The Canadian Field-Naturalist

Volume 129, Number 2 April–June 2015

Using an Integrated Recording and Sound Analysis System to Search for Kirtland's Warbler (*Setophaga kirtlandii*) in Ontario

Stephen B. Holmes[1, 2, 6], Ken Tuininga[3], Kenneth A. McIlwrick[1], Margaret Carruthers[4], and Eric Cobb[5]

[1]Canadian Forest Service, Natural Resources Canada, 1219 Queen St. E., Sault Ste. Marie, Ontario P6A 2E5 Canada
[2]Current address: 23 Atlas St., Sault Ste. Marie, Ontario P6A 4Z2 Canada
[3]Canadian Wildlife Service, Environment Canada, 4905 Dufferin St., Toronto, Ontario M3H 5T4 Canada
[4]Ontario Ministry of Natural Resources, Sault Ste. Marie District, 64 Church St., Sault Ste. Marie, Ontario P6A 3H3 Canada
[5]Ontario Ministry of Natural Resources, North Bay District, 3301 Trout Lake Road, North Bay, Ontario P1A 4L7 Canada
[6]Corresponding author: erin.steve@shaw.ca

Holmes, Stephen B., Ken Tuininga, Kenneth A. McIlwrick, Margaret Carruthers, and Eric Cobb. 2015. Using an integrated recording and sound analysis system to search for Kirtland's Warbler (*Setophaga kirtlandii*) in Ontario. Canadian Field-Naturalist 129(2): 115–120.

We used automated sound recording devices and analysis software to search for Kirtland's Warbler (*Setophaga kirtlandii*) in northeastern Ontario. In 2012, we conducted surveys at 38 locations in three Ontario Ministry of Natural Resources administrative districts: Chapleau, Sault Ste. Marie, and Sudbury. We detected a Kirtland's Warbler at one location in Sault Ste. Marie District on a single date: June 6. We believe that the recording and analysis approach we used is an effective method for detecting Kirtland's Warbler, or other rare bird species, across extensive areas of their potential range.

Key Words: Kirtland's Warbler; *Setophaga kirtlandii*; automated recording devices; sound analysis software; breeding range; northern Ontario; Algoma District

Introduction

Kirtland's Warbler (*Setophaga kirtlandii*) is an endangered species in Canada (COSEWIC 2013*) and the United States (USFWS 2014*). Kirtland's Warbler is a habitat specialist; during its breeding season, it prefers extensive tracts of young, densely stocked Jack Pine (*Pinus banksiana*) growing on well-drained sandy soils (Mayfield 1960; Walkinshaw 1983). The species also occasionally nests in stands dominated by Red Pine (*Pinus resinosa*), provided there is a Jack Pine component (Probst and Weinrich 1993; Anich *et al*. 2011; Richard 2013).

Until fairly recently, the only known breeding locality of Kirtland's Warbler was in the northern Lower Peninsula of Michigan. As a result of habitat management, aggressive control of Brown-headed Cowbird (*Molothrus ater*), and wildfires in the species' core breeding range, the Michigan population expanded considerably starting in the early 1990s (Probst and Weinrich 1993; Kepler *et al*. 1996; Donner *et al*. 2008), leading to an extension of the species' range. Small numbers of Kirtland's Warblers have nested in Michigan's Upper Peninsula since 1995 (Probst *et al*. 2003) and in Wisconsin since 2007 (Trick *et al*. 2008).

There are very few confirmed breeding records for Kirtland's Warbler in Canada. In August 1945, a pair was observed feeding a juvenile near Barrie, Ontario (Speirs 1984), although this record is dubious, because the siting was late in the breeding season, and the location was a mixed deciduous woodlot, not typical Kirtland's Warbler habitat. The best evidence of Kirtland's Warbler breeding in Canada comes from Garrison Petawawa (formerly Canadian Forces Base Petawawa) in Ontario, where six nests containing either eggs or young were found between 2007 and 2012 (Richard 2013). Kirtland's Warblers have been observed in potential breeding habitat at several other locations in Ontario and at one location in Quebec, but breeding has not been confirmed (COSEWIC 2008*).

