An evaluation of 25 years of volunteer nocturnal owl surveys in Manitoba, Canada

Avaliação de 25 anos de monitorização voluntária de rapinas noturnas em Manitoba, Canadá

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ABSTRACT

In April 1991, Patricia Duncan (my wife and fellow zoologist) and I initiated a spring volunteer nocturnal owl survey to provide citizens with a personal experience with owls. Our intention was to make wildlife conservation more relevant to them and to address a gap in existing land bird monitoring programs which do not have suitable owl survey methods. Specific survey objectives included to determine owl species distribution, relative abundance, population trends, and habitat associations. Surveyors were provided resources to identify owl calls. From 1991-1999, both passive listening and owl call playback were used to survey owls from point locations spaced 800 m along linear transects. The use of playback ceased in 2000 and owls were surveyed by passive listening only at intervals of 1.6 km. An estimated 6335 owls of 11 species were detected on a total of 32549 km of linear point count surveys over 25 years (1991 to 2015) by at least 900 surveyors. Northern Saw-whet Owls (*Aegolius acadicus*), Great Horned Owls (*Bubo virginianus*), and Boreal Owls (*Aegolius funereus*) were most numerous accounting for 75% of detections. The Burrowing Owl (*Athene cunicularia*) was the only Manitoba owl species not detected. Owl species detection rates varied annually and cumulatively ranged from 0.08 to 0.36 owls/km surveyed. Survey methods, owl species detection rates, and a summary of volunteer participation and retention over the survey period are described. A summary of the use of this project's citizen science data in published papers, graduate theses, species conservation status assessments, and a breeding bird atlas project are presented. Suggestions for new approaches to facilitating and retaining volunteer participation and maximizing data use for this and other citizen science projects are discussed.

Keywords: Citizen science, owl surveys, population monitoring, Manitoba, Canada

RESUMO

Em abril de 1991, Patrícia Duncan (minha esposa e colega zoologista) e eu iniciámos uma monitorização voluntária de rapinas noturnas durante a primavera, para proporcionar aos cidadãos uma experiência pessoal com estas aves. A nossa intenção foi tornar a conservação da biodiversidade mais relevante para o público e colmatar uma lacuna existente nos programas de monitorização de aves terrestres, os quais não dispunham de metodologias adequadas de monitorização de rapinas noturnas. Os objetivos específicos da monitorização incluíam determinar a distribuição, a abundância relativa, as tendências populacionais e as associações com o habitat das espécies de rapinas noturnas. Foram facultados aos participantes recursos para identificação de vocalizações de rapinas noturnas. Em 1991-1999 foram usadas escutas passivas e com emissão de vocalizações para monitorizar rapinas noturnas em pontos espaçados 800 m em percursos lineares. Deixámos de emitir vocalizações em 2000, tendo a monitorização passado a basear-se exclusivamente em escutas passivas e com intervalos de 1,6 km entre pontos. Foram estimados 6335 indivíduos de 11 espécies em 32 549 km de transectos lineares com pontos de escuta, ao longo de 25 anos (de 1991 a 2015) e envolvendo pelo menos 900 participantes. O mocho-amolador (*Aegolius acadicus*),o bufo-real-americano (*Bubo virginianus*), e o mocho-funéreo (*Aegolius funereus*) foram as espécies mais frequentes, perfazendo 75% das deteções. As taxas de deteção das várias espécies variaram anualmente entre 0,08 e 0,36 indivíduos/km. São descritas as metodologias, as taxas de deteção das várias espécies de rapinas noturnas, e um sumário da participação e retenção de voluntários durante a monitorização. É apresentado um sumário da utilização dos dados deste projeto de ciência cidadã em artigos científicos, em teses académicas, em avaliações do estado de conservação das espécies, e em projetos de atlas de aves nidificantes. São discutidas sugestões de novas abordagens para facilitar e reter a participação de voluntários, e maximizar a utilização dos dados deste e de outros projetos de ciência cidadã.

Palavras-chave: ciência cidadã, Canadá, Manitoba, monitorização de populações, monitorização de rapinas noturnas

Introduction

The distribution and status of several owl species have been determined by nocturnal owl surveys conducted by researchers and based on either spontaneous calling or by using playback recordings to elicit calls (Duncan & Duncan 1997, Smith 1987, Takats & Holroyd 1997, Takats et al. 2001). Such surveys have also been used to locate nests (Frith et al. 1997, Whiklo & Duncan 2014), determine habitat use (Duncan & Kearns 1997, Hinam & Duncan 2002), population densities and fluctuations in populations (Francis & Bradstreet 1997), and document migration (Duncan et al. 2009). Although generally secretive, owls are readily detectable by listening for their songs or calls during the breeding season; either spontaneously or in response to broadcast recordings (playback) of their calls. This latter technique is based on territorial behavior; song or call playback, or vocal imitations, within a territory will often elicit a vocal or visual response by an owl attempting to defend its territory against the "intruder." Owl surveys by individual or small teams of researchers have provided local and intensive results but are impractical to cover large geographic areas over multiple decades.

In April 1991, Patricia Duncan (my wife and fellow zoologist) and I initiated a long-term and widespread volunteer-based spring owl survey in Manitoba. In North America, public participation in scientific research has grown in popularity particularly since the Cornell Lab of Ornithology began marketing this practice as "citizen science" in 1995 (Bonney et al. 2009, 2016). Many kinds of citizen science projects exist today (reviewed in Shirk et al. 2012, Bonney et al. 2016). The Manitoba owl survey is a contributory-style project where researchers enroll and teach volunteers to collect the data, which is returned to them for analysis. Such projects are somewhat similar to the traditional collection of observations by naturalists before professional wildlife scientists existed (Bonney et al. 2016, Edwards 2014).

One of the leading causes of species' range contractions and population declines is habitat loss coinciding with an exponentially growing human population of increasingly urbanized citizens that are disconnected from nature. This latter phenomenon, in part, lead Richard Louv (2005) to coin the phrase Nature-Deficit Disorder. Amidst this cultural phenomenon, Livingston (1981) described a scenario in which scientists were conducting sound science on conservation-dependent wild species to identify what actions were needed to conserve them. He argued that the resulting information failed to result in conservation action due to a lack of support from governments since citizens disconnected from nature did not express sufficient concern or support for such action, such as the protection of critical natural habitats from development. Livingston's thesis suggested that citizens needed to be engaged or provided with opportunities to develop a personal connection or relationship with nature so that they would then support or demand conservation actions. It was with this goal in mind that we started the Manitoba nocturnal owl survey.

