | Rodentia | Special concern | 0.03 | ON, QC |
| Pacific Water Shrew | Soricomorpha | Endangered | 0.01 | BC |
| Townsend's Mole | Soricomorpha | Endangered | 0.13 | BC |
| Eastern Mole | Soricomorpha | Special concern | 0.10 | ON |

Spotted Bat was excluded from this study.

*ON – Ontario; BC – British Columbia; NL – Newfoundland and Labrador; MB – Manitoba; AB – Alberta; YT – Yukon; QC – Quebec; NU – Nunavut; SK – Saskatchewan; NT – Northwest Territories

Source: Database of Wildlife Species Assessed by COSEWIC, http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm.

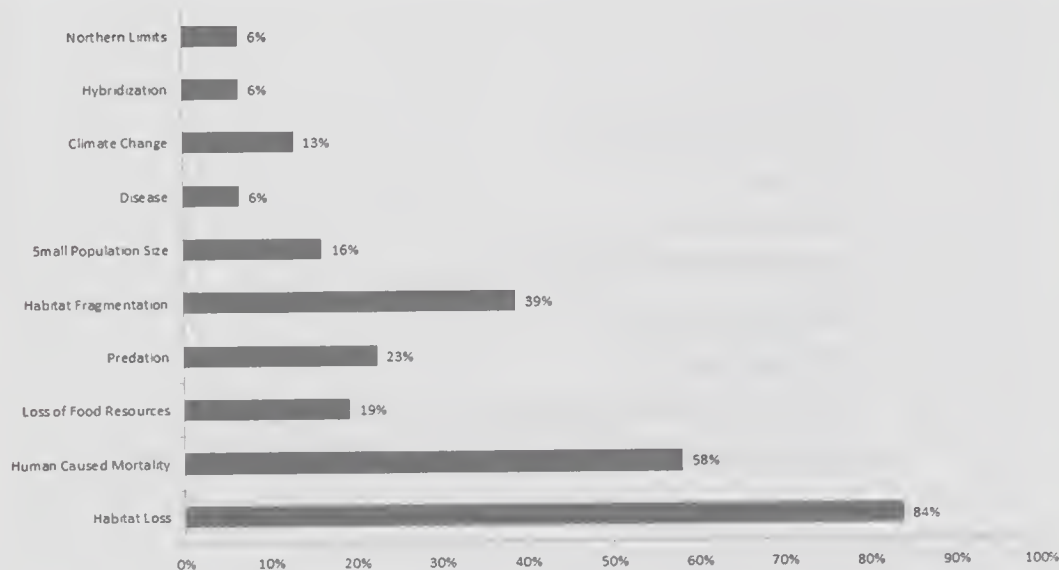


FIGURE 1. Percentage of terrestrial mammal species at risk (assessed by the Committee on the Status of Endangered Wildlife in Canada) impacted by different threat types.

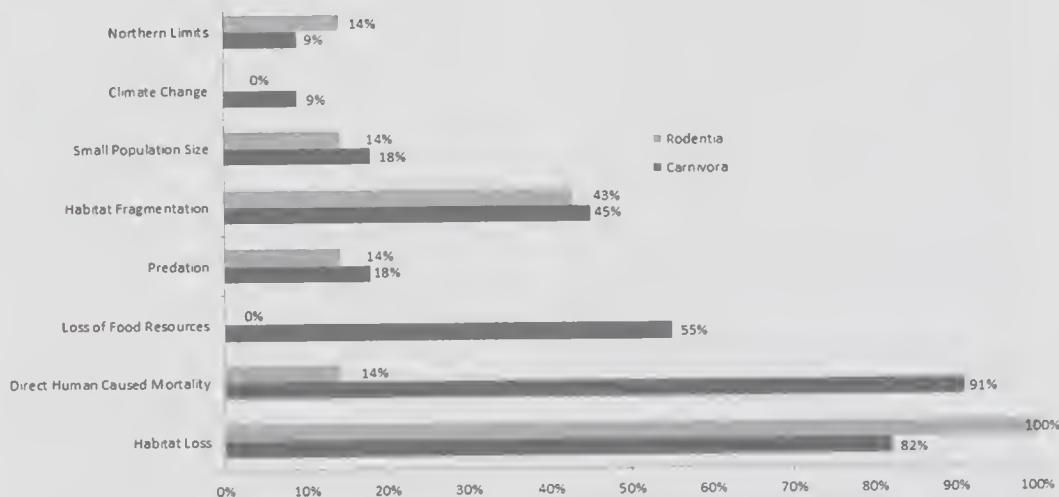


FIGURE 2. Percentage of terrestrial carnivore and rodent species at risk (assessed by the Committee on the Status of Endangered Wildlife in Canada) impacted by different threat types.

Another recent study used remote sensing and species distribution datasets to examine the influence of natural and anthropogenic factors on the density of species assessed by COSEWIC as endangered (including terrestrial mammals) in Canada (Kerr and Cihlar 2004). In addition, Kerr and Cihlar (2004) examined the capacity of protected areas to shelter endangered species. The authors found a strong positive relation-

ship between the density of terrestrial endangered species and agricultural land use, with the latter relating strongly to habitat loss as well as land use intensity. There was no relationship between densities of endangered species and the extent of protected area in watersheds. However, there are virtually no protected areas in the watersheds with the highest concentration of endangered species (Kerr and Cihlar 2004). The latter

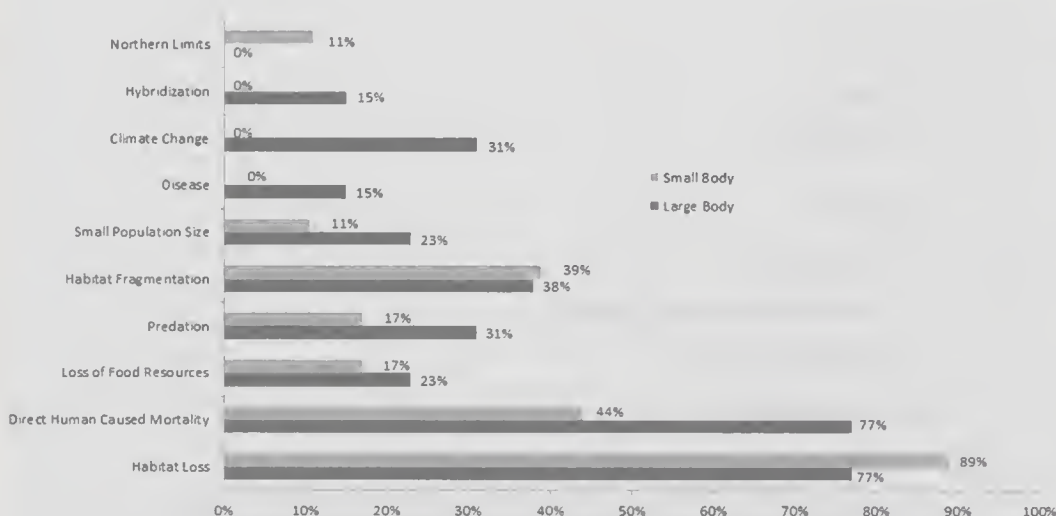


FIGURE 3. Percentage of terrestrial large and small mammals at risk (assessed by the Committee on the Status of Endangered Wildlife in Canada) impacted by different threat types.

findings suggest that existing protected areas have little, if any, potential to reduce extinction rates in Canada (Kerr and Cihlar 2004). The authors concluded that the Species at Risk Act appears to provide habitat protection in an inverse proportion to the needs of endangered species in Canada, with federal lands (which are most readily protected under the Act) being extensive in areas with few endangered species and being very rare in areas with a high number of endangered species.

Can the Species at Risk Act address the leading threats identified in this study? The Act has a limited ability to provide for habitat protection in areas that have already undergone extensive habitat changes due to urbanization and agriculture. Improvement to reserve networks as well as cooperative conservation activities with private landowners are possible avenues for avoiding the rapid extinction of endangered species in Canada (Kerr and Deguise 2004). In terms of mortality caused by humans, the Act is sufficient to stop overexploitation or targeted extermination of a species because it prohibits the killing, harming, or capturing of species declared to be threatened, endangered, or extirpated; however, it cannot prevent indirect sources of human-caused mortality, such as trapping by-catch or collisions with automobiles.

Carnivores and rodents

Resiliency to interaction with human populations will be an increasingly important trait in determining survival of species into the future. Cardillo et al. (2004) pointed out the importance of biology in the persistence of species faced with increasing human population densities and cited carnivores as being particularly at risk for future extinctions. Biological traits, including small geographic range size, low species popula-

tion density, and high trophic level, explained approximately 45% of the variation in extinction risk in carnivores. For carnivore species with high exposure to human populations, however, the addition of gestation length as a factor increased the explanatory power of the model to 80% (Cardillo et al. 2004). Although Cardillo et al. (2004) studied species of carnivores in Africa, their findings are relevant to Canada: carnivores had the most species at risk assessed by COSEWIC, for 91% of the carnivores at risk assessed by COSEWIC, threats related to direct mortality caused by humans were cited as a reason for reduced abundance. Habitat loss was also a factor in 82% of carnivores at risk assessed by COSEWIC.

Some interesting differences in threat categories were observed between carnivores and rodents in this study. While direct human-caused mortality was reported in almost every instance for carnivores, there were far fewer rodents that were affected by threats in this category. This observation is not surprising, as many large carnivorous mammals are hunted for trophy sport or eradicated due to livestock predation, as is the case for Jaguars (*Panthera onca*) in Brazil (Costa et al. 2005). Certainly, this has been the case for Grizzly Bears (*Ursus arctos*) and Eastern Wolves (*Canis lupus lycaon*) in Canada (Species at Risk Public Registry 2011). Even subsistence hunting has been shown to have a negative impact on mid-sized and large vertebrates, particularly when habitats become fragmented by human activity (Peres 2001).

Another observation of note showed loss of food resources as a threat in 55% of carnivore species, while rodents were not affected at all by this category of threat. Brashares (2003) also found mammals with

larger home ranges were more prone to extinction. Carnivores require more extensive home ranges over which prey must persist or be accessible, and this may explain the significance of this threat to these mammals. Rodents on the other hand have smaller home ranges and generally less specific diets than carnivores.

Cardillo et al. (2005) reported that body size was another trait positively associated with high risk of extinction for mammals larger than 3 kg. However, Brashares (2003) found no relation between body size and the persistence of species in the wild. We observed no significant difference in the two major categories of threat between large and small-bodied mammals, suggesting that smaller body size may indeed provide very little protection against major species threats.

One limitation of our data is that the sample size is quite small for broad generalizations, and caution is therefore recommended in the application of these findings. Better data on threats to species at risk would require more research on existing levels of threat. However, these data appear overall to be representative of the major threats that exist elsewhere in the world and point to the need for better understanding of these threats and how they can be mitigated within Canada and globally. A major obstacle to mitigation is that many threats to mammals are correlated with one another, and synergistic effects are highly probable in most circumstances. What cannot be denied is that the origin of these increasing impacts is growth of human populations and the resulting pressures people are placing on global resources.

In conclusion, the major threats facing species at risk in Canada are habitat loss and alteration and direct human-caused mortality. Carnivores and rodents showed substantial differences with respect to direct human-caused mortality and loss of food resources. Differences in threat based on body size did not appear significant for the two major threats identified in this study, but were more substantial for threats due to climate change.

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Has the Western Chorus Frog (*Pseudacris triseriata*) Declined in Western Ottawa, Ontario?

DAVID C. SEBURN¹ and KARI GUNSON²

¹Seburn Ecological Services, 2710 Clarendon Street, Ottawa, Ontario K2B 7S5 Canada; email: davidseburn@sympatico.ca

²Eco-Kare International, 644 Bethune Street, Peterborough, Ontario K9H 4A3 Canada; email: kegunson@eco-kare.com

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To determine whether the Western Chorus Frog has declined in western Ottawa, we conducted auditory surveys at historical locations as well as at various other wetlands. Western Chorus Frogs were detected at 12 of 18 historical locations. Wetland habitat remained at all historical locations where the species was not detected. There was no difference in the year of historical records for sites where Western Chorus Frogs were (median 1987.5) and were not (median 1987.5) detected. In the present study, Western Chorus Frogs were also detected at 30 locations where they had not been previously reported. Historical sites where Western Chorus Frogs were not detected were not significantly farther away from known Western Chorus Frog sites (median distance: 2.2 km) than historical sites where Western Chorus Frogs were detected (median distance: 1.4 km). Land use variables for historical sites where Western Chorus Frogs were and were not detected did not vary significantly at any spatial scale from 0.5 to 2.0 km. Western Chorus Frogs were detected in areas with up to 50% forest cover and up to 86% agricultural cover at the 1.0-km radius. The lack of historical data makes it difficult to assess the current status of the Western Chorus Frog in western Ottawa. The species may have declined, remained approximately the same (by shifting to different breeding sites), or even increased its distribution (by colonizing additional sites).

Key Words: Western Chorus Frog, *Pseudacris triseriata*, amphibian decline, Ottawa, Ontario.

The Western Chorus Frog (*Pseudacris triseriata*) is a small hylid treefrog. It has declined in southern Quebec (Daigle 1997), northern New York (Gibbs et al. 2005), and southeast of Ottawa in eastern Ontario (Seburn et al. 2008). These declines have all occurred in an area where the mitochondrial DNA of specimens resembles that of the Boreal Chorus Frog (*P. maculata*) rather than that of the Western Chorus Frog (Lemmon et al. 2007). Morphologically, however, individuals resemble the Western Chorus Frog, and to date they have retained this species name (COSEWIC 2008*). According to Marsh Monitoring surveys conducted across the Great Lakes region, the Western Chorus Frog declined significantly between 1995 and 2007 (Archer and Jones 2009). Largely as a result of declines in Quebec, the Great Lakes/St. Lawrence–Canadian Shield population of the Western Chorus Frog in Canada has been designated threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2008*).

The Ottawa area is adjacent to the Outaouais region of Quebec, where declines in the Western Chorus Frog have been observed (COSEWIC 2008*). Our objectives were threefold: to assess whether the Western Chorus Frog persisted at historical sites in the Ottawa area, to determine the extent of its current distribution and to examine the effect of habitat variables on its distribution.

Study Area and Methods

All surveys were conducted in suburban and rural western Ottawa (Figure 1), an area of approximately

600 km². Records of calling Western Chorus Frogs were obtained from the Ontario Herpetofaunal Atlas (Oldham and Weller 2000*). The year 1990 was selected as a cut-off date for historical records, as this is before Western Chorus Frogs declined in eastern Ontario (Seburn et al. 2008). A number of records were excluded because of a lack of precise locality information. Additionally, a few records with locations less than 500 m apart were not considered separate locations. This resulted in a total of 18 historical locations with observations dating from 1977 to 1990 (Table 1, Figure 1).

Daytime auditory surveys were conducted during the calling season of the Western Chorus Frog (early to late April) from 2006 to 2010. A known site with Western Chorus Frogs was visited at the start of each survey to confirm calling was occurring that day. Historical locations were relocated using a GPS. Auditory surveys were conducted from roadside locations, with the exception of a few locations in public parks where the location of the historical record was away from a road. Auditory surveys lasted from 1 to 5 minutes, depending upon weather conditions (e.g., strong, temporary wind) and traffic noise. All historical locations where Western Chorus Frogs were not confirmed on the first survey were surveyed in a subsequent year to increase the detection probability. Additional sites were surveyed by listening at wetlands visible from roads and, at one location, on foot in a park.

The degree of isolation for historical sites where Western Chorus Frogs were detected and not detected was tested by measuring the distance from each site to

TABLE 1. Location of historical sites with Western Chorus Frogs (*Pseudacris triseriata*) in western Ottawa pre-1991, showing those sites where Western Chorus Frogs were detected/not detected in follow-up surveys between 2006 and 2010. ID is the Ontario Herpetofaunal Atlas record number.

| ID | Latitude (°N) | Longitude (°W) | Year | Follow-up year | Western Chorus Frogs present |
|--------|---------------|----------------|------|----------------|------------------------------|
| 52915 | 45.3778 | 76.2644 | 1990 | 2008, 2009 | N |
| 48634 | 45.4375 | 76.2351 | 1990 | 2008 | Y |
| 10203 | 45.4495 | 76.2149 | 1988 | 2008 | Y |
| 48573 | 45.2632 | 76.1230 | 1990 | 2007, 2009 | N |
| 48570 | 45.2445 | 76.0971 | 1990 | 2007 | Y |
| 48567 | 45.2365 | 76.0868 | 1990 | 2007 | Y |
| 48560 | 45.1685 | 76.0473 | 1990 | 2008 | Y |
| 10204 | 45.1520 | 75.9796 | 1988 | 2008, 2009 | N |
| 10205 | 45.2502 | 75.9698 | 1985 | 2006 | Y |
| 10206 | 45.3466 | 75.9600 | 1988 | 2007 | Y |
| 123366 | 45.3952 | 75.9582 | 1982 | 2007 | Y |
| 10214 | 45.3607 | 75.8823 | 1987 | 2009 | Y |
| 10215 | 45.3509 | 75.8745 | 1987 | 2006 | Y |
| 10217 | 45.3401 | 75.8705 | 1987 | 2009 | Y |
| 10216 | 45.3520 | 75.8464 | 1987 | 2006 | Y |
| 10208 | 45.3026 | 75.8304 | 1987 | 2006, 2009 | N |
| 123356 | 45.3000 | 75.8214 | 1977 | 2006, 2009 | N |
| 10209 | 45.3235 | 75.8051 | 1987 | 2006, 2009 | N |

the closest known occupied site. The two groups (historical sites where Western Chorus Frogs were detected and historical sites where Western Chorus Frogs were not detected) were compared using the non-parametric Mann-Whitney test. Land use information was obtained from the Southern Ontario Land Resource Information System (SOLRIS). The layer represents the landscape in 15 × 15 m pixels from 2000 to 2003, and it is derived from a combination of satellite imagery, topographic maps, and aerial photography (Ontario Ministry of Natural Resources 2007). Land use was separated into the following classes for analysis: forest cover (>60% tree cover, including plantations), built-up area (including residential, commercial, and industrial areas, and outdoor recreation areas, such as golf courses), wetlands (≥ 0.5 ha in area), and agriculture (a broad category that includes intensive croplands as well as old fields and forest clearings). Road information was obtained from the Ontario Roads Network vector layer (Ontario Ministry of Natural Resources).

We calculated the proportional area for each land use class (expressed as a percentage) and the length of road (in km) surrounding each site at radii of 0.5, 1.0, 1.5, and 2.0 km. Land use variables at a larger spatial scale may be correlated with frog landscape ecology (e.g., Gibbs et al. 2005), but, in this case, a larger radius would result in some areas extending across the Ottawa River into adjacent Quebec. The proportional area for each land use class was also calculated for 104 random, non-overlapping sites at a 1.0-km radius to describe the variability in the land use data across the study area. We used binary logistic regression to test whether land use classes could be used to distinguish

occupied Western Chorus Frog sites from random sites. ArcMap 10.0 was used for all spatial analyses and Minitab and R for all statistical analyses.

Results

Western Chorus Frogs were heard calling at 12 of 18 historical locations (Table 1, Figure 1), a 33% decline in detection. Wetland habitat remained at all 6 historical locations where Western Chorus Frogs were not detected. There was no difference in the year of historical records of sites where Western Chorus Frogs were (median 1987.5) and were not (median 1987.5) detected. Additional surveys confirmed Western Chorus Frogs at 30 new locations (Table 2, Figure 1).

Historical sites where Western Chorus Frogs were not detected had a median distance of 2.2 km (range 0.8–4.4 km) from any known extant Western Chorus Frog location, while historical sites where Western Chorus Frogs were detected had a median distance of 1.4 km (range 0.8–5.1 km). This difference was not significant ($W = 105.0$, $P = 0.43$).

Land use variables for historical sites where Western Chorus Frogs were and were not detected did not vary significantly at any spatial scale ($P > 0.05$). Habitat variables at 1.0 km are presented to illustrate the range of the data (Table 3). Land use variables for forest ($P = 0.36$), wetland ($P = 0.24$), and agriculture ($P = 0.67$) were not significant in the logistic regression analysis comparing sites where Western Chorus Frogs were detected to random sites. Western Chorus Frogs were detected in areas with forest cover ranging from <1 to 50%, reflecting, essentially, the full range of habitat variation found within the study area (Table

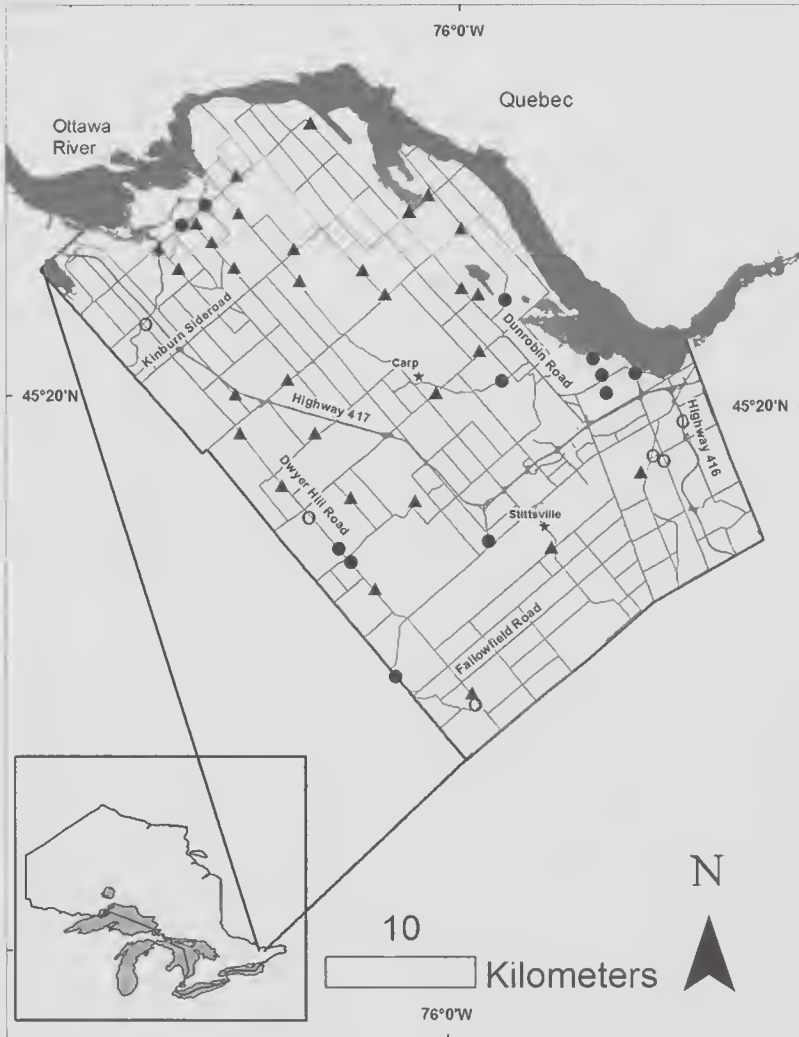


FIGURE 1. Distribution of Western Chorus Frog (*Pseudacris triseriata*) locations in western Ottawa. Circles represent historical locations (pre-1991). Filled circles: Western Chorus Frogs detected on follow-up surveys between 2006 and 2010; open circles: Western Chorus Frogs not detected on follow-up surveys between 2006 and 2010. Triangles represent additional locations where Western Chorus Frogs were detected between 2006 and 2010.

4). Western Chorus Frogs were detected in areas with up to 86% agricultural land, whereas over 12% of the landscape sites had greater agricultural cover (Table 4).

Discussion

There are a number of limitations to this study. The historical data were not collected systematically, but opportunistically, as part of the Ontario Herpetofaunal Atlas (Oldham and Weller 2000*). The data were collected by multiple people and it is possible that some auditory reports were confused with the agonistic or territorial call of a Spring Peeper (*Pseudacris*

crucifer) which is also a trill (COSEWIC 2008*). In addition, locality information may not have been correctly recorded. While these errors may have occurred, the historical data for the 6 locations where Western Chorus Frogs were not detected in the current survey were all submitted by known and experienced observers. It is unlikely that the Western Chorus Frogs were misidentified or that erroneous locality information from the past would correspond to an existing wetland.

An additional limitation is that the historical data are not geographically well dispersed. Historical sites

TABLE 2. Location of additional sites in western Ottawa surveyed between 2006 and 2010 where Western Chorus Frogs (*Pseudacris triseriata*) were detected.

| Latitude (°N) | Longitude (°W) | Location | Year |
|---------------|----------------|-----------------------|------|
| 45.2752 | 76.0875 | South March Road | 2006 |
| 45.2739 | 76.0327 | Old Almonte Road | 2007 |
| 45.3986 | 75.9813 | Constance Lake Road | 2007 |
| 45.3389 | 76.0160 | March Road | 2007 |
| 45.2818 | 76.1463 | Upper Dwyer Hill Road | 2008 |
| 45.3130 | 76.1826 | Upper Dwyer Hill Road | 2009 |
| 45.2926 | 75.8404 | Stony Swamp | 2009 |
| 45.4021 | 75.9954 | March Road | 2009 |
| 45.4381 | 75.9960 | Thomas Dolan Parkway | 2009 |
| 45.4576 | 76.0245 | Vance's Sideroad | 2009 |
| 45.4476 | 76.0409 | Vance's Sideroad | 2009 |
| 45.4999 | 76.1264 | Dunrobin Road | 2009 |
| 45.4453 | 76.1867 | Carp Road | 2009 |
| 45.4114 | 76.2371 | Mohrs Road | 2009 |
| 45.4230 | 76.2539 | Mohrs Road | 2009 |
| 45.4677 | 76.1884 | Galetta Sideroad | 2009 |
| 45.1592 | 75.9822 | Dwyer Hill Road | 2010 |
| 45.4386 | 76.2223 | John Shaw Road | 2010 |
| 45.4280 | 76.2093 | John Shaw Road | 2010 |
| 45.4128 | 76.1898 | John Shaw Road | 2010 |
| 45.4241 | 76.1389 | Kinburn Road | 2010 |
| 45.4121 | 76.0799 | Stonecrest Road | 2010 |
| 45.3979 | 76.0605 | Stonecrest Road | 2010 |
| 45.3363 | 76.1869 | Breezy Hills Road | 2010 |
| 45.3458 | 76.1425 | Panmure Road | 2010 |
| 45.3136 | 76.1188 | Vaughn's Sideroad | 2010 |
| 45.3644 | 75.9794 | March Road | 2010 |
| 45.4053 | 76.1334 | Carp Road | 2010 |
| 45.2205 | 76.0661 | Dwyer Hill Road | 2010 |
| 45.2470 | 75.9162 | Fernbank Road | 2010 |

are clustered in some areas and completely lacking in other areas (Figure 1). Another limitation is the lack of historical data on wetlands where Western Chorus Frogs were known to be absent in the past. Natural succession can lead to amphibians selecting different breeding sites. This may result in no net loss in the number of breeding populations, but resurveys of only historical sites would detect a decline (e.g., Skelly et al. 2003).

It seems unlikely that Western Chorus Frogs persist at any of the 6 historical locations where they were not detected in the current survey period, as a follow-up survey was carried out in a subsequent year and the species was not detected at any of the 6 sites (Table 1).

The level of apparent decline detected in the current study is comparable to that reported elsewhere: Western Chorus Frogs are now absent at 34.6% of historical locations in northern New York state (Gibbs et al. 2005) and approximately 30% of known locations in the Outaouais area of Quebec (across the Ottawa River from Ottawa) (COSEWIC 2008*). In contrast, the Western Chorus Frog was not detected at 95% of historical locations in eastern Ontario southeast of Ottawa (Seburn et al. 2008) and is gone from approximately

90% of its range in the Montérégie area, south of the St. Lawrence River, in Quebec (COSEWIC 2008*).

The cause or causes of declines in the Western Chorus Frog remain speculative. Destruction of wetlands is a major threat in some areas of Quebec (Daigle 1997; Picard and Desroches 2004*); however, Western Chorus Frogs have also disappeared from areas where wetlands remain (Gibbs et al. 2005; Seburn et al. 2008; current study). The presence of wetlands during the breeding season may not be sufficient, as changes in precipitation can lead to ponds drying earlier and the loss of some amphibian species (McMenamin et al. 2008). Regional decline in total precipitation does not appear to be the issue in Ottawa, as the wettest 5-year period in the last 25 years was from 2006 to 2010 (Environment Canada 2011*).

There may be large-scale landscape differences between western Ottawa and the area east of Ottawa where Western Chorus Frogs are known to have declined (Seburn et al. 2008). For example, in eastern Ontario soils are generally less acidic in western Ottawa and to the west (Marshall et al. 1979). Western Chorus Frogs in New York state were also more likely to persist in areas with less acidic soil (Gibbs

TABLE 3. Land use variables associated with historical sites (pre-1991) where Western Chorus Frogs (*Pseudacris triseriata*) were detected/not detected in follow-up surveys between 2006 and 2010 at the 1.0-km radius (range in parentheses). Land use variables (except roads) are expressed as a percentage of the total area from each observation point. Road data are presented in kilometers of road. Land use variables were compared using the non-parametric Mann-Whitney test (*W*).

| Land use 2006–2010 | Historical sites resurveyed, 2006–2010 | | <i>W</i> | <i>P</i> |
|--------------------|--|-----------------------------------|----------|----------|
| | Western Chorus Frogs detected | Western Chorus Frogs not detected | | |
| | median (range) | median (range) | | |
| Forest (%) | 28.0 (7.9–50.2) | 16.7 (7.0–37.4) | 44.0 | 0.2417 |
| Built-up (%) | 0.8 (0–36.5) | 0.1 (0–14.0) | 46.5 | 0.4824 |
| Wetlands (%) | 26.9 (12.5–51.9) | 28.8 (18.3–63.3) | 65.0 | 0.4824 |
| Agriculture (%) | 41.8 (8.3–67.9) | 34.7 (5.3–72.5) | 54.0 | 0.8149 |
| Roads (km) | 4.4 (1.6–10.9) | 4.0 (2.8–13.5) | 59.0 | 0.8883 |

TABLE 4. Land use variables (expressed as a percentage) associated with all sites where Western Chorus Frogs (*Pseudacris triseriata*) were detected during surveys between 2006 and 2010 ($n = 42$) and at random locations across the landscape ($n = 104$) at the 1.0-km radius (range in parentheses). Threshold indicates the percentage of landscape sites that exceeded the maximum land use value for Western Chorus Frog sites (e.g., 2.9% of landscape sites have >50.2% forest cover).

| Land use (%) | Sites where Western Chorus Frogs were detected | Random locations across the landscape | Threshold (%) |
|--------------|--|---------------------------------------|---------------|
| | median (range) | median (range) | |
| Forest | 17.8 (0.3–50.2) | 16.7 (0–69.1) | 2.9 |
| Wetlands | 18.6 (2.8–66.7) | 12.0 (0–74.3) | 1.9 |
| Agriculture | 46.5 (8.1–86.4) | 50.8 (5.2–95.8) | 12.5 |

et al. 2005); however, studies have suggested that reduced pH has no effect on growth or development of Western Chorus Frog tadpoles (Kiesecker 1996).

As Western Chorus Frog populations are extirpated, remaining populations may be more at risk of extirpation as a result of increased geographic isolation and reduced connectivity across the landscape (COSEWIC 2008*). This may be exacerbated by the fact that populations of the short-lived Western Chorus Frog are likely to be relatively prone to extirpation as the result of even a single extreme event (e.g., premature drying up of a breeding pond).

Western Chorus Frogs typically remain within 275 m of the breeding pond (Desroches et al. 2001*), suggesting that dispersal is relatively limited. Historical sites where Western Chorus Frogs were not detected were not farther away from extant Western Chorus Frog sites than currently occupied sites were, although there are limitations to our isolation analysis. It is unlikely that all sites with Western Chorus Frogs were detected, given the fact that surveys were largely restricted to wetlands visible from roads. The probability of extirpation also likely varies between small isolated wetlands and areas with multiple wetlands (e.g., Trenham et al. 2003). In addition, while distance is a measure of isolation, the type of intervening habitat is likely just as important for dispersal (e.g., Seburn et al. 1997), and it is known that roads impede the dis-

persal of Western Chorus Frogs (Picard and Desroches 2004*; Whiting 2004).

Isolation may be a significant factor for at least two historical sites where Western Chorus Frogs were not detected in the current survey. The most eastern historical location where Western Chorus Frogs were not detected has urban landscape to the east and a major highway directly to the west. It had the highest values for roads and built-up areas at all spatial scales, making it highly unlikely that Western Chorus Frogs could recolonize the site. Similarly, the most western historical site where Western Chorus Frogs were not detected is now surrounded by a landscape of intensive agricultural croplands. This site had the lowest forest cover and highest agricultural cover at all spatial scales, and it has apparently little suitable habitat for Western Chorus Frogs.

Western Chorus Frogs occupied a wide range of habitats in the study area, occurring in areas with forest cover ranging from <1 to 50% at a radius of 1.0 km (Table 4). Given that most of the study area had less than 50% forest cover, this maximum value likely does not reflect a true threshold limit for the species. In addition, Western Chorus Frogs were found in areas with up to 86% agricultural cover. Their absence from areas with greater agricultural cover may indicate that such areas are inhospitable to Western Chorus Frogs. Future studies should continue to determine threshold

values for land use variables in a variety of landscapes so that habitat-predictive models for Western Chorus Frogs can be developed.

Surrounding agricultural land use at a 1-km scale was not a significant factor influencing Western Chorus Frog distribution in our study. In contrast, in upstate New York, Western Chorus Frogs were found to decline in areas with greater cultivated land (Gibbs et al. 2005); however, this relationship was documented at a 5–10 km scale. This apparent contradiction is possibly due to differences in scale as well as a difference in the way agricultural land use was classified in the two studies. In the present study, the land classification pooled data for habitats that are likely to be suitable for Western Chorus Frogs (e.g., old field) with inhospitable habitats (e.g., intensive cropland) into one broad category, while the New York study differentiated agriculture into cultivated grasses, row crops, and pasture.

If surveys had been conducted at historical locations only, it would appear that the Western Chorus Frog had declined by 30% in western Ottawa. The additional surveys indicated that it remains widespread across most of the region. Although the Western Chorus Frog may have declined, there are two other ways the data can be interpreted: 1) the number of Western Chorus Frog sites remained essentially unchanged over time, with a shift to different breeding sites but with no net loss of sites; or 2) the number of Western Chorus Frog sites increased, with a shift to different breeding sites resulting in a net increase in the number of sites. A key question is how many of the 30 new Western Chorus Frog sites are newly colonized breeding sites and how many are just newly documented. Without historical data on these 30 sites, it is difficult to know whether the Chorus Frog has truly declined. Given the declines in other areas, future monitoring is warranted.

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Alpine Plant Range Extensions for Northern British Columbia, Including Two Species New to the Province

KENDRICK L. MARR¹, RICHARD J. HEBDA^{2,3,4}, and WILLIAM H. MACKENZIE⁵

¹ Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2 Canada; email: kmarr@royalbcmuseum.bc.ca

² Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2 Canada; email: rhebda@royalbcmuseum.bc.ca

³ Department of Biology, University of Victoria, P.O. Box 1700, Victoria, British Columbia V8W 2Y2 Canada

⁴ School of Earth and Ocean Sciences, University of Victoria, P.O. Box 1700, Victoria, British Columbia V8W 2Y2 Canada

⁵ British Columbia Ministry of Forests, Lands and Natural Resource Operations, 3333 Tatlow Road, Smithers, British Columbia V0J 2N0 Canada; email: Will.MacKenzie@gov.bc.ca

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Between 2002 and 2011, we collected vascular plants from alpine areas of northern British Columbia (B.C.). We have found one species that has not previously been collected in the province: *Phippsia algida*. Collections of an additional three species represent significant range extensions of species already known to occur in the province: *Aphragmus eschscholtzianus*, *Papaver alboroseum*, and *Montia bostockii*. Our collections of *Delphinium brachycentrum* initially appeared to be the first records for the province; however, examination of herbarium specimens at the Royal British Columbia Museum herbarium indicated that this species had been collected prior to our field work but had been misidentified. We indicate the distribution of this species in B.C. for the first time, and we present a corrected distribution map for *Tephroseris yukonensis* that includes our own collections.

Key Words: alpine vascular plants, new records, range extensions, *Tephroseris yukonensis*, *Phippsia algida*, *Delphinium brachycentrum*, *Aphragmus eschscholtzianus*, *Papaver alboroseum*, *Montia bostockii*, British Columbia.

Collections of the alpine flora of northern British Columbia have been limited because of poor access and rugged terrain. To improve our understanding of the distribution of alpine species, we carried out systematic sampling of vascular plants on 65 mountains or high plateaus between the years 2002 and 2011 (Figure 1). At each site, we spent one to three days collecting all vascular plants within each distinct habitat type, from the upper krummholz zone to the high alpine nival zone. We acquired more than 10 000 specimens representing approximately 440 species. These are deposited in the herbarium of the Royal British Columbia Museum (V) (herbarium acronyms follow Thiers 2011*).

In this paper, we report two new species for the province, significant range extensions for three species, a corrected distribution map for a sixth species, and brief comments about smaller range extensions for four species. We present the North American distribution of these species based on specimens from the following herbaria: University of Alaska Museum of the North in Fairbanks (ALA), the University of Alberta (ALTA), the B. A. Bennett Herbarium, Yukon Government (BABY), the National Herbarium of Canada at the Canadian Museum of Nature (CAN), the National Collection of Vascular Plants at Agriculture and Agri-Food Canada (DAO), the Prince Rupert Forest Region of the B.C. Ministry of Forests in Smithers (SMI), the University of British Columbia (UBC), the University of Calgary (UAC), the University of Victoria (UVIC), the

Royal British Columbia Museum (V), and the Burke Museum of Natural History and Culture at the University of Washington (WTU). These distribution maps include recent collections in addition to our own that have not been presented on previously published floras of Alaska (Hultén 1968), Yukon (Cody 2000), or B.C. (Douglas et al. 2002b). With the exception of *Phippsia algida*, whose range extends outside western North America, these maps present the entire known distribution of these species in North America. The data, including nomenclature of associated species, for each specimen that is cited below is repeated as it appears on the label itself.

Asteraceae

Tephroseris yukonensis (A. E. Porsild) Holub (Yukon Groundsel) — BRITISH COLUMBIA: Teslin Plateau, Llangorse Mountain W side of summit area, occasional in hygic-mesic alpine turf meadow on block field talus, organic soil, W-facing 0–10 degree upper slope, with *Salix polaris*, *Carex microchaeta*, *Luzula* sp., 59°23'57"N, 132°48'35"W, 1820 m, 8 August 2008, K. Marr, R. Hebda, W. MacKenzie 08-1373 (V 203992); Cassiar Mountains, Dease Plateau, N end Horseshoe Range, W side, uncommon in mesic alpine gravel and silt scree among blocks shattered by frost, 59°28'35"N, 128°54'20"W, 1920 m, 6 August 2004, K. Marr, R. Hebda, W. MacKenzie, A. Banner 04-1104 (V 193214); Stikine Ranges, slopes E of "Little Blue Sheep" Lake, nearly level alpine meadows near summit, granitic

bedrock, with thick lichens, *Carex microchaeta*, *Hierochloa alpina*, *Salix stolonifera*, *Autennaria monocephala*, 58°43'17"N, 128°13'48"W, 1992 m, 12 August 2007, K. Marr, R. Hebda, W. MacKenzie 07-1676 (V 202011).

According to Douglas et al. (2002a) and Cody (2000), *Tephrosieris yukonensis* (syn. *Senecio yukonensis* A. E. Porsild) is endemic to B.C., Yukon, the western Northwest Territories, and Alaska; however, the occurrences in the Northwest Territories and B.C. were evidently overlooked by Barkley and Murray (2006). Based on the key and descriptions in Barkley and Murray (2006), five species of *Tephrosieris* that bear four or fewer heads occur in northwestern North America, and we used this treatment to identify *T. yukonensis*. Involucral hairs are yellow in *T. yukonensis*, whereas they are white or white with purple cross-walls in *Tephrosieris frigida* (Richardson) Holub, *Tephrosieris tundricola* (Tolmatehew) Holub, and *Tephrosieris lindstroemii* (Ostenfeld) Å. Löve and D. Löve. Involucral hairs of *Tephrosieris kjellmauii* (A. E. Porsild) Holub are distinctly brown as compared to the above species. All of the specimens at V that we have identified as *T. yukonensis* appear to lack ray flowers; however, these flowers are actually present, but the strap is very short, nearly as short as the adjacent phyllaries.

Our work to document the range of this species (Figure 2a) corrects the distribution maps of Douglas et al. (2002a and 2002b). *Tephrosieris yukonensis* does not occur as far south as these maps indicate because the southernmost record is an error based upon the wrong coordinates for one if not two specimens (a difference of approximately 300 km). According to the label of K. I. Beanish and J. Pojar 730435 (UBC V145162, DAO 208382), the plant was collected from "Table Mt., Cassiar area" with the coordinates as 56°N and 126°W. This location is far south of the town site of Cassiar at 59°17'N, 129°50'W, and J. Pojar (personal communication) has confirmed that the "Table Mt." referred to on the label is near Cassiar.

The label of a second specimen at V (17874) lacks geographical coordinates, but states the following: "Cambrey Mt., A. G. Slocombe, 8 July 1945". No such location exists in either printed or online gazetteers, although there is a "Cambria Peak" at 56°03'N, 129°43'W. However, other specimens collected by A. G. Slocombe on that date come from the Alaska Highway in the vicinity of 59°59'N, 131°32'W. Therefore, it is most likely that the "Cambrey Mt." referred to on the label is along the Alaska Highway.

After correcting for the above two records, our collections extend the range of *Tephrosieris yukonensis* approximately 100 km south of previous collections and document the presence of this species in the Cassiar Mountains of north-central B.C. There are also previous collections from the Liard Plateau and northwestern B.C.

Brassicaceae

Aphragmus eschscholtzianus Andr. ex DC. (Aleutian Cress) — BRITISH COLUMBIA: Cassiar Mountains, Stikine Ranges, Mount Shea, in valley approximately 2 km S of summit, alpine hydric seep meadow, organic soil > 10 cm, W-facing 0–10 degree slope, 58°18'41"N, 128°56'28"W, 1818 m, 9 August 2007, K. Marr, R. Hebda 07-1316 (V 201317); Stikine Ranges, gentle slopes 4 km NE of "Little Blue Sheep" Lake, mossy alpine rivulet on cobbles, SE-facing 0–5 degree upper slope, with *Poa alpina*, *Saxifraga nelsoniana*, and *Eriophorum*, 58°44'37"N, 128°12'49"W, 1836 m, 13 August 2007, K. Marr, R. Hebda, W. MacKenzie 07-1782 (V 202067); Stikine Ranges, Cassiar Mountains, eastern part of Spatsizi Plateau between 2 small, 1 km long lakes, 13 km S of Pitman River, uncommon in alpine hydric-mesic alpine meadow, lower slope, NW-facing 0–10 degree mossy runnel with *Salix reticulata*, *Claytonia sarmentosa*, *Carex podocarpa*, *Corydalis pauciflora*, *Polygonum viviparum*, 57°51'44"N, 127°55'46"W, 1623 m, 22 July 2009, K. Marr, R. Hebda, W. MacKenzie 09-0242 (V 204869).

Aphragmus eschscholtzianus is an amphiberian species occurring in B.C., Yukon, Alaska, and eastern Russia. It is considered to be rare in B.C. (Douglas et al. 2002a). Plants somewhat resemble *Cardamine bellidifolia* L., with their low stature (less than 5 cm tall) and petiolate basal leaves, as well as habitat preference. They differ in that the fruit of *A. eschscholtzianus* is shorter and more elliptical and the inflorescence is immediately subtended by a few leaves, whereas in *C. bellidifolia* the fruit is linear and the flowering stalk is naked.

We have added three new locations for north-central B.C. (Figure 2b) approximately 420 km southeast of the previous single collection from the "Haines Triangle" (Tatshenshini-Alsek Park in the northwestern corner of B.C.). The single collection from the Brooks Range, Alaska, far from other collections, has been verified by Jordan Metzgar (personal communication). Al-Shehbaz (2010) did not record the species for B.C.

Papaveraceae

Papaver alboroseum Hult. (Pale Poppy) — BRITISH COLUMBIA: Nass River, Mount Beirnes, along SW ridge 1 km S of peak, rare on alpine serec, SW-facing 10–35 degree upper slope, soil of sand and gravel from shale, less than 10 cm, wind exposed, with *Polemonium* and *Trisetum*, 56°57'42"N, 128°33'30"W, 1977 m, 29 July 2005, K. Marr, R. Hebda, W. MacKenzie 05-0360 (V 194657); Nass River, Mount Beirnes, along SW ridge 1 km S of peak, rare, E-facing sparsely vegetated alpine serec, 10–35 degree slope, mesic-hygic silty soil on sedimentary rocks, with *Potentilla diversifolia*, *Poa alpina*, *Artemisia norvegica*, *Oxyria*, *Myosotis*, 56°57'09"N, 128°32'46"W, 1771 m, 29 July 2005, K. Marr, R. Hebda, W. MacKenzie 05-0253 (V 194605); Skeena Mountains, Spatsizi Plateau, NW of

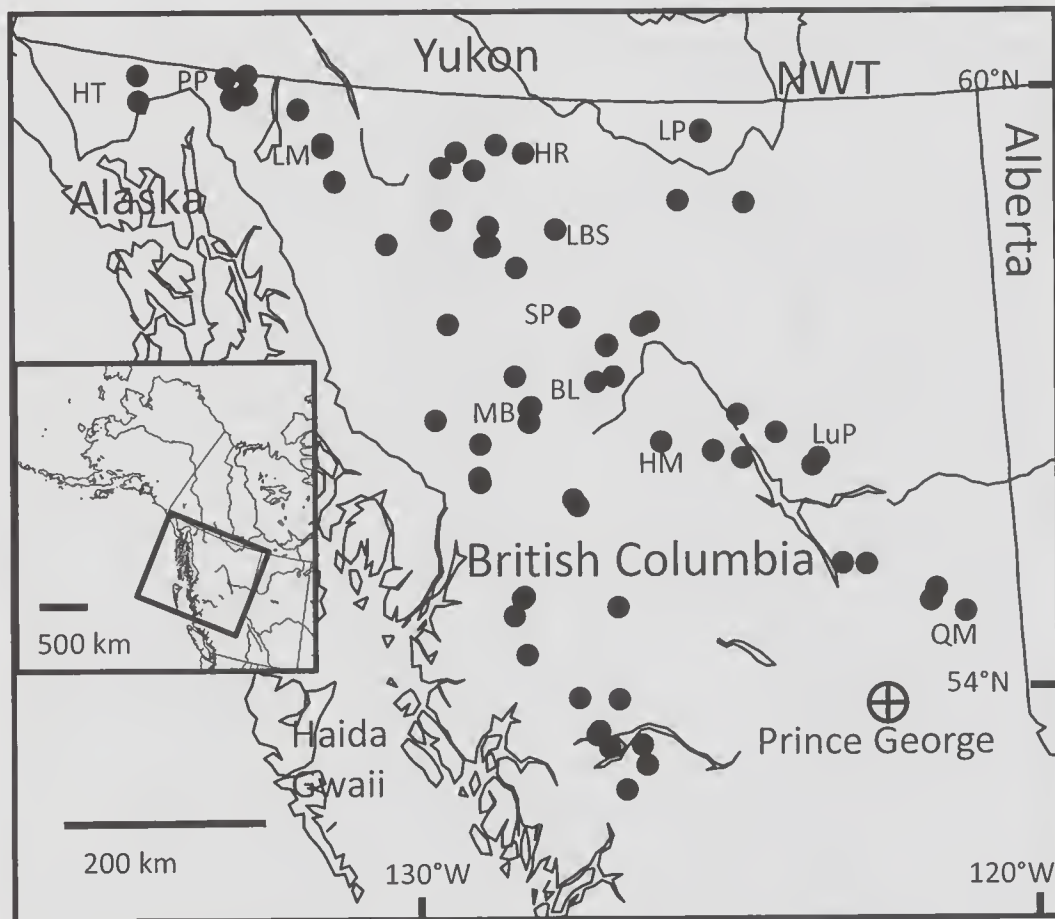


FIGURE 1. Alpine plant collection localities in northern British Columbia, 2002–2011. Selected locations noted in text abbreviated as follows: BL, Brothers Lake; HM, Hogem Mountains; HR, Horseranch Range; HT, Haines Triangle; LBS, Little Blue Sheep Lake; LM, Llangorse Mountain; LP, Liard Plateau; LuP, Ludington Peak; MB, Mount Beimes; PP, Paddy Pass; QM, Quintette Mine; SP, Spatsizi Plateau.

Brothers Lake, mesic-xeric sparsely vegetated alpine fine scree, late snow, silty soil with gravel and boulders, N-facing 10–35 degree mid-slope, sliding, with *Myosotis asiatica*, *Silene acaulis*, *Artemisia norvegica*, *Luzula spicata*, *Oxyria digyna*, 57°13'23"N, 127°25'50"W, 1950 m, 26 July 2009, K. Marr, Hebda, Richard, W. MacKenzie 09-0770 (V 205481); Omineca Mtns., Hogem Ranges, massif W of Two-Mile Cr., 10–20 degree NE-facing upper slope, sparsely vegetated alpine sedimentary fine scree 0–15 cm deep over bedrock with *Oxyria*, *Ranunculus eschscholtzii*, *Carex pyrenaica*, *Epilobium anagallidifolium*, *Saxifraga nelsoniana*, 56°41'06.0"N, 127°00'05.7"W, 1847 m, August 19, 2011, K. Marr, R. Hebda, N. Hebda 11-715 (207187).

Papaver alboroseum occurs in B.C., Yukon, Alaska, and far eastern Russia, including Kamchatka (Kiger and Murray 1997). It is easily recognized by its white petals—unique among B.C. *Papaver*—that yellow to

wards the base and the decumbent habit (Figure 3a). This species is rare and was previously known from only three locations within B.C. (Douglas 2002a) (Figure 2c). We have added three additional locations. In addition to the Brothers Lake population noted above, we also noted a population on the southeastern side of the lake (57°08'46.4"N, 127°21'06.2"W, 1928 m, on 27 July 2009), but did not collect a specimen.

Despite our widespread and comprehensive collecting, this species occurs in only a cluster of locations in north-central B.C. to date. This cluster is approximately 420 km from the nearest locality to the northwest and may represent a genuine disjunct distribution. The area near these southern collections is poorly surveyed, and additional populations may be expected. The habitat for this species appears to be quite specific and is restricted to high-elevation, unstable, fine-textured sedimentary scree. The persistence of *Papaver alboroseum* in these sites may be dependent upon the instability of

the substrate. This instability prevents other species from becoming established and overtopping *P. alboroseum*, a nearly prostrate plant whose flowers typically are decumbent, resting upon the ground.

Poaceae

Phippsia algida (Soland.) R.Br. (Icegrass) — BRITISH COLUMBIA: Level Mountain Range, Meszah Peak, rounded plateau surface on mountain 2 km S of summit, uncommon, on sparsely vegetated, mesic NW-facing alpine scree/gravel 10-degree mid-slope, soil less than 10 cm deep, 58°27'49"N, 131°26'03"W, 1933 m, 2 August 2004, R. Hebda, K. Marr, W. MacKenzie 04-0593 (V 192155); Level Mountain Range, Meszah Peak, small valley 2 km S of summit, occasional in an alpine, level fen in valley bottom, with *Petasites*, *Ranunculus*, organic, silty, hygric soil less than 10 cm deep, 58°28'24"N, 131°26'52"W, 1881 m, 2 August 2004, R. Hebda, K. Marr, W. MacKenzie 04-0621 (V 192157); Nimbus Mountain, SW of summit, low cover and rare in level, mesic-hygric, gravelly edge of alpine fen meadow, organic soil > 10 cm on gravel, with *Carex*, *Aconitum delphinifolium*, *Polemonium*, mosses, 59°02'16"N, 132°31'18"W, 1637 m, 6 August 2008, K. Marr, R. Hebda, W. MacKenzie 08-1180 (V 203806); Nimbus Mountain, N of summit, occasional in hygric, alpine rivulet below melting snow, 0–10 degree N-facing mid-slope, fine soil, with *Poa alpina*, mosses, 59°02'29"N, 132°30'23"W, 1853 m, 6 August 2008, K. Marr, R. Hebda, W. MacKenzie 08-1199 (V 203816); Mount Brown, 2 km W of summit, SW of "Lanning Lake", moss covered alpine seep, N-facing 0–5 degree lower slope, with *Oxyria digyna*, *Poa paucispicula*, *Ranunculus pygmaeus*, 59°48'07"N, 134°27'32"W, 1536 m, 4 August 2008, K. Marr, R. Hebda, W. MacKenzie 08-0959 (V 203670); Teslin Plateau, Llangorse Mountain, S of summit, occasional in hygric-mesic alpine runnel meadow below melting snow, granitic soil amidst stone stripes, 20 degree, W-facing, mid-slope, with mosses, lichens, *Poa*, 59°22'53"N, 132°48'30"W, 1572 m, 8 August 2008, K. Marr, R. Hebda 08-1414b (V 204033); Teslin Plateau, Llangorse Mountain, NW of summit, low cover but frequent in hygric-hydric alpine late snow meadow on wet granite cobbles/gravel, level at base of slope, with *Saxifraga ferruginea* and mosses, subject to freeze-thaw, 59°24'11"N, 132°49'09"W, 1717 m, 8 August 2008, K. Marr, R. Hebda 08-1378 (V 203997); Cassiar Mountains, Stikine Ranges, Mount Shea, in valley approximately 2 km S of summit, uncommon in alpine hydric seep meadow, organic soil greater than 10 cm, W-facing 0–10 degree slope, 58°18'41"N, 128°56'28"W, 1818 m, 9 August 2007, K. Marr, R. Hebda 07-1314 (V 201315); Stikine Ranges, gentle slopes 4 km NE of "Little Blue Sheep" Lake, mossy alpine rivulet on cobbles with flowing water, SE-facing 0–5 degree upper slope, with *Poa alpina*, *Saxifraga uelsoniana*, and *Eriophorum* (single head), 58°44'33"N,

128°12'49"W, 1886 m, 31 August 2007, K. Marr, R. Hebda, W. MacKenzie 07-1781 (V 202066); Stikine Ranges, slopes of peak north of "Little Blue Sheep" Lake, uncommon in level mesic-xeric alpine summit on shattered rock surface subject to cryoturbation, limestone gravel less than 10 cm, 58°45'07"N, 128°13'12"W, 2105 m, 11 August 2007, K. Marr, R. Hebda, W. MacKenzie 07-1607 (V 201952); Stikine Ranges, gentle slopes NE of "Little Blue Sheep" Lake, hygric alpine rivulet at base of E-facing late snow melt hollow, on limestone, possibly metamorphosed, with *Saxifraga lyallii*, *Poa alpina*, mosses, 58°43'46"N, 128°14'19"W, 1703 m, 13 August 2007, K. Marr, R. Hebda, W. MacKenzie 07-1770 (V 202060); Stikine Ranges, slopes north of "Little Blue Sheep" Lake, low cover but frequent on limestone gravel of alpine late snow slope, 10–20 degree NE-facing upper slope, 0–2 cm organic soil, with *Saxifraga lyallii*, 58°44'27"N, 128°14'47"W, 1871 m, 11 August 2007, K. Marr, R. Hebda, W. MacKenzie 07-1519 (V 201811); French Range, W of Dease Lake, Mount Rath, S of summit, low cover in alpine gravel bar subject to flooding, N-facing, 1–2 degree slope, 58°43'40"N, 130°24'38"W, 1662 m, 10 August 2007, K. Marr, R. Hebda, W. MacKenzie 07-1440 (V 201562); Cassiar Mountains, Stikine Ranges, Mount Shea, approximately 1 km S of summit, alpine hygric-hydric, gentle N-facing seep meadow subject to flooding, with *Ranunculus*, *Caltha leptosepala*, *Petasites frigidus*, 58°18'55"N, 128°56'34"W, 1816 m, 9 August 2007, K. Marr, R. Hebda, 07-1241 (V 201243); Cassiar Mountains, Stikine Ranges, Mount Shea, approximately 1 km S of summit, uncommon in runnels of alpine, level, mesic-hygric turf meadow over angular gravel/boulders, with lichens, mosses, *Festuca altaica* tussocks with scattered *Cassiope tetragoua*, 58°19'06"N, 128°56'42"W, 1860 m, 9 August 2007, K. Marr, R. Hebda, 07-1231 (V 201236); Stikine Ranges, Cassiar Mountains, Spatsizi Plateau, eastern part of plateau, between 2 small 1 km long lakes 13 km S of Pitman R., low cover and rare, level alpine hygric-hydric meadow at edge of lake, organic soil with gravel, subject to flooding, with *Salix reticulata*, 57°51'15"N, 127°55'43"W, 1606 m, 22 July 2009, K. Marr, R. Hebda, W. MacKenzie 09-0176 (V 204839); Stikine Ranges, Cassiar Mountains, Spatsizi Plateau, eastern part of plateau, above 1 km long lake 13 km S of Pitman R., low cover and rare in alpine snow-melt seep in standing or gently flowing water, level bench on ridge top, with mosses, *Claytonia sarnentosa*, *Salix polaris*, 57°51'06"N, 127°52'54"W, 1946 m, 22 July 2009, K. Marr, R. Hebda, W. MacKenzie 09-0264 (V 204883); Skeena Mountains, Spatsizi Plateau, Brothers Lake, NW of lake, low cover and rare in hygric, alpine meadow subject to flooding at edge of pond, S-facing, mid-slope, muddy, ephemeral, with *Koenigia islandica*, *Phippsia algida*, *Eriophorum*, *Ranunculus eschscholtzii*, 57°13'16"N, 127°26'34"W, 1935 m, 26 July 2009, K. Marr, R. Hebda, W. MacKenzie 09-0838 (V 205551);

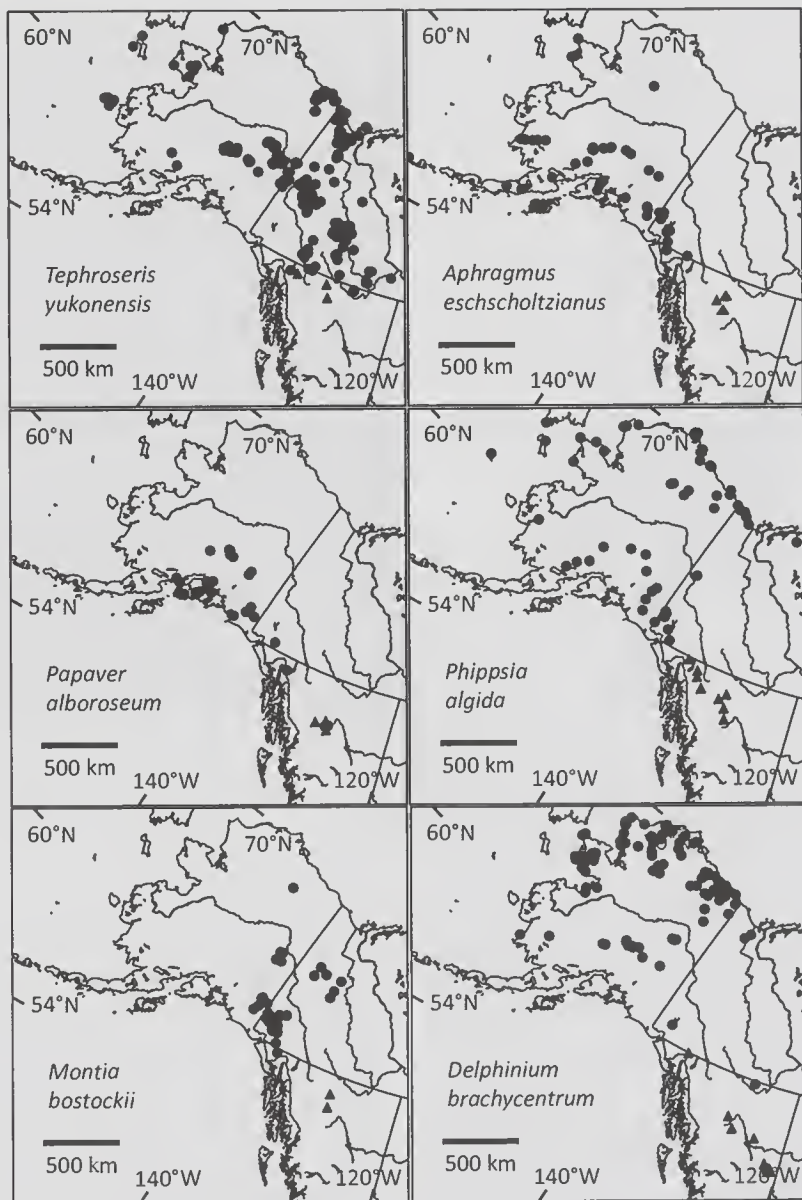


FIGURE 2. Species discussed in the text collected between 2002 and 2011 and deposited at the Royal British Columbia Museum herbarium. Triangles represent collections made by Marr, Hebda, and MacKenzie (MHM); circles represent collections made by other collectors.

Skeena Mountains, Spatsizi Plateau, Brothers Lake, NW of lake, alpine fine scree, S-facing, 10–35 degrees, upper slope and ridge apex, 57°13'30"N, 127°28'W, 2000 m, 26 July 2009, K. Marr; R. Hebda, W. MacKenzie 09-0856 (V 205570).

Phippsia algida occurs throughout the circumpolar Arctic (Consaul and Aiken 2007; Hultén 1968). It is a diminutive plant, often less than 2 cm tall, with

relatively narrow leaves, and it is easy to overlook. One species of similar habitats is *Poa paucispicula* Scribn. and Merr., from which *Phippsia algida* differs in having a more compact panicle with more rigid branches and a single floret per spikelet rather than two or more. Both *Phippsia* and *Poa* have prow-like leaf tips that are easily discerned by running a leaf between thumb and finger and noting whether the tip splits in two.

Phippsia algida is not listed in the comprehensive Illustrated Flora of B.C., where it is given as an "excluded species" (Douglas et al. 2001). Citing Taylor and MacBryde (1977), Douglas et al. (1981) reported it as "rare in British Columbia." However, we have not found any specimens that were collected prior to our 2004 collection from northwestern B.C. in the Level Mountain Range. We have since collected it from nine locations (Figure 2d) in B.C. west of the Rocky Mountain Trench to as far south as Brothers Lake (57°13'16"N), a southward range extension, with localities in between, of approximately 630 km from the nearest previous collections, in southwestern Yukon. This species is one of several arctic-alpine plants with a disjunct distribution that includes northern B.C., the Beartooth Plateau (on the Montana-Wyoming border just east of Yellowstone), and northern Colorado (Marr et al., *in press*)

Portulacaceae

Montia bostockii (Porsild) Welsh (Bostock's Minerslettuce) — BRITISH COLUMBIA: Stikine Ranges, gentle slopes 4 km NE of "Little Blue Sheep" Lake, mesic alpine S-facing thick turf meadow, 10–35 degree mid-slope, metamorphosed limestone gravel and cobbles, with *Salix reticulata*, cryptogams, *Dryas integrifolia*, *Carex*, *Polygonum viviparum*, *Potentilla biflora*, 58°44'37"N, 128°12'49"W, 1836 m, 13 August 2007, K. Marr, R. Hebda, W. MacKenzie 07-1784 (V 202068); Stikine Ranges, Cassiar Mountains, eastern part of Spatsizi Plateau, NE of small lake 10 km S of Pitman R., uncommon, S-facing, lower slope 0–10 degrees, meadow patches and gravel runnels among *Betula nana*–*Pentaphylloides*, with *Sphagnum*, *Artemisia norvegica*, *Festuca altaica*, *Salix reticulata*, *Senecio triangularis*, *Sanguisorba canadensis*, *Polygonum viviparum*, 57°53'10"N, 127°57'40"W, 1394 m, 21 July 2009, K. Marr, R. Hebda, W. MacKenzie 09-0085 (V 204773).

Montia bostockii is endemic to northern B.C., Yukon, and eastern Alaska (Miller 2003). It is considered to be rare in B.C. (Douglas 2002a). Other Portulacaceae species also occur in alpine habitats; however, these all belong to *Claytonia*, a genus with opposite stem leaves, whereas those of *Montia* are alternate. Our two collections extend the range to the south and east by approximately 600 km from the previous single B.C. location, in the Haines Triangle (Figure 2e).

Ranunculaceae

Delphinium brachycentrum Ledebour (syn. *Delphinium chamissonis* Pritzl ex Walpers) (Northern Larkspur) — BRITISH COLUMBIA: Rocky Mountain Foothills, Roman Mountain, 5 km WNW of Quintette Mountain, S of Babcock Creek, occasional in alpine meadow heath with *Empetrum nigrum*, *Cassiope* sp. and cryptogams, weakly terraced NE-facing mid-slope, less than 10 degrees, soil 1–10 cm deep

cryptogamic humus on gravel and conglomerate outcrops, 54°53'13"N, 120°56'56"W, 1692 m, 11 August 2003, R. Hebda, K. Marr, R. Forsyth, KM5492 (V 191306); Rocky Mountain Foothills, saddle 2 km WSW of Mt. Spieker summit, in a SE-facing upper sub-alpine mesic meadow with rivulets, beside road, disturbed by digging, mid-slope, 10–35 degrees, *Abies lasiocarpa*, *Picea engelmannii* forest with *Artemisia norvegica*, *Poa* sp., *Trisetum spicatum*, *Epilobium angustifolium*, 55°07'21"N, 121°25'30"W, 1700 m, 12 August 2003, R. Hebda, K. Marr, R. Forsyth KM5675 (V 191032); Rocky Mountains, Mount Ludington, next major ridge to the W, rare on S-facing 10 degree slope near top of ridge, mesic to xeric rocky alpine meadow with *Dryas*, soil gravelly, less than 1 cm deep, 56°28'14"N, 123°23'24"W, 1915 m, 6 August 2003, R. Hebda, K. Marr, W. MacKenzie, R. Forsyth KM4681 (V 191285); Paddy Pass, E of Bennett Lake, peak on plateau 7–8 km N of pass, uncommon in xeric, alpine S-facing, 10–35 degree rocky slope, with *Saxifraga bronchialis*, *Carex*, *Poa*, *Potentilla*, organic soil 0–5 cm, 59°56'03"N, 134°51'46"W, 1789 m, 1 August 2008, K. Marr, R. Hebda, W. MacKenzie 08-0433 (V 203428); Omineca Mountains, Samuel Black Range, Sable Mine area, 6–8 km N of Black Lake, mesic alpine *Festuca altaica* meadow, greater than 10 cm organic soil on limestone bedrock, 0–10 degree SW-facing mid-slope, with *Salix stolonifera*, *Erigeron peregrinus*, *Artemisia norvegica*, *Myosotis asiatica*, 57°17'10"N, 127°06'50"W, 1756 m, 29 July 2009, K. Marr, R. Hebda, W. MacKenzie 09-1174 (V 205901); Omineca Mountains, Swannell Ranges, N of Johanson Lake, valley and slopes at SE end of Wrede Range, mesic alpine *Festuca altaica*–*Salix arctica* meadow, less than 10 cm organic soil on gravel boulder till, W-facing mid-slope; with *Artemisia norvegica*, *Pedicularis bracteosa*, *Juniperus communis*, 56°38'13"N, 126°12'35"W, 1750 m, 30 July 2009, K. Marr, R. Hebda, W. MacKenzie 09-1218 (V 205952).

Delphinium brachycentrum is an amphiberian species (Cody 2000) that has not previously been reported to occur in B.C.; however, at least three specimens at V (V078288, V094471, V089553) that were initially identified as *D. glaucum* S. Wats. have now been identified as *D. brachycentrum*. Our collections, together with those previously determined as *D. glaucum*, constitute a major range extension southward into the Rocky Mountains (Figure 2f). The southernmost collection is approximately 1200 km south of the nearest previously known locality, in the Yukon, where it is considered to be rare (Cody 2000).

In B.C., the distribution of two other species of *Delphinium*—*Delphinium glaucum* (throughout B.C. east of the coastal ranges) and *Delphinium glareosum* Greene (southwestern B.C. only)—includes alpine habitats (Douglas and Meidinger 1999). *Delphinium glareosum* is glabrous, whereas *D. brachycentrum* is pubescent (Warnock 1997). Compared to *D. glaucum*, *D. brachycentrum* is a smaller plant 20–50(–80) cm tall,



FIGURE 3. a) *Papaver alboroseum* (photo of K. Marr, R. Hebda, N. Hebda 11-715 — Omineca Mountains, Hogen Ranges, massif west of Two Mile Creek); b) *Delphinium brachycentrum* (R. Hebda, K. Marr, W. MacKenzie, R. Forsyth KM4681 — Rocky Mountains, Mount Ludington, next major ridge to the west). See entries for each species for more complete collection location information. Photos: a) Kendrick Marr; b) Carlo Mocellin, Royal British Columbia Museum.

often pubescent, with fewer flowers (5–18), leaves on the lower fifth of the stem and with the ultimate lobes 1–7(–15) mm wide, and pubescent follicles. In *D. glaucum*, plants are (60–)100–200(–300) cm tall, glabrous to puberulent, have more flowers ((13–)40–90(–140)), leaves the full length of the stem, the ultimate lobes 5–24 (–35) mm wide, and with glabrous to puberulent fruit (Warnock 1997).

Following the key and descriptions of Warnock (1997), specimens that we have identified as *D. brachycentrum* are less than 50 cm tall, bear 13 or fewer flowers, have densely pubescent follicles, glabrous to pubescent stems, and the leaves mostly on the lower fifth of the stem (Figure 3b). Hybrids between *D. brachycentrum* and *D. glaucum* evidently occur and have been named *D. × nutans* A. Nelson (Warnock 1997). Some of our six collections may be a result of hybridization or even introgression between these two species, as they are intermediate in some characters between *D. brachycentrum* and *D. glaucum*, with some specimens bearing leaves above the lower fifth of the stem, but in all other characters they much more closely resemble *D. brachycentrum*.

A thorough morphometric/genetic analysis of alpine *Delphinium* species in B.C. would be helpful to more

clearly delineate the characters by which *D. brachycentrum* can be distinguished, to evaluate the possibility of hybridization/introgression with *D. glaucum*, and thus to more fully understand the distribution of *D. brachycentrum*. Existing collections of *D. glaucum* from mountains of B.C., Yukon, and Alberta should be checked to see if some of these are *D. brachycentrum*.

Discussion

In general, most of our collections extend the range of the species reported southward and eastward into areas with limited or no collections. We expect that further collecting in the high elevations of the northern interior of B.C. will add more localities for some of these species. With the exception of *D. brachycentrum*, the focus of collecting should be on relatively restricted habitats of limited distribution, e.g., flowing water and shallow lakes, wind-blown ridges, scree, and gravelly seepage sites, especially near melting snow beds.

Our work also resulted in interesting but much shorter range extensions for four other species. *Hippuris montana* Ledebour is more widespread east of the Coast Mountains and further north in British Columbia than previously documented; the range of *Potentilla*

elegans Cham. & Schlecht., an amphiberian species rare in B.C. (Douglas et al. 2002a), is extended southward by approximately 70 km; *Gentiana platypetala* Griseb., endemic to Pacific coastal North America (Hultén 1968), is more widespread in the eastern slopes of the Coast Mountains than was previously known; and we found three new locations of *Arctophila fulva* (Trin.) Andersson, rare in British Columbia (Douglas et al. 2002a).

Acknowledgements

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Slender False Brome (*Brachypodium sylvaticum*, Poaceae), an Invasive Grass New to Ontario, Canada

BRIAN M. MILLER¹, ROBERT J. AITKEN¹, MICHAEL J. OLDHAM², and ANTON A. REZNICEK³

¹ Aboud & Associates Inc. (Consulting Arborists, Ecologists and Landscape Designers), 591 Woolwich Street, Guelph, Ontario N1H 3Y5 Canada; email: brian.miller063@gmail.com and robaitken@trentu.ca

² Ontario Natural Heritage Information Centre, Ontario Ministry of Natural Resources, 300 Water Street, Peterborough, Ontario K9L 1C8 Canada; email: michael.oldham@ontario.ca

³ University of Michigan Herbarium, 3600 Varsity Drive, Ann Arbor, Michigan 48108-2287 USA; email: reznicek@umich.edu

Miller, Brian M., Robert J. Aitken, Michael J. Oldham, and Anton A. Reznicek. 2011. Slender False Brome (*Brachypodium sylvaticum*, Poaceae), an invasive grass new to Ontario, Canada. *Canadian Field-Naturalist* 125(3): 235–240.

Brachypodium sylvaticum, Slender False Brome, an invasive Eurasian grass, is reported for the first time in Ontario and eastern Canada from Grey County, southern Ontario. The only previous Canadian record is from Vancouver Island, British Columbia. The species is widespread in the U.S. Pacific Northwest, where it is spreading aggressively throughout much of western Oregon. In the eastern U.S.A., known populations are few and localized, although the species will likely spread.

Key Words: *Brachypodium sylvaticum*, Slender False Brome, Poaceae, invasive, new record, Grey County, Ontario, Canada.

The invasive Eurasian grass species *Brachypodium sylvaticum* (Huds.) P. Beauv. (Slender False Brome) was recently discovered in Ontario, and is here reported as new to the flora of the province and eastern Canada. On 5 and 19 August 2011, Brian Miller and Robert Aitken encountered an unfamiliar grass species while conducting a volunteer vascular plant inventory of the Nordin Nature Reserve, a 13.5 ha parcel of land owned by the Escarpment Biosphere Conservancy in Grey County, Ontario. A specimen was collected and photographs were taken (Figure 1). Photographs were emailed to Michael Oldham of the Ontario Natural Heritage Information Centre, who was also unfamiliar with the grass. Oldham forwarded the photographs to Anton Reznicek of the University of Michigan. Reznicek provided a tentative identification of *Brachypodium sylvaticum*, a species previously unreported in Ontario. Miller, Aitken, and Oldham visited the site on 18 October 2011 and confirmed that the unknown grass was *B. sylvaticum*. Additional specimens were collected by Oldham at this time and have been deposited in regional herbaria (herbarium acronyms follow Thiers 2011*) (see voucher specimens below). The general location of *Brachypodium sylvaticum* collected in Grey County, southern Ontario, is plotted on the map in Figure 2.

Brachypodium sylvaticum (Huds.) P. Beauv. is a perennial grass native to Europe, Asia, and North Africa (Piep 2007). Only subspecies *sylvaticum* is known to be present in North America (Piep 2007). The species was first found in North America near Eugene, Lane County, Oregon, in 1939 (Kaye 2001*), and by 1966 it was thoroughly naturalized and formed at least two large colonies in the Corvallis-Albany area of Benton County, Oregon (Chambers 1966). In western North

America, it was subsequently discovered in San Mateo County, California, in 2003 (Johnson 2004) and near Cowichan Lake, Vancouver Island, British Columbia, in 2008 (Fenneman 2010*). It is now also known from the state of Washington (Daniel and Werier 2010). Unconfirmed reports exist for Colorado and Utah (Kaye 2001*; Piep 2007). *Brachypodium sylvaticum* is highly invasive in the Pacific Northwest. It currently covers an estimated 10 000 ha of forested and open habitats in Oregon (Kaye 2003*). By examining nuclear microsatellites and chloroplast haplotype variation in 23 introduced populations of *B. sylvaticum* in western North America and 25 native populations of *B. sylvaticum* in western Europe, Rosenthal et al. (2008) suggested that there were two independent historical introductions of the species in Oregon and a separate introduction in California.

Brachypodium sylvaticum is rare in eastern North America. There are no previous reports of *B. sylvaticum* from Ontario (Dore and McNeill 1980; Morton and Venn 1990; Newmaster et al. 1998) or elsewhere in Canada east of Vancouver Island (Scoggan 1978-1979; Kartesz 1999; Brouillet et al. 2011*). In the eastern U.S.A., *B. sylvaticum* is currently highly localized. It was first reported in Virginia (Piep 2007) and has recently been reported from Genesee County and Tompkins County in New York State (Daniel and Werier 2009, 2010). It is well established at Bergen Swamp in Genesee County, where it has been present since at least the mid-1990s (Daniel and Werier 2010). In Michigan, *B. sylvaticum* is known from Benzie County, where it was first collected in 1984 (Reznicek et al. 2011*).