The extensive areas of Jack Pine forest across Ontario are potential breeding habitat for the Kirtland's Warbler. If the core population in Michigan continues to increase and eventually saturates the available habitat, it is likely that the species will continue to expand into suitable habitat in Ontario (Environment Canada 2006*). Although several targeted surveys have recently been conducted in Ontario to detect breeding Kirtland's Warblers, no evidence has been found except for the nests at Garrison Petawawa (Environment Canada 2006*). However, the area searched has been relatively small compared with the potential habitat available, and it is possible that the species may be present in remote locations that have yet to be surveyed (COSEWIC 2008*).

Automated recording systems have been shown to be a useful tool for documenting the distribution of forest bird species-at-risk in highly fragmented agricultural

landscapes (Holmes *et al*. 2014). They have also been recommended as a means to facilitate large-scale monitoring of birds in remote locations, such as Canada's boreal forest (Venier *et al*. 2011). The use of recordings has two potential advantages over site visits by observers in terms of documenting the presence of rare species: conducting multiple recordings on multiple days makes the detection of a rare species more likely (Holmes *et al*. 2014); and sound recordings provide a permanent record (Haselmayer and Quinn 2000) from which the species of concern can be unambiguously identified.

In this paper, we present the results of a survey conducted using automated recording devices in 2012 to determine the occupancy of apparently suitable habitat patches by one of Canada's rarest bird species, the Kirtland's Warbler.

Methods

We deployed recorders (Song Meter SM2; Wildlife Acoustics, Inc., Concord, Massachusetts, USA) at 38 locations in three Ontario Ministry of Natural Resources (OMNR) administrative districts (Chapleau, Sault Ste. Marie, and Sudbury) in northeastern Ontario (Figure 1, Table 1). In consultation with members of the Canadian Wildlife Service's Kirtland's Warbler recovery team and OMNR foresters and biologists, survey locations were chosen to be representative of potentially suitable Kirtland's Warbler habitat, i.e., Jack Pine dominated stands, less than 20 years old (Table 1). We also deployed recorders in three known Kirtland's Warbler territories in Michigan's eastern Upper Peninsula, as a check on the system's ability to detect the species.

We programmed the recorders to make eight recordings each day: a 75-min recording starting 15 minutes before sunrise; and seven, 10-minute recordings starting 75, 100, 125, 150, 175, 200, and 225 minutes after sunrise. Daily sunrise was determined by date and geographic location. The number of days that locations were surveyed varied from 5 to 38 (median 10) depending on the availability of recorders and personnel. Recordings were made at a sample rate of 24 000 Hz and saved as 16-bit pulse code modulation (PCM) wav files.

We analyzed the recordings using Song Scope version 4.1.1 automated recognition software (Wildlife Acoustics, Inc.), which uses patented algorithms to build a recognizer from training data containing samples of a species' vocalizations. Our Kirtland's Warbler recognizer was built using training data from the Borror Laboratory of Bioacoustics, Ohio State Univer-