The Manitoba nocturnal owl survey was also initiated to complement established daytime breeding bird surveys conducted in summer but which fail to effectively detect owl species because owls initiate reproduction in early spring, are mostly nocturnal, and occur at low densities. Populations of owls and their prey fluctuate between years decreasing the ability to detect owl population changes over shorter survey periods. As a result, owl surveys need to be conducted over longer periods in order to obtain reliable or useful data (Saurola 1997).

In summary, the Manitoba nocturnal owl survey objectives were to:

1. Provide an organized opportunity for volunteers to:
   a. learn about owls through pre-survey training,
   b. have a personal experience with wild owls and nature through participation, and
   c. develop or enhance a conservation ethic through participation.

The remaining objectives were to increase our understanding of owl ecology through the collection of data by volunteers, specifically:

2. Determine relative owl species abundance and distribution;
3. Determine owl species habitat associations; and
4. Describe multi-annual fluctuations in the number of owls detected.

This paper summarizes the results of this 25-year owl survey, explores the influence of call playback on owl detections, and reviews survey outcomes relative to its objectives.

Methods

Participants were provided owl territorial or breeding vocalizations (i.e., http://www.naturenorth.com/summer/sound/Owl_Calls.html) to learn to identify the 12 owl species occurring in Manitoba by sound. Owl vocal recordings were obtained from Cornell University (http://www.birds.cornell.edu/AllAboutBirds/owlp) and other sources (e.g., Hardy et al. 1990). Volunteers were provided with owl survey instructions,

cover sheet and summary instructions, and data sheets to record information and observations during the survey (Appendices 1, 2, 3: https://www.researchgate.net/project/Manitoba-Nocturnal-Owl-Survey). Volunteers' abilities to identify owl species or to detect owls were not tested.

Routes along roads were established and assigned in a non-random manner by the survey coordinator, with occasional input from local volunteers. This was necessary because access to roads in late winter and early spring in Manitoba is variable and limited due to thick snow cover and/or spring flooding. Volunteers were encouraged to conduct the same route from year to year and were only required to complete one survey/route per year, however many volunteers surveyed more than one survey/route per year.

Surveys were conducted in the last two weeks of March and the first two weeks of April each year. Surveys started at least 30 min after sunset and finished by midnight. Temperature, cloud cover, wind speed and snow thickness were recorded at the beginning and end of a survey route. At each stop along a route surveyors recorded individual owls detected (heard or seen) and the owl's estimated distance and direction from the stop. Some individual owls could be heard from multiple stops. Therefore, surveyors recorded if an owl detected was also detected at a previous stop or stops. Ancillary information recorded at each stop included time, an odometer reading, noise interference and the number of passing cars.

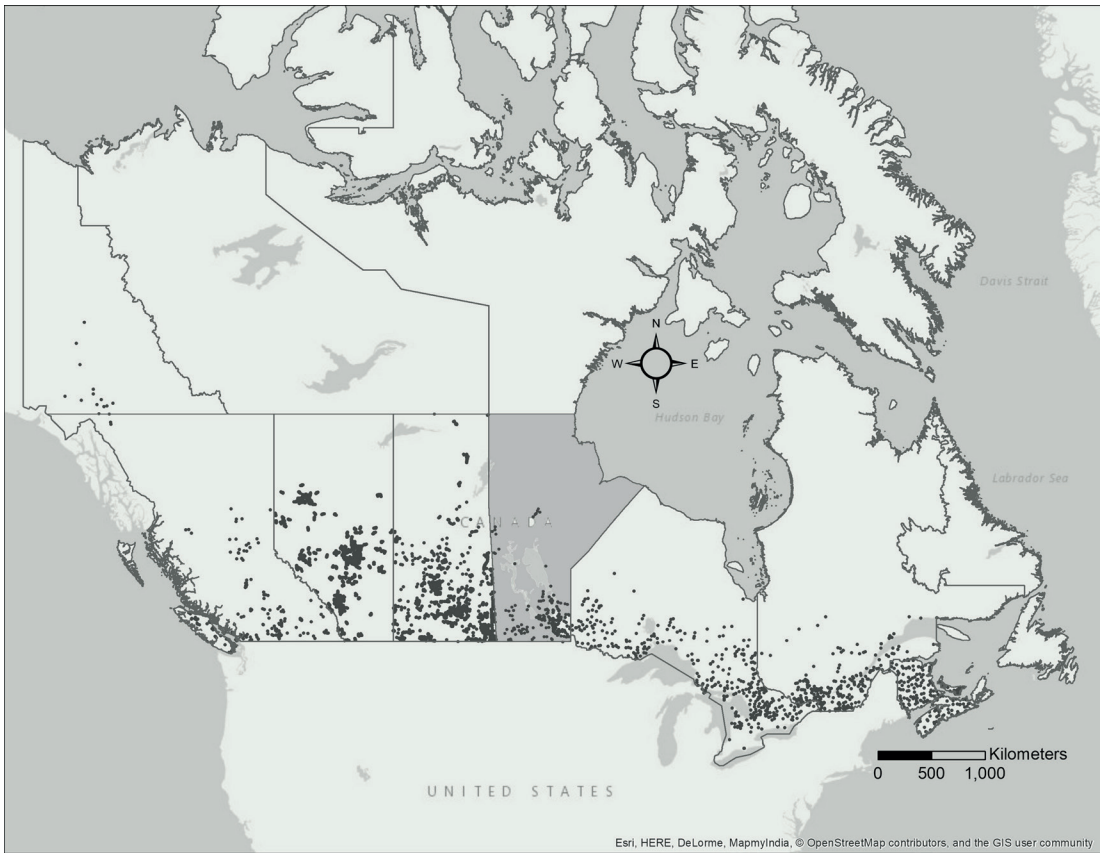
Completed survey sheets were sent to the project coordinator for review. The number of individual owls detected per route was estimated and, along with other information, was entered into a database. Annual owl species indices were calculated as the estimated number of individuals detected/km surveyed to standardize variable annual survey effort. Summary statistics and analyses were prepared using 2016 Microsoft Excel Data Analysis Tool Pack (Winston 2016). Over time, the geographic extent of the owl survey expanded within Manitoba and the survey protocol changed part way through the project as follows.