The Ontario population of *Brachypodium sylvaticum* is located between Priceville and Flesherton in Grey



FIGURE 1. Spikelets of *Brachypodium sylvaticum* in Grey County, Ontario, 19 August 2011. Photo: Brian Miller.

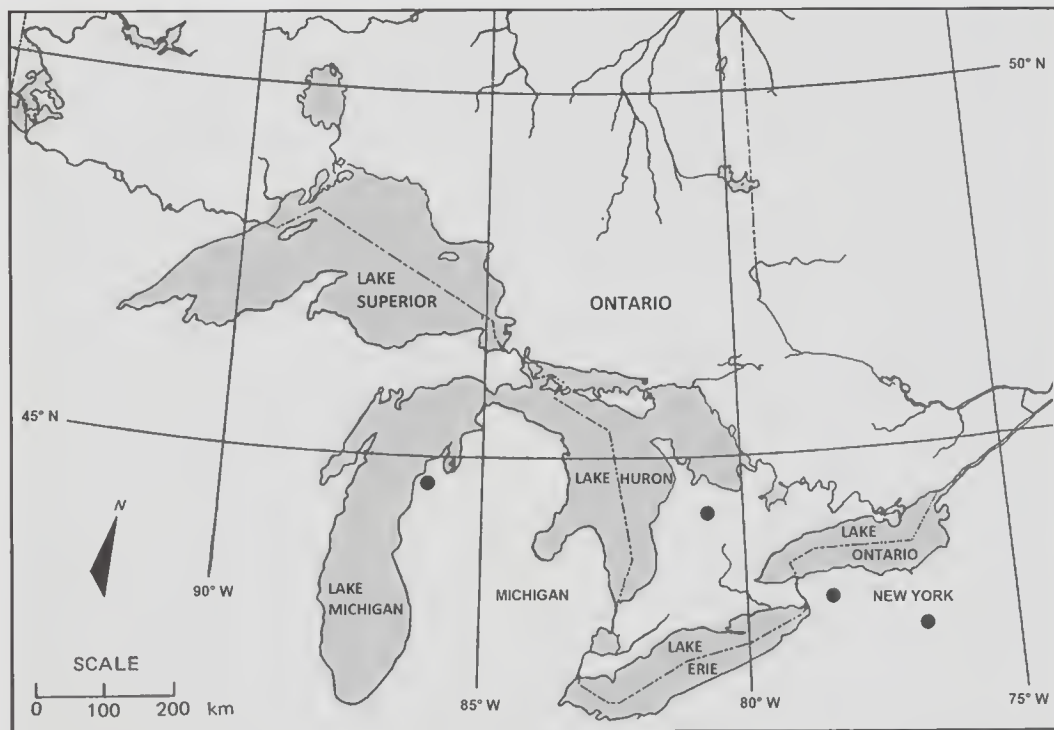


FIGURE 2. General locations of *Brachypodium sylvaticum* in Grey County (Ontario), Benzie County (Michigan) and Genee and Tompkins Counties (New York). Base map source: Dore and McNeill (1980).

County south of Grey Road 4 (44.217°N, 80.597°W). In the Nordin Nature Reserve, the population occurs on a small wooded upland knoll dominated by an understory of Eastern White Cedar (*Thuja occidentalis*) and Balsam Fir (*Abies balsamea*) and a semi-open canopy of Sugar Maple (*Acer saccharum*), Paper Birch (*Betula papyrifera*), Yellow Birch (*B. alleghaniensis*) and Eastern Hop-Hornbeam (*Ostrya virginiana*). The knoll

is surrounded by a large swamp dominated by Eastern White Cedar, Black Ash (*Fraxinus nigra*), and Red Maple (*Acer rubrum*). Several thousand plants of *Brachypodium sylvaticum* were estimated to occur on the upland knoll; none were observed growing in the surrounding wetland (Figure 3). All vascular flora observed growing on the knoll with *B. sylvaticum* is listed in Table 1.

TABLE 1. Plant species observed growing with *Brachypodium sylvaticum* in Grey County, Ontario, in 2011.

| Scientific name (common name) | Scientific name (common name) |
|---|--|
| <i>Abies balsamea</i> (Balsam Fir) | <i>Fraxinus</i> sp. (ash species) |
| <i>Acer saccharum</i> (Sugar Maple) | <i>Leucanthemum vulgare</i> * (Oxeye Daisy) |
| <i>Actaea pachypoda</i> (White Baneberry) | <i>Ostrya virginiana</i> (Hop Hornbeam) |
| <i>Agrimonia gryposepala</i> (Tall Agrimony) | <i>Polygala panicifolia</i> (Gaywings) |
| <i>Betula alleghaniensis</i> (Yellow Birch) | <i>Polygonatum pubescens</i> (Hairy Solomon's-seal) |
| <i>Betula papyrifera</i> (Paper Birch) | <i>Prunella vulgaris</i> (Heal-all) |
| <i>Brachyelytrum</i> sp. (Shorthusk) | <i>Pteridium aquilinum</i> (Bracken Fern) |
| <i>Carex arctata</i> (Drooping Woodland Sedge) | <i>Schizachne purpurascens</i> (False Melic Grass) |
| <i>Carex gracillima</i> (Graceful Sedge) | <i>Solidago canadensis</i> (Canada Goldenrod) |
| <i>Carex pedunculata</i> (Long-stalked Sedge) | <i>Solidago rugosa</i> (Rough-stemmed Goldenrod) |
| <i>Clinopodium vulgare</i> (Wild-basil) | <i>Symphotrichum urophyllum</i> (Arrow-leaved Aster) |
| <i>Danthonia spicata</i> (Poverty Oat Grass) | <i>Thuja occidentalis</i> (Eastern White Cedar) |
| <i>Diervilla lonicera</i> (Northern Bush-honeysuckle) | <i>Viola</i> cf. <i>labradorica</i> (Violet) |
| <i>Epipactis helleborine</i> * (Helleborine) | |

* Non-native (exotic) species



FIGURE 3. *Brachypodium sylvaticum* (Slender False Brome) population in Grey County, Ontario, 18 October 2011. The graminoid vegetation in the foreground and right side of the photo is almost entirely *Brachypodium sylvaticum*. Photo: Michael Oldham.

In the flora of Ontario, *Brachypodium sylvaticum* most closely resembles species in the genus *Bromus*, particularly *Bromus pubescens* (Hairy Woodland Brome), due to its hairy leaves and spikelets. However, *Brachypodium* can be distinguished from *Bromus* by its open leaf sheaths (closed in *Bromus*) and spikelets arising singly from the rachis on short pedicels (branched inflorescences in *Bromus*). The only other *Brachypodium* species in eastern North America, *Brachypodium pinnatum* (Heath False Brome), is rare in disturbed ground and waste areas in Massachusetts (Haines 2011). It can be distinguished from *Brachypodium sylvaticum* by its rhizomes, usually hairless culms and leaf sheaths, stiffer racemes, and short or absent lemma awns (Piep 2007; Paszco 2008).

In its native range in Eurasia, *Brachypodium sylvaticum* is a forest understory plant, but it also occurs in open grassland (Shouliang and Phillips 2006; Stace 2010). *B. sylvaticum* is considered highly invasive in the U.S. Pacific Northwest, where it has rapidly expanded its range, thrives in a variety of ecological conditions, and often forms dense monospecific stands (Kaye 2001*, 2003*; Johnson 2004). Preliminary observations suggest this plant is quite invasive in New

York State as well (Daniel and Werier 2010). Observations of the Ontario population, where *B. sylvaticum* forms a dense, monospecific stand on the east side of the knoll and appears to be spreading to other areas of the knoll, support this suggestion. Although new aliens appear regularly in the flora of eastern Canada, many are highly localized and do not pose a threat to native biodiversity. *Brachypodium sylvaticum* is a potentially serious invader of natural communities in Ontario. A variety of control methods are being researched and used in the U.S. Pacific Northwest to try to control the species (see the web page of the False-brome Working Group: <http://www.appliedeco.org/invasive-species-resources/FBWG>).

The origin of the Grey County, Ontario, population of *Brachypodium sylvaticum* is unknown. Invasion via an abandoned railway line (now a walking trail) that runs approximately 100 m south of the population is possible; however, no sign of *B. sylvaticum* was observed along the former railway or along Grey County Road 4, located approximately 350 m to the north-east. Additionally, recreational activities (e.g., hiking) do not appear to have initiated this population—the vegetation surrounding the knoll is thick and undis-

turbed, and there are no formal or informal footpaths. Seeds may have been dispersed to the site from an undiscovered population in the general area. In the U.S. Pacific Northwest, long-distance seed dispersal of *B. sylvaticum* is usually associated with logging activities, roadside maintenance, and recreational activities (e.g., hiking), with short-distance dispersal occurring via wildlife, particularly ungulates (Fenneman 2010*). White-tailed Deer (*Odocoileus virginianus*) are common in the vicinity of the Grey County population, and they may be responsible for local dispersal.

Brachypodium sylvaticum should be watched for elsewhere in southern Ontario and eastern Canada. Populations should be controlled wherever possible in order to prevent the widespread invasion of the species in eastern North America, as has occurred in Oregon and other areas of the Pacific Northwest.

Voucher specimens

Poaceae

Brachypodium sylvaticum (Huds.) P. Beauv. (Slender False Brome)—ONTARIO: Grey County, Municipality of Grey Highlands (former Township of Artemesia), Nordin Nature Reserve (Escarpment Biosphere Conservancy), ~2.5 km northeast of Priceville (or 6 km southwest of Flesherton) south of Grey Road 4 and north of Durham Road, patches of this grass in the bottom to mid-slope section of a distinct wooded knoll surrounded by *Thuja occidentalis* swamp and *Fraxinus nigra* swamp, associated species observed at this location were *Pteridium aquilinum*, *Carex gracillima*, *Carex arctata*, *Actaea pachypoda*, *Polygonatum pubescens*, and *Polygala paucifolia*, 44.217°N, 80.597°W, 19 August 2011, *B. Miller* (OAC); ONTARIO: Grey County, Municipality of Grey Highlands (former Township of Artemesia), Nordin Nature Reserve (Escarpment Biosphere Conservancy), ~2.5 km northeast of Priceville (or 6 km southwest of Flesherton) south of Grey Road 4 and north of Durham Road, locally common, several thousand plants estimated on wooded knoll dominated by Eastern White Cedar and Balsam Fir, with *Pteridium aquilinum*, *Brachyelytrum* sp., *Schizachne purpurascens*, *Epipactis helleborine*, *Solidago rugosa*, *Prunella vulgaris*, 44.217°N, 80.597°W, 18 October 2011, *M. J. Oldham*, *B. M. Miller*, and *R. J. Aitken 39441* (CAN, DAO, MICH, NHIC, TRT, UWO).

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Additions to the Vascular Flora of Ontario, Canada, from the Sutton Ridges, Hudson Bay Lowland Ecoregion

MICHAEL J. OLDHAM¹ and SAMUEL R. BRINKER²

¹Ontario Natural Heritage Information Centre (NHIC), Ontario Ministry of Natural Resources, 300 Water Street, 2nd Floor, North Tower, P.O. Box 7000 Peterborough, Ontario K9J 8M5 Canada; email: michael.oldham@ontario.ca

²Ontario Natural Heritage Information Centre (NHIC), Ontario Ministry of Natural Resources, 300 Water Street, 2nd Floor, North Tower, P.O. Box 7000 Peterborough, Ontario K9J 8M5 Canada; email: sam.brinker@ontario.ca

Oldham, Michael J., and Samuel R. Brinker. 2011. Additions to the vascular flora of Ontario, Canada, from the Sutton Ridges, Hudson Bay Lowland ecoregion. *Canadian Field-Naturalist* 125(3): 241–247.

Field studies in the Hudson Bay Lowland ecoregion of northern Ontario during 2010 resulted in the discovery of four native vascular plant species not previously confirmed from the province: Arctic Bellflower (*Campanula uniflora*; Campanulaceae), Lapland Diapensia (*Diapensia lapponica*; Diapensiaceae), Alpine Azalea (*Kalmia procumbens*; Ericaceae), and Alpine Brook Saxifrage (*Saxifraga rivularis*; Saxifragaceae). These four species are widespread arctic plants occurring in both North America and Eurasia and were found on the Sutton Ridges, a Precambrian bedrock inlier surrounded by the extensive wetlands of the Hudson Bay Lowland.

Key Words: Arctic Bellflower, *Campanula uniflora*, Campanulaceae, Lapland Diapensia, *Diapensia lapponica*, Diapensiaceae, Alpine Azalea, *Kalmia procumbens*, Ericaceae, Alpine Brook Saxifrage, *Saxifraga rivularis*, Saxifragaceae, Hudson Bay Lowland ecoregion, Sutton Ridges, range extensions, new records, arctic-alpine, Ontario, Canada.

Fieldwork in northern Ontario was conducted by Ontario Ministry of Natural Resources staff as part of the provincial Far North community-based land use planning initiative. This fieldwork is aimed primarily at improving our knowledge of the natural features and biodiversity values of potential protected areas and is being conducted in collaboration with local First Nations communities. Some of the work in 2010 took place in the Sutton Ridges, a series of Precambrian granitic outcrops in the Hudson Bay Lowland. The Sutton Ridges are an unusual geological feature in the otherwise largely flat and wet Phanerozoic Hudson Bay Lowland (Riley 2011). Several other vascular plant species are known largely or exclusively from these acidic bedrock outcrops in Ontario, e.g., Northern Bentgrass (*Agrostis mertensii*), Alpine Sweetgrass (*Anthoxanthum monticola*), Northern Woodrush (*Luzula confusa*), and Greenland Stitchwort (*Minuartia groenlandica*) (Riley and Walshe 1985; Riley 2003). Continentally, these acidic granite upland habitats are isolated from equivalent Precambrian subarctic habitats at least 400 km to the west and east by Paleozoic lowlands, marine clay flats, peatlands, and ocean, and from boreal habitats 200 km to the southwest by Paleozoic lowlands, marine clay flats, and peatlands. These disjunct habitats were also among the earliest upland islands to emerge above the postglacial Tyrrell Sea 8500 YBP (McAndrews et al. 1982).

During the 2010 field studies, four vascular plant species not previously documented from Ontario (Scoggin 1978, 1979; Morton and Venn 1990; Newmaster et al. 1998; Kartesz 1999; Riley 2003; Brouillet et al. 2011*) were encountered in the Sutton Ridges area (Figure 1). All four species have been added to the list

of provincially significant species tracked by the Ontario Natural Heritage Information Centre (NHIC). They are ranked S1 (critically imperilled) in the province (Ontario Ministry of Natural Resources 2012*).

Details on the additions are presented below. Herbarium acronyms follow Thiers (2011*).

Campanulaceae

Campanula uniflora L. (Arctic Bellflower)—KENORA DISTRICT: Precambrian bedrock outcrop, ca. 65 km S of Hudson Bay coast, ca. 83 km ESE of Peawanuck, shaded, moist north-facing cliff base, flowering (but mostly in bud) patch of ca. 100 plants, with Fragile Fern (*Cystopteris fragilis*), Black Crowberry (*Empetrum nigrum*), Bog Labrador Tea (*Rhododendron groenlandicum*), and Rusty Woodsia (*Woodsia ilvensis*), 54.689, –84.262, 6 July 2010, M. J. Oldham & C. Latremouille 37798 (TRT); Precambrian bedrock outcrop, 98 km SE of Peawanuck Airport, 5 km E of Aquatuk Lake, Sutton Ridges, 12 flowering clumps on cool, dry, shaded shale and sandstone cliff base overlain by diabase with Bog Birch (*Betula pumila*), Northern Sedge (*Carex deflexa*), Northern Single-spine Sedge (*C. scirpoidea*), *Cystopteris fragilis*, *Rhododendron groenlandicum*, Lapland Rosebay (*R. lapponicum*), Hairy Willow (*Salix vestita*), Bog Blueberry (*Vaccinium uliginosum*), and Lingonberry (*V. vitis-idaea*), 54.304, –84.488, 7 July 2010, S. R. Brinker 1640 (CAN, MICH).

In 2010, Arctic Bellflower (Figure 2) was located at two sites on the Sutton Ridges. Arctic Bellflower is a showy perennial wildflower that is a widespread species in the High Arctic. It is rare in large parts of its range (Ægisdóttir and Thórhallsdóttir 2006). It occurs

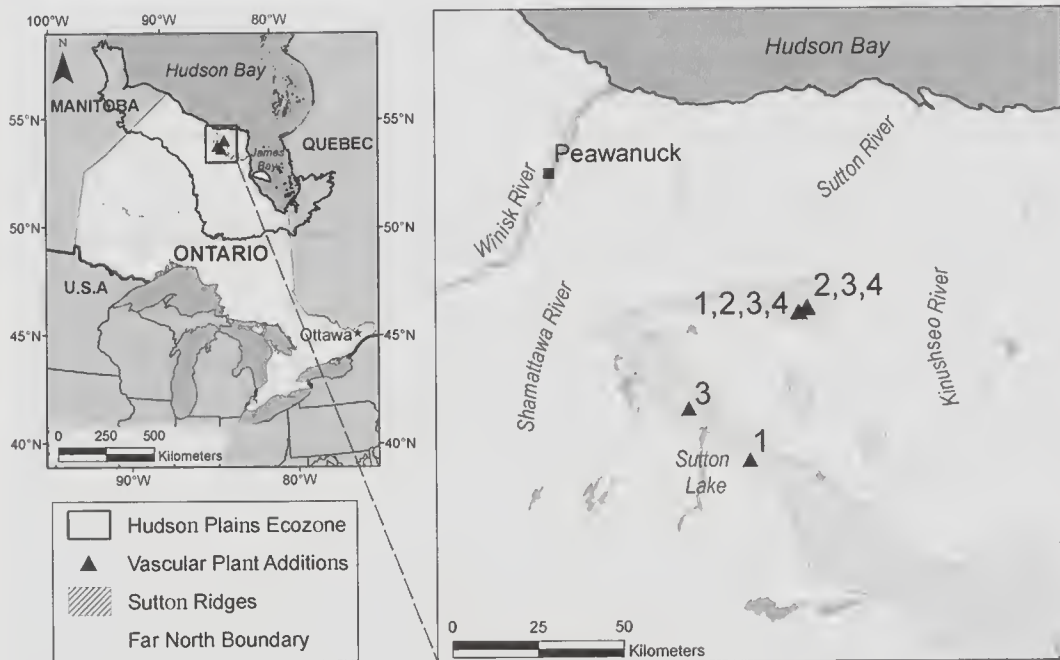


FIGURE 1. Map showing general location of study area within the Hudson Bay Lowland ecoregion, northern Ontario. Numbered triangles represent locations of vascular plant additions: (1) Arctic Bellflower (*Campanula uniflora*), (2) Lapland Diapensia (*Diapensia lapponica*), (3) Alpine Azalea (*Kalmia procumbens*), and (4) Alpine Brook Saxifrage (*Saxifraga rivularis*).

in arctic North America as well as western Europe and eastern Asia (Hultén 1968). In the southern Hudson Bay region, it is also known from Churchill, Manitoba, the coast of Hudson Strait, and the eastern Hudson Bay coast, south to Pointe Louis-XIV (Cape Jones), 54°37'N (Scoggan 1979; Blondeau and Cayouette 2002). *Campanula uniflora* is uncommon to rare in the Churchill area (Johnson 1987).

With its single, nodding, pale blue flowers, *Campanula uniflora* is unlikely to be confused with other species in the flora of the Hudson Bay Lowland, except for Bluebell (*C. rotundifolia*), which has a glabrous calyx (pubescent in *C. uniflora*) and often multiple flowers per stem.

Diapensiaceae

Diapensia lapponica L. (Lapland Diapensia)—KENORA DISTRICT: Precambrian bedrock outcrop, ca. 65 km S of Hudson Bay coast, ca. 83 km ESE of Peawanuck, mossy, exposed ledge, north-facing, rare and local, with *Empetrum nigrum* and *Vaccinium uliginosum*, 54.689, -84.258, 6 July 2010, M. J. Oldham & C. Latremouille 37780 (CAN, MICH, NHIC, TRT); Precambrian bedrock outcrop, 84 km ESE of Peawanuck Airport, 27 km ENE of Hawley Lake, exposed rocky outcrop with Bigelow's Sedge (*Carex bigelowii*), Tufted Bulrush (*Trichophorum cespitosum*), *Vaccinium*

uliginosum, and *V. vitis-idaea*, 54.703, -84.222, 11 July 2010, S. R. Brinker 1723 (DAO, TRT).

In 2010, *Diapensia lapponica* (Figure 3) was collected at two sites on the Sutton Ridges. It was also noted at a third site growing on a low north-facing cliff above wetland, with Capitulate Sedge (*Carex capitata*), *Rhododendron groenlandicum*, Marsh Labrador Tea (*R. tomentosum*), and *Vaccinium uliginosum* (M. J. Oldham, sight record). *Diapensia lapponica* is an arctic and subarctic low shrub restricted to high-latitude areas of the Northern Hemisphere (Nesom 2009). Day and Scott (1981, 1984) studied the autecology and biology of *Diapensia lapponica* in Newfoundland and provided a map of its North American distribution (Day and Scott 1984). Although *Diapensia lapponica* is known from northern Manitoba (Baralzon Lake, 60°N) and the eastern James Bay coast in Quebec (Scoggan 1979), it has not been previously reported from Ontario or from the Hudson Bay Lowland. In 2010, populations of *Diapensia lapponica* were located on two Precambrian Shield granitic rock outcrops close to each other in the Sutton Ridges area, adding a new species and a new family to the Ontario flora.

Ericaceae

Kalmia procumbens (L.) Gift & Kron (Alpine Azalea)—KENORA DISTRICT: Precambrian bedrock out-



FIGURE 2. Arctic Bellflower (*Campanula uniflora*) on the Sutton Ridges, Ontario, 7 July 2010. Photo: S. R. Brinker.

crop, 75 km SE of Peawanuck Airport, 1.6 km SE of Raft Lake, Sutton Ridges area of interest, over shallow mossy bedrock in perched fen with Northern Bog Sedge (*Carex gynocrates*), Tussock Cottongrass (*Eriophorum vaginatum*), and Alpine Bulrush (*Trichophorum alpi-*

num), 54.439, -84.761, 3 July 2010, S. R. Brinker 1540 (CAN, TRT); Precambrian bedrock outcrop, ca. 65 km S of Hudson Bay coast, ca. 83 km ESE of Peawanuck, moss-covered edges of exposed bedrock, with Bog Rosemary (*Andromeda polifolia*), *Empetrum nigrum*,



FIGURE 3. Lapland *Diapensia* (*Diapensia lapponica*) on the Sutton Ridges, Ontario, 11 July 2010. Photo: S. R. Brinker.

Black Spruce (*Picea mariana*), *Rhododendron tomentosum*, Cloudberry (*Rubus chamaemorus*), and *Vaccinium vitis-idaea*, 54.688°, -84.257°, 6 July 2010, M. J. Oldham & C. Latremouille 36682 (NHIC, TRT); Precambrian bedrock outcrop, 84 km ESE of Peawanuck Airport, 27 km ENE of Hawley Lake, exposed rocky outcrop with *Agrostis mertensii*, *Carex capitata*, *C. deflexa*, and *Vaccinium vitis-idaea*, 54.704, -84.222, 11 July 2010, S. R. Brinker 1717 (MICH).

In 2010, *Kalmia procumbens* (Figure 4) was collected at three sites close to each other on the Sutton Ridges (Figure 5). *Kalmia procumbens* was also noted at two other sites growing on the edges of rock outcrops with reindeer lichen (*Cladonia* sp.), *Empetrum nigrum*, *Kalmia polifolia*, Stiff Clubmoss (*Lycopodium annotinum*), *Rhododendron tomentosum*, and *Vaccinium uliginosum* (M. J. Oldham, sight record); and several small patches were observed on shallow, moist mossy bedrock with Loose-flowered Alpine Sedge (*Carex rariflora*), *Empetrum nigrum*, and *Kalmia polifolia* (S. R. Brinker, sight record).

Kalmia procumbens is a circumpolar arctic and sub-arctic low shrub, widespread in northern North America and also occurring in northern Eurasia (Liu et al. 2009). This plant was traditionally placed in the genus *Loiseleuria* (*Loiseleuria procumbens*), but Kron et al. (2008) recently included *Loiseleuria* within *Kalmia* based on genetic evidence (e.g., Kron 1997), a treat-

ment followed by Liu et al. (2009). Although it has been mapped from Ontario by Liu et al. (2009), we are not aware of the basis for this report; the species is not attributed to the province by Scoggan (1979), Morton and Venn (1990), Newmaster et al. (1998), Kartesz (1999), or Riley (2003). Soper and Heimburger (1982) suggested that *K. procumbens* should be expected in Ontario, based on its distribution in adjacent Manitoba and Quebec. An earlier literature report from Hawley Lake, Kenora District, Ontario, by Kershaw and Rouse (1971) was excluded by Riley (2003) because it was not based on any collected voucher specimens, nor was Riley aware of any Ontario collections or other reports.

Kalmia procumbens is known elsewhere in the Hudson Bay region from northeastern Manitoba, south to Churchill, and from islands in James Bay, Quebec (Scoggan 1979). According to Johnson (1987), it is locally common on dry peat in the Churchill area. Riley (2003) provided a distribution map of the eastern Canadian distribution.

Saxifragaceae

Saxifraga rivularis L. (Alpine Brook Saxifrage)—KENORA DISTRICT: Precambrian bedrock outcrop, ca. 65 km S of Hudson Bay coast, ca. 83 km ESE of Peawanuck, cool, moist, shaded talus at north-facing base of outcrop, in moss mat with *Cystopteris fragilis*



FIGURE 4. Alpine Azalea (*Kalmia procumbens*) on the Sutton Ridges, Ontario, 3 July 2010. Photo: S. R. Brinker.



FIGURE 5. Sutton Ridge Precambrian granitic inlier, with talus, cliff, and rim communities, noted for their concentrations of rare species, 9 July 2010. Photo: S. R. Brinker.



FIGURE 6. Alpine Brook Saxifrage (*Saxifraga rivularis*) on the Sutton Ridges, Ontario, 11 July 2010. Photo: S. R. Brinker.

and *Rubus chamaemorus*, with *Rhododendron groenlandicum* nearby, 54.689, -84.263, 6 July 2010, *M. J. Oldham & C. Latremouille 37801* (NHIC, TRT, determined by R. Elven, March 2011); Precambrian bedrock outcrop, 84 km ESE of Peawanuck Airport, 27 km ENE of Hawley Lake, 20 mostly non-flowering plants in moist, shaded north-facing moss-covered rock crevice and talus with Spreading Woodfern (*Dryopteris expansa*), *Empetrum uigrum*, *Rhododendron tomentosum*, Skunk Currant (*Ribes glandulosum*), and Long Beechfern (*Phegopteris connectilis*), 54.703, -84.225, 11 July 2010, *S. R. Brinker 1728* (CAN, MICH).

In 2010, *Saxifraga rivularis* (Figure 6) was located at two sites on the Sutton Ridges. *Saxifraga rivularis* presents one of the most extreme disjunctions known in the arctic flora: it has a small amphi-Beringian range (*Saxifraga rivularis* subsp. *arctolitoralis*) and a larger amphi-Atlantic one (*Saxifraga rivularis* subsp. *rivularis*) (Westergaard et al. 2010). Ontario plants belong to subsp. *rivularis* (Brouillet and Elvander 2009). *Saxifraga rivularis* belongs to a taxonomically complex group of arctic-alpine plant species (Jørgensen et al. 2006) found in northern areas of North America and Europe (Hollingsworth et al. 1998). The group consists of small perennial herbs with palmate leaves, rounded leaf lobes, and small white or pink flowers. Scoggan (1978), Johnson (1987), Blondeau and Cayouette (2002), and Riley (2003, based on *Brown 695, 1951,*

CAN) report the species from Churchill, Manitoba, although Brouillet and Elvander (2009) do not map it from the province and Brouillet et al. (2011*) exclude the species from Manitoba. It is known from nearby Quebec at Pointe Louis-XIV (Cape Jones) in southeastern Hudson Bay (Scoggan 1978) and elsewhere along the east coast of James and Hudson bays (Blondeau and Cayouette 2002). Reidar Elvin (personal communication, 18 March 2011) confirmed the identification of one of the Ontario *S. rivularis* specimens (*M. J. Oldham & C. Latremouille 37801*).

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Notes

Hairy St. John's-wort (*Hypericum hirsutum* L.) in the Toronto Area, New to North America

PAUL A. HEYDON¹, GAVIN C. MILLER², and MICHAEL J. OLDHAM³

¹Grow Wild Native Plant Nursery and Biological Consulting, 3784 Highway 7, Omeme, Ontario K0L 2W0 Canada; email: info@grow-wild.com

²Toronto and Region Conservation Authority, 5 Shoreham Drive, Downsview, Ontario M3N 1S4 Canada; email: gmiller@trca.on.ca

³Ontario Natural Heritage Information Centre (NHIC), Ontario Ministry of Natural Resources, 300 Water Street, 2nd Floor, North Tower, P.O. Box 7000, Peterborough, Ontario K9J 8M5 Canada; email: michael.oldham@ontario.ca

Heydon, Paul A., Gavin C. Miller, and Michael J. Oldham. 2011. Hairy St. John's-wort (*Hypericum hirsutum* L.) in the Toronto area, new to North America. *Canadian Field-Naturalist* 125(3): 248–251.

Hairy St. John's-wort (*Hypericum hirsutum* L.) is newly reported for Canada and North America based on two collections from the Toronto, Ontario, area. This perennial Eurasian herb has a large natural range from western Europe to western China. It grows in moist successional, edge, and meadow habitats. It should be looked for in such habitats elsewhere in eastern North America.

Key Words: Hairy St. John's-wort, *Hypericum hirsutum*, Hypericaceae, herbs, first records, range expansion, Ontario, eastern Canada, North America.

Biological inventories by the Toronto and Region Conservation Authority in 2008 and 2011 led to the discovery of Hairy St. John's-wort (*Hypericum hirsutum* L.), a new record for the North American continent.

On 2 October 2008, while conducting a vegetation survey adjacent to the Pickering Nuclear Generating Station, P. A. H. (at that time a staff biologist with the Toronto and Region Conservation Authority) discovered two patches of an unfamiliar species of *Hypericum* (St. John's-wort) in Pickering, Durham Regional Municipality, Ontario (43.813, -79.053). It could not be identified at that time using literature on local and regional floras. Seeds were collected in 2008 and grown at Grow Wild Native Plant Nursery in Omeme, Ontario. A voucher specimen was prepared in September 2011 from the cultivated material (*M. J. Oldham & P. Heydon 39413*; CAN, DAO, HAM, MICH, NHIC, TRT, UW0) (herbarium acronyms follow Thiers 2011*). The Pickering site was revisited on 19 September 2011 by P. A. H. and M. J. O., and no plants were found during a brief search. However, the site is quite overgrown and it is possible the species still persists at that location.

On 20 July 2011, G. C. M. discovered and photographed the same species at the Guild Inn property in Scarborough (east Toronto), Ontario (43.748, -79.190), approximately 18 km west of the Pickering site. On 13 September 2011, a voucher specimen was collected from the Scarborough population (*G. Miller 131*; CAN). The species was tentatively identified as *Hypericum hirsutum* by G. C. M., and photographs were sent to Peter Ball (University of Toronto) and Anton Reznicek (University of Michigan), both of whom

agreed with this identification. Norman Robson (Natural History Museum, London, U.K.) provided final confirmation based on these photographs.

Hairy St. John's-wort has not been previously reported from Ontario (Morton and Venn 1990; Newmaster et al. 1998), Canada (Scoggan 1978-1979; Gillett and Robson 1981; Brouillet et al. 2011*), or North America (Kartesz 1999; Robson, in preparation). A 19th-century North American reference (Strong 1850) fits the description of the plant only in part and is likely spurious and based on another *Hypericum* species. *Hypericum hirsutum* will be placed in the family Hypericaceae in the upcoming Flora of North America treatment (Robson, in preparation). *Hypericum hirsutum* is placed in section *Taeniocarpium* and is native to China, Europe (except the Mediterranean region), northwestern Africa, and southwestern Asia (Xiwen and Robson 2007; Robson 2010). Section *Taeniocarpium* consists of 28 Eurasian and North African *Hypericum* species, none of which has previously been reported from North America (Robson 2010).

Superficially, *Hypericum hirsutum* is similar to Common St. John's-wort (*H. perforatum*) and Spotted St. John's-wort (*H. punctatum*), but it can be distinguished from these and from other North American *Hypericum* species by its combination of conspicuously hairy stems and leaves (Figure 1) and stalked, black glands on the sepals and petals (Figure 2). *Hypericum hirsutum* is a perennial with stems to 1 m and yellow petals 15 to 22 mm across.

Both of the sites in Ontario where *Hypericum hirsutum* was found were fairly disturbed but there was no evidence of deliberate planting or escape from adjacent



FIGURE 1. Stem and leaves of Hairy St. John's-wort (note conspicuously pubescent stems and leaves), Guild Inn, Toronto, 20 July 2011. Photo: Gavin Miller.

gardens (the species is not known to be in cultivation in southern Ontario). Of the two patches at Pickering, one was in a hedgerow with associated species, including Trembling Aspen (*Populus tremuloides*), Common Buckthorn (*Rhaunus cathartica*), Bell's Honeysuckle (*Lonicera × bella*), Red-osier Dogwood (*Cornus stolonifera*), Smooth Brome (*Bromus inermis*) and Tall Goldenrod (*Solidago altissima*). The other patch was in an adjacent old-field meadow dominated by Tall Goldenrod and Smooth Brome, with associated species such as Red-osier Dogwood, asters (*Symphotrichum* spp., especially *S. ericoides*, White Heath Aster), and Purple Crown-vetch (*Securigera varia*).

In Scarborough, about 30 plants of *H. hirsutum* were found in a strip about 15 m long at the edge of a young forest dominated by Red Ash (*Fraxinus pennsylvanica*). The shrub layer in the vicinity is largely Common Buckthorn and Choke-cherry (*Prunus virginiana*). Ground vegetation consists of Yellow Trout-lily (*Erythronium americanum*), Dog-strangling Vine (European Swallow-wort) (*Cynanchum rossicum*), and Garlic Mustard (*Alliaria petiolata*). Common St. John's-wort, Heal-all (*Prunella vulgaris*), Wood Avens (*Geum urbanum*), and Erect Hedge-parsley (*Torilis*

japonica) are also present. The soils in the vicinity of the Scarborough site were moderately moist silty clay loams.

In the British Isles, where it is native, *H. hirsutum* grows in semi-wooded successional areas, riverbanks, and damp grasslands (Stacc 1997).

The origin of the Ontario populations of *Hypericum hirsutum* is unknown. *Hypericum perforatum* is abundant in eastern North America and is frequently used for its medicinal properties. It is possible that *H. hirsutum* is also occasionally used for such purposes, deliberately or accidentally mixed or confused with *H. perforatum*. The plant is possibly overlooked and could be present in other locations in the region or elsewhere in North America, where it should be watched for.

As a new introduced exotic species, this plant should also be assessed for invasive potential. It did not appear to be aggressively spreading in the two locations in the Toronto area where it was observed, but it was well established and was spreading locally at the Scarborough site, which is municipally owned. The Pickering population does produce viable seed, as approximately 70% of the seed germinated after a period of 90 days of moist-cold stratification.



FIGURE 2. Inflorescence of Hairy St. John's-wort (note stalked black glands on the sepals), Guild Inn, Toronto, 20 July 2011. Photo: Gavin Miller.

We hope that *Hypericum hirsutum* will not become a major threat to ecosystems, but invasiveness can sometimes manifest itself only after a long latency period. For example, *Cynanchum rossicum*, which is one of the worst invasive species in natural areas in southern Ontario, became evident as a problem only decades after it had first appeared (Kricsfalussy and Miller 2008; Miller and Kricsfalussy 2008*). Cappuccino (2004) attributed this to a positive feedback situation (the Allee effect), whereby plant vigour and competitive ability increase as populations increase.

Voucher specimens

ONTARIO, Durham Regional Municipality, Pickering, Montgomery Park Road, adjacent to Pickering Nuclear Generating Station, overgrown old field dominated by *Solidago canadensis*, *Symphytotrichum lanceolatum*, *S. novae-angliae* (New England Aster), *Vicia cracca* (Tufted Vetch), *Epilobium parviflorum* (Small-flowered Willowherb), *Securigera varia*, and *Poa pratensis* (Kentucky Bluegrass), plant grown from seed collected in 2008 by Paul Heydon, 4 or 5 plants orig-

inally seen at site in 2008, 43.813, -79.053, 19 September 2011, *M. J. Oldham & P. Heydon 39413* (CAN, DAO, HAM, MICH, NHIC, TRT, UWO); Metropolitan Toronto, Scarborough, Guild Inn/Guildwood Park (Scarborough Waterfront block 'B'), about 30 plants seen at edge of somewhat disturbed forest of Red Ash by parking lot, with *Fraxinus pennsylvanica*, *Rhamnus cathartica*, *Cynanchum rossicum*, *Torilis japonica*, *Hypericum perforatum*, 43.748, -79.190, 13 September 2011, *G. Miller 131* (CAN).

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Long-term Survival and Reproduction in a North American River Otter (*Lontra canadensis*) with an Intraperitoneal Radio-Transmitter

JENNIFER A. BOHRMAN,¹ SADIE S. STEVENS,^{1,2} and THOMAS L. SERFASS^{1,3}

¹ Department of Biology and Natural Resources, Frostburg State University, Frostburg, Maryland 21532 USA

² Department of Environmental Conservation, University of Massachusetts, Amherst, Massachusetts 01003 USA

³ Corresponding author (email: tserfass@frostburg.edu)

Bohrman, Jennifer A., Sadie S. Stevens, and Thomas L. Serfass. 2011. Long-term survival and reproduction in a North American River Otter (*Lontra canadensis*) with an intraperitoneal radio-transmitter. *Canadian Field-Naturalist* 125(3): 252–254.

Intraperitoneal implantation of radio-transmitters is a useful method of monitoring free-ranging aquatic and semi-aquatic mammals; however, some researchers are concerned about the physiological effects of such implants. Few studies have investigated the long-term consequences of intraperitoneal implants on survival or reproductive performance. An adult female North American River Otter (*Lontra canadensis*) surgically equipped with an intraperitoneal radio-transmitter and released in north-western Pennsylvania in June 1990 as part of a reintroduction project was killed in March 1999. The North American River Otter was estimated to be 10 years old and was pregnant with two fetuses at the time of her death. Our observation suggests that wild North American River Otters surgically equipped with intraperitoneal radio-transmitters can live long after implantation of the radio-transmitter and continue to reproduce successfully.

Key Words: intraperitoneal, North American River Otter, *Lontra canadensis*, radio-telemetry, radio-transmitter, reproduction, survival.

Radio-telemetry is one of the most common methods of monitoring translocated animals following release into an area. Several different types of radio-transmitters may be used, depending on factors such as cost, invasiveness, and species morphology and behavior. For aquatic and semi-aquatic mammals, intraperitoneal radio-transmitters are considered particularly practical biotelemetry devices (Smith and Whitney 1977; Melquist and Hornocker 1979; Reid et al. 1986; Horning et al. 2008) because, unlike radio-collars and harnesses, they are appropriate for the lifestyle and body shape of various species (Garshelis and Siniff 1983; Reid et al. 1986; Rado and Terkel 1989; Van Vuren 1989). However, several complications can potentially result from surgery and implantation of intraperitoneal radio-transmitters, including infection, incision dehiscence, and blockage of internal organs. Moreover, biologists are often concerned about the potential effects of intraperitoneal transmitters on long-term survival, growth, and reproduction (e.g., Van Vuren 1989).

Several studies have investigated the effects of intraperitoneal radio-transmitters on survival and reproduction in aquatic and semi-aquatic mammals (Reid et al. 1986; Horning et al. 2008). Ralls et al. (1989) found no complications associated with intraperitoneal implantation of radio-transmitters in adult Sea Otters (*Enhydra lutris*) and documented normal reproductive performance in females. Similarly, Horning et al. (2008) studied captive California Sea Lions (*Zalophus californianus*) and Steller Sea Lions (*Eumetopias jubatus*) that had been surgically equipped with radio-transmitters and tracked them post-release. After observing low morbidity and zero mortality, Horning et al. (2008)

concluded that intraperitoneal radio-transmitters are viable radio-tracking devices.

Reid et al. (1986) assessed the reproductive performance of 7 adult female North American River Otters equipped with intraperitoneal radio-transmitters. Six of the North American River Otters in their study were pregnant at the time of implantation, and they progressed successfully through parturition, with 2 of the females giving birth again in the following season. No adverse effects of the implants were documented at any stage of the reproductive cycle (Reid et al. 1986).

Hernandez-Divers et al. (2001) investigated survival and reproduction in 22 North American River Otters surgically equipped with intra-abdominal radio-transmitters and released in western New York. Although 2 of the North American River Otters experienced surgical complications, both recovered. Three individuals died within the first year of monitoring (1 from an automobile collision and 2 from unknown causes); the remaining 19 North American River Otters in their study established new home ranges. No reproduction was documented during the post-release radio-telemetry monitoring period; however, biologists subsequently observed a pair of the reintroduced North American River Otters in a den with young and received reports of other released individuals having successfully reproduced.

Despite the concern that intraperitoneal radio-transmitters may be harmful, long-term data are not available for most studies of animals surgically equipped with a transmitter. As a result of the relatively short battery life of traditional internal radio-transmitters, researchers cannot generally monitor survival or repro-

ductive performance for periods longer than three years (Horning et al. 2008). We present a case study of a North American River Otter that carried an intraperitoneal radio-transmitter for nearly 10 years and successfully reproduced.

From 1982 to 2003, 153 North American River Otters were reintroduced into areas in Pennsylvania where the species had been extirpated. Several of the North American River Otters were surgically equipped with intraperitoneal radio-transmitters prior to release (Serfass et al. 1996). In March 1999, a North American River Otter surgically equipped with an intraperitoneal radio-transmitter (field ID: TC-1-99a) was accidentally killed near Kellettsville, Pennsylvania (41.55°N, 79.26°W), approximately 3 km from her release site, by a fur trapper using a #330 Conibear® trap (Oneida Victor, Cleveland, Ohio) set for American Beaver (*Castor canadensis*).

The North American River Otter was originally captured in New York in June 1990 by a trapper and was purchased from the trapper. She was then held in a lab for 14 days to facilitate medical evaluations and surgery to implant a radio-transmitter. She weighed 5.4 kg. On 22 June 1990, TC-1-99a was sedated using an intramuscular injection of ketamine hydrochloride (Serfass et al. 1993), and a region of her abdomen was shaved in preparation for surgery. The radio-transmitter (IMP/200/L, Telonics, Mesa, Arizona) was inserted into her peritoneal cavity through a 4-cm lateral skin incision. A lateral approach was chosen rather than a ventral approach because of North American River Otters' habit of dragging their abdomen along the ground (Serfass et al. 1993). In June 1990, TC-1-99a was 1 of 4 North American River Otters to be surgically equipped with an intraperitoneal radio-transmitter and released at Tionesta Creek (41.61°N, 79.15°W) in northwestern Pennsylvania. Radio-telemetry data collected from 29 June 1990 to 5 March 1991 indicated that TC-1-99a remained within 7 km upstream and 30 km downstream of her release site post-release.

The carcass of TC-1-99a was retrieved in March 1999, and a necropsy was conducted. The necropsy included inspecting the digestive tract for food content, checking for ear tags, evaluating the overall physical condition (weight, condition of teeth, etc.), and extracting the lower canines for cementum aging by a commercial laboratory (Matson's Laboratory, Milltown, Montana). The North American River Otter weighed 5.2 kg. Her radio-transmitter remained where it had been inserted in the mid to caudal portion of the abdominal cavity and was surrounded by the omentum. There was no evidence of adhesion, inflammation, or localized infection. Because TC-1-99a's ear tags were no longer present, her radio-transmitter was sent back to the manufacturer so that she could be identified by her radio-transmitter's frequency. Both her upper and lower canines were worn to the incisor level. Cemen-

tum aging of the lower canines estimated her to be 10 years old (± 1 year). At the time of her death, she was pregnant with two fetuses. Inspection of the digestive tract revealed a poorly masticated prey content of 7 Smallmouth Bass (*Micropterus dolomieu*) and approximately 20 Smoothbelly Darters (*Etheostoma* spp.).

Our information represents the first long-term data on survival and reproduction of a wild North American River Otter surgically equipped with an intraperitoneal radio-transmitter. At 10 years old, TC-1-99a was near the maximum reported life span of a wild North American River Otter, reported by Kruuk (2006) as 14 years. Her canines were severely worn, also indicating her age as old. TC-1-99a appeared to be in good health, and there were no indications of complications associated with her implant. Despite her age, TC-1-99a was reproductively active. TC-1-99a's age and pregnancy demonstrate that her radio-transmitter implant introduced no detriment to her longevity or reproductive performance. Our observations suggest that intraperitoneal radio-transmitters may not disrupt the life history characteristics of North American River Otters, lending more support to their efficacy as biotelemetry devices.

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American Pygmy Shrew, *Sorex hoyi*, Consumed by an Arctic Grayling, *Thymallus arcticus*

THOMAS S. JUNG¹, ANGELA MILANI, OLIVER E. BARKER, and NATHAN P. MILLAR

Yukon Department of Environment, P.O. Box 2703, Whitehorse, Yukon Y1A 2C6 Canada

¹ Corresponding author (email: thomas.jung@gov.yk.ca)

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Arctic Grayling, *Thymallus arcticus*, are rarely reported to consume small mammals. We report an American Pygmy Shrew, *Sorex hoyi*, consumed by an Arctic Grayling caught in southern Yukon, Canada. This is the first record of an American Pygmy Shrew being consumed by an Arctic Grayling, and it confirms that Arctic Grayling will consume shrews (*Sorex* spp.) when they are available. We suspect that the body size of prey is a limiting factor in Arctic Grayling consuming small mammals, with some species of shrews being small enough for Arctic Grayling to consume.

Key Words: Arctic Grayling, *Thymallus arcticus*, diet, American Pygmy Shrew, *Sorex hoyi*, Yukon.

Several species of freshwater fish are known to consume small mammals. For example, Cochran and Cochran (1999) reported consumption of small mammals by a Brown Trout (*Salmo trutta*), and Northern Pike (*Esox lucius*) are well known as predators of small mammals (Lawler 1965). The occurrence of small mammals in the diet of Arctic Grayling (*Thymallus arcticus*), however, is rare. Prey items found in the stomachs of adult Arctic Grayling have largely been aquatic invertebrates, but terrestrial invertebrates, fish (including eggs), crustaceans, and molluscs have also been identified (Miller 1946; Stewart et al. 2007*). Moore and Kenagy (2004), however, found 2 Montane Shrews (also known as Dusky Shrews) (*Sorex monticolus*) and 3 Masked Shrews (*Sorex cinereus*) in the stomachs of 2 of 93 (2.2%) Arctic Grayling from Alaska, and de Bruyn and McCart (1974*) reported 7 unidentified shrews (*Sorex* spp.) eaten by 136 Arctic Grayling in northern Yukon. Moreover, in Russia, Teplov (1943) reported that the Common Shrew (*Sorex araneus*) was a significant prey item of the congeneric European Grayling (*Thymallus thymallus*). Juvenile collared lemmings (*Dicrostonyx* spp.) have also been found consumed by Arctic Grayling in the Northwest Territories (1 of 102 examined, 1.0%; Miller 1946). Here, we report an American Pygmy Shrew (*Sorex hoyi*) found eaten by an Arctic Grayling.

On 15 August 2010, we measured an average-sized, adult female Arctic Grayling (mass = 400 g; fork length = 342 mm) captured by an angler from Fish Lake (60.60°W, 135.24°W, 1109 m above sea level), in southern Yukon, Canada, and we collected the stomach. Examination of the stomach contents revealed a partially digested shrew and unidentified invertebrates, representing approximately 90% and 10% of the stomach contents, respectively. Using the keys of van Zyll de Jong (1983) and Nagorsen (1996), we readily identified the specimen as an American Pygmy Shrew (*Sorex hoyi*) based on dentition. This American Pygmy Shrew was the only small mammal found in the stomachs of 259 Arctic Grayling sampled in the Yukon

during the period 1992 to 2010. Terrestrial invertebrates (i.e., bees, wasps, beetles, ants, spiders) were found in the stomachs of many Arctic Grayling sampled (Yukon Department of Environment, unpublished data).

Predators of American Pygmy Shrews are not well known. The main predators of American Pygmy Shrews are likely terrestrial carnivores, such as weasels (*Mustela* spp.), snakes, and owls (Long 1974; van Zyll de Jong 1983; Nagorsen 1996). This is the first record of an American Pygmy Shrew being consumed by an Arctic Grayling; we are not aware of any other documented records of fish consuming American Pygmy Shrews.

Typically, shrews are found near water (e.g., Wrigley et al. 1979; Doyle 1990), and they may occasionally enter the water, either intentionally or accidentally. Once in the water they are susceptible to predation by fish, or they may drown and later be scavenged. With regards to our observation, we do not know whether the Arctic Grayling killed and ate the American Pygmy Shrew or the Arctic Grayling found it already dead in the water and scavenged it. Arctic Grayling regularly consume terrestrial invertebrates that fall onto the water's surface, and they may also readily take small mammals in the water. However, we suspect that the body size of prey is a limiting factor in Arctic Grayling consumption of small mammals, with some species of shrews being small enough for Arctic Grayling to consume. Larger bodied small mammals (≥ 10 g), such as voles (*Myodes* and *Microtus*) and deer mice (*Peromyscus*), are more abundant than shrews in the boreal forest (e.g., Krebs and Wingate 1976), but Arctic Grayling are likely limited by gape size from consuming them, except, perhaps, for juvenile small mammals.

Our observation is one of a few records of Arctic Grayling consuming shrews (*Sorex* spp.), and it confirms that Arctic Grayling will occasionally consume shrews when they are available in the water. Shrews are several orders of magnitude larger than the invertebrates that constitute the bulk of the diet of the Arctic Grayling, and they would represent a substantial

amount of energy for the effort expended to consume them. Thus, we expect Arctic Grayling would consume shrews as opportunity allows.

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Consumption of Bats (*Myotis* spp.) by Raccoons (*Procyon lotor*) During an Outbreak of White-Nose Syndrome in New Brunswick, Canada: Implications for Estimates of Bat Mortality

DONALD F. MCALPINE^{1,2,3}, KAREN J. VANDERWOLF^{1,2}, GRAHAM J. FORBES², and DAVID MALLOCH¹

¹New Brunswick Museum, 277 Douglas Avenue, Saint John, New Brunswick E2K 1E5 Canada

²Department of Biology, University of New Brunswick, Fredericton, New Brunswick E3B 6E1 Canada

³Corresponding author (email: donald.mcalpine@nbn-mnb.ca)

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Across their range, Raccoons (*Procyon lotor*) will opportunistically exploit bats (Chiroptera) roosting in caves as a source of food. During a significant mortality event associated with white-nose syndrome (WNS) at a cave in eastern Canada, we estimate that Raccoons consumed 3169–3827 dead and dying Little Brown Bats (*Myotis lucifugus*) and Northern Long-eared Bats (*M. septentrionalis*) infected with white-nose syndrome, equivalent to 62.0–74.9% of the total bat mortality at this site. However, the generally small dispersal distances of Raccoons and their reduced activity during the period when bats are hibernating suggest that Raccoons are likely not a significant vector for moving the fungus associated with white-nose syndrome, *Geomyces destructans*, between most caves at this latitude. Nevertheless, since we show that significant numbers of bats can be consumed in hibernacula through opportunistic feeding by Raccoons, estimates of in-cave mortality due to white-nose syndrome should incorporate any evidence of consumption of bats by Raccoons and other predators.

Key Words: *Geomyces destructans*, *Myotis lucifugus*, Little Brown Bat, *Myotis septentrionalis*, Northern Long-eared Bat, Vespertilionidae, predation, *Procyon lotor*, Raccoon, scavenging, white-nose syndrome, New Brunswick, Canada.

White-nose syndrome (WNS) is a disease of hibernating vespertilionid bats first identified at Howes Cave, Albany, New York, in 2006 (Blehert et al. 2009). Since then, the U.S. Fish and Wildlife Service has estimated that 5.7–6.7 million North American cavernicolous bats have died following infection with the causative agent, the recently described ascomycete, *Geomyces destructans* (Lorch et al. 2011). *Geomyces destructans* is a slow-growing, psychrophilic (cold-adapted) fungus particularly well adapted to the cool, humid conditions characteristic of bat hibernacula. The disease has been described as the first sustained epizootic affecting bats in recorded history, with deaths far exceeding the rate and magnitude of any previously known natural or anthropogenic mortality event in bats (Cryan et al. 2010). The disease has spread rapidly from its apparent epicentre at a single cave and as of December 2011 has been confirmed in 17 U.S. states and 4 Canadian provinces.

Currently, the means of transmission and spread of *Geomyces destructans* are unknown (Foley et al. 2011). Although bat-to-bat contact appears to be the most likely means of routine dispersal (Lorch et al. 2011), ectoparasites have also been suggested (Foley et al. 2011). Wildlife managers currently have few strategies for controlling WNS that might reduce mortality (Foley et al. 2011). Nevertheless, in an effort to slow the spread of the disease, the U.S. Fish and Wildlife Service and state agencies have closed caves on public lands to recreational caving, and a detailed biosecurity protocol for those entering caves is now recommended

(U.S. Fish and Wildlife 2011*). In New Brunswick, the Department of Natural Resources is asking people to avoid entering caves and abandoned mines that are known overwintering sites for bats (New Brunswick 2011*).

Here we examine the implications of opportunistic predation and scavenging by Raccoons on dying and dead bats (*Myotis* spp.) for estimates of mortality due to WNS. We also comment on the possibility that bat mortality coupled with opportunistic feeding by Raccoons (and other mammals) on bats infected with WNS could play a role in cave-to-cave transmission of *Geomyces destructans*.

Methods

WNS was first confirmed on hibernating vespertilionid bats (*Myotis lucifugus* and *M. septentrionalis*) in New Brunswick (Canada) at Berryton Cave (45°52.524'N, 64°52.271'W), south of Moncton, on 15 March 2011. We made multiple visits to the site (six visits between October 2010 and June 2011). During our first encounter with bats with WNS (15 March 2011), we estimated mortality at 20% among the 6084 bats present in the hibernaculum. On the third and fourth visits (20 and 21 April 2011), with bat mortality estimated at 83%, we noted large quantities of Raccoon (*Procyon lotor*) faeces at several sites starting at the cave entrance and extending to 150 m into the cave, which is 300 m long (Arsenault et al. 1997). Most of the faeces were concentrated within 50 m of the entrance in latrines, with scat of uniform diameter and blunt-

ended, features typical for Raccoon. The state of the faeces (some fresh, some frozen into ice in the front of the cave) and the overgrowth of fungi suggested one or more animals had been resident in the cave or had visited on multiple occasions over the previous month. Tracks evident on the cave floor suggested much recent Raccoon activity at the site (Figure 1). On 21 April we collected 3100.3 g of Raccoon faeces. On 10 June, with only a small amount of ice still present in the cave, we removed a further 1266.9 g of Raccoon faeces from the cave.

Pure cultures of *G. destructans* from samples collected from the Berryton Cave were established on modified (without oxgall and sodium propionate) dextrose-peptone-yeast extract (DPYA) agar (Papavizas and Davey 1958) and incubated at 7°C in a low-temperature incubator. About 8 g of Raccoon faeces collected from the cave were sterilized in an autoclave and inoculated from lab cultures with *G. destructans* and tracked to observe growth and sporulation.

Samples of Raccoon faeces collected from the cave were macerated in water under a dissecting microscope and examined for content. All faeces collected were then washed through a 36-mesh/cm² sieve (No. 40 USA Standard Test Sieve), oven-dried (~60°C), and weighed to the nearest 0.1 g, after the method of Greenwood (1979).

We used the wet weight digestibility coefficients presented by Greenwood (1979) for small mammals (based on *Peromyscus* sp. and *Microtus* sp.) and a song-bird (*Agelaius phoeniceus*) to convert the dry weight of faecal residue to estimated total wet weight (g) of bat tissue consumed. Using this conversion, we estimated the actual number of bats consumed, based on a mean body weight of 5.7 g (SD ± 0.82), derived from a sample of 366 *Myotis lucifugus*/*M. septentrionalis* collected from the floor of Berryton Cave on 17 March 2011.

Results

We examined collected faecal samples under a dissecting microscope and found them to be composed entirely of *Myotis* spp. hair, bone, fragments of wing, and tail membrane. Rarely was a near-intact or only partially digested bat found in the faeces. Some faeces were moist and appeared fresh, some were dry and dehydrated, and others supported extensive fungal growth (mostly *Mucor* sp. and *Mortierella* sp.). *Geomyces destructans* grew readily on autoclaved samples of Raccoon faeces, sporulating at 7°C in <21 days.

Greenwood (1979) found food residues (i.e., faeces) were usually expelled by Raccoons within two days. Although phalanges and radii-ulnae were common in faecal remains (demonstrating that bat wings were consumed), we also observed many wings scattered on the cave floor, indicated that a scavenger was sometimes preferentially eating the bodies and leaving the wings. Table 1 provides the results of converting wet weight

of faecal material collected in Berryton Cave to bat numbers and suggests that Raccoons consumed 3169–3827 individual *Myotis* spp., or an estimated 62.0–74.9% of the calculated total bat mortality for Berryton Cave in 2011.

Discussion

Across their range, Raccoons will opportunistically exploit bats as a source of food at cave sites. Winkler and Adams (1972) found Raccoons the most frequent, among several predatory mammals, utilizing Brazilian Free-tailed Bats (*Tadarida brasiliensis*) at roosts in Texas. Evidence presented showed that fallen bats were a major seasonal food item for Raccoons in the vicinity of the four caves studied. Munson and Keith (1984) demonstrate a long-term predator-prey relationship between Raccoons and *Myotis* spp. in Wyandotte Cave, Indiana, suggesting a consumption rate of 1150 bats/year over a period as long as 1500 years.

Although we have occasionally observed Raccoons using bat hibernacula in New Brunswick as winter denning sites (i.e., Markhamville Mine in 2010), we have not previously observed predation on or scavenging of bats overwintering in New Brunswick caves or mines. This is probably because bats, which normally roost high on the ceiling or walls, are not easily accessible to predators in the hibernacula we have visited, and winter mortality of bats is normally low. However, with the onset of WNS in Berryton Cave, the roosting behaviour of bats during the winter changed dramatically, a feature of the disease reported more generally (Foley *et al.* 2011). Large numbers of bats moved to the front 50 m of Berryton Cave (in part, to an area near the entrance where winter temperatures dropped below 0°C and considerable ice was present). The bats were observed roosting low on the walls, some at floor level. In these areas, dying and dead bats also littered the cave floor. The most significant deposits of Raccoon faeces were found within this first 50 m of the passage at the cave entrance, suggesting that Raccoon presence in the cave was associated with the availability of food. Scattered piles of isolated wings were likewise found in this area. Bats were also observed flying from the cave into the still snow-covered landscape. Although approximately 50 bat carcasses were recovered outside the cave near the entrance, no signs of scavenging were observed there.

The ratio of pelage to muscle, bone, and viscera is certainly higher in a bat than it is in either *Peromyscus* or *Microtus* (probably even when bat wings are not eaten), meaning that when equivalent amounts of whole-body bat and small rodent are consumed, a larger quantity of bat fur and bone than small rodent fur and bone should appear in the faeces. This suggests that the *Peromyscus-Microtus* coefficient of Greenwood (1979) will likely lead to an overestimation of the quantity of bat tissue consumed. However, none of the coefficients for whole vertebrates reported by Greenwood



FIGURE 1. Tracks evident on the floor of a passage in Berryton Cave, New Brunswick, in April 2011 suggest much Raccoon activity in the cave following an outbreak of white-nose syndrome in hibernating bats (*Myotis lucifugus* and *M. septentrionalis*).

(1979) are below 18.3; even using the lower songbird coefficient to reflect the suggested lower digestibility of bats still indicates a consumption rate of bats infected with WNS by Raccoons in Berryton Cave of >60%.

Clearly, significant numbers of bats can be removed from hibernacula through Raccoon predation and/or scavenging during WNS outbreaks. Had we not made multiple visits to this site to track the progress of the disease and to count bats, we would likely have significantly underestimated bat mortality. Estimates of in-cave mortality due to WNS should therefore incorporate any evidence of predation on or scavenging of bats by Raccoons and other predators. Accurate estimates

appear to require at least three visits spread across the hibernation period. Although Raccoons do not range widely during winter, it is also possible that not all faeces derived from bats in Berryton Cave were deposited in this cave, so our lower consumption estimates may be conservative.

We determined that Raccoon faeces provide a suitable growth medium for *Geomyces destructans* in the laboratory. In the cave habitat, however, fast-growing fungi, such as *Mucor* sp. and *Mortierella* sp., were prominent on the older faeces and had overgrown (but not necessarily destroyed) slower growing fungi such as *Geomyces destructans*. Although it has yet to be

TABLE 1. Estimated number of *Myotis lucifugus* and *M. septentrionalis* infected with white-nose syndrome consumed by Raccoons in Berryton Cave, New Brunswick, between March and May 2011.

| Faecal wet weight (g) | Faecal dry weight (g) | Coefficient of faecal dry weight to whole prey ¹ | Approximate wet weight of <i>Myotis</i> spp. consumed (g) | Approximate number of <i>Myotis</i> spp. consumed ² |
|-----------------------|-----------------------|---|---|--|
| 4 367.2 | 987.1 | 18.3 (songbird) | 18 063.9 | 3 169.1 |
| 4 367.2 | 987.1 | 22.1 (mouse) | 21 814.9 | 3 827.2 |

¹Greenwood (1979)

²Based on a mean body weight of 5.7 g (SD \pm 0.82)

determined whether the spores of *Geomyces destructans* can survive passage through the Raccoon gut, the significant consumption of bats infected by WNS documented here suggests that Raccoons foraging in multiple caves could play a role in transporting *Geomyces destructans* on their pelage across karst landscapes. Although Raccoons have been observed to move several hundred km (Lotze and Anderson 1979), most Raccoons disperse short distances (<3 km), with only a small proportion moving distances >20 km (Cullingham et al. 2008). In addition, Raccoon activity and movements are reduced during the winter months at northern latitudes (Peterson 1966), where resident bats hibernate and when opportunistic consumption of bats infected by WNS can occur. Although a small number of long-distance Raccoon dispersers could move WNS cave to cave, it would appear that WNS dispersal by Raccoon predators would be important only where bat hibernacula are clustered within 20 km or less of each other and where Raccoons remain relatively active during the winter months. This would not include eastern Canada or the northeastern U.S., where the Raccoon is near the northern limit of its range (Forbes et al. 2010). Although the means of transmission and spread of WNS are still unknown, bat-to-bat contact remains the most likely avenue.

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Book Reviews

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

ZOOLOGY

Birds of North America and Greenland

By Norman Arlott. 2011. Princeton University Press, 41 William Street, Princeton, New Jersey, 08540-5237. 224 pages. 15.95 USD. Paper.

North America has some very fine field guides to the birds. After the original Peterson [and still the best for beginners] we have been given Audubon, Golden, National Geographic, Sibley and Crossley Guides to choose from. So why do we need another guide to the birds of North America?

I have to admit I am a fan of Norman Arlott's books. I have used his guides in other parts of the world with success. The author normally covers a larger range than most books. By restricting the number and size of illustrations he keeps the books small and therefore more portable. This applies to this his latest book that is only 19 cm x 13 cm x 1.5 cm.

Arlott's illustrations are typically accurate. Birds are the correct shape and posture showing the author has field experience as an observer. He is careful and detailed in depicting the finer points of the bird's plumage. However, I had only reached plate 2 when I saw a critical error: the bill of the Snow Goose is missing the gape, essential for separating it from Ross's Goose. As I poked on I noticed more inconsistencies, like the wrong colour for American Woodcock and Upland Sandpiper. In fact many of the plates are over coloured [see Cedar Waxwing]. The critical beak shape is wrong for Hoary Redpoll. The differential colour of House and Purple Finch is non-existent.

The author uses European names – but this is a guide to North America. The Knot is not a Knot on this side of the Atlantic – it is a Red Knot. Worse, *Gavia immer* is not a diver but is a loon; ask any Canadian [The index does list loon and diver]. Why write a book and not use the official names?

The book is also out-of-date. Earlier this year I officially ticked the Pacific Wren, after it had been split from Winter Wren. This is mentioned only as a subspecies. Other splits, like Gallinule and Moorhen, are also missed. AOU name changes like Nelson's Sparrow [changed in 2009] are incorrect. Tree Sparrow is the European Tree Sparrow [the second name in parentheses].

The range maps are very small, about 1.4 cm square, but readable. This is the only way you can define the birds of Greenland, because they are rarely identified in the text. A list of birds of Greenland would have been most useful. Worse Snowy Owl has a winter and summer range, but the Hawk Owl has only a year-round resident status. The southward drift in winter is ignored.

The text is short, but inconsistent. Some vagrants have a short description [e.g., vagrant to Alaska], but others do not. The Lapwing, for example, is listed as a "vagrant from Europe." It would have been easy and useful to add "to north-eastern coast, primarily Newfoundland." The Hawfinch is also designated a vagrant from Europe, where as a rare bird in Alaska it is better termed a vagrant from Asia.

It is sad that an author of Arlott's ability has wasted his talent on an error-filled book. He could have written a portable guide to areas where the need is greater, such as the Middle East or Brazil. These would have filled in a real gap, rather than add to the over-stuffed North American market. I do not recommend this book to beginners, but experienced, travelling birders may find the size convenient. Disappointing.

ROY JOHN

2193 Emard Crescent, Ottawa, K1J 6K5

Field Guide to the Birds of Trinidad and Tobago

By Martyn Kenefick, Robin Restall, and Floyd Hayes. 2011. A & C Black Ltd., 50 Bedford Square London WC1B 3DP, UK. 288 pages. 40.00 USD. Paper.

For many years avid birders needed to take two books when visiting Trinidad and Tobago. Birds of Trinidad and Tobago by Richard French is about the best written field guide and provides excellent information. However it is a little large for a pocket and has

few illustrations. You needed to take A Guide to the Birds of Venezuela [by R. Meyer de Schauensee and W. Phelps] to have good visual coverage.

In 2008 Kenefick et al. produced a compact guide that solved this problem. However they used plates

from *Birds of Northern South America: an identification guide* [by Robin Restall, Clemencia Rodner and Miguel Lentino, Christopher Helm, London & Yale University Press.] and these are poor for some species. Now the authors have released a second edition that contains many revised illustrations. This resolves most, but not all, of my issues with the illustrations.

The book starts with a brief description of the geography, habitats, and climate of the two islands. There are descriptions of the best places to find birds which are both accurate and realistic.

The book covers 470 species, both native and introduced. The text is brief but informative, with a useful section on similar species. The new plates are essential for the difficult species, like *clanias* and flycatchers. I would never have identified a Small-billed *Elania* without Kenefick's original book, and this revised edition is an improvement. Most remarkable is the five plates of New World warblers, that has the most detailed coverage of any guide. Most species have several plumages, ranging from the dullest immature to the brightest male. For example, there are six plumages of Chestnut-sided Warbler shown. In all 20 of the two dozen species I see each year are illustrated, making this book useful in Canada as well as Trinidad.

The taxonomy is up-to-date. The Blue-crowned Motmot is now the Trinidad Motmot [*Momotus bahamensis*], but I wonder why it isn't the Tobago or, at least, the Trinibago Motmot. This year I saw 0.5 motmots per day in Trinidad, while I hit four or more per day on Tobago. Likewise Cayenne Tern is split from

Sandwich. Moorhen carries the new [old?] name – Common Gallinule.

Some of the illustrations I did not like have been retained. There are birds that look more like museum specimens, than birds in the field. This is not critical for a distinctive species like Crested Caracara, with its odd, gangly pose. However I had great difficulty identifying an immature Ornate Hawk Eagle from this plate. *Birds of Venezuela* shows more clearly the wing and body shape and the description backs this up. I later checked these characteristics against photos on the internet. There are no range maps.

These criticisms notwithstanding this is now the essential guide to these exotic islands. For the best part it is accurate, easy to use and portable. The text while short is useful. The text in french is more extensive [and therefore worth having as a reference]. It is interesting to note that Kenefick does not include Groove-billed Ani [which does not occur in Trinidad] while french does. However french says the lone record is "certainly a mistake for [Smooth-billed Ani]." Why then do I see this species recorded by many visitors on their trip list. Clearly they need Kenefick et al's book.

Note the publisher has changed from Yale University Press to Christopher Helm of London, the natural history arm of A & C Black Ltd, I am not sure how this will affect the North American distribution. If you are going to T&T this well done book is a must have guide; wherever you need to go to buy it.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5

Managed Annihilation: An Unnatural History of the Newfoundland Cod Collapse

By D. Bavington, 2010. UBC Press, 2029 West Mall, Vancouver, British Columbia V6T 1Z2. 186 pages. 85.00 CAD. Paper.

The mismanaged cod stocks off Newfoundland make for a global monument in time. But by now it's also a feast for environmental writers both local and far away. This book by D. Bavington is one of those books, and it must 'swim among its competitors'. I find, it barely floats.

The Foreword by G. Wynn ("*This Is More Difficult Than We Thought*") makes for an impressive stand-alone read though. The subsequent 8 chapters then continue to re-tell us the story we all know (and which many "lived"): A super abundant fish with a complex and fascinating life history and of huge cultural value (like most other fish and natural renewable resources, for that matter) went lost. The book then moves into a governmental and apologetic view, elaborates on self-organizing, holarctic and open (SOHO) systems, presents a great review of 'how cod is killed', shows aspects of managing fish and fishermen, displays some rarely discussed issues of cod farming ("egg to plate"; as promoted by the Norwegians and politicians), and from there gives eventually common conclusions: the government messed it up, the resource and its culture is

destroyed for good, but nobody is personally to blame (a widely found Canadian tradition that results in a national blur and public guilt). I find that the book falls somewhat short though on the implied promise of its catchy title (it does not really cover the failure of the individual managers, and the management-science brotherhood).

People new to this subject will still find the facts and details provided refreshing perhaps, e.g., that China is processing shrimp from Newfoundland, the 'underutilized species' fisheries for krill and jellyfish, and also that many of the inshore bays were (locally) over-fished since the 18th century. But an audience of Canadian naturalists and fishermen who know the situation locally, or from similar experience elsewhere, might be less enthused with this text. The social science perspective might be interesting to some, but the wordy and lengthy style without too much hard facts is annoying to others. In times like this, and as naturalists, perhaps we must be grateful for anything that is not a resource-destroying propaganda? The role of scientists gets widely delivered in the text, but it leaves

out the infighting and humiliation of "the researchers and experts that actually suffered" but who were not in the spotlight such as the now celebrated Ram Myers and Jeff Hutchison. Of course, in a book like this, Maximum Sustainable Yield (MSY), the infamously disastrous Beverton and Holt curves, and the tragic ITQ and TAC quota systems are discussed, as well as the impact of international fisheries. 'Jiggers', proceduralism, and the royal crown and Canadianisation are mentioned too. The efforts by the Norwegian fisheries expert Adolph Nielsen in 1889 on Dildo Island provides for an informative lesson in fisheries history.

The question whether to fish for money or for food makes for a central scheme indeed, and is of global relevance. Granted, the author makes the brilliant point that leisure fishing for cod is now basically illegal ("Criminalization of fishing as a way of life"). The elaborations of political and imperial ecology provide a nice new and needed angle in the public discussion. For instance the statement that "management – an idea rooted in the political and economic context of capitalistic resource extraction" still needs to be understood by many. The same is true for the fact that "Fisheries science, technology, and management have all been aimed at creating and sustaining this context of capitalist resource extraction by transforming fisheries around the world into an industrial sector". Management comes with a political and business ideology, and which does not consider, nor mix with, wilderness and natural resources. Personally, I also like the accumulation of human impact and ethics literature references and footnotes (among one of the best on the cod issue). The index is crisp but helpful; 2 pages of abbreviations are included. Cartoons, figures and many quotes are presented, e.g., the one made by J.R. Saul: "Management is a tertiary skill – a method, not a value. And yet we apply it to every domain as if it were the ideal of our civilization", or by M. Parker "More than any other form of knowing or practice, management is claimed to be absolutely nomadic and universally useful".

The notion of "success through failure" must come as a cynical and inappropriate view and considering all the loss our nature, society and the oceans went

through. Neither climate change nor UNCLOS, or offshore oil and gas exploration (or chronic oil spills) are covered in this book though. Corruption is kindly ignored once more ("Once the stock status was agreed upon, TAC levels were secretly negotiated by DFO officials and hand-picked representatives from the fishing industry"). It's too bad that no true institutional, legal and economic change was requested by the author. Institutions like ICES, NAFO, ICNAF and certainly DFO, and global seafood processing corporations got away with the murder of fish and a fishery. This book barely delivers on the DFO problem; the role of our banking system gets ignored. And we all still eagerly wait for a documented public review of the Memorial University of Newfoundland (MUN) and its role in the 'cod game'.

The Newfoundland fisheries were one of the most advanced and well-funded fisheries, and with a huge science-base right before it crashed to commercial extinction. Many know the infamous citation by R. de Soncino (London 18 Dec. 1497): "The sea is covered with fish which are caught not merely with nets but with baskets". But too bad that most ignore that our western regime and lifestyle, the assumed manageability of the world, resulted in "an ecological crime comparable to the Soviet Union's draining of the Aral Sea" (and as also stated in this book). Which ideology really is better for the natural resource and the world?

In conclusion, this book adds some new views, but has many competitors in the published landscapes. It adds to the long and tragic list of existing and forthcoming environmental history publications in Canada and the western world. Canada has unfortunately much to write about and more is in stock. The author confirms what we already all know: a poor (Canadian) governance and one that is bought out by other interest than food, fishermen and long-term sustainability, sets us all up for global bankruptcy (the type we just experience in 2011). It's time to change dogmas, again.

FALK HUETTMANN

Institute of Arctic Biology, Biology & Wildlife Department,
University of Alaska-Fairbanks (UAF), Fairbanks Alaska
99775 USA

Ecosystem – Based Management for Marine Fisheries: An Evolving Perspective

By A. Belgrano and C. W. Fowler. 2011. Cambridge University Press, 32 Avenue of the Americas New York, New York, 10013-2473 USA. 384 pages. 115.00 CAD. Cloth.

In the year 2011 it becomes clear that capitalism has widely failed us financially, socially, in the atmosphere and also when dealing with fisheries worldwide. This book and its 12 chapters make the current global misery more obvious than ever. This text features many truisms, and some text citations go like this "...over-exploitation generally leads to depleted fish stocks...", "...interplay between prey and predators remains dynamic and challenging given the complexities of marine

food webs...", "we discuss the potential failure of simple management models" or "The dynamics, circumstances, and condition of ecosystems have a clear impact on fisheries (and fish stock dynamics)" (!?) Naturalists learn here that our governments and their institutions and representatives have widely lost it, play with words, and that ecosystem management is still in its formative phase and infancy, at best. What has the discipline of ecology, and its representatives, really

achieved during the last 100 years? By now, it just turned into a common scheme to exploit the wilderness (which evolved for millions of years), and then once all is destroyed, we start talking and publishing about complex intellectual schemes that our governments don't want, or cannot, implement anyway (as seen and expressed in virtually all chapters by the 36 worldwide contributors). From 'no management' to adaptive management to ecosystem-based and systemic management. What really works, and how much more will the western philosophy and its related business philosophy fail us any further?

