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Research Paper, part of a Special Feature on Quantifying Human-related Mortality of Birds in Canada

Estimated Number of Birds Killed by House Cats (*Felis catus*) in Canada

Estimation du nombre d'oiseaux tués par les chats domestiques (*Felis catus*) au Canada

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ABSTRACT. Predation by house cats (*Felis catus*) is one of the largest human-related sources of mortality for wild birds in the United States and elsewhere, and has been implicated in extinctions and population declines of several species. However, relatively little is known about this topic in Canada. The objectives of this study were to provide plausible estimates for the number of birds killed by house cats in Canada, identify information that would help improve those estimates, and identify species potentially vulnerable to population impacts. In total, cats are estimated to kill between 100 and 350 million birds per year in Canada (> 95% of estimates were in this range), with the majority likely to be killed by feral cats. This range of estimates is based on surveys indicating that Canadians own about 8.5 million pet cats, a rough approximation of 1.4 to 4.2 million feral cats, and literature values of predation rates from studies conducted elsewhere. Reliability of the total kill estimate would be improved most by better knowledge of feral cat numbers and diet in Canada, though any data on birds killed by cats in Canada would be helpful. These estimates suggest that 2-7% of birds in southern Canada are killed by cats per year. Even at the low end, predation by house cats is probably the largest human-related source of bird mortality in Canada. Many species of birds are potentially vulnerable to at least local population impacts in southern Canada, by virtue of nesting or feeding on or near ground level, and habitat choices that bring them into contact with human-dominated landscapes where cats are abundant. Because cat predation is likely to remain a primary source of bird mortality in Canada for some time, this issue needs more scientific attention in Canada.

RÉSUMÉ. La prédation par les chats domestiques (*Felis catus*) est une des causes de mortalité liées aux humains les plus importantes chez les oiseaux sauvages aux États-Unis et ailleurs; elle a également été mise en cause dans l'extinction et le déclin de populations de plusieurs espèces. Toutefois, la situation au Canada est plutôt méconnue. Cette étude visait à obtenir des estimations plausibles du nombre d'oiseaux tués par les chats domestiques au Canada, à déterminer les informations additionnelles pouvant contribuer à améliorer ces estimations et enfin, à identifier les espèces dont les populations pourraient être touchées. Dans l'ensemble, nous avons estimé que les chats tuaient entre 100 et 350 millions d'oiseaux par année au Canada (> 95 % des estimations se trouvaient dans cette plage), les chats sauvages tuant vraisemblablement la majorité de ces oiseaux. Cette plage d'estimations est fondée sur des relevés indiquant que les Canadiens possèdent 8,5 millions de chats domestiques environ, une approximation grossière du nombre de chats sauvages se situant entre 1,4 et 4,2 millions et des taux de prédation tirés d'autres recherches menées ailleurs qu'au Canada. Une meilleure connaissance du nombre de chats sauvages et de leur régime alimentaire au Canada permettrait d'améliorer grandement la fiabilité de l'estimation du nombre d'oiseaux tués, bien que n'importe quelle donnée sur les oiseaux tués par les chats au Canada y contribuerait également. Nos estimations indiquent que de 2 à 7 % des oiseaux dans le sud du Canada sont tués par les chats chaque année. Même en considérant l'estimation la plus prudente, la prédation par les chats domestiques est probablement la cause de mortalité d'oiseaux liée aux humains la plus importante au Canada. De nombreuses espèces d'oiseaux sont potentiellement vulnérables à des effets sur leurs populations au moins localement dans le sud du Canada, en raison de leur nidification ou de leur alimentation au sol ou près du niveau du sol, et des choix d'habitats qui les amènent dans des paysages dominés par les humains où les chats sont abondants. Étant donné que la prédation par les chats demeurera vraisemblablement une source importante de mortalité d'oiseaux au Canada dans un avenir rapproché, cet enjeu mérite davantage d'attention scientifique au Canada.

Key Words: *bird mortality; cat predation; house cats*

[1]Environment Canada

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INTRODUCTION

House cats (*Felis catus*) are estimated to kill large numbers of birds in countries and regions where this source of bird mortality has been studied, for example 1-4 billion birds killed per year in the United States (Dauphine and Cooper 2009, Loss et al. 2013), 27 million in spring and summer in Great Britain (Woods et al. 2003), and 0.1-0.3 million per spring month in Switzerland (Tschanz et al. 2011). These estimates suggest that cats are one of the largest human-related mortality factors for birds, at least in the United States (Klem 2004, Eriksson et al. 2005, Loss et al. 2013).