From 1991 – 1999, both passive listening and owl call playback were used to survey owls. While the primary objective was to survey for all Manitoba owl species, there was an initial emphasis on the Boreal Owl (*Aegolius funereus*) and the Great Grey Owl (*Strix nebulosa*) in boreal forest regions. Consequently, only playback of these species were initially used. Starting in 1995, the survey area expanded to include aspen parkland and grassland regions, and in these regions playback of Northern Saw-whet Owl (*Aegolius acadicus*) and Eastern Screech Owl (*Megascops asio*) territorial calls were used. From 1991 – 1999, survey stops were 0.8 km apart and each survey point took a minimum of 3 min and 40 s to complete: 1 min of listening, 20 s playback of Boreal Owl or Northern Saw-whet Owl, 1 min of listening, 20 s playback of Great Grey Owl or Eastern Screech Owl, 1 min of listening. No standard survey route length was prescribed.

In 1999, Manitoba hosted a workshop of biologists interested in starting volunteer-based owl surveys in other jurisdictions and to explore standardizing survey methods across Canada, and possibly in the United States. The workshop resulted in the adoption and publication of standard owl survey guidelines (Takats et al. 2001). Starting in 2000, the Manitoba owl survey adopted these guidelines and stopped the use of playback. Instead participants surveyed for owls by passive listening for 2 min per stop for 10 stops (spaced 1.6 km apart) per route. Manitoba's volunteer nocturnal owl survey eventually expanded to other Canadian provinces and territories and is now a recognized Canadian citizen science project under the auspices of Bird Studies Canada (Fig. 1).

Figure 1 - Location (dots) of volunteer owl surveys conducted in Canada up to 2017. Owl surveys started in Manitoba (central province shaded in grey) in 1991 and eventually spread across Canada. It became a national citizen science survey program under Bird Studies Canada in 2005.
(Map created by Murray, C. from data from Bird Studies Canada, Beaverhill Bird Observatory, and Nature Saskatchewan)

Figura 1 - Localizações (pontos) do programa voluntário de monitorização de rapinas noturnas no Canadá até 2017. As amostragens tiveram início em Manitoba (província central a cinzento) em 1991 e acabaram por se estender por todo o país. Veio a tornar-se um programa nacional de ciência cidadã da Bird Studies Canada em 2015.
(Mapa criado por Murray, C. a partir de dados de Bird Studies Canada, Observatório de Aves de Beaverhill, e Nature Saskatchewan).



Results

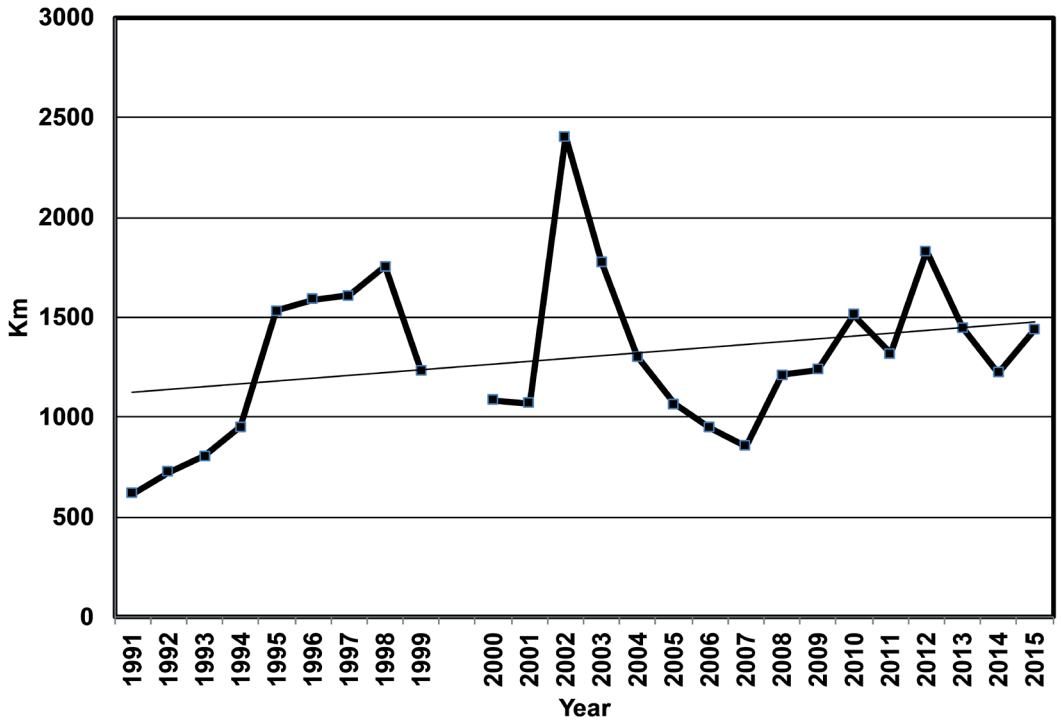
Survey effort

A cumulative total of 3953 owl surveys were conducted in Manitoba by volunteers over the 25-year period, with a mean of 158.1 surveys per year (range 49-308, SD ±57.2). This equaled a cumulative total of 32549 km surveyed for a mean effort of 1302 km per year (SD ±403). The distance surveyed increased annually from 1991 to 1998, and then varied thereafter (Fig. 2). Survey effort increased from a minimum of 618 km in the first year to a maximum of 2403 km in 2002, and generally increased over the course of the project (Fig. 2).

The change in survey methods did not appear to change the annual survey effort per se considering that the total annual distance surveyed grew in the first eight years (1991-1998). Thereafter (1999-2015) it fluctuated around a mean of 1373 km per year (Range 856-1547, SD ±377). Note that survey effort stated herein does not include the distance driven by volunteers to and from their survey routes.

Figure 2 - Number of km surveyed for owls by year in Manitoba, Canada. Straight line is a linear regression. Gap between 1999 and 2000 represents a change in survey methodology (see text).

Figura 2 - Número de km monitorizados por ano em Manitoba, Canadá. A linha representa uma regressão linear. A interrupção entre 1999 e 2000 representa a alteração na metodologia de amostragem (ver texto).