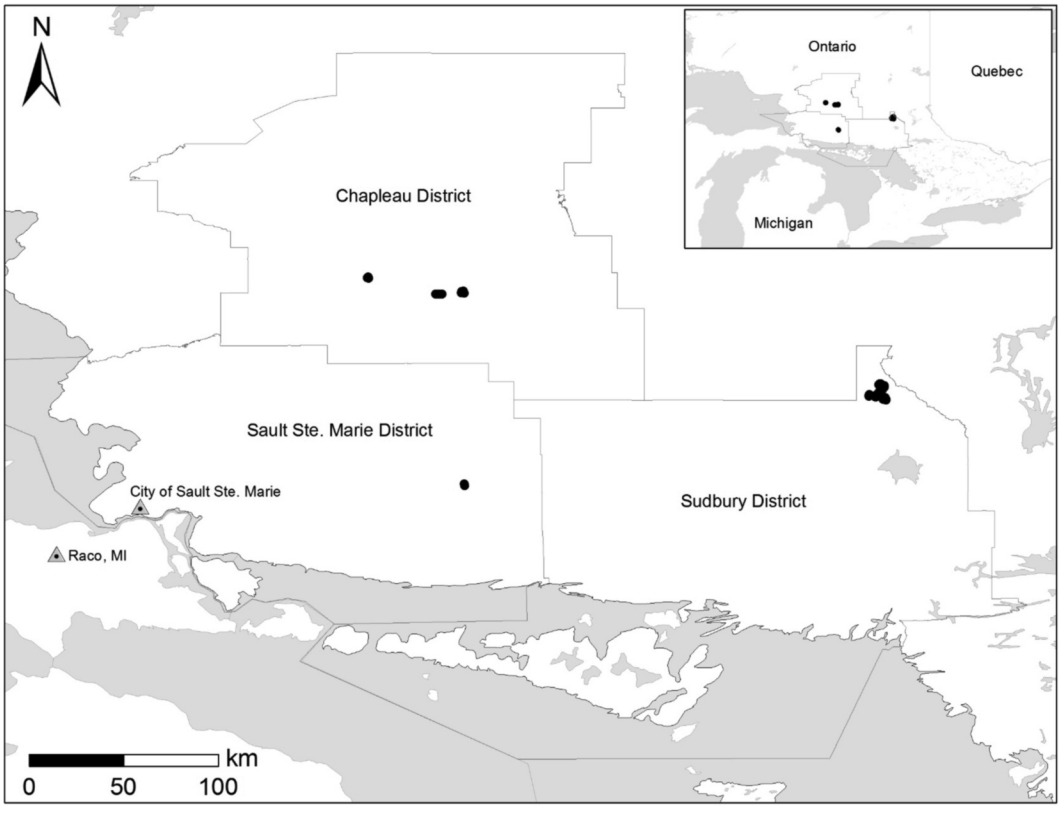

FIGURE 1. Location (black dots) of 38 sound recorders deployed to detect the Kirtland's Warbler (*Setophaga kirtlandii*) in northeastern Ontario, 1 June to 8 July 2012.

TABLE 1. Details of recordings made in potential Kirtland's Warbler (*Setophaga kirtlandii*) habitat in northeastern Ontario, Canada, 1 June to 8 July 2012.