Cats can substantially reduce bird populations in some circumstances. For example, feral cats have been implicated in the extinction of at least 33 bird species (Lever 1994, as cited in Nogales et al. 2004), primarily on oceanic islands where cats have been reported to kill in excess of a million seabirds per year (Pascal 1980, Chapuis et al. 1994). And there is increasing evidence of impacts on mainland bird populations, at least at a local scale (Churcher and Lawton 1987, Crooks and Soulé 1999, Hawkins et al. 2004, Baker et al. 2005, 2008, van Heezik et al. 2010, Balogh et al. 2011).

Notably, there has been very little rigorous study of cat predation on birds or other wildlife in Canada, even though Guthrie (2009) speculated that more than 165 million birds are killed per year by free-roaming cats in Canada. Toner (1956) studied prey returns by two pet cats on a farm in Haliburton, Ontario; only a few songbirds were recorded among hundreds of prey retrieved. Few conclusions can be drawn from such a limited sample size, particularly because individual cats differ markedly in numbers and types of prey retrieved (Toner 1956, Barratt 1998, Woods et al. 2003, Tschanz et al. 2011, Thomas et al. 2012). Dunn and Tessaglia (1994) summarized bird kills reported by feeder-watchers across the U.S. and southern Canada: cats were responsible for 29% of bird kills for which the predator was identified, ranking second to the Sharp-shinned Hawk (*Accipiter striatus*). Kills were not reported separately for Canada. A questionnaire approach is currently being used to document numbers of dead birds returned by pet cats in Edmonton, Alberta (E. Bayne, *personal communication*); a total of 797 birds had been reported from 494 households with cats through 2010. A study of Song Sparrows (*Melospiza melodia*) nesting in Rithet's Bog Conservation Area, British Columbia, found that feral and pet cats were responsible for 22% of predation events caught on camera (RBCS 2011; L. Zanette, *personal communication*). From these and a variety of anecdotal reports (e.g., Campbell et al. 1997, Hudon 1999, COSEWIC 2004*a*) it is clear that birds and bird nests are preyed upon by cats in Canada; the challenge is understanding the magnitude of that kill and its importance to bird populations in Canada.

The main objective in this paper is to provide a plausible range of estimates for the number of birds killed annually by house cats in Canada, based on a review of data and literature available in Canada and other temperate-zone countries, so that this source of bird mortality can be compared to other anthropogenic sources. A secondary objective is to examine the sensitivity of mortality estimates to values used for each parameter included in the calculations, to identify data that would most improve precision of future estimates of birds killed by cats in Canada. A final objective is to identify bird species that are most likely to be vulnerable to population impacts from predation by cats in Canada, based on characteristics of birds susceptible to cat predation elsewhere.

METHODS

The general approach used to estimate the number of birds killed by cats in Canada was to multiply estimates of the number of cats in Canada by estimates of the average number of birds killed per cat per year, with predation rate derived from data outside Canada. Because reported predation rates elsewhere differ for pet cats vs. feral cats, and may differ for urban vs. rural pets, analyses were separated for each of three classes of cat, i.e., urban pet, rural pet, feral cat, and results summed. Additional parameters were added to refine predation rates of pet cats, by estimating proportion of pets outdoors, and by applying an adjustment to convert birds returned home by pets to birds killed by pets.

The specific formulae used were:

- Birds killed per year by urban pet cats:
  $BKu = nPC \times (1\text{-}pRP) \times pOd \times BpU \times Adjust$
- Birds killed per year by rural pet cats:
  $BKr = nPC \times pRP \times pOd \times BpR \times Adjust$
- Birds killed per year by feral and stray cats:
  $BKf = nFC \times KpF$
- Total birds killed per year = $BKu + BKr + BKf$

where *nPC* is the number of pet cats in Canada, *pRP* is the proportion of pet cats that are rural, *pOd* is the proportion of pet cats with at least some access to the outdoors, *BpU* (or *BpR*) is the average number of birds returned to owners per outdoor urban (or rural) pet cat, *Adjust* is a multiplier to convert birds returned and detected by owners to birds killed by pets, *nFC* is the number of feral cats in Canada, and *KpF* is the average number of birds killed per feral cat.

Based on existing data and rationale provided below, a plausible range of values was established (Table 1) for each parameter in the formulae above. Estimates of total bird kills were calculated using a Monte Carlo approach, selecting a value at random for each parameter from within ranges listed in Table 1, and then applying the formulae. All ranges of values were treated as continuous distributions between low and high values, except that number of pet cats (*nPC*) was treated as a normal distribution, and birds returned per urban outdoor pet per yr (*BpU*) was treated as a continuous distribution with 50%

Table 1. Parameters and ranges of values used in calculations to estimate bird kills in Canada. Acronyms used in formulae are listed for each parameter.