Surveyor recruitment occurred mainly by word of mouth and without an advertising campaign. An anomalous spike in survey effort in 2002 (Fig. 2) followed the wide distribution of a printed promotion inserted within Manitoba Hydro bill mail outs. More people were interested in participating in the owl survey in 2002 than routes available or within a distance they were willing to travel.

Relative owl species abundance

A total of 6335 owls of 11 species were detected during the 25-year survey period (Table 1). The provincially and nationally endangered Burrowing Owl was the only Manitoba owl species that went undetected. Northern Saw-whet Owls, Great Horned Owls (*Bubo virginianus*), and Boreal Owls were most numerous, accounting for 75% of detections (Table1). These three species, along with the Barred Owl (*Strix varia*), Great Grey Owl, and the Northern Long-eared Owl (*Asio otus*), were detected in every year of the survey.

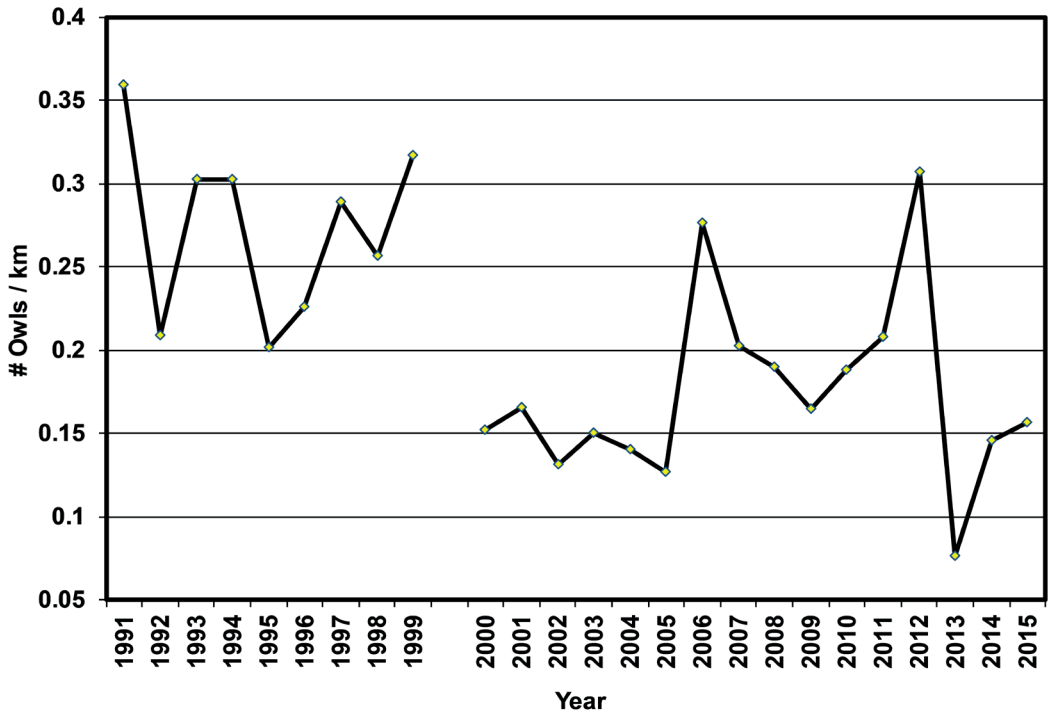
Five of 12 Manitoba owls were detected less frequently than the aforementioned species by an order of magnitude, and were also not detected on at least 6 or more years of the survey period (Table 1). These included the Eastern Screech Owl, Northern Hawk-owl (*Surnia ulula*), Short-eared Owl (*Asio flammeus*), American Barn Owl (*Tyto furcata*), and Snowy Owl (*Bubo scandiacus*).

Multi-annual fluctuations in the number of owls detected

Pooled annual owl detection rates (all owls by year for 25 years) averaged 0.21 owls/km surveyed and cumulatively ranged from 0.08 to 0.36 owls/km surveyed (Table 1, Fig. 3).

Figure 3 - Total owl detections per km surveyed by year in Manitoba, Canada. Gap between 1999 and 2000 represents a change in survey methodology (see text).

Figura 3 - Número total de registos de rapinas noturnas por km e por ano em Manitoba, Canadá. A interrupção entre 1999 e 2000 representa a alteração na metodologia de amostragem (ver texto).



Likewise, the annual detection rates of individual owl species varied over time (Table 1, Fig. 4 & Fig. 5). There was a significant decrease in the pooled owl species detection rate from the first survey period (using playback, etc.) that used a different survey method than the second survey period (no playback, etc., Table 2, Fig. 3). Five of the six more frequently and regularly detected owl species also showed a significant decrease in detection rates after the survey methods changed (Table 2). The detection rates of the five species less frequently and irregularly detected showed either no change or increases after the survey methods changed (Table 2).

The number of owl species pairs that covaried significantly was examined for the six species that were detected more frequently and regularly during the surveys. The covariance was examined in three sets of survey years: the first 9 and last 16 years that used different survey methods, and then the total 25 year-period. The number of owl species pairs that covaried significantly increased from 13% of 15 pairs for the first 9 year-period, to 20% and 60% of 15 pairs for the last 16-year and pooled 25-year periods, respectively (Table 3).

Documenting the distribution of owls and determining owl species habitat associations

The use of data from this survey to document the distribution of owls and to determine owl species habitat associations have been published elsewhere and is reviewed in the discussion.

Providing volunteers with a personal experience with wild owls and nature

At least 900 individual volunteers participated over the 25-year period. A mean of

Table 1- Summary statistics for owl detections and detection abundance indices (#owls detected/km surveyed) of volunteer nocturnal owl surveys in Manitoba, Canada (n = 25 years, 1991-2015).

Tabela 1 - Resumo das estatísticas da deteção de rapinas noturnas e dos índices de abundância (n.º de indivíduos/km) em monitorizações voluntárias de rapinas noturnas em Manitoba, Canadá (n = 25 anos, 1991-2015).