This book of 384 pages, and with many species trend and harvest figures and a few color maps, asks: what does an Ecosystem Management, and based on holistic principles, really look like? At minimum, it is clear to us that a holistic view would include Deep Ecology, Embodied Energy, Mother Earth Rights and Generational Justice, and that it must avoid climate change and, thus man-made carbon pollution and ocean acidification. How can this not mean massive changes in the way we do business, and in society and (fisheries) institutions, and certainly in our legal system and education? And why are native and indigenous ways of doing business (a concept that worked better for thousands of years and without changing the climate etc.) not celebrated or used as a role model? However, that is the last thing these editors and contributors promote here and is the failure of this book. Instead they just sail off on another new pipe-dream (= their defined scheme of ecology) that sounds cosy in public. But, as shown here, it has no solid footing, is too slow to catch on, and just promotes business as usual and even to increase fish harvest and money making for just a few, e.g., the upper western society and its corporate industry and the political and science support machinery. Every naturalist sees it 'out there', daily and firsthand. Only a few chapters, authors picked up on the contradictory fact that when stakeholders are included in resource decisions, industry will just grab it all ("*Stakeholder-based policy is not ecosystem-based policy and makes holism impossible in conventional management*").

Every ecologist should balk at the use of linear management units, such as NAFO and PICES ones and non-quantitative Large Marine Ecosystem (LME) units; but this book and its authors do not. And some chapters make reference to the U.S. Magnusson-Stevens Act, but this policy tool cannot be a good global example neither and includes a hardwired industrial and bank overruling (and subsequently, this is not addressed in this book neither. Management is linked to financial institutions). Formulas that determine national harvest quotas are only hinted at (but not shown in detail). This publication falls entirely flat on elaborations about the fallacies with the so-called '*Tragedy of the Commons*' (where the destruction of a public good is invited and actually caused by the framework and the governance

scheme, but not by the public user!). The '*Tyranny of the Locals*' (where locals demand all rights and grab the resource until over-exploited) is also lacking. It is widely puzzling that ICES, PICES and CCAMLR (a founder of Ecosystem Management, but which widely failed on its flagship species: the Toothfish) are not reported on in this book even. And it is of uttermost disappointment (but not really surprising) that the editors, the Cambridge publisher and all chapter contributors leave the disaster of Economic Growth, of our Globalized Economy, as well as the bad role of IUCN, FAO, The World Bank and WWF almost entirely untouched (not to speak of the Tuna Commission, the International Halibut Commission or Russian NIRO). Native views are also ignored. Although this attitude and approach of a 'selected and convenient silence' is well in line with what Jane Lubchenco's NOAA and NMFS, as well as the EU, are promoting, it stands in a wide conflict with common sense, human honesty, humanity, the American Fisheries Society, the Ecological Society of America, and ecological base-concepts, e.g., as promoted in Ecological Economics (the inclusion of such representatives in this book would have been of huge value to the readers and the book scheme overall). Thus, alone from the literature references it can be seen that this book caters a political ideology. It is entirely silent on the issue of corruption, crime, drug abuse and smuggling, money making deals, cheap labour and abuse in fisheries, in international waters and with fisheries management and ocean planning. The presented climate change and ocean acidification details still underachieve, too. Nor is seabirds (ecological indicators) part of this book. Apparently, many managers and book authors want to implement an ecology-based management without such issues (despite their repeated statements about the supposed appreciation of the 'holistic', social and human factors and values in fisheries). I could go on here about ecological sustainability shortcomings of this text (let alone the lack of including third world nations, 101 ecological key references and textbooks, and the many nonsensical figures supposed to show ecosystem complexity, parsimony and how it is managed), but clearly this is all very serious business and affecting us all. Considering that over 80% of the fish stocks of the world are overfished, FIRING THE VAST MAJORITY OF MANAGERS IMMEDIATELY and closing their institutions 'for good' makes for a decent conclusion and can hardly be worse for all of us. Fisheries Management is an extremely expensive business, draining public budgets (an annual loss of 54 billion dollars is discussed by Dan Pauly; a subject most managers and authors avoid like the plague, and so did this book). The relevance of 'ethical ports', or at least 'ecological ports' (the harbours which only land, process and cater from approved fleets) is equally left undiscussed. Why not simply recall all fishing vessels right now until the overharvest problem is resolved (some book chapters

call already for an 80% harvest reduction)? Considering that fisheries are a global subsidy business, fisheries is paid by, and belongs to the people and thus should contribute to human and global well-being. That statement would be radical, or not realistic? Try to keep going otherwise; what is realistic there? Harvesting down all fish stocks, food webs and oceans any further (as many book chapters clearly state and cite)? We are 'peak fish', 'peak soil' (agriculture) and 'peak oil' but have rising human populations and climate change to come (these are all subjects this book widely ignores). And why would food conflicts then not lead to armed tensions and world wars? This book provides us with no answer; the institutions represented by the authors seem not to care. We would hope for a better ecosystem-management than that.

Some managers and their institutions, and the corporate industry and their NGOs, play god here. However, they widely failed and we all pay the prize. Managers should be accountable (Eikeset *et al.* this publication). Only in a few instances other management failures are hinted at in the text, e.g., with the 'big brother' in agriculture. Naturalists already know first-hand that forest resources, mining, oil sands, drinking water, epidemics, DNA food and the atmosphere are also widely mismanaged.

This book is showing us what the 'modern' western society and their urbanized people with an 8h day job can, and cannot produce. Turning Korea into a fish ranch is a stunning feat (but certainly it is not ecological). This publication is useful though in getting a basic overview about world fisheries, about some of the management attitudes, and their statistics, time series and claimed achievements, and the missing ethics on the agenda. Perhaps naturalists will enjoy some of the international literature references (a minor and repetitive selection of Pauly, Myers etc. is often included). The index counts 22 (!) pages.

Despite its huge value for fisheries management, the internet and open access data play no role to the authors. Views from fisheries nations like Japan and Iceland/Greenland are lacking in this publication. The Bay of Fundy chapter I found disappointing. The Alaska book chapter show us what some of the shortcomings are: the 'expert' authors all come from outside of the resource's state, tend to live in urban centers (Seattle), essential fish habitat (EFH) is not defined well, Alaska's cheap labour and drug issues are not discussed, overfishing is slightly mentioned but a complete cumulative picture is not shown (e.g., that many

stocks are harmed, lack a thorough EIS, and stand in concert with many other problems such as invasive species, shipping, oil and gas development). Alaska still gets cited as a good example and untouched wilderness (this is far from true, and just when considering already overfished crab, Pollock, Arctic cod, herring and rockfish stocks and the deep sea coral problems).

Many authors further fell for the "fallacy of recovery" and forgot that a rebuilding of fish stocks really means a rebuilding of the global society (which is not promoted here). So far, the industrial global society clearly has a problem with fish, but also with ecology. The failure of fisheries only means the failure of NGOs and of civil society (a reality only touched upon marginally in this book).

What do I like about this book? Perhaps the chapter about the Baltic Sea and its 'deadlock' (irresolvable problems one way or another, and "...irrefutable evidence of the transformation of a formerly productive eastern North Sea into an ichthyological desert due to intense fishing.") and the documented lack of vision there. Further I like some of the sea mammal writings, the critique of "misdirected reductionism", the chapter about "...unintended consequences sneaking in the back door", and that "...we do know enough to make decisions". The relevance of making time-critical decisions is mentioned many times, that fishing for some species now is 51 times higher than observed among marine mammals, and that "...considering greater levels of complexity is mostly rhetoric rather than concrete actions". Documenting and admitting failure is useful to know for sure. Just give us our fish back.

"We are witness to a history of management that fails..., and results in more problems than are solved".

In conclusion from this book: virtually all our fish harvest rates are too high and must be immediately reduced. Single species management should be a thing of the past and outlawed. This book is still full of real non-achieving but typical management slang (ecological 'posing'). It does not only harm us, but also our children, and their children (and their fish stocks). Such views and understanding of ecology as presented here harm the ecosystem the most (one must think like the universe). This publication will make every concerned naturalist cry, guaranteed.

FALK HUETTMMANN

Institute of Arctic Biology, Biology & Wildlife Department,
University of Alaska-Fairbanks (UAF), Fairbanks Alaska
99775 USA

Decline and Recovery of the Island Fox: A Case Study for Population Recovery

By Timothy J. Coonan, Catherin A. Schwemm, and David K. Garcelon, with Linda Munson and Cheri Asa. 2010. Cambridge University Press, Cambridge, UK. 212 pages, illus.

Decline and Recovery of the Island Fox is a love story and a mystery story. Not in a romantic or detective way, but more in the sense of deep affection and

care, curiosity and concern, inquiry and responsibility, and unwavering devotion. Nothing less would have saved the island fox, *Urocyon littoralis* – a rapidly and

recently evolved species of carnivore smaller than its mainland gray fox ancestor (actually the smallest canid in North America), inhabiting only the Channel Islands off the coast of Southern California. Before reading this book, I didn't know this distinct little fox existed.

How did such a unique species evolve so rapidly? Chapter 2, "Evolution and genetics," provides the details. Interestingly, island foxes illustrate both (1) *dwarfism*, a phenomenon sometimes found among island species, which makes them smaller than their mainland ancestors, and (2) the *island syndrome* which makes the life history characteristics of island species different from their mainland relations due to the limiting factors of island environments. The island syndrome not only made island foxes different from mainland gray foxes, it also resulted in morphological distinctions among the foxes inhabiting each of the six individual Channel Islands – San Miguel, Santa Rosa, Santa Cruz, San Nicolas, Santa Catalina, San Clemente – resulting in six *Urocyon littoralis* sub-species!

Chapter 3 deals with social structure, reproduction, population dynamics, and mortality and survivorship of the island foxes. Research has revealed, for example, that island foxes have lower litter sizes, smaller territories, and higher densities than mainland foxes. Their high survival rates result from the high quality of the grassland, scrub and chaparral habitat, as well as the typical absence of predation. Yet those survival rates changed dramatically and mysteriously in the 1990s. Inquiry revealed that disease and golden eagle predation were reducing island fox populations to near-extinction levels.

The discovery called for swift, complex, and dramatic measures, which I will not attempt to represent accurately except to mention that they included capture and captive breeding. The fascinating and inter-related story of foxes, golden eagles, feral pigs, dogs, disease, bald eagles, humans, and more is told in Chapters 5 to 11.

Chapter 4, "Food habits, habitat use, activity patterns, and dispersal," I found particularly interesting because it helped me get to know the island foxes better. They make opportunistic use, not surprisingly, of a wide variety of plant and animal resources on the islands. A curious animal resource is the introduced garden snail, which may provide an easily caught and

consumed food source for older foxes, providing them with essential nutrition they may not be able to obtain otherwise. The authors observe that the snails are particularly abundant on San Nicolas Island, where the fox population age structure is more skewed to older age classes. The authors also note that because island foxes are able to make use of so many different island resources and habitats, the animals may be in a good position to adapt to predicted effects of climate change.

Later chapters in the book discuss social, educational, and political aspects of the island fox recovery story. Environmental groups – in particular "Save our Species" (SOS) and "Friends of the Island Fox" (FIF) – played important roles in raising awareness of island foxes and related issues, in collaborating with government and NGOs, and in raising funds for island fox captive breeding and recovery efforts.

The SOS group is particularly interesting. Organized and operated by children, SOS organized special educational events and raised a total of \$10,000 in support of island foxes. The group generated so much visibility that it gained the attention of Jane Goodall, eventually participating in her Roots and Shoots program. "The once third graders are now in high school," write the authors, "but ... these young adults will always know that they contributed to recovery of an endangered species" (p. 145).

The recovery of island foxes – their return from the brink of extinction – is indeed something these young people, and others involved in the "dramatic, heroic and, at times, controversial" (p. xii) story can be proud of. There is a lot to the story, and so much more to this relatively short, but dense, complex and meticulously referenced little book than I can possibly represent in this book review.

Suffice it to say that *Decline and Recovery of the Island Fox* is indeed a mystery and love story – about a unique little animal in difficulty, and about people who were not only troubled enough to determine the causes of its decline, but concerned enough to perform heroic deeds to bring it back. In the end, the book is a story of hope – hope that species loss is not inevitable, and hope that people can care enough to take positive action.

RENATE SANDER-REGIER

3, 11th Line, Bristol, Quebec

Greater Sage-Grouse, Ecology and Conservation of a Landscape Species and Its Habitats

By Steven T. Knick and John W. Connelly, editors. 2011 Studies in avian biology No. 38. A publication of the Cooper Ornithological Society. xvii, 646 pages. 122.75 CAN.

This is an impressive book and a treasure trove of information that I read with excitement and pleasure for I study grouse, population dynamics, and know several of the authors. I am greatly impressed by all that is accomplished but left with some aspects still uncovered. The book is 646 pages of packed print, maps,

diagrams, and graphs and ends with 1683 references. The material presented ranges from grouse eggs to the control of wild horses (*Equus caballus*) by the number of harems removed. My abilities, time, and space for this review compromise a more accurate, deeper, and fuller explanation of the book. There are 24 chapters

by 38 authors, many leaders in their field. They are from 20 institutions; state, federal, university, and NGOs. The aim is to provide the best information for the understanding and long-term survival of the Greater Sage-Grouse (*Centrocercus urophasianus*) and the Sagebrush (*Artemisia spp.*) Biome in as natural a state as possible so "that generations long into the future will be able to experience the sun rising on a vast open landscape, smell the pungent scent of sagebrush, and marvel at the centuries old rite of Greater Sage-Grouse displaying on a lek." Amen!

The book is a state of the art text on the biology, ecology, and population dynamics of the sage-grouse and their sagebrush habitat. But most important, it also discusses the huge effort and difficulty in making fact into value, influencing public policy, and obtaining legality for action. The sage-grouse is in trouble with generally declining numbers, shrinking distributions, and deteriorating habitats. From 1999 to 2005, 9 petitions to place Greater Sage-Grouse in protection under the Endangered Species Act were submitted to the United States Fish and Wildlife Service (USFWS). In March 2010, the USFWS warranted the listing under the Act but immediate action was prevented by higher priorities. Many people and agencies view the Act as a loss of rights to land and revenue. I just recently read that in 2010 the Governor of Wyoming issued an order outlining a new strategy to protect Sage Grouse while allowing a development in core area. The action is to prevent an adverse effect upon the economy. Clearly, science, resources, and politics are covered and the information used to construct a road map where all the many who are involved with or value Sage Grouse and their habitat may plan and act for their care.

A Preface by the editors outlines aims and broad limits. Next, a Foreword on thoughts on the role of science in making public policy. Then the editors write an introduction to the Greater Sage-Grouse and sagebrush under the heading An Introduction to the Landscape. Knick begins the chapters with Historical Development. Principal Federal legislation, and Current Management of Sagebrush Habitats. Chapter two completes the first; The Legal Status of Greater Sage-Grouse and the Organisational Structure of Planning Efforts. Key points are: most sage-grouse are on unprotected private lands, and legal status is by state law as wildlife and game birds. However, many plans of stewardship are acted upon.

Chapters three and fifteen are the heart of the matter and deal with the biology, population dynamics, and long-term trends of the populations of sage-grouse. Here, the Greater-Sage-Grouse is called one of North America's most unique species of bird. It shares the myth of the West in its sagebrush home on the range. I claim the Blue Grouse (*Dendragapus spp.*) is at least equal to the Sage Grouse in remarkable features (Zwickel, F. C. and Bendell, J. F. 2004. Blue Grouse: Their Biology and Natural History. NRC Research

Press, Ottawa, Ontario. 284 pages) and there is a great similarity between the two genera. Most striking is the migration between winter and summer ranges. Other similar attributes include: natal down, secondary sexual characteristics, behaviour, large size, long length of life as adults, and habitats and foods used by hens and chicks during the breeding season. A fundamental difference is that Sage Grouse use sagebrush in relatively flat, open landscape for winter food and cover. Blue Grouse use conifer trees, generally in the alpine zone. Most winter habitats of Blue Grouse are inaccessible to humans, but sage-grouse are exposed to human throughout the year with generally destructive consequences.

The numbers of sage-grouse throughout their entire range were measured by counting males on 9,870 leks with a total of 75,598 counts since 1965. Many leks were counted each year through 2007 yielding greater than 30 years of abundance data. A minimum estimate is 88,816 male sage-grouse on 5,042 leks over 530, 000 kilometres square where sagebrush is the dominant cover. Leks with adequate data were grouped into 23 populations and analysed by several accepted mathematical models to derive annual rates of population change. A few populations are predicted to remain stable in number but most will decline. For example, 13% of the analysed populations may decline below an effective size of 50 birds within the next 30 years. Clearly, strong action must be taken to arrest the decline and increase the numbers of sage-grouse.

Overall, 20 of the 24 chapters are devoted to environmental and other factors that may be linked to the abundance and distribution of Sage Grouse. Clearly paramount, Sage Grouse need sagebrush; as goes the sagebrush, so goes the Sage Grouse and a large community of desirable plant and animal associates. Many pages are devoted to the kinds, ecology, and requirements of sagebrush. The abundance and distribution of sagebrush is declining and shrinking. The causes are complex and include: burning, conversion to crop land, grazing by domestic stock and feral horses and burros (*Equus sp.*), competition with invasive and exotic plants, mineral and gas claims and extraction, and the myriad impacts of human settlement.

An obvious need is to determine how the density of Sage Grouse is set by their environment. Some of the usual explanations for population limitations for this and other species of grouse are hunting, predation, and disease. Disease is given special attention with the recent appearance, negative impact, and rapid spread of the West Nile Virus. Gratefully, the long held belief that the grouse generally cannot be reduced in breeding density by hunting because of their high birth rate is questioned. And numbers shot should be adjusted to desired densities of breeders. Disease and predation may cause local reductions of population but neither can be blamed as a general cause of density and distribution.

Other features and factors found frequently in the vast grouse literature relevant to population are missing or treated lightly. Some may be critical in focussing research and recommending management. As examples: with the long runs of census data, are sage-grouse cyclical in numbers? What aspects of behaviour might drive density? What is the impact of the quantity and quality of foods eaten throughout the year by both sexes of all ages? What is the influence of climate, weather, and micro-climate, especially where micro-climate may determine next site selection and success?

I could find no clear answer as to how densities of Sage Grouse are limited. Perhaps the intention is to emphasize habitat as the only way to management. Other studies of grouse suggest breeding densities are determined by the spacing behaviour of hens for their requirements for nesting and the insect food needed by their young chicks. The book does note that the quality of hens may be a driving cause of the productivity and persistence of leks. Quality may influence behaviour and originate genetically and/or in an environmental factor such as food. Recent work on grouse and mammals shows levels of stress may be measured by amounts of metabolites of progesterone in blood or faecal droppings to reveal modification of behaviour and reproduction the may affect population.

The last few pages of the text are entitled A Road Map to Conservation. 1. Much additional work needs to be done to better understand the impacts of hunting,

predation, and disease. 2. Habitat protection is the best strategy to stabilize or recover many populations. 3. Habitat restoration with improve many protected areas. And 4. Accurate monitoring and assessment are necessary to provide an objective appraisal of improvements or damage to sage-grouse populations and habitats.

Without question, this book is an enormous amount of excellent information, but will it and the Road Map be followed? Certainly by professionals and naturalists dealing with wildlife, other natural resources, and the land. Politicians, captains of industry, and the general public may find it overwhelming and forbidding and too difficult to follow. Perhaps there should be a condensation of the book with the main points made in simpler language and illustrated with many coloured pictures. Pictures that show the salient fact and stunning beauty. Perhaps a CD should be included. And above all, explain why we must keep the experiences of the sun rising on vast expanses of sagebrush and the spectacular courting dances of the sage-grouse.

Many healthy populations of sage-grouse and much sagebrush habitat remain. But the alarm bells are ringing. Hopefully, the dedication and the excellent work of the authors will translate into the long-term appreciation and survival of the sage-grouse of "this icon of the West."

JIM BENDELL

RR #2 Clayton, Ontario, K0A 1P0

Handbook of the Mammals of the World. Volume 2. Hoofed Mammals

By Don E. Wilson, and Russell A. Mittermeier (Editors), 2011. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 886 pages. 160.00 EUR. Cloth.

The second tome in this series contains accounts of some of the world's most exciting animals. Nobody can fail to be impressed when they get close to their first wild Elephant, or be charmed by a baby with its rubbery, little trunk. This issue covers Aardvark, Hyraxes, Elephants, Pangolins, Horses and relatives, Rhinoceroses, Tapirs, Camels, Pigs and Peccaries, Hippopotamuses, the deer group [Chevrotains, Musk-deer, Deer], Hollow-horned Ruminants, Pronghorn and Giraffe and Okapi.

Each family has an introductory section that covers the systematics of the living and extinct species. While the extinct species are covered in this section they are not included with the species accounts. The authors discuss their choice of [living] species, including controversial splits and lumps. For example the African Savannah and Forest Elephants are split, but not the three Asian populations. The Giraffe is left as a single species, but six of the nine sub-species are illustrated. These decisions were easily digested, but as I read more of the book I became more overwhelmed. By the time the reader reaches Hollow-horned Ruminants it seems all populations that were previously considered sub-

species are now elevated to full status. Thanks to DNA there are 279 distinct species bovines; twice the number from five years ago. It appears I may have seen three, not two, species of Wildebeest. I need to check my notes and photographs to see if I can justify a new life mammal! It does not stop there. The Thompson's Gazelle [the cute little beast that so often ends up as a Cheetah's lunch] is split into two [another lifer?]. [This means you must look under S and E, not T in the index for Serengeti and Eastern Thompson's Gazelle] The Hartebeest complex now contains eight species, and there are a dozen and a half look-alike wild sheep. In all there are over 400 species in the book, with two thirds being Hollow-horned Ruminants.

The introductions to each family deal with habits and habitats as they relate to feeding and breeding. It also covers movements and social behaviour, critical elements for many of the wide-ranging mammals. These introductory sections are well illustrated by photographs. Some of these are truly memorable like the sleeping Eurasian Wild Boar mother with her little piglet snoozing on her belly out of the snow, but all are first-rate.

Then each species is illustrated on an identification plate, that is followed by an account, including a range map. The text gives a description to back up the plate and summarises the species biology. I found out some surprising information by reading these accounts. The beautiful Scimitar-horned Oryx has been extinct for about 40 years. Those I saw at the edge of the Sahara were re-introduced from zoo stock. The Dromedary is also extinct in the wild although there are some feral populations, primarily in Australia. Some of the animals in this book are important in the daily life of eastern cultures. Not only are they a valuable resource, but are part of legends and traditions. I have checked ranges, descriptions and other information and cannot find any problems.

There are three features that I find particularly enlightening. The first is how the reader is able to put species in perspective. For example the relationship between all the world's buffalo is easy to see. Simi-

larly seeing the three bison [American Bison, Wisent (or European Bison) and Yak] clearly shows their obvious relationship. The second feature is that the book covers all mammals, not just the showy ones. Check the mammal section of your library and you will find books on whales, big cats, bears and elephants. It is rare to find a book on the small beasts. So this volume lets you find out about the more obscure mammals like the pangolins and dik-diks. Finally, it is good to have the African gazelles and their allies treated systematically. It clarifies the confusion I have had when reading different field guides with mixture of English and, sometimes, scientific names.

Overall I think this a great book and an important addition to mammalian literature. It will be a valuable reference for many years to come. Expensive yes, but well worth the price.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario, K1J 6K5

A Field Guide to Sea Stars of the Pacific Northwest

By N. McDaniel. 2011. Harbour Publishing, PO Box 219, Madeira Park, BC V0N 2H0. Eight fold 9 inch by 36 inch plasticized sheet. 7.95 CAD.

Exploring Neil McDaniel's *A Field Guide to Sea Stars of the Pacific Northwest* is a little like exploring an intertidal pool. This durable, water resistant, 8-fold, field guide overwhelms and disorients the viewer with its wealth of information and images. This is a pamphlet for serendipitous browsing, not systematic use. Revel in the abundance of the species and the suggestiveness of the names. Even without the vibrant, accompanying photographs, names such as "Bat Star," "Fat Blood Star," "Dwarf Star," "Leather Star," "Slime Star," "Gunpowder Star," "Velcro Star," and "Cookie Star" are enough to enthral a child, or set a naturalist to dreaming.

On a practical level, the pamphlet contains a myriad of fascinating facts. As an avid kayaker, and someone who spent many childhood hours exploring the seashore, I already knew about the tube feet, the pressure regulating madreporite, and the calcareous plates. However, information about sea star features such as the photosensitive "eyespot" and the forceps like pedicellariae, or minipincers, in all their variety, had escaped me. Similarly, though I have often watched glaucous-winged seagulls spend over half an hour choking down a sea star, I had never realized that sharks and Puget Sound king crab might also be predators. In the future, too, I will scrutinize sea stars for various parasites and for commensal scale worms.

McDaniel's attractive, colourful photographs are a big feature of this pamphlet. They—together with the concise, well-thought-out, descriptive notes about range, depth, prey, and identifying markings—should be a big help in identifying specimens. Another useful feature of the field guide is that it refers the user to other publications, including an online version of the guide and Dr. Chris Mah's fascinating www.echino.blogspot.com.

My one serious complaint about this excellent production is that it is neither fish nor starfish, book nor pamphlet. Printed on a plastic laminate, it is presumably intended for scuba divers and for families exploring beach intertidal areas. Unfortunately, the foldout format allows only limited space. The glorious photographs are often too small and too cramped. The print size is too small for older eyes to read easily, particularly when white print is used on an orange background. Because of the crowding, linking images to image subtitles is also difficult at times. This publication really should have been allowed more space, really should have been a book, especially given the \$7.95 price.

ANDRE GERARD

10-2649 Quebec Street, Vancouver, British Columbia, V5T 3A6

BOTANY

Outbreak, Harm and Control of Algal Blooms in Lakes of China

By Yang Y. Liuyan and Xiao Lin. 2011. Science Press, Beijing. 281 pages. 69.00 CNY.

Fresh-water algae are found in a large range of habitats, such as ponds, lakes, reservoirs, streams and so on. They are usually a natural and essential part of the aquatic ecosystem, acting as the base of the food chain. However, algae are usually sensitive to the environmental changes and its life cycle is short. When nitrogen, phosphorus and other nutrients in a lake or a river reach a certain level, growth and reproduction of algae tend to be accelerated, and the numbers of algae might increase explosively, resulting in an algal bloom. Lakes, ponds, and slow-moving rivers are most susceptible to blooms. Algal blooms generally occur where there are high levels of nutrients, coupled with the occurrence of warm, sunny and calm conditions. Human activity often can also trigger or accelerate algal blooms. Natural sources of nutrients such as phosphorus or nitrogen compounds can be supplemented by a variety of human activities, for example, in rural areas, agricultural runoff from fields can wash fertilizers into the water; in urban areas, nutrient sources can include treated wastewaters from septic systems and sewage treatment plants, and urban stormwater runoff that carry nonpoint-source pollutants. The outbreak of algal blooms is an important indicator of pollution in fresh water body, or a visual representation of lake eutrophication, or ecological unbalance in other aspects.

Typically, only one or a small number of phytoplankton species are involved in an algal bloom. Some blooms may be recognized by discolouration of the water resulting from the high density of pigmented cells. So far there is no unanimously recognized threshold level, but algae can be considered to be blooming at concentrations of hundreds to thousands of cells per millilitre, depending on the severity. The recurrent or severe blooms can cause dissolved oxygen depletion as the large numbers of dead algae decay. In highly eutrophic lakes, algal blooms may lead to anoxia and death of fish. The odours and unattractive appearance of algal blooms can also detract from the recreational value of water bodies. Some algae produce toxic chemicals and released into water when dying and decaying, which pose a threat to fish, other aquatic organisms, wild and domestic animals, and humans.

In recent years, along with the rapid economic development in China, large amounts of industrial wastewater, urban sewage, and agricultural non-point source of nitrogen and phosphorus were discharged, and flowed with runoff into lakes, causing a rapid increase in the levels of pollutants in lakes. In the five largest freshwater lakes of China, the outbreak of algae blooms frequently happened in recent years, especially in Lake Taihu, Lake Chaohu. The newly published book *Outbreak, Harm and Control of Algal Blooms in Lakes of*

China, described the present situations of eutrophication and algal bloom of the lakes in China, and systematically elucidated the latest research results on algae growth, ecology and biogeochemical cycling of main elements in lakes of China.

The main contents included Chapter I describes Lake ecosystems and algal blooms, including lake eutrophication and algal blooms in China and the world, the biology, species and distribution of algae in lakes and the biogeochemical cycling of nutrient elements (nitrogen, phosphorus and carbon) in lake. Chapter II explains environmental factors and microcystis bloom, including nutrients, growth and metabolism of microcystis aeruginosa, the exogenous phosphorus concentrations and the growth of microcystis aeruginosa, different forms of phosphorus and the metabolism of microcystis aeruginosa, different N/P ratios and the growth of microcystis aeruginosa; hydrological, meteorological factors and the outbreak of microcystis blooms, temperature, duration of illumination, disturbance, and the other environmental factors, such as redox potential and the growth of microcystis aeruginosa, and the phosphorus metabolism of microcystis bloom. Chapter III covers microcystis blooms and the interaction with epiphytic bacteria, including the epiphytic bacteria in microcystis bloom, phosphorus metabolism of microcystis aeruginosa and the epiphytic bacteria, impacts of environmental factors on the phosphorus metabolism of microcystis and epiphytic bacteria, microbial community succession in the water body with algal blooms. Chapter IV describes the impacts of outbreaks of cyanobacteria blooms on water ecosystems, including the effects of nitrogen removal of microcystis blooms, nitrogen and phosphorus migration and cycling in water body with cyanobacteria outbreaks, impacts of algae outbreak on the macrophytes, fish and other aquatic animals in aquatic ecosystems, the responses of aquatic community structure to algal blooms. Chapter V explains the disaster of cyanobacteria outbreak and algal toxin, including the harm of algae outbreak on drinking water, fishery and tourism; the types, mechanism and the spatio-temporal distribution of algal toxin, as well as its bioaccumulation, migration and transformation (physical and chemical degradation, and biodegradation) in the environment. Chapter VI elucidates the control of lake algae and the transformation into resources, including the control of lysine on the growth of microcystis aeruginosa and the toxicological effects, the control of cyanobacteria virus on algae, the transformation of aquatic plants into resources, hydrogen production from cyanobacteria. Chapter VII reveals the progress and prospects of the research on lake algal blooms, including

the physiological and biochemical characteristics of cyanobacteria, the external conditions for the formation of algal blooms, and the development process of the disaster, the control of lake eutrophication and the ecological restoration of lakes, prospects on the research on the lake ecology and algal bloom.

This book will become a good reference for the persons who are engaged in algology, botany, population or ecosystem or conservation ecology, hydrology, environmental science and management so on.

After all, prevention of a problem is always better than trying to fix it after its happening. In order to prevent human-induced fresh-water algal blooms, control-

ling agricultural, urban, and stormwater runoff, properly maintaining septic systems, and properly managing residential applications of fertilizers might be the most effective measures, which apply to not only China but also other countries with similar situations.

LI DEZHI¹ QIN AILI²

¹Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N), Shanghai, China. 200062; ²Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd. Songjiang, Shanghai, China, 201600)

OTHER

Atlas of Biodiversity and Conservation in the Yangtze River Basin

By Ouyang Zhiyun and Zhu Chunquan (Editor-in-Chief). 2011. Science Press, Beijing. 380 pages. 128.00 CNY.

The Yangtze River basin is important as the birthplace of Chinese civilization. For thousands of years, generations of Chinese people diligently work in this area, and promote the development of Chinese civilization with wisdom and sweat. The vast area is characterized by numerous lakes, fertile land, mild climate, abundant resources, long history and abundant cultures. The area is about 19% of the whole area of China. Its length, flow and basin area ranks the first in the major rivers of China. The population, GDP and grain output of this area is about 1/3 or more of China's total, thus this area occupies an important position in China. Hence, the status of ecosystem health of the Yangtze River Basin directly affects the sustainable development of China's national economy.

The biodiversity of the Yangtze River Basin is historically abundant. However, for a long time, the frequent and intensive human activities and various disturbance have imposed changes on this area. In recent decades, along with the rapid population growth and economic development, as well as the construction of large-scale infrastructure, the natural resources this area was over-exploited, leading to degeneration of natural vegetation, soil erosion, river block, wetland and lake shrinkage, water pollution, habitat fragmentation, endangered species increase and other ecological and environmental problems. Thus, biodiversity resources in this area suffered from unprecedented threats. Yangtze River basin has become one of the most prominent centres of interweaved conflicts in terms of regional economic development, natural resource exploitation and biodiversity conservation in China.

To scientifically protect the biodiversity in the Yangtze River basin, WWF organized a research project on the distribution pattern of biodiversity resources and the conservation planning based on priority degrees of the different areas of the Yangtze River Basin, aiming at

promoting the rational protection and use of the regional natural resources, and providing a basis for the General Plan for the Yangtze River Ecoregion 2010-2015, while providing a reference basis for the decision-making departments. The Atlas of Biodiversity and Conservation in the Yangtze River Basin is the reflection of such integrative research project.

To keep the integrity of regional ecosystems and wildlife habitats, the book included the Qiantang Nature Reserve, Ruoergai region, the northern slope of Qinling Mountains, Qiantang River basin, Hunan and Jiangxi Province into the range of the evaluation and planning. The main content of the book is Part I – a Brief Introduction to the Yangtze River Basin. The sections include the location and the administrative divisions in the Yangtze River Basin, and the topography, climate, soil types, water system, water resources, population distribution, cities, economic development, transportation systems and land use in the Yangtze River Basin. Part II covers Spatial Patterns of Biodiversity and Identification of Priority Conservation Areas. The sections included ecosystem types and their distribution in the Yangtze River Basin, such as forest, wetland, grassland, desert and agricultural ecosystems; the distribution of the major organism groups in the Yangtze River Basin, such as the key plants, mammals, birds, amphibians, reptiles; priority conservation areas in the Yangtze River Basin; assessments on the biodiversity conservation areas; analysis of threats to the biodiversity conservation areas; the impacts of township settlements, road, tourism, environmental pollution, exploitation of mineral resources, hydrological engineering, geological disasters, earthquake and floods. Part III defines Introduction to Priority Conservation Areas for Biodiversity in the Yangtze River Basin. Part IV breaks down Biodiversity Conservation Strategies and Recommendations for the Yangtze River Basin.

This book will become a good reference for the persons who are engaged in geography, GIS assisted geographic mapping, conservation ecology, population or ecosystem ecology and so on, or any other persons who are interested in the field of biodiversity conservation in the Yangtze River Basin of China.

LI DEZHI¹ QIN AILI²

(¹Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N), Shanghai, China, 200062; ²Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd, Songjiang, Shanghai, China, 201600)

Climate Change and Arctic Sustainable Development: Scientific, Social, Cultural and Educational Challenges

UNESCO (2009) UNESCO Publishing, Paris. 376 pages.

This publication is unbelievable, and naturalists working "on the ground" know about it. The failure of big and UN governments about Arctic and Climate issues manifests itself here in writing, once again and across many of the covered and diverse topics. Despite some well-meant voices and chapters, most of the writings of this style and by governmental representatives will stand out as a monument in time in regards to "talking big but doing (and achieving) virtually nothing" and for curbing Arctic climate change and global decay. The presented Conservation of Arctic Flora and Fauna (CAFF) program makes for one of many examples. "*Today their aim is to conquer, exploit and colonise*", this is what the UNESCO Goodwill Ambassador for Arctic Polar Issues has to say about the nations that are busy in the Arctic. Here we see what contributes to the global climate disorder. What has mankind really learned and improved upon?

This book keeps communicating "challenges", but fails to solve them, e.g. by promoting a global financial reform, big institutional changes and through a new (better) form of governance and society. Who should not strive for such a change in times of global crisis?

By now, virtually everybody can see worldwide that Sustainable Development eventually has failed, and that it is very harmful. We have reached the end of another era and its ideology, again; and nature paid the bill once more. This is widely published in the scientific literature and elsewhere, and it can be seen already for decades with Climate Change, as well as in the myriads of habitat and species loss problems. This book has much in stock for naturalists in Canada and elsewhere. Impacts of 'Canadisation' are presented. However, most of our major governmental institutions still keep promoting their disastrous concepts of 'green development' and modernisation, but meanwhile destroying, at full steam, the earth, its biodiversity, habitat and people. This can hardly be called noble and royal. Along the Foreword section of this book and written by various dignities ("*HSH Prince Albert II of Monaco also attended the closing session*") makes you already wonder about the environmental mind of our royal families (e.g. Monaco, Denmark, UK, Holland, Sweden and Norway; many are the heads of major oil-run nations

and of their industries) and of many world leaders. The Nobel prize is still rooted in such a mind set.

Each of the nine book chapters cover three to six topics (with appendices 4 to 18 brief pages) and by many different authors. A wide variety of Arctic topics is discussed: Ice, Oceans and Atmosphere; Biodiversity and Ecosystem Services; Community-Level Impacts and Adaptation; Health and Well-Being; Economic Development and Social Transformations; Education; Ethics, Responsibility and Sustainability; Monitoring Systems. All Arctic nations and many stakeholders are represented, including many indigenous voices and cultural entities (It is notable here that the U.S. has no Ministry of Culture). Many of the color illustrations, some tables and the literature references (done for each chapter) are informative and can serve as a lasting reference to the readership on political, statistical and Arctic details.

I would like to present here the Greenland chapter in order to exemplify my critique (the book is full of many other examples that fall flat in real world sustainability, such as the Arctic Wetland one and its adaptive management suggestion authored by large NGOs): The climate change disaster is already well-known for these countries; but further, relatively small nations and without any military power and relevant budgets like Greenland (or Iceland for instance) can easily get bought out by the corporate industry and by wealthy nations. Just another social engineering experiment is there in the making: But this time it is run by the corporate industry and covered up by the 'free world'. The chapter authors and editors simply forgot here to consider and to report on all the victims of climate change and of an ideological regime which just favours schemes of resource extraction and money first. Balanced and fair approaches (e.g., at least a 50:50 deal, or much better) seem not to exist (Greenland just gets a 25% deal for its people). Alone seven more (!) mines are expected to operate in Greenland soon, oil is to be delivered, and the Arctic Shipping Lane comes handy to provide and transport supplies and resources (not to mention all the arctic air traffic; a topic that is not addressed at all in this book). And as if Greenland is not already widely over-harvested and overused enough, e.g. in regards to browsed vegetation, fisheries and seabirds (similar details can be reported for adja-

cent Iceland also and where 7% of Atlantic Puffins are yearly harvested and now have problems to even raise any chicks). The promotion of one-sided economic growth schemes does not fight poverty, it simply makes it worse. The Persistent Organic Pollutant (POP) contamination now makes for a great but sad example, and where the supplied European-style food does not provide a good and healthy balance to Greenlanders, whereas the original subsistence food items (but which are now contaminated) are toxic and contribute to cases of diabetes, sudden cardiac death and psychiatric disturbances. That's how climate change starts to look like in real life.

While this book and its impact unfolds, any naturalist can witness here just another genocide in the making. Once more, and same as in Africa (e.g., Hutu and Tootsie conflict, or Sudan and Liberia for decades), or with many other indigenous populations. UNESCO does nothing against it really and huge human losses and sufferings occur. The powerless pay our bills. The presented law suits against Exxon Mobil by the tiny Alaskan village of Kivalina regarding the sea level rise and the disappearance of their home island make that case clearly (villages like Shishmaref and many others have similar issues to fight).

And where is the church from the western world (which otherwise has a strong grip on the UN) and acclaimed gate keeper of humanity (their missionary wrong-doings are covered in some chapters, and so is the colonial history of the Arctic)? The petition lead by Inuit leader and Nobel Peace Prize nominee S. Watt-Cloutier about an urgent "*relief from human rights violations resulting from the impacts of global warming and climate change caused by acts and omissions of the United States*" clearly show the culprits. The Male Declaration on the Human Dimensions of Climate Change calls for similar action.

But Achim Steiner, Executive Director of UNEP and a known hardcore, long-term promoter of sustainable development from the west, still states in the Foreword of this book boldly: "*If you look at climate change in the context of the Arctic you are witnessing humanity's capacity for irrationality at its zenith*". But then he kindly missed his own history and UNEP's track-record, and the fact that it is not humanity, but a pseudo-democracy and where the people have not much to say or to decide. Instead, in a sustainable world that would be truly based on scientific facts (but not on purely political administrations), UNEP and its leaders, its funders and business concept would be among the first to go.

On the good side, this book of 356 very well layed-out pages, promotes open access and data sharing, and thus transparency of science, governments (funding) and decision-making. It can be seen as a countermeasure to global corruption. However, many of the book contributors are not supporting and enforcing this great scheme in full, e.g., Norway, U.S. National Science

Foundation (NSF), Canada and Russia (The International Polar Year IPY only has a 40% compliance rate of its data policy). And due to the digital divide (a subject hardly addressed in this book), many of the small countries do not even have the capacity and skill to participate in such endeavour. Cloud computing might provide help (but is not covered in this book).

Besides not considering even the basics of ecological economics or a strict 40% protection scheme, this book also left out the oil & gas, and mining industry voices (likely they just prefer to stay quite?). But as an improvement to previous Arctic publications elsewhere, the "*Political tensions over sovereignty of the Arctic Ocean*" are shown as a real problem and the notion of an 'Arctic Treaty' (similar to the Antarctic Treaty) is at least discussed. Environmental ethics made it into several chapters also.

However, despite being an international UNESCO publication, this book fails also on the inclusion of African, Brazilian, Indian, Korean and Chinese voices (no chapters are devoted to them or provided by them; even views from Poland, Belgium, France and UK are missing).

Our last hope then is the Annex: International Expert Meeting 'Report and Recommendations' (based on the Monaco meeting and leading to this book and 67 recommendations). Well, the urgency of the Arctic problem got expressed, knowledge gaps outlined, and recommendations were made (many of which most governmental participants themselves frequently violate or do not follow even) and which follow the major schemes of the book chapters (Education, communication and outreach; Cultural heritage; Well-being and health; Economic development and resource management; Arctic governance; Establishing, sustaining and strengthening research monitoring systems; Information access and data sharing; Policy and decision support). And so goes the Arctic theatre and with the UN governance.

When it comes to the Circumpolar Arctic, to Climate Change and Sustainable Development, institutions and entities like the Arctic Council, CAFF, the Circumpolar Biodiversity Monitoring Program (CBMP), IUCN, The World Bank, WWF, EU-DAMOCLES and UN all widely failed their basic mandates. They are not proactive, have 'no teeth', no honest performance evaluation, and provided poor leadership thus far resulting in a global environmental crisis which global humanity has never witnessed before. A link with human suffering and loss of life can easily be made worldwide, and with 7 billion people and rising. Therefore, the assigned powers should be withdrawn from these institutions and for a REAL NEW Green Deal to come. This is because, and as every naturalist knows: Nature is our only master.

FALK HUETTMANN

Institute of Arctic Biology, Biology and Wildlife Department,
University of Alaska-Fairbanks 99775 USA

Life of Earth – Portrait of A Beautiful, Middle-Aged, Stressed-Out World

By Stanley A. Rice. 2011 Prometheus Books, 59, John Glenn Drive, Amherst, New York 14228-2119. 255 pages.

The emergence of life on Earth is so magical and fascinating that there are almost no other events in the world can attract so many people's lasting passion. Although the final reasons on many mysteries of Earth life, such as the origin and evolution, so far still have not yet been completely revealed. After the Gaia hypothesis was formulated, heated debate over whether all organisms and their inorganic surroundings on Earth are closely integrated to form a single and self-regulating complex system, maintaining the conditions for life on the planet, and the extent to which non-intelligent life on Earth is able to adjust planetary conditions to promote its continued survival and prosperity, was launched and prolonged up to now. Hitherto, the published books about the various aspects of Earth's life, including its relationship with environment, are voluminous in the world. They are all with characteristics, different in points of view, narrative ways, content arrangement and so on. So, it would be very hard for an author to elucidate such a classical topic in a new and unique way, even based on abundant new material and deep ideas. It is impressive and commendable that the newly published book *Life of Earth – Portrait of a Beautiful, Middle-Aged, Stressed-Out World*, written by Stanley A. Rice, gave a fresh and new style of description on the Earth with plentiful material and deep insights.

The author did a masterful job of integrating knowledge from a variety of disciplines, showing the many connections of life on Earth. Eloquent in tone and panoramic in perspective, the book fosters a vivid appreciation of our planet, reflecting the author has an unrivalled knowledge of the history of the Earth and its implications for human society. The book described the Earth with the evolutionary development of an unknowable wealth of species as a profusely complex and beautiful planet, and regarded Earth is on about halfway through its approximately ten-billion-year existence. Humans are in the unique position of being able to look back and reconstruct the past, look around and discover its ferocious beauty, and look forward to predict its future.

Out of the run of the most other books on Earth's life history, which narrate the story of life on Earth in terms of chronological period one after another, this book discussed the rich and colourful diversity on Earth in terms of pivotal evolutionary developments, among which, the importance of symbiosis, sexual selection, altruism and photosynthesis were emphasized as crucial determinants of the Earth's biodiversity. The book believes that the time at which single cells began working together sparked the sudden appearance of complex animals. Much later, symbi-

otic relationships led to flowering plants that depended on animals for pollination and seed dispersal. With the advent of sexual selection there developed an astonishing world of complex behaviour and a dizzying array of life-forms. In humans, sexual selection exerted a great influence on the development of our large brains. Species learning to work together resulted in even greater variety and complexity. In early humans, altruism gave rise to ever-widening social circles and contributed to the spread of culture. Beyond dispute, photosynthesis of green plant plays an irreplaceable and important role of in maintaining the function of the whole ecosystem of Earth. Thus, the book regarded these events as crucial events in the life evolution and biodiversity maintenance on Earth.

The factors influencing on the evolution and the diversity of life on Earth are multifold, among which the most important one differs in various periods, to which no unanimous conclusion can be drawn. Ancient natural catastrophes caused wide-spread extinctions several times, yet life on Earth still tenaciously recovered and reached a new prosperity. When the human population rises in swift and violent manner compared to any other wild life populations on the Earth, humans gradually become a new increasingly powerful strength affecting or shaping the life evolution or biodiversity on Earth. Humans represent the most incredibly complex development and interweaving of not only sexual selection and altruism but also religion and reason – more than in any other species that has ever lived on the planet. The book focused on human evolution and the extraordinary effect human beings have had on the Earth. The author does not overlook the immense prehuman history of the planet, thereby emphasises the importance of the evolutionary process to understanding human development and action. This comprehensive book illuminated the subject and the important role of humans. We have every reason to believe that humans' role in the future life development or evolution on Earth will become more and more critical and strong. However, if humans cannot restrain or regulate their behaviours so as not to seriously disturb the balance of the Earth's ecosystem, life on Earth would fall into ecological crisis.

The book was written as prose, employing an entertaining and informal style, expressing and explaining the complex relationships of earth science, and the weirdness and wonder of the evolutionary history on our Earth. It is described in easily understood ways and engaging language, and with excitement and humour, as well as profound sentiments. It is the book that can lead readers to experience the life story of Earth in an exciting way never before imagined. The author's cov-

erage of diverse topics would appeal to all who wish to understand the multifold meaning of the evolution of the planet.

That main contents of the book included Introduction: A Pile of Rocks in the Middle of Kansas; Chapter 1 Meet Mother Earth; Chapter 2 Inevitable Evolution; Chapter 3 Innovation; Chapter 4 Symbiosis; Chapter 5 Sex; Chapter 6 Altruism; Chapter 7 Religion; Chapter 8 Science; Chapter 9 Faith in photosynthesis.

This book would become a good reference for the people who are engaged in anthropology, biology, hu-

man ecology, conservation ecology, population or ecosystem ecology and so on, or any other persons who are interested in the field of Earth life.

LI DEZHI¹ QIN AILI²

⁽¹⁾Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N), Shanghai, China, 200062;

⁽²⁾Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd. Songjiang, Shanghai, China. 201600)

5 Easy Pieces – The Impact of Fisheries on Marine Ecosystems

By D. Pauly. 2010. Island press, 1718 Connecticut Avenue, N.W., Suite 300, Washington, D.C. 20009-1148 USA. 236 pages. 25.00 USD. Paper.

Fisheries is making an annual global loss of 54 billion dollars; it is therefore no wonder that we have an ongoing global crisis (in terms of ecology, food, in our society, financially and even in the sciences who widely promote such an approach still). Thus, and as expected, this book by the infamous Prof Dan Pauly from the University of British Columbia (UBC), Vancouver, and with the Sea Around Us project (www.seaaroundus.org) makes for fireworks. It is presenting in a remarkable but simple and convincing style the scientific evidence and arguments for the decline of the oceans (c. 2/3 of the living world) and which is fuelled by the global management and institutions of western dominance, e.g., the Food and Agriculture Organisation (FAO).

This book is done by THE GRAND MASTER of sustainable world fishery analysis. It re-tells and explains the exciting story of five of his high impact studies published with the prestigious journals of SCIENCE and NATURE (and as discussed in newspapers worldwide and even in *The Economist*). Besides a general background reading and an introduction to his life's work, naturalists might also be interested in learning about the intimate backstage stories and various rebuttals to colleagues and editors about those high impact papers. The preface of this book states all key features, and thus the subsequent text sections make for an easy but very informative read.

Like many others did before, Pauly exposes B. Lomborg once more for his nonsensical pro-industry statements, e.g., that 90 million tonnes of fish harvest would just be a small price (!?) to pay for global overfishing. An entire chapter is devoted to the widely cited 100 million tonnes myth of a sustainable global fish harvest. It gets assessed in this book and basically declared as a poorly founded fairy tale and that it is unsustainably high resulting into a global suicide. The underlying quota-setting formulas, and often developed in the 1960s and when computers, good data and modern (non-linear) statistics hardly existed, such as Beverton

& Holt, Schaefer Model, Gulland equation and Ricker Curve are discussed. Their flaws are exposed in concept and detail. The science of the Total Allowable Catch (TAC) is elaborated, and so is the Maximum Sustainable Yield (MSY) concept and that the potential yield would consist of 50% of natural mortality of the stock and its unexploited biomass. Naturalists learn in an easy to comprehend language about the various problems in the fisheries sciences, with their underlying assumptions and quota computations (referred by the author as "dead bones get transferred from one grave to another"). And so, throughout the book Pauly elaborates convincingly that fish harvest is limited by nature (a fact that many leading officials with The World Bank, International Monetary Fund, World Trade Organization, Asian Development Bank etc. still proudly ignore to this very day). It was Dan Pauly who showed that basically 30% of ocean algae guarantee the world's fish production. Of course, 'Harvesting Down the Food chain' makes for the major scheme of this publication, and as it relates to the infamous Ecopath & Ecoim model work, and Froese's online database 'Fishbase' (www.fishbase.org). Indeed, we are at 'peak fish' (a situation which will get worse for society now after 'peak oil' to fuel fisheries, and after 'peak soil' and 'peak farming') and while the human population and consumption rises. It becomes clear that no reasons exist why 'the rise of slime' will not occur (another scheme promoted by Pauly and where eventually only small critters can survive the human pressures and nets).

Naturalists will further appreciate the deep concepts of 'embodied energy' (Odum 1988) and of 'Farming up the Foodweb' (a hot issue for Canadians on both coasts. Facts are presented that aqua farming cannot really sustain our world hunger; nor does it provide many jobs. It's a sink).

Over the 193 pages of this exciting book Pauly shares with us the world view of a widely miss-managed fisheries, and specifically from the tropical view point. The

author started his career with the International Center for Living Aquatic Resources Management (ICLARM) in Manila/Philippines, e.g., showing us that single species concepts are widely failing for most of the global fisheries. Unfortunately, Pauly does not share with the audience his German training experience and how the university in Kiel treated him and his views, and why he was not employed there (or in the EU, in U.S. and with NMFS and NOAA, all of which are in need of a massive overhaul). Canada and UBC got a bargain instead and now host the leading sustainable fisheries scientist with Dan Pauly (a fact the Department of Fisheries and Oceans DFO and many government representatives are probably all but happy about).

This great book takes on the 'bureaucratic mummifications' of our institutions, and how harmful a reductionism view really is (although the work by Pauly and his team unfortunately is still heavily vested in frequency statistics, linear hypothesis testing and parsimony even). It gets shown that fisheries science is still a relatively young discipline, and was initially set up in full support of industry; a feat that it still has not recovered from well and which is at the core of the global fisheries management crisis: an aggressive neo-colonial western economic growth culture rules, still assuming we are the gods of the universe running 'objective' science'.

And so, here we learn the many facets how in FAO and other fisheries agencies, politics trumps science, supporting industrial and monetary interests. Pauly phrases this for Canada in the following way: "...the capture by the fishing industry of the very agencies that are supposed to regulate them (well documented in Canada, Rose 2008)". The integrity of the system becomes widely compromised and resulting into situations like the "*Systematic Distortion in World Fisheries Catch Trends*".

Pauly also shows us clearly that FAO is the only agency that maintains global fisheries statistics, and thus having a monopoly and which should come with a thorough ethic. By now, it just must make everybody cynical that the FAO staff even themselves confirm that their own catch statistics are not detailed and reliable enough for many valid interpretations (or for an urgently needed conservation management). Pauly refers to such cases as a '*judo argument*' (supposed to be a defensive fact but that actually is in favour of the presented argument of a poor management and overfishing). And with that, what should one really think about FAO's own '*Code of Conduct*' (designed to provide trust in the agency)? Sounds cosy though. And how much trust is really to be placed in such an assigned world leadership (or can it just be called what it really is: overfishing terror favouring environmental destruction on a global scale fuelled by many western nations)?

Many industry lobbies argue against Pauly's facts, trying to extend their 'business as usual' scheme as long as possible, and trying to make a living from the fact that the ocean is known for its ongoing and new

taxonomic species descriptions documented every year. But this book shows the true role of taxonomic fiddling and species resolution, and where depending on the assigned taxonomic system, findings can greatly differ showing the magnitude impacts. In the FAO case this results into FAO masking relevant trends in their own statistics, presenting figures of 'no impact' (but which are in reality underestimates) and which really must be fixed to avoid the global bankruptcy (overall, that's where we are all heading at). Pauly and his colleagues also show the role of cycling fish species populations (e.g., Anchoveta, Chilean horse mackerel, Japanese and American pilchards, Alaska Pollock) for accurate global fisheries statistics, quotas and interpretations. By now it comes to no big surprise that even the FAO fisheries management zones (an essential unit for quota assessment) basically come from the 1950s and are based on no, or outdated, science.

Another bigger section of this hook covers the fraudulent statistics (here: over reporting of fish harvest) submitted by China to FAO and to the world. That can be equalled to a crime because it results not only in wrong quotas, but also in wrong investments and fisheries protection measures. It easily makes for a global food and ecosystem betrayal scheme. We must thank Pauly for this (dangerous) detective work. In FAO, apparently nobody really noticed the Chinese reporting scam for decades (which becomes quickly obvious to experts just by looking at numbers and local marine realities).

To be used in a public discussion, the naturalist will finally enjoy the great examples and documentation about overfishing, e.g., for the Bay of Fundy, the Black Sea, Namibian fisheries, parts of India and China. Notably Large Skates disappeared in the Irish Sea (unfortunately the many overfishing examples of British Columbia or the nearby Puget Sound crisis are ignored in this text, so are the Alaskan ones). I am also deeply disappointed that the Canadian Department of Fisheries (DFO) and all its wrong doings are virtually unmentioned in this book, nor the internal FAO, Science and UBC University politics and lead ups, including how China, India, Russia act in FAO (needless to say that Canada is a big international player, and its role and representatives are not mentioned here even). Naturalists with an open mind and reading between the lines will find out that FAO basically presents a politically fabricated image to the global public, and which results into crimes against nature, but while some companies are happily make big bucks. It is too bad that Pauly himself does not elaborate more on this (unethical) issue and which likely is rife with sophisticated crime and corruption schemes potentially involving many key players, governments and NGOs in Canada and beyond.

But Pauly clearly shows that governmental scientists (providing for the largest number of fisheries scientists) are silent when a conflict of interest occurs. Thus, scientists in universities must provide all details

and make the case public and for a resolution instead. This burden is on them.

Pauly and colleagues suggest that for the next decades effort is to be spent to re-building fish populations embedded within functional food webs, within large "no take" marine protected areas. With that, it's almost funny to learn that R. Gutting Jr stated "*vast ocean areas have already been set aside as no-fishing zones*" (in reality just less than 1% of the oceans are protected, and this number will not change much in the coming decade for ecologically relevant areas).

I find that despite the great facts and writing, the last chapter on 'Future of fisheries' widely underachieves. It's almost inappropriate that Pauly does not mention in this book climate change and population growth impacts (or the related notions of religion, birth control and development aid). Further, he does not elaborate much on the fact that most large fisheries now are owned by international corporations and supported by big NGOs (e.g., as done indirectly by WWF), seen by all for all as sound investment projects, and thus with decisions widely driven by banks (and who then get bailed out on the public dime; The Iron Triangle rules). We do disagree beyond an oversight by Dan Pauly that he still does not put Economic Growth and its promotion as a major culprit of the global fisheries crises and created by the west and its institutions (a fact that the American Fisheries Society AFS has widely acknowledged; see steadystate.org for position statements on Economic Growth by AFS etc.).

This text overall is asking whether Fisheries and Ecology are a contradiction? Many other bits and pieces are also of interest and are a joy to read, e.g., the section titled "The world according to Stuart Pimm" or about finding the Fermi solution (how to get at the complete, or reasonable, estimate when only a fraction of the data are known) and the scandalous fact that "*The markets display vast arrays of seafood of uncertain origin and identity...*". I really enjoyed the historical overview for world fisheries and for sustain-

ability (Naturalists knowledgeable about native societies though will take issue with Pauly's views that once people get technology in their hands, resources just tend to get overused).

The overwhelming majority of fisheries is said to collapse by 2050s (this also happens to be the predicted date when summer sea ice in the Arctic is to disappear and when polar bears and other ice-related species are predicted to be largely gone). We learn that the only gains in fisheries are just brought by spatial expansion and increases of fishing depth effort. And so it remains not clear why Jane Lubchenco, fishery ecologist par excellence and now head of NOAA (arguably one of the world's most powerful national fisheries services) still does not implement Pauly's views (and which have been around for over two decades)? It's the American carbon reduction failure re-visited, this time just with fish.

It should be mentioned that the text also consists of great figures and graphs, including a very readable endnote sections and three appendices. It is completed with nice (global) fisheries statistics for the naturalist to use for his/her enjoyment and public argument.

Although this books is about relatively easy and logic subjects that most people know and see daily anyway (e.g., that "...the concept of 'sustainable growth' is nonsensical"), it must rank as one of the top 10 books on global fisheries and food provisioning (similar books about the global rice, grain, corn etc. crisis still have to be written). So yes, Island Press, Dan Pauly and his world-wide team of students, scientists and journalists did it again.

Rose A. (2008). *Who killed the Grand Banks: the untold story behind the decimation of one of the world's greatest natural resources*. John Wiley & Sons, Mississauga, 320 pages.

FALK HUETTMANN

University of Alaska-Fairbanks (UAF), Fairbanks Alaska
99775 USA

Wetlands of the Ontario Hudson Bay Lowland: A Regional Overview

By John L. Riley. 2011. Nature Conservancy of Canada, Toronto, Ontario. 156 pages. + appendices. Paper and available online: NCC – <http://www.natureconservancy.ca> OMNR – <http://www.mnr.gov.on.ca/en/Business/FarNorth>

What is a fen? Are there different kinds of fens and how do you tell them apart? Here is an overview that answers these and many other questions for one of the most important wetland areas in the world. In fact the Hudson's Bay Lowland is the world's third largest wetland and the largest in North America, – and 83% of it is in Ontario. It takes up ¼ of the province and spills over into Quebec and Manitoba. The area has a significant effect on earth's climate by sequestering atmospheric carbon. It also home to a fascinating diversity of plants and animals. This globally important landscape is likely to experience rapid environmental changes over the next few decades. This requires effi-

cient and informed land use planning – and here we have the basis for it.

The use of many colour photos not only increases the book's appeal, but also is important in illustrating the subject matter. It is of interest to think a little more about the photos. Several of them show the author and/or his colleagues on a sunny day with a blue sky – and of course it looks like fun. Try to imagine the risks associated with this remote area and the extreme discomfort of biting insects and bad weather. Working in the lowlands was not an easy job.

The first chapter entitled "Regional Overview" covers geology, climate change, carbon storage and bio-

logical diversity. There are a few more studies that might be referred to, but one has to remember that this is an overview and its particular strength is in wetland classification. Those seeking a little more in the area of biodiversity may refer to Desroches *et al.* (2010), James *et al.* (1983), Peck (1972), Prevett & Lumsden (1983), and Sutherland *et al.* (2005). Biological information has been gathered from the more accessible parts of the lowlands around Moosonee and at Churchill, Manitoba, and this can be searched online. It may be of interest to readers that most of the articles listed above were published in Canadian Field-Naturalist. Actually the journal has long played a role providing information on the Hudson Bay Lowlands. It was in 1896 that J. B. Tyrrell and R. Bell were disagreeing over whether or not the land around Hudson Bay was still rising. Bell's article in "The Ottawa Naturalist" entitled "Proof of the Rising of the Land Around Hudson Bay" was supported by later research and Riley cites Weber's figure of 1.2 m per century over the past 1000 years.

The "Regional Wetland Variability" chapter begins with a valuable history of terminology and classification and concludes with a useful description of major wetland formations. The following chapter describes sampling procedures. "Environmental Variability" presents quantitative vegetation ordination (detrended correspondence analysis). A few statistics wizards will want significance tests, best fit regression lines and perhaps a more direct use of correspondence, but as it stands the figures are well chosen and quite adequate to indicate the trends discussed. This chapter provides a good understanding of variation on broad geographic scales and concludes with a useful table of plant indicator species.

The chapter entitled "Ecoregional Wetland Characteristics" describes wetlands of the lowlands on the basis of ecoregions recently established by the Ontario Ministry of Natural Resources (OMNR) and by the National Wetland Working Group two decades ago. How this relates to the national system is not as clear as bog water and may have deserved more discussion, but in fact the boundaries are almost identical. The OMNR ecoregions are shown on Figure 1, page 11. The final chapter is entitled "Major Wetland Types." It included helpful photos and lists of dominant species.

Appendix A includes a key to wetland types including formations, subformations and groups. It is a major contribution. Appendix B is a list of dominant plants in different formations, subformations and groups, as well as indicating their distribution by ecoregion and association with permafrost, – another major contribution. Appendix C is a catalogue of wetland site types showing floristic composition, pH, peat depth, etc. Users will notice that Riley has effectively included the mosses which play such an important role in the lowlands. Appendix D includes graphs showing cover

values and surface water pH for common peatland species. Appendix E provides updated scientific names. Finally the reference list appears complete and will serve as a valuable general source for the lowlands.

This is a very good overview and not much is missing. How the fauna fits into the wetland types, the effects of climate change using improved models, and other aspects require more study. There was definitely no reason for the author to talk about the pre-glacial vegetation of the region, but I find it interesting that Woolly Mammoths may have occupied the area in those times (Nielsen *et al.* 1988) suggesting a different vegetation than the wetland of the postglacial period.

Although I found some minor errors (e.g., *Sagittaria* is spelled wrong on p. 102 and the key to dashed lines on Figure 3 is reversed), this is an impressive, authoritative and essential overview. In fact it is an outstanding summary of older information and contains much new information as well. Any biologist in northern Canada could benefit from it.

Publication support for this document seems to be an excellent way for the Ontario Ministry of Natural Resources (OMNR) to assist First Nations in planning under the Far North Land Use Planning Initiative. It also seems to be an excellent way for the Nature Conservancy of Canada (NCC) to assist in the North where their usual activities of evaluation, acquisition and stewardship are less easily applied. These publication partners are to be applauded for making essential information so readily available.

It is also important to remember the supporters of the many years of research in the lowlands that provides the substance of this overview. The details of this research can be accessed through this overview. The supporters were the Ontario Ministry of Natural Resources (Remote Sensing, Forest Research and Ontario Parks), Canadian Forestry Service, Environment Canada (Canadian Wildlife Service, Lands Directorate) and the Royal Ontario Museum. All of these agencies can take some pride in this accomplishment which is one of many beneficial results of their reliable support over a long period.

Finally John Riley is already a legend with respect to the lowlands – and to conservation in Canada (major syntheses of information on the Niagara Escarpment, Ontario alvars, etc. for conservation planning). An extensive and unique knowledge is required to write this kind of book, but it also requires great dedication, determination and love. In many cases a synthesis of this kind never gets done because the requirements are unusual and unmet. Luckily sometimes they are met. This very valuable and authoritative work will help us understand and protect the lowlands – a huge and important part of Canada. Like some of Riley's other works, it is a major contribution to land use planning based on excellent scientific research.

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PAUL M. CATLING

170 Sanford Ave., Ottawa, Ontario K2C 0E9

Wetlands of the Hudson Bay Lowlands – An Ontario Review

By John Riley. 2011. Nature Conservancy of Canada and the Ontario Ministry of Natural Resources, 36 Eglinton Avenue West, Suite 400, Toronto, Ontario M4R 1A1. 156 pages.

The Hudson Bay Lowlands are the longest marine wetlands in the world and cover an area larger than Great Britain. Because of the harsh living conditions and swampy nature of the area there are few people. The lowlands are shared with Manitoba and Quebec, and the area came to prominence with the construction of the La Grand River hydroelectric project in the 1970s and 1980s. This flooded large areas resulting in the release of mercury that had major impacts on the wildlife [including humans] Similar developments could have major consequences for the Ontario wetlands.

This book is a scientific report of the results of field investigations along the Ontario coast of Hudson and James Bay. Written by John L. Riley, Chief of Science of the Nature Conservancy of Canada and the author Flora of the Hudson Bay Lowland and its post-glacial origins [on the National Research Council Canada's website – put in the title, not the impossibly-long URL]. The current work is an inventory and mapping of the region's plant biodiversity. Its primary purpose is land use planning to enable authorities to identify areas for protection and potential sustainable economic development. The report covers the geology, climate and biology of this remote area. Using defined sampling methods the author establishes wetland variability and succession, environmental variability and wetland types and characteristics. Appendices add further information on the wetlands and vegetation.

This is a book for scientists and very serious amateurs. For example, all the species are identified by their scientific name only. Those who have the background will find this work to be a great resource that contributes significantly to our knowledge base of Northern Ontario. It identifies all the wetland types and gives their critical physical and chemical characteristics. There is good coverage of the vegetation which includes mosses, grasses as well as higher plants. There is little information on animal life and, oddly, the author only uses their common names.

The report is well illustrated by numerous air and ground photos, supplemented by close ups of flowers and seeds. There are several excellent maps and many graphs and charts. These additions and the well organised text make this an easy report to use. There is no index, but I had little difficulty finding what I wanted to research using the index.

The only other comment I have is the author's incorrect use of the word parameter in a report that is otherwise so precise.

This report is a valuable and important addition to an under-researched area of Canada. I hope it will be used by those making decisions on development in this sensitive region. I doubt if many politicians will understand its information, but they should listen to the scientists who advise them. Personally I was delighted to read it, as I will be visiting James Bay this summer, and I extracted much useful material.

ROY JOHN

2193 Emard Crescent, Ottawa, K1J 6K5

NEW TITLES

Prepared by Roy John

† Available for review * Assigned

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

ZOOLOGY

Amphibians and Reptiles – An Introduction to Their Natural History and Conservation. By Marty Crump. 2011. McDonald & Woodward Publishing Company, 431-B East College Street, Granville, Ohio 43023 USA. 264 pages. 29.95 USD. Paper.

Animal Camouflage – Mechanisms and Function. By M. Stevens and Sami Merilaita. 2011. Cambridge University Press, Edinburgh Building, Shaftesbury Road Cambridge CB2 8RU United Kingdom. 376 pages. 65.95 USD. Paper.

Boreal Birds of North America. Edited by J. Wells. 2011. University of California Press, 2012, Berkeley Way, Berkeley, California 94704 USA. 160 pages. 39.95. USD. Cloth.

* **Birds of North America and Greenland.** By Norman Arlott. 2011. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 224 pages. 15.95 USD. Paper.

* **Urban Carnivores: Ecology, Conflict and Conservation.** Edited by S. Gehrt, S. Riley, and B. Cypher. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363 USA. 285 pages. 75.00 USD. Hardcover.

* **Insect Ecology – Behavior, Populations and Communities.** By P. W. Price, R. F. Denno, M. D. Eubanks, D. L. Finke and I. Kaplan. 2011. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013 USA. 801 pages. 85 USD. Paper.

* **Population Demography of Northern Spotted Owls.** By E. Forsman et al. 2011. University of California Press, 2120 Berkeley Way, Berkeley, California 94704 USA. 106 pages. 39.95 USD. Cloth.

Petrels, Albatross and Storm Petrels of North America. By Steve Howell. 2012. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 520 pages. 45.00 USD. Cloth.

* **A Field Guide to Sea Stars of the Pacific Northwest.** By N. McDaniel. 2011. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. Eight fold 9 inch by 36 inch plasticized sheet. 7.95 CAD.

* **Whelks to Whales – Coastal Marine Life of the Pacific Northwest [Second Edition].** By R. Harbo. 2011. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 328 pages. 25.95 CAD. Paper.

BOTANY

A Field Guide to Edible Mushrooms of the Pacific Northwest. By Daniel Winkler. 2011. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 7.95 CAD. Pamphlet.

* **21st Century Guidebook to Fungi.** By David Moore, Geoffrey D. Robson and Anthony P. J. Trinci. 2011. Cambridge University Press, Edinburgh Building, Shaftesbury Road Cambridge CB2 8RU United Kingdom. 627 pages, plus CD. 135.00 USD.

* **Sarraceniaceae of North America.** By Stewart McPherson and Donald Schnell. 2011. Redfern Natural History Productions, 61 Lake Drive, Hamworthy, Poole, Dorset BH15 4LR, United Kingdom. 808 pages. 34.99 GBP.

* **Sarraceniaceae of South America.** By Stewart McPherson, Andreas Wistuba, Andreas Fleischmann and Joachim Nerz. Redfern Natural History Productions, 61 Lake Drive, Hamworthy, Poole, Dorset BH15 4LR, United Kingdom. 562 pages. 34.99 GBP.

ENVIRONMENT

* **Books and Naturalists.** By D. E. Allen. 2010. HarperCollins Canada Ltd., 1995 Markham Road, Scarborough, Ontario M1B 5M8 Canada. 496 pages. 50.00 USD approximately. Paper.

The Face of the Earth – Natural Landscapes, Science, and Culture. By Sue Ellen Campbell. 2011. University of California Press, 2120 Berkeley Way, Berkeley, California 94704 USA. 334 pages. 26.95 CAD. Paper.

Crop Ecology – Productivity and Management in Agricultural Systems [2nd Edition]. By David J. Connor, Robert S. Loomis and Kenneth G. Cassman. Cambridge University Press, Edinburgh Building, Shaftesbury Road Cambridge CB2 8RU United Kingdom. 562 pages. 52.00 USD. Paper.

Convergent Evolution – Limited Forms Most Beautiful. By George McGhee. 2011. The MIT Press. 55 Hayward Street, Cambridge, Massachusetts 02142-1493 USA. 312 pages. 35.00 USD. Cloth.

In the Light of Evolution: Essays from the Laboratory and the Field. By Jonathan B. Losos's Roberts and Company Publishers, 4950 S. Yosemite Street, F2 #197, Greenwood Village, Colorado 80111 USA. 49.95 USD.

Fire Management in the American West – Forest Politics and the Rise of Megafires. By Mark Hudson. 2011. University Press of Colorado, 5589 Arapahoe Avenue, Suite 206C, Boulder, Colorado 80303 USA. 256 pages. 55.00 USD. Cloth.

Okanagan Geology South – Geologic Highlights of the South Okanagan, British Columbia. By Murray A. Roed & Robert J. Fulton, [Eds], 2011. Sandhill Book Marketing Ltd., Unit #4 – 3308 Appaloosa Road, Millcreek Industrial Park Kelowna, British Columbia V1V 2W5 Canada. 257 pages. 24.95 USD. Paper.

† **Social Networks and Natural Resource Management – Uncovering the Social Fabric of Environmental Governance.** By Órjan Bodin and Christina Prell. Cambridge University Press Edinburgh Building, Shaftesbury Road Cambridge CB2 8RU United Kingdom. 390 pages. 55.00 CAD.

British Columbia's Inland Rainforest – Ecology, Conservation, and Management. By Susan Stevenson, Harold

Armleder, André Arsenault, Darwyn Coxson, Craig DeLong and Michael Jull. 2011. UBC Press, University of British Columbia, 2029 West Mall, Vancouver, British Columbia V6T 1Z2 Canada. 456 pages. 95.00 CAD. Cloth.

* **Drive and Curiosity – What Fuels the Passion for Science.** By Istvan Hargittai, Prometheus Books, 59 John Glenn Drive, Amherst, New York 14228-2197 USA. 337 pages. 26.00 USD.

Priority! The Dating of Scientific Names in Ornithology / A Directory to the Literature and its Reviewers. By E. C. Dickinson, L. K. Overstreet and R. J. Dowsett. 2011. Aves Press Limited, 35 Monarch Road, Northampton, NN2 6EH United Kingdom. 320 pages. 90.00 EUR. Cloth.

* **Spatio-Temporal Heterogeneity – Concepts and Analyses.** By P. Dutilleul. 2011. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473 USA. 393 pages. 57.00 USD [Paper]. 125.00 USD [Cloth].

News and Comment

Conservation and Biology of Tortoises and Freshwater Turtles Annual Symposium 2012

The 10th annual symposium on the Conservation and Biology of Tortoises and Freshwater Turtles will be hosted 16-19 August 2012 in Tucson, Arizona. The meeting is co-hosted by the Turtle Survival Alliance

and the IUCN Tortoise and Freshwater Turtle Specialist Group (TFTSG). More information is available at www.turtlesurvival.org.

Dr. Kenneth William Stewart 1936-2011

Herpetologist and Ichthyologist Dr. Kenneth William Stewart died 3 July 2011 at Victoria General Hospital in Winnipeg. Professor Stewart was retired from the Zoology Department, University of Manitoba, where he had taught for 34 years after graduating from the University of British Columbia. Among successful PhD

candidates he supervised were the Canadian herpetologists Patrick Gregory and Francis Cook. In retirement, Ken completed *The Freshwater Fish of Manitoba* co-authored with Doug Watkinson, published in 2004. A comprehensive tribute to Ken is in preparation for a future issue of *The Canadian Field-Naturalist*.

Minutes of the 132nd Annual Business Meeting of The Ottawa Field-Naturalists' Club January 18, 2011

Place and time: Canadian Museum of Nature, Ottawa, Ontario, 7:00 pm
Chairperson: Ann MacKenzie, President

Attendees spent the first half-hour reviewing the minutes of the previous ABM, the Treasurer's report and the OFNC committees' annual reports for 2010. The meeting was called to order at 7:30 pm with some opening remarks from the President.

1. Minutes of the Previous Meeting

It was moved by Annie Bélair and seconded by Diane Lepage that the minutes of the 131st Annual Business Meeting be accepted with the following correction: in the Treasurer's report, the reference to the book "The Lichens of North America" must be deleted and replaced by "The Lichens of the Ottawa Region".

Carried

2. Business Arising from the Minutes

At the 2010 Annual Business Meeting, Frank Pope was asked to follow up with the Nature Conservancy of Canada to see if a commemorative plaque had been installed in recognition of the OFNC's contribution towards the purchase of the Hewlett-Packard property. Frank said that no, a plaque had not been installed yet. The Nature Conservancy is in the process of arranging a management contract with Queens University and they are also negotiating the purchase of adjoining land. A plaque will be installed when this business is wound up.

There was also a discussion about putting speakers' PowerPoint presentation on the OFNC website, or even a video of it. Ann mentioned that it had not been done and more people were needed.

3. Communications Relating to the Annual Business Meeting

There were no communications relating to the Annual Business Meeting.

