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Retrospective comparison of the distribution and abundance of breeding Prairie Warbler (*Setophaga discolor*) along eastern Georgian Bay, Ontario, Canada

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Abstract

Species inhabiting rare habitats or unique geographic regions may be underrepresented in standard surveys. More intensive, periodic surveys may be required to improve data quality, especially for species of conservation concern. Prairie Warbler (*Setophaga discolor*) has experienced range-wide declines of >50% in recent decades and is a species of conservation concern in Canada. The largest continually occupied breeding population of this species in Canada occurs along the shoreline of eastern Georgian Bay, Ontario, where annual Breeding Bird Survey and eBird coverage is generally poor. In 2015, we replicated a spatially intensive 1997 survey of this species along the eastern shore of Georgian Bay, visiting the same sites and using comparable methods. We detected more male birds at the survey sites in 2015 (estimated >350 breeding pairs) than in 1997 (estimated 265 breeding pairs). We also surveyed sites farther north than those covered in 1997, but the breeding range appears not to have moved substantially northward. We also conducted additional surveys and canoe transects in the core range in southern Georgian Bay to ensure that breeding birds were not being missed. Combining data from all our surveys in 2015, we estimated a total of 427 singing males in eastern Georgian Bay. Although overall numbers here appear to have increased in recent decades, localized declines in some areas warrant further investigation. The population appears to be stable or increasing in this region, but we recommend intensively re-surveying this population on at least a 20-year basis.

Key words: Warbler; songbird; Neotropical migrant; survey; conservation; management

Introduction

Monitoring bird species over time and space is critical for documenting population changes and informing management efforts (Ralph *et al.* 1995). When the goal is to infer changes in population distribution or abundance, species occupying rare or more remote habitats may be missed by existing large-scale monitoring efforts (Tulloch *et al.* 2013). This is especially true if high reliability of inference is needed to guide actions, such as assessing a species status (Francis *et al.* 2009) or deciding on management for species of conservation concern (Regan *et al.* 2008). Therefore, habitats or regions that are underrepresented by existing surveys may require periodic targetted surveys to improve data quality and coverage (Tulloch *et al.* 2013).

The breeding range of Prairie Warbler (*Setophaga discolor*) includes much of the eastern United States and a few known locations in southern Ontario, Canada (Lambert and Smith 1984; Sullivan *et al.* 2009; Nolan *et al.* 2020). The widespread, nominate subspecies, *Setophaga discolor discolor*, typically occupies shrubby, early-successional habitats maintained by fire or human disturbance across the breeding range (Askins *et al.* 2012; Akresh *et al.* 2015; Can *et al.* 2019). In Ontario, breeding habitat generally consists of sparsely vegetated rock barrens maintained by periodic fire or harsh climatic conditions, and occasionally sparse, shrubby sand dunes (Lambert and Smith 1984; Sutherland and Harris 2007). Typical breeding sites on vegetated rock barrens include Common Juniper (*Juniperus communis* L.) and a sparse overstorey of Eastern White Pine (*Pinus strobus* L.), White Oak (*Quercus alba* L.), and Red Oak (*Quercus rubra* L.; Harris 1998). The largest continually occupied breeding population of Prairie Warbler in Ontario occurs along the shoreline and numerous nearshore islands in southeastern Georgian

Bay. Other small and intermittently occupied breeding populations occur at a few scattered inland sites on the southern edge of the Precambrian Shield in southern Ontario (Sutherland and Harris 2007; Hannah *et al.* 2021). Given that most Prairie Warbler breeding sites in Ontario are associated with areas of exposed granitic rock and shoreline, road densities in these areas are low and access is logistically challenging. Because most breeding sites remain remote and isolated, routine surveys to assess population status and distribution for this species preclude routine inferences about population status, distribution, and trends. We did not find any nests in our coarse evaluation of habitat so cannot expand on these general descriptions.

Based on estimated range-wide population declines of approximately 53% (−1.72%/year) and ongoing habitat loss on both breeding and wintering grounds, conservation concern for this species is high (Environment Canada 2014; Rosenberg *et al.* 2016). In recent decades, several small, isolated breeding populations have disappeared in southern Ontario (Sutherland and Harris 2007), suggesting the species might be declining in the province. Previous estimates suggest that the population in Ontario consisted of ~320 breeding pairs, with 270 of them occurring in southeastern Georgian Bay (Harris 1998; Sutherland and Harris 2007). In recent decades, increased human activity along eastern Georgian Bay, including residential and cottage developments (Sivarajah *et al.* 2018; Neumann *et al.* 2021), may be negatively affecting breeding habitat for this species at the core of its breeding range in Ontario.