Parameter	Acronym	Range of Values Assumed
number of Pet Cats in Canada	*nPC*	8.5 Million +/- 0.25M (SE)
percent Rural Pets	*pRP*	27% to 33%
percent of pets with access to Outdoors	*pOd*	40% to 70%
Birds returned per Urban outdoor pet / year	*BpU*	0.6 to 6.7 (midpoint 2.8)
Birds returned per Rural outdoor pet / year	*BpR*	2.8 to 14
Adjustment for undetected prey	*Adjust*	2.0 to 5.8
number of Feral Cats in Canada	*nFC*	1.4 to 4.2 Million
birds Killed per Feral cat / year	*KpF*	24 to 64

of values between the low value and midpoint, and 50% between the midpoint and high value. This selection process was repeated 10,000 times to produce a range of estimates for birds killed annually by cats in Canada.

The rationale for the range of values listed for each parameter in Table 1 is as follows:

Number of pet cats in Canada (nPC):
Roberts (2000:2) stated that "According to Statistics Canada, there are approximately 3.5 million dogs and 4.5 million cats in the country." This statement continues to be quoted on many internet sites, though the original source could not be found and Statistics Canada does not collect information on number of pets currently (Statistics Canada 2011*a*). Others have reported a much higher number of pet cats, including three based on stratified statistical surveys: 7.2 million in 2001 (Ipsos-Reid 2001, telephone poll of 1500 urban households across Canada), 8.3 million (HSC 2007, methods unknown), 7.9 million +/- 2.5% (CAHI 2007, based on an Ipsos Reid poll of over 4000 households Canada-wide), and 8.5 million +/- 1.15% (Perrin 2009, based on an Ipsos Reid online survey in fall 2008 with 7208 participants, weighted to reflect population distribution in Canada in the 2006 national census). The latter estimate (8.5M) has been used in this paper because it is the most current and involved the most participants, though the error around the estimate has been increased (to SE = 0.25M, i.e., 95% confidence interval of 8 to 9 million) to account for possible changes since 2006.

Percent rural pet cats (pRP):
Because some literature suggests a higher rate of birds kills by rural vs. urban pets, pet cats were further separated into urban, including suburban, vs. rural pets on the basis of percent of Canadian population classed as rural in 2006 (19.7%, Statistics Canada 2008). This percentage was adjusted to take into account a relatively high number of cats per owner in rural U.S. households (Coleman and Temple 1993, Lepczyk et al. 2004) compared with all U.S. households (APPA 2011). For this paper, the ratio of rural to urban cats per household was assumed to be between 1.5 and 2.0, based on data in Lepczyk et al. (2004). When combined with the 19.7% rural population, the percent of pet cats that are rural was estimated to be between 27 and 33%. Because the definition of "rural" may differ across studies, mortality estimates were also calculated for rural and pet cats combined, to assess sensitivity of the total mortality estimate to this split.

Number of feral and stray cats (nFC):
Strictly speaking, feral cats differ from stray cats in living their full lives in the wild, whereas strays are previously owned cats that now live on their own. Ferals and strays have been treated as one group in this paper because studies of cat numbers and of birds killed by cats have not differentiated between ferals and strays. Neither is likely to be included in pet survey estimates, so must be added. They are referred to collectively as "feral cats" in the remainder of this paper. Baker et al. (2010) use the term "semiferal/feral cats" for this group; Loss et al. (2013) refer to them as "un-owned cats." Barnyard cats that are not considered pets by owners in surveys are presumed to be included here as feral cats.

Although it is known that there is a large and growing population of feral cats in Canada (CFHS 2009), there are apparently no scientific estimates of their numbers. Canadian media sources have reported approximate numbers of feral cats for several Canadian municipalities, based on knowledge of animal care workers. Here, these media-reported numbers are compared to the size of the human population in the same municipality to get a range in number of feral cats per 1000 citizens (Table 2). That ratio was extrapolated to all other municipalities in southern Canada, where southern Canada was defined to exclude 78% of Canada's area that is in arctic and northern forest bird conservation regions (taiga, boreal, northwestern forests, northern Rockies, as delimited in NABCI 2000). The rationale for excluding northern areas is that severe winters are expected to preclude significant populations of feral cats there, though there is no apparent relationship between estimates of feral cats and latitude or January temperature in southern Canada (Table 2), and feral cat numbers may be significant in parts of Alaska (McKinney

Table 2. Feral cat estimates in Canada from media reports, in relation to 2006 human population, latitude, and January temperature.