4. Treasurer's Report – Frank Pope

Frank presented a synopsis of the financial activities of the Club over the last 5 years in three charts. The first covered net assets, the second total revenue and operating revenue, the third, operating revenue and operating expenses. The OFNC is still healthy in terms of net assets. In 2010, the operating revenue was greater than the operating expenses. This is a bit misleading since 6 back issues of the CFN plus 4 issues for 2011 need to be printed this year. The cost of publishing one issue runs about \$9,000.

In April, volume 125 of the CFN is scheduled to be published using the Open Journal System (OJS) that is now being installed. Nevertheless, printed copies of the CFN will still be published, although in reduced numbers. The financial impact of all this has yet to be determined.

Frank then proceeded with the Financial Statement which he covered page by page. He pointed out that this was a "review" and not an "audit". In an audit, source documents are examined. In a review, the financial statements presented by management are accepted as is. They are scrutinized from the point of view generally accepted accounting practices and any discrepancies are followed up. A review is cheaper than an audit and the trend is for small organizations like ours to have a review.

He said that this year, Janet Gehr is stepping down as auditor of OFNC accounts after 20 years of service to the Club. He thanked her on behalf of the Club and personally because she has been of much help to him over the past 10 years.

It was moved by Frank Pope that this financial statement be accepted as a fair representation of the financial position of the Club as of September 30 2010. Seconded by Fenja Brodo.

Carried

Following the Treasurer's Report, there was a discussion about the increase in the 2011 membership fees, as well as the new \$30 fee for hard copies of the CFN. Some Life Members objected to having to pay for printed copies of the CFN, claiming that the agreement when they bought a life membership was that they be provided with printed copies of the CFN. Ann MacKenzie referred to the President's Perspective in an earlier Trail and Landscape that explained the financial situation of the OFNC.

It was also mentioned that a way should be designed to get the members' opinion on issues such as increasing membership fees.

The question of having a student fee was also raised. Ann agreed to bring this to Council for discussion. ACTION: Ann MacKenzie

5. Committee Reports

Ann MacKenzie asked for questions and comments on the 2010 committee reports which had been distributed to the attendees. Some rewording in the Awards Committee's report was suggested. An error in the Conservation Committee Report was also identified. The report reads "The Greenbelt Coalition has so far failed to submit any detailed policy document to the Greenbelt Master Plan Review team." In fact, the policy document was submitted in September.

Moved by Ron Bedford and seconded by Diane Kitching that the reports be accepted with the above correction.

Carried

6. Nomination of the Financial Reviewer

Moved by Frank Pope and seconded by Diane Lepage that the accounting firm of Welch LLP be nominated to conduct a review of the OFNC's accounts for the 2010-11 fiscal year.

Carried

7. Report of the Nominating Committee – Fenja Brodo

SLATE PROPOSED BY THE NOMINATING COMMITTEE

Officers

| | |
|--------------------------------|-----------------|
| President | Ann MacKenzie |
| 1 st Vice President | Fenja Brodo |
| 2 nd Vice President | Jeff Skevington |
| Recording Secretary | Annie Bélair |
| Treasurer | Frank Pope |

Ex-officio members

| | |
|------------------|-------------------|
| Business Manager | Frank Pope |
| Editor CFN | Carolyn Callaghan |
| Editor T&L | Karen McLachlan |
| Hamilton | |
| Webmaster | Sandra Garland |
| ON Nature Rep | Diane Lepage |

Committee Chairs

| | |
|--------------|------------------|
| Awards | Eleanor Zurbrigg |
| Birds | Chris Traynor |
| Conservation | Ken Young |

Education & Publicity
Excursions and Lectures
Executive
Finance
Fletcher Wildlife Garden
Macoun Club
Council
Memberships
Publications

Fenja Brodo
Jeff Skevington
Ann MacKenzie
Barbara Chouinard
Sandra Garland
Rob Lee (not on
Henry Steger
Dan Brunton

Members at large

Julia Cipriani
David Hobden
Diane Kitching (Macoun Club rep)
Jeff Saarela

Moved by Fenja Brodo and seconded by Frank Pope that the above slate be accepted as members of the Council of the OFNC for 2010.

Carried

Ann MacKenzie thanked all members of Council for their dedication over the year and bid farewell to those leaving the Council.

She welcomed the new members and thanked them for accepting this new responsibility

8. New Business

Francis Cook (who was not present at the ABM) asked Carolyn Callaghan to convey, on his behalf, a deep thank you to the Club for years of support, to past and present members of the Publications Committee, and to Sandra Garland, Frank Pope and Roy John.

Moved by Ernie Brodo/Paul Catling that a special note of thanks be presented to Francis Cook for accepting to be chief editor of the CFN for 34 years.

Carried

9. Adjournment

Moved by David Hobden and seconded by Sandra Garland that the meeting be adjourned at 9:00 pm.

Carried

ANNIE BÉLAIR
Recording Secretary

The Ottawa Field-Naturalists' Club Committee Annual Reports for 2010

Awards Committee

The Awards Committee met in January to consider nominations received for the various OFNC awards and candidates who best fit the criteria for an award were selected. The committee recommended to the OFNC Council that five awards be given for 2010 including two Honorary memberships. Citations were prepared for each of the award recipients, and the awards were presented at the annual Soiree in April. Citations will be published in The Canadian Field-Naturalist.

ELEANOR ZURBRIGG
Chair, Awards Committee

Birds Committee

The Birds Committee organized the Fall Bird Count and along with the Club des Ornithologues de l'Outaouais participated in the 2009 Christmas Bird Count. The annual Peregrine Falcon Watch did not go ahead this year due to egg failure. The seed-a-thon was successful in raising money to operate the club's bird feeders. The committee continues to operate

a rare bird alert and the Ottawa bird status line, a recorded telephone message of current bird sightings. Several committee members handle an increasing number of bird identification requests that come in to the elub via its website. An Eastern Screech Owl nest/roost box project was in operation with 15 boxes placed within the Christmas Bird Count circle. The Bird Record Subcommittee met during the year to review rare bird reports.

CHRIS TRAYNOR
Chair, Birds Committee

Conservation Committee

PROPOSED RESOLUTION ON WIND FARMS: Council endorsed Ontario Nature members' proposed resolution on wind farms. The purpose was to promote the need to minimize adverse effects on migratory birds, shoreline birds, waterfowl, and bats.

ALGONQUIN PARK LOGGING AMENDMENTS: A letter with President's signature was sent expressing approval for proposed amendments as a step in the right direction. The amendments would increase by about 5% the area of the park that is protected from logging.

TREE BYLAW VIOLATION: At her request, a letter was sent to Councillor Christine Leadman criticising the City for failing to act against a developer who destroyed a distinctive tree in Kitchissippi Ward.

ALFRED BOG MANAGEMENT PLAN: A letter with President's signature was sent to Ontario Parks expressing approval for the draft plan, except for perceived weakness in regard to rehabilitation and water management, and for giving access privileges to hunters while discouraging access by the public. Council decided not to transfer the OFNC's 50 acres of the bog to Ontario Parks, and later decided to transfer the land to the South Nation Conservation Authority, which will give them a legal right to be consulted.

PROPOSED OTTAWA FOREST KEEPER: In response to a suggestion by members of the South March Highlands Coalition, Council felt that the modest success of the Ottawa Riverkeeper would not be a viable model for a Forest Keeper. There are few regulations protecting forests, and there isn't the same public interest.

NCC GREENBELT MASTER PLAN REVIEW: Stan Rosenbaum and Ken Young sent policy proposals to Sylvie Lalonde, the NCC's head planner, on September 2nd, 2010. The OFNC Council endorsed this document on September 20th and had it posted on the OFNC web site. The proposals include a policy on hay cutting during the nesting season for ground-nesting birds, including the statement: "... leaving the protection of ground-nesting birds at the individual discretion of tenants is not acceptable. Ultimately, the NCC as a federal agency is responsible for the protection of migratory birds on federal land."

The OFNC is a member of the Greenbelt Coalition, a coalition of environmental organizations formed to lobby the NCC on the Master Plan Review. Also in September, 2010, the Coalition submitted a policy document to the NCC.

STAN ROSENBAUM

Chair, Conservation Committee Education & Publicity Committee

This committee met three times formally.

We have a newly purchased digital projector, a laptop computer with a wealth of photographs available for Club presentations. A start has been made to organize the images.

We sent judges to the Ottawa Regional Science Fair, Saturday 10 April 2010 who found worthy recipients for our prizes.

Gillian Marston's display on biodiversity was featured at the National Wild Life Festival, 27-28th March. We participated in National Environment Week at the DND in June. We show-cased our Club at the CMN "Meet the Experts" event on 27-28 November, together with the Fletcher Wildlife Garden and the Macoun Club.

We are often asked to provide speakers or leaders and we fulfilled two such requests. (Requests for leaders often go directly to Dave Moore, not a member of this committee.)

We are advertising more broadly for our monthly meetings and for selected outings. On three occasions we got radio coverage that resulted in increased attendance and possibly a few new members.

The sales desk is ably staffed at each monthly meeting and we are selling our new T-shirts, water bottles with our logo, as well as Christmas cards and back issues of journals and books.

Extra copies of the Breeding Bird Atlas were given away to Michael Runtz and Lenore Fahrig, Carleton University, with specially designed book plates indicating that these were gifts from our Club.

FENJA BRODO
Acting Chair, Education & Publicity

Excursions and Lectures Committee

We had a successful year with our ten monthly meetings, the Soiree, 34 trips, one workshop plus two additional talks at the Fletcher Wildlife Garden Interpretation Centre and one talk at the Canadian Museum of Nature (CMN). This year one excursion was cancelled due to the unavailability of the trip leader and a substitute could not be found. Our Soiree took place uneventfully. Two of our monthly meetings were held at the Neatby Building, Carling Avenue while the CMN was renovating the museum. Following the completion of those renovations, refreshments are no longer served at the monthly meetings due to a change in the CMN catering policies. Birding is the most popular activity, with 16 trips organized in 2010. The number of participants at our biannual Point Pelee National Park trip exceeded our expectations. We need to entice more leaders to lead more birding trips. This was the fourth year that we participated in the North American Butterfly Count. Our six full-day excursions were well attended. We had one weekend trip with canoes to the Barron River Canyon of Algonquin Park. Other trips emphasized geology, mudpuppies, fungi, lichens, botany, insect collecting, tree identification, ferns, and general natural history.

This year we had two events specifically for families and we propose to include more such trips. In addition, we advertised a field trip by the Macnamara Field Naturalists Club to the March Highlands.

Due to a number of interviews on local radio by club members, we have been publicizing our field trips more widely this year. After moving into the new Theatre in the basement of the CMN in June 2010, we are also raising the profile of our monthly talks to the public.

CHRISTINE WONG
Chair, Excursions and Lectures Committee

Finance Committee

The first meeting on February 9 was to look at the financial statements from the previous year. The format of the audited financial statements for the year ending September 30, 2009 was different because of new requirements within the

auditing profession. For example, the capital funds are included in the balance sheet rather than just in a separate note. Both received donations and earned interest are included in revenue. Donations given, such as the ones to the Wild Bird Care Facility and the Nature Conservancy, are shown in the list of annual expenses. Club officials may reformat the statements for management purposes as long as they are called Internal Management Statements and do not purport them to be the audited statements. At the Annual Business meeting in January we had distributed such reformatted statements along with the audited statements.

The Club is continuing to run a deficit. The annual revenue generated does not cover the regular operating costs and the difference is being made up by donations and interest earned on bequests. Despite our large capital account balances we cannot continue to operate the club on a business model of continuous deficits. As part of Council's strategic planning we should consider aiming toward balancing the books in the next three to five years.

The second meeting of the Finance Committee was held August 24th. The purpose of that meeting was to prepare a budget for presentation at the September Council meeting. That budget proposed significant cuts that were not acceptable to Council. The revised budget and membership rate increases were considered at an October meeting after the start of the next year for the Club.

ANN MACKENZIE
Chair, Finance Committee

Fletcher Wildlife Garden

Habitat improvement

This was a difficult year for the management committee as we finally had to make a decision about repairing the dam that created our amphibian pond. Several heavy spring runoffs had eroded the dam to the point where makeshift repairs were no longer adequate. Drummond, the firm who created the original dam, was able not only to rebuild it, but also make the spillway wider and deeper to accommodate higher levels of water in spring. This, in turn, necessitated a longer bridge, for which we hired a carpenter and received considerable help from Agriculture and Agri-Foods Canada.

Control of invasives

Aside from expansion of the butterfly meadow, relatively little work was done on invasives control this year. Muskrats seem to be controlling flowering rush and frog-bit in the pond. We had help from a group of young volunteers to pull garlic mustard one Friday morning in spring, and in late summer we invited the public to help cut dog-strangling vine (DSV). This "blitz" idea, which was also used success-

fully in Kanata, led to plans for a city-wide effort to control DSV and other invasives in 2011.

Outreach

We continue to use our web site and photo blog to reach a wide audience. This year we started a Facebook page for the FWG. We hosted several corporate volunteer groups, school classes, and scout troops, all of whom contributed tremendously to improving various habitats.

SANDY GARLAND
Chair, Fletcher Wildlife Garden

Macoun Club Committee

The Committee met at the beginning of the year to set the Club's overall direction, and after that carried out the month-to-month planning by telephone and e-mail. Committee members supervised or gave presentations at 19 indoor meetings, and led 14 field trips during the school year (plus several special field trips during the summer). All indoor sessions were held in the Fletcher Wildlife Garden building; most field trips took place either at the Club's nature-study area in Ottawa's Greenbelt or on private properties in Lanark County. In May, Ontario Nature organized a special joint field trip at the Perth Wildlife Refuge, bringing together the Macoun Club and the young people of the Kingston and Macnamara Field Naturalists Clubs, together with their leaders.

In July, the Macoun Club lost one of its most committed and active leaders, Martha Camfield, at the age of 90. Memorial donations were directed to the Macoun Club, and they were generous. Furthermore, Martha had sent her own children to Macoun Club in the 1950s, and, now grown, they have proposed to establish an endowment fund for its benefit.

Six years after the last "Seniors" graduated, a small high-school-age group has reformed. Older members have always been important for taking on special responsibilities, such as editing the Club's newsletter. Encouraging numbers of younger children continue to join, though not quite enough to sustain a strong Club.

The Club produces a monthly newsletter, an annual publication (The Little Bear), and maintains a website that is linked to the OFNC site. Additionally, the fifth annual edition of the Macoun Club's notebook on sightings in the Club's nature-study area in the Greenbelt near Bells Corners was bound in hard-cover and distributed to members.

ROBERT E. LEE
Chair, Macoun Field Club

Membership Committee

The distribution of the membership for 2010 at September 30, 2010 is shown in the table below, with the corresponding

| | CANADIAN | | USA | | OTHER | | TOTAL | |
|--------------|------------|--------------|-----------|-------------|----------|------------|------------|--------------|
| | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 |
| Individual | 386 | (376) | 15 | (17) | 0 | (1) | 401 | (394) |
| Family | 293 | (279) | 1 | (1) | 1 | (1) | 295 | (281) |
| Sustaining | 14 | (15) | 0 | (0) | 0 | (0) | 14 | (15) |
| T and L | 4 | (4) | 0 | (0) | 0 | (0) | 4 | (4) |
| Honorary | 21 | (20) | 0 | (0) | 0 | (0) | 21 | (20) |
| Life | 52 | (52) | 3 | (5) | 1 | (1) | 56 | (58) |
| Other | 22 | (24) | 0 | (1) | 1 | (1) | 23 | (26) |
| TOTAL | 792 | (770) | 19 | (24) | 3 | (4) | 814 | (798) |

numbers for 2009 in brackets. "Others" represent, for the greatest part, affiliate organizations that receive complimentary copies of the Club's publications. Local membership (within 50 km of Parliament Hill) was 620 and 650 in 2009 and 2010, respectively. The increase in total membership of 16 is the first in several years and was driven by a significant increase in local membership. There continued to be a decrease in members located more than 50 km from Ottawa. The decrease of 6 in U.S.A and other international membership was mostly due to the return of four members to Canada.

HENRY STEGER
Chair, Membership Committee

Publications Committee

The Publications Committee met four times in 2010.

Four issues of *The Canadian Field-Naturalist* were published to December 13; Volume 122 (3, 4) and Volume 123 (1, 2). Six more issues (Volume 123 (3, 4) and Volume 124 (1-4)) are in an advanced state of preparation and are expected to appear shortly. The four issues published to date contained 412 pages; 35 articles; 17 notes; 60 book reviews; 124 new titles; 21 pages of News and Comments; 5 pages of miscellany; and a 19 page index. Manning fund interest supported 14 papers for a total of \$5027.

This has been a momentous year for *The Canadian Field-Naturalist*. In the approach to online publishing, the ad hoc committee (set up last year to investigate the various aspects) concluded that the system set up by Garland was too narrow

in its approach and would be inadequate, especially for institutional subscribers. The committee recommended using either Open Journal Systems (OJS) to produce the online version, or putting production in the hands of a commercial publisher (e.g., Springer, who submitted a detailed offer). The Publications Committee recommended to Council that OJS be used. Council agreed.

Long time Editor, Francis Cook, said that he will retire with the completion of Volume 124, and intends to have Volume 124 completed before the 2011 Annual General Meeting (an immense task).

A steering committee was struck to search for a new Editor and to find the personnel to set up OJS. The setting up of OJS is likely to be an onerous task, but thereafter should be relatively straightforward to use. It was recognized that the most important tasks are to have *The Canadian Field-Naturalist* caught up, and kept up to date, and to have OJS set up and running. The newly appointed Editor, Carolyn Callaghan, has excellent credentials, and will begin with Volume 125. Jay Fitzsimmons was commissioned to set up OJS, with appropriate help.

Volume 44 of *Trail & Landscape* was published on schedule in four issues containing 196 pages.

I also announced that I would retire as Chair of this Committee, and from Council, at the end of 2010.

RONALD E. BEDFORD
Chair, Publications Committee

Review Engagement Report

To The Members of THE OTTAWA FIELD NATURALISTS' CLUB

I have reviewed the statement of financial position of THE OTTAWA FIELD-NATURALISTS' CLUB at September 30, 2010, the statement of changes in net assets, and the statement of operations and cash flows for the year then ended. My review was made in accordance with Canadian generally accepted standards for review engagements and accordingly consisted primarily of enquiry, analytical procedures and discussions related to information supplied to me by the management. A review does not constitute an audit and consequently I do not express an audit opinion on these financial statements.

Based on my review, nothing has come to my attention that causes me to believe that these financial statements are not, in all material respects, in accordance with Canadian generally accepted accounting principles.

**CHARTERED ACCOUNTANT,
Licensed Public Accountant**

North Gower, Ontario
January 12, 2011

The Ottawa Field-Naturalists' Club Balance Sheet September 30, 2010

| | 2010 | 2009 |
|--|------------------|------------------|
| ASSETS | | |
| CURRENT | | |
| Cash | \$78,103 | \$84,901 |
| Prepaid Expenses | 1,935 | 3,435 |
| Investment certificate (Note 1) | 127,267 | 104,833 |
| Marketable securities (Note 2) | 0 | 50,913 |
| Accounts receivable | 2,388 | 791 |
| | <u>209,693</u> | <u>244,873</u> |
| LAND – ALFRED BOG | | |
| (At cost, assessed value \$19,100) | 3,348 | 3,348 |
| Marketable Securities (Note 2) | <u>334,813</u> | <u>281,300</u> |
| | <u>\$547,854</u> | <u>\$529,521</u> |
| LIABILITIES AND FUND BALANCES | | |
| CURRENT | | |
| Accounts payable and accrued liabilities | 4,478 | \$2,500 |
| Deferred revenue | 10,438 | 9,987 |
| | <u>14,916</u> | <u>12,487</u> |
| LIFE MEMBERSHIPS | <u>5,480</u> | <u>18,744</u> |
| NET ASSETS | | |
| Unrestricted | 280,770 | 258,062 |
| Internally restricted | <u>246,688</u> | <u>240,228</u> |
| | <u>527,458</u> | <u>498,290</u> |
| | <u>\$547,854</u> | <u>\$529,521</u> |

The Ottawa Field-Naturalists' Club
Statement of Operations
For the year ended September 30, 2010 (Unaudited)

| | 2010 | 2009 |
|---|-----------------|------------------|
| REVENUE | | |
| Memberships | \$37,414 | \$23,547 |
| Donations | 10,431 | 17,686 |
| Interest | 15,479 | 19,050 |
| GST rebate | 1,832 | 2,666 |
| Sales | 626 | 437 |
| Other | 187 | 200 |
| | <u>65,969</u> | <u>64,823</u> |
| OPERATING EXPENSES | | |
| Administrator | 2,000 | 2,000 |
| Affiliation fees | 225 | 627 |
| Computer expense | 2,751 | 5,967 |
| Membership committee | 866 | 1,033 |
| Donations | 5,977 | 23,500 |
| Bookkeeper | 6,300 | 6,300 |
| Telephone | 2,768 | 2,729 |
| Insurance | 785 | 770 |
| Office | 856 | 986 |
| Postage | 906 | 666 |
| Professional fees | 2,500 | 2,000 |
| GST | 5,337 | 3,357 |
| Other | 625 | 1,815 |
| | <u>31,896</u> | <u>51,750</u> |
| CLUB ACTIVITY EXPENSES | | |
| Awards | -146 | 377 |
| Birds | 1,510 | 1,681 |
| Canadian Field Naturalist (Note 3) | 4,124 | 8,946 |
| Education and publicity | 912 | 1,109 |
| Excursions and lectures | -3,897 | 429 |
| Macoun Field Club | 145 | 599 |
| Trail and Landscape Fletcher Wildlife Garden (Note 4) | 7,099 | 9,810 |
| | <u>3,638</u> | <u>(2,925)</u> |
| | <u>13,385</u> | <u>20,026</u> |
| | <u>45,281</u> | <u>71,776</u> |
| EXCESS EXPENSES | <u>\$20,688</u> | <u>(\$6,953)</u> |

The Ottawa Field-Naturalists' Club
Statement of Cash Flows
For the year ended September 30, 2010 (Unaudited)

| | 2010 | 2009 |
|---|------------------|------------------|
| Cash Flows from Operating Activities | | |
| Excess (expenditures) revenue for the year | \$ 20,688 | (\$6,953) |
| Net change in non-cash balances | <u>10,812</u> | <u>24,473</u> |
| (Decrease) in Cash from Operating Activities | <u>31,500</u> | <u>17,520</u> |
| Cash Flows From Financing and Investing Activities | | |
| Decrease in Life Memberships | 13,264 | 1,868 |
| Net purchase and sale of investments | -5,913 | (-5,913) |
| | <u>7,351</u> | <u>(-4,045)</u> |
| Net (Decrease) Increase in Cash and GIC | <u>15,636</u> | <u>13,475</u> |
| Cash and GIC, beginning of year | <u>189,734</u> | <u>176,259</u> |
| Cash and GIC, end of year | <u>205,370</u> | <u>\$189,734</u> |
| Net Change in Non-Cash Balances | | |
| Accounts receivable | -1597 | \$17,024 |
| Cumulative unrealized losses on financial assets | 8,480 | 15,982 |
| Prepaid expenses | 1,500 | 3,435 |
| Accounts payable and accrued liabilities | 1,978 | (2,184) |
| Deferred revenue | 451 | (2,914) |
| | <u>\$ 10,812</u> | <u>\$ 24,473</u> |

The Ottawa Field-Naturalists' Club Summary of Significant Accounting Policies

September 30, 2010

1. Purpose of the Organization

The organization is non-profit and incorporated under the laws of Ontario (1884). As a non-profit organization, it is not subject to income taxes under the Income Tax Act. The organization promotes the appreciation, preservation, and conservation of Canada's natural heritage. It encourages investigation and publishes the results of the research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with other organizations engaging in preserving, maintaining or restoring environments of high quality for living things.

2. Financial Instruments

Financial assets and liabilities are recognized and measured as follows:

- Cash, consisting of bank and broker account balances, and short term investment certificates (GIC's due within one year) are classified as a held-for-trading financial asset, measured at fair value and changes in fair value are recognized in the statement of operations.
- Trade accounts receivable are classified as loans and receivables, and measured at amortized cost. In this case the value is at the same amount as originally recorded.
- Marketable securities and investments are classified as available-for-sale investments. They are recognized at fair value and changes in this value are recognized in the statement of changes in net assets until they are sold. When investments are sold the related accumulated gain or loss are recognized in the statement of operations. Any transaction costs are added to the initial cost of the investment.
- Accounts payable and accrued liabilities are classified as other financial liabilities. They are measured at amortized cost using the effective interest method.

3. Financial Risk Management Objectives and Policies

The Club is exposed to various financial risks resulting from both its operations and its investment activities. The Club's management manages financial risks and focuses on actively guaranteeing the Club's short and medium-term cash flows by minimizing its exposure to capital markets.

The carrying amount of the Club's financial assets on the statement of financial position represents the maximum amount exposed to credit risk. This credit risk is primarily attributed to the accounts receivable. The Club does not require a credit check or guarantee from its members. The accounts receivable are limited to small transactions for memberships and subscriptions, with the occasional larger one for articles.

The Club's objectives to managing capital are to safeguard the Club's ability to continue as a going concern and to meet its financial obligations. It meets these objectives by investing in secure obligations and guaranteed investment certificates that mature at various intervals.

4. Capital Assets

Capital assets in excess of \$4,000 cost are recorded as assets at cost and amortized on a straight-line basis. These assets have been fully amortized.

5. Funds and Revenue Recognition

The organization prepares its financial statements using fund accounting. All funds are internally restricted. The purpose of the internally restricted funds are as follows:

- General Reserve – this amount was established by the Board to fund outstanding operating expenses when the Club is terminated.
- Manning – this fund was established by a bequest, and the interest generated is used to assist authors to publish articles in the Canadian Field-Naturalist (80%), and for special Club projects (20%).
- Seedathon – this fund collects donations from the annual bird sighting event and purchases seed for the Clubs bird feeders.
- Anne Hanes Memorial – this fund was raised in memory of Anne Hanes, the founding editor of Trail and Landscape, and is used to finance the annual winners of the Anne Hanes Natural History Award.
- de Kiriline-Lawrence – this was funded by a bequest from the popular author of nature books, and is supplemented by annual donations and used to support conservation efforts.
- Macoun Baillie Birdathon – this fund recognizes the donations and pledges based upon the number of bird sightings in the one day birdathon sponsored by Bird Studies Canada, and is used to support the Macoun Field Club, a club for youth.
- Alfred Bog – a fund established to raise funds for the successful acquisition of Alfred Bog property, and to continue to raise money for purchase of the remaining property in the Bog.

Membership fees and subscriptions are recognized in the year to which they apply. Life memberships are written off over 15 years.

- Donations, and all other fund-raising revenue is recognized when received. GST refunds are recognized when received.
- Realized gains and losses are reported in the statement of operations, while unrealized gains and losses are reported in the statement of changes in net assets.

6. Foreign Currency

Transactions during the year in US dollars have been converted in the accounts to Canadian dollars at the exchange rate effective at the date of the transaction. All monetary assets in US dollars at year end have been converted to Canadian dollars at the rate effective on Sept. 30, 2008. Gains or losses resulting therefrom are included in revenue or expenses.

7. Accounting Estimates

The preparation of financial statements in accordance with Canadian generally accepted accounting principles requires management to make estimates and assumptions that affect the amounts recorded in the financial statements and notes to the financial statements. These estimates are based on management's best knowledge of current events and actions that the Club may take in the future. Actual results may differ from these estimates.

8. Comparative Figures

Certain comparative figures have been reclassified to conform with the presentation adopted in the current year.

9. Future Accounting Standards

In September 2008, the Canadian Institute of Chartered Accountants (CICA) modified the accounting standards that apply only to not-for-profit organizations. Changes that would affect the Club are:

- Revenue and expenses must be recognized and presented on a gross basis when an organization is acting as a principal in transactions;
- New disclosures are applicable when the organization classifies its expenses by function.

These new standards are effective for fiscal years beginning after January 1, 2009, and would apply to the next fiscal year of the Club.

**The Ottawa Field-Naturalists' Club Notes to the Financial Statements
For the year ended September 30, 2010**

| | 2010 | 2009 |
|---|-------------------|-------------------|
| 1. CASH (Note 2, Accounting Policies) | | |
| Chequing | \$ 6,983 | \$ 19,106 |
| Savings | 40,896 | 52,682 |
| Nesbitt Burns | 23,855 | 4,338 |
| Fletcher Wildlife Garden | 6,369 | 8,775 |
| | <u>\$ 78,103</u> | <u>\$ 84,901</u> |
| | Maturity Value | Maturity Date |
| | \$20,600 | 10/01/10 |
| | 78,220 | 9/29/11 |
| | 26,000 | 10/09/12 |
| | Yield | Market Value |
| | .65% | \$ 20,734 |
| | .08% | 78,220 |
| | 4.41% | 28,313 |
| | | <u>\$ 127,267</u> |
| 2. MARKETABLE SECURITIES (Note 2, Accounting Policies) | | |
| | Maturity Value | Maturity Date |
| Prov. of Newfoundland Coupon | 44,782 | 10/17/11 |
| Prov. of Ontario Coupon | 15,376 | 12/02/12 |
| Prov. of Manitoba Coupon | 45,740 | 09/05/13 |
| Prov. of New Brunswick Bond | 60,000 | 12/03/15 |
| Res CIBC Int BB6 | 70,827 | 10/31/14 |
| Ontario Hydro | 28,281 | 11/26/16 |
| Prov. of Ontario Coupon | 57,355 | 12/02/17 |
| Prov. of Newfoundland Bond | 53,117 | 01/07/20 |
| | | Yield |
| | | 4.525% |
| | | 4.591% |
| | | 4.694% |
| | | 3.965% |
| | | 4.144% |
| | | 4.791% |
| | | 5.000% |
| | | 4.360% |
| | | Market Value |
| | | \$ 44,015 |
| | | 14,769 |
| | | 43,092 |
| | | 65,437 |
| | | 62,246 |
| | | 23,495 |
| | | 45,239 |
| | | 36,520 |
| | | <u>\$334,813</u> |
| 3. Canadian Field-Naturalist Operations | | |
| REVENUE | | |
| Subscriptions | 17,208 | \$15,400 |
| Reprints | 4,400 | 2,411 |
| Publication charges | 34,206 | 27,086 |
| Other | 0 | 0 |
| | <u>55,814</u> | <u>44,897</u> |
| EXPENSES | | |
| Publishing | 33,282 | 29,245 |
| Reprints | 996 | 1,200 |
| Circulation | 13,449 | 7,899 |
| Editing | 9,371 | 9,934 |
| Other | 0 | 0 |
| | <u>57,098</u> | <u>48,278</u> |
| Excess Expenses Over Revenue | <u>(\$1284)</u> | <u>(\$3,381)</u> |

**The Ottawa Field-Naturalists' Club Notes to the Financial Statements
For the year ended September 30, 2010 (Unaudited)**

| | 2010 | 2009 |
|--|--------------|--------------|
| 4. Fletcher Wildlife Garden | | |
| REVENUE | | |
| Human Resources and Skills Dev. Canada | 0 | 0 |
| Sales and other income | 3,473 | 5,774 |
| GST refund | 0 | 0 |
| Donations | 935 | 400 |
| | <u>4,408</u> | <u>6,174</u> |
| EXPENSES | | |
| Program | 94 | 89 |
| Backyard | 575 | 765 |
| Buckthorn removal | 0 | 0 |
| Habitats | 6,112 | 817 |
| Interpretation centre | 100 | 980 |
| Administration | 469 | 201 |
| GST | 0 | 27 |
| Fund raising | 563 | 219 |
| Publications | 74 | 70 |
| Pond testing | 0 | 0 |
| Library | 59 | 81 |
| | <u>8,046</u> | <u>3,249</u> |
| Excess Expenses Over Revenue | (\$3,638) | \$2,925 |

5. Statement of Fund Operations and Changes in Net Assets

| | General Reserve | Manning | Seedathon | Anne Hanes Memorial | De Kiriline Lawrence | Macoun Baillie | Alfred Bog | Total |
|--------------------------------------|-----------------|----------------|------------|---------------------|----------------------|----------------|--------------|----------------|
| Revenue | | | | | | | | |
| Donations | 0 | 0 | 495 | 0 | 0 | 2,364 | 0 | 2,859 |
| Interest | 0 | 4,199 | 0 | 0 | 0 | 0 | 0 | 4,199 |
| Sales | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <u>0</u> | <u>4,199</u> | <u>495</u> | <u>0</u> | <u>0</u> | <u>2,364</u> | <u>0</u> | <u>7,058</u> |
| Expenses | | | | | | | | |
| Waived charges, CFN | 0 | 2,840 | 0 | 0 | 0 | 0 | 0 | 2,840 |
| Donations | 0 | 0 | 0 | 0 | 0 | 0 | 3,977 | 3,977 |
| Seed | 0 | 0 | 882 | 0 | 0 | 0 | 0 | 882 |
| Prints | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <u>0</u> | <u>2,840</u> | <u>882</u> | <u>0</u> | <u>0</u> | <u>0</u> | <u>3,977</u> | <u>7,699</u> |
| Net Assets, Beginning of Year | 0 | 1,359 | -387 | 0 | 0 | 2,364 | -3,977 | -641 |
| Net Assets, Beginning of Year | <u>100,000</u> | <u>120,944</u> | <u>409</u> | <u>630</u> | <u>13,064</u> | <u>1,204</u> | <u>3,977</u> | <u>240,228</u> |
| Net Assets, End of Year | <u>100,000</u> | <u>122,303</u> | <u>22</u> | <u>630</u> | <u>13,064</u> | <u>3,568</u> | <u>0</u> | <u>239,587</u> |

6. Publication Liability

A subscription entitles the subscriber to four issues of The Canadian Field-Naturalist based on a calendar year. As the year end of the Club is September 30, the Club incurs a liability for publishing the fourth issue of each publication.

At this time, however, the publication of The Canadian Field-Naturalist is running late. At 30 September 2010, the Club owes subscribers Vol. 2, 3, and 4 of 2009 and 2010. Although most of the work preparing these publications are done by volunteers, the Club must pay for printing and mailing. Based upon recent costs, it is estimated that the Club has a liability of \$60,000 for the outstanding issues. This amount will be reduced by page charges to the authors in the amount of 40% of the printing costs

7. Donations

During the year the Club donated \$2,000 to the Kingston Field-Naturalists toward a study of owls on Amhurst Island.

The Canadian Field-Naturalist — Instructions for Authors

Aim and Scope

The Canadian Field-Naturalist (CFN; ISSN: 0008-3550) publishes peer-reviewed scientific papers on natural history relevant to Canada. Relevance to Canada usually means the species studied must inhabit Canada, even if the research itself occurred outside Canada, e.g., U.S.-based research on a species whose range extends into Canada, or research in Asia on a species introduced into Canada. Natural history comprises organism-scale biological research in diverse fields including behaviour, ecology, conservation, and taxonomy, among others. We publish research on any taxa, from microbes to large-bodied mammals. We encourage manuscript submissions from professional and amateur naturalists. Our journal has been published continuously since 1879 by the non-profit group The Ottawa Field-Naturalists' Club, making it one of the longest-running ecological journals in North America.

Manuscript Types

Articles. Articles report original research and are at least five pages long in printed form. There are no upper-boundary restrictions on the number of pages or references for articles (maximum abstract length: 250 words). Articles are peer-reviewed.

Notes. Like articles, Notes report original natural history research. Notes only differ in being shorter (maximum abstract length: 100 words; maximum page length in final printed form: 4 pages, or approximately 2000 words). Many Notes report novel observations of animal behaviour, diet choice, or range extensions of species. Notes are peer-reviewed.

Book Reviews. We publish many reviews of books of interest to naturalists, from all over the world (i.e., not necessarily related to Canadian species). Each issue includes a list of new book titles received by our Book Reviews Editor with notation on books available for review, although we are open to suggestions of reviews for other titles. All book reviews and inquiries related to book reviews should be sent to our Book Review Editor, Roy John (r.john@rogers.com). Book reviews are edited by Roy John, but are not considered peer-reviewed.

Tributes. Tributes are descriptions of recently-deceased exemplary naturalists who contributed to our understanding of Canadian nature. Please inquire with our Editor-in-Chief, Dr. Carolyn Callaghan, before writing a Tribute. Tributes are not peer-reviewed.

News, Opinions and Reports. Short news items, commentary, or reports of interest to naturalist readers. They are not peer-reviewed, and are normally contributed by our Editor-in-Chief. News item suggestions should be directed to our Editor-in-Chief, Dr. Carolyn Callaghan (editor@canadianfieldnaturalist.ca). Commentary may be similar to articles in format or it may be just a series of paragraphs.

Editorials, Club Reports. These items are contributed by our editors and Ottawa Field-Naturalists' Club personnel, and are not open to submission by others.

Manuscript Guidelines

Manuscripts are to be submitted to the Editor-in-Chief by email (editor@canadianfieldnaturalist.ca) or post, written in the journal style. Authors should consult a recent issue of CFN to understand journal format. A sample issue is available for free online at www.ofnc.ca/cfn/122-1/subscribers-index.php.

Legal issues, ethical conduct

The research reported must be original. Manuscripts cannot have been published, or be under consideration for publication, in part or in entirety in any other publication media including journal, newsletter, book, report, either online or in print. The author(s) is/are expected to confirm that a manuscript submitted for consideration for publication in the Canadian Field-Naturalist has not already been published elsewhere, and will not be published elsewhere unless rejected by the Canadian Field-Naturalist. Published means distributed or otherwise made available in print, either in hard copy or online and with or without peer review.

All co-authors must have read and approved the submitted version of the manuscript. If institutional or contract approval for the publication of data is required, authors should have obtained it prior to manuscript submission. Authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, or minerals. Animal care should comply with relevant institutions' guidelines and be considered ethical by peers. A cover letter, indicating compliance with the preceding points must accompany the manuscript submission when appropriate.

Language

Manuscripts can be submitted in English or French. Manuscripts are permitted, but not required, to include abstracts and keywords in both languages. Canadian spelling of the English language is required on manuscripts submitted in English. A contemporary reference for formal Canadian spelling is the *Canadian Oxford Dictionary*.

Font, page format, file type

Font should be 12-point Times New Roman. Manuscripts should be double-spaced throughout including references with margins 2.5 cm (1 inch) wide. Pages should be numbered sequentially, and lines should be numbered continuously. The file should be saved as .doc (Microsoft Word 2003) file format.

Nomenclature and units of measurement

Species' common names (when available) and scientific names should both be used at least once in the manuscript. Initial letters of species common names should be capitalized. Authorities' names (e.g., "Kuhl" in *Castor canadensis* Kuhl) should be omitted from scientific names unless the manuscript has taxonomic relevance or in the first reference to a featured species. Units of measurement should follow standard metric SI units.

Vouchers, location information, GenBank

All voucher material should include the name and location of the collection and the specimens' catalog numbers. All collections or observations of species should include latitude and longitude in decimal degrees at two decimal points or finer depending on the sensitivity of the information. All genetic sequences should be accompanied by GenBank accession numbers.

Title page

Include the title, a running title (maximum of 35 characters), the list of authors, and the type of submission the manuscript should be considered. For each author provide their

affiliation with postal address (home address is fine for unaffiliated amateurs) and e-mail address. Indicate which author is the corresponding author, and provide their phone number in addition to postal and e-mail address.

Abstract page

The second page of the manuscript (for Articles and Notes) should include the abstract and a list of key words (4-10 key-words).

Manuscript sections

Articles should typically contain the following sections listed as bolded, 16-point font headings, initial caps only: Introduction, Methods, Results, and Discussion. Alternative headings are permitted. Second-level subheadings are permitted and should be italicized in 12-point font. Notes' headings, if any, are at the authors' discretion. Both Articles and Notes should also include Acknowledgements, Documents Cited, and Literature Cited. Acknowledgements should list authors' funding sources and thank people who contributed significantly to the study. Documents and Literature Cited are described below.

Citation format

Below are example citations in CFN style. When more than one document is cited in a citation, sort them chronologically, and alphabetically within the same year, separated by semicolons.

Single author: "... fishers in Maine (Coulter 1966)."

Two authors: "... been observed (MacKinnon and Kennedy 2009)"

Three or more authors: "... diet composition (Arthur *et al.* 1989)."

Multiple documents cited: "... birds and tardigrades are very different (Tufts 1961; Nelson *et al.* 2009)."

References (Documents Cited and Literature Cited)

Cited references should be listed under the headings of Documents Cited (for reports of limited circulation and web documents) and Literature Cited (for journal articles, books, book sections, and theses). All references should have hanging indents. Web documents' citations should include their website address and the date they were accessed. Journal names should be written in full. Below are example references in CFN format.

Documents Cited

Environment Canada. 2008. National Climate Data and Information Archive, Environment Canada. Accessed 5 November 2008. www.climate.weatheroffice.gc.ca.

Friends of Fish Creek Provincial Park Society. 2009. Water quality monitoring report 2009. Accessed 20 March 2011. <http://wsow.brbc.ab.ca/reports/FishCreekStudy2.pdf>.

Stevens, V. 1995. Wildlife diversity in British Columbia: distribution and habitat use of amphibians, reptiles, birds, and mammals in Biogeoclimatic Zones. Working Paper 04. B.C. Ministry of Forest Research Program, and Ministry of Environment, Lands, and Parks' Habitat Protection Branch, Victoria, British Columbia, Canada. 288 pages.

Literature Cited

Arthur, S. M., W. B. Krohn, and J. R. Gilbert. 1989. Habitat use and diet of fishers. *Journal of Wildlife Management* 53: 680-688.

Coulter, M. W. 1966. Ecology and management of fishers in Maine. Ph.D. thesis, Syracuse University, Syracuse, New York, USA.

MacKinnon, C. M., and A. C. Kennedy. 2009. Canada Lynx, *Lynx canadensis*, use of the Chignecto Isthmus and the possibility of gene flow between populations in New Brunswick and Nova Scotia. *Canadian Field-Naturalist* 122: 166-168.

Nelson, D. R., R. Guidetti, and L. Rebecchi. 2009. Tardigrada. Pages 455-484 in *Ecology and Classification of North American Freshwater Invertebrates*, Edited by J. H. Thorp and A. P. Covich. Third edition. Academic Press, San Diego, California.

Tufts, R. W. 1961. The Birds of Nova Scotia. Nova Scotia Museum, Rolph-Clark-Stone, Maritimes Limited, Halifax, Nova Scotia. 481 pages.

Figures and maps

Figures should be pasted on separate pages below the Literature Cited section in the manuscript file. Upon acceptance for publication, the Editor may ask the authors to send figures as separate files with sufficiently high resolution for publication-quality images. Microscopic images should be accompanied by a scale bar. Photographic reproductions of line drawings should be no larger than a standard page. Colour figures can be included in the online version of final articles, but figures are printed in black in printed CFN issues unless authors agree to pay the costs of colour printing (approximately \$650 per figure – contact the Editor-in-Chief if you would like colour printing). Authors should remember that readers often print online articles with black ink printers, so even colour figures online should be interpretable if printed in grayscale.

Not every article requires a map. There is no need for a map that just illustrates the location of a study area. Ideally, a map should make clear the spatial relationship of the data. For example, a paper on a range extension should show how far the species' range has been extended from the previous known limit.

Every map should include a north indicator, using a north arrow or by labeling Longitude (°W) and Latitude (°N) on the map. Although most maps have north at the top, maps can be oriented differently if there is a valid reason. Every map should include a scale bar. A ratio scale (e.g. 1:50000) is not recommended as the scale will change depending upon the published size of the map. An inset map showing the region where the study area is located may be used, and a legend can be used if warranted.

Maps should make use of a strong contrast – a white background with black lines. Avoid using a uniform gray background, but shading is appropriate for certain areas (e.g. lakes) or to indicate affected areas. Maps should be submitted as a separate raster graphic or bitmap file of sufficient resolution to print sharply. The specific file size will depend upon the file format. Some common formats include Windows bitmaps (*.bmp), graphics interchange format (*.gif), and joint photographic experts group format (*.jpg).

Figure captions

Figure captions should be listed in the Figure Captions section following Figures. Figure captions should be listed and numbered in the order cited in the document. In text the word "Figure" should appear in small-caps (e.g., Figure 1) and in figure captions large-caps (e.g., "FIGURE 2. A young adult, melanistic American Red Squirrel (*Tamiasciurus hudsonicus*)").

sonicus) observed foraging in Upper Nine Mile River, Nova Scotia." For multi-part figures, each part should be labelled (in text: e.g., Figure 1A).

Tables

Tables should be listed on separate pages in the Tables section following Figure Captions, with the word "TABLE" in small-caps.

Supplementary Material

Tables, figures, audio files, video files, and data files that compliment Articles or Notes but are not essential to their message can be included as supplementary material at the authors' discretion. Supplementary material will be available online only for subscribers to download. Supplementary material should be submitted during initial manuscript submission. List all supplementary material under the final manuscript heading "Supplementary material." Supplementary material is a new feature for CFN so we do not yet know which file formats can and cannot be accepted; please consult our Journal Manager with any questions about specific formats.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor, who sends it to two qualified reviewers as well as provides an evaluation of the manuscript. Authors are encouraged to suggest at least three suitable referees that could provide unbiased expert reviews. Authors can also request that their manuscript not be sent to certain referees, if proper justification is given. The Editor-in-Chief makes the final decision on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of *The Canadian Field-Naturalist*. As with any scientific journal, extensive revisions may be requested by editors in an effort to improve the clarity, accuracy, style, and overall quality of manuscripts. Changes made by authors at the proof (galley) stage may result in extra charges to the author.

Author Charges, Reprints, pdf files

As a non-profit journal run largely by volunteers devoted to natural history, we make every effort to keep our costs as low as possible. To cover costs we require payment from authors of Articles and Notes: \$90 per printed page, plus \$30 per figure (any size up to one page), and \$90 per page of tables. Under special circumstances, these charges can be waived for authors without grants or institutional support (e.g., amateurs, students, independent researchers). These waivers are courtesy of a generous bequest left by naturalist Tom Manning (1911-1998) to The Ottawa Field-Naturalists' Club. To learn more about Tom Manning and his research, refer to CFN 118(4):618-625 (www.canadianfieldnaturalist.ca/index.php/cfn/article/view/70/70). Authors requesting charge waivers must make their request when submitting their manuscript and again (as a reminder) when authors return their proofs and order form after manuscript acceptance. Manuscripts of authors requesting waivers will not be treated any differently than other manuscripts during the editorial process.

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their pdf file to colleagues and to post it on their research website, but are not permitted to distribute their article commercially.

Although not a requirement, submitting authors are encouraged to maintain personal subscriptions to *The Canadian Field-Naturalist* or membership in The Ottawa Field-Naturalists' Club to further support the mandate and reach of the journal.

How to Submit a Manuscript

Please ensure your manuscript complies with the journal style described above, and has been appraised by a qualified expert (listed in the Acknowledgements) prior to submission.

Please e-mail book reviews to Book Review Editor Roy John, r.john@rogers.com. Please e-mail all other manuscripts to Editor-in-Chief Dr. Carolyn Callaghan at editor@canadianfieldnaturalist.ca. Please also attach a cover letter briefly explaining 1) the significance and novelty of your study in plain terms, 2) why it would be of interest to CFN's readers, 3) confirmation that the submitted manuscript has not been distributed in print, either in hard copy or online and with or without peer review, 4) confirmation that the research was conducted in adherence to all pertinent legislation and institutional guidelines regarding the study, disturbance, or collection of animals, plants, or minerals, 5) the names, affiliations, e-mail addresses, and relevant expertise of at least three experts you feel could evaluate your manuscript without bias or conflicts of interest as referees. You can also request that certain experts not act as referees, as long as you provide adequate justification. We are working to set up a manuscript submission portal on CFN's website in the future that will allow you to track your manuscript as it proceeds along the reviewing process, but until the portal is fully functional please continue to use the e-mail method.

We can also receive manuscripts by postal mail. Please send two copies (double-sided preferably to reduce environmental costs of printing and financial costs of mailing) of your manuscript to:

DR. CAROLYN CALLAGHAN
Editor-in-Chief, CFN
Box 35069, Westgate PO
Ottawa, ON, K1Z 1A2
Canada

Contact Information

CFN website:
<http://www.canadianfieldnaturalist.ca/index.php/cfn/about>

Ottawa Field-Naturalists' Club (our publisher) website:
www.ofnc.ca

Editor-in-Chief: Dr. Carolyn Callaghan
editor@canadianfieldnaturalist.ca

Assistant Editor: Trina Rytwinski
canadianfieldnaturalistae@gmail.com

Book Review Editor: Roy John
r.john@rogers.com

Journal Manager: Jay Fitzsimmons
subscriptions@canadianfieldnaturalist.ca

Book Reviews (*continued*)

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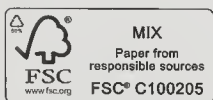
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The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information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

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Business Manager: Frank Pope, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2

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COVER: Dorsal-lateral view of a variant of the amelanistic condition of the Eastern Red-hacked Salamander, *Plethodon cinereus*, collected from Point Pleasant Park, Halifax, Nova Scotia. Photo by Roger Lloyd, Nova Scotia Department of Communities, Culture, and Heritage. See article by Russell, Beslin, Hudak, Ogunbiyi, and Gilhen, pages 359-362.

The Canadian Field-Naturalist

Volume 125, Number 4

October–December 2011

Bees and Butterflies in Burned and Unburned Alvar Woodland:
Evidence for the Importance of Postfire Succession to Insect
Pollinator Diversity in an Imperiled EcosystemALANA N. TAYLOR¹ and PAUL M. CATLING²¹York University, 4700 Keele Street, Toronto, Ontario, M3P 1J3 Canada; email: antaylor@yorku.ca²Agriculture and Agri-Food Canada, Environmental Health, Biodiversity, Wm. Saunders Bldg., Central Experimental Farm, Ottawa, Ontario, K1A 0C6 Canada; email: catlingp@agr.gc.ca

Taylor, Alana N. and Paul M. Catling. 2011. Bees and butterflies in burned and unburned alvar woodland: Evidence for the importance of postfire succession to insect pollinator diversity in an imperiled ecosystem. *Canadian Field-Naturalist* 125(4): 297-306.

The apparent importance of successional habitat to pollinating insects, specifically bees (Hymenoptera) and butterflies (Lepidoptera) was quantified in an alvar landscape in the Ottawa valley through a comparison of burned and unburned alvar woodland. The two adjacent habitats on the same successional gradient were sampled by sweeping with additional data from pitfall traps for bees and by direct observation with close focus binoculars and occasional verification through capture with a net for butterflies. The sampling was done during 11 visits in 2008 beginning 16 May and ending 13 September. Both bee and butterfly diversity were higher in the post-fire burned alvar woodland compared to the adjacent unburned woodland based on species richness, number of individuals and Brillouin's Biodiversity Index which takes evenness and heterogeneity into account. No bees were captured in the unburned area, but 34 species and 201 individuals were captured in the burned site. The most abundant bee species was *Augochlora aurata*. Lepidoptera were represented in the burned site by 35 species and 408 individuals compared to 15 species and 21 individuals in the unburned woodland. The most common butterfly species in the burned woodland was *Callophrys polios*. The higher diversity of pollinators in the burned site was correlated with both higher vascular plant diversity and much higher cover and frequency values for insect-pollinated plants providing nectar and pollen including flowering shrubs such as *Amelanchier alnifolia* var. *compacta*, *Arctostaphylos uva-ursi* and *Prunus virginiana*. The burned site also provided more cover of larval food plants for butterflies and apparently more nesting sites for bees. We suggest that a decrease in fire frequency and in the availability of open successional habitats are contributing factors in the decline of pollinators, and that endangered ecosystems where fire has been a natural phenomenon may require fire or fire-simulated management to sustain their biodiversity.

Key Words: pollinators, biodiversity, Lepidoptera, Hymenoptera, alvar, succession, fire, Ontario, Canada.

Pollination plays a crucial role economically and ecologically (Kevan and Phillips 2001; Luck et al. 2003; Klein et al. 2007; Kremen et al. 2007). Bees (Hymenoptera) are the most important group of pollinating insects in the world (Biesmeijer et al. 2006) and it is estimated that there are over 800 species in Canada (Sheffield, personal communication). Butterflies (Lepidoptera) are another important pollinator group in North America with over 297 species of butterflies in Canada (Layberry et al. 1998). Recent biodiversity surveys have reported declines in both groups worldwide (Committee on the Status of Pollinators 2006; White and Kerr 2006), particularly, in populated regions including parts of Canada such as Southern Ontario. The decline of pollinators has been attributed to a number of possible causes including the use of pesticides (Kevan et al. 1997), the loss of habitat due to anthropogenic activities in the form agricultural intensification

and industrial development (Kevan 1999) and climate change (Parmesan et al. 1999). However, a decline in pollinators could also be caused by loss of early successional stage plant communities resulting from the cessation of natural ecological processes such as fire.

The southern Ontario landscape in pre-settlement times included a variety of successional habitats, largely as a result of natural fires caused by lightning. Incidence of fire was also high as a result of aboriginal communities using fire for agricultural purposes and to improve hunting (Day 1953; Bakowsky and Riley 1994). The arrival of European settlers in North America led to a vastly reduced frequency of fire as a result of fragmentation of wooded landscape, roads acting as fire breaks, and direct fire suppression to protect commercial wood and homes. Newly begun successions became rare and older successions proceeded from the open earlier stages to later seral stages with increasing

tree cover. Now in a fragmented landscape without fire for a few hundred years, many natural areas and entire landscapes have lost or are about to lose the open and semi-open habitats. The fact that certain species need early successional stages is well known. Controlled fire is currently used to maintain ecosystem diversity (Lee et al. 1998) with management processes sometimes adjusted to resemble pre-settlement conditions based on historical records (Whelan 1995) and executed in such a way as to reduce any negative impact on arthropod populations (Siemann et al. 1996). Fire management is well developed in some regions, but it is not utilized at all in others and the importance of successional habitats produced by fire to insects is not well documented, especially for pollinating insects (Bradstock et al. 2005; Nol et al. 2006; Parr and Anderson 2006; Dixon 2009). Although some authors have concluded that catastrophic events such as fire promote pollinator diversity through the establishment of a diverse patchwork of habitats at different successional stages (Swengel 1996; Potts et al., 2001, 2003), just how important this promotion is and how widespread it remains unclear.

Here we use an alvar landscape in the Ottawa valley that was partly burned nine years previously to provide evidence for the importance of successional habitat to pollinating insects, specifically bees (Hymenoptera) and butterflies (Lepidoptera). Alvars, i.e., naturally open areas of thin soil over essentially flat limestone or marble rock with trees absent or not forming a continuous canopy, are among the most unique and threatened habitats in Canada (Catling and Brownell 1999; Brownell and Riley 2000) and are generally considered to be globally imperiled (Reschke et al. 1999). Earlier studies (Catling et al. 2001, 2002; Catling and Sinclair 2002; Catling 2009; and Catling et al. 2010) have suggested the importance of post fire succession to diversity of plants and ground dwelling insects in these imperiled ecosystems, but pollinators had not been studied. Specifically we compare two sites on the same successional gradient: a semi-open boreal woodland that represents climax vegetation for the site, and a nearly adjacent site that previously had similar vegetation but had burned nine years before and developed into a relatively long lasting successional alvar shrubland (Catling 2009).

Methods

The study area

The study area is part of an alvar landscape within Burnt Lands Provincial Park 6 km NE of Almonte in the Ottawa valley of Ontario. Alvars are unusual ecosystems with a fragmented distribution in North America and are considered globally imperiled. The woodland study site included 4 hectares (approximately 10 acres) centered at 45.2569°N, -76.1437°W. The corresponding burned woodland study site 0.5 km to the southeast also included 4 hectares centered at

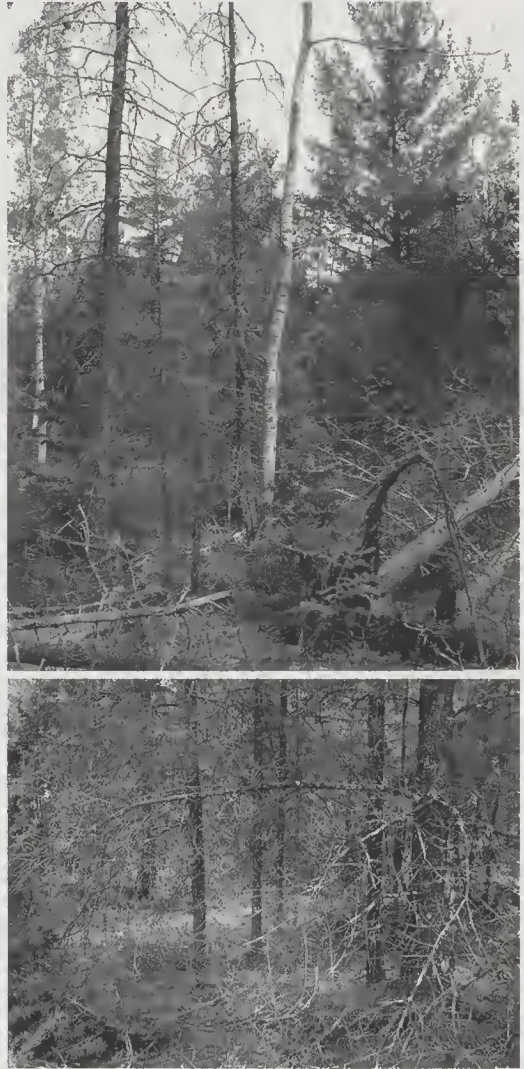


FIGURE 1. Two views of the unburned alvar woodland study area on the Burnt Land Alvar west of Ottawa. Above, fallen and drought-killed trees of *Abies balsamea* and *Picea glauca* with living plants of the former as well as *Pinus strobus*, *Thuja occidentalis*, and *Populus tremuloides*. Below a more shaded area with the ground flora dominated by *Carex eburnea* and mosses. Photo by P. M. Catling at 45.2569 N, -76.1437 W, in late May 2008.

45.2507°N, -76.1437°W. Based on personal observation and examination of aerial photographs, both of these study areas had been semi-open, mixed boreal forest until 23 June 1999 when a fire swept through 152 acres including the southern study site. The forest that remained and the forest that burned (Figure 1) were dominated by *Abies balsamea*, *Picea glauca*, *Pinus strobus*, *Thuja occidentalis*, and *Populus tremu-*



FIGURE 2. Left, alvar shrubland developed from alvar woodland burned 9 years previously. Flowering shrubs of *Amelanchier alnifolia* var. *compacta*, very important to pollinating insects, can be seen below a dead *Thuja occidentalis*. Right, flowering inflorescence of *Amelanchier alnifolia* var. *compacta*, a species that becomes very abundant following fire in alvar woodland and serves as a major source of pollen and nectar for pollinating insects. Photo taken by P. M. Catling at 45.2507°N, -76.1437°W in late May 2008.

loides with an understory of mosses including *Hylacomium splendens* and *Dicranum polysetum* and occasional depauperate shrubs including *Juniperus communis*. Nine years after the fire the burned area had developed into a long-lasting successional shrubland (Figure 2) dominated by shrubs such as *Prunus virginiana*, *Arctostaphylos uva-ursi*, *Amelanchier alnifolia* var. *compacta* and *Symphoricarpos albus*, and herbs such as *Danthonia spicata* and *Carex richardsonii*.

Fire is a natural process on alvars and evidence of past fire is commonly found (Catling and Brownell 1999; Jones and Reschke 2005). The Burnt Lands have long been known to be particularly subject to fire on account of shallow soil on an elevated plateau of porous limestone rock. The area was named the Burnt Lands by settlers in 1870, at the time of the second most recent fire. Additional information on the two study sites is available in Catling (2009).

Collection, identification, biodiversity measures and floristic data

Lepidoptera in the groups Hesperoidea and Papilionoidea were recorded for a 30 minute period during each visit and bees were collected for a second 15 minute period by sweeping vegetation including flowering herbs and shrubs. The observations and collec-

tions were made along transects 100 m in length in each site and during sunny, mild or warm conditions. Information on bees was also derived from pitfall traps as bycatch of a study of ground-dwelling insects. Pan traps were not used because we did not want to stress the pollinator populations at the site and we considered that the limited sweeping and accessory information from the pitfall traps would provide sufficient information to reveal a trend. Ten pitfall traps (15 cm × 10 cm × 5 cm deep) were set out at each site. The traps were buried so that the tops were flush with the ground surface and each trap was filled with antifreeze with a drop of soap to half depth. The traps were checked five days after setting. The survey continued from spring through summer to fall with several gaps. The dates for recording Lepidoptera, collecting bees and checking the traps were 16 May, 1, 9 June, 1, 5, 12 July, 16, 21, 26 August, and 8, 13 September.

Extensive observations on 10 days during two years prior to the study revealed many hundreds of pollinators in the burned area on each occasion compared to less than a dozen in equal areas of forest during equal amount of time. This suggested that differences between pollinators in the burned area and the surrounding woodland were very substantial with the woodland

TABLE 1. Apidae recorded on the Burnt Lands Alvar showing species collected during the 2008 collecting season and host plants.

| Bee Species | sweep | trap | Date | Plant host/trap | Bee Species | sweep | trap | Date | Plant host/trap |
|-----------------------------------|-------|------|--------|---|-----------------------------------|------------|-----------|--------|--------------------------------|
| <i>Apis mellifera</i> | 2 | | 06-May | <i>Arctostaphylos uva-ursi</i> | | 4 | | 21-Aug | <i>Oligoneuron album</i> |
| <i>Andrena alleghaniensis</i> | 1 | | 24-May | <i>Prunus virginiana</i> | | 1 | | 16-Aug | <i>Solidago</i> sp. |
| <i>Andrena asteroides</i> | 1 | | 06-May | <i>Amelanchier alnifolia</i> ¹ | <i>Colletes inaequalis</i> | 5 | | 06-May | <i>Arctostaphylos uva-ursi</i> |
| | 1 | | 16-May | <i>Prunus virginiana</i> | | 2 | | 10-May | <i>Amelanchier alnifolia</i> |
| <i>Andrena dunningi</i> | 3 | | 06-May | <i>Arctostaphylos uva-ursi</i> | <i>Lasioslossum divergens</i> | 1 | | 06-May | <i>Arctostaphylos uva-ursi</i> |
| <i>Andrena illinoensis</i> | 2 | | 06-May | <i>Amelanchier alnifolia</i> | | 4 | | 10-May | <i>Arctostaphylos uva-ursi</i> |
| <i>Andrena milwaukeeensis</i> | 1 | | 06-May | <i>Arctostaphylos uva-ursi</i> | | 2 | | 10-May | Yellow flower |
| <i>Andrena nasotii</i> | 6 | | 06-May | <i>Amelanchier alnifolia</i> | <i>Lasioslossum imitatum</i> | 2 | 1 | 10-May | Trap |
| | 2 | | 10-May | Yellow flower | <i>Lasioslossum foxii</i> | 7 | | 06-May | <i>Amelanchier alnifolia</i> |
| <i>Andrena vicina</i> | 1 | | 10-May | <i>Amelanchier alnifolia</i> | | 5 | | 10-May | <i>Amelanchier alnifolia</i> |
| | 2 | | 24-May | <i>Prunus virginiana</i> | | 3 | | 16-May | <i>Prunus virginiana</i> |
| <i>Augochloropsis metallica</i> | 1 | 1 | 10-May | Trap | | 2 | | 24-May | <i>Prunus virginiana</i> |
| <i>Augochlora aurata</i> | 1 | 1 | 10-May | Trap | <i>Lasioslossum rufitarsis</i> | 3 | | 06-May | <i>Amelanchier alnifolia</i> |
| | 1 | | 10-May | Yellow flower | | 5 | | 10-May | <i>Amelanchier alnifolia</i> |
| | 1 | | 24-May | <i>Prunus virginiana</i> | | 1 | | 16-May | <i>Prunus virginiana</i> |
| | 10 | 10 | 01-Jun | <i>Prunus virginiana</i> | | 1 | | 16-May | <i>Prunus virginiana</i> |
| | 7 | 5 | 03-Jun | <i>Prunus virginiana</i> | <i>Lasioslossum versatum</i> | 3 | | 24-May | <i>Prunus virginiana</i> |
| | 1 | 1 | 09-Jun | <i>Prunus virginiana</i> | | 1 | | 06-May | <i>Amelanchier alnifolia</i> |
| | 1 | 1 | 05-Jul | Trap | | 1 | | 10-May | <i>Amelanchier alnifolia</i> |
| | 2 | | 16-Aug | <i>Solidago</i> sp. | | 1 | | 16-May | <i>Prunus virginiana</i> |
| | 1 | 1 | 21-Aug | <i>Oligoneuron album</i> | | 2 | 2 | 01-Jun | Trap |
| | 3 | | 08-Sep | Trap | <i>Lasioslossum versans</i> | 2 | 4 | 16-Aug | Trap |
| <i>Bombus binaclitatus</i> queen | 3 | | 06-May | <i>Arctostaphylos uva-ursi</i> | | 1 | | 21-Aug | <i>Oligoneuron album</i> |
| <i>Bombus binaclitatus</i> worker | 1 | | 11-Jun | <i>Rosa</i> sp. | | 1 | | 06-May | <i>Amelanchier alnifolia</i> |
| <i>Bombus ternarius</i> | 3 | 1 | 10-May | <i>Arctostaphylos uva-ursi</i> | <i>Halictus confusus</i> | 2 | | 24-May | <i>Prunus virginiana</i> |
| <i>Bombus terricola</i> queen | 1 | 1 | 06-May | Trap | | 2 | | 10-May | Yellow flower |
| <i>Bombus impatiens</i> queen | 1 | | 10-May | <i>Arctostaphylos uva-ursi</i> | <i>Halictus ligatus</i> | 3 | | 24-May | <i>Prunus virginiana</i> |
| <i>Bombus impatiens</i> worker | 1 | | 11-Jun | <i>Rosa</i> sp. | <i>Halictus rubicundus</i> | 1 | | 16-Aug | <i>Oligoneuron album</i> |
| | 2 | | 08-Sep | <i>Solidago</i> sp. | | 1 | | 10-May | Yellow flower |
| <i>Ceratina calcarata</i> | 2 | | 10-May | Yellow flower | | 1 | | 24-May | <i>Prunus virginiana</i> |
| | 1 | 1 | 03-Jun | Trap | <i>Hoplitis pilosifrons</i> | 2 | 2 | 01-Jun | Trap |
| | 5 | | 09-Jun | Trap | <i>Hylaeus illinoensis</i> | 1 | 3 | 09-Jun | Trap |
| | 8 | | 16-Aug | <i>Solidago</i> sp. | <i>Lasioslossum leucocozonium</i> | 1 | | 08-Sep | <i>Solidago nemoralis</i> |
| | 11 | | 21-Aug | <i>Oligoneuron album</i> | | 1 | | 24-May | <i>Prunus virginiana</i> |
| <i>Ceratina dupla</i> | 2 | 1 | 10-May | Yellow flower | <i>Osmia atriventris</i> | 1 | 1 | 09-Jun | Trap |
| | | | 09-Jun | Trap | <i>Osmia proxima</i> | 4 | 4 | 11-Jun | <i>Packeria paupercula</i> |
| | | | | | Totals | 155 | 46 | | |

All *Amelanchier alnifolia* is referable to var. *compacta*.

having very low diversity and numbers. Had this been any less obvious, the sampling procedure here may have involved replicates and detailed statistical analyses. However, considering the extent to which the trend was clear, we decided that it was only necessary to quantify it and to ensure that the transects were representative. Based on a general survey of the area, these transects were fully representative of the burned area and the surrounding forest in both vegetation and topography which varied over distances much larger than 100 m.

The Lepidoptera – Hesperioidea and Papilionoidea were identified by P. M. Catling using Layberry et al. (1998). Hymenoptera – Apoidea were identified by A. Taylor and J. Gibbs using Packer et al. (2007), Romankova (2003), Mitchell (1960) and Gibbs (submitted). Bees collected were deposited in the bee collection of L. Packer at York University.

Biodiversity of collected insects was compared with respect to total number of species and numbers of individuals within species and with regard to Brillouin's Index which is appropriate for collections (Krebs 1999). The calculation was made using software provided by Krebs (2008).

To compare the pollinator diversity results with the potential value of the vegetation at each of the sites to pollinating insects, we compared average cover and total frequency values for insect pollinated plant species known to, or suspected of, providing pollen or nectar rewards. This included excluding all wind-pollinated species from data that were obtained as part of a floristic inventory based on thirty 1 m² quadrats placed 3 m apart along a transect at each site (Catling 2009). The cover was then estimated for each plant species within each quadrat as 1/2 of the surface area of all plants to 2 m tall (i.e., the percentage of the square meter that would be covered by all vegetation overlapping the square if all plants were laid flat and not overlapping.). The average cover for each species was then summed and expressed as a percentage of the total average cover of all species at each site. Frequency was determined as the number of quadrats within which a species occurred at a site. Both of these measures suggest the relative biomass and abundance of plants beneficial to pollinators. Although biodiversity and abundance are not direct indicators, like the number of flowers, they are considered to be reasonable surrogates since there is a clear relationship between flower number and both biomass and abundance.

Results

The difference in diversity of bees between woodland and successional shrubland (that was woodland only 9 years earlier) was substantial. In the woodland one individual *Bombus* sp. and one individual *Osmia* sp. were observed in flight and no bees were captured with nets or in traps. In the burned area, 34 species and 219 individuals were captured, and of the latter,

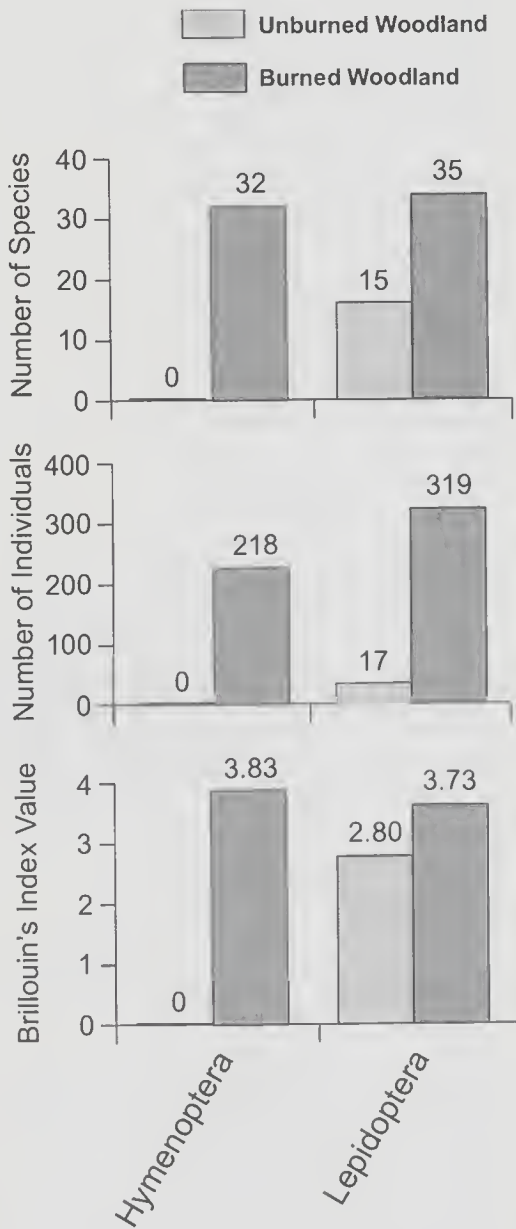


FIGURE 3. Histograms showing number of species, number of individuals, and the value of Brillouin's Index for burned and unburned alvar woodland.