* *T. f. = Tyto furcata, M. a. = Megascops asio, B. v. = Bubo virginianus, B. s. = Bubo scandiacus, S. u. = Surnia ulula, A. c. = Athene cunicularia, S. v. = Strix varia, S. n. = Strix nebulosa, A. o. = Asio otus, A. fl. = Asio flammeus, A. f. = Aegolius funereus, A. a. = Aegolius acadicus.*

	CUMULATIVE 25 YEAR TOTALS AND INDICES		SUMMARY OF ANNUAL INDICES				
Owl Spp.*	Total # Detected	Index: Total #Detected/ Total km Surveyed	Mean Index	Min Index	Max Index	SD Index	#Years no Owls Detected
All Owls	6335	0.195	0.210	0.076	0.359	±0.073	-
A. a.	1927	0.059	0.065	0.014	0.130	±0.031	0
B. v.	1737	0.053	0.055	0.021	0.111	±0.022	0
A. f.	1100	0.034	0.036	0.005	0.085	±0.022	0
S. n.	446	0.014	0.016	0.005	0.071	±0.014	0
A. o.	410	0.013	0.014	0.005	0.030	±0.007	0
S. v.	394	0.012	0.014	0.003	0.040	±0.008	0
S. u.	108	0.003	0.003	0	0.025	±0.005	8
M. a.	91	0.003	0.002	0	0.009	±0.003	9
A. fl.	82	0.003	0.002	0	0.009	0.003	6
T. f.	16	0.000	0.000	0	0.005	±0.001	18
B. s.	9	0.000	0.000	0	0.002	±0.001	19

110.6 people participated each year (range 45-252, SD ±42.5). Over this period, individuals participated from 1 to 23 years (mean 3.1, SD ±3.7) and conducted an average of 4.4 routes each, however participation was skewed (Mode = 1, Median = 2, SD ±7.4) and a large number of volunteers (379 or 42.1%) participated in only one year of the survey (Fig. 6).

Developing or enhancing a conservation ethic in volunteers through participation

This paper does not include an analysis of results for this survey objective but the subject is reviewed in the discussion.

Discussion

The initial success in recruiting and retaining volunteers led to the expansion and growth of this citizen science project largely through word of mouth and without an active communication strategy. While survey effort increased over the 25-year period it appeared to have leveled out after eight years and thereafter fluctuated annually (Fig. 2). The annual fluctuation of effort highlights the need to derive owl detection indices that are standardized to account for variation in effort. Future data analyses can explore the influence of other variables such as wind speed, date, snow cover, noise interference and moon phase on owl detections. The

Figure 4 - Owl detections per km surveyed by year in Manitoba, Canada, for regularly detected owl species*. Gap between 1999 and 2000 represents a change in survey methodology (see text).

Figura 4 - Registos das espécies de rapinas noturnas detetadas com regularidade por km e por ano em Manitoba, Canada. A interrupção entre 1999 e 2000 representa a alteração na metodologia de amostragem (ver texto).

* A. a. = *Aegolius acadicus*, B. v. = *Bubo virginianus*, A. f. = *Aegolius funereus*, S. n. = *Strix nebulosa*, S. v. = *Strix varia*, A. o. = *Asio otus*.

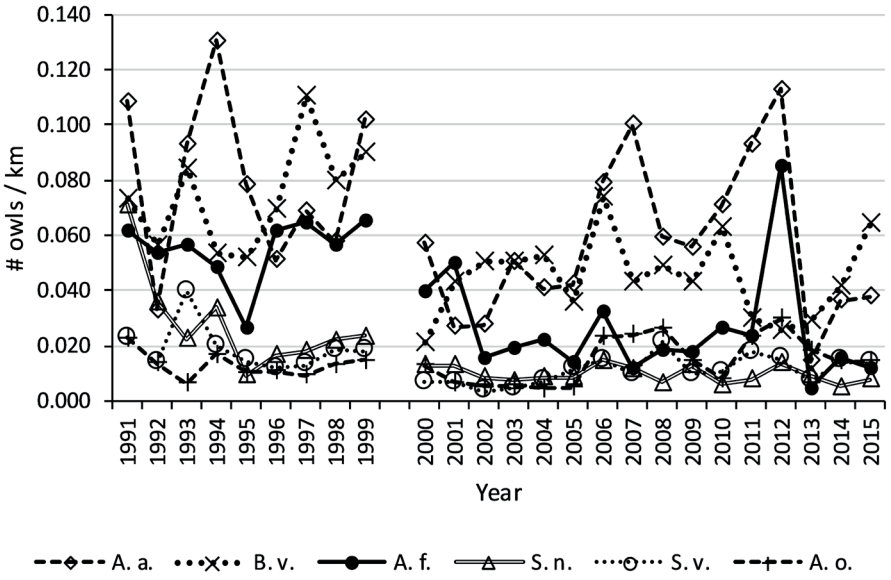


Figure 5 - Owl detections per km surveyed by year in Manitoba, Canada, for irregularly detected owl species*. Gap between 1999 and 2000 represents a change in survey methodology (see text).
Note: A 2006 data point of 0.025 owls / km for the Northern Hawk-owl (Surnia ulula) was removed solely to create this figure.

Figura 5 - Registos das espécies de rapinas noturnas detetadas pontualmente por km e por ano em Manitoba, Canada. A interrupção entre 1999 e 2000 representa a alteração na metodologia de amostragem (ver texto).
Nota: para criar esta figura foi removido um ponto de 2006 com o registo de 0,025 indivíduos/km, referente a Surnia ulula.

* S. u. = *Surnia ulula*, M. a. = *Megascops asio*, A. fl. = *Asio flammeus*, T. f. = *Tyto furcata*, B. s. = *Bubo scandiacus*.

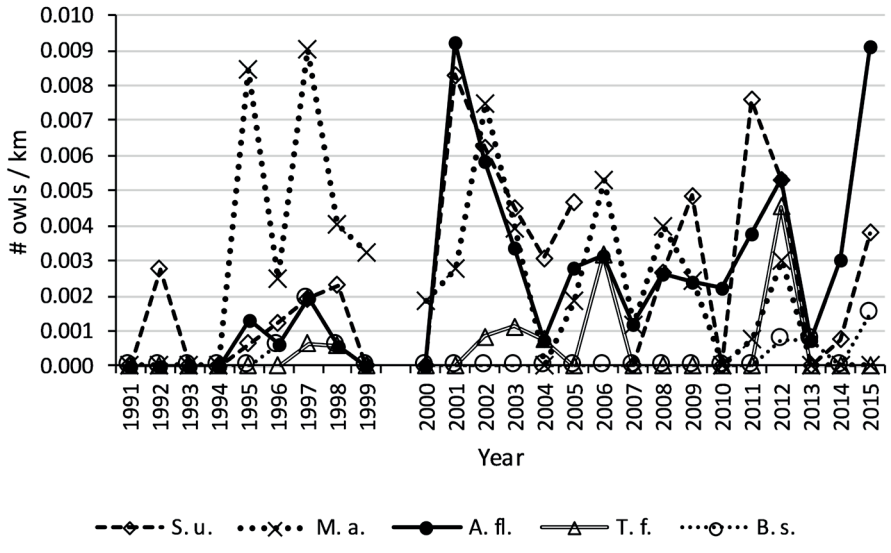


Table 2- Two-sample t-Tests assuming unequal variances for mean owl species detection rates (# owls/km surveyed) for two owl survey periods using different methods (playback used 1991-1999, no playback 2000-2015, see methods) for the volunteer nocturnal owl survey in Manitoba, Canada.