In 1997, Harris (1998) conducted the largest and most systematic survey of Prairie Warbler in eastern Georgian Bay to date, visiting 420 sites with suitable habitat. In 2015, we repeated and expanded the spatial extent of this original survey. We hypothesized that the population may have declined in recent decades, based on increased human development in eastern Georgian Bay, combined with increased threats during the non-breeding season (Rosenberg *et al.* 2016). We also hypothesized that, because of these human developments and the possible succession of habitat into more closed-canopy forests through climate change (Hitch and Leberg 2007), the breeding population of this species may have expanded northward. Because very few breeding season records exist for this species along the northern half of the eastern shore of Georgian Bay (Sullivan *et al.* 2009), we were uncertain whether the current breeding range was a result of lack of survey coverage, a habitat or climate limitation, or both. To determine if the species occurs north of the previously described range, we also selected and surveyed random sites north of those visited by Harris (1998). Finally, we summarize the results from all of our surveys and incidental detections in eastern Georgian Bay in 2015 to estimate the total number of Prairie Warbler in our study area.

Methods

Study area

Georgian Bay is the eastern arm of Lake Huron and has a surface area of 15 000 km^2 (Campbell 2017). The shoreline of eastern Georgian Bay is rugged, consisting of granite outcrops and numerous offshore islands (Harris 1998). Vegetation is characterized by mature, but stunted, forest (e.g., ~3–6 m canopy), consisting mainly of mature White Pine, Red Oak, White Oak, and Common Juniper (Lambert and Smith 1984). The area also contains small, localized agricultural and urban developments (~6% of the area; Neumann *et al.* 2021).

Survey designs

Harris 1997—Harris (1998) restricted surveys (Figure 1) to sections of the eastern Georgian Bay shoreline with suitable habitat or sites where Prairie Warbler was recently sighted. Habitat was judged visually for suitability based on the presence of open rock outcrops with mature trees (pine and oak) and shrubby vegetation (juniper and oak). A total of 420 locations were visited across the survey area, stretching from Midland in the south, to just west of Parry Sound in the north. Attempts were made to maintain a minimum distance of 400–500 m between adjacent survey points because bird song seemed to travel extensively over water, but because of the convoluted nature of the shoreline this was not always possible. Sites were visited systematically to reduce the potential for duplicating counts of singing birds. Given the low density of roads in this area and the high suitability of shoreline habitat for this species, most surveys, with few exceptions, were conducted by motorized boat. All survey sites were recorded on a 1:10 000 base map of the region.

Harris re-survey 2015—Survey sites visited by Harris in 1997 were georeferenced so that 2015 revisits were as close to the original sampling sites as possible. Similar to the 1997 surveys, we used motorized boats and visited sites systematically to reduce potential for double-counting individual birds (Harris 1998).

Northern Georgian Bay—To sample areas north of the original Harris survey area from 1997, we used a grid consisting of 1-ha (~50-m radius) hexagons along the shoreline of Georgian Bay as our sampling frame. The general sampling area extended from Parry Sound in the south to French River Provincial Park in the north (Figure 1). To include birds on numerous large nearshore islands, we extended the sampling grid out to 2 km from the mainland. Hexagons with centroids located in water were eliminated