OMNR district*	Location ID	Start date	End date	Number of recording days	Recording time (h:min.)	Stand age (years)	Stand composition†
Chapleau	Sultan2-A	1 June	8 July	38	85:10	8	Pj100
	Sultan1-C	1 June	8 July	38	85:10	9	Pj90 Sb10
	Sultan3-C	1 June	8 July	38	85:10	6	Pj100
	Sultan3-E	1 June	8 July	38	85:10	6	Pj100
	Sultan2-C	1 June	8 July	38	85:10	8	Pj100
	Sultan1-A	1 June	8 July	38	85:10	9	Pj90 Sb10
	Sultan3-D	1 June	8 July	38	85:10	6	Pj100
	Sultan3-B	1 June	8 July	38	85:10	6	Pj100
	Sultan3-A	1 June	8 July	38	85:10	6	Pj100
	Sultan2-D	1 June	8 July	38	85:10	8	Pj100
	Sultan2-E	1 June	8 July	38	85:10	8	Pj100
	Sultan2-B	1 June	8 July	38	85:10	8	Pj100
	Sultan1-B	1 June	8 July	38	85:10	9	Pj90 Sb10
Sault Ste. Marie	Algoma East	1 June	28 June	28	67:40	6	Pj34 Pr33 Sb33
Sudbury	Howey3	1 June	7 June	7	16:55	14	Pj70 Sb20 Po10
	Howey6	8 June	12 June	5	12:05	14	Pj70 Sb20 Po10
	Marconi 5	13 June	22 June	10	24:10	19	Pj80 Sb10 Po10
	Howey14	23 June	29 June	7	16:55	17	Pj70 Sb20 Po10
	Marconi1	1 June	7 June	7	16:55	14	Pj80 Sb20
	Howey9	8 June	12 June	5	12:05	14	Pj80 Sb20
	Marconi6	13 June	22 June	10	24:10	19	Pj80 Sb10 Po10
	Howey15	23 June	29 June	7	16:55	18	Pj80 Sb10 Po10
	Marconi2	1 June	7 June	7	16:55	14	Pj80 Sb20
	Marconi3	8 June	12 June	5	12:05	19	Pj80 Sb10 Po10
	Marconi7	13 June	22 June	10	24:10	18	Pj70 Sb20 Po10
	Howey12	23 June	29 June	7	16:55	17	Pj70 Sb20 Po10
	Howey4	1 June	7 June	7	16:55	14	Pj80 Sb20
	Howey8	8 June	12 June	5	12:05	14	Pj80 Sb20
	Howey10	13 June	22 June	10	24:10	14	Pj80 Sb10 Bf10
	Howey17	23 June	29 June	7	16:55	18	Pj80 Sb10 Po10
	Howey1	1 June	7 June	7	16:55	14	Pj70 Sb20 Po10
	Howey5	8 June	12 June	5	12:05	14	Pj70 Sb20 Po10
	Marconi4	13 June	22 June	10	24:10	19	Pj80 Sb10 Po10
	Howey16	23 June	29 June	7	16:55	18	Pj80 Sb10 Po10
	Howey2	1 June	7 June	7	16:55	14	Pj70 Sb20 Po10
	Howey7	8 June	12 June	5	12:05	14	Pj80 Sb20
	Howey11	13 June	22 June	10	24:10	14	Pj80 Sb10 Bf10
	Howey13	23 June	29 June	7	16:55	17	Pj70 Sb20 Po10

*OMNR = Ontario Ministry of Natural Resources.
†Stand composition based on Ontario's most recent Forest Resource Inventory; Bf = Balsam Fir (*Abies balsamea*), Pj = Jack Pine (*Pinus banksiana*), Po = Poplar sp., Pr = Red Pine (*Pinus resinosa*), Sb = Black Spruce (*Picea mariana*).

sity, Columbus, Ohio, USA (285 vocalizations from 29 individuals). Song Scope scans new recordings to produce a spreadsheet of candidate vocalizations that match the recognizer. These candidates must be examined individually (spectrogram and/or audio) to confirm the identification. See Holmes *et al*. (2014) for a full description of the process.

Results

We scanned approximately 1631 h of recordings made between 1 June and 8 July 2012 at 38 Ontario locations (Table 1). The scan produced 4129 candidate vocalizations, which required about 2 h to review. Sixty-six of 74 candidate vocalizations from a single date (6 June 2012; Table 2) at one location in the Sault Ste. Marie District (Algoma East location) were confirmed to be Kirtland's Warbler (Table 2). The first song at the Algoma East location was detected at 7:25 a.m. and the last song at 9:31 a.m. In contrast, Kirtland's Warblers recorded in Michigan sang on multiple days (range 17–29 days; Table 2), and the first song of the day was usually before sunrise (57 of 68 first songs occurred before 5:45 a.m.). The species was not detected at any locations in the Chapleau or Sudbury districts.

According to Ontario's Forest Resource Inventory, the Algoma East Kirtland's Warbler detection was in a 20.4-ha stand that had been harvested in 2005 and planted in 2006 with 34% Jack Pine, 33% Red Pine, and 33% Black Spruce (*Picea mariana*) (Table 1). In 2012, we estimated tree species composition to be 80%

TABLE 2. Detection of Kirtland's Warbler (*Setophaga kirtlandii*) at one location in Ontario (Algoma) and three locations in Michigan, 1 June to 5 July 2012.