173 were swept from flowering plants and 46 were obtained in pitfall traps (Table 1). Hundreds of bees were seen but not captured during the standard collecting procedure in the burned area. The most abun-

TABLE 2. Lepidoptera – Hesperioidea and Papilionoidea recorded on the Burnt Lands Alvar showing species encountered during the 2008 survey in burned and unburned alvar woodland.

| Species | Burned | | Unburned | | Totals |
|------------------------------------|-----------|------------|----------|--------|--------|
| | Unburned | Burned | Unburned | Burned | |
| <i>Aglais milberti milberti</i> | 1 | 2 | | | |
| <i>Amblyscirtes vitalis</i> | 1 | 11 | | | |
| <i>Boloria bellona</i> | 0 | 15 | | | |
| <i>Calliphrys henrici</i> | 1 | 0 | | | |
| <i>Calliphrys niphon</i> | 3 | 0 | | | |
| <i>Calliphrys polios</i> | 2 | 128 | | | |
| <i>Celastrina (ladon) lucia</i> | 2 | 20 | | | |
| <i>Cercyonis pegala</i> | 0 | 2 | | | |
| <i>Coenonympha tullia inornata</i> | 0 | 19 | | | |
| <i>Colias eurytheme</i> | 0 | 5 | | | |
| <i>Colias philodice</i> | 0 | 22 | | | |
| <i>Danaus plexippus</i> | 0 | 3 | | | |
| <i>Enodia antheodon</i> | 1 | 0 | | | |
| <i>Erynnis icelus</i> | 0 | 7 | | | |
| <i>Erynnis juvenalis</i> | 0 | 18 | | | |
| <i>Erynnis lucitius</i> | 2 | 35 | | | |
| <i>Glaucopsyche lygdamus</i> | 0 | 4 | | | |
| <i>Hesperia sassacus</i> | 0 | 2 | | | |
| <i>Limnitis arthemis arthemis</i> | 0 | 4 | | | |
| <i>Limnitis archippus</i> | 0 | 3 | | | |
| <i>Megisto cymela cymela</i> | 2 | 0 | | | |
| <i>Nymphalis antiopa</i> | | | 1 | | |
| <i>Nymphalis vaualbum j-album</i> | | | 0 | | |
| <i>Papilio canadensis</i> | | | 1 | | |
| <i>Papilio polixenes</i> | | | 0 | | |
| <i>Phyciodes tharos</i> | | | 0 | | |
| <i>Pieris oleracea</i> | | | 0 | | |
| <i>Pieris rapae</i> | | | 0 | | |
| <i>Poanes hobomok</i> | | | 1 | | |
| <i>Polites mystic</i> | | | 0 | | |
| <i>Polites themistocles</i> | | | 0 | | |
| <i>Polygona comma</i> | | | 0 | | |
| <i>Polygona faunus</i> | | | 0 | | |
| <i>Polygona interrogatoris</i> | | | 1 | | |
| <i>Polygona progné</i> | | | 1 | | |
| <i>Speyeria aphrodite</i> | | | 0 | | |
| <i>Speyeria cybele</i> | | | 1 | | |
| <i>Thorybes pylades</i> | | | 0 | | |
| <i>Thymelicus lineola</i> | | | 0 | | |
| <i>Vanessa cardui</i> | | | 0 | | |
| <i>Wallengrénia egeremet</i> | | | 0 | | |
| Totals | 21 | 408 | | | |

TABLE 3. Comparison of average cover¹ and total frequency² (20m² quadrats) values for insect pollinated plants in burned and unburned alvar woodland.

| Species | Woods ¹ | Burn ¹ | Woods ² | Burn ² | Species | Woods ¹ | Burn ¹ | Woods ² | Burn ² |
|---|--------------------|-------------------|--------------------|-------------------|---|--------------------|-------------------|--------------------|-------------------|
| <i>Achillea millefolium</i> | 0.13 | 0 | 2 | 0 | <i>Packera paupercula</i> (<i>Senecio</i>) | 0.06 | 2.7 | 2 | 17 |
| <i>Amelanchier alnifolia</i> var. <i>compacta</i> | 0.1 | 14.43 | 3 | 11 | <i>Penstemon lirsutus</i> | 0 | 0.76 | 0 | 7 |
| <i>Anemone cylindrica</i> | 0 | 0.5 | 0 | 7 | <i>Polygala senega</i> | 0 | 0.43 | 0 | 5 |
| <i>Antennaria</i> sp. | 0.03 | 0 | 2 | 0 | <i>Potentilla norvegica</i> | 0 | 0.13 | 0 | 1 |
| <i>Apocynum cannabinum</i> | 0 | 0.5 | 0 | 3 | <i>Prunella vulgaris</i> | 1.96 | 0.13 | 6 | 3 |
| <i>Aquilegia canadensis</i> | 0.6 | 0.63 | 8 | 6 | <i>Prunus virginiana</i> | 0 | 22.43 | 0 | 14 |
| <i>Arabis tirsuta</i> | 0 | 0.06 | 0 | 4 | <i>Rhamnus cathartica</i> * | 0.2 | 0 | 3 | 0 |
| <i>Arctostaphylos uva-ursi</i> | 4.53 | 18.13 | 13 | 19 | <i>Rhus aromatica</i> | 0 | 0.2 | 0 | 4 |
| <i>Arenaria serpyllifolia</i> * | 0 | 0.1 | 0 | 3 | <i>Rhus typhina</i> | 0 | 0.13 | 0 | 4 |
| <i>Aster macrophyllus</i> | 0 | 0.06 | 0 | 4 | <i>Rosa acicularis</i> | 0.63 | 5 | 8 | 15 |
| <i>Astragalus negelecta</i> | 0 | 1 | 0 | 3 | <i>Rosa blanda</i> | 0 | 0.23 | 0 | 5 |
| <i>Calystegia spithamea</i> | 0 | 0.46 | 0 | 7 | <i>Rubus idaeus</i> ssp. <i>strigosus</i> | 0 | 0.53 | 0 | 6 |
| <i>Campanula rotundifolia</i> | 0 | 1 | 0 | 11 | <i>Rubus odoratus</i> | 0 | 0.2 | 0 | 3 |
| <i>Cirsium discolor</i> | 0 | 0.03 | 0 | 3 | <i>Scutellaria parvula</i> | 0 | 0.2 | 0 | 5 |
| <i>Cirsium vulgare</i> * | 0 | 0.03 | 0 | 3 | <i>Shepherdia canadensis</i> | 0.26 | 0 | 3 | 0 |
| <i>Clinopodium vulgare</i> | 0.1 | 0.03 | 2 | 3 | <i>Silene antirrhina</i> | 0 | 0.03 | 0 | 3 |
| <i>Cornus sericea</i> ssp. <i>sericea</i> (<i>C. stolonifera</i>) | 0 | 3.63 | 0 | 8 | <i>Sisyrinchium montanum</i> | 0 | 0.33 | 0 | 3 |
| <i>Diervilla lonicera</i> | 0 | 0.13 | 0 | 3 | <i>Solidago canadensis</i> | 0 | 0.4 | 0 | 4 |
| <i>Echium vulgare</i> * | 0 | 0.96 | 0 | 5 | <i>Solidago juncea</i> | 0.13 | 1.36 | 3 | 12 |
| <i>Erigeron philadelphicus</i> | 0 | 0.26 | 0 | 3 | <i>Solidago nemoralis</i> | 0.03 | 3.46 | 2 | 16 |
| <i>Euthamia granitifolia</i> | 0 | 0.26 | 0 | 4 | <i>Symphoricarpos albus</i> | 6 | 7.76 | 19 | 19 |
| <i>Fragaria virginiana</i> | 0.46 | 2.43 | 7 | 15 | <i>Symphoricarpos ciliolatum</i> (<i>Aster</i>) | 1.3 | 3.03 | 6 | 17 |
| <i>Frangula alnus</i> * | 0.2 | 0 | 4 | 0 | <i>Taraxacum officinale</i> * | 0 | 0.33 | 0 | 6 |
| <i>Geranium bicknellii</i> | 0 | 0.03 | 0 | 3 | <i>Toxicodendron rydbergii</i> (<i>Rhus</i>) | 0.16 | 4.13 | 3 | 16 |
| <i>Hedeoma piperitoides</i> * | 0.13 | 0.03 | 0 | 3 | <i>Tragopogon dubius</i> * | 0 | 0.23 | 0 | 3 |
| <i>Hieracium piloselloides</i> * | 0.1 | 1.96 | 2 | 14 | <i>Trifolium hybridum</i> * | 0 | 0.56 | 0 | 8 |
| <i>Hypoxis brachiatus</i> | 0 | 0.23 | 0 | 4 | <i>Verbascum thapsus</i> * | 0 | 0.03 | 0 | 3 |
| <i>Lilium philadelphicum</i> | 0 | 0.4 | 0 | 4 | <i>Viola adunca</i> | 0 | 0.76 | 0 | 8 |
| <i>Linaria vulgaris</i> * | 0.1 | 0 | 0 | 3 | <i>Viola nephrophylla</i> | 0.06 | 0.16 | 3 | 4 |
| <i>Lonicera tatarica</i> * | 0.03 | 0 | 2 | 0 | <i>Waldsteinia fragarioides</i> | 2.03 | 0.26 | 10 | 4 |
| <i>Matanthenium canadense</i> | 0.66 | 0 | 6 | 0 | Total | 19.99 | 107.67 | 121 | 400 |
| <i>Medicago lupulina</i> * | 0 | 0.53 | 0 | 11 | Total possible | 120.22 | 167.59 | 254 | 553 |
| <i>Oligoneuron album</i> (<i>S. ptarmicoides</i>) | 0 | 2.9 | 0 | 7 | Percentage | 16.62 | 64.24 | 47.63 | 75.58 |

* = introduced species.

dant bee species caught was *Augochlora aurata* (Smith) with 45 individuals (Table 1) with *Andrena nasonii* (Robertson), *Ceratina calcarata* (Robertson), and *Lasioglossum (Evylaeus) foxii* (Robertson) among the most common species captured (Table 1). More species and individuals of Lepidoptera in the groups Hesperoidea and Papilionoidea were also evident in the burned site which had 35 species and 408 individuals compared to 15 species and 21 individuals in the unburned woodland (Table 2). The most abundant butterfly in the burned area was the locally rare *Callophrys polios* (Layberry et al. 1982).

The value for Brillouin's biodiversity index was higher for the Lepidoptera in the burned area but could not be calculated for bees in woodland since none were captured. The value of the index was higher for bees found in the burned site than for Lepidoptera in either site (Figure 3).

The cover of insect-pollinated plants in the burned area was five times greater than that of the woodland and represented 64.24% of the total as compared to 16.62% for the woods. Flowering plants with substantial nectar and pollen resources such as *Amelanchier alnifolia* var. *compacta*, *Arctostaphylos uva-ursi* and *Prunus virginiana* had much higher cover values and were much more frequent in the successional shrubland (Table 3). Among the most important individual species, *Amelanchier alnifolia* var. *compacta* had approximately 15 times the cover value in the successional habitat, *Arctostaphylos uva-ursi* had about 5 times the cover and *Prunus virginiana* had more than 22 times the cover than in unburned woodland. Even when present as relict individuals in the woodland, these species bloomed sparingly there.

Discussion

The basis for the increased pollinator diversity in the successional shrubland is evidently the vastly increased value of this habitat to pollinators. The diversity of pollinators is at least partially dependent on habitat quality (Winfree et al., 2007). If a habitat does not offer pollinators accommodation for larval stages and/or floral resources for foraging adults, it would be unsuitable to sustain pollinator communities. With regard to floral resources, the burned woodland is far superior to the unburned woodland being dominated by flowering shrubs providing both abundant pollen and nectar for bees and food sources for both adult and larval butterflies. Although *Arctostaphylos uva-ursi*, the larval food plant of *Callophrys polios* was only 1.46 times as frequent in the burned area, its cover value was four times greater (Table 3) providing an explanation for the much greater abundance of the butterfly there. Despite the higher density of vegetation in the burned area there was extensive open ground including rock, shallow bare soil and turf. Many of the shrubs emerged from cracks in the shallowly underlying limestone rock. The more extensive open ground likely increased avail-

able nesting sites for bees including *Andrena nasonii*, *Lasioglossum foxii*, and *Lasioglossum imitatum* which were among the most common bee species caught within the burnt alvar habitat (Table 2). Each of the bee species noted above nest in the ground (Grixti and Packer, 2006). The abundance of ground-nesting bees in the burned site is not surprising as fire tends to remove leaf litter and debris that might otherwise cover potential nest sites. As succession proceeds in post-fire habitat more cavities become available for nests as a result of dead trees and also from the establishment of pithy stemmed mid-successional stage species such as *Rubus* spp. This may explain the abundance of cavity nesting species such as *Augochlora aurata* and *Ceratina calcarata* (Table 2).

Our study suggests that successional shrubland that develops after fire in semi-open, conifer-dominated alvar woodland is far more important for pollinating insects than the original woodland. It supports and quantifies earlier general observations and detailed studies in other regions (Fahrig 2003; Grixti and Packer 2006, Swengel and Swengel 2007, Vogel et al. 2007) that indicate the importance of successional habitat in providing nesting sites and floral resources (Fahrig, 2003; Grixti and Packer, 2006). Early successional stages continued for some time (decades to a few hundred years) after the cessation of ecological processes such as fire which occurred regularly up to 100-200 years ago. The lag period now appears to be coming to an end and the effects of lack of fire are increasingly obvious. We suggest that the loss of fire and open successional habitats is a contributing factor in the decline of pollinators, and that endangered ecosystems, such as alvars, where fire was a natural phenomenon require fire or fire-simulated management to sustain their biodiversity.

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Some Observations of Short-eared Owl, *Asio flammeus*, Ecology on Arctic Tundra, Yukon, Canada

DONALD G. REID¹, FRANK I. DOYLE², ALICE J. KENNEY³, and CHARLES J. KREBS³

¹Wildlife Conservation Society Canada, Whitehorse, Yukon Y1A 5T2 Canada

²Wildlife Dynamics Consulting Ltd., Smithers, British Columbia V0J 2N0 Canada

³Department of Zoology, University of British Columbia, Vancouver, British Columbia V6T 1Z4 Canada

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We investigated nesting behavior, food habits, and interspecific interactions of Short-eared Owls (*Asio flammeus*) within an arctic tundra raptor community on Herschel Island and Komakuk Beach, northern Yukon, Canada. Short-eared Owls were the least common nesting raptor. We found only three nests, all on Herschel Island. All nests were on relatively elevated sites with fairly substantial vegetative cover. All nests failed in the egg stage, from a combination of human disturbance and possible predation by Arctic Fox (*Vulpes lagopus*) or Red Fox (*Vulpes vulpes*). Short-eared Owls nested only in years when small rodent densities were at least 4 to 5 individuals per hectare in the spring. Short-eared Owls ate Northern Collared Lemmings (*Dicrostonyx groenlandicus*), Brown Lemmings (*Lemmus trimucronatus*), and Tundra Voles (*Microtus oeconomus*) almost exclusively, without clear selectivity. Peregrine Falcons (*Falco peregrinus*) killed two adult Short-eared Owls. In northern Yukon, the Short-eared Owl remains an uncommon summer resident and uses the region as a migration route. Spring rodent densities and interspecific predation are prominent limiting factors, and human disturbance also limits nesting success. We recommend restricting access to most tundra areas during periods when the birds are mating, initiating nesting, and incubating eggs. We recommend that human infrastructure be designed so that it cannot support novel nesting (and therefore local range expansion) by other nesting raptors that compete with and prey on Short-eared Owls.

Key Words: Short-eared Owl, *Asio flammeus*, Herschel Island, Komakuk Beach, nesting success, prey selection, raptor community, Herschel Island-Qikiqtaruk Territorial Park, Ivvavik National Park of Canada, Yukon.

The Short-eared Owl, *Asio flammeus*, is one of the most widespread birds of prey globally. It generally occupies open habitats, such as grasslands, marshes, heaths, and tundra (Wiggins et al. 2006). In Canada, the Short-eared Owl has been classified as a species of special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), primarily because of population declines apparently resulting from loss or alienation of grassland and marshland habitats (COSEWIC 2008*). In Canada, the Short-eared Owl is on Schedule 3 of the Species at Risk Act.

In northern Canada, habitat loss has been much less than in the south. However, other factors that limit the population size, nesting density, and nesting success of the Short-eared Owl in more southerly regions may also apply in the Arctic. These limiting factors include the abundance of prey (Clark 1975; Priestley et al. 2008); competitive interactions with other predators of rodents, including kleptoparasitism (Clark 1975; Lein and Boxall 1979); nest predation (Wiggins et al. 2006); and mortality resulting from agonistic encounters with other raptors (Murie 1929; Sooter 1942; Killpack 1951; Holt 1992). Populations of the Short-eared Owl congregate in areas with relatively high population densities of small rodents (which are the primary prey of the Short-eared Owl). Clutch size and nesting success also increase with higher rodent densities (Pitelka et al. 1955a; Village 1987; Korpimäki and Norrdahl 1991). The aggregative response to increased numbers of prey appears to result from wide-ranging, nomadic

movements (Clark 1975). In addition, some populations of Short-eared Owls, including those nesting in boreal or arctic Yukon, are migratory (Sinclair et al. 2003; Wiggins et al. 2006).

The species has received relatively little attention in arctic regions. Pitelka et al. (1955a, 1955b) studied raptors at Point Barrow on the Arctic Coastal Plain in Alaska, and they found that Short-eared Owls nested only when Brown Lemmings (*Lemmus trimucronatus*) were at cyclic high densities. Short-eared Owls were completely absent at low densities of Brown Lemmings. Nesting success was poor (only about 13% of eggs surviving to young leaving the nest), with egg and chick loss resulting from predation by Pomarine Jaegers (*Stercorarius pomarinus*) coupled with disturbance by humans (Pitelka et al. 1955a, 1955b). Salter et al. (1980) classified Short-eared Owls as "uncommon summer residents" on the Arctic Coastal Plain of northern Yukon, with highest numbers observed during spring migration. Considering the entire Beaufort Sea coastal region, Johnson and Herter (1989*) found that this species was generally uncommon and nested irregularly, notably when small rodent numbers were particularly high. Short-eared Owls have been observed nesting and foraging further north in the Canadian Arctic (Parks Canada Agency 2002*; Therrien 2010) than was confirmed by Wiggins et al. (2006).

From 2007 to 2009, we monitored the abundance and nesting success of all raptors at two Low Arctic sites in northern Yukon, Canada, including observa-

tions of Short-eared Owl nesting sites, nesting success, food habits, and interspecific interactions. We report these results here to broaden the general understanding of factors limiting the population dynamics of this raptor in the northerly portions of its range and to discuss implications for conservation.

Study Area

Terrain

We gathered data in an area 25 km² encompassing the eastern end of Herschel Island (Herschel Island–Qikiqtaruk Territorial Park) (69°N, 138°W) and an area 9 km² on Komakuk Beach, Ivvavik National Park of Canada (69°N, 140°W). Both sites are on the coast of the Beaufort Sea in northern Yukon, Canada, and both fall within bioclimate zone D or Low Arctic (Walker et al. 2005) (most of the perennial shrub growth is dwarf but sometimes erect up to 50 cm in height). Elevations range from sea level to 95 m at Herschel and to 25 m at Komakuk.

Herschel Island is a well-drained upland plateau, with permafrost-rich clay and mud cliffs falling into the ocean around most of its shoreline. The two dominant upland vegetation types are Cottongrass Tussock Tundra (sedge tussocks composed of 10–20% cover of *Eriophorum vaginatum*, Cottongrass) (Smith et al. 1989) and Arctic Willow/*Dryas*-Vetch (dwarf-shrub heath) (Smith et al. 1989). A few drainages end in low-elevation alluvial fans vegetated with sedge (*Carex* spp.) meadows with patches of *Salix richardsonii* (Richardson's Willow) up to 1 m high (Smith et al. 1989). The coastal plain at Komakuk is quite flat and relatively poorly drained. Sedge and Cottongrass meadows dominate the landscape, interspersed with better drained Cottongrass Tussock Tundra.

Prey

Northern Collared Lemmings (*Dicrostonyx groenlandicus*) and Brown Lemmings are the most abundant small rodents on Herschel Island, being more common, respectively, in the more open heath and the more structured tussock tundra. Tundra Voles (*Microtus oeconomus*) occupy the wetter streamside communities, which have the most vegetative cover. The two lemming species reached peak densities asynchronously, and their combined summer densities were moderately high on upland tundra in 2007 and 2008 (5–19/ha) and quite low in 2009 (2–6/ha) (Krebs et al. 2011). At Komakuk, densities of small rodents were persistently quite low (<4/ha), with Tundra Voles being most abundant, Brown Lemmings nearly as abundant, and Northern Collared Lemmings virtually absent (Krebs et al. 2011). The most common nesting passerine birds at each site were Lapland Longspur (*Calcarius lapponicus*) and Savannah Sparrow (*Passerculus sandwichensis*). The dominant shorebirds were Baird's Sandpiper (*Calidris bairdii*), Semipalmated Sandpiper (*Calidris pusilla*), and American Golden Plover (*Pluvialis dominica*) at Herschel, and Pectoral Sandpiper

(*Calidris melanotos*) and Red-necked Phalarope (*Phalaropus lobatus*) at Komakuk.

Other raptors and mammals

At Komakuk, Peregrine Falcons (*Falco peregrinus*), Common Ravens (*Corvus corax*), Rough-legged Hawks (*Buteo lagopus*), and Parasitic Jaegers (*Stercorarius parasiticus*) nested in all years, with Peregrine Falcons and Common Ravens relying on the military radar tower for nesting platforms. Arctic Foxes (*Vulpes lagopus*) denned in 2008, and Least Weasels (*Mustela nivalis*) were resident in all years. At Herschel, Peregrine Falcons, Rough-legged Hawks, Long-tailed Jaegers (*Stercorarius longicaudus*), and Sandhill Cranes (*Grus canadensis*) nested each year, and Snowy Owls (*Bubo scandiacus*) were present each year but nested only in 2008. Northern Harriers (*Circus cyaneus*) were transient non-breeders in both areas. Mammalian predators at Herschel in all years included Arctic Fox and Red Fox (*Vulpes vulpes*) and Least Weasel.

Methods

Field crews kept records of Short-eared Owl observations as part of a wide range of ecological observations on Herschel Island from late May to mid-September in 2007, 2008, and 2009, and on Komakuk Beach from mid-June to late June in 2008 and 2009 and from mid-August to late August in 2007, 2008, and 2009.

Short-eared Owl nesting sites and nesting success

To find Short-eared Owl nests, we walked across the tundra through the study areas every two-three days from late May to late June each year (2007, 2008, and 2009 on Herschel Island and 2008 and 2009 at Komakuk). We also performed crepuscular scans from vantage points to observe foraging birds and to locate their resting sites, which we subsequently visited to look for nests. If a nest was located, we avoided the area except for a purposeful visit in mid-July to check on status and extent of hatching and a further visit in mid-August to check on status. To investigate the hypothesis that Short-eared Owls preferentially choose sites providing a combination of greater cover and good local vantage (Pitelka et al. 1955a), we recorded the vegetation type (cover and terrain types in Smith et al. 1989) at each nesting site and its general landscape position.

Small mammals

Our other studies included mark-recapture population abundance estimates of small rodents on two live-trapping grids of 9 ha each in upland tundra, one grid of 1.8 ha on an alluvial fan, and two index lines of 300 m each (details in Krebs et al. 2011). To test the hypothesis that there is a threshold prey density in spring that must be reached before Short-eared Owls will initiate nesting, we related the mean density of small rodents from live-trapping in early to mid-June

to years and sites in which Short-eared Owls initiated nesting.

Short-eared Owl food habits

Our investigation of diet was based on identification of prey remains in cast pellets. We collected pellets at nests and at perches (locally elevated vantage points within 500 m of nests) and on repeatedly searched routes. Prey items were identified by molar tooth patterns (Banfield 1974), hair morphology, feather morphology, and occasionally other bones. We tested selectivity for prey species by Short-eared Owls using the forage ratio (w) (proportion in the diet divided by proportion available, based on estimates of rodent abundance) as a selection index and the G -test statistic to assess the significance of selection (after Krebs 1999).

Interspecific interactions

To investigate potential competitive effects on nest spacing, we mapped the locations of all raptor nests in the study areas to measure distances between nests. To investigate potential interspecific predation, we identified prey remains at the nests of other raptors, and we were always on the lookout for kill sites.

Results

We observed Short-eared Owls most frequently during their spring (late May) and autumn (September) migrations. The observations during migration were all made on Herschel Island, as we did not visit Komakuk at those times. The owls were particularly attracted to the relatively high densities of Brown Lemmings (approximately 10/ha in spring 2007 and approximately 31/ha in September 2008) on an alluvial fan (Pauline Cove). Up to 5 Short-eared Owls hunted this sedge meadow habitat at one time between mid-September and late September. They occasionally cached Brown Lemmings before foraging again. Signs in fresh snow (30 September 2008) indicated that a Short-eared Owl had killed and partially consumed a juvenile Glaucous Gull (*Larus hyperboreus*). The latest date we observed a Short-eared Owl was 29 September (in 2008). Apart from these observations during migration, we rarely observed Short-eared Owls except in association with known nests. It appeared that a few non-breeders stayed on the mainland coastal plain through the summer, judging by occasional observations at Komakuk, where we found no evidence of nesting.

Nesting

We found only three Short-eared Owl nests during the three years, two in 2007 and one in 2008, all on Herschel Island (Table 1). The nests were in a variety of vegetation types, but all were in association with taller grass (*Arctagrostis latifolia*, Polargrass) or tussocks (*Eriophorum vaginatum*) that provided some cover. The nests were all on relatively high landscape positions that offered wide views (Table 1). Nest cups had some dead grass stalks that provided rudimentary bedding.

TABLE 1. Characteristics and fate of Short-eared Owl nests on Herschel Island, Yukon, 2007–2009. Names of vegetation types are from Smith et al. (1989).

| Site | Date found | Fate | Topographic position | Aspect | Slope (°) | Vegetation type |
|--------|------------|--|---------------------------------------|-----------|-----------|--|
| 2007-1 | 10 June | 1 egg; nest abandoned prior to 12 June (human disturbance). | Ridge crest | Southeast | 5 | Arctic Willow/Dryas-Vetch with patchy grass (<i>Arctagrostis latifolia</i>) |
| 2007-2 | 21 June | 3 eggs, all lost prior to 7 July (possible predation by Arctic Fox). | Side-slope, 20 m below ridge crest | South | 15 | Arctic Willow/Lupine – Forget-me-not with substantial recent colonization by <i>Salix richardsonii</i> and <i>Arctagrostis latifolia</i> . |
| 2008-1 | 24 June | 8 eggs, all lost prior to 12 July (cause uncertain, possible fox predation). | Top of gradual slope, 50 m from crest | Northwest | 10 | Cottongrass (<i>Eriophorum vaginatum</i>) – moss tussock tundra with patchy <i>Arctagrostis latifolia</i> . |

All three nests failed during the egg stage. One failed very early, with only one egg, and abandonment appeared to have resulted from our disturbing the incubating female at this sensitive time. The most likely nest predator (based on frequency of activity near nests and evidence) was foxes (two nests predated in 2007 by Arctic Fox and one nest predated in 2008 by either Arctic or Red Fox). When the two nests were checked in mid-July, the nests had no eggs or egg fragments, no downy feathers, and no pellets. Other potential predators included Sandhill Crane, Wolverine (*Gulo gulo*), and Grizzly Bear (*Ursus arctos*). However, the cause of nest failure was unclear, and human disturbance may have influenced success of all three nests.

Densities of small rodents in early to mid-June varied considerably among years and sites, but we found evidence of Short-eared Owls nesting only in years with the highest rodent densities (Figure 1). There was no evidence of nesting at Komakuk, where rodent densities were persistently low. Our limited data suggest a minimum threshold density of approximately 4 to 5 lemmings per hectare before the owls will initiate nesting (Figure 1).

Food habits

We collected 111 pellets for diet analyses (21 in 2007, 60 in 2008, and 30 in 2009), all from Herschel Island. Nearly every pellet had only one prey type. Short-eared Owls consumed small rodents almost exclusively, with a few passerine birds taken in 2008 (Figure 2). The Short-eared Owls successfully hunted all three small rodent species, foraging across the full diversity of tundra types on the island. They took Northern Collared Lemmings more often than other species, but the availability of each species varied among years. Our assessment of Short-eared Owls' selection of the three small rodent species (Table 2) shows no statistically significant selection of one prey species over another in any of the three years, but there was a tendency to select Tundra Voles in 2007 and 2008. Short-eared Owls did not select for Northern Collared Lemming, the species living in the more open tundra habitats, but the owls were able to forage successfully for Tundra Voles, which inhabit the more structurally complex valley floor habitats.

Interspecific interactions

Short-eared Owls nested in a summer raptor community on Herschel Island that included Snowy Owl, Peregrine Falcon, Rough-legged Hawk, and Long-tailed Jaeger. Snowy Owls nested only in 2008 but were frequently present, especially early in the summer, in other years. The other raptors nested in each of the three years. Peregrine Falcons and Rough-legged Hawks nested on mud cliffs mostly along the coastline, and therefore at the periphery of the study area. Snowy Owls, Short-eared Owls, and Long-tailed Jaegers partitioned the inland space. Short-eared Owls were the least common nesting raptor, except in 2007, when Snowy Owls did not nest on Herschel Island.

In 2007, the mean distance from a Short-eared Owl nest to the nearest nest of another raptor (including the other Short-eared Owl nest) was 538 m. The same year, the mean distance from any raptor nest (excluding the two Short-eared Owl nests) to the nearest raptor nest (including the two Short-eared Owl nests) was 583 m. In 2008, mean distance from the Short-eared Owl nest to the nearest nest of another raptor was 2000 m. The same year, the mean distance from any raptor nest (excluding the Short-eared Owl nest) to the nearest raptor nest (including the Short-eared Owl nest) was 768 m. With our low sample sizes, we could not reject the hypothesis that the Short-eared Owls nested closer to other raptors in 2007 (Mann-Whitney $U = 8.5$, $P > 0.20$) or 2008 (Mann-Whitney $U = 14$, $P = 0.10$). However, the single nest in 2008 was relatively isolated compared to those of other species. In 2007, the nearest nesting neighbours were Long-tailed Jaegers, and in 2008 Snowy Owls.

We did not observe any agonistic encounters between the Short-eared Owls and other nesting raptors. However, in July 2007 we found two carcasses of Short-eared Owls. We judge these to have been killed by Peregrine Falcons, based on the close proximity of the kill sites (<300 m) to active Peregrine Falcon nests and the presence of whitewash, plucked feathers, and carcass remains, all within a few square metres. FD found remains of Short-eared Owls at a number of Peregrine Falcon nests along the Mackenzie River in 2005, including three individuals at one nest. We observed a Short-eared Owl attacking a Sandhill Crane within 10 m of a Short-eared Owl nest, but we have no direct evidence that the Sandhill Crane had found the nest. This nest subsequently lost two eggs from the clutch, but no egg remains were left behind. On another occasion, we observed a pair of Short-eared Owls (probably the same pair) chasing and attacking a lone Red Fox.

Discussion

Our findings confirm some previous knowledge of Short-eared Owl ecology in the northern Yukon and the Low Arctic tundra. This is an uncommon raptor, using the region in migration, sporadically for nesting, and uncommonly as non-breeding summer range. We confirm the observation made by Salter et al. (1980) that the Short-eared Owl is an "uncommon summer resident". As reported by Pitelka et al. (1955a), nesting is limited to years with high small rodent prey densities, egg laying occurs in mid-June, and the birds choose nest sites with relatively good vantage yet relatively high vegetative cover. The maximum clutch size we observed ($n = 8$) is the same as that reported from Alaska (Pitelka et al. 1955a). Our findings that the Short-eared Owls abandon nests when disturbed early in laying and that they prey almost exclusively on small rodents reinforce the information of Pitelka et al. (1955b).

Our findings also augment previous knowledge. They suggest that a minimum prey density of 4 to 5

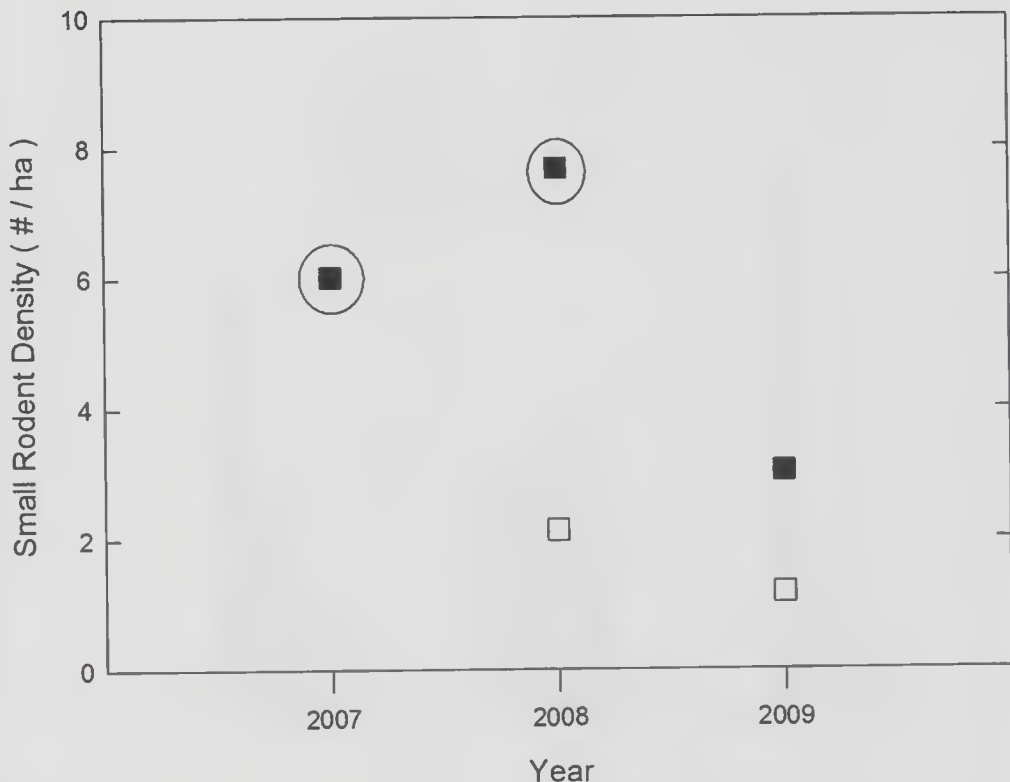


FIGURE 1. Combined density of small rodents (lemmings and voles) in early June to mid-June on Herschel Island in 2007, 2008, and 2009 (black squares) and on Komakuk Beach in 2008 and 2009 (open squares), plotted for each of the three years. Circled data points indicate springs when Short-eared Owls nested (i.e., 2007 and 2008 on Herschel Island).

small rodents (lemmings and voles) per hectare is necessary before Short-eared Owls will start nesting, although this hypothesis needs further testing. We found that this raptor is able to take advantage of all three resident small rodent species, even preying relatively heavily on Tundra Voles, which occupy the wetter habitats with the tallest and thickest growth of graminoid and willow (*Salix* spp.) vegetation.

We have some indication that Short-eared Owl nests are susceptible to predation, with foxes and Sandhill Cranes being potential predators. Since Sandhill Cranes are known to hunt lemmings (both *Dicrostonyx* and *Lemmus*) and young birds on breeding grounds in the Arctic (Reed 1988; Tacha et al. 1992) and can take Canada Goose (*Branta canadensis*) eggs (Hoffman 1980), Sandhill Cranes need to be considered as potential nest predators.

We suggest that Short-eared Owls nest infrequently in northern Yukon primarily because of low prey abundance and agonistic interactions with other raptors. Our studies indicate that lemmings and voles persist at low densities (<4/ha) on the mainland coastal plain but exceed this threshold more frequently on Herschel

Island (Krebs et al. 2002, 2011). Consequently, Short-eared Owls may not find sufficient prey on the mainland coastal plain in most years to support nesting. Our results, and observations by Talarico and Mossop (1986*), indicate that Short-eared Owls nest on Herschel Island only in years with higher prey abundance. The same pattern applies to Snowy Owls, with no recorded nesting on the mainland coastal plain and only intermittent nesting on Herschel Island (Salter et al. 1980; Talarico and Mossop 1986*; Sinclair et al. 2003).

When prey are abundant, Short-eared Owls have to find nesting territories at the same time as Snowy Owls and jaeger species (which also congregate in areas with high rodent densities in spring) (Pitelka et al. 1955b) are selecting nesting sites. Interspecific competition for nesting territories may limit Short-eared Owl nesting in some years. In addition, Peregrine Falcons, Gyrfalcons (*Falco rusticolus*), and Snowy Owls are known to kill adult Short-eared Owls during the nesting season (Muric 1929; Wiggins et al. 2006), and Peregrine Falcons can limit the survival of adult Short-eared Owls on Herschel Island.

The risk of intra-guild predation is increasingly recognized as a prominent process structuring ecological communities of raptors, through direct mortality, habitat and temporal segregation, or distributional changes (Sergio and Hiraldo 2008). Killer species always weigh more than victim species, by a ratio of at least 1.13:1.0 (Sergio and Hiraldo 2008). The ratio for Peregrine Falcons (*tundrius* subspecies) and Short-eared Owls is approximately 2.0:1.0 (White et al. 2002; Wiggins et al. 2006). On the Yukon coastal plain, Peregrine Falcons nest on structures such as radar towers. Gyrfalcons nest in the British Mountains and the Barn Range (Barn Mountains) and they forage on the plain (Sinclair et al. 2003). The risk of intra-guild predation may result in Short-eared Owls avoiding nesting in landscapes with falcons (i.e., much of the coastal plain).

Although nesting opportunities may be limited for the Short-eared Owl in northern Yukon, the region is clearly an important migratory route for these birds (Salter et al. 1980). Our observations indicate that alluvial fan habitats on Herschel Island can be particularly valuable for migratory Short-eared Owls and some other raptors, such as Northern Harrier.

The ecological relationship between Short-eared Owls and Snowy Owls is particularly interesting, as they have similar life histories, responding in an aggregative fashion to high prey densities, having fairly large clutches, and feeding on small rodents. They differ in their hunting tactics, however. The Short-eared Owl is an "active search" raptor (Jaksic and Carothers 1985). It can catch prey in the thicker vegetation because it hunts on the wing, quartering close to the ground, sometimes hovering, using hearing and sight to locate prey at short range, and readily dropping from the air onto prey (Wiggins et al. 2006). This foraging behaviour contrasts with that of the Snowy Owl, which is a "sit-and-wait" raptor, hunting primarily from a perch and relying mostly on vision to detect prey at relatively long distances, followed by direct chase (Jaksic and Carothers 1985; Parmalee 1992).

In a warming climate, cover of woody perennials and some forbs is increasing on Herschel Island, and the vegetation is becoming structurally more complex with an influx of Polargrass and increased spread and height in willows (*Salix glauca*, *S. pulchra*, and *S. richardsonii*) (Kennedy et al. 2001; Myers-Smith et al. 2011). These trends will provide more cover for small rodents, likely reducing the foraging success of Snowy Owls. We believe the vegetation changes will benefit the Short-eared Owl and likely the Northern Harrier, because these species can forage successfully in habitats with much heavier growth than is currently present on most of Herschel Island and because the intensity of competition from Snowy Owls is likely to decline.

Conservation implications

We conclude that Short-eared Owls in arctic Yukon are primarily limited by natural factors, most notably

TABLE 2. Short-eared Owl selection of the three species of small rodent on Herschel Island, 2007–2009. Small rodent densities are the mean of those estimated in mid-summer (July) (the period when most pellets were cast) on the two upland tundra grids and the index lines (the foraging habitats of nesting owls) (see Methods). Values of the selection index (w) greater than 1 indicate a tendency to select that prey type, and values less than 1 a tendency to avoid it. The G -test statistic provides a test of the hypothesis of use in proportion to availability (i.e., random capture of each prey type).

| Year | Prey | Prey density (no./ha) | Proportion of prey available (p) | Pellets with prey (n) | Proportion of prey in pellets (o) | Selection index ($w = o/p$) | 95% confidence interval on w | G -test statistic |
|------|---------------------------|-----------------------|----------------------------------|-----------------------|-----------------------------------|-------------------------------|--------------------------------|-----------------------------|
| 2007 | Northern Collared Lemming | 2.33 | 0.69 | 12 | 0.57 | 0.83 | 0.46 to 1.21 | 1.382 @ 2 df, $P = 0.50$ |
| | Brown Lemming | 0.75 | 0.22 | 6 | 0.29 | 1.32 | 0.25 to 2.39 | |
| | Tundra Vole | 0.32 | 0.09 | 3 | 0.14 | 1.56 | -0.45 to 3.57 | |
| 2008 | Northern Collared Lemming | 0.86 | 0.33 | 20 | 0.34 | 1.03 | 0.58 to 1.48 | 5.094 @ 2 df, $P = 0.08$ |
| | Brown Lemming | 1.33 | 0.50 | 22 | 0.38 | 0.76 | 0.46 to 1.06 | |
| | Tundra Vole | 0.45 | 0.17 | 16 | 0.28 | 1.65 | 0.82 to 2.48 | |
| 2009 | Northern Collared Lemming | 0.78 | 0.66 | 21 | 0.70 | 1.06 | 0.76 to 1.31 | 0.916 @ 2 df, $P = 0.96$ |
| | Brown Lemming | 0.21 | 0.18 | 6 | 0.20 | 1.11 | 0.14 to 2.08 | |
| | Tundra Vole | 0.19 | 0.16 | 3 | 0.10 | 0.63 | -0.19 to 1.44 | |

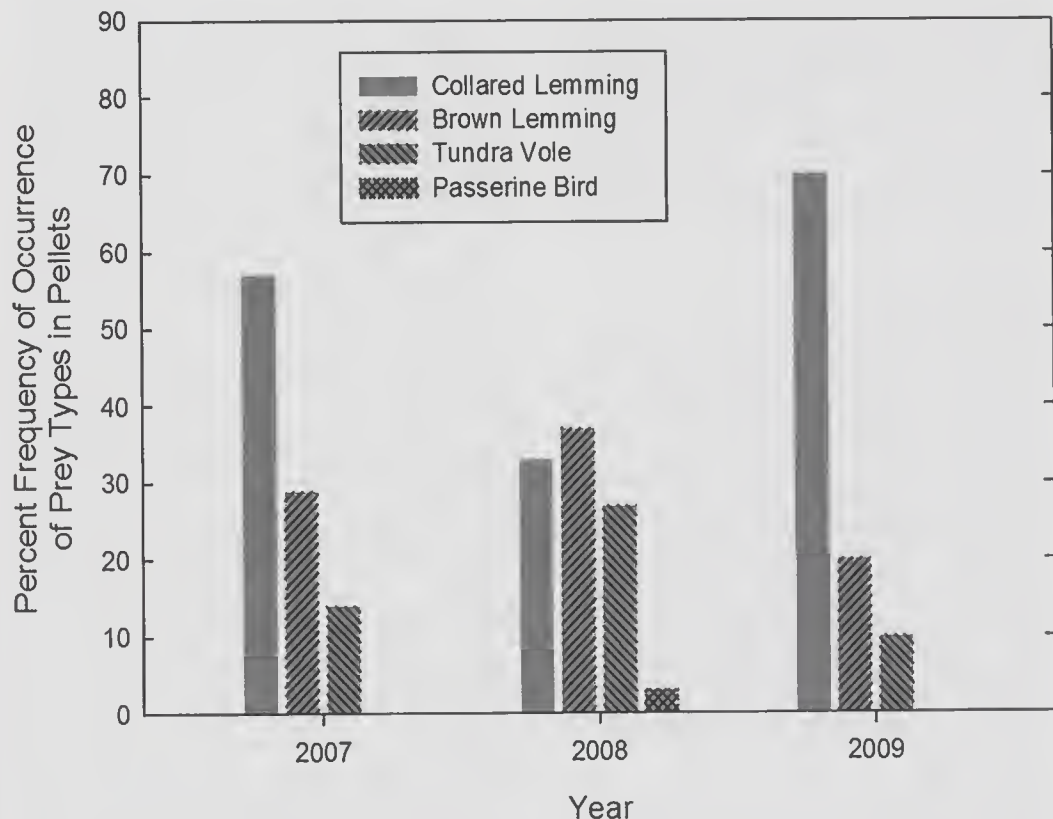


FIGURE 2. Food habits of Short-eared Owls on Herschel Island, Yukon, expressed as the percentage frequency of occurrence of different prey types in cast pellets.

low prey abundance and adult mortality from intra-guild predation. Human disturbance can limit nesting success. Nesting opportunities are probably uncommon for this owl in the region, so human activities need to be closely managed to avoid any reduction in those opportunities. We recommend restrictions on human access to the tundra from late May to late June so as to reduce the risk of Short-eared Owls abandoning nests following disturbance. Prohibiting access would be to the benefit of all birds that nest on the tundra and would be particularly valuable in protected areas like Herschel Island–Qikiqtaruk Territorial Park and Ivvavik National Park.

We also recommend that any new structures built for transportation, communications, industrial, or other applications be designed to minimize their suitability as nesting platforms for falcon species or for Rough-legged Hawks and Common Ravens, which might build nests that would subsequently be used by falcons. Some of the northern Yukon tundra is currently not within the breeding territories of falcon species. For Short-eared Owls to prosper, it needs to remain that way.

We recommend more extensive identification (through spring and fall surveys) and protection of high-quality migratory foraging habitats, such as those we already identified. These are protected in Herschel Island–Qikiqtaruk Territorial Park and Ivvavik National Park, but not elsewhere along the coast. We also recommend more monitoring of small rodent populations in the Arctic to better understand their population dynamics, which are key to the conservation of the Short-eared Owl and many other predators.

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Effects of Post-Fire Salvage Logging on Cavity-Nesting Birds and Small Mammals in Southeastern Montana

WILLIAM J. KRONLAND¹ and MARCO RESTANI²

¹Department of Biological Sciences, St. Cloud State University, St. Cloud, Minnesota 56301 USA

Current address: Center for Natural Lands Management, 215 West Ash Street, Fallbrook, California 92028 USA

²Department of Biological Sciences, St. Cloud State University, St. Cloud, Minnesota 56301 USA; corresponding author (email: restani@stcloudstate.edu)

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We investigated how post-fire salvage logging of Ponderosa Pine (*Pinus ponderosa*) affected populations of cavity-nesting birds and small mammals in southeastern Montana in 2004 and 2005. We examined two salvage and two control plots with three point-count stations and one small mammal trap site randomly distributed across each plot. We used point counts and distance sampling methods to estimate density of cavity-nesting birds on each treatment. We also searched each plot for nests and used program MARK to construct a set of candidate models to investigate variations in nest survival related to treatment, year, and time. We used live traps arranged in webs centered on trapping sites and distance sampling methods to estimate small mammal density. Habitat characteristics were also quantified on each plot. Density of all cavity-nesting birds combined and of Hairy Woodpeckers (*Picoides villosus*) in particular were higher on the control than the salvage treatment. Density of large trees and abundance of active cavities were higher on the control treatment. Nest cavities on the salvage treatment were most often located in non-logged watersheds. Nest survival estimates were uniformly high, with only marginal variations attributed to treatment and year. Density of Deer Mice (*Peromyscus maniculatus*) was higher on the salvage than the control treatment, reflecting the amount of downed woody debris created during harvest.

Key Words: cavity-nesting birds, downed woody debris, forest management, nest survival, salvage logging, wildfire, Hairy Woodpecker, *Picoides villosus*, Deer Mouse, *Peromyscus maniculatus*, Custer National Forest, Montana.

The current fire regime within the Ponderosa Pine (*Pinus ponderosa*) forest type in western North America is thought to differ significantly from historical patterns and processes as a result of fire suppression, logging, and livestock grazing (Agee 1993; Arno and Allison-Bunnell 2002). The accumulation of woody fuels from decades of fire suppression is driving a shift from an historical regime of slow-burning ground fires to one that has a greater proportion of severe crown fires (Covington and Moore 1994; Allen et al. 2002). As a result, U.S. state and federal agencies are implementing the Healthy Forest Initiative and the Healthy Forest Restoration Act of 2003 to reduce fuels and the associated risk of severe wildfires and to address demand for commercial timber (Franklin et al. 2003). Federal policy promotes post-fire logging by exempting sales <100 ha from environmental review and allows operations to occur on lands otherwise unavailable for harvest (Federal Register 2003*). Ecologists are questioning the merit of salvage logging because of documented negative effects on soil, vegetation, and wildlife (McIver and Starr 2001; Beschta et al. 2004; Lindenmayer and Noss 2006; Hutto 2006). In addition, salvage logging may actually promote conditions suitable for severe wildfire and hinder forest regeneration (Donato et al. 2006; Greene et al. 2006).

Although burned forests are rare habitats at the landscape scale, spatial heterogeneity created by the patchy distribution of fire severities supports high biodiversity (Turner et al. 2003; Schmiegelow et al. 2006; Hut-

to 2006). Salvage logging homogenizes this forest structure and alters the post-fire wildlife community. Typically, large trees (>23 cm diameter at breast height [DBH]) favored by foraging and breeding cavity-nesting birds (Covert-Bratland et al. 2006; Pope et al. 2009) are harvested during salvage logging. Consequently, the abundance of cavity-nesting birds declines (Hutto 1995; McIver and Starr 2001; Kotliar et al. 2002) as they are replaced by ground- and shrub-nesting species (Morissette et al. 2002; Cahall and Hayes 2009; Castro et al. 2010). Size and distribution of burned tree stands that remain after salvage logging also shape composition of the cavity-nesting bird assemblage. For example, Black-backed Woodpeckers (*Picoides arcticus*) and American Three-toed Woodpeckers (*P. dorsalis*) require relatively large stands of burned trees, whereas Lewis's Woodpeckers (*Melanerpes lewis*) often occupy smaller stands typical of logged areas (Saab and Vierling 2001; Morissette et al. 2002; Hutto and Gallo 2006). In addition to spatial scale, temporal scale (measured as time since fire) affects the abundance of insect prey of primary and secondary cavity nesters and thus the composition of the post-fire bird assemblage (Saab et al. 2004; Smucker et al. 2005; Covert-Bratland et al. 2006; Hutto 2006).

Little is known about the effects of post-fire salvage logging on fauna other than cavity-nesting birds (McIver and Starr 2001; but see Converse et al. 2006). Salvage logging may increase the amount of downed woody debris (Donato et al. 2006), which provides

small mammals with additional habitat for reproduction, foraging, and predator avoidance (Harmon et al. 1986). The accumulation of downed woody debris following wildfire correlates with the rate of recolonization and an increase in the diversity of small mammals (Carey and Johnson 1995; Fisher and Wilkinson 2005; Converse et al. 2006). In contrast, removal of downed woody debris following salvage of trees damaged by a tornado was correlated with a decrease in the abundance of small mammals (Loeb 1999).

A stand-replacement fire of moderate to high intensity that was ignited by lightning occurred over 26 527 hectares of Ponderosa Pine in southeastern Montana in 2002. The U.S. Forest Service implemented a management plan in summer 2003 to reduce the risk of fire by salvage logging all standing dead trees >25 cm DBH on 485 ha. Literature reviews (McIver and Starr 2001; Kotliar et al. 2002) urged more research into the effects of post-fire salvage logging, so we took the opportunity to compare the density of cavity-nesting birds and the density of small mammals on salvage-logged and control plots. We also estimated breeding success of cavity-nesting birds, because most studies investigating the effects of logging have not measured this important parameter (Sallabanks et al. 2000; Kotliar et al. 2002; but see Saab et al. 2011).

Nest abundance and foraging activity of cavity-nesting birds after fire has been shown to be positively correlated with the size and density of standing snags (Haggard and Gaines 2001; Nappi et al. 2003). Therefore, we predicted that salvage logging would lead to a significant decrease in the number of active nest sites and a significant decrease in the overall abundance of cavity-nesting species. We expected that the volume of downed woody debris would be greater on logged areas (Donato et al. 2006), and we predicted that the density of small mammals would be greater on salvage plots.

Methods

Study area

The study area is located in a Ponderosa Pine forest approximately 40 km southeast of Ekalaka, Montana, U.S.A., in the Long Pines unit of the Custer National Forest (45°38'N, 104°11'W). The study site (1320 ha) is part of a larger forested area (28 368 ha) intermixed with pine savannah, native grassland (*Achnatherum* spp., *Bouteloua* spp., *Carex* spp., and *Pseudoroegneria* spp.), and woody draws. The area consists of hills and rocky buttes (elevation 1000–1200 m) surrounded by lower elevation sagebrush shrubland (*Artemisia* spp.), native grassland, and cultivated hayfields. Mean annual temperature in 2004 and 2005 (January through September) was 7°C and 10°C, respectively, with mean precipitation of 20 cm and 42 cm, respectively (National Oceanic and Atmospheric Administration 2005*). All surface water was ephemeral except for cattle tanks and a few small reser-

voirs. The area was managed for multiple use, including recreation, grazing, and timber harvest.

We were limited in our study design by management activities and fire behavior. The U.S. Forest Service selected salvage sites based on the presence of pre-existing roads and merchantable timber rather than by randomization, a problem common to wildlife forest management studies (Marzluff et al. 2000; Sallabanks et al. 2000). Distribution and size of patches of burned forest also limited the number and interspersions of independent replicates we were able to consider. Other studies that examined effects of salvage logging faced similar design limitations (Saab and Dudley 1998; Hutto and Gallo 2006). Consistency in the results of multiple independent examinations of salvage logging could overcome lack of power associated with individual efforts. We therefore saw value in conducting this study despite the limitations in randomization, sample size, and interspersions.

We examined the response of the vertebrate community to a reduction in fuels on two salvage-logged and two control plots in 2004 and 2005 (two and three years post-fire; Figure 1). We used Geographic Information Systems (GIS) timber data to select control sites with burn severity and commercial timber value similar to pre-logged salvage sites, distributing two control and two salvage plots (45 to 50 ha), each representing continuous patches of salvaged and non-salvaged forested habitat, to improve experimental design (Hurlbert 1984; Underwood 1997). The salvage areas were mechanically logged in summer 2003. All trees >25 cm DBH with an intact bole and <50% live green crown cover were removed. Trembling Aspen (*Populus tremuloides*) and Green Ash (*Fraxinus pennsylvanica*) were not harvested, and a no-cut buffer of 15.2 m was placed on either side of ephemeral streams to maintain watershed quality.

We used the Minnesota Department of Natural Resources Sample Generator Extension v. 1.1 for ArcView 3.0 to randomly place three point-count stations and one small mammal trap site per plot, positioning point-count stations ≥ 250 m apart in order to reduce the likelihood of double counting individual cavity-nesting birds (Hutto et al. 1986) (Figure 1). Small mammal trap sites were placed ≥ 500 m apart, also to maintain sample independence, and all points were positioned ≥ 50 m from treatment boundaries to avoid collecting data beyond treatment boundaries.

Bird sampling

We conducted 10-minute surveys of cavity-nesting birds from each point-count station from mid-April to 1 July. Point counts were conducted from sunrise to 0900 following standard protocols (Hutto et al. 1986), and an estimated distance of detection was assigned at 10-m intervals from the observer to each bird (Buckland et al. 2001). We excluded from analyses all flyovers or birds detected >100 m from the observer.

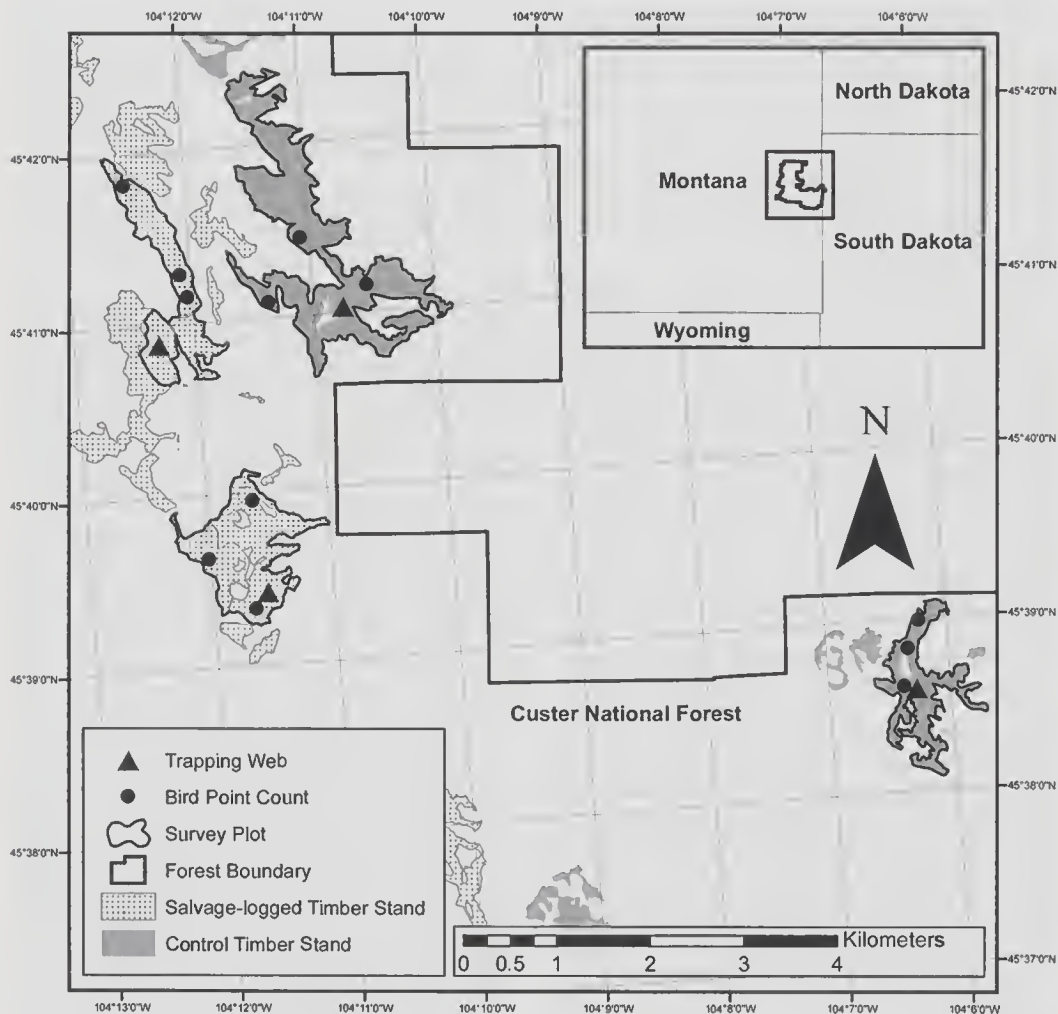


FIGURE 1. Plots and survey points sampled on salvage-logged and control treatments, Custer National Forest, Montana, 2004 and 2005.

Nest searches were conducted from mid-April through 1 July 2004 and 2005. We visited each plot every one to two days and located nests by observing adult behavior and systematically searching for cavities. Target species included Northern Flicker (*Colaptes auratus*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), Hairy Woodpecker (*P. villosus*), Eastern Bluebird (*Sialia sialis*), Mountain Bluebird (*S. currucoides*), and European Starling (*Sturnus vulgaris*). We recorded the location of active nests with a Garmin E-trex Global Positioning System (GPS) receiver and flagged a bearing tree no closer than 30 m away.

We visited each cavity every three days for up to 30 minutes, or until the status of the nest (active or inactive) could be determined by observing adults or nestlings inside the cavity (Martin and Geupel 1993; Kronland 2007). We estimated nest stage according to

courtship displays, duration of adult visits to the nest (courtship and egg laying vs. incubation), food deliveries, and nestling vocalizations. We monitored active cavities from the time of location to the completion of the nesting effort. We determined that a nest had failed if predation or usurpation was observed, or if the nest stage was known and inactivity occurred before the estimated fledge date (Martin and Geupel 1993; Kronland 2007). We considered a nest successful if fledglings were observed <20 m from the cavity, or if the fledge date was known and the cavity did not show signs of predation (e.g., enlarged cavity entrance or feathers at base of tree).

Small mammal sampling

We used trapping webs (one for each area) and distance sampling methods to estimate density based

on likelihood of detection rather than area trapped (Anderson et al. 1983). Each web consisted of 12 traplines radiating from a central point at 30° intervals (Jett and Nichols 1987). Trap stations consisted of two Sherman style live traps (8 cm × 8 cm × 25 cm) placed every 20 m along a trapline ($l = 130$ m) using 100-m tapes, starting 10 m from the center, for 168 traps per web. We covered exposed traps with aluminum flashing, rocks, or bark to provide shade, and we baited all traps with peanut butter. We trapped each web over four consecutive nights in August 2004 and 2005 in random order. Traps were checked daily beginning at sunrise and baited after each check. We applied a uniquely numbered ear tag to each individual (No. 1005-1 Monel, National Band and Tag Company, Newport, Kentucky, USA) and examined capture histories to determine if new animals were being detected at the innermost ring on the final night of trapping. We also examined data *post hoc* to ensure that movement of individuals across trap stations within trapping webs did not occur (Buckland et al. 2001).

We identified the species and sex of each captured animal. We measured tail, body, ear, and hind foot to the nearest mm with a stainless steel 30-cm ruler, and we weighed individuals to the nearest 1 g with a 100-g spring scale. Numerous Deer Mice (*Peromyscus maniculatus*) were captured in 2004 ($n = 761$) and 2005 ($n = 869$). We aged Deer Mice as juvenile or adult based on mass after examining the distribution of 20 to 30 individuals aged by pelage in the field (Pearson et al. 2003). We recorded ear tag number and trap location (trapline and ring) within the web before releasing animals at the trap site.

Habitat sampling

We measured habitat characteristics, such as size and density of burned trees, because of their known influence on the distribution and abundance of cavity-nesting birds (Hutto 1995; Murphy and Lehnhausen 1998; Nappi et al. 2003; Smucker et al. 2005). We recorded habitat features on plots of 11.3 m radius at the random point-count locations used to sample cavity-nesting birds in 2005 (Figure 1). Three subplots were arranged 120° from each other and 30 m from a central subplot centered on point-count locations, for a total of four subplots (Martin et al. 1997). Bearing of the first subplot from each point-count location was chosen semi-randomly in the field by multiplying the time in seconds by 6.

We measured DBH of all trees >7.5 cm DBH on each subplot, and we also recorded species and status (alive or dead). We categorized each subplot (1 = least decayed, 7 = most decayed) according to crown condition, bark retention (%), and the severity of the burn (%) (Nappi et al. 2003). In 2005, we also arranged four subplots around each nest tree found on the two replicates per treatment, and we conducted the same habitat measurements to describe these nest sites (salvage: $n = 22$; control: $n = 27$). For each nest tree, we recorded

species, DBH, crown condition, bark retention (%), and the severity of the burn (%). Nest trees were often used by multiple pairs in a single season, and we considered measurements taken at these sites as independent samples when representing different species. We measured each nest site and nest tree only once if it was reused by the same species (Hutto and Gallo 2006).

Small mammal abundance has been positively correlated with the amount of downed woody debris (Carey and Johnson 1995). We therefore measured downed woody debris on subplots centered on each random point count used to survey cavity-nesting birds (Figure 1). We recorded downed woody debris lying at an angle of less than 45° with the ground that intersected a plane 1.8 m high and extended 11.3 m from the subplot center in a random direction (Brown and Roussopoulos 1974). Mean kg of downed woody debris per ha per point was calculated following methods described in Brown and Roussopoulos (1974).

Statistical analyses

We considered mean number of detections per point across years as an index of individual species abundance between treatments. We used distance sampling methods to estimate density (individuals per ha) of all cavity-nesting birds per treatment because we lacked sufficient observations to fit detection curves to species-specific data. Concern about independence of errors associated with sampling points within replicates over multiple occasions led us to pool data across visits and within replicates. We binned observations into five distance categories (0-20 m, 21-40 m, 41-60 m, 61-80 m, 81-100 m,) and used program DISTANCE 6.0 to fit global detection curves to salvage-logged and control treatment datasets (Buckland et al. 2001; Thomas et al. 2005*). We considered the full combination of uniform, half-normal, and hazard rate key functions with cosine, simple-polynomial, and Hermite-polynomial expansion terms, and we removed models with poor fit according to shape of the detection curve (shape criterion) and χ^2 goodness-of-fit tests (Buckland et al. 2001).

We used Program MARK (White and Burnham 1999*) and methods described by Dinsmore et al. (2002) to estimate nest survival (S). We first constructed a set of candidate models that included the full combination of underlying treatment-, year-, and time-varying effects on S . We then ranked models according to difference in Akaike's Information Criterion for small samples (ΔAIC_c), removed models that contained virtually no Akaike weight ($w_i < 0.01$) and failed to estimate parameters, and calculated a weighted-average survival estimate (\bar{S}) across the remaining models (Burnham and Anderson 2002). We ended nest observation while some nests were still active, so we used only nests with complete histories (i.e., fledged or failed) to estimate reproductive success ($n = 39$). Nest survival estimates represent the period of mid-April through 1 July and were calculated for all cavity-

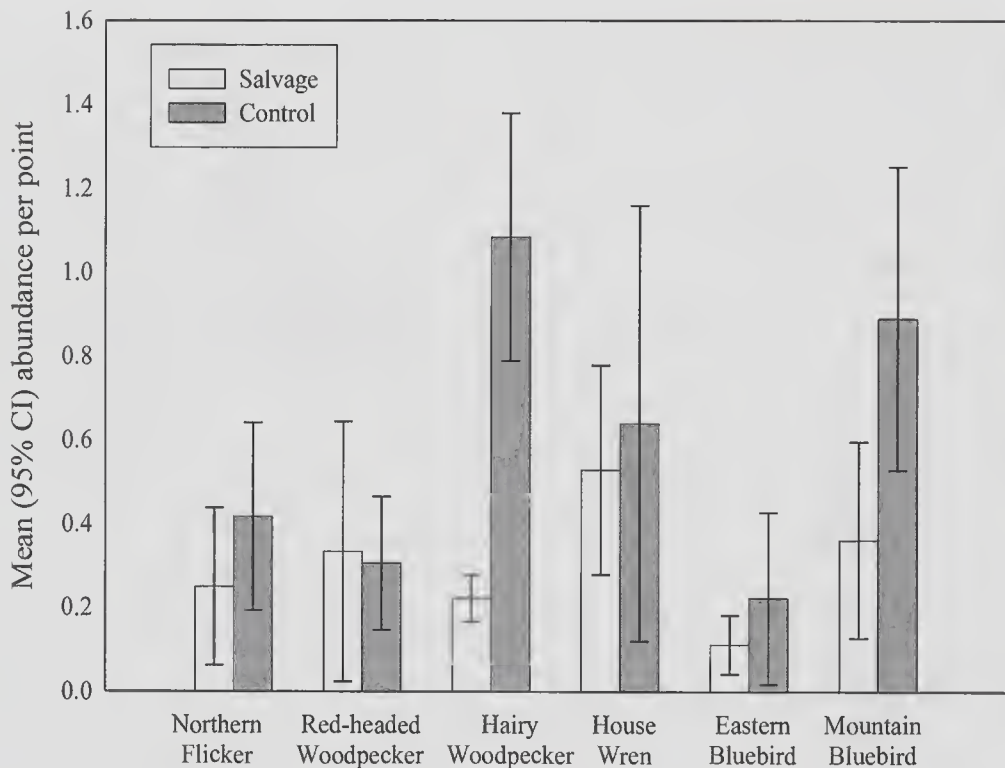


FIGURE 2. Mean (95% CI) abundance of selected cavity-nesting species per point count (pooled across years) on salvage-logged and control treatments, Custer National Forest, Montana, 2004 and 2005.

nesting species combined because sample sizes for individual species were small. We accounted for variation in size of nest-search plots by dividing the number of nests located by plot size to estimate density of active cavity nests (number of nests ha^{-1}).

We used program DISTANCE 6.0 to estimate small mammal density (individuals per ha) from initial captures by fitting detection curves to the full combination of uniform and cosine key functions combined with cosine, simple-polynomial, and Hermite-polynomial expansion terms (Buckland et al. 2001; Thomas et al. 2005*). We did not consider the hazard-rate or negative-exponential key functions because these models have been shown to overestimate density (D) and perform poorly with trapping-web data (Parmenter et al. 2003). We removed models with poor fit according to shape of the detection curve (shape criterion) and χ^2 goodness-of-fit test (Buckland et al. 2001), ranked remaining models based on difference in Akaike's Information Criterion (ΔAIC), assigned Akaike weights, and calculated weighted-average estimates of density (\bar{D}) across models (Burnham and Anderson 2002). Variance and 95% confidence intervals were calculated using formulas described in Buckland et al. (2001) and Burnham and Anderson (2002). Data were pooled

across sampling occasions at each trapping web, and reported estimates represent the mean density of small mammals across sites within each treatment.

We used nested MANOVA to compare habitat characteristics between treatments at point-count locations (salvage: $n = 6$; control: $n = 6$) and nest sites (salvage: $n = 22$; control: $n = 27$). Variables included mean density of large trees, mean density of small trees, mean crown condition, the mean percentage of bark remaining on the tree bole, and the mean percentage of the tree that had been burned (severity). We also used nested MANOVA to examine difference in mean DBH, the crown condition, the bark remaining (%), and the severity of the burn (%) of individual nest trees on each treatment.

Results

Birds

We recorded the highest mean number of detections per point across years for Hairy Woodpecker ($\bar{x} = 0.65$, $\text{SE} = 0.21$), Mountain Bluebird ($\bar{x} = 0.63$, $\text{SE} = 0.18$), and House Wren (*Troglodytes aedon*) ($\bar{x} = 0.58$, $\text{SE} = 0.2$), followed by Northern Flicker ($\bar{x} = 0.33$, $\text{SE} = 0.1$), Red-headed Woodpecker ($\bar{x} = 0.32$, $\text{SE} = 0.12$), and Eastern Bluebird ($\bar{x} = 0.17$, $\text{SE} = 0.08$).

TABLE 1. Akaike's Information Criterion (AIC_c) ranking, Akaike weight (w_i), number of parameters estimated (K), and log likelihood (-2log(L)) of candidate models examining treatment (g), year (y), and constant (.) effects on nest survival.

| Model | AIC _c | ΔAIC _c | w _i | K | -2log(L) |
|--------|------------------|-------------------|----------------|---|----------|
| S(g) | 137.8717 | 0 | 0.4114 | 2 | 133.8546 |
| S(.) | 138.2474 | 0.3757 | 0.3409 | 1 | 136.2417 |
| S(y) | 140.1623 | 2.2906 | 0.1309 | 2 | 136.1452 |
| S(g*y) | 140.3893 | 2.5176 | 0.1168 | 4 | 132.3322 |

White-breasted Nuthatch (*Sitta carolinensis*), American Kestrel (*Falco sparverius*), and Red-breasted Nuthatch (*S. canadensis*) were rarely detected during point counts (mean detections per point <0.1). No cavity-nesting species was found exclusively on either treatment, but mean abundance per point was greater on the control than the salvage treatment for Hairy Woodpecker (i.e., non-overlapping 95% CI, Figure 2).

The uniform key function with cosine expansion term was the only model that fit cavity-nesting bird data according to shape of detection curves and χ^2 goodness-of-fit tests (control: $\chi^2 = 5.7$, df = 3, $P = 0.13$; salvage: $\chi^2 = 0.1$, df = 1, $P = 0.75$). Estimated density of cavity-nesting birds was greater in 2005 ($\hat{D} = 3.83$; 95% CI - 3.5 to 4.11) than 2004 ($\hat{D} = 2.05$; 95% CI - 1.61 to 2.49) on the control treatment, and did not differ between years on the salvage treatment (2004: $\hat{D} = 1.39$; 95% CI - 0.98 to 1.59; 2005: $\hat{D} = 2.33$; 95% CI - 1.5 to 2.72). Density of cavity-nesting birds across both years was greater on the control ($\hat{D} = 2.94$; 95% CI - 2.7 to 3.15) than the salvage ($\hat{D} = 1.86$; 95% CI - 1.24 to 2.17) treatment.

We located 36 nest cavities on the control treatment (2004: $n = 17$; 2005: $n = 19$), representing 48 nest attempts (1.3 attempts per cavity), and 29 nest cavities on the salvage treatment (2004: $n = 15$; 2005: $n = 14$), representing 43 nest attempts (1.5 attempts per cavity). Red-headed Woodpeckers accounted for 34% of located cavities, and were the only species that had higher nest density on the salvage than the control treatment (0.20 nests/ha versus 0.12 nests/ha, respectively, $n = 31$). Other cavity nesters included Hairy Woodpecker (salvage: 0.07 nest/ha; control: 0.14 nests/ha; $n = 20$), Mountain Bluebird (salvage: 0.05 nests/ha; control: 0.11 nest/ha; $n = 15$), Northern Flicker (salvage: 0.06 nests/ha; control: 0.07 nests/ha; $n = 12$), Eastern Bluebird (salvage: 0.03 nests/ha; control: 0.05 nests/ha; $n = 8$), and European Starling (salvage: 0.02 nests/ha; control: 0.03 nests/ha; $n = 5$). Hairy Woodpeckers were known, through direct observation, to have constructed 32% ($n = 21$) of the located nest cavities. Excavator was uncertain for 52% ($n = 34$) of cavities, Red-headed Woodpeckers produced 11% ($n = 7$) of cavities, and 5% ($n = 3$) of cavities were created naturally.

We compared eight candidate models of nest survival, and four models received some support (Table 1). Weighted-average estimates of S between treat-

ments and across years were high (salvage: $\hat{S} = 0.96$, SE = 0.01 (2004), $\hat{S} = 0.97$, SE = 0.01 (2005); control: = 0.98, SE = 0.01 (2004), $\hat{S} = 0.98$, SE = 0.01 (2005)) and strongly overlapped, indicating that differences in nest survival between treatments were negligible. Eight of 19 nest attempts with known histories failed on the salvage treatment, compared to 9 of 20 attempts on the control treatment. Red-headed Woodpeckers were responsible for 11 nest failures (65%) by depredating or usurping nests. House Wrens were observed filling 2 Mountain Bluebird cavities with twigs, and the cause of 5 nest failures remained unknown.

Small mammals

We captured 1630 Deer Mice and 64 Meadow Voles (*Microtus pennsylvanicus*) in 2004 and 2005. Other species that accounted for <1% of captures included Hispid Pocket Mouse (*Chaetodipus hispidus*), Thirteen-lined Ground Squirrel (*Spermophilus tridecemlineatus*), Olive-backed Pocket Mouse (*Perognathus fasciatus*), Western Harvest Mouse (*Reithrodontomys megalotis*), Bushy-tailed Woodrat (*Neotoma cinerea*), White-footed Mouse (*P. leucopus*), and Eastern Cottontail (*Sylvilagus floridanus*).

We estimated density of Deer Mice only, because other species did not comprise a large enough sample to use distance-based models. We derived yearly estimates of density because excessive lumping of detections between 70 m and 110 m in the pooled dataset prevented us from fitting a detection curve. Models consisting of the uniform and half-normal key functions with cosine adjustment had strong support across treatments and years (Table 2). Density of Deer Mice was greater on salvage-logged (2004: $\hat{D} = 24.2$, 95% CI - 18.9 to 30.9; 2005: $\hat{D} = 21.5$, 95% CI - 15.4 to 30.0) than control areas (2004: $\hat{D} = 6.5$, 95% CI - 3.3 to 12.6; 2005: $\hat{D} = 5.8$, 95% CI - 3.5 to 9.5). We categorized Deer Mice weighing ≤ 17 g as juveniles, based on mass of a subset of individuals that were aged by pelage. The mean ratio of juveniles to adults captured per trapping web was 1:1.3 on salvage-logged and 1:0.8 on control sites.

Habitat

Large trees (>23 cm DBH) were less abundant on salvage-logged ($\bar{x} = 6.64$ trees ha⁻¹, SE = 2.62) than control sites ($\bar{x} = 53.1$ trees ha⁻¹, SE = 8.64), as determined by habitat measurements at point-count locations (Table 3). Microsites surrounding nest trees on

the control treatment also had greater mean density of trees >23 cm DBH (salvage: $\bar{x} = 26.45$ trees ha⁻¹, SE = 4.97; control: $\bar{x} = 62.27$ trees ha⁻¹, SE = 3.64) and more bark remaining on the tree bole (salvage: $\bar{x} = 5.17$, SE = 0.29; control: $\bar{x} = 1.95$, SE = 0.08) than salvage-logged sites (Table 3).

Nest trees on the salvage had more deteriorated crowns (salvage: $\bar{x} = 5.00$, SE = 2.37; control: $\bar{x} = 2.85$, SE = 1.85) and less bark remained on the tree bole (salvage: $\bar{x} = 3.86$, SE = 2.34; control: $\bar{x} = 2.63$, SE = 1.62) than nest trees on the control plots (Table 3). Nest attempts on the salvage were most often (61%; $n = 15$) located in non-logged stands of green Ponderosa Pine, Trembling Aspen, or Green Ash. Only 7% ($n = 2$) of nest attempts in control areas occurred in those trees.

Mean volume of downed woody debris was greater on the salvage ($\bar{x} = 1964$ kg/ha, 95% CI = 822 to 3160) than the control treatments ($\bar{x} = 460$ kg/ha, 95% CI = 189 to 731). Mean number of downed woody debris pieces on the salvage treatment was 5.7 per replicate with a mean volume of 89 cm³. Mean number of pieces of downed woody debris on the control treatment was 1.9 per replicate with a mean volume of 122 cm³.

Discussion

Our results were consistent with the growing body of evidence demonstrating that post-fire salvage logging has significant negative effects on cavity-nesting birds, at least two to three years following a wildfire (Hutto 1995; Saab and Dudley 1998; Smucker et al. 2005; Hutto and Gallo 2006). Density of cavity-nesting birds was lower on the salvage than the control treatment. Moreover, few potential nest sites existed on the salvage treatment and occupied cavities were most often located in riparian buffer strips or in stands of green trees and hardwoods not subject to harvest. In contrast, abundance of Deer Mice was greater on salvage-logged than on control plots, and was closely associated with the high amount of downed woody debris on the salvage treatments.

Dense stands of trees >23 cm DBH were also more common on the control than the salvage treatment. The stands provided potential foraging opportunities for primary cavity nesters, such as Hairy Woodpeckers, probably because large trees contain high densities of beetle larvae (Cerambycidae and Buprestidae) (Mannan et al. 1980; Nappi et al. 2003; Hanson and North 2008). Cavity nesters, particularly Hairy Woodpeckers, were infrequently detected during point counts in areas dominated by small trees. At least 18% of the excavations produced by Hairy Woodpeckers were used by other cavity nesters, and the paucity of Hairy Woodpeckers in salvage-logged areas probably had a negative effect on secondary cavity nesters. For example, both Mountain Bluebirds and House Wrens nested less often in the salvage-logged than the control areas. Post-fire logging therefore had both direct and indirect negative effects on the cavity-nesting assemblage.

TABLE 2. Akaike's Information Criterion (AIC_c) ranking, Akaike weight (w_i), number of parameters estimated (K), log likelihood ($-2\log(L)$), and results of χ^2 goodness-of-fit test for candidate models used to estimate population density of Deer Mice on salvage-logged and control treatments, 2004 and 2005.

| Treatment | Year | Model | AIC | ΔAIC | w_i | K | $-2\log(L)$ | χ^2 | df | P |
|-----------|------|----------------------------------|---------|--------------|-------|---|-------------|----------|----|------|
| Salvage | 2005 | Half-normal + cosine | 2155.73 | 0 | 0.70 | 4 | -1073.87 | 2.12 | 2 | 0.35 |
| | | Uniform + cosine | 2157.43 | 1.69 | 0.30 | 4 | -1074.71 | 3.83 | 2 | 0.15 |
| Salvage | 2004 | Half-normal + cosine | 2281.54 | 0 | 0.67 | 2 | -1138.77 | 7.75 | 4 | 0.10 |
| | | Uniform + cosine | 2282.97 | 1.44 | 0.33 | 3 | -1138.49 | 7.9 | 3 | 0.07 |
| Control | 2005 | Half-normal + cosine | 1180.28 | 0 | 0.54 | 3 | -587.14 | 3.96 | 3 | 0.27 |
| | | Uniform + cosine | 1180.56 | 0.29 | 0.46 | 3 | -587.28 | 4.3 | 3 | 0.23 |
| Control | 2004 | Uniform + cosine | 354.95 | 0 | 0.24 | 2 | -175.48 | 1.33 | 2 | 0.52 |
| | | Uniform + Hermite polynomial | 355.2 | 0.25 | 0.21 | 2 | -175.6 | 1.65 | 2 | 0.44 |
| | | Uniform + simple polynomial | 355.2 | 0.25 | 0.21 | 2 | -175.6 | 1.65 | 2 | 0.44 |
| | | Half-normal + cosine | 356.22 | 1.27 | 0.13 | 3 | -175.11 | 0.58 | 1 | 0.45 |
| | | Half-normal + Hermite polynomial | 256.41 | 1.46 | 0.11 | 3 | -175.21 | 0.77 | 1 | 0.38 |
| | | Half-normal + simple polynomial | 356.56 | 1.61 | 0.11 | 3 | -175.28 | 0.92 | 1 | 0.34 |

The distribution and abundance of breeding habitat that remained after salvage logging differed between treatments and affected nest site use. Stands of high tree density on salvage treatments existed only in non-harvested areas. Non-logged areas represented approximately 15% of the total area on salvage treatments, yet they contained 71% of nest cavities. In contrast, most nest cavities on the control were in habitats that would have been logged (e.g., stands of large dead Ponderosa Pine). Trembling Aspen and Green Ash accounted for only 6% of nest attempts on the control while representing 40% of attempts on the salvage. If Trembling Aspen and Green Ash had been preferred breeding habitat, the number of nest attempts in these habitats would probably have been similar between treatments. Regardless of treatment, cavity nesters were found most often in areas with high densities of large trees, habitat features considered important legacies in burned forests (Franklin et al. 2000; Hutto 2006).