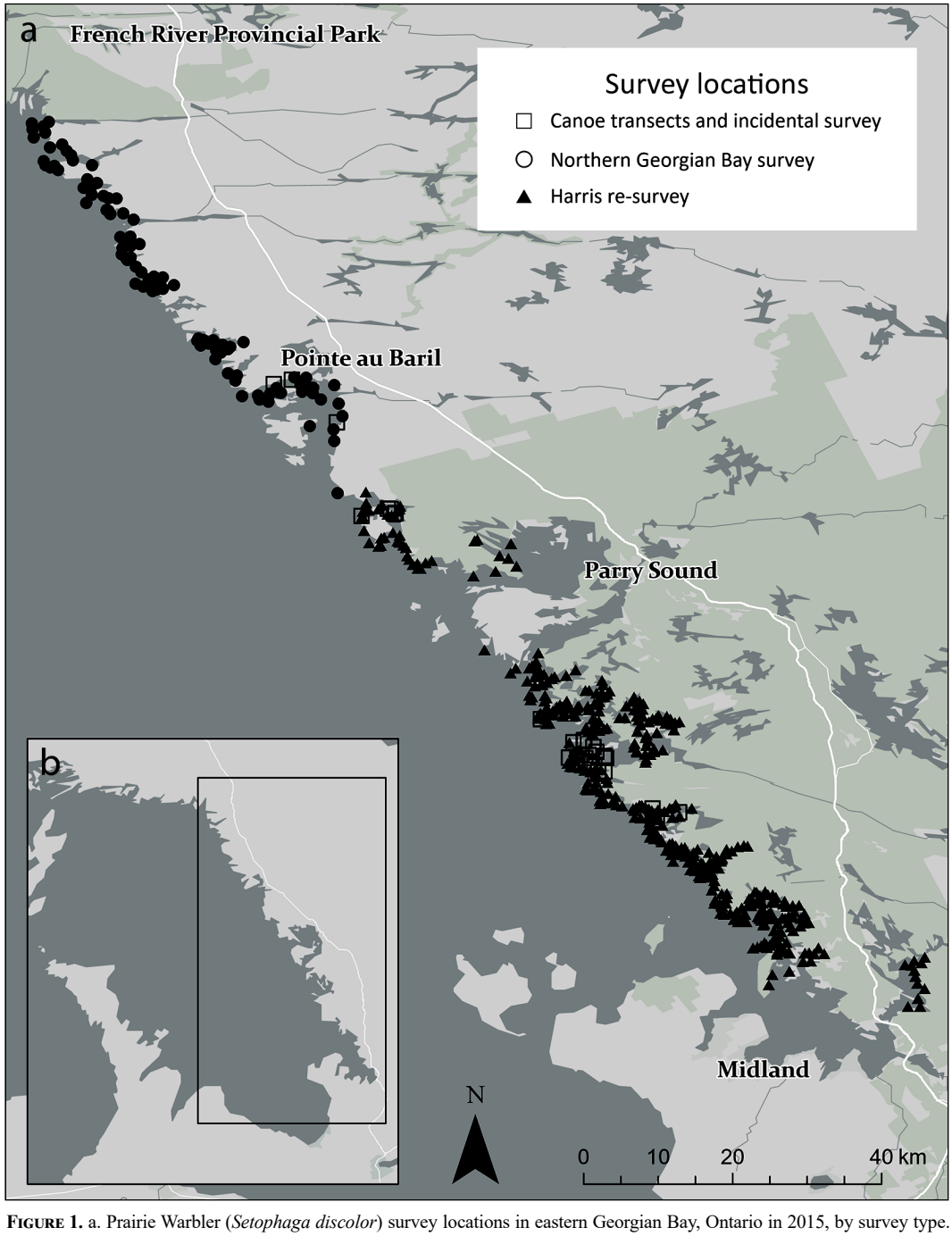

FIGURE 1. a. Prairie Warbler (*Setophaga discolor*) survey locations in eastern Georgian Bay, Ontario in 2015, by survey type. Inset map b. provides the location of the study area in eastern Georgian Bay.

unless 25–75% of the total area within the hexagon was land. Given that male Prairie Warblers appear to prefer shoreline habitat in this area, this range was chosen to avoid selecting sites with little or no shoreline. We randomly selected 350 centroids as our survey sample.

Canoe transects—In extensive areas of shoreline in both northern Georgian Bay and the core of the Prairie Warbler's breeding range, we were unable to conduct surveys using motorboats. We supplemented counts from motorboats with constant-effort shoreline surveys conducted by canoe (Figure 1). This method enabled us to sample many of the shallow bays and small inlets that motorboats were unable to access. The starting points for transect survey routes were selected based on existing spatial coverage gaps, but we defined specific survey routes and sampling duration by daily logistics and weather. Canoes were occupied by a team of two observers and transect routes were typically within hearing distance (≤100 m) of the shoreline.

Field methods

Point count surveys—At each survey point for both the Harris 1997 re-survey and the Northern Georgian Bay survey, we conducted a standard 5-min, unlimited radius point count. Surveys were conducted from 26 May to 20 June 2015, starting around local sunrise and typically ending by late morning. On days when weather permitted, we extended surveys into the afternoon to cover more points. Male Prairie Warblers continue vocalizing well into the afternoon and evening, although often at reduced rates (Harris 1998; Hannah *et al.* 2021). To account for reduced singing rates, we broadcast a 1-min playback of the primary song of Prairie Warbler immediately following the 5-min passive point count during every survey. Harris (1998) mentions including call playback during surveys as well, but the duration and success of this approach were not described. We added an additional 1-min passive listening period following playback to record any birds not detected during the first 5 min. We conducted point counts on days with favourable weather (calm winds) and little precipitation.