District/county	Recorder location	Recording period	No. of days detected	No. of songs detected
Algoma, Ontario	Algoma East	1–28 June	1*	66
Chippewa, Michigan	Raco1	7 June – 5 July	29	1094
	Raco2	6 June – 5 July	22	1435
	Raco3	5–21 June	17	1388

*Kirtland's Warbler detected on 6 June 2012.

Jack Pine and 20% Red Pine, with a stem density of 2708 stems/ha. Shrub species at the site included Pin Cherry (*Prunus pensylvanica*, 20–30% cover) and willow (*Salix* spp., 0–20% cover), and ground vegetation included blueberry (*Vaccinium* spp., 30–60% cover) and Sweet-fern (*Comptonia peregrina*, 0–25% cover). The occupied stand was located in a larger area (~2500 ha) of predominantly Jack Pine forest (> 70% Jack Pine) of mixed ages and stand sizes.

Discussion

The detection of Kirtland's Warbler in Algoma East is the tenth record of the species in northern Ontario (COSEWIC 2008*; Petrucha *et al*. 2013) and only the fourth of an individual in potential breeding habitat (others were two males and one unknown; Richard 2013). The other records were for Sault Ste. Marie in 1978, Makwa Lake in Sudbury District in 1982 (potential breeding habitat), Minaki in Kenora District in 1988 (potential breeding habitat), Killarney Provincial Park in Sudbury District in 1993 and 1998, the Thessalon area in Algoma District in 1997 (potential breeding habitat), Meldrum Bay on Manitoulin Island in 2007, the Mississagi Straits in Manitoulin District in 2008, and Lake Manitou on Manitoulin Island in 2009 (COSEWIC 2008*; Petrucha *et al*. 2013).

The fact that the Kirtland's Warbler recorded in Algoma East was singing on 6 June, but not during the 5 days before or 22 days after this date, suggests two possibilities: the recording location was outside the core range of a bird that was defending a breeding territory nearby; or a bird was prospecting in the area for a mate, but was unsuccessful and moved to another location. A 1-h search of this area using playbacks on 2 June 2013 did not locate any Kirtland's Warblers (P. Burke, personal communication). The fact that this particular Kirtland's Warbler was detected on only 1 of 28 recording days in 2012 demonstrates the usefulness and power of this method. An observer-based survey conducted at this location on any other day than 6 June would not have detected the species.

The Algoma East Kirtland's Warbler record is somewhat unusual in that it was from a mixed stand of 6-year-old Jack Pine and Red Pine on a site that had been harvested in 2005 and planted with Jack Pine, Red Pine, and Black Spruce in 2006. Typical Kirtland's Warbler habitat in the core of the species range in Michigan's Lower Peninsula is homogeneous stands of 6–23-year-old Jack Pine that have regenerated after wildfire or that have been planted and managed specifically for Kirtland's Warbler (Walkinshaw 1983; Kashian *et al*. 2003; Donner *et al*. 2008). However, Kirtland's Warblers have also been reported nesting in Red Pine-dominated plantations in Wisconsin (Anich *et al*. 2011) and in mixed Jack Pine–Red Pine stands at Garrison Petawawa in Ontario (Richard 2013). The Kirtland's Warbler also prefers dense stands (stem densities > 2500 stems/ha) for nesting (Probst and Weinrich 1993), a condition that the Algoma East location did satisfy (> 2700 stems/ha).

Our survey method required minimal time in the field (about 9 days to deploy and retrieve the recorders) and did not rely on the participation of skilled observers. Problems with observer-based survey methods include: the expense and logistics involved in maintaining a crew in the field (e.g., for our study, the same level of survey effort using observers would have required hundreds of days of fieldwork); lack of availability of highly trained personnel in some regions (Hobson *et al*. 2002), which can be the case in sparsely populated areas such as northern Ontario; and differences in physical ability and skill level among observers, leading to differences in ability to detect and correctly identify birds (Rempel *et al*. 2005). Using the recording method, no skill in Kirtland's Warbler identification was necessary other than the approximately 2 h required by a single individual to review candidate vocalizations on the recordings.