Tabela 2 - Teste de t com duas amostras (assumindo heterogeneidade de variâncias) aplicado à média das taxas de deteção de rapinas noturnas (n.º de indivíduos/km) em dois períodos de amostragem do programa voluntário de monitorização em Manitoba, Canadá. Foram utilizados métodos diferentes (emissão de vocalizações em 1991-1999, escutas passivas em 2000-2015, ver métodos).

** T. f. = Tyto furcata, M. a. = Megascops asio, B. v. = Bubo virginianus, B. s. = Bubo scandiacus, S. u. = Surnia ulula, A. c. = Athene cunicularia, S. v. = Strix varia, S. n. = Strix nebulosa, A. o. = Asio otus, A. fl. = Asio flammeus, A. f. = Aegolius funereus, A. a. = Aegolius acadicus.*

	MEAN OWL DETECTION RATE BY SURVEY PERIOD						
Owl Spp.*	1991-1999	2000-2015	+/-	P(T<=t) one-tail	P(T<=t) two-tail	Significance	Change in Detection Rate
All Owls	0.274	0.174	-0.100	0.000	0.000	S	Decrease
A. a.	0.080	0.057	-0.024	0.039	0.077	NS	
B. v.	0.074	0.045	-0.030	0.001	0.001	S	Decrease
A. f.	0.055	0.026	-0.030	0.000	0.000	S	Decrease
S. n.	0.028	0.010	-0.018	0.008	0.017	S	Decrease
S. v.	0.019	0.011	-0.008	0.011	0.021	S	Decrease
A. o.	0.013	0.015	0.002	0.269	0.538	NS	
M. a.	0.003	0.002	-0.001	0.261	0.522	NS	
S. u.	0.001	0.005	0.004	0.013	0.026	S	Increase
A. fl.	0.000	0.003	0.003	0.000	0.001	S	Increase
B. s.	0.000	0.000	0.000	0.262	0.524	NS	
T. f.	0.000	0.001	0.001	0.076	0.151	NS	

change in survey methods starting in 2000 did not appear to affect the overall survey effort over the long term (Fig. 2). Interest in the Manitoba owl survey grew across Canada to the point where national survey standards were developed and adopted, and the survey became national in scope (Fig. 1).

The ability of the owl survey to meet its objectives is herein assessed using survey outcomes.

Relative owl species abundance

The owl survey was successful at detecting the relative abundance for 11 of the 12 owl species native to Manitoba. However, some owl species were likely under detected, and in one case not detected, due to the survey methods not matching the life history traits of these owl species.

The six most commonly detected species included three species that were targeted using call playback during the initial 9-year survey period (see methods, Table 1). Of these six species, all but the Northern Long-eared Owl and the Northern Saw-whet Owl experienced a significant decrease in their detection rates in the second survey period (2000-2015) during which playback was not used, survey stops were farther apart, and

Figure 6 - Frequency histogram of cumulative number of surveys conducted over 25 years by individual volunteer owl surveyors in Manitoba, Canada (1991-2015). Data labels are the number of volunteers.

Figura 6 - Histograma de frequências do número acumulado de monitorizações de rapinas noturnas realizadas ao longo de 25 anos por voluntários em Manitoba, Canadá (1991-2015). Os valores no topo das barras representam o número de voluntários.

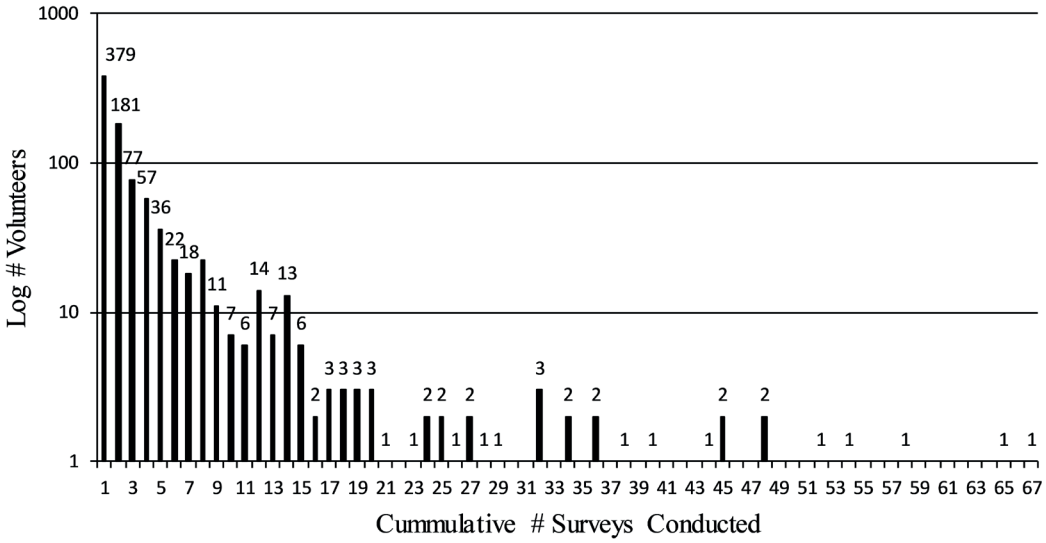


Figure 7 - Relative abundance based on pooled detection rates (#owls/km surveyed) for regularly detected owl species* within each of two survey periods with different survey methodologies** in Manitoba, Canada (1991-2015).

Figura 7 - Abundância relativa baseada nas taxas de deteção (n.º de indivíduos/km) agrupadas para as espécies de rapinas noturnas detetadas frequentemente* em cada um dos dois períodos de amostragem com diferentes metodologias** em Manitoba, Canadá (1991-2015).