Canoe transect surveys—Tracklogs were recorded on handheld global positioning units and a locational waypoint was recorded whenever a singing Prairie Warbler was detected. We used a compass to estimate distance and bearing for each singing bird from a marked waypoint to estimate its location more accurately. We mapped these waypoints and compared them with the locations of our other survey points (i.e., historical and northern Georgian Bay point counts). To avoid double-counting individuals, we removed any detections of singing birds from canoe surveys that were ≤400 m from an existing survey location. Similar to point counts, surveys often extended into the afternoon, so we used shorter 3-min call-playback surveys (1 min passive listening, 30 s call playback, 90 s passive listening) at sites with apparently suitable habitat, but outside the typical morning bird survey period, to encourage male singing. Transect surveys were also conducted during favourable weather conditions.

Incidental detections—We marked waypoints and estimated the distance and direction of all incidental detections of singing birds heard ≥400 m from an existing survey location. We also conducted targetted searches along extensive stretches of shoreline in areas of suitable habitat not covered by existing point counts. Our survey technique involved slowly cruising the shoreline in the motorboat listening for singing birds, noting their location if present and periodically conducting short-duration (3 min) call-playback surveys if spontaneous singing was not detected. We focussed our incidental survey efforts in the core areas of the breeding range in southeastern Georgian Bay.

Population estimate

To estimate the population size in the areas we surveyed in eastern Georgian Bay, we counted all individual singing male Prairie Warblers. This estimate includes a total count of unique males from the Harris 2015 re-survey, the northern Georgian Bay survey, the canoe transect surveys, and any additional incidental detections.

Results

Compared with Harris's 1997 survey (Harris 1998), we detected more birds (321 versus 241) in 2015 at the same sites and more of the 416 accessible sites were occupied (233 versus 170; Table 1). To

TABLE 1. Detection of Prairie Warbler (Setophaga discolor) in a 1997 survey and in our 2015 re-survey.

	1997 sites*		2015 sites
	All	Accessible in 2015†	
No. sites surveyed	420	416	416
No. occupied sites (%)	174 (41.4)	170 (40.9)	223 (53.6)
Total no. individuals observed	245	241	321
Mean no. birds per site (SD)	0.582 (0.843)	0.579 (0.838)	0.772 (0.872)
Estimated no. breeding pairs (+10%)	270	265	353

*Harris 1998.

†Four sites visited in 1997 were not accessible in 2015 because of slightly lower water levels and use of a larger motorboat.

determine any potential northward shifts in the core Prairie Warbler breeding range, we surveyed 97 randomly selected sites in northern Georgian Bay from 1 to 7 June and detected only three singing males at two sites. Given that sites occupied by males were at the southern limit of our northern survey and we detected no additional males farther north, we discontinued this survey to focus our efforts elsewhere.

We detected 36 male Prairie Warbler on the 12 canoe transects (2–11 June) which covered 211.58 km of shoreline (average 17.63 km ± 5.6 km SD). We recorded an additional 28 males incidentally in eastern Georgian Bay, while travelling in motorboats from 2 to 20 June 2015. Although the detection of several males was purely incidental (e.g., hearing spontaneous singing while anchored near shore), we detected several birds while slowly cruising the shoreline or circumventing several large, previously unsurveyed islands that were outside the Harris (1998) survey area.

In total, we detected 388 individual singing male Prairie Warbler from the Midland area in the south, north to Pointe au Baril Channel (Figure 2) during point count surveys, canoe transect surveys, and incidental observations in eastern Georgian Bay.

Discussion

In our various surveys in eastern Georgian Bay in 2015, we detected 388 male Prairie Warbler. Although this is a considerable increase over the previous estimate of 270 breeding birds in 1997, we surveyed areas that were previously missed (Harris 1998; Sutherland and Harris 2007). Even though Harris (1998) compensated for missing birds on his 1997 surveys by adding an additional 10% to the total count (as we did: see Table 1), this is still likely an underestimate. As Harris (1998) made no reference to incidental observations (i.e., birds detected at non-survey locations), it is assumed there were none. In contrast in 2015, we spent considerable time conducting additional surveys in areas of suitable habitat that were not surveyed in 1997 and documenting all incidental observations. Given the >4500 km of shoreline in eastern Georgian Bay (Midwood *et al.* 2012), portions of which remain relatively inaccessible, the number of male Prairie Warbler we detected likely still represents an underestimate. Adding an additional 10% to our 388 total—a conservative number— results in a total estimate of 427 males in our survey area.