Post-fire salvage logging did not reduce reproductive success of cavity-nesting birds on our study area in southeastern Montana, despite negative effects on bird abundance. To our knowledge, only three other studies have reported reproductive information while investigating effects of post-fire logging on cavity-nesting birds. One study found no effect and two studies found reduced reproductive success, but only for Hairy and Lewis's woodpeckers (reviewed by McIver and Starr 2001; Saab et al. 2011). The small number of existing studies on post-fire effects reflects the general pattern reported by Sallabanks et al. (2000), where only 13% of studies investigating effects of silviculture on birds collected demographic data. Clearly, data on reproductive success and survival remain a research priority (Kotliar et al. 2002).

Density of Deer Mice was greater on salvage than control plots. This reflected the four-fold difference in volume of downed woody debris across treatments. Mechanical removal of trees during logging led to an incidental and rapid accumulation of downed branches, debris used by small mammals for breeding, foraging, and predator avoidance (Harmon et al. 1986; Ucitel et al. 2003). Dead trees on the control remained standing two to three years post-fire and had not yet replaced downed woody debris consumed during the fire. Debris on the control would be expected to continue to accumulate as trees deteriorated (Tinker and Knight 2001; Russell et al. 2006), whereas the amount of debris on the salvage treatment had probably reached its maximum because most standing dead trees had been harvested.

Although Deer Mice responded favorably to the accumulation of downed woody debris on the salvage treatment, density of small mammals may not reflect habitat quality if dominant individuals exclude subordinates from the best habitats (Van Horne 1983; Rodenhouse et al. 1997). Adult Deer Mice defend territories against non-reproducing juveniles (Long and Mont-

TABLE 3. Results of Multivariate Analysis of Variance (MANOVA) tests comparing habitat characteristics at point-count locations in salvage-logged and control plots and at nest sites on salvage-logged and control plots, and comparing nest-tree characteristics on salvage-logged and control treatments, Custer National Forest, Montana, 2004 and 2005.

| Habitat characteristic | Point counts | | | Nest sites | | | Nest trees | | |
|-------------------------------------|--------------|-----|-------|------------|------|--------|------------|------|-------|
| | F | df | P | F | df | P | F | df | P |
| Trees 10–23 cm DBH ha ⁻¹ | 0.003 | 1,8 | 0.958 | 1.576 | 1,45 | 0.216 | NA | NA | NA |
| Trees >23 cm DBH ha ⁻¹ | 22.519 | 1,8 | 0.001 | 38.761 | 1,45 | <0.001 | NA | NA | NA |
| \bar{x} tree DBH (cm) | NA | NA | NA | NA | NA | NA | 3.267 | 1,45 | 0.077 |
| Crown condition ^a | 0.096 | 1,8 | 0.764 | 3.111 | 1,45 | 0.085 | 12.434 | 1,45 | 0.001 |
| Bark retention ^b | 0.183 | 1,8 | 0.68 | 163.139 | 1,45 | <0.001 | 5.28 | 1,45 | 0.026 |
| Burn severity ^c | 0.019 | 1,8 | 0.894 | 0.748 | 1,45 | 0.392 | 2.987 | 1,45 | 0.091 |

^a Relative amount of twigs, branches, and limbs on tree crown (1 = intact crown, 7 = broken top).

^b Percentage of bark remaining on tree bole (1 = 100%, 7 = no bark).

^c Percentage of tree burned (1 = unburned, 7 = completely burned).

gomerie 2006), so a large juvenile to adult ratio would indicate low-quality habitat. However, adults were more abundant than juveniles on the salvage treatment where densities of Deer Mice were highest. This supports the conclusion that density reflects high-quality habitat. Information regarding individual reproductive status (not recorded in this study) might have provided further insight into habitat quality between treatments for Deer Mouse.

Despite temporarily benefiting Deer Mice populations, the rapid accumulation of downed woody debris may have increased the short-term risk of wildfire because woody ground debris is a primary determinant of fire behavior (Donato et al. 2006). One of the goals of salvage logging is to reduce the probability of large wildfires, and failure to achieve fire management objectives is particularly important in southeastern Montana because of the historically high frequency of wildfires (Brown and Hull Sieg 1996). The risk of future fire could be reduced by creating heterogeneous landscapes of logged and non-logged areas, where woody debris would accumulate and deteriorate at different rates, thus creating fuel breaks. Retaining some intact stands of large trees (>23 cm DBH) could also mitigate the negative effects of salvage logging on cavity nesters.

Current federal and state guidelines recommend retaining 6 to 10 dead trees per hectare (Hutto 2006). However, salvage prescriptions that retain a specific number of trees per hectare or uniformly remove a specific size class of tree (e.g., >25 cm DBH) accelerate post-fire succession and create homogeneous landscapes unsuitable for many cavity-nesting birds (Hutto 1995; Kotliar et al. 2002; Hutto 2006; Schmiegelow et al. 2006). Conserving intact stands of large trees would create heterogeneous landscapes that resemble natural post-fire conditions and harbor many of the legacies deemed important in such landscapes (Franklin et al. 2000). Although further investigation is needed to determine the size and distribution of burned tree stands that should be retained, conditions resulting from salvage logging in this study provided lower quality habitat than unlogged areas.

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Saxicolous Bryophytes of an Ordovician Dolomite Escarpment in Interlake Manitoba, with New Species Records for the Province

RICHARD T. CANERS

442 Earth Sciences Building, Department of Renewable Resources, University of Alberta, Edmonton, Alberta T6G 2E3 Canada; email: rcaners@ualberta.ca

Caners, Richard T. 2011. Saxicolous bryophytes of an Ordovician dolomite escarpment in Interlake Manitoba, with new species records for the province. *Canadian Field-Naturalist* 125(4): 327-337.

An assessment of bryophyte species growing on an Ordovician dolomite escarpment in the Interlake region of Manitoba known as Marble Ridge revealed a diverse flora composed mostly of circumboreal floristic elements. Two liverwort families (including three species) and four moss species are reported for Manitoba for the first time: the liverworts *Athalamia hyalina* (Sommert.) Hatt. (Cleveaceae), *Mannia fragrans* (Balbis) Frye et Clark (Aytoniaceae), and *Mannia sibirica* (K. Müll.) Frye et Clark (Aytoniaceae) and the mosses *Brachythecium collinum* (Schleich. ex C. Müll.) Schimp. in B.S.G., *Grimmia teretinervis* Limpr., *Schistidium frigidum* H. H. Blom, and *Seligeria donniana* (Sm.) C. Müll. An annotated summary of these and other bryophyte species documented at the site is provided. The diversity of encountered bryophytes can mostly be attributed to the moist and shaded microclimatic conditions on the escarpment and the large number of microhabitats the escarpment supports. This study represents one of few accounts of bryophytes in the region and highlights the importance of this particular geologic formation in supporting a number of species that are expected to be regionally uncommon.

Key Words: *Athalamia hyalina*, *Brachythecium collinum*, bryophyte, circumboreal, floristic affinity, *Grimmia teretinervis*, Interlake, life form, liverwort, Manitoba, *Mannia fragrans*, *Mannia sibirica*, Marble Ridge, moss, phytogeography, *Schistidium frigidum*, *Seligeria donniana*.

A geologic formation in the Interlake region of south-central Manitoba was documented in terms of its bryophyte diversity, providing one of the first accounts of bryophytes in this part of the province. The formation is referred to as Marble Ridge on topographic maps and represents an impressive escarpment of Upper Ordovician dolomite. The bedrock at the site is part of an outcrop belt of Paleozoic rocks in southwestern Manitoba that extends from Winnipeg and Garson through the Interlake and Dawson Bay regions to the Precambrian Shield from Athapapuskow Lake to Ponton (Bannatyne 1988). Topographic relief in the Interlake is generally low (Bannatyne 1988; Land Resource Unit 1999), making Marble Ridge a conspicuous and important habitat for a number of bryophytes. Although other inland escarpments of varying sizes are found in the region, they are infrequent and are considered to be smaller than Marble Ridge (Nature Conservancy of Canada, Manitoba Region, personal communication, 2 February 2012). Documenting species diversity at the site is regarded as an important first step in understanding bryophyte occurrences in the region and recognizing issues related to their conservation.

Under the appropriate growing conditions, calcareous rock formations are known to support a number of characteristic bryophyte species, especially calciphiles (Robinson and Wells 1956; Foote 1966; Crum and Anderson 1981; Haig et al. 2000). Several features of Marble Ridge, including its large size (in relation to other geologic features in the region), variety of microhabitats, bedrock chemistry, and mesic habitat conditions,

suggested before this study that it had the capacity to harbour a substantial bryophyte flora. Indeed, Marble Ridge has already been shown to host a number of provincially rare vascular plant species, including *Cypripedium arietinum* Ait. f. (Ram's Head Lady's-slipper), *Pellaea gastonyi* Windham (Gastony's Cliffbrake), *Pellaea glabella* ssp. *occidentalis* (E. Nels.) Windham (Western Dwarf Cliffbrake), and *Selaginella densa* Rydb. (Prairie Spikemoss) (Manitoba Association of Plant Biologists, personal communication, 6 January 2011; Manitoba Conservation, personal communication, 12 October 2011).

Objectives of this study were 1) to document the occurrence of moss and liverwort species on Marble Ridge, 2) to characterize the flora of the escarpment in terms of its floristic affinity, and 3) to identify the most important factors likely to affect the persistence of bryophytes at the site.

Methods and Study Area

Study area

Marble Ridge is located approximately 150 km north of Winnipeg, Manitoba, in the Rural Municipality of Fisher, between the towns of Fisher Branch and Hodgson (Figure 1; 51°11'N, 97°37'W). The area lies within the Interlake region of the province in close proximity to both Lake Manitoba and Lake Winnipeg. Marble Ridge extends for several hundred metres and rises up to 5.1 m in elevation above the adjacent landscape (Figure 2), providing a large surface area for bryophyte colonization. The escarpment is oriented from

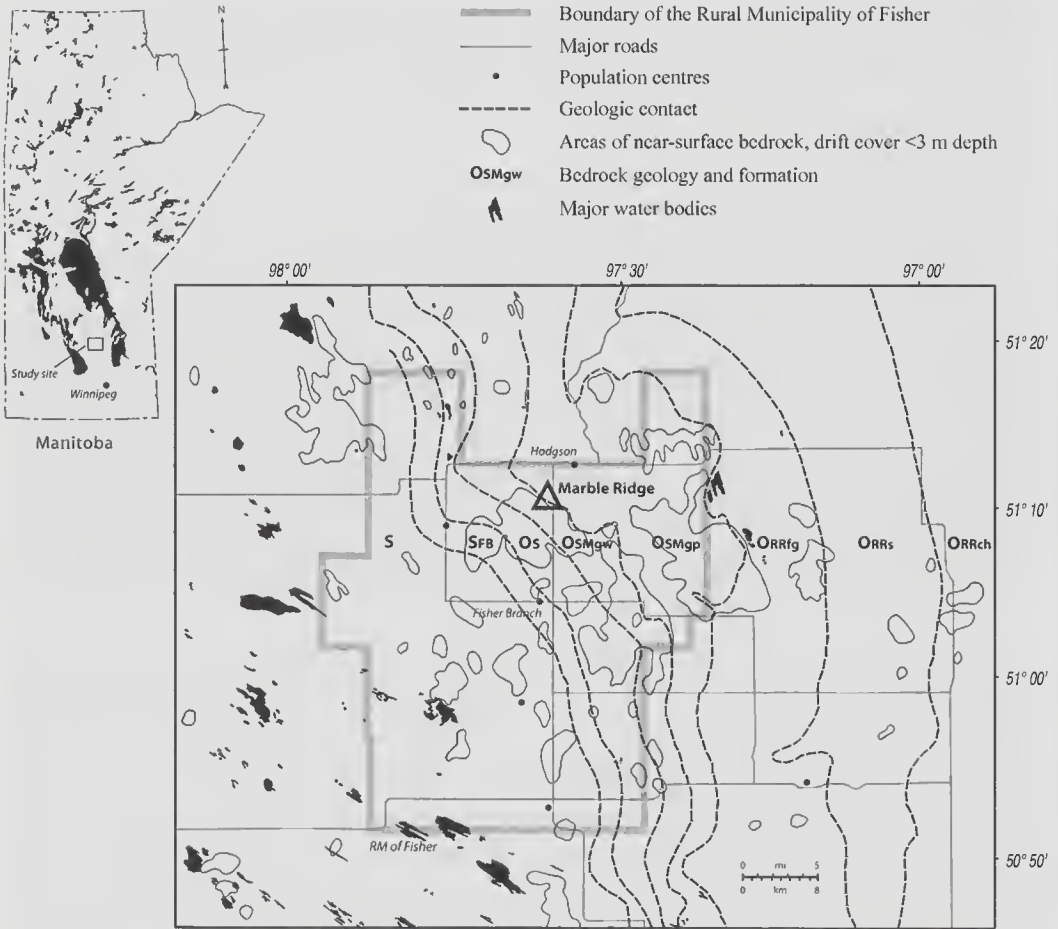


FIGURE 1. Location of the study site in Manitoba, with surrounding bedrock stratigraphy (adapted from Bannatyne 1988). The following codes refer to exposed surficial bedrock formations: S: Silurian, Interlake Group; SFB: Silurian, Fisher Branch Formation; Os: Ordovician and Silurian, Stonewall Formation; OSMgw: Ordovician, Stony Mountain Formation, Gunton Member and Williams Member; OSMgp: Ordovician, Stony Mountain Formation, Gunn Member and Penitentiary Member; ORRfg: Ordovician, Red River Formation, Fort Garry Member; ORRs: Ordovician, Red River Formation, Selkirk Member; ORRch: Ordovician, Red River Formation, Cat Head Member.

the north-northwest to the south-southeast with an east-to northeast-facing aspect, and it is sheltered to the east by boreal forest of mixed tree species. *Populus tremuloides* Michx. (Trembling Aspen) and *Betula papyrifera* Marsh. (Paper Birch) are found immediately adjacent to the rock face, and *Picea glauca* (Moench) Voss (White Spruce) becomes more abundant at slightly lower elevations in nearby areas to the east. The escarpment forms the eastern boundary of an adjacent alvar habitat, broadly defined as prairie vegetation over limestone or dolostone plain, with thin to absent soils (Reschke et al. 1999*). Alvars are considered to be uncommon worldwide and rare in Canada. There are few alvars west of Ontario in North America, the majority being concentrated in the Great Lakes region and in parts of Québec (Reschke et al. 1999*).

Marble Ridge lies within the Interlake Plain Ecoregion of the Boreal Plains Ecozone (Ecological Stratification Working Group 1995). This ecoregion extends northwest from the southeastern corner of Manitoba to the Manitoba-Saskatchewan border north of the Porcupine Hills, and it is characterized by a broadleaf-dominated forest that marks the southern limit of the closed-crown boreal forest and the northern extent of arable agriculture (Ecological Stratification Working Group 1995). The climate is sub-humid low-boreal, characterized by warm summers and cold winters (Ecological Stratification Working Group 1995). In the vicinity of Marble Ridge, the mean annual daily temperature is 1.5°C and the mean total annual precipitation is 511.9 mm, with approximately 80% falling as rain (Table 1; Environment Canada 2011*).



FIGURE 2. Marble Ridge. In both photographs, the escarpment is facing approximately east. Top: portion of the escarpment with a canopy cover of Trembling Aspen and Paper Birch. Bottom: a mesic rock face supporting numerous large colonies of the uncommon moss *Grimmia teretinervis*.

Surficial and bedrock geology

Marble Ridge is situated within the Fisher River Plain, a level to gently undulating area of shallow lacustrine materials underlain by glacial till (Groom 1985; Land Resource Unit 1999). Local relief is generally characterized by slopes of 0–2%, except where higher till, beach ridges, and rock outcrops are 2–5% above the plain (Land Resource Unit 1999). Surficial materials are predominantly shallow calcareous till over bedrock, lacustrine deposits, and organic soils, with glaciofluvial deposits of sand and gravel (Land Resource Unit 1999).

The exposed bedrock at Marble Ridge belongs to the Gunton Member of the Stony Mountain Formation (Bannatyne 1988; Gaywood Matile, Manitoba Innovation, Energy and Mines, personal communication, 28 July 2011). The exposed bedrock maintains a relatively uniform lithology, consisting of pale yellowish-brown, faintly mottled, very finely crystalline, dense, sparsely fossiliferous dolomite and showing a thin nodular bedding (Glass 1990). The Gunton Member has a maximum thickness of 11 m and is economically the most important of the Stony Mountain Formation, being the major source of crushed stone aggregate for the Winnipeg and southern Interlake region (Bannatyne 1988; Norford et al. 1994). Several quarry leases are currently held on Crown lands immediately west of Marble Ridge (Government of Manitoba 2011*).

The Ordovician to Lower Devonian rocks that are currently preserved in the Western Canada Sedimentary Basin (including the Interlake region) are remnants of extensive sheets of sediment that were deposited over the North American craton (Precambrian rock) and its western ocean margin (Norford et al. 1994). Carbonate rocks of the Paleozoic outcrop belt in southwestern Manitoba were subsequently eroded in the interval from the post-Devonian Period to the Mesozoic Era, when extensive karsting and channelling occurred (Bannatyne 1988). Present-day surficial bedrock exposures in the region decrease in geologic age from east to west, from Early Ordovician at Lake Winnipeg to Lower Devonian at Lake Manitoba (Figure 1). Marble Ridge lies in close proximity to the Ordovician–Silurian boundary and contains areas of exposed Silurian bedrock at the uppermost positions on the escarpment (personal observation).

Species sampling

A total of approximately 30 hours of sampling was conducted at Marble Ridge at various times over the 2008, 2010, and 2011 growing seasons. Sampling focused on saxicolous species (those growing on rock) and was restricted to habitats on the escarpment face and adjacent rock slabs, although one noteworthy species was collected in the adjoining alvar system. Species

TABLE 1. Temperature and precipitation normals for the period 1971–2000¹ for the Fisher Branch South meteorological station (51°03'10.03"N, 97°31'42.00"W).

| | January | February | March | April | May | June | July | August | September | October | November | December | Year ² |
|---------------------|---------|----------|-------|-------|------|------|------|--------|-----------|---------|----------|----------|-------------------|
| Temperature | | | | | | | | | | | | | |
| Daily maximum (°C) | -13.4 | -8.8 | -1.7 | 9.0 | 18.1 | 22.6 | 25.2 | 24.2 | 17.4 | 9.6 | -2.1 | -11.0 | 7.4 |
| Daily minimum (°C) | -23.9 | -19.9 | -12.8 | -3.6 | 3.5 | 8.8 | 11.8 | 10.1 | 5.1 | -1.0 | -10.5 | -20.1 | -4.4 |
| Precipitation | | | | | | | | | | | | | |
| Total rainfall (mm) | 0.3 | 2.3 | 6.4 | 19.4 | 45.7 | 84.5 | 62.9 | 72.9 | 61.8 | 39.4 | 8.3 | 0.9 | 404.7 |
| Total snowfall (cm) | 18.3 | 14.1 | 16.2 | 13.1 | 2.5 | 0.0 | 0.0 | 0.0 | 0.2 | 6.3 | 17.3 | 19.4 | 107.1 |

¹Calculated for 19 to 20 years during the period 1971–2000.

²Yearly values. Temperature variables are averages; precipitation variables are totals.

growing in forest habitats (e.g., tree trunks, dead wood, forest floor) are not reported here.

Taxonomic nomenclature for mosses follows Anderson et al. (1990), except *Brachythecium laetum*, which follows Robinson and Ignatov (1997) and Ignatov et al. (2008); *Schistidium frigidum*, which follows McIntosh (2007); and *Syntrichia ruralis* and *S. norvegica*, which follow Mishler (2007). Nomenclature for liverworts is based on Stotler and Crandall-Stotler (1977). For vascular plants, nomenclature is based on NatureServe (2011*). World phylogeographic distributions for mosses are based on Belland (1987) (unless otherwise noted) and for liverworts on Schuster (1966–1992), Damsholt (2002), and Belland (2011*). Vouchers of species have been deposited at the University of Manitoba herbarium (WIN) (herbarium acronym follows Thiers 2012*).

Annotated List of Species

A total of 58 species was documented at Marble Ridge: 51 mosses (87.9% of the flora) and 7 liverworts (12.1%). Two liverwort families (consisting of three species) and four moss species are reported for Manitoba for the first time (Canadian Endangered Species Conservation Council 2011*; NatureServe 2011*)—the liverworts *Athalamia hyalina* (Sommert.) Hatt. (Cleveaceae), *Mannia fragrans* (Balbis) Frye et Clark (Aytoniaceae), and *Mainia sibirica* (K. Müll.) Frye et Clark (Aytoniaceae) and the mosses *Brachythecium collinum* (Schleich. ex C. Müll.) Schimp. in B.S.G., *Grimmia teretinervis* Limpr., *Schistidium frigidum* H. H. Blom, and *Seligeria donniana* (Sm.) C. Müll. One species, *Mannia fragrans*, was not found on the escarpment itself but nearby on a thin layer of calcareous soil over dolomite bedrock in the adjacent alvar habitat.

The phylogeographic distribution of the bryophyte flora of the escarpment is predominantly circumboreal (58.6% of the flora), with smaller proportions of other boreal, temperate, and arctic elements (Table 2). Documented species exhibited a wide variety of life forms (based on Hill et al. 2007), but dominant forms were rough mats (29.3%), tufts (20.7%), and turfs (19.0%) (Table 3).

The following is an annotated list of all species growing on the escarpment and adjacent rocks. Species and families marked with † are reported as new to the province of Manitoba, and those followed by the symbol ∇ (ancient Greek element of water) are known to be associated with mesic microhabitats. All collection numbers are those of the author unless otherwise indicated. The abbreviation “c.fr.” following collection numbers refers to specimens with sporophytes, whereas “c.ge.” refers to specimens bearing asexual propagules. The same collection number was sometimes used for more than one species for expediency in the field. Collection numbers are associated with the following collection dates: 5261–5289, 24 April 2008; 5719–

TABLE 2. World phylogeographic distributions of bryophyte species documented at Marble Ridge.

| Group | No. of species | % of flora |
|------------------------|----------------|------------|
| Cosmopolitan | 3 | 5.2 |
| Circumboreal | 34 | 58.6 |
| Boreal disjunct | 5 | 8.6 |
| Boreal endemic | 1 | 1.7 |
| Circumtemperate | 3 | 5.2 |
| Temperate disjunct | 4 | 6.9 |
| Temperate endemic | 1 | 1.7 |
| Circummontane | 0 | 0.0 |
| Montane disjunct | 0 | 0.0 |
| Montane endemic | 0 | 0.0 |
| Arctic-alpine | 6 | 10.3 |
| Distribution not known | 1 | 1.7 |
| Total | 58 | 100.0 |

TABLE 3. Life forms of bryophyte species documented at Marble Ridge.

| Life form ¹ | No. of species | % of flora |
|------------------------|----------------|------------|
| Cushion | 4 | 6.9 |
| Fan | 1 | 1.7 |
| Mat, rough | 17 | 29.3 |
| Mat, smooth | 5 | 8.6 |
| Mat, thalloid | 3 | 5.2 |
| Thread | 1 | 1.7 |
| Tuft | 12 | 20.7 |
| Turf | 11 | 19.0 |
| Weft | 4 | 6.9 |
| Total | 58 | 100.0 |

¹Definitions of bryophyte life forms (adapted from Hill et al. 2007). Cushion: dome-shaped colony formed by variously oriented shoots with a central origin; fan: shoots arising from vertical bark or rock, branching repeatedly in horizontal plane; mat, rough: shoots that creep over substratum, having numerous erect lateral branches; mat, smooth: shoots that creep over substratum, having leafy branches that generally lie flat; mat, thalloid: shoots that creep over substratum, composed of a layer of thalli; thread: thread-like, variously oriented stems that crawl through or over substrate or vegetation; tuft: forming loose cushions not necessarily of central origin; turf: many loosely or closely packed vertical stems with limited branching.

5781, 16 July 2010; 6076–6114, 3 May 2011; 6115–6166, 22 May 2011; 6636–6661, 19 October 2011. Collection numbers that are not presented in the annotated list of species are either duplicate or unverified samples, or were collected at other locations in the Interlake.

Liverworts

AYTONIACEAE[†]

Mannia fragrans (Balbis) Frye et Clark[†] ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, large thalloid mats of scattered gametophytes on thin calcareous mineral soil over limestone or dolomite bedrock in the adjacent alvar habitat, in association with *Didymodon rigidulus*

var. *rigidulus*, *Tortella fragilis*, and *Abietinella abietina*, 51°11'N, 97°37'W, *Caners* 6661.

Infrequent. Arctic-alpine (arctic; Damsholt 2002).

Mannia sibirica (K. Müll.) Frye et Clark[†] ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small thalloid mats on mineral soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5744.

Plants had ventral scales with 1 appendage and several (8–10) oil bodies per cell, and lacked the brush of scales found at the ends of thalli in *Mannia fragrans*. Epidermal cells of the thallus had large trigones and air chambers that contained additional walls. The species is rare in North America, being reported in Canada from Ontario, where it is ranked by NatureServe as Critically Imperilled (S1), and in the United States from Iowa and Minnesota, where the species is unranked (NatureServe 2011*). Infrequent. Arctic-alpine (arctic; Damsholt 2002).

CLEVEACEAE[†]

Athalamia hyalina (Sommert.) Hatt.[†] ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small to large grey-green thalloid mats on mineral soil over rock ledges in shaded, humid areas, 51°11'N, 97°37'W, *Caners* 5780 c.fr., 5781 c.fr., 6107 c.fr.

The species is best distinguished by gynoecea that form away from thallus margins. Infrequent on Marble Ridge. Arctic-alpine (subarctic-subalpine; Damsholt 2002).

GEOCALYCEAE

Lophocolea minor Nees ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small smooth mats on rock slabs close to the forest floor or as scattered shoots among other bryophytes, 51°11'N, 97°37'W, *Caners* 5745 c.ge.

Infrequent. Circumboreal (Belland 2011*).

JUBULACEAE

Frullania inflata Gott. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, thin, smooth dark green mats on vertical surfaces or the undersides of shaded, humid crevices, 51°11'N, 97°37'W, *Caners* 5742 c.fr., 5770.

Specimens had clavate papillae of the perianth mouth, conforming with descriptions of *F. saxicola* (sometimes considered synonymous with *F. inflata*). In Manitoba, *F. inflata* has previously been reported from the Winnipeg area (Stringer and Stringer 1974a; Stringer and Stringer 1974b). Moderately frequent. Circumtemperate (widespread in temperate and warm areas of North America south to Mexico; Schuster 1966–1992).

PLAGIOCHILACEAE

Plagiochila porreoloides (Torrey ex Nees) Lindenb. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small wefts or as single shoots among other bryophytes, over rock ledges and in microhabitats that receive greater moisture, 51°11'N, 97°37'W, *Caners* 5721.

Infrequent. Circumboreal (Belland 2011*).

RADULACEAE

Radula complanata (L.) Dum. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small smooth mats on surfaces of rock slabs adjacent to the escarpment, often near ground level, 51°11'N, 97°37'W, *Caners* 5723 c.fr., 6113 c.fr.

Infrequent. Circumboreal (Belland 2011*).

Mosses

AMBLYSTEGIACEAE

Campylium chrysophyllum (Brid.) J. Lange ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats on humus over rock ledges or as single shoots among other bryophytes, 51°11'N, 97°37'W, *Caners* 5732, 5734.

Moderately frequent. Circumboreal.

Campylium hispidulum (Brid.) Mitt. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats on humus over ledges or more commonly as single shoots among other bryophytes, 51°11'N, 97°37'W, *Caners* 6106.

Infrequent. Boreal endemic.

Conardia compacta (C. Müll.) Robins. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats along ledges or crevices, 51°11'N, 97°37'W, *Caners* 5289 c.ge., 5731 c.ge., 5771 c.ge.

Infrequent. Distribution not known (in North America the species has a temperate distribution; Crum and Hedenäs 2010*).

ANOMODONTACEAE

Anomodon minor (Hedw.) Fűrnr.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats along escarpment ledges, often in association with *Anomodon rostratus*, 51°11'N, 97°37'W, *Caners* 5262, 5264, 5734.

Infrequent. Temperate disjunct.

Anomodon rostratus (Hedw.) Schimp.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, large rough mats along escarpment ledges, 51°11'N, 97°37'W, *Caners* 5269, 5272, 5733, 5755.

The species has been reported only once from Manitoba, also from the Interlake region, at Buffalo Lake north of Grand Rapids (CANM 280285 and 280299). Frequent. Temperate disjunct.

AULACOMNIACEAE

Aulacomnium palustre (Hedw.) Schwaegr. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turf on soil

over an adjacent rock slab, near the ground surface, 51°11'N, 97°37'W, *Caners* 6157.

Only a single colony was observed. Infrequent. Circumboreal.

BRACHYTHECIACEAE

Brachythecium acuminatum (Hedw.) Aust.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, large rough mats over escarpment ledges and adjacent rock slabs, 51°11'N, 97°37'W, *Caners* 5273, 5286.

Frequent. Temperate endemic.

Brachythecium collinum (Schleich. ex C. Müll.) Schimp. in B.S.G.†—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats over escarpment ledges, infrequent on rock slabs, 51°11'N, 97°37'W, *Caners* 6089, 6091.

Infrequent. Boreal disjunct.

Brachythecium laetum (Brid.) B.S.G.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats over escarpment ledges; infrequent on rock slabs, 51°11'N, 97°37'W, *Caners* 5750, 6076.

Infrequent. Temperate disjunct.

Brachythecium salebrosum (Web. & Mohr) Schimp. in B.S.G.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small to large rough mats on rock slabs adjacent to the escarpment, 51°11'N, 97°37'W, *Caners* 6106.

Moderately frequent. Circumboreal.

Eurhynchium pulchellum (Hedw.) Jenn.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats on rock slabs adjacent to the escarpment, 51°11'N, 97°37'W, *Caners* 5723.

Infrequent on the escarpment but frequent in adjacent forested areas. Circumboreal.

BRYACEAE

Bryum caespitium Hedw.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turfs on humus over rock ledges or as single shoots among other bryophytes, 51°11'N, 97°37'W, *Caners* 5764 c.fr.

Moderately frequent. Cosmopolitan.

Bryum pseudotriquetrum (Hedw.) Gaertn. et al. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turfs on humus over rock ledges or as single shoots among other bryophytes, *Caners* 5721.

Moderately frequent. Circumboreal.

Pohlia cruda (Hedw.) Lindb.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher

Branch and Hodgson, small tufts on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 6645.

Infrequent. Circumboreal.

Rhodobryum ontariense (Kindb.) Par. in Kindb. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, large tufts on deep humus over ledges and adjacent rock slabs, 51°11'N, 97°37'W, *Caners* 5275, 5720, 6079 c.fr.

Frequent. Circumtemperate.

DITRICHACEAE

Distichium capillaceum (Hedw.) Bruch & Schimp. in B.S.G. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small tufts on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5276 c.fr., 5740, 5753.

Moderately frequent. Circumboreal.

Ditrichum flexicaule (Schwaegr.) Hampe—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small tufts on rock slabs adjacent to the escarpment, 51°11'N, 97°37'W, *Caners* 6160.

Infrequent. Circumboreal.

ENCALYPTACEAE

Encalypta procera Bruch—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small tufts on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5265 c.fr., 5267 c.ge., 5272 c.ge., 5285, 5753.

Moderately frequent. Circumboreal.

Encalypta rhapsocarpa Schwaegr.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small tufts on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5737 c.fr.

Infrequent. Circumboreal.

FISSIDENTACEAE

Fissidens bryoides Hedw. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turfs on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5735, 5777.

Infrequent. Circumtemperate.

GRIMMIACEAE

Grimmia teretervis Limpr.† ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, numerous large cushions on rock surfaces along the length of the escarpment, on rock slabs alongside the escarpment, and on boulders in the adjacent alvar system, 51°11'N, 97°37'W, *Caners* 5728, 5729, 6652, 6653, 6660.

The species is abundant at the site and appears to preferentially colonize large blocks of smooth, thick-bedded dolomite, as high colony densities were frequently observed on these surfaces. Many colonies appeared to be growing from horizontal fissures in the rock surface (Figure 2). This occurrence in Manitoba represents one of relatively few localities

of the species in central North America (Hastings 2002) and is potentially one of the largest populations of the species on the continent (R. Hastings, personal communication, 19 October 2011), supporting more than 1000 individual colonies by preliminary estimates. The next closest record of the species is approximately 650 km to the southeast in the Thunder Bay District of Ontario (La Verendrye Provincial Park; CANM 299965). Further research is being conducted on the species at Marble Ridge. Frequent. Temperate disjunct.

Schistidium frigidum H. H. Blom[†]—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small cushion on vertical rock surface, 51°11'N, 97°37'W, *Caners* 5741 c.fr.

Only a single colony was observed. Infrequent. Arctic-alpine (arctic-montane; Hill et al. 2007).

HEDWIGIACEAE

Hedwigia ciliata (Hedw.) P. Beauv.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small to large rough mats on rock slabs adjacent to the escarpment, 51°11'N, 97°37'W, *Caners* 5719, 5725 c.fr.

Moderately frequent. Cosmopolitan.

HYLOCOMIACEAE

Hylocomium splendens (Hedw.) Schimp. in B.S.G.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, large weft over an escarpment ledge, 51°11'N, 97°37'W, *Caners* sight record.

Only a single colony was observed on the escarpment, but the species was common in the adjacent conifer-dominated forest. Infrequent. Circumboreal.

HYPNACEAE

Hypnum vaucheri Lesq.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, large rough mats over escarpment ledges and adjacent rock slabs, 51°11'N, 97°37'W, *Caners* 5270, 5284, 5752, 6082 c.fr.

The species is widely distributed in boreal and arctic areas, and is predominantly continental in distribution in North America (Schofield 2006*). A few specimens at Marble Ridge had blunt foliose pseudoparaphyllia. Frequent. Arctic-alpine.

Isopterygiopsis pulchella (Hedw.) Iwats.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5763.

Moderately frequent. Circumboreal.

Platydictya jungermannioides (Brid.) Crum ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small colonies as threads on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5268, 5735.

Frequent. Circumboreal.

Pylaisiella polyantha (Hedw.) Grout—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between

Fisher Branch and Hodgson, small rough mats on vertical rock faces, 51°11'N, 97°37'W, *Caners* 6637 c.fr., 6642 c.fr.

Infrequent on rock surfaces on the escarpment but frequent on bark at the base of Trembling Aspen in the immediate vicinity. Circumboreal.

LESKEACEAE

Leskeella nervosa (Brid.) Loeske—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats on rock faces, on both the escarpment and less frequently on adjacent rock slabs, 51°11'N, 97°37'W, *Caners* 5727 c.ge.

Infrequent. Circumboreal.

Pseudoleskeella tectorum (Funck ex Brid.) Kindb. in Broth.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats on humus over rock ledges, 51°11'N, 97°37'W, *Caners* 5281, 5282, 5726, 5738, 5754, 5770.

Moderately frequent. Boreal disjunct.

MNIACEAE

Mnium ambiguum H. Müll.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turfs on humus over escarpment ledges, 51°11'N, 97°37'W, *Caners* 5277, 5721 c.fr.

Moderately frequent. Circumboreal.

Mnium spinulosum Bruch & Schimp. in B.S.G.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turfs on humus over escarpment ledges and also on adjacent rock slabs, 51°11'N, 97°37'W, *Caners* 5771.

Moderately frequent. Boreal disjunct.

Mnium thomsonii Schimp.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turfs on humus over escarpment ledges, 51°11'N, 97°37'W, *Caners* 5745.

Infrequent. Circumboreal.

Plagiomnium cuspidatum (Hedw.) T. Kop.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small smooth mats on adjacent rock slabs, often occurring close to the forest floor, 51°11'N, 97°37'W, *Caners* 6083 c.fr., 6108 c.fr.

Moderately frequent. Circumboreal.

Plagiomnium medium (Bruch & Schimp. in B.S.G.) T. Kop. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small smooth mats on adjacent rock slabs, often occurring close to the forest floor, 51°11'N, 97°37'W, *Caners* 6657.

Moderately frequent. Circumboreal.

NECKERACEAE

Neckera pennata Hedw.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small fan on humus over vertical rock surface, 51°11'N, 97°37'W, *Caners* 6643.

Only a single colony was observed. Infrequent. Boreal disjunct.

ORTHOTRICHACEAE

Orthotrichum anomalum Hedw.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small cushions on vertical rock surfaces along the escarpment and on adjacent rock slabs, 51°11'N, 97°37'W, *Caners* 5265 c.fr., 5282 c.fr., 5722 c.fr., 5763 c.fr., 5765 c.fr.

Frequent. Circumboreal.

Orthotrichum obtusifolium Brid.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small cushion on vertical rock surface on the escarpment, 51°11'N, 97°37'W, *Caners* 6658 c.ge.

Only a single colony was observed. This obligate corticolous species is rarely found on rock in North America, but is reported as growing on calcareous rock in subarctic and subalpine regions of Fennoscandia (Crum and Anderson 1981). Nyholm (1974) indicates the species occurs rarely on rocks. Infrequent. Circumboreal.

POTTIACEAE

Barbula convoluta Hedw.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turfs on soil over escarpment ledges, 51°11'N, 97°37'W, *Caners* 5779.

Infrequent. Circumboreal.

Bryoerythrophyllum recurvirostre (Hedw.) Chen—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turfs on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5265 c.fr., 5269 c.fr., 5285 c.fr., 5724, 5769 c.fr.

Frequent. Cosmopolitan.

Didymodon rigidulus Hedw. var. *rigidulus* ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turfs on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5732, 5763, 5772, 5776.

Moderately frequent. Circumboreal.

Gymnostomum aeruginosum Sm. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small turfs on soil over rock ledges, or on the undersides of crevices above rock ledges, 51°11'N, 97°37'W, *Caners* 5269, 5279, 5756, 5758, 5767.

Frequent. Circumboreal.

Syntrichia norvegica F. Weber—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small tuft on humus over adjacent rock slab, 51°11'N, 97°37'W, *Caners* 6159.

Only a single colony was observed. Infrequent. Arctic-alpine.

Syntrichia ruralis (Hedwig) F. Weber & D. Mohr—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small tufts on humus over adjacent rock slabs, 51°11'N, 97°37'W, *Caners* 5723, 5762.

Frequent. Circumboreal.

Tortella fragilis (Hook. & Wils in Drumm.) Limpr.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small tufts on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5269, 5274, 5282.

Frequent. Circumboreal.

Tortella tortuosa (Hedw.) Limpr.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small tufts on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5274, 5763.

Infrequent. Circumboreal.

Tortula mucronifolia Schwaegr.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small tufts on soil over rock ledges, 51°11'N, 97°37'W, *Caners* 5265 c.fr.

Moderately frequent. Circumboreal.

PTERIGYNANDRACEAE

Myurella julacea (Schwaegr.) Schimp. in B.S.G. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small rough mats on soil and humus over rock ledges, 51°11'N, 97°37'W, *Caners* 5269, 5287, 5736, 5747.

Some plants with leaves widely spaced and terminating in a short, often recurved apiculus, approaching *Myurella tenerima* in appearance. Frequent. Circumboreal.

SELIGERACEAE

Seligeria domiana (Sm.) C. Müll.† ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, large turf on vertical rock walls in a shaded, humid crevice, 51°11'N, 97°37'W, *Caners* 5288 c.fr.

Only a single colony was observed. Infrequent. Boreal disjunct.

THUIDIACEAE

Abietinella abietina (Hedw.) Fleisch.—MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, large wefts over escarpment ledges and adjacent rock slabs, 51°11'N, 97°37'W, *Caners* 5263, 5266.

Frequent. Circumboreal.

Thuidium recognitum (Hedw.) Lindb. ∇ MANITOBA: Rural Municipality of Fisher, Marble Ridge, between Fisher Branch and Hodgson, small to large wefts on humus over ledges and adjacent rock slabs, 51°11'N, 97°37'W, *Caners* 5779.

Moderately frequent. Circumboreal.

Discussion

Marble Ridge supports a variety of bryophytes with differing floristic affinities and life forms, including several species that are reported for Manitoba for the first time. The fact that the escarpment can support this diverse assemblage of species is largely attributable to the concurrence of several habitat features. Namely, the escarpment contains an assortment of surfaces, ledges, and crevices, with varying degrees of humidity and exposure, that create a diversity of microhabitats for bryophyte species with different biological requirements. The species *Athalamia hyalina*, *Frullania inflata*, and *Seligeria donniana*, for example, were found almost exclusively in rock crevices or sheltered microhabitats with high humidity and low exposure. In comparison, vertical rock faces and adjacent rock slabs were more exposed to air currents and incident solar radiation, and they supported a higher number of bryophytes that were apparently tolerant of drier growing conditions, including *Abietinella abietina*, *Anomodon rostratus*, *Brachythecium acuminatum*, *Hedwigia ciliata*, *Orthotrichum anomalum*, and *Syntrichia ruralis*.

The wide range of bryophyte life forms documented along the escarpment may be indicative of the diversity of microhabitats at the site. Bryophyte life forms correlate strongly with moisture and light conditions, and can provide insights into the local environment (Gimingham and Birse 1957; Bates 1998). On hard substrates, including rock, rough mats are commonly associated with dry and shaded habitats, whereas tall turfs are more closely affiliated with mesic and more exposed habitats (Bates 1998). In comparison, short turfs and many tufts (*sensu* Hill et al. 2007) are often found in microhabitats that are both dry and exposed. Dominance of these life forms at Marble Ridge confirms the general observation that a range of microhabitat conditions are present at the site.

Two other important features of the escarpment for maintaining bryophytes are the east-facing aspect and the forest canopy cover which in many places help maintain shaded, cooler, and more humid microhabitats for species by reducing incident solar radiation, surface and air temperatures, and wind. Approximately one-third of all species documented at Marble Ridge are mesophytes; they would be detrimentally affected by drier conditions along the escarpment with forest canopy removal or a more arid regional climate. Any human-induced disturbances to forest or bedrock habitat in the immediate vicinity of Marble Ridge should consider the potential impacts on species and their specialized habitat requirements.

Several species documented on Marble Ridge are likely to be found on other bedrock outcrops of varying size in the Interlake Plain Ecoregion, especially species

with wide phylogeographic distributions like the circumboreal ones. However, some species will almost certainly remain regionally uncommon in view of the exceptional growing conditions at Marble Ridge and the comparatively few known occurrences of these species in other parts of Canada (e.g., *Athalamia hyalina*, *Frullania inflata*, *Grimmia teretinervis*, *Mannia sibirica*, *Seligeria donniana*). *Anomodon rostratus* is known from several localities in most eastern provinces (Canadian Endangered Species Conservation Council 2011*) but is likely uncommon in Manitoba and Saskatchewan, where the species approaches its western distributional limits in the country. Inventories of bryophytes at other bedrock exposures along the Paleozoic outcrop belt in southwestern Manitoba are required 1) to better understand the occurrences of uncommon species in the region and the habitat conditions under which they are most likely to occur and 2) to assess the conservation value of bedrock exposures for their capacity to support saxicolous bryophytes.

The large proportion of circumboreal species at Marble Ridge is not surprising, given that the site is located in the Boreal Plains Ecozone. However, the majority of species (five out of seven) reported here as new to the province have phylogeographic distributions other than circumboreal (e.g., arctic, temperate). This suggests that Marble Ridge plays an important role in supporting both a large number of species characteristic of the boreal biome and those with outlying floristic affinities. Conservation and management plans in Interlake Manitoba should consider the inherent value of Marble Ridge, and potentially other geologic formations in maintaining regional biodiversity.

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Rarity Status Assessments of Bugseeds (Amaranthaceae: *Corispermum*) in Manitoba

DIANA BIZECKI ROBSON

The Manitoba Museum, 190 Rupert Avenue, Winnipeg, Manitoba R3B 0N2 Canada; email: drobson@manitobamuseum.ca

Robson, Diana Bizecki. 2011. Rarity status assessments of bugseeds (Amaranthaceae: *Corispermum*) in Manitoba. *Canadian Field-Naturalist* 125(4): 338-352.

To provide a more accurate assessment of the rarity of the plant genus *Corispermum* (Amaranthaceae), commonly known as bugseeds, in Manitoba, I undertook a survey of all historical populations. In total, 68 quarter sections were selected for presence/absence surveys; 37 of them contained at least one species of bugseed. Only 10 of the 20 historical populations in Manitoba were relocated. The total estimated size of known bugseed populations in Manitoba in 2010-2011 was approximately 9 820 to 13 060 individuals. American Bugseed (*C. americanum* (Nutt.) Nutt. var. *americanum*) is the most abundant and widespread of the bugseeds in Manitoba, followed by Hairy Bugseed (*C. villosum* Rydb.). There is only one population of Hooker's Bugseed (*C. hookeri* Mosyakin var. *hookeri*) in the province. Pallas' Bugseed (*C. pallasii* Steven) was not relocated and should probably be considered extirpated in Manitoba. The habitats at 61% of the localities where bugseeds were confirmed are anthropogenically disturbed, the most common habitat being roadsides with exposed bare sand. Of the localities where bugseeds were not relocated, 67% occurred in natural sandy areas, suggesting that dune stabilization is a major threat to the continuing persistence of these species.

Key Words: Bugseeds, Manitoba, *Corispermum americanum* var. *americanum*, *Corispermum villosum*, *Corispermum hookeri* var. *hookeri*, *Corispermum pallasii*, distribution, habitat, psammophile, status.

Drastic declines in the area of bare sand in major dune fields in western Canada have recently been documented (Hugenholz and Wolfe 2005; Wolfe and Thorpe 2005). The area of bare sand in the largest dune field in Manitoba, the Brandon Sand Hills, has shrunk by about 50% since 1950 (Wolfe et al. 2000). As a result of this habitat loss, some psammophilic (sand-loving) plants and animals, including Hairy Prairie Clover (*Dalea villosa* (Nutt.) Spreng. var. *villosa*), Smooth Goosefoot (*Chenopodium subglabrum* (S. Wats.) A. Nels.), Prairie Skink (*Plestiodon septentrionalis* Baird 1858), and Dusky Dune Moth (*Copablepharon longipenne* Grote 1882), are considered nationally rare and are now protected under the Species at Risk Act (Government of Canada 2011). Herbarium labels indicate that annual bugseed (*Corispermum* spp.) plants are also psammophilic, occurring almost exclusively on bare or partially stabilized dunes, or bare, sandy areas created by human activities.

The bugseeds are a genus of annual, ruderal (growing in waste places), herbaceous plants, recently moved to the family Amaranthaceae from the Chenopodiaceae (Chase and Reveal 2009). Plants in this family are often highly stress-tolerant, growing in sandy, calcareous, serpentine, and saline habitats (Robertson and Clements 2003). Some species are of economic importance because they are edible (e.g., Spinach, *Spinacia oleracea* L., and Quinoa, *Chenopodium quinoa* Willd.), weedy (e.g., Russian Thistle, *Salsola tragus* L., and Redroot Pigweed, *Amaranthus retroflexus* L.), or ornamental (e.g., Love-lies-bleeding, *Amaranthus caudatus* L., and cockscomb, *Celosia* spp.). Bugseeds are widespread in Canada occurring from Vancouver east to the St. Lawrence River in Quebec, and from the shores

of Lake Erie in the south to the MacKenzie River in the Northwest Territories (Robson 2010).

I recently examined Canadian herbarium specimens of *Corispermum* as part of a nomenclatural updating project (Robson 2010) prompted by changes to the taxonomy of this genus (Mosyakin 1995, 2003). During the herbarium research, I determined that four species of bugseeds were historically found in Manitoba (Robson 2010). However, the majority of the specimens (77%) had been collected prior to 1975, so up-to-date information on the current distribution and abundance of these species was lacking. Status recommendations using the revised *Corispermum* herbarium data for both NatureServe (2011*) and Canadian Endangered Species Conservation Council (2011) ranking systems were recently made in Robson (2010).

The rarity status assessment of species is important, as it provides a snapshot of the health of various ecosystems. Declines in species abundance can indicate that the ecosystems they occur in are under stress and in need of management changes. The objective of this project was to determine the current rarity status of bugseed species in Manitoba by conducting a field study to attempt to relocate all previously identified populations and to assess whether habitat has been lost or altered.

Methods

Collections at the herbaria in the following institutions were examined (acronyms follow Thiers 2012*): University of British Columbia (UBC), Royal British Columbia Museum (V), University of Alberta (ALTA), University of Calgary (UAC), University of Lethbridge (LEA), Royal Alberta Museum (PMAE), University

of Saskatchewan (SASK), University of Manitoba (WIN), Manitoba Museum (MMMN), Royal Ontario Museum (TRT), University of Waterloo (WAT), National Collection of Vascular Plants, Agriculture and Agri-Food Canada (DAO), Canadian Museum of Nature (CAN), Université de Montréal (MT), and McGill University (MTMG).

A total of 102 specimens were examined, and the data recorded on the labels were summarized in a spreadsheet; 69 specimens were determined to be locality duplicates. To determine where to conduct the field surveys, I obtained a latitude and longitude for each previously known locality as well as for areas containing open dunes and beaches. Geographic coordinates, either recorded by the original collector or derived from the label information by the staff at the herbaria housing the specimens, were available for 11 of the localities. No geographic coordinate(s) were supplied by the collector for most specimens (89%). For those localities, the place name on the herbarium label was entered into the Atlas of Canada website (<http://atlas.nrcan.gc.ca/site/english/maps/topo/map>) search function, and the latitude and longitude were noted. Sometimes detailed locality descriptions (e.g., 5 miles west of Deleau) could be used in conjunction with Atlas of Canada maps to pinpoint a more accurate set of coordinates. The preliminary geographic coordinates used to select the quarter sections for field surveys were only approximate but likely were within a 10–25 km radius of the historical population. By entering the preliminary geographic coordinates into the Atlas of Canada search function, I could examine satellite maps of the general area where the bugseed specimens had been found in the past. In particular, I searched areas of what appeared to be bare sand and/or native grassland.

A total of 60 quarter sections (approximately 65 ha each) in the most likely areas where bugseeds had been found in the past were selected for surveys. An additional 8 quarter sections containing potential bugseed habitat were also surveyed, for a grand total of 68. The number of quarter sections searched at each locality is noted in Table 1. The geographic coordinate in Table 1 represents the location of the first *Corispermum* plant found at each locality or, if *Corispermum* was not found in the quarter section, the starting point of the field survey at that locality. Using the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) definition of a population as “a geographically or otherwise distinct group within a wildlife species that has little demographic or genetic exchange with other such groups” (COSEWIC 2010*), I determined that the localities occurred in 13 separate populations.

All landowners were contacted to obtain their permission for a site visit. Collection permits for Grand Beach Provincial Park, Patricia Beach Provincial Park, and Spruce Woods Provincial Park were obtained from Manitoba Conservation.

TABLE 1. Names of all historical and extant *Corispermum* populations and localities in Manitoba, number of quarter sections surveyed and occupied, and presence/absence survey results.

| Population | Locality | Latitude and longitude | No. of quarter sections surveyed | No. of quarter sections containing <i>Corispermum</i> species | Survey results | |
|---|------------------------------|------------------------------|----------------------------------|---|--|-------------------------------|
| | | | | | Species present (no. of quarter sections) | Species absent |
| Baldur | Baldur | 49,385 -99,244 ¹ | 1 | 0 | | <i>Corispermum americanum</i> |
| Birds Hill | Birds Hill Provincial Park | 50,006 -96,909 ² | 2 | 2 | <i>C. americanum</i> (2) | |
| Brandon Sand Hills | Assiniboine Corridor | 49,666 -99,566 ² | 1 | 1 | <i>C. americanum</i> ^{2,3} (1) | |
| | CFB Shilo | 49,806 -99,537 ² | 5 | 5 | <i>C. americanum</i> (4) <i>Corispermum villosum</i> ⁴ (1) | |
| Goodlands ⁵ Lake Manitoba | Glenboro | 49,556 -99,291 ¹ | 1 | 0 | | <i>C. americanum</i> |
| | Melbourne | 49,883 -99,151 ² | 3 | 1 | <i>C. americanum</i> ⁴ (1) | <i>Corispermum pallasii</i> |
| | Pine Creek | 49,959 -99,168 ¹ | 1 | 0 | | <i>C. villosum</i> |
| | Pratt | 49,768 -98,911 ² | 1 | 1 | <i>C. americanum</i> ⁴ (1) | |
| | Sidney | 49,901 -99,057 ² | 2 | 2 | <i>C. americanum</i> (2) | <i>C. pallasii</i> |
| | Spruce Woods Provincial Park | 49,665 -99,286 ² | 5 | 3 | <i>C. americanum</i> (3) <i>Corispermum hookeri</i> (1) | |
| Goodlands ⁵ Lake Manitoba | Goodlands | 49,094 -100,604 ¹ | 3 | 0 | | <i>Corispermum</i> |
| | Chimney Marsh | 50,222 -98,177 ¹ | 1 | 0 | | <i>C. villosum</i> |
| | Delta Marsh | 50,198 -98,205 ¹ | 3 | 0 | | <i>C. villosum</i> |

TABLE 1. Names of all historical and extant *Corispermum* populations and localities in Manitoba, number of quarter sections surveyed and occupied, and presence/absence survey results. (continued)

| Population | Locality | Latitude and longitude | No. of quarter sections surveyed | No. of quarter sections containing <i>Corispermum</i> species | Species present (no. of quarter sections) | Survey results | Species absent |
|------------------------------------|---|------------------------------|----------------------------------|---|---|--------------------------|----------------------|
| Lake of the Woods Lake Winnipeg | Reed River | 49.142 -95.276 ¹ | 1 | 0 | <i>Corispermum</i> ? ⁶ | | |
| | Albert Beach | 50.687 -96.523 ² | 1 | 1 | <i>C. villosum</i> ⁴ (1) | | |
| | Gimli | 50.607 -96.963 ² | 1 | 1 | <i>C. villosum</i> (1) | | |
| | Grand Beach Provincial Park | 50.568 -96.602 ² | 2 | 2 | <i>C. villosum</i> ⁴ (2) | | |
| | Ironwood Point | 50.651 -96.597 ² | 1 | 1 | <i>C. americanum</i> (1) | | |
| | Lester Beach | 50.598 -96.584 ² | 1 | 1 | <i>C. villosum</i> ⁴ (1) | | |
| | Matlock | 50.433 -96.964 ¹ | 1 | 0 | | | <i>C. villosum</i> |
| | Netley-Libau Marsh | 50.392 -96.781 ³ | 0 | ? | <i>Corispermum</i> ? ⁷ | | <i>Corispermum</i> |
| | Patricia Beach ⁸ | 50.425 -96.613 ¹ | 1 | 0 | <i>C. americanum</i> (1) | | |
| | Victoria Beach | 50.700 -96.561 ² | 1 | 1 | <i>C. villosum</i> (1) | | |
| | Winnipeg Beach ⁸ | 50.500 -96.968 ¹ | 1 | 0 | | | <i>Corispermum</i> |
| | Lauder/Oak Lake/ Routledge Sand Hills ⁹ | Deleau | 49.576 -100.672 ² | 3 | 1 | <i>C. americanum</i> (1) | |
| Grande-Clairière | | 49.503 -100.654 ² | 1 | 1 | <i>C. americanum</i> (1) | | |
| Lauder | | 49.391 -100.677 ¹ | 1 | 0 | | | <i>C. americanum</i> |
| Melita | | 49.390 -100.902 ¹ | 1 | 0 | | | <i>C. americanum</i> |
| Miami | Oak Lake | 49.769 -100.599 ¹ | 2 | 0 | | | <i>C. villosum</i> |
| | Miami | 49.371 -98.244 ¹ | 2 | 0 | | | |
| Portage Sand Hills | Rathwell | 49.651 -98.462 ² | 4 | 3 | <i>C. americanum</i> (3) | | |
| | Portage la Prairie | 49.798 -98.281 ² | 6 | 5 | <i>C. americanum</i> (5) | | |
| St-Lazare Sand Hills | St-Lazare | 50.415 -101.362 ² | 6 | 5 | <i>C. americanum</i> (1) <i>C. villosum</i> (4) | | |
| | Treherne | 49.629 -98.697 ¹ | 1 | 0 | | | <i>C. pallasi</i> |
| Red River | Winnipeg | 49.884 -97.146 ¹ | 1 | 0 | | | <i>C. americanum</i> |
| | Total | | 68 | 37 | | | |

¹ Represents the geographic coordinate of the survey starting point in the first quarter section visited; no *Corispermum* was verified in these areas.

² Represents the geographic coordinate of the first *Corispermum* plant encountered in the locality.

³ Represents the geographic coordinate of the approximate area where *Corispermum* was found historically using Atlas of Canada satellite maps.

⁴ Represents a new, previously undocumented occurrence.

⁵ Represents a locality documented by Manitoba Conservation staff (C. Friesen, personal communication, 2010).

⁶ Locality was unconfirmed due to inaccessibility of the site for surveys.

⁷ No specimen was collected at this locality but it was listed as occurring on beaches and exposed sand in Grosshans et al. (2004).

⁸ No *Corispermum* was historically found at these sites but a survey was conducted due to the presence of potential habitat.

⁹ As the Lauder/Oak Lake/Routledge Sand Hills are geographically contiguous, plants growing there were considered to be part of one population.

Due to time limitations, only presence/absence surveys were conducted. As most herbarium records indicated that the plants had been growing on bare or disturbed sand, these habitats were examined particularly closely and, in most cases, were selected as the starting point for each survey. Habitats clearly unsuitable for the species (i.e., wetlands, dense aspen bluffs) were avoided in order to increase efficiency. If bugseeds were present, they were typically encountered within the first 10–15 minutes of searching. In some cases, bugseed plants were found on the public land road allowance, so no survey of the adjacent private property was required to verify the species' presence in that particular quarter section. This means that a large number of the extant populations were noted as occurring along roadsides. More thorough surveys of the occupied quarter sections may reveal that there are additional plants on natural habitats farther from the roads.

The 68 quarter sections in southern Manitoba were visited for a total of 15 days (~105 hours) split evenly over two years in late August and early September when the plants were in seed. As a fair portion of that time was spent travelling to the sites, only 63 hours (on average 56 minutes per quarter section) was actually spent surveying or recording population and habitat data. Due to flooding in 2011, one locality along Lake Winnipeg could not be visited.

When a bugseed plant was found, a Global Positioning System was used to record the location. Thus the accuracy of the extant localities is very high and that of the historical localities (Figures 1–4) is lower. Digital photographs of the habitat and the plant were taken, and information regarding the habitat and associated species was recorded. The approximate size of the population was determined. If the population was relatively small (<100 plants), I counted the total number of plants. If the population was large, I counted the number of plants in 25 randomly located quadrats of 1 m² each, took the average, and multiplied it by the total area occupied by the population and rounded to the nearest ten.

Voucher specimens were collected and pressed for study at The Manitoba Museum, as confirmation of the species typically requires measurement and microscopic study of the seeds, especially when they are not fully ripe. In localities with large numbers of two or more bugseed species, it is possible that some errors were made when estimating the population size of each species, as not every single plant was examined. To minimize impact, I collected only part of the plant (i.e., one stem with a few seeds). Identifications were based on keys and descriptions in Mosyakin (2003).

The habitats of the species were grouped into one of two categories: natural areas not directly affected by humans and areas where humans have disturbed the soil in some manner. Natural areas were further divided into four categories: (1) inland active sand dunes and blowouts, (2) inland sandy hills and plains, (3) lacustrine beaches and dunes, and (4) riparian sand banks and dunes. Anthropogenically modified areas were further divided into three categories: (1) sand and gravel pits, (2) sandy firebreaks, and (3) sandy roadsides.

Results

Historical species and populations

A review of the herbarium records and literature indicated that four species of bugseed were historically found in Manitoba: American Bugseed (*C. americanum* var. *americanum*), Hooker's Bugseed (*C. hookeri* var. *hookeri*), Pallas' Bugseed (*Corispermum pallasii*), and Hairy Bugseed (*C. villosum*). There were 20 historical populations consisting of 33 localities, most of which were American Bugseed (Table 2). Ten of those Bugseed populations (15 localities) were located again during the survey. The other 10 populations (18 localities) may be extirpated. The average collection date of the specimens at the possibly extirpated localities was 1948 (the median is 1946), so plants at these sites may have disappeared decades ago. Since Pallas' Bugseed (*C. pallasii*) was not encountered at any of the three sites where it historically occurred and has not been seen since 1960, it should be considered possibly extirpated in Manitoba. Grosshans et al. (2004) reported another bugseed species (*Corispermum hyssopifolium* L.) on beaches and exposed sand at Netley-Libau Marsh at the extreme south end of Lake Winnipeg. However, since no specimen was collected, the exact identity of this plant could not be confirmed; it was likely American or Hairy bugseed. Flooding in 2011 prevented closer examination of this area.

The rediscovery of historical populations using herbarium data can be difficult because of the lack of detailed location information. Although most labels list a town or city as a point of reference, the exact direction and distance from it are not always noted. Relocating a population with a broad locality description necessitates searching large areas to increase the chance of success. Thus it is possible that some localities may still have extant individual plants in quarter sections that were not searched during this study.

In some cases, examining historical literature can help provide information on the likely location of a population. For example, using such information I was able to deduce that the population of Hairy Bugseed collected by John Macoun in 1872 was very likely from the present-day Whitemud Watershed Wildlife Management Area, Edrans Unit, along Pine Creek, northeast of present-day Carberry. The label listed "Western Manitoba" as the locality, and this suggests that it was collected near St-Lazare or in the Oak Lake Sand Hills/Routledge Sand Hills. The current western boundary of southern Manitoba is just east of the 102nd meridian, but in 1872 Manitoba extended westward only as far as about the 99th meridian. At that time, "Western Manitoba" probably referred to the area near the Brandon Sand Hills.

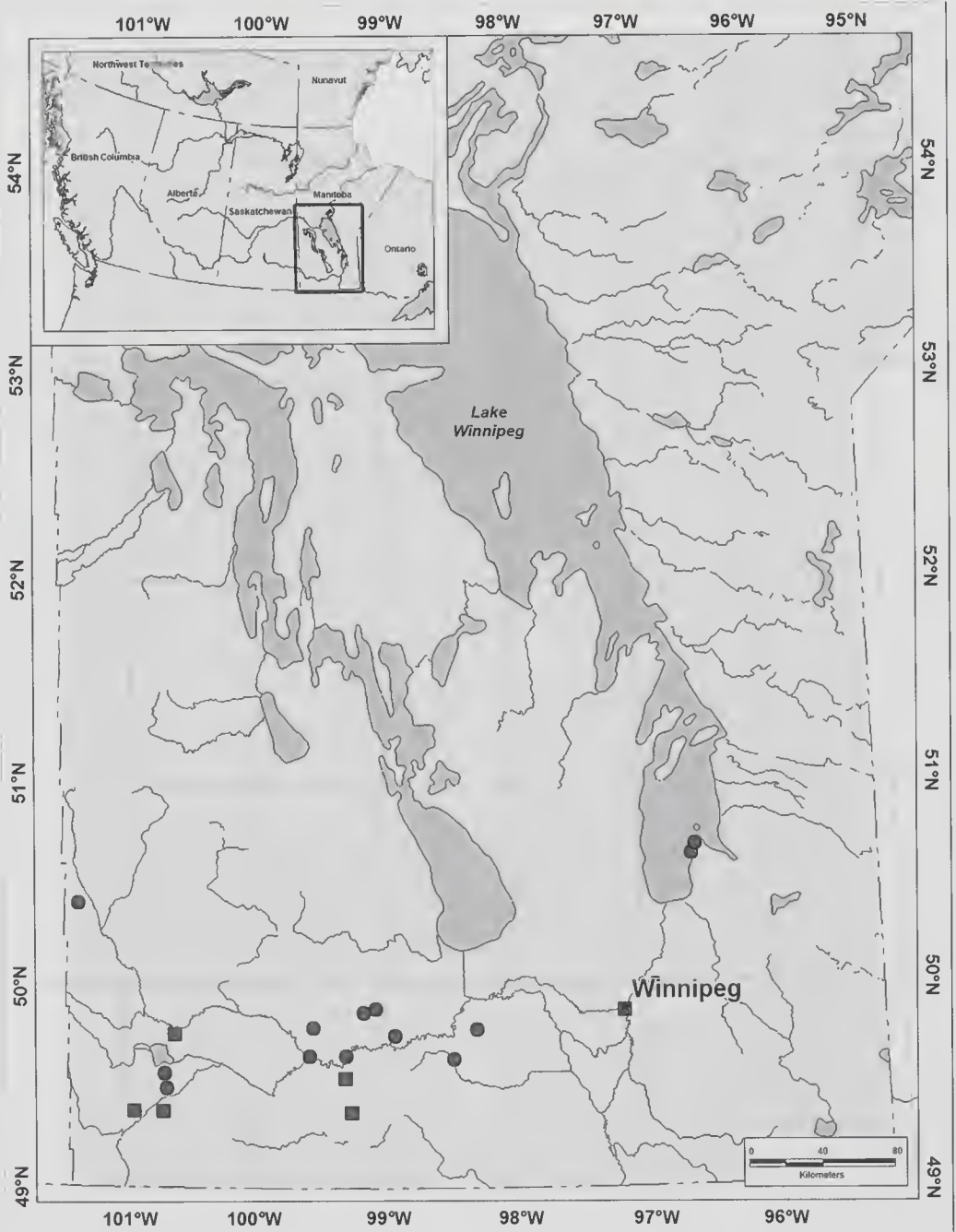


FIGURE 1: Distribution map of American Bugseed, *Corispermum americanum*, in Manitoba based on Canadian herbarium specimens and presence/absence surveys in 2010 and 2011. Circles indicate extant localities and squares historical ones.

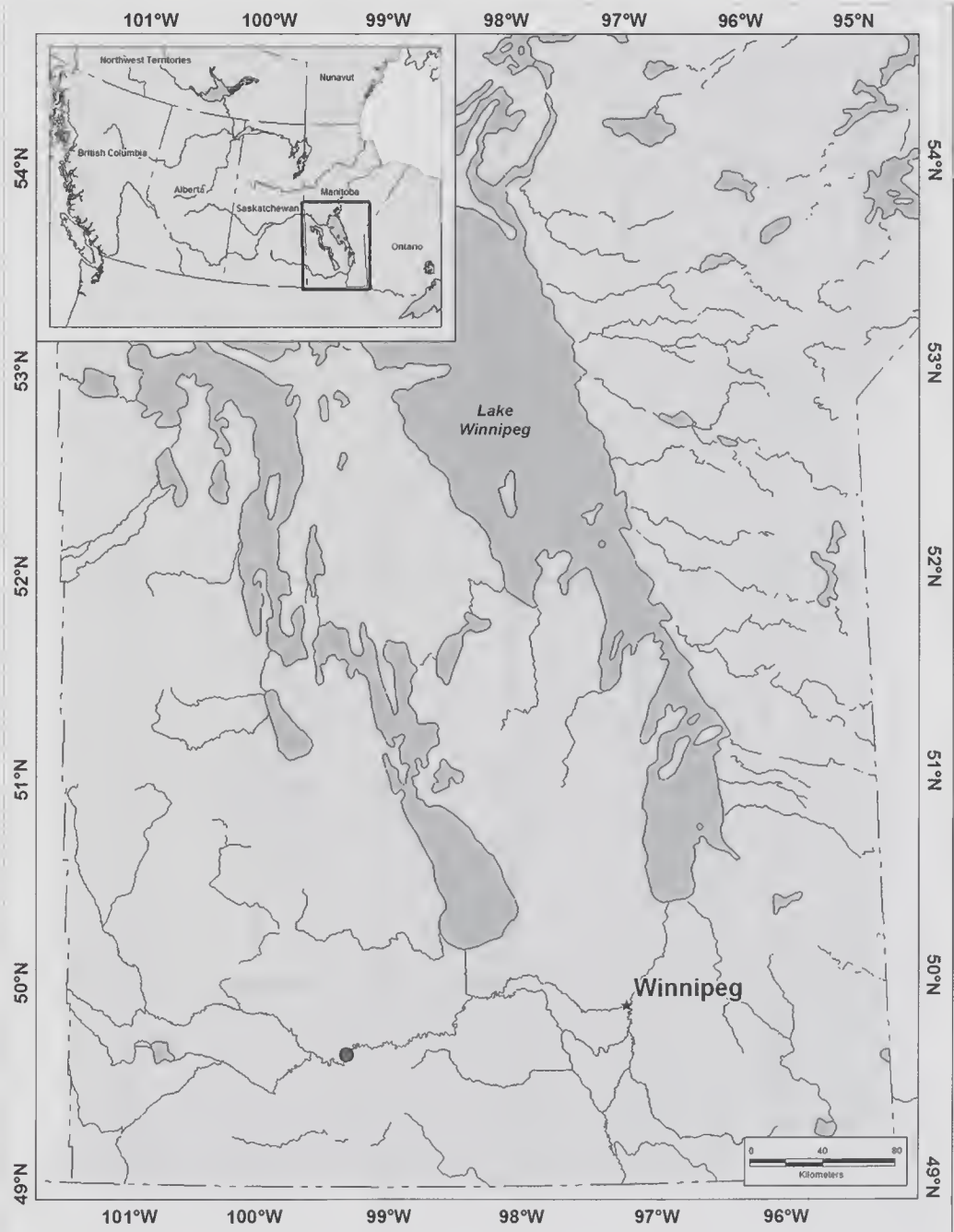


FIGURE 2: Distribution map of Hooker's Bugseed, *Cotyspermum hookeri* var. *hookeri*, in Manitoba based on Canadian herbarium specimens and presence/absence surveys in 2010 and 2011. The circle indicates an extant/historical locality.

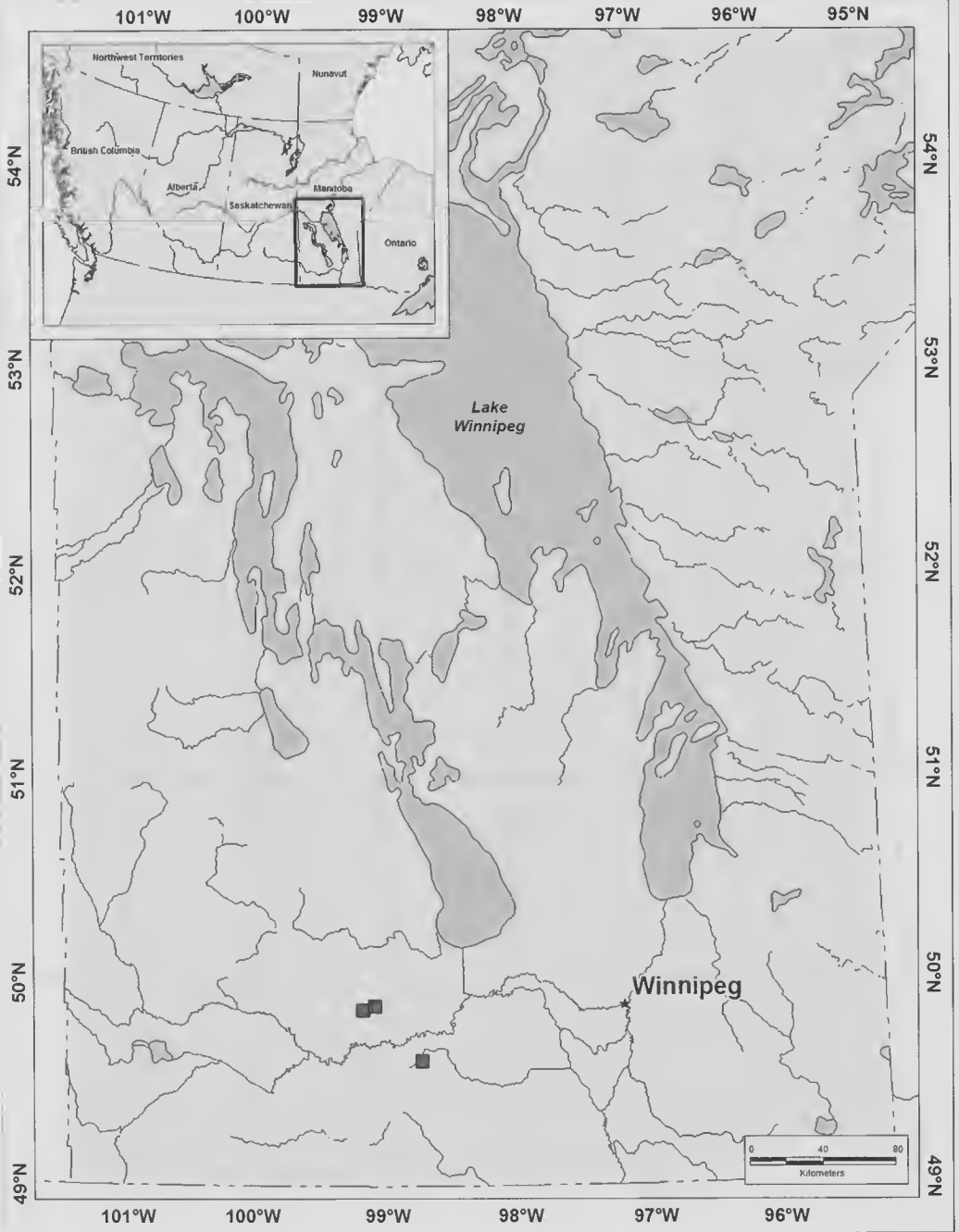


FIGURE 3: Distribution map of Pallas' Bugseed, *Corispermum pallasii*, in Manitoba based on Canadian herbarium specimens and presence/absence surveys in 2010 and 2011. No extant populations were found. Squares indicate historical localities.