* B. v. = *Bubo virginianus*, S. v. = *Strix varia*, S. n. = *Strix nebulosa*, A. o. = *Asio otus*, A. f. = *Aegolius funereus*, A. a. = *Aegolius acadicus*.
** Survey Period 1 = 1991-1999, Survey Period 2 = 2000-2015.
** Período de amostragem 1 = 1991-1999, período de amostragem 2 = 2000-2015.

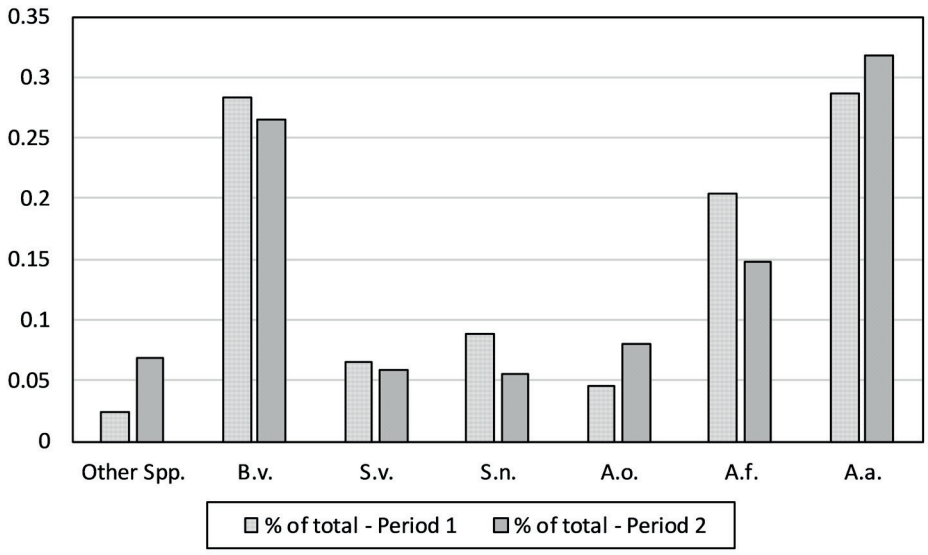


Table 3- Covariance of owl species* detection rates (# owls/km surveyed) for regularly detected owls for two owl survey periods using different methods (playback used 1991-1999, no playback 2000-2015, see methods) and over 25 years (1991-2015) for the volunteer nocturnal owl survey in Manitoba, Canada.

Tabela 3 - Covariância da média das taxas de deteção (n.º de indivíduos/km) das várias espécies* de rapinas noturnas detetadas regularmente em dois períodos de amostragem e ao longo de 25 anos do programa voluntário de monitorização em Manitoba, Canadá. Foram utilizados métodos diferentes (emissão de vocalizações em 1991-1999, escutas passivas em 2000-2015, ver métodos).

** B. v. = Bubo virginianus, S. v. = Strix varia, S. n. = Strix nebulosa, A. o. = Asio otus, A. f. = Aegolius funereus, A. a. = Aegolius acadicus.*

1991-1999 (n = 9 Years)

Owl Species	B. v.		S. v.		S. n.		A. o.		A. f.	
	r	P	r	P	r	P	r	P	r	P
S. v.	0.13	0.74								
S. n.	-0.13	0.74	0.20	0.61						
A. o.	-0.30	0.43	-0.17	0.67	0.84	0.00				
A. f.	0.70	0.04	0.10	0.80	0.30	0.43	0.13	0.74		
A. a.	-0.02	0.95	0.44	0.23	0.35	0.35	0.41	0.27	-0.04	0.92

2000-2015 (n = 16 Years)

Owl Species	B. v.		S. v.		S. n.		A. o.		A. f.	
	r	P	r	P	r	P	r	P	r	P
S. v.	0.07	0.81								
S. n.	-0.15	0.57	-0.13	0.62						
A. o.	-0.19	0.48	**0.72**	**0.00**	0.31	0.25				
A. f.	-0.27	0.32	0.13	0.63	**0.55**	**0.03**	0.29	0.28		
A. a.	-0.09	0.73	0.49	0.06	0.34	0.19	**0.67**	**0.00**	0.49	0.06

1991-2015 (n = 25 Years)

Owl Species	B. v.		S. v.		S. n.		A. o.		A. f.	
	r	P	r	P	r	P	r	P	r	P
S. v.	**0.43**	**0.03**								
S. n.	0.37	0.07	**0.43**	**0.03**						
A. o.	-0.23	0.27	0.25	0.23	0.22	0.30				
A. f.	**0.45**	**0.02**	**0.42**	**0.04**	**0.55**	**0.00**	0.13	0.54		
A. a.	0.21	0.32	**0.56**	**0.00**	**0.44**	**0.03**	**0.50**	**0.01**	**0.48**	0.02

Table 4 - Number of owl survey species records incorporated into the Manitoba Breeding Bird Atlas (2010-2014, http://www.birdatlas.mb.ca).

Tabela 4 - Número de registos das espécies de rapinas noturnas amostradas que integraram o Atlas das Aves Nidificantes de Manitoba (2010-2014, http://www.birdatlas.mb.ca).

OWL SPECIES	NUMBER OF RECORDS
Northern Saw-whet Owl (*Aegolius acadicus)*	120
Great Horned Owl (*Bubo virginianus)*	82
Boreal Owl (*Aegolius funereus)*	54
Northern Long-eared Owl (*Asio otus)*	46
Great Gray Owl (*Strix nebulosa)*	33
Barred Owl (*Strix varia)*	28
Northern Hawk-owl (*Surnia ulula)*	9
Short-eared Owl (*Asio flammeus)*	6

time spent at each stop reduced (see methods, Table 2).

If the chance of detecting four regularly detected common species decreased statistically in the second survey period, then we would expect changes in the proportion of these between the two periods. As expected, Fig. 7 illustrates the change in relative abundance of regularly detected common owl species for the two survey periods within each of the two survey periods that used different survey methods. Hence the influence of the survey methods and survey coverage on the detection rates of owls needs to be studied in more detail. Further factors, such as habitat use and diet, may also account for the relative abundance of these six species.