In contrast to our first hypothesis that numbers of birds have declined because of various threats, we detected more Prairie Warbler overall and a greater average number of birds per survey site in 2015 (Table 1) compared with 1997 (Harris 1998). In addition to detecting more individuals and more occupied sites in the 2015 surveys, we also detected 64 additional males during canoe transects and incidentally, methods not used and data not collected by Harris (1998). Our more spatially extensive systematic survey in the core range of Prairie Warbler in Canada included many areas of suitable habitat that had not been previously surveyed. Most areas with suitable habitat appeared to be occupied by singing males, detected as a result of our increased sampling efforts.

Disregarding these additional detections, our repeat point counts could suggest a population increase since 1997. Harris (1998) thought it unlikely that he had overlooked significant sections of the Georgian Bay shoreline and immediately adjacent mainland, based on the 420 sites surveyed. It seems unlikely that a substantial amount of additional suitable habitat would have been created in the decades since the original survey. Because both surveys were conducted in a single year and bird density can vary between years (e.g., Sillett *et al.* 2000; Rodenhouse *et al.* 2003), it is possible that one or both survey years may not have been representative of the typical population. However, surveying this population more frequently is both logistically challenging and costly, although subsampling smaller areas in the core breeding range might be a feasible compromise.

We did not find evidence of a substantial northward expansion of the breeding range of Prairie Warbler in eastern Georgian Bay caused by habitat changes and human development, our second hypothesis. Harris (1998) detected six individuals at five sites in the two most northerly survey areas near Parry Sound. Our 2015 count in these areas was only slightly higher at nine individuals at eight sites. Despite the lack of any obvious visual changes in the habitat structure or tree species composition along the eastern shore of Georgian Bay, we only detected a small number of birds north of the known breeding range. Others have suggested that the breeding range of Prairie Warbler, a neotropical migrant, has shifted slightly north in recent decades as a result of global climate change (e.g., 1967–1971 versus 1998–2002 in Hitch and Leberg 2007; Rushing *et al.* 2020). Although we detected male Prairie Warbler in the Pointe au Baril area, ~30 km north of the most northerly occupied sites in the Parry Sound area in 1997, this area was not surveyed by Harris. Therefore, it is possible that breeding Prairie Warbler may have been this far north in Georgian Bay, but were not detected previously. The cooler temperatures of the bay could moderate the climate of the eastern Georgian Bay shoreline Prairie Warbler habitat; reduced insect prey abundance or availability may therefore limit the bird's distribution in this region. Continued monitoring of suitable habitats north of the known breeding range may be important