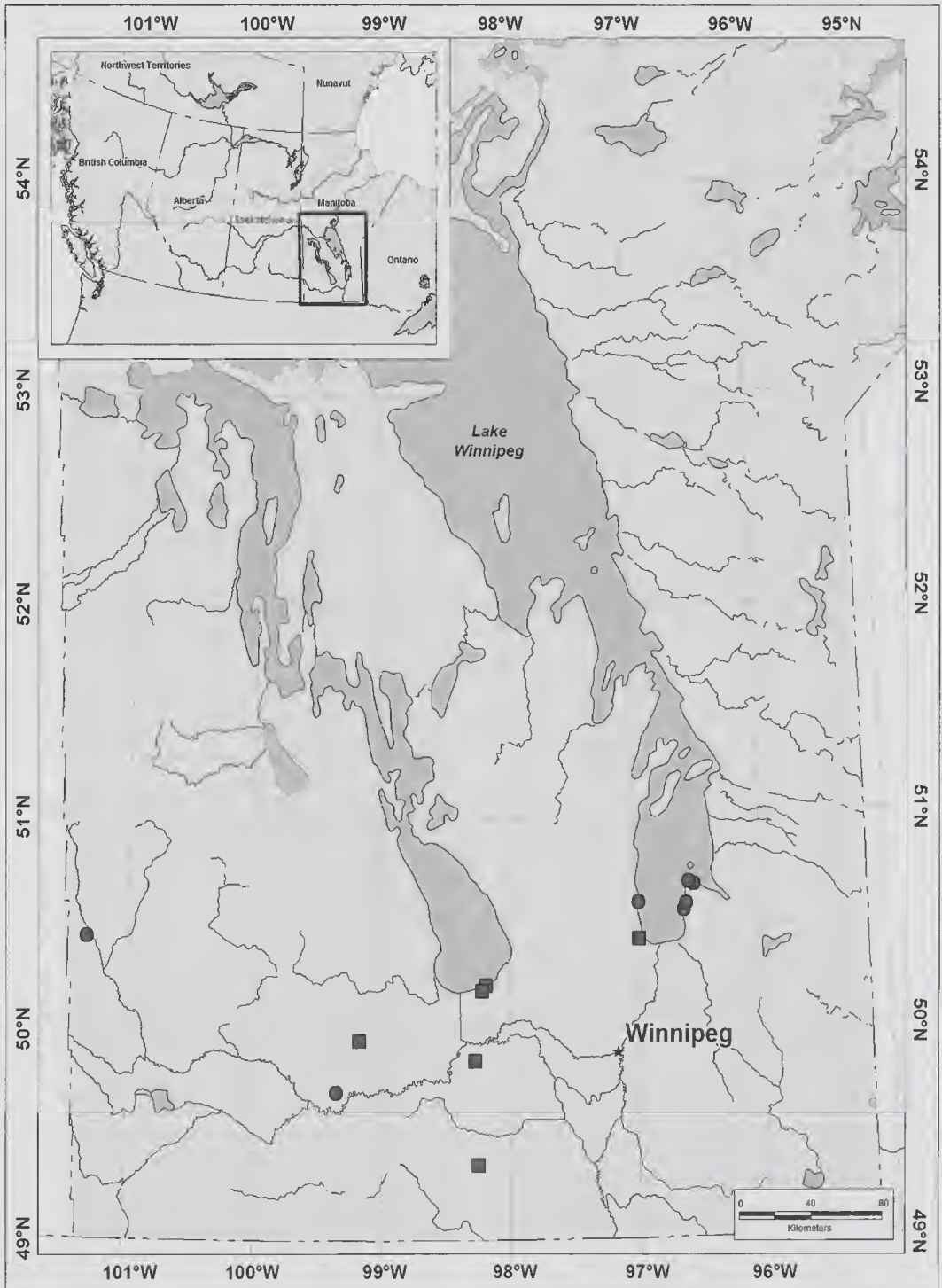


FIGURE 4: Distribution map of Hairy Bugseed, *Corispermum villosum*, in Manitoba based on Canadian herbarium specimens and presence/absence surveys in 2010 and 2011. Circles indicate extant localities and squares historical ones.

TABLE 2. Summary of the number of historical, extirpated/unconfirmed, confirmed, and new bugseed populations and localities in Manitoba.

| Scientific name | No. of populations (no. of localities) | | | | | | Total extant |
|--|--|------------|------------------------|-----------|-------|---------|--------------|
| | Common name | Historical | | | | New | |
| | | Historical | Extirpated/unconfirmed | Confirmed | New | | |
| <i>Corispermum americanum</i> var. <i>americanum</i> | American Bugseed | 8 (17) | 2 (6) | 6 (11) | 0 (3) | 6 (14) | |
| <i>Corispermum hookeri</i> var. <i>hookeri</i> | Hooker's Bugseed | 1 (1) | 0 (0) | 1 (1) | 0 (0) | 1 (1) | |
| <i>Corispermum pallasi</i> | Pallas' Bugseed | 2 (3) | 2 (3) | 0 (0) | 0 (0) | 0 (0) | |
| <i>Corispermum villosum</i> | Hairy Bugseed ¹ | 6 (9) | 3 (6) | 3 (3) | 0 (4) | 3 (7) | |
| <i>Corispermum</i> sp. | Bugseed | 3 (3) | 3 (3) ¹ | 0 (0) | 0 (0) | 0 (0) | |
| Total | | 20 (33) | 10 (18) | 10 (15) | 0 (7) | 10 (22) | |

¹ One unconfirmed locality is not represented by a herbarium specimen but was listed as occurring on beaches and exposed sand in Grosshans et al. (2004).

Examination of the field journals prepared by Macoun and his companion on the journey, Sandford Fleming, provided additional information that confirms this hypothesis. The journal clearly states that they encountered a region of sand dunes in 1872 near Pine Creek while travelling along the Carlton trail from Winnipeg to Edmonton (Fleming 1874). Historical maps of the Carlton trail show it passing through the northern portion of the Brandon Sand Hills across Pine Creek. Further, Macoun noted that White Spruce (*Picea glauca*) was common in this area. Since White Spruce is common in the Brandon Sand Hills but less common in dunes further west, the hypothesis receives additional support.

Extant species and populations

There are at least ten extant populations of bugseeds in Manitoba: three species occur in the Brandon Sand Hills, two along Lake Winnipeg, two in the St-Lazare Sand Hills, and one each in the Portage Sand Hills and the Lauder/Oak Lake Sand Hills/Routledge Sand Hills (Table 3). Seven new bugseed localities containing either American or Hairy bugseed were discovered during the surveys, but none were part of a new population. The most widespread and abundant species in Manitoba is American Bugseed, followed by Hairy Bugseed. The largest American Bugseed population was in the Brandon Sand Hills, and the largest population of Hairy Bugseed was along Lake Winnipeg. Most American Bugseed plants (71%) occurred south of the 50th parallel, whereas most Hairy Bugseed plants (92%) were north of it. Only one population of Hooker's Bugseed was found in the province and this was the historical population.

As the primary goal of this project was to determine the presence or absence of bugseed species at all historical sites, the quarter sections visited were not surveyed thoroughly enough to prepare accurate estimates of the population size or area of occupancy (Henderson 2009*). However, while surveying, I recorded the number of individual plants observed during the time available, and this provides a minimum size estimate for each locality. The total population size of bugseeds at all known localities is estimated to be between 9 820 and 13 060 plants. The population size estimates from the two largest populations, the Brandon Sand Hills and Lake Winnipeg, are the most likely to be inaccurate, as the entire dune area/beach could not be searched due to time constraints and accessibility issues, including flooding of some sites and military restrictions at Canadian Forces Base (CFB) Shilo. The Brandon Sand Hills, in particular, which have large active dunes, may house significantly larger populations of bugseeds than estimated. Further, the military maintains firebreaks, which churn up the sandy soil throughout the CFB Shilo range. Since I observed a large number of bugseed plants on just a small portion of the firebreaks that I examined, the number of individual plants at the base could be quite large.

TABLE 3. Area occupied by and estimated sizes of all extant *Corispermum* populations observed in 2010 and 2011.

| Population ¹ name | Area occupied ² (km ²) | Estimated population size | | |
|---|--|---|---|-----------------------------|
| | | <i>Corispermum americanum</i> var. <i>americanum</i> | <i>Corispermum hookeri</i> var. <i>hookeri</i> | <i>Corispermum villosum</i> |
| Birds Hill | 1.29 | ~1110–1510 | — | — |
| Brandon Sand Hills | 9.06 | ~2860–3960 | ~1900–2900 | ~200 |
| Lake Winnipeg | 4.53 | ~350 | — | ~1160–1750 |
| Lauder/Oak Lake Sand Hills/Routledge Sand Hills | 1.29 | 70 | — | — |
| Portage Sand Hills | 5.18 | ~940 | — | — |
| St-Lazare Sand Hills | 3.24 | 10 | — | ~1220–1370 |
| Estimated total size | 24.59 | ~5340–6840 | ~1900–2900 | ~2580–3320 |

¹ A population is defined as "a geographically or otherwise distinct group within a wildlife species that has little demographic or genetic exchange with other such groups" (COSEWIC 2010*). Populations may consist of plants at several localities.

² These figures represent the area of all the quarter sections in which the presence of *Corispermum* was confirmed. The actual area occupied by *Corispermum* plants is substantially lower than this.

Bugseed plants were also recently found by Chris Friesen (personal communication, 2010) along the Assiniboine River in the Assiniboine Corridor Wildlife Management Area, which is also part of the Brandon Sand Hills. Since the Assiniboine River passes through a substantial amount of sandy habitat, bugseeds could be more abundant there than estimated. The catastrophic floods that occurred along this river in 2011 eroded the banks and exposed new areas of sand, which could, in the future, provide bugseeds with additional habitat.

Stevens et al. (1995) found that what they called *Corispermum nitidum* Kit. (which likely represents *C. americanum*) readily reinvaded riparian areas after a flood along the Colorado River. Further, Canadian herbarium labels indicate that some bugseed species have been found germinating in the sandy substrate dredged from the bottom of the Fraser River in British Columbia. This information suggests that some bugseed species are tolerant of submersion and can exploit areas of recently submerged sand. Thus my estimated population size for the Brandon Sand Hills is likely too low, perhaps by one order of magnitude. Nonetheless, this research provides a base from which to conduct future bugseed surveys should any of the species be nominated for national or provincial protection.

Hairy Bugseed was found at three of the beaches lacking historical records of bugseeds that were surveyed: Albert Beach, Grand Beach, and Lester Beach. No bugseeds were encountered at Patricia Beach or Winnipeg Beach. Three new American Bugseed localities were discovered near the Assiniboine Corridor Wildlife Management Area, Pratt, and Melbourne while I was searching for other rare species in the area.

Habitats

Most plants that were relocated (61%) occurred in quarter sections that have been anthropogenically modified in some manner; 39% occurred in natural areas such as sand dunes (Table 4). Of the natural areas, the most common habitats were inland sand dunes, and lacustrine beaches and dunes along Lake Winnipeg. Sandy roadsides that cut into a stabilized dune were the most common anthropogenically modified habitat of bugseeds (Table 4). American Bugseed was more tolerant of disturbance than Hairy Bugseed, as 69% of the populations of American Bugseed occurred in anthropogenically modified areas compared to 45% of Hairy Bugseed (Table 4). Of the populations that are likely extirpated, 67% were described as occurring in natural habitats, 11% in anthropogenically disturbed habitats, and 22% had no habitat description on the label (Table 5). During the surveys, at least some native vegetation was located at 57% of the localities where bugseeds had likely occurred historically; 7% of the localities occurred near a water body and were flooded.

Associated rare species

There were 16 other species of rare plants found in association with bugseeds in various locations (Table 6). Two of the rare species are nationally rare and are

TABLE 4. Habitat in each quarter section containing an extant *Corispermum* population in Manitoba.

| Habitat | No. of quarter sections ¹ | | | Total |
|---------------------------------------|--|--|-----------------------------|-------|
| | <i>Corispermum americanum</i> var. <i>americanum</i> | <i>Corispermum hookeri</i> var. <i>hookeri</i> | <i>Corispermum villosum</i> | |
| Natural areas | | | | |
| Inland active sand dunes and blowouts | 6 | 1 | | 7 |
| Inland sandy hills and plains | 1 | | | 1 |
| Lacustrine beaches and dunes | 1 | | 4 | 5 |
| Riparian sand banks and dunes | 1 | | 2 | 3 |
| Subtotal | 9 | 1 | 6 | 16 |
| Anthropogenically modified areas | | | | |
| Sand and gravel pits | 3 | | 2 | 5 |
| Sandy firebreaks | 3 | | 1 | 4 |
| Sandy roadsides | 14 | | 2 | 16 |
| Subtotal | 20 | 1 | 5 | 25 |
| Total | 29 | 1 | 11 | 41 |

¹ Quarter sections rather than localities were chosen to analyze these data, as the habitats varied within some localities.

TABLE 5. Habitat types of historical localities in Manitoba from which *Corispermum* has been extirpated or in which *Corispermum* could not be confirmed.

| Habitat type | Localities | | | | Total |
|---------------------------------------|--|-----------------------------|-----------------------------|------------------------|-------|
| | <i>Corispermum americanum</i> var. <i>americanum</i> | <i>Corispermum pallasii</i> | <i>Corispermum villosum</i> | <i>Corispermum</i> sp. | |
| Natural areas | | | | | |
| Inland active sand dunes and blowouts | 3 | | | | 3 |
| Inland sandy hills and plains | | 2 | 1 | | 3 |
| Lacustrine beaches and dunes | | | 3 | 1 | 4 |
| Riparian sand banks and dunes | 1 | | | 1 | 2 |
| Subtotal | 4 | 2 | 4 | 2 | 12 |
| Anthropogenically modified areas | | | | | |
| Sand and gravel pits | 1 | | | | 1 |
| Sandy roadsides | | | 1 | | 1 |
| Subtotal | 1 | 0 | 1 | 0 | 2 |
| No habitat description | 1 | 1 | 1 | 1 | 4 |
| Total | 6 | 3 | 6 | 3 | 18 |

protected by the federal Species at Risk Act: Smooth Goosefoot and Hairy Prairie Clover (Government of Canada 2011). Hairy Prairie Clover is also protected provincially by the Manitoba Endangered Species Act (Government of Manitoba 2011). Seven species are considered nationally rare (i.e., with a Wild Species Status code of 1, 2, or 3) but are not legally protected while the other seven are rare only provincially (Canadian Endangered Species Conservation Council 2011). Sand Nut-sedge (*Cyperus schweinitzii* Torr.) was the rare plant found the most frequently with bugseeds (23 quarter sections). The Brandon Sand Hills contained the highest number of rare plants (12 species).

Rarity status

The current subnational rankings assigned to *Corispermum* spp. in Manitoba by NatureServe (2010*) and the Canadian Endangered Species Conservation Council

(2011), as well as the new suggested ranks incorporating the information obtained in this study, are noted in Table 7. Four rank changes are recommended.

Discussion

This research suggests that all bugseed species in Manitoba are becoming rarer, as less than half of the historical localities still contain plants. This change appears to be due primarily to dune stabilization (Wolfe et al. 2000; Hugenholtz and Wolfe 2005) rather than outright habitat loss associated with cultivation or development, as 57% of the localities from which bugseeds have been extirpated or in which bugseeds were unconfirmed still contained some native vegetation. The research of Van Asdall and Olmstead (1963), who found that bugseeds decreased in density along a successional gradient of reduced light intensity and

TABLE 6. Status and location of nationally and provincially rare plants associated with *Corispermum*.

| Scientific name | Common name | Population location | Wild Species Status Code ¹ | |
|---|-------------------------|--|---------------------------------------|------------|
| | | | National | Provincial |
| <i>Achnatherum hymenoides</i> (R. & S.) Bankw. | Indian Ricegrass | Brandon Sand Hills | 4 | 2 |
| <i>Andropogon hallii</i> Hack. | Sand Bluestem | Brandon Sand Hills, Lauder/Oak Lake Sand Hills/ Routledge Sand Hills | 2 | 2 |
| <i>Aristida purpurea</i> Nutt. var. <i>longiseta</i> (Steud.) Vasey | Red Three-awned Grass | Brandon Sand Hills | 4 | 2 |
| <i>Chamaesyce geyeri</i> (Engelm.) Small | Geyer's Spurge | Lake Winnipeg, St-Lazare Sand Hills | 2 | 2 |
| <i>Chenopodium subglabrum</i> (S. Wats.) A. Nels. | Smooth Goosefoot | Brandon Sand Hills | 1 | 1 |
| <i>Cycloloma atriplicifolium</i> (Spreng.) Coult. | Winged Pigweed | Brandon Sand Hills | 4 | 2 |
| <i>Cyperus schweinitzii</i> Torr. | Schweinitz's Flatsedge | Brandon Sand Hills, Lake Winnipeg, Lauder/Oak Lake Sand Hills/ Routledge Sand Hills, Portage Sand Hills, St-Lazare Sand Hills | 3 | 2 |
| <i>Cyperus squarrosus</i> L. | Awned Flatsedge | Portage Sand Hills | 4 | 2 |
| <i>Dalea villosa</i> (Nutt.) Spreng. var. <i>villosa</i> | Hairy Prairie Clover | Brandon Sand Hills, Lauder/Oak Lake Sand Hills/Routledge Sand Hills | 1 | 1 |
| <i>Draba reptans</i> (Lam.) Fern. | Carolina Whitlow-grass | Birds Hill Provincial Park | 3 | 5 |
| <i>Eriogonum flavum</i> Nutt. | Yellow Buckwheat | St-Lazare Sand Hills | 4 | 3 |
| <i>Helianthus petiolaris</i> Nutt. | Prairie Sunflower | Brandon Sand Hills | 4 | 3 |
| <i>Orobancha ludoviciana</i> Nutt. | Louisiana Broomrape | Brandon Sand Hills, St-Lazare Sand Hills | 4 | 2 |
| <i>Lesquerella arenosa</i> (Richards.) Rydb. | Great Plains Bladderpod | Brandon Sand Hills | 4 | 5 |
| <i>Shinersoseris rostrata</i> (Gray) S. Tomb. | Annual Skeletonweed | Brandon Sand Hills | 2 | 2 |
| <i>Verbena bracteata</i> Lag. & Rodr. | Large-bracted Yervain | Brandon Sand Hills | 4 | 3 |

¹ Key to Wild Species Status Codes (Canadian Endangered Species Conservation Council 2011*):

1 = At risk; 2 = May be at risk; 3 = Sensitive; 4 = Secure; 5 = Undetermined

TABLE 7. Current NatureServe and Wild Species status ranks for bugseed (*Corispermum*) taxa in Manitoba and proposed ranks.

| Species | Provincial status ranks | | | |
|--|--------------------------|---------------------------|-----------------------|---------------------------|
| | NatureServe ¹ | Proposed by Robson (2010) | Proposed (this paper) | Proposed by Robson (2010) |
| <i>Corispermum americanum</i> var. <i>americanum</i> | 2/3 | 3 | 2 | 3 |
| <i>Corispermum hookeri</i> var. <i>hookeri</i> | 1 | 1 | 1 | 2 |
| <i>Corispermum pallasi</i> | U | 1 | H | 2 |
| <i>Corispermum villosum</i> | 1/2 | 2 | 1 | 2 |

¹ Key to NatureServe (2011*) Status Ranks

1 = Critically Imperilled; 2 = Imperilled; 3 = Vulnerable; U = Uncertain; H = Possibly extirpated

² Key to Wild Species Status Codes (Canadian Endangered Species Conservation Council 2011*):

0.1 = Extirpated; 1 = At Risk (protected under the Species at Risk Act or listed by the Committee on the Status of Endangered Wildlife in Canada or a provincial governing body); 2 = May Be At Risk; 3 = Sensitive; 5 = Undetermined

soil and air temperatures, supports this assertion. Burial by sand has been found to stimulate growth in bugseed plants, suggesting that, as dunes become stabilized, plants may become smaller and may be less able to compete with other species (Perumal and Maun 2006).

The fact that habitats of bugseeds at 61% of extant localities are anthropogenically modified suggests that bugseeds are becoming increasingly dependent on these habitats. Pavlovic (1994) notes that certain human-caused disturbances mimic natural ones closely enough that rare disturbance-dependent plants will occupy anthropogenically modified sites. The creation of sand pits and firebreaks and the grading of roadsides have become some of the only sources of disturbance left on the prairie landscape, now that ecosystem engineers like the Bison (*Bison bison*) have been largely exterminated and wildfires suppressed (Fox et al. 2012). Although bugseeds were found along railway tracks in the early 1900s, most of these areas are now completely covered by perennial and annual exotics. Thus some anthropogenically disturbed habitats for bugseeds have also been lost in the last century.

Some habitat for bugseeds has also been lost due to high water levels along Lake Manitoba and Lake Winnipeg. Since 1975, when the Nelson River was first dammed for hydroelectric power, lake levels have been regulated within a narrower range than occurred historically (Nielsen 1998; Grosshans et al. 2004). This regulation prevents low water levels and, in combination with isostatic uplift, has suppressed the growth of emergent vegetation. The result of the higher water levels and less vegetation is erosion of island and barrier beaches by wave action (Grosshans et al. 2004). Excessive runoff into both the Red River and the Assiniboine River during 2010 and 2011 increased water levels even further. As a result, many of the beaches and sandbars were flooded, resulting in less sandy habitat for the bugseeds that historically grew there.

No bugseed plants at all were found along the south shore of Lake Manitoba during this study. Along Lake Winnipeg, the largest locality remaining is a newly discovered cluster of Hairy Bugseed plants growing in the dunes at Grand Beach Provincial Park. A small cluster of Hairy Bugseed plants was found farther north, at Gimli, but no plants were observed at Matlock. The beaches and dunes at Victoria Beach and Albert Beach have eroded significantly (Nielsen 1998) and at present contain only small populations of bugseeds. High water levels on Manitoba's great lakes combined with storm surges have recently caused significant erosion of the beaches at the south end of the lakes where bugseeds occurred. Thus the loss of riparian and lacustrine habitat for bugseed on Manitoba's great lakes is due partly to natural causes (e.g., flooding) and partly human activities (e.g., alteration of lake levels and drainage).

Any future estimates of population size should take into account the annual nature of bugseed plants.

Research suggests that the seeds of bugseeds are capable of remaining dormant for decades, germinating only when conditions are favourable (Van Asdall and Olmstead 1963; Maun 1994; Zhang and Maun 1994). Maun (1994) found that bugseed germination tended to increase in years with high rainfall in dunes along Lake Michigan. Van Asdall and Olmstead (1963) noted that bugseed species may exhibit a biennial cyclic alternation of sparse and dense populations in areas where parent plants are buried with fruits attached on the surfaces of dunes where sand is deposited. Thus population size may fluctuate from year to year, depending on the weather and local disturbance patterns (Nunney 2002). A fluctuating pattern has been observed in other annual dune plants (Schat and Scholten 1985; Pavlovic 1994; Li et al. 2005; Robson 2006).

Based on the results of this survey, changes to several of the Manitoba status rankings are recommended. The NatureServe (2011*) rankings for *C. americanum* and *C. villosum* in Manitoba should be upgraded to "imperilled" and "critically imperilled," respectively, due to the small number of populations and individuals observed and documented declines in habitat size and quality. These ranks are rarer than recommended in Robson (2010), as the field surveys indicated that many of the historical localities no longer contain *Corispermum* plants. This underscores the importance of conducting revisitation surveys, as examining herbarium data only in this case resulted in an overestimation of the number of extant populations.

The status of Pallas' Bugseed in Manitoba is somewhat difficult to interpret. Mosyakin (2003) states that this species is native to northern Asia and probably native to North America. However, it is possible that it was wholly or partly introduced into North America from Europe (where it is not native). In Dolnik et al. (2011), Pallas' Bugseed was noted to spread as a "ruderal weed along railroads, and in urban, industrial and other anthropogenically disturbed sites" throughout northern Europe after it was released from horticultural collections of Siberian species in southwestern Germany in the early 19th century.

In Manitoba, the three historical localities were in close proximity to the Canadian Pacific Railway, so it is possible that Pallas' Bugseed spread along railway corridors. Nowadays, most railway tracks in southern Manitoba are dominated by exotic ruderal plants, such as Summer Cypress (*Kochia scoparia* (L.) Schrad. ssp. *scoparia*), Lamb's-quarters (*Chenopodium album* L.), Wild Barley (*Hordeum jubatum* L.), Crested Wheatgrass (*Agropyron cristatum* (L.) Gaertn.), Russian Thistle, and Common Knotweed (*Polygonum aviculare* ssp. *depressum* (Meisner) Arcangeli). If Pallas' Bugseed did grow along railways in the past, it does not appear to occur there now. Thus, the NatureServe (2011*) rank for Pallas' Bugseed should change from "uncertain" to "possibly extirpated" and the Canadian Endangered Species Conservation Council Status Rank (2011*) should change from "undetermined" to "extir-

pated". If this species is determined to be introduced rather than native, the status would then change to "exotic".

The longevity of bugseed seeds is potentially quite high, enabling them to tolerate burial and to exploit new bare areas of sand when they appear (Maun and Lapierre 1986). Bugseed seeds are common in the seed banks of stabilized dune areas, simply waiting for a disturbance in the vegetative cover (Pavlovic 1994; Leicht-Young et al. 2009). Therefore, measures that encourage the reactivation of some dunes in the province may be beneficial for bugseeds as well as other rare psammophilic species. Although traditionally conservation meant not disturbing a habitat, the adaptation of rare dune plants to periodic disturbance means that some disturbance is essential for their persistence (Pavlovic 1994).

The presence of two species of bugseeds on the firebreaks created throughout CFB Shilo is evidence of the beneficial effect of moderate soil disturbance on these species. The reactivation of stabilized dunes, potentially by reintroducing Bison, has been suggested as a way of increasing the available habitat for psammophilic plants and animals (Fox et al. 2012). Bison grazing combined with fire in the Nebraska Sand Hills was found to decrease bunchgrass cover (primarily Little Bluestem, *Schizachyrium scoparium* (Michx.) Nash), and increase annual forb cover, a result that would be likely to increase wind erosion (Pfeiffer and Steuter 1994). Although testing of the hypothesis that the activity of Bison in an enclosed area (as opposed to migratory activity) would benefit sand dune plants and animals still needs to be performed, the reintroduction of Bison into provincial parks containing sand dunes would be desirable for other reasons, including conservation of the natural fauna, restoration of a more natural disturbance regime, and as an additional ecotourism attraction. The reintroduction of Bison and possibly fire on public lands should be considered as part of the recovery planning for rare Canadian psammophilic species.

In summary, this research indicates that a substantial amount of habitat for rare psammophilic species like bugseeds has been lost over the last century. This habitat loss is due mainly to dune stabilization resulting from the loss of natural disturbances and from the flooding of lacustrine and riparian habitats. Thus conservation of these species will likely require a restoration of the traditional disturbances to which they are adapted.

Acknowledgements

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Notes

Gray Wolf (*Canis lupus*) Movements and Behavior Around a Kill Site and Implications for GPS Collar Studies

L. DAVID MECH^{1,2}

¹U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711 – 37th Street SE, Jamestown, North Dakota 58401-7317 USA; email: david_mech@usgs.gov

²Mailing address: Raptor Center, 1920 Fitch Avenue, University of Minnesota, St. Paul, Minnesota 55108 USA

Mech, L. David. 2011. Gray Wolf (*Canis lupus*) movements and behavior around a kill site and implications for GPS collar studies. *Canadian Field-Naturalist* 125(4): 353-356.

Global Positioning System (GPS) radio-collars are increasingly used to estimate Gray Wolf (*Canis lupus*) kill rates. In interpreting results from this technology, researchers make various assumptions about wolf behavior around kills, yet no detailed description of this behavior has been published. This article describes the behavior of six wolves in an area of constant daylight during 30 hours, from when the pack killed a Muskox (*Ovibos moschatus*) calf and yearling on Ellesmere Island, Nunavut, Canada, to when they abandoned the kill remains. Although this is only a single incident, it demonstrates one possible scenario of pack behavior around a kill. Combined with the literature, this observation supports placing a radio-collar on the breeding male to maximize finding kills via GPS collars and qualifying results depending on whatever other information is available about the collared wolf's pack.

Key Words: Behavior, Gray Wolf, *Canis lupus*, Muskox, *Ovibos moschatus*, global positioning system collar, GPS radio-collar, predation, Ellesmere Island, Nunavut.

The use of Global Positioning System (GPS) radio-collars on Gray Wolves (*Canis lupus*) (Mech et al. 1998; Merrill et al. 1998) soon led to attempts to study wolf predation (Sand et al. 2005; Demma et al. 2007; Zimmerman et al. 2007; Sand et al. 2008; Webb et al. 2008; Palacios and Mech 2010). Such attempts rely on the assumption that when wolves make a kill, they remain at or near the kill for a long enough period so that clusters of the GPS locations taken from the kill site can be distinguished from GPS locations recorded while the animals are traveling. Usually candidate kill locations are ground-truthed using a hand-held GPS system to locate and search the clusters for kill remains and evidence of wolf presence after the wolves have left.

Although researchers have used this technique successfully to locate kills and estimate kill rates, the correct interpretation of the findings depends on assumptions about wolf behavior around kill sites. Wolves usually function in packs, especially in winter, yet rarely do researchers place a radio-collar on every pack member. In fact, collars are usually placed on only one or two pack members (Demma et al. 2007; Zimmerman et al. 2007; Sand et al. 2008; Metz et al. 2011), even though wolf packs can include 15 or more individuals (Mech 1970). Thus kills and travels of a wolf with a GPS radio-collar strictly pertain to that wolf and not necessarily to the entire pack. Assumptions that such data describe the behavior of an entire pack require verification from the field (Metz et al. 2011).

Correct interpretation of information about wolf kills thus requires accurate knowledge about the behavior of wolf packs around their kills. However, most wolf

kills are large, so much of the time that wolves spend in association with a kill is at night, when it has not been possible to observe the wolves' movements and behavior. With smaller kills, such as White-tailed deer (*Odocoileus virginianus*), a large pack of wolves may consume a kill in a few hours and move on, so two aerial visits in a day might be required just to determine kill rate (Fuller 1989). With larger prey, such as Moose (*Alces alces*), packs may feed for as many as three days on a single kill, and all or part of the pack might leave the kill a few times, rest miles away, and return periodically (Mech 1966). The details of wolf movements and behavior around kills have never been reported from beginning to end. Information about such behavior would be valuable to allow a more complete understanding of data obtained via GPS radio-telemetry. Only one attempt has been made to assess the effect of Gray wolf behavior around kills on the results of a GPS study of Gray wolf kill rate (Metz et al. 2011).

This article describes the behavior of a pack of six wolves around the kill of a Muskox (*Ovibos moschatus*) calf and yearling in an area of 24-hour daylight, from the moment of the kill to when the pack left it, 30 hours later. The observation represents one scenario, which, when combined with other observations, can improve the accuracy of interpreting data on kill rates derived from GPS radio-collars.

Study Area

This study was conducted on the Fosheim Peninsula on the west side of Ellesmere Island, Nunavut, Canada (80°N, 86°W). The area includes hills, lowlands, creek

bottoms, ridges, and considerable uneven terrain with many dips and trenches. Unlike much of the surrounding region, this area is generally free of permanent snow and ice in July and August and contains rock, gravel, bare soil, scattered tundra, and northern wetland vegetation. However, fresh snow can cover the ground at any time (Mech 2004). Wolves, Muskoxen, and Arctic Hares (*Lepus arcticus*) are common in the area (Tener 1954), wolves have denned in this region for decades or possibly centuries (Parmelee 1964; Grace 1976; Mech 1988; Mech and Packard 1990). The main foods of the wolves are Muskoxen (especially calves during summer), Arctic Hares (Tener 1954), and occasionally Caribou (*Rangifer tarandus*) and seals (*Phoca* spp.).

Methods

Wolves in the study area have long been unafraid of humans (Parmelee 1964; Grace 1976; Mech 1988). During the present study, a pack of eight allowed me to observe them from within a few meters and to accompany them on all-terrain vehicles (ATVs) when they were traveling (Mech 1994). Thus observer presence was not a problem in making this observation. This pack consisted of a breeding male (based on his raised-leg urination), a female with pups at a den, a non-breeding two-year-old female, a two-year-old male, and four female yearlings (Mech 1995).

During the present study, which took place in July 1989, an associate and I had been trying to locate the current year's wolf den by finding the pack and following it on all-terrain vehicles. When we located the pack on 4 July, the two adult females were not with it. The rest of the pack was about to attack a herd of Muskoxen. We observed them, first through binoculars, and then, after they had made their kills, we lay in a tundra depression 50–100 m away and observed them directly.

Results

Following are lightly edited field notes of our observations, including for context the behavior of the wolves just before and after the kill period:

At 1320, the wolves switched direction and headed southwest up a hill where I could see several Muskox herds 1–2 km away. The wolves quickly got to the nearest herd (nine adults and two calves) 800 m away, and at 1325 looked intently at the herd from a distance of about 200 m, but the herd was already tightly grouped. Both wolves and Muskoxen lay down 1325–1405. Then the Muskoxen grouped tighter, and the wolves left.

The wolves continued west up a hill and disappeared, and it took us a while to catch up to them. When we did, we came to a river gully draining the west mountains and saw the wolves and various Muskoxen on a flat on the west side. There was a group of four cows and three calves grouped very tightly and about 200 m away a herd of nine cows

and three calves. In between, about 50 m from the smaller herd, stood a calf apparently confused about which way to turn. The six wolves sped by the larger herd and headed straight to the calf. They all then grabbed the calf around the head as usual and pulled it down (1422). The wolves killed the calf within about 5 minutes.

Then I noticed about 50 m straight ahead of us (the rest of the action was taking place to our right and ahead) what turned out to be a yearling Muskox already wounded in the nose. The wolves came back and worked on it, grabbing it mostly by the hind legs until they had it down. They killed that animal within about 5 minutes also and began feeding on it (1437).

After killing the yearling and calf and running back and forth between them, the wolves noticed a single bull that we had seen "hiding" in the creek gully, which was about 25 m wide and 4 m deep, run up the bank and try to get to the herd of nine cows and three calves. The wolves headed straight toward him and tried to attack, but the bull whirled and charged them, and within 30–60 seconds, the wolves had given up, and the bull got into the herd.

This may not have been this bull's herd, however. There were two other adults elsewhere in the gully that also came up and joined the larger herd. The wolves tried to attack them also but gave up quickly.

The whole herd (now consisting of nine cows, three calves, two adults, and one bull) then began gradually to drift away from the wolves, which were feeding about 150 m away. As the herd moved away, individuals became anxious and began to move faster. Soon the whole herd was running toward the gully. Instantly the wolves stopped feeding and headed straight toward the herd, which fled across the gully and then stood on top of the east bank and fought off the wolves.

(My whole impression of the overall area is that the terrain helped the wolves. Perhaps they used the gullies to get close to the Muskoxen. There must have been quite a bit of surprise and confusion when the wolves arrived, since the calf had been left out alone, the bull was caught alone in the gully, and the two other adults were in the gully, all separated from the two herds.)

The last wolf stopped feeding on the calf at 1552. At 1600, one wolf came to the yearling, ate a few bites, and then headed southeast across the gully and disappeared at 1605.

The wolves slept and rested individually around and between the kills after feeding. At 1615, however, the breeding male arose and headed to a few other wolves and they licked up to him and trooped with him [licked him around the mouth and walked excitedly with him in a close-knit group] and he took them back to the calf carcass, where they fed again.

The wolf that had left and gone toward the southeast returned at 1705, and the other five wolves greeted it.

The wolves then slept until 2118, when a female yearling awoke, squat urinated, and howled six times; all the others then arose, three squat urinated, and the pack headed across the gully to the southeast. We followed at 2126. They went only about 150 m and rested. The first two turned around, and all six then headed back to the yearling kill, which was only 10–20% eaten. Only two fed on it, then just one, and the rest remained around the general area from 2220 to 2316.

At 2316, the wolves arose and played and slept on the bank across from the kill. One wolf left at 2330 and headed east. My associate crossed the gully and watched with binoculars. The yearling female left at 2350 and my associate watched her. One went to Eastwind Lake and back, and the other chased Muskox herds near Eastwind Lake.

The breeding male fed on the yearling Muskox and took part off and fed on it. (Two yearlings fed off and on from the yearling carcass until 1310 the next day [July 5].)

At 0020 on July 5, the breeding male looked east and howled intermittently. Then he went back to sleep 0030–0055. He got up again, changed spots, looked east and southeast, and slept again. At 0056, one yearling headed southeast and rolled in the snow and another one looked southeast intently.

One wolf returned from the southeast at 0104 and lay beside the breeding male and another wolf. At 0210, one Gray Wolf headed northeast up the creek and circled back. At 0214, a two-year-old wolf howled ten times. At 0221, this wolf howled seven times and got up at 0226 and met one Gray Wolf returning. At 0230, another Wolf returned.

All slept for the rest of the morning until 0729, when the breeding male arose and fed until 0805 from the yearling Muskox. Then all slept again. My associate watched from 1000 to 1230. The breeding male fed again at 1340 for a few minutes, and two others fed with him for a while. The breeding male raised-leg urinated and fed at 1357.

All slept all afternoon until 1754, when they arose and headed to the calf kill, where they fed and rested until 2022. We checked the yearling femur marrow, and the fat had been totally depleted.

The whole pack left the kill remains at 2022 and headed east, then northeast. We lost sight until 2035, when we saw them heading northeast toward two Muskox herds and a single Muskox out on some broad flats northeast of Eastwind Lake. At 2045 the wolf pack charged a herd of five adults and one calf. The herd grouped up, and the wolves left.

At 2050–2100 they charged directly at a herd of ten adults and two calves from ≥ 200 m away, but the

herd grouped up and the wolves gave up in a few minutes. They then headed to a single Muskox and chased it for about 5 minutes, half the time out of our view, but then gave up.

At 2115, the wolves chased two adult Muskoxen for about 2 minutes, gave up, and continued northeast towards the pass between the northeastern end of Black Top Ridge and the mountain north of it and disappeared at 2124. We left at 2130.

Discussion

During this observation, a pack of six Wolves fed on a Muskox calf and yearling off and on for 30 hours, leaving only a few bones, hair, and rumen contents. Although there is no way of knowing the weight of the Muskoxen, captive calves weigh an average of 72 kg when 6 months old (Reinhardt and Flood 1983), so a reasonable estimate of calf weight in July would be 30 kg. Yearlings weigh about 98 kg (Alaska Department of Fish and Game 2012*). Thus the total Muskox kill mass would have been approximately 128 kg; assuming 7% uneaten parts (Peterson 1977), this would leave 119 kg, or 20 kg of food, per wolf. The pack dedicated 30 hours to the consumption of this amount of food.

The only comparable information of this type we found was a report of two wolves eating and caching an estimated 90 kg of Muskox over a period of at least 28 hours and 49 minutes (Mech and Adams 1999). In that instance, the male wolf remained at or near the kill for the entire period while the (barren) female left several times to cache food as far away as 2.3–5.0 km (Mech and Adams 1999).

During the 30 hours of the present observation, the wolves fed and slept intermittently, and individuals, with the exception of the breeding male, left the area and returned at various times. When the breeding male left the kill scene, all the others did too, and they immediately began chasing other Muskoxen, similar to the behavior of wolves hunting Moose (Mech 1966).

A GPS radio-collar on the breeding male would have yielded location data revealing this location as a probable kill, even if the location-acquisition rate had been as little as twice per day. However, such a collar on one of the other pack members that left the kill scene intermittently might not have revealed the kills, depending on the location-acquisition rate. This information agrees with that reported by Mech and Adams (1999), Sand et al. (2006), and Metz et al. (2011).

This single set of observations provides detailed information that will be useful in interpreting GPS data and suggests that additional observations of wolves over long, continuous periods would also help researchers better interpret GPS data. Such observations should be made of packs of various sizes killing various prey during all seasons.

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Butterflies Recorded on Flattop Mountain, Anchorage, Alaska

LANCE A. DURDEN

Department of Biology, Georgia Southern University, Statesboro, Georgia 30460-8042 USA; e-mail: ldurden@gcorgia-southern.edu

Durden, Lance A. 2011. Butterflies recorded on Flattop Mountain, Anchorage, Alaska. *Canadian Field-Naturalist* 125(4): 357-358.

Eleven species of butterflies were recorded on Flattop Mountain, Anchorage, Alaska, during a four-day period in July 2006: *Colias philodice vitabunda* (Clouded Sulphur), *Pieris angelika angelika* (Arctic White), *Lycaena dorcas arcticus* (Dorcas Copper), *Plebejus glandon bryanti* (Arctic Blue), *Plebejus idas alaskensis* (Northern Blue), *Plebejus optilete yukona* (Cranberry Blue), *Boloria chariclea butleri* (Purplish Fritillary), *Boloria alaskensis alaskensis* (Mountain Fritillary), *Speyeria mormonia bischoffii* (Mormon Fritillary), *Oeneis bore mckinleyensis* (White-veined Arctic), and *Carterocephalus palaemon skada* (Arctic Skipperling). Based on previously published distribution maps, the records for *Plebejus idas* and *P. optilete* represent range extensions; *P. optilete* was relatively common in sheltered valleys on the mountain.

Key Words: butterflies, Northern Blue, *Plebejus idas*, Cranberry Blue, *Plebejus optilete*, range extensions, Alaska, Anchorage.

From 18 to 21 July 2006, I recorded butterflies along the Flattop Mountain Trail in Chugach State Park (61°04'59" N, 149°39'10" W), about 10 km southeast of Anchorage, near the base of the Kenai Peninsula in Alaska, U.S.A. This is the most frequently climbed mountain in Alaska, with a starting (parking lot) elevation of 688 m and a peak elevation of 1070 m (Zimmerman 1997).

Butterflies were mainly active in wind-sheltered valleys with abundant wild flowers when the sun was not obscured by clouds but, during cloud cover, some butterflies were observed nectaring on, or clinging to, flowers. Butterflies were recorded along, or adjacent to, the hiking trail from 12:00 to 17:00 each day; maximum daily temperatures on the mountain during the four-day period ranged from 12 to 16°C. Specimen photographs deposited in the Department of Biology, Georgia Southern University (accession numbers L-3356 to L-3366), serve as vouchers for these records (Macadam 2006). Butterfly taxonomy follows Pelham (2011). The species and subspecies, numbers, sexes (if easily determined), and elevational distributions of the 11 species of butterflies recorded were as follows.

Pieridae

Colias philodice vitabunda Hovanitz (Clouded Sulphur): 35 males, 8 females (790–1050 m).

Pieris angelika angelika Eitschberger (Arctic White): 3 males (690–824 m).

Lycaenidae

Lycaena dorcas arcticus (Ferris) (Dorcas Copper): 1 male (1070 m; hilltopping on mountain peak).

Plebejus glandon bryanti Leussler (Arctic Blue): 2 males (826 m).

Plebejus idas alaskensis Chermock (Northern Blue): 2 males, 1 female (732–826 m).

Plebejus optilete yukona Holland (Cranberry Blue): 18 males, 2 females (700–870 m).

Nymphalidae (sexes not determined)

Boloria chariclea butleri (Edwards) (Purplish Fritillary): 42 (730–1038 m).

Boloria alaskensis alaskensis (Holland) (Mountain Fritillary): 8 (730–1066 m).

Speyeria mormonia bischoffii (Edwards) (Mormon Fritillary): 51 (778–1022 m).

Oeneis bore mckinleyensis dos Passos (White-veined Arctic): 6 (822–1065 m).

Hesperiidae (sex not determined)

Carterocephalus palaemon skada (Edwards) (Arctic Skipperling): 1 (688 m).

According to published distribution maps, two of the lycaenid species reported here, *Plebejus idas* and *P. optilete*, have not previously been recorded as far south as the Kenai Peninsula in south-central Alaska (Scott 1986; Opler 1999; Brock and Kaufman 2003). Some of these works use different generic names for the two species, but the specific and common names are the same in all. Appreciating that the published range maps are schematic, I note that the southern range limit of *P. idas* in this part of Alaska is shown by Scott (1986) as ~30 km to the north of Flattop Mountain and the southern range limit of *P. optilete* as ~100 km to the north of this site (Scott 1986). Opler (1999) and Brock and Kaufman (2003) show the southern limits in this part of Alaska to be ~100 km and ~200 km to the north of Flattop Mountain, respectively, for these two species. Also, in a website on butterflies of the Anchorage area, Hopson (no date*) provides images of *P. idas* from Mount Baldy, about 30 km to the north of Flattop Mountain.

Despite the lack of previously published records, it is likely that both *P. idas* and *P. optilete* are fairly widely distributed in the Kenai Peninsula to the south of Flattop Mountain and also in suitable habitats to the north, east, and west of Flattop Mountain. Other butterfly records documented here are noteworthy because a list of butterflies and their elevational distributions on Flattop Mountain have not previously been published.

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A Second Amelanistic Eastern Red-backed Salamander, *Plethodon cinereus*, from Nova Scotia, Canada

RONALD W. RUSSELL¹, WILFRIED BESLIN¹, MAIA HUDAK¹, AYOKUNLE OGUNBIYI¹, AVERY WITHROW¹, and JOHN GILHEN²

¹Department of Biology, Saint Mary's University, 923 Robie Street, Halifax, Nova Scotia, B3H 3C3 Canada; email: ron.russell@smu.ca

²Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6 Canada; email: gilhenja@gov.ns.ca

Russell, Ronald W., Wilfried Beslin, Maia Hudak, Ayokunle Ogunbiyi, Avery Withrow, and John Gilhen. 2011. A second amelanistic Eastern Red-backed Salamander, *Plethodon cinereus*, from Nova Scotia, Canada. *Canadian Field-Naturalist* 125(4): 359-362.

In 2011, an amelanistic Eastern Red-backed Salamander, *Plethodon cinereus*, was discovered in Point Pleasant Park in Halifax, Nova Scotia. This is the second amelanistic Eastern Red-backed Salamander that has been documented from the Halifax area. Albino and leucistic individuals have also been identified from Nova Scotia. These aberrant conditions, including the two amelanistic individuals, were discovered in isolated, fragmented, and disturbed habitat.

Key Words: amelanistic, Eastern Red-backed Salamander, *Plethodon cinereus*, anomaly, isolated, fragmented, disturbed, habitat, Point Pleasant Park, Halifax, Nova Scotia, Canada.

The Eastern Red-backed Salamander, *Plethodon cinereus*, is the most common and widespread salamander in Nova Scotia (Gilhen 1984). It is highly variable in colour and pattern throughout its range, and three morphs (redback, leadback, and erythristic or all red) are recognized in eastern North America. The redback and leadback colour morphs are common throughout Nova Scotia, however the third morph (erythristic) is known only from the deciduous forest of North Mountain (King's County), the Cobequid Mountains, and the Pictou highlands, all on the mainland. In Nova Scotia, the erythristic morph has been found only in association with the redback morph (Gilhen 1984).

Colour and pattern in all three morphs are plastic. Three anomalous conditions (albino, leucistic, and amelanistic) have been found in isolated, fragmented, and disturbed habitat in Nova Scotia (Moore and Gilhen 2011) (Figure 1). Leucistic salamanders are characterized by a general reduction in pigmentation, unlike albinism, where all pigmentation is absent. Amelanistic salamanders lack melanin but preserve other pigments, and thus retain more coloration than albino and leucistic anomalies. This note documents the observation of an amelanistic *Plethodon cinereus* in a highly disturbed forested site.

Study Area

Point Pleasant Park in Halifax, Halifax County, Nova Scotia, was formally established in 1866. Between 1749 and 1946, the park area was cleared repeatedly for agricultural and military purposes. It is a 77-ha fragment of Acadian forest in the south end of peninsular Halifax. It is highly disturbed, having suffered damage from the introduction of the Brown Spruce Longhorn Beetle (*Tetropium fuscum*) in 1998 (2000 trees were ultimately destroyed), from a severe ice storm in 2001 (during which 10 000 trees were damaged), and from Hurri-

cane Juan in 2003 (75% of the park's forest—over 60 000 trees—were toppled overnight) (Halifax Regional Municipality 2008*).

The forest at the site where the Eastern Red-backed Salamander was captured consists of a conifer and deciduous mix dominated by Red Maple (*Acer rubrum*), Red Oak (*Quercus rubra*), Eastern White Pine (*Pinus strobus*), and Eastern Hemlock (*Tsuga canadensis*). Other trees noted were standing and fallen Paper Birch (*Betula papyrifera*), Yellow Birch (*Betula alleghaniensis*), American Beech (*Fagus grandifolia*), White Spruce (*Picea glauca*), and Balsam Fir (*Abies balsamea*). Understory trees and shrubs include Speckled Alder (*Alnus incana rugosa*), Pin Cherry (*Prunus pensylvanica*), and Canada Yew (*Taxus canadensis*). Both Great Laurel (*Rhododendron maximum*) and English Oak (*Quercus robur*) were present in low numbers as exotic species.

The well-kept roads and paths are used extensively on a daily basis. Prior to Hurricane Juan, the forest was well manicured, and dead wood was removed. Since Hurricane Juan made landfall and passed through Point Pleasant Park, the numerous windfalls have been left under an open canopy to decay naturally on a thick bed of leaf and needle litter.

Point Pleasant Park is surrounded on three sides by marine waters and the city of Halifax to the north. There is a narrow strip of highly fragmented habitat on either side of a railway line that runs along the southwestern side of the city of Halifax. This railway comes within 300 m of the park at its nearest approach.

Methods

Limited surveys for the Eastern Red-backed Salamander have been conducted, mostly by university students, in Point Pleasant Park since 2003 (< 100 captures per year). On 18 October 2011, four students from

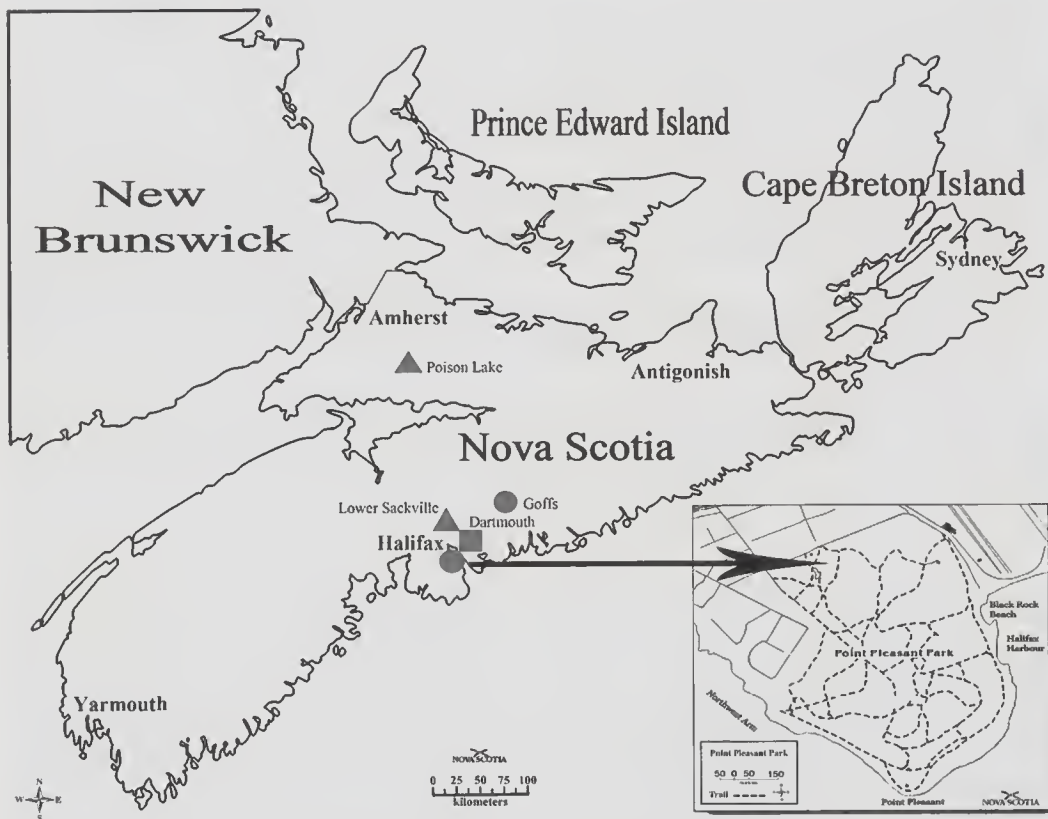


FIGURE 1. Distribution of three aberrant forms of the Eastern Red-backed Salamander, *Plethodon cinereus*, in Nova Scotia. The square represents one albino from near the Dartmouth side of the Angus L. Macdonald Bridge; triangles represent leucistic individuals, one from Lower Sackville and one from the Poison Lake area (Gilhen, unpublished data); circles represent amelanistic individuals, one from the Goffs area (Moore and Gilhen, 2011) and one from Point Pleasant Park, Halifax.

Saint Mary's University (W. B., M. H., A. O., and A. W.) were collecting Eastern Red-backed Salamanders by turning over rocks and coniferous and deciduous logs in the park (44°37.564'N, 63°34.390'W).

The amelanistic salamander collected on 18 October 2011 was measured with a digital caliper.

Results and Discussion

Eastern Red-backed Salamanders thrive under the cover of fallen logs and rocks on deep leaf and needle litter in this isolated and disturbed habitat (Figure 2). A total of 20 *Plethodon cinereus* (12 redback, 7 leadback, and 1 amelanistic) were captured in fall 2011. The amelanistic individual collected on 18 October 2011 (Figure 3) was young, measuring 15.0 mm body length and 24.31 mm total length. The head, trunk, and tail were white, with a brief peach-red or peach-yellow (depending on light and magnification) stripe on the back and across the front of the snout. The iris was white and the pupil was grey. The underside of the

abdomen (Figure 4) was translucent white, and the red pumping heart was visible in the live specimen. It was placed in the Nova Scotia Museum of Natural History Amphibian Collection (catalogue number NSM 55572).

Of 48 *Plethodon cinereus* captured between October and December 2010 in Point Pleasant Park, 29 were redback individuals. Since 2003, the redback morph has constituted 61% and the leadback 39% of captures in Point Pleasant Park, and only the one amelanistic salamander (collected in 2011) has been observed.

The amelanistic Eastern Red-backed Salamander described in this note was clearly a juvenile, and anomalous individuals like this one may not survive to reproduce. Moore and Gilhen (2011) reported an adult amelanistic *P. cinereus* observed adjacent to a clear-cut in Nova Scotia. This second observation of an amelanistic salamander in Nova Scotia (in an area that had been devastated by Hurricane Juan) could indicate an advantage of this colour anomaly in highly disturbed habitats or it could be a consequence of genetic drift



FIGURE 2. Habitat where a variant of the amelanistic condition of the Eastern Red-backed Salamander, *Plethodon cinereus*, was discovered in Point Pleasant Park, Halifax, Nova Scotia. Photo: Roger Lloyd, Nova Scotia Department of Communities, Culture, and Heritage.



FIGURE 3. Dorsal-lateral view of a variant of the amelanistic condition of the Eastern Red-backed Salamander, *Plethodon cinereus*, from Point Pleasant Park, Halifax, Nova Scotia. Photo: Roger Lloyd, Nova Scotia Department of Communities, Culture, and Heritage.



FIGURE 4. Ventral view of a variant of the amelanistic condition of the Eastern Red-backed Salamander, *Plethodon cinereus*, from Point Pleasant Park, Halifax, Nova Scotia. Photo: Roger Lloyd, Nova Scotia Department of Communities, Culture, and Heritage.

in a small, isolated population. This could also be a chance observation of a rare event.

Maintenance of colour polymorphism in *P. cinereus* is attributed to differential physiology and behaviour leading to increased predation on the unstriped lead-back morph (Moreno 1989; Venesky and Anthony 2007). Because Eastern Red-backed Salamanders have small territories (0.16–0.33 m²) (Petranka 1998) and disperse less than 2 m per year (Ousterhout and Liebgold 2010), it is likely that the population of Eastern Red-backed Salamanders in Point Pleasant Park is spatially and genetically isolated from nearby populations. The nearest documented population of Eastern Red-backed Salamanders is approximately 650 m away from the capture location, on the southern extent of the campus of Saint Mary's University adjacent to the railway line. Other populations exist on McNabs Island (1800 m distant) and Williams Lake (565 m distant), both across marine waters.

In this era of global climate change and extensive habitat modification and fragmentation, anomalous conditions such as amelanism may increase in populations. This note constitutes a call for documentation of observations of such anomalous salamanders.

Acknowledgements

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Communal Oviposition in the Northern Two-lined Salamander (*Eurycea bislineata*) in Algonquin Provincial Park, Ontario

DAVID L. LEGRIS

Department of Biology, Laurentian University, 935 Ramsey Lake Road, Sudbury, Ontario P3E 2C6 Canada; email: dl_legros@laurentian.ca

LeGros, David L. 2011. Communal oviposition in the Northern Two-lined Salamander (*Eurycea bislineata*) in Algonquin Provincial Park, Ontario. *Canadian Field-Naturalist* 125(4): 363-365.

While surveying a stream for amphibians in Algonquin Provincial Park, Ontario, Canada, I discovered a clutch of Two-lined Salamander (*Eurycea bislineata*) eggs on the underside of a partially submerged rock. I counted 165 eggs and measured them using ImageJ from a digital photograph. The quantity of eggs is far greater than any known clutch size for this species, and it was likely deposited by more than one female. This is the first report of communal oviposition in this species in Canada.

Key Words: Northern Two-lined Salamander, *Eurycea bislineata*, communal oviposition site, Algonquin Provincial Park, Ontario.

The Northern Two-lined Salamander (*Eurycea bislineata*) occurs throughout much of the northeastern United States and adjacent Canada (Petranka 1998), and it can be quite common in suitable habitat (Burton and Likens 1975). The Northern Two-lined Salamander is well studied in parts of its range, and many life history details are known. In Ontario, however, it has been comparatively understudied, and as a result much of the information on Canadian populations is extrapolated from research done by herpetologists working in the United States. One such aspect of the life history of the Northern Two-lined Salamander is oviposition and clutch size.

Observations

This observation was made on 12 May 2010 during a stream survey in Algonquin Provincial Park, central Ontario, Hunter Township, in the vicinity of Brown Lake, 45°37'N, 78°51'W. The stream consists of several pools, riffles, and short areas of swift current, and the width ranges from 0.75 to 1.5 m. The stream bottom consists of sand, gravel, and cobble. The margins of the stream have many mossy rocks and wet leaf litter. The surrounding forest is dominated by Sugar Maple (*Acer saccharum*) and Yellow Birch (*Betula alleghaniensis*).

The site of oviposition was in a section of fast-moving water, approximately 3 m upstream of a large pool where over 10 larval *E. bislineata* were found. The stream appeared to have many other rocks suitable for oviposition.

While turning rocks in the stream, I uncovered a clutch of Northern Two-lined Salamander eggs. The cluster of 165 eggs was attached in a single layer to the underside of a rock (Figure 1). The rock, which was roughly triangular in shape, measured about 25 cm by 20 cm at the largest points, approximately 250 cm². Two adult salamanders were also underneath this rock, but they escaped prior to capture. Several digital photos were taken in the field, and the stone was replaced in its original position within minutes.

A second egg mass was found on the same day several metres downstream; it contained approximately

35 eggs. There was no apparent embryonic development in either egg mass, suggesting these eggs had been recently deposited. Over the course of the field season, many other adult and larval *E. bislineata* were frequently found in this stream.

The digital photo was printed and the eggs were counted on paper. All subsequent measurements were made based on the digital photograph. Using the Vernier callipers present in the photograph for scale, measurements were calibrated using ImageJ (Rasband 2010*). From the digital photo, a subsample of 53 eggs, measured using ImageJ, had a mean diameter of 3.06 mm (2.3–3.79 mm, SE 0.367). The surface area of the eggs was also measured using ImageJ, and it occupied 4432 mm², or roughly 90 mm × 50 mm.

Discussion

The number of eggs found in this account exceeds that found in Ohio by Bauman and Huels (1982), who found a maximum of 110 and a mean of 39.4 eggs. Wood and McCutcheon (1954) found between 25 and 115 ova (mean of 71.5) in gravid two-lined salamanders in southern Virginia (*Eurycea bislineata* × *cirrigera*). It is clear that the number of eggs found in the first observation in Algonquin Provincial Park came from more than one female, so this likely is an instance of communal oviposition. It is estimated that 7% of salamanders of the family Plethodontidae exhibit this behaviour, but it is under-reported because of the difficulty in finding salamander eggs (Doody et al. 2009). Two-lined salamanders typically deposit eggs on the undersides of stones or other debris in streams, with females remaining with the clutch, defending them from predators (Petranka 1998). Communal nesting in *Eurycea bislineata* has been documented in New York (Bishop 1941), Virginia (Wood 1953), and likely in Ohio (Bauman and Huels 1982).

Some researchers suggest that suitable oviposition sites are limited and the small number of sites may limit population size (Stewart 1968). Ideal locations may therefore be used by more than one female. In fact, several brooding females may be found under the



FIGURE 1. Northern Two-lined Salamander (left), Northern Two-lined Salamander eggs attached to the underside of the partially submerged rock (right), Algonquin Provincial Park, 12 May 2010. Note: Not all 165 eggs are in frame. Photo: David LeGros.

same cover object (Petranka 1998). Communal oviposition in a habitat with few suitable sites is logical, but it is not clear why it occurs in habitat that seemingly has an abundance of sites. The best oviposition sites have obvious benefits, such as high hatching success and proximity to good natal habitat (Refsnider and Janzen 2010). Other adaptive factors such as female survivorship and reduced risk of predation of a particular female's eggs may also influence the frequency of communal nesting in salamanders (Doody et al. 2009). In a review of communal oviposition in reptiles and amphibians, (Doody et al. 2009) explained that some species are more likely to oviposit where another female has previously oviposited and hatched young.

To my knowledge, this is the first reported case of communal oviposition of *E. bislineata* in Ontario. The range of the Northern Two-lined Salamander is surprisingly extensive in Ontario (Desroches et al. 2010) and other eastern Canadian provinces (Cook 1984), but few researchers visit these regions. Continued observation of this species in the northernmost part of its range would be of value.

Acknowledgements

I would like to thank Shane Pratt for helping with the survey of the stream. This observation could not have been made without the assistance and permission of Algonquin Provincial Park, Ontario Parks (permit number AP-10-DLG). This observation was

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Fetid Dogweed (*Dyssodia papposa*; Asteraceae) and Slender Russian Thistle (*Salsola collina*; Amaranthaceae), New to Alberta, Canada

MICHAEL J. OLDHAM¹, JOYCE GOULD², and JANE M. BOWLES³

¹Ontario Natural Heritage Information Centre, Ontario Ministry of Natural Resources, 300 Water Street, Peterborough, Ontario K9L 1C8 Canada; email: michael.oldham@ontario.ca

²Parks Division, Alberta Tourism, Parks and Recreation, 2nd Floor, 9820 106 Street, Edmonton, Alberta T5K 2J6 Canada; email: joyce.gould@gov.ab.ca

³Herbarium, Department of Biology, University of Western Ontario, London, Ontario N6A 3K7 Canada; email: jbowles@uwo.ca

Oldham, Michael J., Joyce Gould, and Jane M. Bowles. 2011. Fetid Dogweed (*Dyssodia papposa*; Asteraceae) and Slender Russian Thistle (*Salsola collina*; Amaranthaceae), new to Alberta, Canada. *Canadian Field-Naturalist* 125(4): 366-369.

Two non-native vascular plants, Fetid Dogweed (*Dyssodia papposa*; Asteraceae) and Slender Russian Thistle (*Salsola collina*; Amaranthaceae), are added to the flora of Alberta, Canada, based on collections and sight records made in 2011. Fetid Dogweed was found along roadsides at eight sites in southern Alberta, and Slender Russian Thistle was found along a hiking trail in Dinosaur Provincial Park near Drumheller. Both species are weedy and are probably expanding their range in North America.

Key Words: Fetid Dogweed, *Dyssodia papposa*, Asteraceae, Slender Russian Thistle, *Salsola collina*, Amaranthaceae, new records, Alberta, Saskatchewan, Canada.

Fetid Dogweed or Fetid Mayweed (*Dyssodia papposa* (Ventenant) Hitchcock) is an aromatic member of the aster family (Asteraceae) native to much of central and western North America. In eastern North America, it is expanding its range along gravel road shoulders and has recently been reported new to Manitoba and Quebec (Oldham and Klymko 2011). In its native range, Fetid Dogweed occurs in grasslands and open woodlands, but is also weedy in fields and along roadways (Strother 2006). In western Canada, Fetid Dogweed has been reported only from Saskatchewan, where it was first collected near Regina in 1990 (Hudson 1994) (although it was not mapped from Saskatchewan by Strother 2006). In Saskatchewan, the species has been recorded only along roadsides (V. L. Harms, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, personal communication, 2010), and Harms (2003) considers it introduced to the province, as do Brouillet et al. (2011*).

While travelling by automobile in southern Alberta and southern Saskatchewan in late August 2011, we observed *Dyssodia papposa* at eight sites in Alberta and eight sites in Saskatchewan (Table 1). Locations were recorded using a dashboard-mounted global positioning system (GPS); specimens were collected from two sites in Alberta and three sites in Saskatchewan. All populations were on gravel roadsides along major highways, where the species was likely introduced and dispersed by vehicles, including mowing machines and snow plows. Populations varied in size from a few dozen plants to many thousands of plants in continuous patches for several kilometres of highway.

Our collections from Alberta (specimens deposited at the University of Alberta, Edmonton (ALTA), the

National Collection of Vascular Plants, Agriculture and Agri-Food Canada, Ottawa (DAO), and the Canadian Museum of Nature, Gatineau (CAN) (herbarium acronyms follow Thiers 2012*); see Table 1) are the first documented records from the province (Moss 1983; Kartesz 1999; Strother 2006; Brouillet et al. 2011*; Oldham and Klymko 2011).

Fetid Dogweed is an erect to ascending multi-branched annual from a large taproot. It grows to about 30 cm in height and has opposite, deeply pinnatifid, glabrous leaves with scattered tan to red glands. The leaves are up to 3.5 cm long and 1.5 cm broad with leaf divisions that are linear with a few coarsely serrate teeth on the margins. Petals are yellow, but the ray flowers are small and inconspicuous. A most distinctive characteristic is the strong aroma, particularly when plant parts are crushed, which gives the plant its common and generic name (Strother 2006; Oldham and Klymko 2011). Colour photographs of *Dyssodia papposa* appear in Oldham and Klymko (2011). No other *Dyssodia* species occur in Canada (Strother 2006; Brouillet et al. 2011*).

Slender Russian Thistle (*Salsola collina* Pallas; Amaranthaceae) is one of three species in the genus occurring in Canada. All are non-native (Mosyakin 2003; Beckie and Francis 2009). Common Saltwort (*Salsola kali* subsp. *kali*) occurs in Canada primarily along the east coast, while Prickly Russian Thistle (*S. tragus*) is a widespread weed of open areas in southern Canada from British Columbia to the Maritimes. Slender Russian Thistle is the rarest member of the genus in Canada, reported only from Quebec, Ontario, and Saskatchewan (Mosyakin 2003; Brouillet et al. 2011*). However, it is much more common in Ontario than published records

TABLE 1. Locations of collections (collection number and herbaria where deposited listed under Record) and sight records of *Dyssodia papposa* and *Salsola collina* in Alberta and Saskatchewan in August 2011.

| Date | Record | Province | Location | Latitude, longitude |
|-------------------------|-------------------|----------|---|---------------------|
| <i>Dyssodia papposa</i> | | | | |
| 30 August 2011 | sight | AB | Irvine, Hwy. 1 | 49.954, -110.268 |
| 30 August 2011 | 39285 (ALTA, DAO) | AB | Hwy. 1, west of Irvine, east of Medicine Hat, 1.5 km east of Buffalo Trail intersection, 3.5 km east of Dunmore | 49.975, -110.529 |
| 30 August 2011 | sight | AB | Hwy. 1, 0.4 km southeast of Box Springs Road NW, Medicine Hat | 50.053, -110.735 |
| 30 August 2011 | sight | AB | Hwy. 1, 2.5 km SE of Bowell, ca. 20 km NW of Medicine Hat (at Hwy. 3 junction) | 50.142, -110.919 |
| 30 August 2011 | sight | AB | Hwy. 1, 2.4 km NW of Dennis, ca. 33 km NW of Medicine Hat (at Hwy. 3 junction) | 50.192, -111.079 |
| 30 August 2011 | sight | AB | Hwy. 1, Suffield | 50.217, -111.161 |
| 23 August 2011 | 39245 (ALTA, CAN) | AB | Drumheller, Hwy. 838 (North Dinosaur Trail), near Royal Tyrell Museum | 51.467, -112.753 |
| 30 August 2011 | sight | AB | Hwy. 36, ca. 1 km south of Township Road 294, 9 km west of Sheerness, ca. 10 km south of Hwy. 9 | 51.496, -111.786 |
| 28 August 2011 | 39283 (ALTA, DAO) | SK | Hwy. 21 at Hwy. 728, 35 km north of Maple Creek | 50.224, -109.463 |
| 28 August 2011 | sight | SK | Hwy. 7, ca. 2 km west of Netherhill | 51.475, -108.879 |
| 28 August 2011 | sight | SK | Hwy. 7, 4 km west of Kindersley (Hwy. 21 junction) | 51.475, -109.111 |
| 28 August 2011 | 39251 (ALTA, DAO) | SK | Hwy. 7 at Ditson Drive/C Street, Kindersley | 51.475, -109.145 |
| 24 August 2011 | sight | SK | Hwy. 7, west of Kindersley | 51.478, -109.373 |
| 28 August 2011 | sight | SK | Hwy. 7, 4 km west of Fiske | 51.483, -108.452 |
| 24 August 2011 | sight | SK | Hwy. 31, west of Rosetown | 51.502, -108.315 |
| 28 August 2011 | 39250 (ALTA, CAN) | SK | Hwy. 7, 3.5 km northeast of Harris (junction Hwy. 768) | 51.760, -107.551 |
| <i>Salsola collina</i> | | | | |
| 30 August 2011 | 39286 (ALTA, DAO) | AB | Dinosaur Provincial Park, Badlands Trail | 50.761, -111.512 |

(Crompton and Bassett 1985) suggest, primarily along railways and roadsides, and is likely overlooked elsewhere in Canada. *Salsola collina* can be distinguished from other *Salsola* in Canada by its typically erect stems, only weakly spiny leaves and bracts, appressed bracts (which are strongly imbricate at maturity), and dense spikes (which are usually not interrupted at maturity) (Mosyakin 1996, 2003).

We encountered Slender Russian Thistle along a hiking trail in Dinosaur Provincial Park, Drumheller, Alberta, where it was growing with Prickly Russian Thistle (Table 1, Figures 1 and 2). It was locally common in dry, open sandy and gravelly soil. Specimens have been deposited at the University of Alberta, Edmonton (ALTA), and Agriculture and Agri-Food Canada, Ottawa (DAO). There are no previous records of *Salsola collina* from Alberta (Moss 1983; Crompton and Bassett 1985; Kartesz 1999; Mosyakin 2003; Beckie and Francis 2009; Brouillet et al. 2011*).

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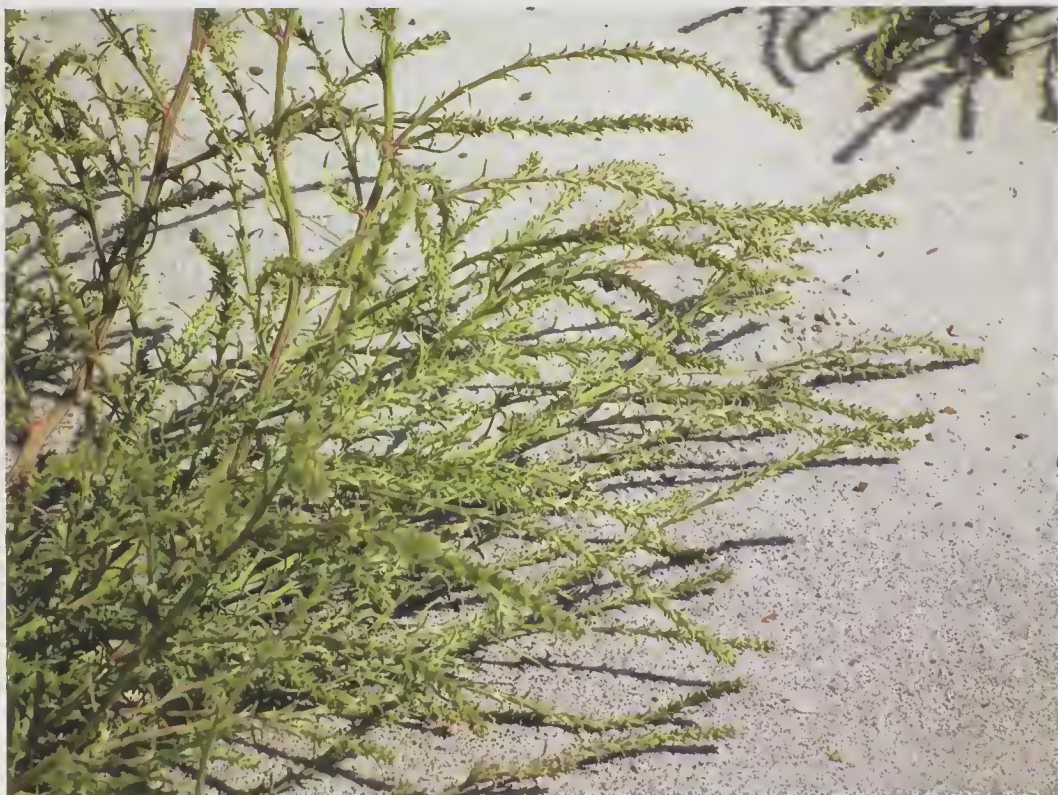


FIGURE 1. Slender Russian Thistle (*Salsola collina*), Dinosaur Provincial Park, Alberta, 30 August 2011. Photo: M. J. Oldham.



FIGURE 2. Slender Russian Thistle (*Salsola collina*) growing with Prickly Russian Thistle (*Salsola tragus*, left centre), Dinosaur Provincial Park, Alberta, 30 August 2011. Photo: J. M. Bowles.

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Robert (Bob) Ronald Campbell (1943–2011): Biologist, Conservationist, Pastor

CLAUDE B. RENAUD

Research and Collections Division, Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, Ontario K1P 6P4 Canada; email: crenaud@mus-nature.ca

Renaud, Claude B. 2011. Robert (Bob) Ronald Campbell (1943–2011): biologist, conservationist, pastor. *Canadian Field-Naturalist* 125(4): 370-372.

Bob Campbell was born in London, Ontario, on 5 January 1943 and died of cancer in Ottawa, Ontario, on 23 December 2011. His birth parents were Lee and Joseph Schrock and his adoptive parents were Jenny and Archibald Campbell. Bob contacted Social Services in the late 1980s to locate his birth parents, but it was only in 1999 that he finally met his natural mother and his four younger brothers, John, Robert, Peter, and Allan. He is survived by his wife Rosemary (nee Ford), two children (Rhonda and Robert Jr.) from a previous marriage, and five grandchildren, Samantha, Amanda, Nicholas, Dylan, and Katsia. He was predeceased by his first wife, Sandra (nee Roberts).

Bob received a B.A. in Zoology from the University of Western Ontario in 1967, a Secondary School Teaching Certificate from Althouse College in 1968, a M.Sc. in Agriculture from the University of Guelph in 1972, and a Ph.D. in Environmental Physiology from the same institution in 1980. His master's thesis was "Inheritance of Several Traits with Flight in Crosses of Wild Mallards and Domestic Ducks," and his doctoral dissertation was "Ecophysiological Studies of Lesser Snow Geese of La Perouse Bay, Manitoba." After a long career as a biologist, he went back to university and obtained a B.T. (Bachelor of Theology) in 2007 and a M.P.T. (Master of Pastoral Theology) in 2009, both from St. Paul University, Ottawa.

The word that best sums up Bob's life is service. His service was rendered in four main areas: military, professional, conservation, and community.

Early on, Bob wished to serve his country. Between 1956 and 1961, he was an Army Cadet with Forest District High School Cadet Corps. He joined the military reserve in 1968 and retired in 2001 with the rank of Major. During this period, he served as Deputy Commanding Officer of the 11th and 30th field regiments, Royal Canadian Artillery, for three years was Senior Staff Officer, Human Resources, for the Ottawa Militia District, and for three years Senior Staff Officer, Operations and Administration, for the Hamilton Militia District. He was awarded the Canadian Forces Decoration in 1980 for long service with good conduct.