Across all sites and dates, the automated scan produced a large number of false-positive detections; 4063 of 4129 candidate vocalizations (98.4%) were subsequently determined to be from species other than Kirtland's Warbler. For the eight recordings from the Algoma East location on the date the Kirtland's Warbler was detected, the false-positive rate was much lower: only 8 of 74 candidate vocalizations (10.8%) were from other species.

The scans also resulted in a large number of false negatives. Of the 323 Kirtland's Warbler vocalizations detected by visually scanning spectrograms of the 6 June Algoma East recordings (S. Holmes, unpublished data), 257 were missed by the Song Scope software for a false-negative rate of 79.6%. For a species such as the Kirtland's Warbler, which sings loudly and frequently, this large false-negative rate is probably not a major problem, if the goal is simply to determine

whether the species is present. However, for more secretive species, it could lead to biased estimates of site occupancy. The false-negative rate can be reduced by increasing the sensitivity of the scan, but this would result in more false-positive detections, increasing the time required to review the candidate vocalizations (see Holmes *et al*. 2014 for details). Based on knowledge of the species and the goal of the research project, the false-positive and false-negative rates can and should be adjusted accordingly.

Both field observers and individuals listening to recordings will vary in the number of species they overlook and misidentify, with errors tending to be greater for rarer species (Campbell and Francis 2011). An advantage of the recording method, however, is that it produces a permanent record of a species occurrence that can be confirmed by reference to a library of type vocalizations or by consulting known experts (Holmes *et al*. 2014). Unambiguous identification is an important consideration in conservation planning for rare and endangered species.

We believe that the recording and analysis approach described above and elsewhere (Holmes *et al*. 2014) is a sensitive, efficient, and cost-effective method for detecting rare or uncommon bird species across extensive parts of their potential range, and it could be applied successfully in a search for breeding Kirtland's Warblers in northeastern Ontario. Given that the breeding population in Michigan has been steadily increasing, that there is a well-established breeding population in Michigan's Upper Peninsula close to Sault Ste. Marie, and that there have been two recent sightings of Kirtland's Warbler in Algoma (1997 and 2012), the likelihood that the species may expand its range into northeastern Ontario is far greater than in the past. We suggest that a systematic search of potential Kirtland's Warbler breeding habitat (6–25-year-old Jack Pine stands and mixed stands of Jack Pine and Red Pine) using 20–25 recorders over 2–3 years, and concentrating in and around the area north of the Algoma East detection would be a good next step in the search for additional Kirtland's Warblers in northeastern Ontario. The pattern of detections arising from such a survey would hopefully point to a more limited area that could be intensively searched by skilled personnel in the field.

Acknowledgements

We thank Dr. Paul Aird for his advice on potentially suitable habitat and recording locations in Chapleau District and Mr. Steve Sjogren for deploying recorders in Michigan. Recordings of Kirtland's Warbler were obtained from the Borror Laboratory of Bioacoustics, Ohio State University, Columbus, Ohio, all rights reserved.

Documents Cited (marked * in text)

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2008. COSEWIC assessment and update status report on the Kirtland's Warbler *Dendroica kirtlandii*, in Canada. COSEWIC, Ottawa, Ontario, Canada. Accessed 19 February 2014. http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_kirtlandwarbler_0808_e.pdf.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2013. Canadian Wildlife Species at Risk. COSEWIC, Gatineau, Quebec, Canada. Accessed 26 February 2014. http://www.cosewic.gc.ca/eng/sct0/rpt/csar_e_2013.pdf

Environment Canada. 2006. Recovery Strategy for the Kirtland's Warbler (*Dendroica kirtlandii*) in Canada. Species at Risk Act recovery strategy series. Environment Canada, Ottawa, Ontario, Canada. Accessed 19 February 2014. http://publications.gc.ca/collections/Collection/En3-4-7-2006E.pdf

USFWS (United States Fish and Wildlife Service). 2014. Find endangered species. Database. USFWS, Falls Church, Virginia, USA. Accessed 25 February 2014. http://www.fws.gov/endangered/index.html.