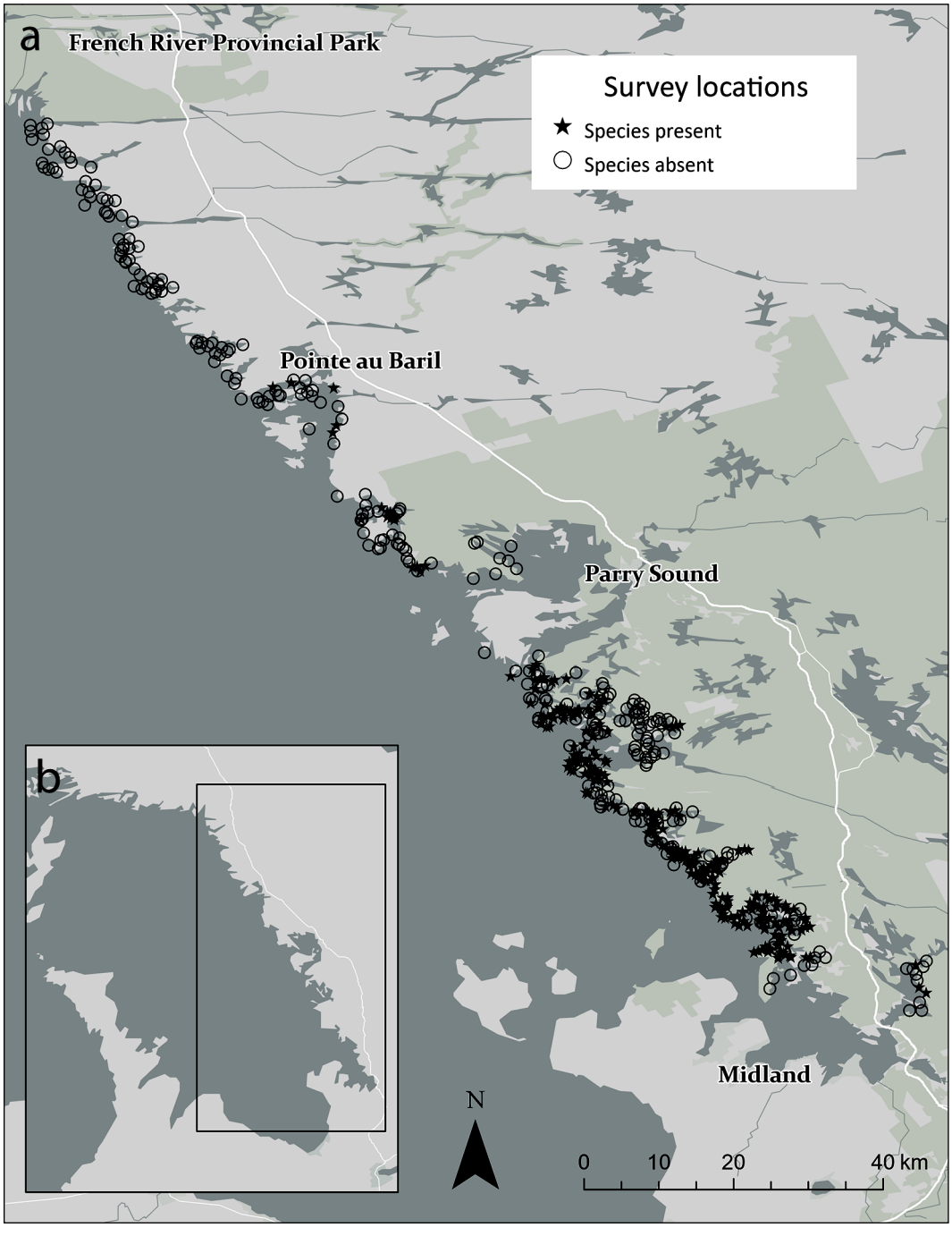

Figure 2. a. Survey locations in eastern Georgian Bay, Ontario, where Prairie Warbler (*Setophaga discolor*) was present or absent in 2015. Inset map b. provides the location of the study area in eastern Georgian Bay.

in understanding if range shifts are occurring. Similarly, it would be valuable to develop species distribution models in eastern Georgian Bay to understand which habitat variables are important for this species and their distribution in this region.

Clearly, despite the perceived habitat changes re-

sulting from increased housing and cottage development in this region in recent decades (Sivarajah *et al.* 2018; Neumann *et al.* 2021), there was no decline in the detectable Prairie Warbler population. Our surveys suggest that Prairie Warblers are largely unaffected by the presence of lakeside cottages, as many birds detected in 2015 were close (<100 m) to dwellings. The limited presence of human activity during the June nesting period may be one reason why the birds seem undisturbed by the presence of cottages, many of which were not in active use during the 2015 survey period. Perhaps too, because the vast majority of cottage owners have left their properties in a natural state (i.e., native vegetation, such as Common Juniper, not replaced with manicured lawn), the openings around the dwellings still provided good breeding habitat for Prairie Warblers. The southeast portion of the study area was an exception to this pattern of cottage activity and native landscaping; housing density along the shoreline often approached urban levels. Many cottages in this area were used year-round, in part because of ease of road access, and many were surrounded by manicured grounds. It may not be coincidental that few Prairie Warblers were found in that area in 2015.

Despite recent concerns for this breeding population of Prairie Warbler in eastern Georgian Bay, our survey results clearly suggest that this population has not declined overall in recent decades and may, in fact, have increased. Given the remoteness of much of this region and the lack of coverage by most bird monitoring programs, we recommend that this survey be repeated on a 20-year basis. In addition, as in our 2015 survey, efforts should be made to survey suitable habitat between established point count locations and in shallow bays. Finally, future surveys should also be considered north of Pointe au Baril to determine if the range of this breeding population is moving northward.

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