As a professional biologist, Bob worked in the private sector and for the Ontario and Canadian governments. From 1969 to 1972, he was a Wildlife Biologist with the Ontario Department of Lands and Forests and



FIGURE 1. Bob Campbell celebrating mass during the Van-kleek Hill Parish picnic held at the farm of parishioners Linda and Terry Skelly, June 2010. Photo: Rosemary Ford-Campbell.

from 1972 to 1974 a Laboratory Supervisor with the Ontario Ministry of Agriculture and Food. He gained an enormous amount of natural history knowledge during the time he was a Wildlife Biologist, conducting inventories of plants and fishes in no less than 25 lakes, ponds, rivers, and creeks in the Lake Huron watershed, as well as banding waterfowl and making population estimates of White-tailed Deer and American Beaver. In 1974, he founded a company called BEC Consultants, which stood for Biological Ecological Consulting. From 1974 to 1980, his company con-

ducted field investigations and sample collections in support of endocrinology and xenobiological studies of fishes in the Great Lakes. After receiving his Ph.D., he joined the federal civil service, working first for the Department of Fisheries and Oceans (1980–1991) and later for the Canadian Wildlife Service at Environment Canada (1991–2001). In his first few years at Fisheries and Oceans, he worked closely with the late Roméo LeBlanc (1927–2009), who was Minister of Fisheries and Oceans from 1974 to 1982 and later became Governor General (1995–1999). Bob deeply respected LeBlanc as a man and a most competent minister of the Crown. At Fisheries and Oceans, Bob held three positions. He began as a Project Supervisor (1980–1982) in charge of developing and managing fish health studies in the Great Lakes. In 1982, he was Program Supervisor in charge of developing and implementing biological oceanographic studies in Arctic waters. From 1982 to 1991, he was Senior Policy Program Advisor, Northern and Inland Fisheries, with administrative responsibility for all national and international science programs related to northern and inland fisheries, particularly in the area of environmental issues, and those pertaining to endangered species. In 1991, Bob left Fisheries and Oceans and joined Environment Canada, where he stayed until 2001. During the ten years Bob worked at Environment Canada, he was the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) Administrator. In 2001, Bob left Environment Canada and returned as Chief Officer of BEC, the consulting company he had founded 27 years earlier.

Bob published 37 scientific articles (see Bibliography, below). Remarkably, these dealt with fishes and birds as well as marine mammals. According to Google Scholar (accessed 1 January 2012), nine of these papers have been cited between 10 and 29 times in the scientific literature, a testimony to their significance and relevance (see citation annotations following the respective articles under Bibliography).

Bob also served the scientific community as an Associate Editor of the *Canadian Field-Naturalist* for over 20 years (1990–2011). Between 1984 and 2001, he was primary editor for the status reports on fishes and marine mammals approved by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (he was at that time Chair of the Fish and Marine Mammals Subcommittee and Co-Chair of the Freshwater Fishes Subcommittee. Status reports were published on rare and endangered species in these groups in 15 issues of this journal: 110 fishes (including 7 updated reports), 58 marine mammals (including 6 updated reports), and one mollusc (the Northern Abalone) (issues 98(1), 99(3), 101(2), 102(1), 102(2), 103(2), 104(1), 105(2), 106(1), 107(4), 110(3), 111(2), 112(1), 115(1), 115(4)). Bob was able to obtain support to cover full page charges from Fisheries and Oceans and later from Environment Canada to publish in these

issues. Chairs in other taxonomic groups lacked equivalent access to funding, but some individual authors supported publication of their own status reports. Subsequently, all COSEWIC status reports were made available on the internet by Environment Canada, and further journal publication was discontinued.

Bob's service to conservation is best exemplified by his 27-year tenure with COSEWIC. From 1982 to 1999, he was Chair of the Fish and Marine Mammals Subcommittee and then from 1999 to 2009 he was Co-Chair of the Freshwater Fishes Subcommittee. I served as the other Co-Chair during the period 1999–2007 and I can confirm that Bob carried out the lion's share of a formidable workload. On the international scene, Bob was Secretary of the International Walrus Technical and Scientific Committee (1991–1995) and a member of the Sturgeon Specialist Group, Species Survival Commission, International Union for Conservation of Nature.

Bob was a deeply religious man. His service to the community began as a Rector's Warden (1990–1992), Lay Reader, and Lay Assistant (2000–2001) at St. Thomas Anglican Church in Woodlawn, Ontario, and then Lay Reader and Lay Assistant (2001–2009) with the Anglican Parish of Hawkesbury, Ontario. In September 2009, he was named Lay Leader-in-Charge with the Anglican Parish of Vankleek Hill, Ontario. After his diaconate ordination on 5 October 2009, he was named Deacon-in-Charge and after his ordination to the priesthood on 26 April 2010 he became the Pastor of that parish (Figure 1). He also served as Senior Chaplain for the sea cadets on HMCS *Quadra*, British Columbia, during the summer of 2003 and at the National Army Cadet Training Centre, Connaught, Ontario, during the summers of 2004, 2007, 2008, and 2011. Bob officiated at the funeral service for his birth mother in May 2011, only seven months before he passed away.

Bob left a legacy of caring for nature and people. His dedication to conservation will be sorely missed.

Acknowledgements

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A Tribute to Joseph Schieser Nelson, 1937–2011

ALISON M. MURRAY¹, MICHAEL G. SULLIVAN², and JOHN ACORN³

¹ Department of Biological Sciences, University of Alberta, Edmonton, Alberta T6G 2E9 Canada; email: ammurray@ualberta.ca

² Fish and Wildlife Division, Alberta Sustainable Resource Development, Edmonton, Alberta T6H 4P2 Canada; email: michael.g.sullivan@gov.ab.ca

³ Department of Renewable Resources, University of Alberta, Edmonton, Alberta T6G 2H1 Canada; email: jacorn@ualberta.ca

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FIGURE 1. Joseph S. Nelson in the fish collection of the University of Alberta Museum of Zoology, circa 2008. Photo: Emma Gilbertson.

“Tiger Joe,” who died 13 August 2011, was one heck of a fine fellow. Joseph Schieser Nelson (Figure 1) was born 12 April 1937 in San Francisco, California, his parents’ third child, 10 and 13 years younger than his brothers. Eight months later, Joe’s father, a mining engineer, moved the family to Allenby, near Copper Mountain in the Thompson Okanagan region of British Columbia—a move from the 12th largest city in the United States, with more than 600 000 people at the time, to a small town with only 68 homes. Thus, Joe

grew up surrounded by the outdoors, in a place rich with fish-filled lakes. Later, in his high school years in Vancouver, Joe also kept himself surrounded by fishes as an aquarist.

Despite a passionate interest in astronomy, Joe turned to ichthyology at the University of British Columbia, where he was influenced by many well-known, or soon-to-be-well-known, names such as Cas Lindsey and Don McPhail. He completed an honour’s thesis there, in 1960, on Kokanee Salmon (*Oncorhynchus nerka*).

From Vancouver, Joe ventured to the other side of the Rockies, and he spent the next two years at the University of Alberta, in Edmonton, pursuing an M.Sc. degree under the supervision of J. Ralph Nursall. Joe returned to Vancouver in 1962 and began his Ph.D. with Cas Lindsey. For his dissertation, he examined hybridization between two *Catostomus* sucker species. Joe built an ungainly hatchery near Prince George to rear the offspring of his artificially hybridized fish. His supervisor thought privately that the gangling contraption would never work, but he was wrong. In fact, it worked beautifully!

During this time, Joe also met his future wife, Claudine, whom he married on 31 August 1963; they were married for nearly 48 years. Joe is survived by Claudine and their four children—Brenda (Mark Brown), Janice (David Kelly), Mark, and Karen (Rob Baron)—and four grandchildren—Anna Nicholls, Kaitlind Kelly, and twins Zaria and Zephra Kelly. Joe was a devoted and loving husband to Claudine and a superb father to his children. They always speak glowingly of him, especially of their experiences in the field with their father when they were kids. In his later years, meeting Joe in the hallway inevitably led to a recent story about his grandchildren.

After his doctoral studies, Joe briefly returned to the United States as a Research Associate at Indiana University, where he became Assistant Director of the Indiana University Biological Stations. During this sojourn in the south, Joe began his work on stickleback fishes, investigating Ninespine Sticklebacks (*Pungitius pungitius*) in the Missouri River drainage. His interest in the Gasterosteidae continued throughout his life, and his last submitted paper was on variation in Brook Stickleback (*Culaea inconstans*) populations in Astotin Lake, Alberta. In all, Joe published over 120 scholarly articles (listed below).

Joe returned to the University of Alberta in 1968 as an Assistant Professor, and he remained there for the duration of his career, progressing through Associate Professor and then attaining the top rank of Professor, and eventually taking on a number of administrative positions, including Associate Dean of Student Services for the Faculty of Science. He supervised 18 master's and 9 doctoral projects, and his students went on to positions in institutions throughout the world, including Iran (Dr. Yasdan Kievany, Isfahan University of Technology), Brazil (Dr. Ierecê Maria de Lucena Rosa, Universidade Federal da Paraíba), Thailand (Dr. Jaranthada Karnasuta, Permanent Secretary, Ministry of Agriculture and Cooperatives), as well as closer to home (e.g., Dr. Mrinal Das, MacEwan University, Alberta; Dr. James Reist, Fisheries and Oceans Canada Freshwater Institute, Manitoba). Joe was also responsible for the teaching and research collections of fishes as the Curator of Ichthyology for the University of Alberta Museum of Zoology (UAMZ). These collections were greatly increased during his tenure as Cura-

tor, and Joe also enhanced the diversity of fish represented, providing many additional taxa for ichthyology students to learn.

To most people, Joe was best known as the author of *Fishes of the World* and as the co-author (with Martin Paetz) of *The Fishes of Alberta*. Both of these books are classics in their fields, and both have won high praise from biologists. Joe participated fully in the ichthyological community with memberships in many organizations, including the American Elasmobranch Society, American Fisheries Society, American Society of Ichthyologists and Herpetologists (and Chairman of the associated Names of Fishes Committee), Canadian Society of Zoologists, Canadian Society of Environmental Biologists, Canadian Society for Ecology and Evolution, Federation of Alberta Naturalists, Ottawa Field-Naturalists' Club, European Ichthyological Union, Ichthyological Society of Japan, Société Française d'Ichtyologie, Society of Systematic Biologists, and Society of Vertebrate Paleontology.

He also was on the editorial board of *Fish and Fisheries* and was part of the International Commission on Zoological Nomenclature for many years. He also served on the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) from 1981 until 2007, first as a member of the Fish and Marine Mammals Subcommittee and then, after the subcommittees were reorganized, on the Freshwater Fishes Subcommittee.

In recognition of his contributions to the study of fishes, Joe was the recipient of many awards, some of which were the Fry Medal (Canadian Society of Zoologists, 2010), Robert H. Gibbs, Jr. Memorial Award and the Robert K. Johnson Award (2002 and 2010, respectively, American Society of Ichthyologists and Herpetologists), and the Distinguished Service Award (as chair of the Names of Fishes Committee) and the William E. Ricker Resource Conservation Award (2000 and 2011, respectively, American Fisheries Society).

During his career, Joe named 20 species and one genus of fishes (list below). Four species of fishes were also named for Joe: *Barilius nelsoni* Barman, 1988 (Cyprinidae) from River Gumti, northeastern India; *Bembrops nelsoni* Thompson & Suttkus, 2002 (Perciformes) from the Philippine Islands and western Indian Ocean; *Granulacanthus joenelsoni* Hanke, Wilson, & Lindoe, 2001 (an extinct Silurian acanthodian) from the Northwest Territories, Canada; and *Myopsaron nelsoni* Shibukawa, 2010 (Perciformes) from Japan.

Of course, Joe was much more than an academic; he was also an extremely likeable and inspiring person. Early on in his career, he acquired the nickname "Tiger Joe," the origins of which are now obscure. Some say it was his tenacity that made him Tiger Joe; others say the name was a bit of irony, since his demeanour was generally not at all tiger-like. We advocate for the following "Tiger Joe" nickname creation myth. During the extensive field work necessary to collect data for the original *Fishes of Alberta* book, Joe's two field

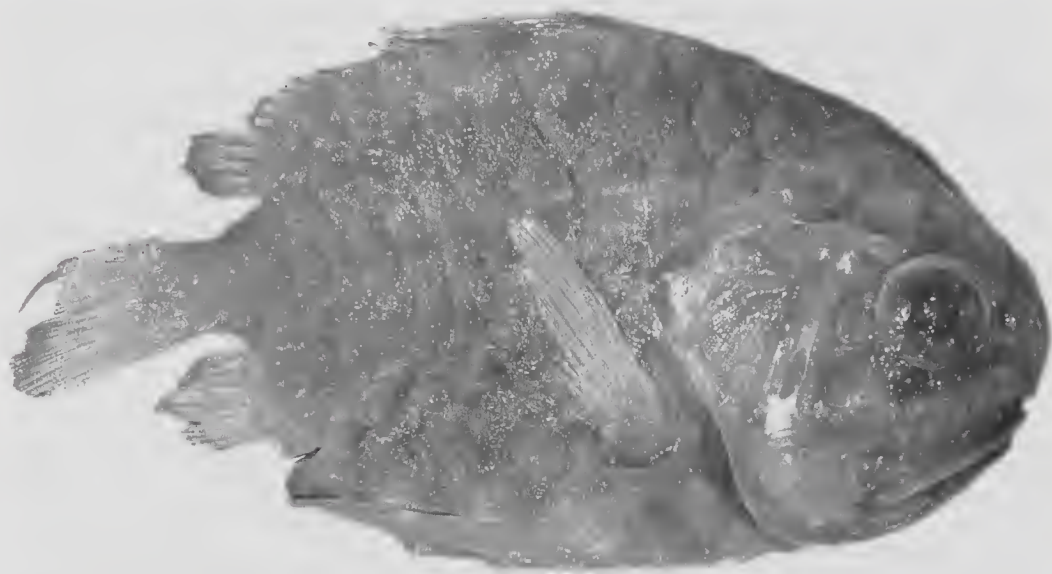


FIGURE 2. The pinecone fish (Monocentridae), named for its appearance, not its habitat. From the collections that were curated by Joe Nelson at the University of Alberta Museum of Zoology (UAMZ 7854).

assistants were classic 1960s incarnations of hairy, hard-working, hard-drinking biology students (both of whom went on to become famous Canadian fisheries personalities in their own right—another story...). At the end of each field day, a trip was made to the nearest small-town hotel for cold beer. The field assistants would drink multiple pints each, while Joe only ever ordered a single half-glass. The students teased him about his abstemious behaviour, calling him ‘a Tiger!’

Joe was soft-spoken, but he had a rich and powerful voice. If he ever lost his temper, or swore, we are not aware of it. His strongest expletive was “Garsh!” For many of his biologist colleagues, however, the fact that Joe was also an accomplished martial artist, with a 7th degree black belt in Wado Karate, gave the impression that there was a hidden, perhaps less gentle, side to his personality. In fact, this was never the case. Joe took up the study of karate after a nerve-racking mugging on a train platform in a foreign city he was visiting to attend a scientific conference, but he continued with it long after it was clear he could defend himself if need be, and he became a sensei (teacher) of others. As his fellow karateka Ken Wasserman put it at the memorial service, “Mighty as he was, this sensei always offered kindness and support, and patient leadership with constant emphasis on being a good citizen, perfection of one’s own character, and respect for others and one’s self.” Joe was mighty, and he was compassionate. If anything, his legacy as a karate sensei and his legacy as an academic mentor are perfect mirror images of one another.

Joe was not a confrontational person by nature, but he did stand on points of principle. When a taxonomic name change occurred that shifted a number of trouts from the genus *Salmo* into the salmon genus *Oncorhynchus*, Joe was asked by those with a business interest if they could now market their salmon as the more valuable trout. Joe replied as a good taxonomist would: no, but if they wished to, they could now market their trout as salmon! When other taxonomists around him were caught up in the systematics wars of the 1980s, pitting cladists against pheneticists and evolutionary taxonomists, Joe practised a sort of academic judo, deflecting the attacks rather than battling them head-on. Although he leaned toward what was called “evolutionary taxonomy” himself, he understood and taught his students about the differences among the practices.

This non-confrontational manner, coupled with an ability to keep his mind on the truly important things, allowed Joe to sooth turbulent waters when necessary. A great example of this was during an important meeting regarding stream fragmentation caused by culverts acting as fish barriers. Representatives from federal and provincial fisheries agencies were arguing over issues such as Fisheries Act definitions of “important fish” and “critical habitat” and potential repercussions to industry. In the midst of a particularly heated discussion, Joe quietly but firmly interrupted and declared, “Anyone who prevents sticklebacks from spawning should be made to suffer the same fate.” Everyone laughed, and the tone of the discussion reverted to a responsible discussion to solve a real problem.

That story illustrates a key quality of Joe's personality. Joe Nelson was a gentleman, in the most honoured and delightful sense of the word. Always polite, always truthful and honest, always focused on the principles and importance of the bigger picture. MGS, who is periodically called upon as an expert witness, was deeply moved by Joe's example, and he keeps a small museum vial with a Brook Stickleback in the breast pocket of his going-to-court suit. During nasty cross-examination on questions of habitat destruction, he always feels for the stickleback and remembers that Joe taught him to be a gentleman." Joe taught many of us by example, although we may not all carry vials of fish in our pockets.

Joe could be serious, but he was also a playful man in many respects (he was actually caught on film flying down the hallway towards his office on a child's scooter). He retained an almost childlike fascination with and love of natural history throughout his life. He loved a good joke, and he especially loved a joke he could keep alive for a long time. Many of us remember the protracted kidding that Joe shared with his entomologist friends over the pinecone fish (Monocentridae). He innocently mentioned this fish (Figure 2) one day, but the entomologists said he was making it up, and a wonderful mythology developed in which the fish lived at the tops of pine trees, far from water.

He was a regular author of published letters to the editor in the *Edmonton Journal*, undoubtedly because his arguments were brief, clear, and diplomatic. When pet stores in Edmonton began carrying tropical fish with injected dyes to make them more colourful, Joe responded in typical fashion. His short and eloquent letter described the beauty of natural fishes, their immense diversity, and the wonder of their adaptations. The argument didn't criticize or offend anyone, yet it completely refuted the concept behind injecting colours into fish. As he would often instruct, "If you give politeness and respect, you get politeness and respect back. If you give anger and distrust, you get anger and distrust back." We think of those instructions, and his quiet adherence to them, as his most profound gift to those who knew him.

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Taxa described by J. S. Nelson

- Neophrynichthys angustus* Nelson, 1977
- Neophrynichthys magnicirrus* Nelson, 1977
- Limnichthys polyactis* Nelson, 1978
- Bembrops morelandi* Nelson, 1978
- Hemerocoetes morelandi* Nelson, 1979
- Hemerocoetes artus* Nelson, 1979
- Psychrolutes sio* Nelson, 1980
- Ebinania macquariensis* Nelson, 1982
- Ebinania malacocephala* Nelson, 1982
- Pteropsaron heemstrai* Nelson, 1982
- Osopsaron natalensis* Nelson, 1982
- Creedia alleni* Nelson, 1983
- Creedia partimquamigera* Nelson, 1983
- Crystallodytes pauciradiatus* Nelson and Randall, 1985
- Cottunculus nudus* Nelson, 1989
- Psychrolutes microporos* Nelson, 1995
- Bembrops cadenati* Das and Nelson, 1996
- Ambophthalmus* Jackson and Nelson, 1998
- Ambophthalmus eurystigmatephoros* Jackson and Nelson, 1999
- Neophrynichthys heterospilos* Jackson and Nelson, 2000
- Ebinania australiae* Jackson and Nelson, 2006

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Book Reviews

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

ZOOLOGY

Handbook of Birds of the World. Volume 16

Tanagers to New World Blackbirds. Edited by: Josep del Hoyo, Andrew Elliott and David Christie. 2012. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 896 pages. 277.00 USD. Cloth.

When I opened the box containing HBW 16 I half-expected to hear a loud trumpet fanfare. Volume 1 appeared in 1992 and it has taken almost twenty years to complete the first book series to cover an entire Class of the Animal Kingdom. This has required more than 200 writers, 35 illustrators and 834 photographers from over 40 countries. The last volume published in December 2011 covers the Thraupidae (Tanagers), Cardinalidae (Cardinals), Emberizidae (Buntings and New World Sparrows) and the Icteridae (New World Blackbirds).

It is almost mundane to say the text illustrations and photographs are uniformly excellent. For Americans this book contains a lot of familiar species. In 2009 issue of *The Auk*, the Fiftieth Supplement to the American Ornithologists' Union Check-list of North American Birds deprived of our Canadian Tanagers, although we still call them tanagers. HBW 16 has given us our tanagers back, at least temporarily. More important, the information provided on Scarlet and Western Tanagers would have been valuable in identifying an out-of-range Western Tanager some years ago. This dull-plumaged bird generated a long debate, in part caused by lack of information.

Most of us have taken trips to the Caribbean and South America where the bulk of the Tanagers [including Euphonias, Spindalis, Dacnis and Honeycreepers] live. Going through the pages you can find old friends and colourful new birds you have yet to see. As usual the prominent subspecies are illustrated. There are four subspecies of the common Blue-grey Tanager next to the similar Sayaca Tanager. I must say I cheated earlier this year when I identified the Sayaca Tanager by geographic range. The variable-plumaged Bananaquit has 41 subspecies of which 10 are shown. They are treated as a single species, but the taxonomic discussion leaves room for future changes. There are 283 species in this family and some have restricted ranges so seeing them all would be an expensive challenge. HBW 16 will provide a good planning tool for such a venture.

The Cardinals family also has some colourful species, again with many familiar to North Americans. It also includes saltators, grosbeaks and buntings. Emberizidae (Buntings and New World Sparrows) and this

includes several "cardinals" and not all of them are red. It also includes those birds that can give people a hard time, giving them the acronym LBJ or little brown job. A couple of years ago I visited a grassy sparrow field. Several species of sparrow were calling, including some Grasshopper Sparrows. One popped out on a plant stem and I took some nice photos. Back home I realised my photos showed the birds had yellow on the face and at the bend of the wing. Had I misidentified this creature? I searched some field guides, but found nothing on this feature until I reached Earl Godfrey's classic "Birds of Canada." Then I tried the Internet and many photos showed the yellow marks. I suppose we cannot expect all books to be perfect and HBW 16 does not mention the yellow on the lesser wing coverts.

I was surprised to see the authors had split the Fox Sparrow into four species. While the geographical difference in colour has long been known, these have been regarded as sub-species. Recent DNA analysis has suggested there are three, maybe four, separate species. No decision has been made before further studies of hybridization are done. This is especially true of the uncertainly distinct Slate-colored and Thick-billed Fox Sparrows.

The last family, and it is the *last*, is the Icteridae (New World Blackbirds). The last bird is the fluty-songed Western Meadowlark, but mostly this section covers the exotic orioles and oropendolas. Not the Eurasian orioles [Oriolidae] of course, as these are in HBW 13. By splitting the Amazonian Oropendula in to two HBW recognizes 10 species of the raucous birds. While the illustrations for the Baltimore Oriole are wonderful, nothing can capture the glow of a spring. This only lasts a week or so and then these birds look like the illustrations.

The book has two other features. There is an essay on the impact of climate change on birds [Note – it is titled correctly and not as global warming]. Ignoring the debate about the cause of the current changes, the weather is different and this impacts birds. The author present the results of numerous studies, mostly from Europe, that document observed differences in breeding, migration and other aspects of their annual cycle.

The author is careful in his interpretation of the data, so the effects of other, confounding changes [e.g., in land use] are eliminated. This is an excellent summary of our current knowledge and if you read nothing else of this fine essay, at least read Andres Moller's thoughtful conclusion.

There is a plasticized index to the passerines [volumes 8 to 16]. The index to the non-passerines was in volume 7 and has been incredibly useful. The size of each volume and the mass of all 16 volumes makes it hard to search for a single species. These indices are a godsend.

So we have come to the end of an era [and likely the beginning of a new one]. My congratulations to all the people involved for you have created 16 volumes that are a treasure trove of solid information for all naturalists. Admittedly the early books are now "old" but on checking recent splits I found the authors to be prophetic and the new species illustrated [as a subspecies]. I am sure it will still be the major reference in another 20 years.

ROY JOHN

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

National Geographic Field Guide to the Birds of North America – Sixth Edition

By Jon L. Dunn and Jonathan Alderfer. 2011. National Geographic Society, 777 South State Road 7, Margate, Florida 33068 USA. 574 pages. 32.00 USD.

This new edition of the familiar and popular National Geographic Guide is very similar to earlier versions. Why should it really change? It was always an excellent field guide.

This is the most significant update since the original, 25 year-old edition. Three hundred new illustrations have been inserted into the artwork. A new innovation is the inclusion of subspecies maps. The authors have included current migration information on the species maps. They have added field-mark labels to all the illustrations. This similar to the original Peterson system of little marks that point to the key feature for identification. The National Geographic Guide adds brief notes such as "distinct crest" or "white throat."

The text and the sequence of species meet the taxonomic changes of the last few years. This means you can no longer flip the book open to a familiar spot for gulls or warblers. To offset this they have added thumb-

tabs so you can locate the key sections. Using the American Ornithologists' Union checklist the guide contains all 960 North American species and that includes the accidental birds. As there are several depictions for each species there are 4,000 full-color illustrations by a string of bird artists. The range maps have been updated. The cover has flaps that act as a quick-reference and as book mark.

The only, very mild, disappointment was that the coverage of Red Crossbill was not extensive enough to cover all types. This species appears headed for an eight or nine way split, but only three are illustrated.

Despite the official price of \$32 we placed a bulk order for several books that worked out at \$21 each. This is an excellent price for an excellent guide – every North American birder should have one.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5

Carnivores of the World

By Luke Hunter. 2011. Princeton University Press, 41 William Street, Princeton, New Jersey, 08540-5237 USA. 240 pages. 29.95 USD. Paper.

When this book arrived I flicked through and noted it contained the Giant Panda, a vegetarian. A second flick and I realised the seals were missing. On page 1 the author explains the book covers 245 species of *terrestrial* mammals that trace back to a single Paleocene ancestor [hence no seals]. Instead there is a plethora of cats, dogs, weasels, mongooses and bears.

In early 2012 an unknown beast was caught on camera trap regularly feeding on a cow carcass. It was a Giant Panda, so they are not totally vegetarian. However the authors of this book quote "Recorded occasionally scavenging for carrion ..." and so are current with their knowledge.

The book begins with the 120 species of cats. These range from the widespread Wildcat [*Felis sylvestrus*]

to the most endangered large cat; the Tiger [*Panthera tigris*]. There are currently 161 species in the dog family. This includes the 36 species of pinnipeds, not covered in this book. Each species has a description, including all the major forms, and notes the distribution and habitat. There follows an account of the animal's feeding and social behaviours. Finally there are sections on reproduction and its current status.

There are 84 plates of drawings of skulls. This is useful in the field because an active naturalist often finds skeletal remains. Perhaps what is more remarkable is how similar these skulls are. You might expect the snubby-nosed cats to be comparable, but you can see the close relationship with the longer-nosed dogs. Clearly nature has evolved a great design for cami-

vore structure and is sticking with it. The last section is 86 plates of footprints, another useful field guide.

The art work is very good. The form depicted is realistic from the little Black-footed Cat to the massive Polar Bear, showing that the artist, Priscilla Barrett, has a field as well as an anatomical knowledge of each species. Where useful the different forms are included. So there are four forms of the Grey Wolf, three for Brown Bear and three sub-species of Tiger. In addition to the coloured depictions there are small black-and-white vignettes of cubs, feeding activities or social behaviour.

I believe the text is accurate and up-to-date. Everything I checked [see my comments on the Giant Panda] was correct. I was disappointed by the limited, but not incorrect, information on the Eastern Wolf (*Canis lycaon*). This may be a subspecies of Gray Wolf (*Canis lupus lycaon*) or a distinct species closely related to

the Red Wolf. This is mentioned in the introductory section on the Canid group, but not in the texts on the individual species.

Because of its size this is a useful field guide and it would be handy to carry anywhere in the world. You will not see a Sea Otter in Africa, but there is still much of the book that would be useful, and this is true for any continent. The problem is not the book, but seeing the beasts. After years of wandering the wild I rarely see a Mink; a very common mammal, and I have not seen a Striped Skunk for three years; another common mammal. Smaller animals are even more difficult to find. If you are lucky enough to see a carnivore this book will help you identify it and learn something of its life.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5

Insect Ecology: Behavior, Populations and Communities

By Peter W. Price, Robert F. Denno, Micky D. Eubanks, Deborah L. Finke, and I. Kaplan. 2011. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473 USA. 801 pages. 87.00 CAD, Paper, 168.00 CAD. Cloth.

In the age of electronic books and tablet-designed texts, there is something to be said for the feeling of picking up a hefty new (or used) textbook at the beginning of an undergraduate course. The intriguing cover art, the long list of authors and the impressive table of contents all add to the experience of diving into a new subject in a truly immersive fashion. Unlike many textbooks, *Insect Ecology* by Price *et al.* is not a barely indistinguishable "new" edition. While three editions of *Insect Ecology* were published between 1975 and 1997, this is a complete rewrite with new figures and new subject areas included. In the introduction, the authors make it clear that the book is constructed as a textbook. The subject matter is carefully arranged to suit a course with fifteen weeks of lectures. The approach is an inductive one, moving from individual insect behavior, through population and community ecology, to global patterns of insect diversity.

The book, itself, is well-constructed and impressive. Text layouts are clear and easy to follow. Summaries, study questions, and further reading lists are provided at the end of each section. Separate author, subject, and taxonomic indices are extremely helpful as is the complete reference list. Figures are ample and informative, but are almost all black and white and sometimes of less-than-ideal quality. A link is provided to access electronic versions of all figures. Undoubtedly, this approach to the figures was employed to keep down the already considerable cost of the book; a move surely appreciated by cash-strapped undergraduates.

Despite the demonstrated high quality of this text-

book, the question remains — is this a course in which you would want to enroll? The authors of *Insect Ecology* make a convincing argument that members of the class Insecta represent the best organisms for the study of ecology. Insects inhabited the terrestrial environment for a full 20-25 million years before vertebrates emerged from the water. Flying insects were the only inhabitants of the aerial realms for over 150 million years. Insects inhabit an incredible breadth of ecological niches, from freshwater to deserts to hot springs to within other organisms. It is this ancient and diverse ecology, in the authors' opinion, that makes insects such ideal examples of ecological principles. Knowledge of insect ecology also serves to inform any number of other areas of study as well. Insects function as vectors of human and animal disease, pollinators and pests of crops, and vital elements of practically every food chain on Earth. Studying their individual behaviours, species interactions, and global patterns of diversity can help us to better understand our complex relationships with our insect neighbours.

As assigned reading for an advanced undergraduate course, *Insect Ecology* is well worth the trip to the campus bookstore. It is also likely to be the sort of textbook you keep on the shelf for regular future reference. This book is also recommended for those who wish to assign themselves fifteen weeks of reading as a means to brush up on their own knowledge of the invertebrate world.

JOEL F. GIBSON

Biodiversity Institute of Ontario and Department of Integrative Biology, University of Guelph, Guelph, Ontario.

Petrels, Albatrosses and Storm Petrels of North America

By Steve N. G. Howell. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 493 pages. 45.00 USD. Cloth.

I spent 18 days at sea during December 2011 and the first half of January 2012. Of those seven were in the North Atlantic. The rest were in the South Atlantic and South Pacific. Thus I was faced with identifying many species of tubenoses on most days. This was a daunting [terrifying?] task, in part because of a lack of information.

Steve Howell's book aims to fill that knowledge gap; or at least try to. What caught my eye first was a section on field identification. In particular two photos of Buller's Shearwater; one showing the classic "W" wing pattern and the other a more uniform brown bird. I have a photo of me holding such a brown bird, caught off Alaska two years ago, as I puzzled with its identification. I did identify it eventually by its underwing pattern, but not before a lot of grief. Howell goes on to show how fog and light affect to colours we see. One fascinating pair of photos show the same bird, a juvenile White-faced Storm-Petrel, taken a few minutes apart, after the light changed. One is distinctly grubbier and browner, the other greyer and whiter. So apart from viewing conditions there are species differences, colour phases and moult to resolve. And you have to deal with these issues while swaying around and holding binoculars steady in the wind.

Starting back at the beginning Howell introduces us to tubenoses and the ocean's they live in. There is a detailed review of the current taxonomic knowledge and then, the excellent section on field identification. The author provides a short section on how to see tubenoses and seabird conservation. The bulk of the book is given over to the species accounts.

Each species has notes on the taxonomy, the origin of the names and the status. For some there is a range map, with migration patterns overlaid. The majority of the text is on species identification. This is covered in impressive detail and is accompanied by numerous photographs. Similar species photographs are also included, eliminating the annoying need to flip back and forth. Birds are shown sitting on the water and in flight and some museum specimens are shown for comparison. Is the text accurate? Quite frankly I do not really know because this is a difficult field to study. I think

it is because it deals with the Cory's-Scopoli's Shearwater issue, the Manx Shearwater complex, Leach's-Ainley's - Townsend's Storm-Petrel splits and so on. He uses Light-mantled Sooty Albatross instead of the current AOU term, Light-mantled Albatross, and says that this latter is "an insipid name coined by emotionally castrated landlubbers."

Taking photos of birds is difficult on land. Add the problems of a moving boat, the swell and the waves and the process is frustrating. Having tried this for many hours this year I am really impressed with the quality of the photos by Howell and his colleagues. There is an advantage to taking any photograph with a digital camera. Even a poor quality one can reveal details that are hard to pick out in real life. Digital also means you need not feel bad about those wasted shots of half a bird disappearing behind a wave.

Do not expect to resolve all your identification issues. I saw a number of Soft-plumaged Petrels [*Pterodroma mollis*] south of the equator. I am confident that they are correctly identified. I have photographs and I was in the known territory for this species. My problem is I saw three birds that had the same plumage around 25°N - just south of the Canaries, off the coast of Western Sahara. This new book introduces two more possibilities. Fea's Petrel [*Pterodroma feae*] and Zion's Petrel [*Pterodroma madeira*] both breed in the eastern Atlantic. Now I need to review my notes [and memory!] and hope they are good enough. This is a good example of the difficulties of studying birds at sea.

So now I have to pour through my collection of photos from this last trip to re-identify as many individuals as possible. I want to make sure I was correct and that I did not miss any different species. This excellent and detailed book will help me do that. For a novice this book may be intimidating, but for the enthusiast it is an essential purchase. There has not been such an important contribution to understanding seabirds since Peter Harrison's classic "Seabirds of the World. 1983. Houghton Mifflin."

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5

Venomous Reptiles of the United States, Canada, and Northern Mexico. Volume 2. Crotalus

By Carl H. Ernst and Evelyn M. Ernst. 2012. Johns Hopkins University Press. xiv + 391 pages. 75.00 USD.

This is the second of two volumes on venomous reptiles of North America. Volume 1, published in 2011, covered 13 species: 2 lizards, 5 elapid snakes (4 coral snakes and 1 sea snake), and 6 viperid snakes. This new volume covers 21 (of the 30+) species of rattlesnakes in the genus *Crotalus*. Together these books are an up-

date to Carl Ernst's 1992 book *The Venomous Reptiles of North America*.

The geographic focus of both volumes is the area north of 25° Latitude, which corresponds to the tip of the Baja peninsula of Mexico. This means that rattlesnakes found in northern Mexico are included in

the book, but the many species found farther south are excluded.

The book begins with a brief introduction to the viperids and a key to the species of *Crotalus* covered in this book. Chapters on reptile venom, statistics on envenomation, treatment of envenomation, and the conservation of venomous reptiles are in volume 1. The bulk of the book provides detailed species accounts of the 21 rattlesnakes. The accounts follow the same standardized format as in Volume 1: recognition (detailed description of the species including colour patterns, scale counts and body lengths), geographic variation, confusing species, karyotype, fossil record, distribution, habitat, behaviour and ecology, reproduction, growth and longevity, diet and feeding behaviour, venom delivery system, venom and bites, predators and defence, parasites and pathogens, populations (available data on abundance), and remarks (miscellaneous information). Each account also includes black and white photos of the species as well as a distribution map. The species accounts vary in length depending upon how much information is available. The account for the Tortuga Island Rattlesnake (*C. tortugensis*) is less than 5 pages (including photos and a distribution map) but most accounts are at least twice that length. The book also includes colour photos of all the species and most of the subspecies. In general, the photos are fairly good.

Overall, the quality of the text is quite high. The authors have summarized a vast amount of scientific literature. The literature cited for the book is over 90

pages in length. There are curious omissions. For example, the species account for the Santa Catalina Island Rattleless Rattlesnake (*C. catalinensis*) does not mention that it was once at risk from introduced feral cats (now eradicated) and that it is still at risk from illegal collecting. It also does not mention that this species is one of only two species of *Crotalus* considered critically endangered globally by the IUCN. The account for the Southern Pacific Rattlesnake (*C. helleri*) states that a population on Santa Catalina Island is at risk from introduced pigs. Why is this not a threat to the Santa Catalina Island Rattleless Rattlesnake? The book doesn't mention that it is a different Santa Catalina Island (although this can be inferred from the distribution map). The species account for the Timber Rattlesnake (*C. horridus*) correctly mentions that it has been extirpated from Maine and Ontario, but fails to mention that it has also been extirpated from Rhode Island.

The largest omission is any attempt to put the species into some kind of broader context. The authors state that there are 30 to 35 species of *Crotalus* but there is no central discussion of this debate. An introductory chapter on the genus, illustrating the major groups and outlining taxonomic debates would have been valuable. Nonetheless, this book is a great summary of the literature on North American rattlesnakes.

DAVID SEBURN

Seburn Ecological Services, 2710 Clarendon Street, Ottawa, Ontario K2B 7S5

BOTANY

Cactus Plant Resources and Utilization

Edited by: Tian Guohang and Zhao Tianbang. 2011. Science Press, Beijing, China. 323 pages. 98.00 CNY.

Cactus plants belong to the Cactaceae family which is subdivided into multiple genera. There are more than 2000 cactus plant species or varieties which are found in various colors, shapes and forms. It is believed that cactus plants have grown thirty to forty million years ago, and is usually referred to as the New World plant. Their range extends from Patagonia to southern Canada, but they are densest and most diverse in the regions of northern Mexico and the southern tropics of Argentina and Bolivia. Many cactus species have become naturalized outside the Americas after having been introduced by people or migratory birds. Cacti inhabit diverse regions and habitats, from coastal plains to high mountain areas. Although cactus plants are vigorous and prosperous in many areas in the world, some species have become endangered in the wild because of over-harvesting for sale as an ornamental plant. All cacti are covered by the Convention on International Trade in Endangered Species of Wild Fauna and Flora, and many species, by virtue of their inclusion in Appendix I, are fully protected.

The cactus form is often heralded as a striking example of the tight relationship between form and function in plants. Cactus plants are quite unusual and are adapted to grow in hot and tropical climates and desert areas where there is very low rainfall. They have developed many unique strategies to enhance their chances for survival under inhospitable conditions. The evolution of cactus plants reflects in at least three important aspects, the loss of leaves, which reduced the total transpirational surface area, the expansion of the cortex into a succulent water-storage tissue, and the conversion of leaves into spines, which protect the stored water. The most basic survival adaptation is its shape. To minimize water loss from the surface, the ideal shape is to have the lowest surface area for a given volume. The appearance of cactus plants with a wide range of shapes and sizes is very distinctive as a result of adaptations to conserve water in dry and/or hot environments. The plant body itself is also capable of absorbing moisture (through the epidermis and the spines), which is especially important for plants that

receive most of their moisture in the form of fog. Its fleshy, succulent, long-lived photosynthetic green stem performs the function of the leaves and carries out the CAM photosynthesis process with high water use efficiency, and allows it to survive periods of extreme drought while maintaining well-hydrated tissues. Cacti are very slow growing, resulting in that their water requirements per unit time are low, and can survive after considerable water loss. The development of an intimidating defensive shield, an array of spines, is another important survival strategy, which not only defend the cactus against herbivores but also provide shade that lowers the plant's water loss through transpiration. Although some cacti are spineless or nearly so, they tend to produce toxic substances that compensate for the lack of protection from grazers offered by spines. Cactus plants have an extensively complicated and big root system which enables it to absorb water from the soil. The commonly very shallow and widely spreading root system of cacti enables them to exploit water deposited in surface horizons by short periods of rain. The combination of a shallow root system and hooked spines facilitates its effective dispersal.

In many places of China, drought-resistant plants are increasing in popularity, due to water restrictions in these areas. In recent years, numerous cactus plant species have been introduced in some places of China, and entered widespread cultivation, as ornamental plants, or fodder, forage, fruits, cochineal production and other purposes. Under this background, the book *Cactus Plants Resources and Utilization* was written by Tian Guohang and Zhao Tianbang (editor-in-chief), and was published by Science Press, Beijing, China, 2011.

The main contents of the book included chapter I overview of cactus plants, including significance of cultivation, geographical distribution, morphological characteristics (e.g., shape of individual plant, leaf, edge, warts, thorn base, hair, flower shape, flower position, flowering period, flowering age, fruit type and shape), ecological characteristics (e.g., adaptability to

temperature, requirements for daylight, response to water, adaptability to soil) and breeding (e.g., stock breeding, cross breeding, introduction and domestication, nomenclature of hybrids and varieties); chapter II classification system of cactus plants, including the brief history of classification, classification system, the focus and reasons of contention about the classification system of cactus plants, evolutionary trends of classification system (combination school, detailed-classification school and intermediate school); chapter III resources of cactus plant family, including the main morphological features of five subfamilies, 10 tribes, 161 genera (including 32 hybrid genera), 696 species (including 84 hybrid species), 2 subspecies, 180 varieties, 173 variants and 132 breeds, with 388 photos and 12 plates; chapter IV cultivation techniques for cactus plants, including propagation techniques (e.g., cutting, grafting, segmentation, sowing), cultivation techniques (cultivation conditions, planting techniques, post-planting management), plastic arts (technology for potted landscape with cactus plants) and pest control; chapter V exploitation and use of cactus plants, including introduction of cactus culture in Mexico, edible cactus, medicinal cactus, ornamental cactus, cactus planting in barren mountains and deserts, establishing a cactus botanical garden.

This book is abundant in contents and concise in writing with clear illustrations. It would become a good reference for the persons who are engaged in botany, conservation ecology, cactus plant biology, cultivation, classification and breeding, and so on.

LI DEZHI¹ and QIN AILI²

⁽¹⁾Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tianlong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N), Shanghai, China, 200062;

⁽²⁾Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd. Songjiang, Shanghai, China, 201600

Walnut Germplasm Resources in China

Edited by: Pei Dong and Lu Xinzheng, 2011. China Forestry Press, c/o Flat 21, 20/F, Acacia Building, 150 Kennedy Road, Wan Chai, Hong Kong. 208 pages. 63.00 USD.

The loss of valuable genetic resources worldwide happens in many plant species in long-term cultivation. After Vavilov first called attention to the potential of crop relatives as a source of novel trait variation for crop improvement, the establishment of modern germplasm banks was motivated, which include inbred lines, land races, open pollinated varieties, wild relatives, cultivars, and other breeding stocks. The primary importance of germplasm banks is that it carries undefined variation that is proving to be a valuable resource for breeders and research scientists in improving plant spe-

cies, and giving insight into the biology of the plant species. However, until recently, the ability of scientists and researchers to maintain and preserve plant genetic resources was very limited. There are basically two approaches for conservation of plant genetic resources, namely *in situ* and *ex situ*.

Germplasm conservation demands that collection methods initially capture maximum variation and subsequently, conservation and regeneration techniques minimize losses through time. To this effect, plant genetic resources conservation activities comprise of col-

lecting, conservation and management, identification of potentially valuable material by characterization, and evaluation for subsequent use.

Collecting involves gathering samples of a species from populations in the field or natural habitats for conservation. The unit of collection may be seeds or vegetative propagules, depending on the breeding system of the species. Collecting may be easy in species producing small botanic seeds in abundance. However, it becomes problematic when seeds are unavailable or non-viable due to damage of plants by grazing or diseases, large and fleshy seeds that are difficult to transport or where samples are not likely to remain viable during transportation due to remoteness of the collecting site from the genebank. Advances in biotechnology provide useful solutions for collecting such problem species.

The walnut tree is a perennial deciduous fruit tree, with large economic values. It belongs to *Juglans* and Juglandaceae. *Juglans* consists of over 20 species distributed in Asia, Europe and the Americas. Five species originated in China, namely *J. regia*, *J. mandshurica*, *J. cathayensis*, *J. sigillata* and *J. hopeiensis*. Two species are widely cultivated, i.e., the common walnut and *J. Sigillata*. The former one widely distributes throughout the north and south of China, and the latter one is mainly distributed in the Southwest area. China is one of the major countries for walnut production. China has a long history for walnut cultivation starting in the Western Han Dynasty, and there have been many treatise about the varieties, distribution, characters, cultivation techniques and economic usage of walnuts published from A.D. 400 onwards. Traditional Chinese medicinal literatures believe that walnut is healthy to man's brains, and the fruit, peel, seed shell, wood and leaves of walnut tree can be used in industry and many other purposes. The nucleoli is nutritious with unique flavor. Walnut is recognized as one of the four famous nuts in the world. Walnut trees can play important roles in afforestation of waste land, soil and water conservation and improving the environment. Walnut has been extensively used by Chinese people for long time. The research on the walnut germplasm resources is of great significance in promotion of walnut production, use and exploitation of walnut resources, and breeding of new excellent varieties.

In China, intensive cultivation of walnut using few productive varieties is causing genetic uniformity, and some genetic resources of walnuts are disappearing at unprecedented rates, which sometimes makes these walnut plantation more vulnerable to pests and environmental stresses. Making better use of a broader range of the walnut's genetic diversity is becoming one optional solution to this problem. Fully using walnut

germplasm resources can help scientists bring out more new varieties and increase the genetic diversity of cultivated walnut. The full spectrum of walnut dermplasm should comprise diversity of genetic material contained in traditional varieties, modern cultivars, wild species and other relatives. These resources of genetic diversity provides plant breeders with options to develop, through selection and breeding, new and more productive varieties, that are resistant to virulent pests and diseases and adapted to changing environments.

Using local walnut germplasm resources, walnut breeding in China has made some achievements in the past years, breeding a large number of good varieties and superior clones. With the improvement of living standards of Chinese people, and the recognition of the nutritional value and the medical effects of walnut, the demand for higher quality walnut has been increasing, promoting the development of walnut product and expanding the use and exploitation of walnut resources. Further cultivation of high-yield, strongly-resistant, better-quality and easily-processed walnut varieties is becoming an important goal for walnut breeding in the future of China.

To summarize the research results of walnut germplasm in China and introduce the achievements to more people who are interested in it, the book *Walnut Germplasm Resources in China* was published by China Forestry Press in 2011. Based on the walnut germplasm resources in 15 provinces or autonomous regions and municipalities of China, the book comprehensively introduced the walnut germplasm resources in China. The book is divided into two parts. The first part introduced the origin, cultivation history and the main usages of walnut, and the outlines of germplasm conditions of the common walnut, pecan and beak walnut. The second part introduced all varieties of the common walnut, pecan and beak walnut, and the geographic distribution of germplasm resources, the biological characteristics and the main features of cultivation. The book is informative, comprehensive and characteristic in both theoretical elucidation and practicality in walnut management. The book would become a good reference for the persons who are engaged in walnut geography, biology, breeding, management and other relevant fields.

LI DEZHI¹ and QIN AILI²

¹Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N), Shanghai, China, 200062; ²Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd. Songjiang, Shanghai, China, 201600)

OTHER

Interactions and Coevolution of Life and Earth Environment

Edited by: Xie Shucheng, Yin Hongfu, Shi Xiaoying. 2011. Science Press, c/o Flat 21, 20/F, Acacia Building, 150 Kennedy Road, Wan Chai, Hong Kong. 345 pages. 78.00 RMB.

In the vast universe, the Earth is the only planet so far known for the existence of life. It's exclusive position in the solar system, results in the best environmental conditions for life, such as the appropriate planetary gravitation, moderate sunshine, limited temperature difference between day and night, and so on. The Earth provides life with all the basic elements and unique environment required for the survival, development and reproduction of life. The rise of life triggered the emergence of the biosphere in the earth surface system, which as the most active sphere in the Earth, not only promotes the earth surface system to circulate much faster, but also buffers the earth environment and facilitates the environmental evolution. The interactions or coevolution of life with its environment, or biosphere with other spheres, through Earth history, has become an essential for the earth system science, which is also the main focus of the newly emerging geobiology.

Earth history has been heavily fluctuated due to a series of unusual environmental events, which was well reflected in the earth surface system. Life has experienced major geological events through the life-environment coevolution, and the evolutionary life provided natural cues to divide the Earth history during the Phanerozoic and the pre-Phanerozoic time. During the Proterozoic, life and Earth environment evolved smoothly and symmetrically until the Neoproterozoic when the Earth became extremely active. Since Phanerozoic, the environmental cues and fossil records have become abundant and the life-environment coevolution has become obvious. The life-environment interactions and coevolution during the great turning periods of Earth history, which is prominently marked by the phenomenon of mass extinction, are the most remarkable. The environmental change facilitates life to evolve into new adaptation, and the surviving and new-emerging organisms are always trying to alter the environment and reconstruct new ecosystems to better adapt to the changed environment. The actions of environmental events are usually short, while the followed reconstruction led by organisms is relatively long.

Coevolution between organisms and their environment is an inherent feature of living systems on the Earth. Life on Earth is based on networks of biochemical reactions that interact with the environment to maintain a biosphere that has been remarkably resilient to environmental challenges. However, understanding of the whole relationships between life and the environment is not easy, requiring a synthesis that draws from many different fields of science. Coevolution of life and the environment is dynamic, and proceeds at all organism levels. For example, prokaryotic microor-

ganisms have played a critical role in shaping our planet. The diversity of life on Earth today is actually a result of the dynamic interplay between genetic opportunity, metabolic capability and environmental challenges.

It should be mentioned that in the 1970s, the chemist James Lovelock formulated the Gaia hypothesis (it later was called Gaia theory), which proposed that all organisms and their inorganic surroundings on Earth are closely integrated to form a single and self-regulating complex system, maintaining the conditions for life on the planet. The Gaia theory's unique approach discovered and addressed the interaction between life and environment on the Earth. The later scientific investigation of the Gaia hypothesis focussed on observing how the biosphere and the evolution of life forms contributed to the stability of global temperature, ocean salinity, oxygen in the atmosphere and other factors of habitability in a preferred homeostasis. Some of the principles summarized by the Gaia theory nowadays have been adopted in fields like biogeochemistry, systems ecology, geophysiology and earth system science.

Actually, besides the Gaia theory, there has been much progress related to the issue of interactions and coevolution of life and earth environment scattered across various scientific fields worldwide. The newly published book *Interactions and Coevolution of Life and Earth Environment* introduced some important concepts for research progress in some key areas of geobiology, a new cross discipline between Earth science and life science, focussing on the interactions and the co-evolution of life and environment. The book through in-depth theoretical elucidation and abundant result demonstration convinces readers that the history of the evolution of life and the Earth can only be appreciated by deciphering their interdependencies. It is divided into three parts. The first part mainly introduced the subject system and the basic task of geobiology; the second part involved a number of important branches of geobiology, including the molecular geobiology, geomicrobiology and geoecology (such as reef ecosystems, bacteria and algae ecosystems, and tropical rain forest ecosystems); the third part dealt with the geobiological research on major geological change periods (pre-Cambrian, the extinction period of Phanerozoic and contemporary era). Each part introduced authors's findings based on the review of the international research progress in the relevant fields. The book was currently most extensive monograph on geobiology including various branches in China. The main contents included Chapter 1 Overview of geobiology, Chapter 2 molecular records of interaction

between life and environmental systems on Earth, Chapter 3 some important geomicrobiological processes of the Earth, Chapter 4 the biological processes of the Earth and the formation and collapse of some typical ecosystems on Earth, Chapter 5 the geological roles of the microbes in Precambrian and the evolution of Earth's surface system, Chapter 6 globally episodic biological crisis when turning from Paleozoic to Mesozoic, and the global environmental system abnormalities, Chapter 7 modern living systems and environmental systems under the anthropogenic disturbance.

Humans are increasingly perturbing Earth's biogeochemical cycles and the living environment. Currently the so called Gaian homeostatic balance is being stirred, and today's Earth is entering a new great turning period due to the rapid increase of human population and the serious impact of their activities to the environment, based on which Paul Crutzen applied a new term "Anthropocene" to name the present era of Earth. Obviously, research on how these changes caused by

humans will affect the Earth environment as well as the interactions and coevolution of life and the environment will become a new and urgent task of scientists. Harmonious Gaia and sustainable interactions and coevolution of life and environment must be our common expectation.

The book would be a good reference for the persons who are engaged in paleontology, sedimentology, stratigraphy, geomicrobiology, molecular organic geochemistry, biogeochemistry, ecology, geology and other relevant fields.

LI DEZHI¹ and QIN AILI²

(¹Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N), Shanghai, China, 200062; ²Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd. Songjiang, Shanghai, China, 201600)

Techniques for Restoration and Reconstruction of Mangrove Forests in China

By Liao, Baowen, Li, Mei, Chen, Yujun, Guan, Wei. 2011. Science Press, Flat 21, 20/F, Acacia Building, 150 Kennedy Road, Wan Chai, Hong Kong. 434 pages. 98.00 CNY.

Mangrove forest is composed of mangrove family of plants, the Rhizophoraceae, or even more specifically the mangrove trees of the genus *Rhizophora*. Mangroves worldwide grow in estuaries and saline coastal sediment habitats in the tropics and subtropics, mainly between latitudes 25°N and 25°S. Though a given mangrove forest typically features only a small number of tree species, the ecosystem embraces a great variety of other organisms, and the mangrove forests are among the most productive ecosystems on Earth. Some evidence suggests that mangrove diversity is limited by evolutionary transition into the stressful marine environment and that the number of mangrove lineages has increased steadily over the Tertiary with little global extinction. All mangrove tree species are not necessarily related, but they all demonstrate convergent evolution, showing similar solutions to the tropical conditions of variable salinity, tidal range (inundation), loose, wet and anaerobic soils, periodic tidal submergence and intense sunlight, they thereby out-compete other species under these harsh conditions. In addition, mangroves have one of the most unique reproductive strategies in the plant kingdom; like most mammals, they all possess different degrees of vivipary with propagule (seedling) formation, accomplishing seed germination while still attached to the parent tree, rather than producing dormant resting seeds like most flowering plants. Mangroves disperse propagules via water with varying degrees of vivipary or embryonic development while the propagule is attached to the parent tree.

Mangroves have special aerial roots and salt-filtering tap roots that enable them to thrive in brackish water. Their massive root systems are efficient at collecting sediments, slowing the water's flow, dissipating wave energy and helping to protect coastal areas from erosion, storm surge (especially during hurricanes), and tsunamis. Over time, the roots can collect enough debris and mud to extend the edge of the coastline further out. In at least some cases, export of carbon fixed in mangroves is important in coastal food webs.

At the intersection of land and sea, mangrove forests support a wealth of life, and may be more important to the health of the planet than we ever realized. The importance of mangrove swamps is well established in regard to shoreline erosion control and ecological productivity. They function as nurseries and adult habitat for shrimp and recreational fisheries, exporters of organic matter to adjacent coastal food chains, and enormous sources of valuable nutrients. Because of the irreplaceable functions of mangrove ecosystems in coastal areas, and the increasingly threatened situations resulted from the coastal development, expanding human population, and dredging, filling, diking, oil spills, herbicide and human waste runoff, as well as the significant decline in their integrity and productivity, conservation of mangrove ecosystems are become necessary and urgent worldwide, and has become one of the most important flagship ecosystems for the international biodiversity conservation and wetland protection. However, so far, only some limited efforts are underway to enhance the protection of these valuable ecosystems.

The distribution of mangrove forests in the south-eastern coast of China is at their northern edge of their range, not being the ideal habitats for the growth of mangroves. The mangroves in China had been abundant in the history (statistics showed that the mangrove forests in China had even reached 250000 ha), however, in recent decades, mangrove forests in the southeast coast of China have been damaged seriously. 50 years ago, there was about 50000 ha mangrove forests in China, but nowadays, it drops to less than 23000 ha, due to the reasons similar to other countries as mentioned above. The dramatic decline of mangrove forests in China resulted in the serious environmental degradation in coastal area, 60-90% decline of the production of shore economic animals, including the fish resources, crisis of pearl cultivation, seriousness of red tides, coastal land erosion, harbor siltation, increase of typhoon-induced economic loss, increase of abandoned land in the coastal area and monotonicity of coastal landscapes.

Under this background, the restoration and reconstruction of mangrove forests in China is becoming more and more imperative. To do this work more effec-

tively, the publication of the book *Techniques for Restoration and Reconstruction of Mangrove Forests in China* timely meets the current and urgent demands. Using the principles of restoration ecology, the book comprehensively elucidated the theory and methods of restoration and reconstruction of mangrove forests in China. The contents included seed origin selection, introduction, seeding, planting, pest control, reconstruction of inefficient forest, effects of restoration, resource protection and management. The book put forward some new ways for the effective protection and restoration of the mangrove ecosystem in China, which would be of scientific value not only in China but also to other countries with similar situations.

LI DEZHI¹ and QIN AILI²

¹Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N), Shanghai, China. 200062;

²Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd. Songjiang, Shanghai, China. 201600)

!Priority! The Dating of Scientific Names in Ornithology: A Directory to the Literature and its Reviewers

Compiled and edited by: Edward C. Dickinson, Leslie K. Overstreet, Robert J. Dowsett and Murray D. Bruce. Aves Press, Northampton, U.K. 319 pages. 135.00 USD. Cloth.

The *International Code of Zoological Nomenclature* (I.C.Z.N.) governs the application and use of scientific names in zoology. The date of its starting point has long been arbitrarily fixed as 1 January 1758, the year that Linnaeus published *Systema Naturae*. One of the founding principles of the I.C.Z.N. is the Principle of Priority, which historically, with a few exceptions, has been applied strictly and consistently. But, as was stated in 1948 concerning botanical scientific names, "it demands much time to unearth certain notes, comments or reference, concerning dates of publication."

Publication of this sumptuous treasure trove of interesting and often useful facts is proof that the complicated search for even earlier names and descriptions of taxa continues. The four compilers have brought together "a compendium of what has been learned and published" with "references to where to find the best advice on dating." They explain how, until recently, James L. Peters' 16-volume *Check-list of the Birds of the World*, begun in 1931 and completed twenty years after his death in 1986, has served as the baseline. They investigate in detail 156 books and 118 leading journals, noting particularly how long-accepted dates of publication given in a book or journal may vary appreciably from the actual date of appearance in print. They present a useful Glossary, an extensive reference list and peripheral items that include Russian names for

months, the French Revolutionary Calendar which functioned from 1792 to 1806, and explain where to search for watermarks. They provide helpful background, discuss implications of their findings, and attach a compendious CD-ROM for detailed reference.

The four compilers – aided by 80 contributors (including 3 from Canada) and 184 others who supplied information, have relied heavily on two unpublished card indexes. One had been compiled by Charles Davies Sherborn (1862-1942) in the general library of the Natural History Museum in London, England, and the other by Charles Wallace Richmond (1868-1932) in the Division of Birds in the Natural Museum of Natural History in the Smithsonian Institution, Washington, D.C. The book is dedicated to their memory. The four compilers also speak highly of *Zoonomen*, "a rich and helpful web resource" – whose webmaster is a medical pathologist in Walla Walla, Washington.

The compilers rate 156 "landmark" (my term) books that have contained new scientific names. In 50 instances they have rated the exact dates of publications as Resolved, 83 as Best Available and 23 as Unresolved. Similarly for 118 scientific journals, only 37 were Resolved, 40 were Best Available, and a surprisingly high 41 were Unresolved. Another 47 listed journals have not yet been assessed. The CD ROM, attached to the inside back cover of the book, provides tables of dates compiled for 18 of the books and 47 of the

periodicals and a 34-page table of taxon names where a new name appeared in a work that was previously misdated. Even so, some of the provisional dates given here "are expected to be modified as a consequence of future work."

The reader is left with the fear that undetected or inadequately studied dates may in future cause a few type specimens currently accepted, to be proven not to have the priority assumed. Let me provide one example from Saskatchewan experience. As late as 1995 Banks and Browning (*Auk* 112:633-648, 1995) proved that *Fauna Boreali-Americana, volume 2, The Birds*, with a stated publication date of 1831, had not reached print until February 1832, whereas Nuttall's 1832 *Manual* was available for sale in December 1831! This discovery stripped the credit for the first or "type" specimen of the Olive-sided Flycatcher from Richardson and Drummond's 1827 specimen from Carlton on the North Saskatchewan, named *Contopus borealis* by Swainson. After use for 163 years, the priority was awarded to Nuttall's specimen from Mount Auburn, next door to Boston.

The compilers admit they rushed this incomplete study into print because of impending publication of the 4th edition of the *Howard and Moore Complete Checklist of the Birds of the World*. They consider *Priority!* to be its pre-requisite. Thus their ongoing project is in itself a little scary. Now that taxonomy is already, appropriately, in turmoil due to new sophisticated studies of bird vocalizations and especially DNA-based studies, which call for division of some genera

into new species, I propose a question. Will it not soon be time (e.g., the 300th anniversary of Linnaeus's *Systema Naturae* in 2158), to give a definite date when, for practical reasons, a study of priority should cease?

Priority! catalogues past errors, irregular timing of journal publication, and unfortunate errors in documentation by first describers of new genera, species and subspecies. It is moderately reassuring that many books and journals can be accepted as fact, but 23 of the books and 43 of the journals studied require further investigation of their dates of publication.

In summary, this book, the first to explain the importance of priority in naming new bird taxa, is only a beginning. One cannot turn back the clock, but I cannot help wishing that someone had undertaken this prodigious five-year effort a century sooner. The compilers call for "standard usage of names" (p.8), yet they identify sources where dates are sufficiently variable, inconsistent or obscure, that taxonomists with an historical bent can search for new priorities that will change current names, contravening rather than supporting standard usage. The compilers admit that "many ornithologists regard dates as of trivial importance." Only for someone like me who is interested in ornithological nomenclature, will this book be fun to read; yet at times it becomes repetitious and at times pedantic with minutiae. In spite of its relatively high price, I predict it will become a must for every major University library and museum.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

A Zoologist on Baffin Island – 1953

By Adam Watson. 2011. Paragon Publishing, 4 North Street, Rotherrsthorpe, NN7 3BJ, UK. 241 pages. 49.99 USD. Cloth.

I have skimmed, read, re-skimmed and re-read this book, savouring its account of the days when groups of young men (almost exclusively), many of them non-Canadian, were doing almost all the field research in arctic Canada. (My wife and I, living alone in a tent and researching Ogac Lake, on Baffin Island in 1957, were among rare exceptions.) The cover and title page are unusually expansive: "By husky and foot over sea, snow and tundra," "A zoologist has the time of his life in his Arctic paradise, by Inuit dog-sledge, foot, snowshoe and ski, on sea-ice, coast, valley, mountain, with a special study of snowy owls and lemmings;" and "four months of Arctic adventure." And so is the book. The author was one of the 14-member 1953 expedition by the Arctic Institute of North America to Pangnirtung Pass and the nearby mountains and glaciers beyond Cumberland Sound, Baffin Island, and now largely within Ayuittuq National Park. The main part is a daily narrative compiled from field notes and published accounts by the author and others, and is focused on days in at the "Bio Camp" in the Pass, but also gives

space to the work and adventures of other groups (and mis-adventures, including a tragic death in a raging meltwater stream). Everything is permeated by the joys of adventure and the stamina needed to contend. The book is illuminated by a large number of stunning, mostly colour, images, themselves a priceless glimpse into those wondrous days.

"Part B" has chapters on the author's zoological work, not as intended on the then low-cycle ptarmigan, but largely on breeding biology of Snowy Owls and their links with lemmings, on passerine birds, flora and insects, and short biographies of expedition members, in more detail for some. There are two afterthoughts – both really laments. One, in the chapter of biographies, is "a look back at the expedition's scientific work after 58 years." The other is in the final chapter on "Then and now." There is no doubt that the 1953 expedition was productive of good science, and that funding has been curtailed for such multi-disciplinary expeditions, along with large-scale, long-term research. And I certainly share Watson's concerns about pres-

ent focus on arctic sovereignty and economic return. However, his rant on "Health and Safety laws and Nanny State jokers" (p. 235) might have been tempered by his memory of one death (chapter 15) and one "near-death experience" (chapter 16) during the 1953 expedition. In truth, smaller groups and individual researchers using modern technologies can now address old questions more easily, and ask new ones unanswerable in the 1950s. Glaciologists' arguments about locally non-glaciated "nunataks," are now settled by small samples from rock surfaces to determine if and when they were sheltered from cosmic rays by ice cover. Much of the behavioural biology of birds so well studied by Watson can now be more rapidly and extensively understood using DNA samples, video recorders, data loggers, and tiny transmitters with much less slog-

ging in the field. The author also seems strangely dismissive of the evidence for global warming and hostile to papers linking population trends and predictions about birds, etc., that can be obtained from large, admittedly ill-controlled data sets by non-scientific observers (think: Breeding Bird Surveys); modern statistical inference can squeeze important results out of large amounts of such data.

Despite its idiosyncrasies and rather disorganized structure, I strongly recommend this book as a delight to read and for its insights into how arctic field research was done in those far-off days.

IAN McLAREN

Biology Department, Dalhousie University, Halifax, Nova Scotia B3H 4J1

NEW TITLES

Prepared by Roy John

† Available for review * Assigned

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

ZOOLOGY

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Aves de Portugal; Incluindo os arquipélagos dos Açores, da Madeira e das Selvagens [Portuguese]. By Helder Costa, Eduardo de Juana and Juan M. Varela. Lynx Edicions, Montseny, 8, 8193 Bellaterra, Barcelona, Spain. 240 pages. 20.00 EUR. Cloth.

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News and Comment

Alliance of Natural History Museums of Canada Awards 2011

A special reception of the Alliance of Natural History Museums of Canada (ANHMC) was held on October 24, 2011 on Parliament Hill, where the fifth annual Bruce Naylor Award was presented. The Bruce Naylor Award is named for the former director of the Royal Tyrrell Museum of Palaeontology. Deceased in 2007, Dr. Naylor had also served as president of the ANHMC.

This year's recipient was Dr. David Green, noted conservationist and one of Canada's foremost experts on amphibians. The award recognizes significant contributions to the museum-based study of natural history in Canada. Dr. Green is currently a professor at McGill University and Director of the Redpath Museum. He has made his mark over a 30-year career as a scientist, museum administrator, teacher and conservation advocate. He has authored more than 120 scientific articles, books and publications, mainly about frogs and other amphibians. Dr. Green was a founding member of the Canadian Association of Herpetologists and the first Editor of their Bulletin.

"I was lucky to have discovered a passion for wildlife when I was very young, and I have long considered it a privilege to be able to pursue that passion professionally," he says. His academic path has taken him across Canada, from undergraduate studies at UBC to a doctorate at the University of Guelph. After post-doctoral work at the University of California at Berkeley, he had brief stints as a biology professor at McMaster University and the University of Windsor. By 1986, he had landed at McGill University and the Redpath Museum, where he continues today.

Green's passion for nature goes well beyond the lab and his fieldwork. He is a leading figure in the promotion of conservation, demonstrated most visibly through his membership with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), which he chaired for four years starting in the late 1990s. Every year this national group issues a public report identifying species at risk, based on scientific data.

While serving as co-chair of COSEWIC's Amphibians and Reptiles Subcommittee, he completed the first

assessment of all Canadian amphibians at risk. He also led a task force that documented the decline in amphibian populations in Canada – a phenomenon that garnered much media attention given associations with environmental degradation and habitat destruction. Also as Chair of COSEWIC, Dr. Green manoeuvred through a maze of policy and politics to bring COSEWIC assessments into the new Species at Risk Act.

Over his 25 years at the Redpath Museum, Green's drive and determination has ensured that the museum – one of Canada's oldest – was brought into McGill University's Faculty of Science. Since 2005, under his leadership as Director, the museum's public program has expanded and achieved stable funding, its teaching lab has been completely renovated, and a new program Minor in Natural History has been instituted along with new museum courses.

As noted by his nominators: "Any one of Professor Green's records of accomplishment in the fields of science, wildlife conservation, public service, education or advancement of museums would be—and have been—worthy of commendation. Combined, they demonstrate the exceptional contributions that he has made to museum-based natural history sciences and policy in Canada."

The network was created in 2003 to enhance collaborative work in the areas of research, collections development, and education about the natural environment. The 17 members of ANHMC are: the Royal B.C. Museum, the Beaty Biodiversity Museum, the Vancouver Aquarium, Royal Alberta Museum, Royal Tyrrell Museum of Palaeontology, Prince of Wales Northern Heritage Centre, Yukon Beringia Interpretive Centre, Royal Saskatchewan Museum, Manitoba Museum, the Royal Ontario Museum, Toronto Zoo, Canadian Museum of Nature, Montreal's Espace pour la Vie (Biodôme, Insectarium, Botanical Gardens and Planetarium), Montreal's Redpath Museum, New Brunswick Museum, Nova Scotia Museum of Natural History, and The Rooms Provincial Museum (Newfoundland and Labrador).

The Canadian Herpetologist (TCH) 1(2), Fall 2011

The Canadian Herpetologist (TCH) is a publication produced twice each year by the Canadian Association of Herpetologists and the Canadian Amphibian and Reptile Conservation Network.

CONTENTS: Executive Members of Societies — Instructions for Authors — Editorial Notes — Meet-

ings: CARCNET/ CAH CONFERENCE — Feature Article: Withering Funds, Haves and Have-nots: Dwindling Support for Basic Research in Canada by *Steve Hecnar* — Field Notes: A Review of Historic and Unverified Butlers Gartersnake Locations in Southern Ontario by *Jonathan Choquette* — Book

Reviews — Thesis Abstracts in Canadian Herpetology: **Choquette, J. D.** M.Sc. 2011. University of Guelph, Guelph, ON. (Supervisor: Robert Corry). Reconnecting Rattlers: Identifying potential connectivity for an urban population of Eastern Massasauga Rattlesnakes. — **Larocque, S. M.** M.Sc. 2011. Carleton University, Ottawa, ON. (Supervisors: Gabriel Blouin-Demers and Steve Cooke). Occurrence and mitigation of freshwater turtle bycatch and mortality associated with inland commercial hoop net fisheries. — **Paterson, J.**

E. M.Sc. 2011. Laurentian University, Sudbury, ON. (Supervisor: Jacqueline Litzgus). Resource selection in a freshwater turtle community in central Ontario. — **Robson, L. E.** M.Sc. 2011 University of Ottawa, Ottawa, ON. (Supervisor: Gabriel Blouin-Demers). The spatial ecology of eastern hognose snakes (*Heterodon platirhinos*): habitat selection, home range size, and the effects of roads on movement patterns. — Recent Publications in Canadian Herpetology — News and Announcements — Membership Form: CAH.

Naming Rights to Two Newly Discovered Lichens Auctioned Off as Fundraisers for Two B.C. Environmental Groups

Naming rights to two undescribed lichens came to close at public auctions on December 15, 2011. The lichens were discovered in British Columbia's southern interior by acclaimed lichenologist Trevor Goward, curator of lichens at the Beaty Biodiversity Museum of the University of British Columbia. Earlier this year Trevor decided to donate his new species as fundraisers, one to the Ancient Forest Alliance (AFA) and the other to The Land Conservancy (TLC), both based in Victoria.

The lichen donated to The Ancient Forest Alliance was a *Bryoria* or "Horsehair Lichen", which forms elegant black tresses on the branches of trees. Wildlife artist Anne Hansen bid \$4,000 for the right to name this species *Bryoria kockiana*, in memory of her husband, University of Guelph horticulturist Henry Kock,

who passed away in 2005. The Ancient Forest Alliance will use the money in their efforts to halt the liquidation of B.C.'s remaining oldgrowth forests.

The Sulyma family purchased naming rights to the other lichen, a *Parmelia* or "Crottle Lichen", also a branch-dweller, from The Land Conservancy for \$17,900. The family named their lichen *Parmelia sulymae*, in honour of B.C. forester and caribou biologist Randy Sulyma who died tragically in early 2011. The money will help The Land Conservancy create a wildlife corridor for southern Wells Gray Provincial Park.

Trevor hopes the success of these auctions will encourage taxonomists around the world to put new species to work on behalf of the ecosystems that support them — an initiative he refers to as "taxonomic titling".

Phillip Merrill Youngman: 1927-2011

Phillip Merrill Youngman, mammalogist and all-around naturalist, passed away 22 November 2011 at age of 84 after a long illness. Phil spent most of his career at the Canadian Museum of Nature, 1960-1992, beginning when the museum was called the National Museum of Natural Sciences. He served in various positions including Curator of Mammals, Exhibits Planner, and finally Assistant Curator of Quaternary Zoology. Among his publication were Mammals of the Yukon Territory, *Museum of Natural Sciences, National*

*Museums of Canada, Publications in Zoology (10) 192 pages (1975); Distribution and systematics of the European mink *Mustela lutreola* Linnaeus 1761. *Acta Zoologica Fennica 166: 1-48 (1982); The Pleistocene small carnivores of Eastern Beringia. *The Canadian Field-Naturalist 107(2): 139-163 (1993).* A detailed tribute and bibliography by Irwin M. Brodo and Francis R. Cook will be published in a future issue of *The Canadian Field-Naturalist.***

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Book Reviews. We publish many reviews of books of interest to naturalists, from all over the world (i.e., not necessarily related to Canadian species). Each issue includes a list of new book titles received by our Book Reviews Editor with notation on books available for review, although we are open to suggestions of reviews for other titles. All book reviews and inquiries related to book reviews should be sent to our Book Review Editor, Roy John (r.john@rogers.com). Book reviews are edited by Roy John, but are not considered peer-reviewed.

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Environment Canada. 2008. National Climate Data and Information Archive, Environment Canada. Accessed 5 November 2008. www.climate.weatheroffice.gc.ca.

Friends of Fish Creek Provincial Park Society. 2009. Water quality monitoring report 2009. Accessed 20 March 2011. <http://wsow.brbc.ab.ca/reports/FishCreekStudy2.pdf>.

Stevens, V. 1995. Wildlife diversity in British Columbia: distribution and habitat use of amphibians, reptiles, birds, and mammals in Biogeoclimatic Zones. Working Paper 04. B.C. Ministry of Forest Research Program, and Ministry of Environment, Lands, and Parks' Habitat Protection Branch, Victoria, British Columbia, Canada. 288 pages.

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Arthur, S. M., W. B. Krohn, and J. R. Gilbert. 1989. Habitat use and diet of fishers. *Journal of Wildlife Management* 53: 680-688.

Coulter, M. W. 1966. Ecology and management of fishers in Maine. Ph.D. thesis, Syracuse University, Syracuse, New York, USA.

MacKinnon, C. M., and A. C. Kennedy. 2009. Canada Lynx, *Lynx canadensis*, use of the Chignecto Isthmus and the possibility of gene flow between populations in New Brunswick and Nova Scotia. *Canadian Field-Naturalist* 122: 166-168.

Nelson, D. R., R. Guidetti, and L. Rebecchi. 2009. Tardigrada. Pages 455-484 in *Ecology and Classification of North American Freshwater Invertebrates*. Edited by J. H. Thorp and A. P. Covich. Third edition. Academic Press, San Diego, California.

Tufts, R. W. 1961. The Birds of Nova Scotia. Nova Scotia Museum, Rolph-Clark-Stone, Maritimes Limited, Halifax, Nova Scotia. 481 pages.

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Editor-in-Chief, CFN
Box 35069, Westgate PO
Ottawa, ON, K1Z 1A2
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Contact Information

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Ottawa Field-Naturalists' Club (our publisher) website:
www.ofnc.ca

Editor-in-Chief: Dr. Carolyn Callaghan
editor@canadianfieldnaturalist.ca

Assistant Editor: Trina Rytwinski
canadianfieldnaturalistae@gmail.com

7677 21
Book Review Editor: Roy John
r.john@rogers.com

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subscriptions@canadianfieldnaturalist.ca

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