Five owl species were less frequently and irregularly detected, likely for a variety of reasons. The limited, largely urban distribution of the Eastern Screech Owl in Manitoba (Taylor 2003) and the irruptive dispersal and, predominantly, diurnal calling behavior of the Northern Hawk-owl (Duncan & Duncan 1998) account for their lower and irregular detection rates (Table 1). The low detection rate for the Short-eared Owl reflects its threatened status in Manitoba. It is relatively rare in the province in most years, and likely quickly migrates north each spring past Manitoba's southern prairie region's once lush grasslands to the intact Arctic 'prairies' or tundra to breed (Taylor 2003). The American Barn Owl is both rare and accidental in Manitoba and the majority of Snowy Owls depart southern Manitoba for their Arctic breeding range prior to the survey period (Taylor 2003). Lastly, the provincially and nationally endangered Burrowing Owl was never detected due to its arrival in Manitoba as a late spring migrant (Taylor 2003) after the survey period ended. It also has a small range limited to mixed grass prairies in extreme southwestern Manitoba where few owl surveys took place. These five species require species-specific targeted survey methods to adequately monitor their populations in Manitoba.

Multi-annual fluctuations in the detection rate of owls

This survey documented some dramatic fluctuations in the detection rate (owls/km)

over time (Fig. 3, Fig. 4 & Fig. 5). Data from this survey can be used with other independent lines of evidence (i.e., specimens, banding data) to corroborate these population changes over time, and other data (e.g., mammalian predators and prey monitoring) to explore reasons why such fluctuations exist. In this study, the number of owl species pairs (for frequently and regularly detected owls) that covaried significantly increased with survey period duration (Table 3). This might support the concept that longer-term monitoring of fluctuating or cyclic owl species is required to detect significant results (Saurola 1997) and to explore ecological concepts such as competition, niche overlap among a guild of similar predators, and the influence of climate on populations. However, getting more significant combinations with more years and combining two distinct methodological periods might simply be due to a larger sample size (resp. n = 9, 16, 25 years), (See https://select-statistics.co.uk/blog/importance-effect-sample-size/).

To explore the aforementioned ecological concepts we would need longitudinal data (same observer, same routes, comparable conditions) rather than random samples or a combination of this as we have available in our dataset. Figure 6 illustrates that some volunteers worked constantly yielding such longitudinal data. However, most observers cooperated only once yielding random samples.

Future analysis could split the dataset into longitudinal and randomized data. Bootstrapping techniques would help because they select random samples of the entire dataset and run statistics a few 1000 times to get stability.

Survey data may also yield insight into larger geographic migration or dispersal patterns. An analysis of covariance between Northern Saw-whet Owl survey data from this project with that from another owl survey project over 770 km southeast in Wisconsin, USA provided the first evidence of a spring migration in this species in central North America, and one that is influenced by prey availability (Duncan et al. 2009).

Documenting the distribution of owls

The ability of owl survey data to increase the documented range of owl species in Manitoba (relative to species expected range and/or previously documented range) was assessed for a 5-year period (1991-1995): An 88% increase occurred for the Northern Saw-whet Owl, followed by a 40% and 19% increase for the Boreal and Great Grey Owls, respectively, and smaller increases for the Northern Hawk-owl (10%), Barred Owl (8%) and Great Horned Owl (6%) (Duncan & Duncan 1997). It is interesting to note that the largest increases in distribution occurred for the three species initially targeted by this survey and for which call playback was used. More recently, from 2010-2014, the owl survey contributed almost 400 owl location records for the Manitoba Breeding Bird Atlas (http://www.birdatlas.mb.ca, Table 4). Data on species distributions and how they change over time are essential criteria used to assess the conservation status of species at various geographic scales.

Determine owl species habitat associations

Owl location data from this survey was used to assess the effects of habitat fragmentation and slope on the distribution of Great Horned Owls, Great Grey Owls and Barred Owls in western Manitoba (Hinam & Duncan 2002). Owl survey data was also, in part, used to locate Barred Owl home ranges and nests to assess habitat suitability and describe nest and nest site habitat characteristics (Duncan & Kearns 1997, Whiklo & Duncan 2014). Additional studies of owl habitat use are possible with the data collected by this survey.

Providing volunteers with a personal experience with wild owls and nature

Most volunteers had a repeated or prolonged experience with owls and nature through their participation in this survey (Fig. 6). The value of this survey as an entry level opportunity for the general public to gain such experience lies in its simplicity when compared to other types of bird or species monitoring programs. There are few owl species to identify and they have distinct primary territorial calls or songs that are easy to learn. Volunteers only have to do one survey a year and it occurs at night after most people are finished working a typical daytime shift. Lastly, many people find owls mysterious, attractive and/or interesting.

Developing or enhancing a conservation ethic in volunteers through participation

One intended outcome of this survey project was to awaken or strengthen a conservation ethic or values among volunteers through the experience of participating. While changes in values are known to result in behavioural changes, a review of social science studies concluded that values are quite resistant to change (Manfredo et al. 2017). This paper documents the feasibility of engaging citizens, and the value of the information collected to enhance our knowledge about owls. The effectiveness of participation in this project in developing or enhancing the conservation ethic of volunteers is explored elsewhere (Ng et al. 2018). Ng et al. (2018) also examined other participant variables such as age and gender, in a questionnaire-based study and collected feedback from citizen scientists to assess and describe what motivated volunteers to participate in the owl survey. They concluded that a main motivator of participants surveyed was a chance to have fun with family and friends while also contributing information about owls.

The Future of Owl Monitoring

The Manitoba program manager of Bird Studies Canada assumed coordination of the Manitoba Owl Survey in 2016 and has created opportunities for participants to enter their survey data online through Nature Counts (https://www.birdscanada.org/birdmon) which improves both the management of information and the volunteer's experience. Developing an online self-assessment program would help surveyors improve their ability to identify species or to detect owls, increasing the quality of data collected. Better methods of analysis of owl survey data, including the potential for open data sharing with researchers around the world, will result in learning opportunities for students and ultimately help conserve and manage owls and the habitats they depend on. A recent study of the volunteers and their motivations will help both this owl survey and the design of new participatory citizen science projects (Ng et al. 2018).

The 900 volunteer surveyors gained new personal experiences with wild owls and nature while contributing new data and information on owls. Both these results have fostered better support for the long-term protection and conservation of owls, other wildlife and their habitats. Further statistical analysis is recommended by splitting the data into longitudinal and randomized data sets.

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