Literature Cited

Anich, N. M., J. A. Trick, K. M. Grveles, and **J. L. Goyette.** 2011. Characteristics of a Red Pine plantation occupied by Kirtland's Warblers in Wisconsin. Wilson Journal of Ornithology 123: 199–205.

Campbell, M., and **C. M. Francis.** 2011. Using stereo-microphones to evaluate observer variation in North American Breeding Bird Survey point counts. Auk 128: 303–312.

Donner, D. M., J. R. Probst, and **C. A. Ribic.** 2008. Influence of habitat amount, arrangement, and use on population trend estimates of male Kirtland's warblers. Landscape Ecology 23: 467–480.

Haselmayer, J., and **J. S. Quinn.** 2000. A comparison of point counts and sound recording as bird survey methods in Amazonian Southeast Peru. Condor 102: 887–893.

Hobson, K. A., R. S. Rempel, H. Greenwood, B. Turnbull, and **S. L. Van Wilgenburg.** 2002. Acoustic surveys of birds using electronic recordings: new potential from an omnidirectional microphone system. Wildlife Society Bulletin 30: 709–720.

Holmes, S. B., K. A. McIlwrick, and **L. A. Venier.** 2014. Using automated sound recording and analysis to detect bird species-at-risk in southwestern Ontario woodlands. Wildlife Society Bulletin 38: 591–598.

Kashian, D. M., B. V. Barnes, and **W. S. Walker.** 2003. Landscape ecosystems of northern lower Michigan and the management and occurrence of the Kirtland's Warbler. Forest Science 49: 140–159.

Kepler, C. B., G. W. Irvine, M. E. DeCapita, and **J. Weinrich.** 1996. The conservation management of Kirtland's Warbler *Dendroica kirtlandii*. Bird Conservation International 6: 11–22.

Mayfield, H. F. 1960. The Kirtland's Warbler. Cranbrook Institute of Science, Bloomfield Hills, Michigan, USA.

Petrucha, M. E., P. W. Sykes, Jr., P. W. Huber, and **W. W. Duncan.** 2013. Spring and fall migrations of Kirtland's Warbler (*Setophaga kirtlandii*). North American Birds 66: 382–427.

Probst, J. R., D. M. Donner, C. I. Bocetti, and **S. Sjogren.** 2003. Population increase in Kirtland's warbler and summer range expansion to Wisconsin and Michigan's Upper Peninsula, USA. Oryx 37: 365–373.

Probst, J. R., and **J. Weinrich.** 1993. Relating Kirtland's Warbler population change to landscape composition and structure. Landscape Ecology 8: 257–271.

Rempel, R. S., K. A. Hobson, G. Holborn, S. L. Van Wilgenburg, and **J. Elliott.** 2005. Bioacoustic monitoring of forest songbirds: interpreter variability and effects of configuration and digital processing methods in the laboratory. Journal of Field Ornithology 76: 1–11.

Richard, T. L. 2013. Characterization of Kirtland's Warbler (*Setophaga kirtlandii*) habitat on a Canadian military installation. MSc thesis, Royal Military College of Canada, Kingston, Ontario, Canada.

Speirs, D. H. 1984. The first breeding record of Kirtland's Warbler in Ontario. Ontario Birds 2: 80–84.

Trick, J. A., K. Grveles, D. DiTommaso, and **J. Robaidek.** 2008. The first Wisconsin nesting record of Kirtland's Warbler (*Dendroica kirtlandii*). Passenger Pigeon 70: 93–102.

Venier, L. A., S. B. Holmes, G. W. Holborn, K. A. McIlwrick, and **G. Brown.** 2011. Evaluation of an automated recording device for monitoring birds. Wildlife Society Bulletin 36: 30–39.

Walkinshaw, L. H. 1983. Kirtland's Warbler: the natural history of an endangered species. Bulletin 58, Cranbrook Institute of Science, Bloomfield Hills, Michigan, USA.

Received 30 April 2014
Accepted 14 February 2015