Location	Feral Cat Estimates (# of estimates) [†]	Midpoint (approx.)	Human Pop'n (1000s) 2006 Census [‡]	Feral Cats / 1000 Persons	Latitude (N) [§]	January Avg Temp (C) [§]
Vancouver	Tens of thousands (1)	25,000	2117	12	49.2	3.3
Toronto	20,000 to 500,000 (4)	200,000	2503	80	43.7	-5.3
Windsor	25,000 to 50,000 (2)	35,000	383	91	42.3	-4.5
Regina	25,000 (1)	25,000	221	113	50.4	-16.2
Montreal	100s of thousands (1)	250,000	1854	135	45.5	-10.3
Winnipeg	50,000 to 200,000 (4)	100,000	636	157	49.9	-17.8
Province of Quebec	1.6 Million (1)	1,600,000	7544	212		
Halifax	110,000 (1)	110,000	373	295	49.8	-5.2

[†]Sources: Stray Cats a Big Problem 2008, Horan 2009, Lakey 2009, Lowe 2009, Pearson 2009, Winnipeg's Stray-Cat Population... 2009, Tindal 2010, Botelho 2011, Cat Populations Increase... 2011, Ormsby and Wilkes 2011, Skerritt 2011, Sullivan 2011, THS Feral Cat Clinics Coming in May 2011, Winnipeg's Feral Cat Population Grows 2011; P. Curry, S. Eberl, and P. Vogt, unpublished document.
[‡]Source: Statistics Canada 2007
[§]Source: Environment Canada 2011; averages used if more than one weather station met WMO standards

2008). Southern Canada included 91% of Canada's human population in 2006 (data from Statistics Canada 2007). Based on numbers in Table 2, and ignoring the highest and lowest values, the number of feral cats per 1000 persons in southern Canada was assumed to be between 50 and 150, which gives a range of 1.4 to 4.2 million feral cats in southern Canada.

Feral and other free-ranging cats are caught in substantial numbers during trap, vaccinate, and release programs for raccoon rabies in Ontario; for example Rosatte et al. (1997) reported 9058 cat captures in a 1400 km² area of predominantly rural Ontario farmland. Also, 856 cats were trapped and vaccinated in two weeks in a 710 km² rural area of eastern Ontario (Rosatte et al. 2001). Extrapolated to the area (3350 km²) and human population size of Leeds and Grenville county in 2006 (99,206, Statistics Canada 2007), this gives roughly 41 feral and free-ranging cats per 1000 persons. This is slightly below the range selected above, though it is likely that not all feral cats were captured, and population density in the area trapped was almost certainly lower than in the full county.

Proportion of pets outdoors (pOd):
Some pet cats are kept strictly indoors and do not contribute to the kill of wild birds. The proportion of pet cats with at least some access to the outdoors has been reported as 50 to 77% in the United States (American Pet Products Manufacturers Association 1997, as cited in Kays and DeWan 2004, Crooks and Soulé 1999, FFWCC 2003, Kays and DeWan 2004, Winter 2004; C. Fiore and K. B. Sullivan, *unpublished manuscript*), though C. Fiore and K. B. Sullivan (*unpublished manuscript*) found evidence in scat analysis that some cats categorized as "indoor cats" by owners did kill wild birds. The proportion with access to the outdoors was similar in a New Zealand study (66%, van Heezik et al. 2010), and in Switzerland (72%, Tschanz et al. 2011). Guthrie (2009) assumed that at least 70% of pet cats in Canada have access to the outdoors, based on experience of humane society staff. In this report, the percent of pets with at least some access to the outdoors in Canada was assumed to be somewhere between 40 and 70%.

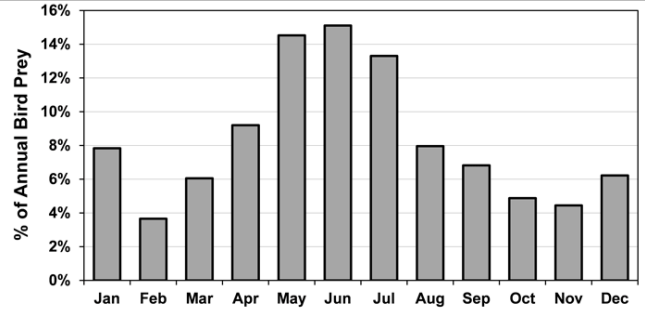
Birds brought home per urban outdoor pet cat per year (BpU):
Studies that reported rates of birds killed by pet cats generally relied on numbers of prey brought home and detected by owners. There are no such published data from Canada, though one study is in progress in Edmonton, Alberta (E. Bayne, *personal communication*). Data from other temperate-zone countries have been used to provide a range for the rate of bird returns per outdoor pet cat per year, on the assumption that the average rate of bird returns per pet cat in Canada is somewhere within this range (preliminary data from Edmonton do fall within the range of other studies).

Studies of prey returns by one or a few nonrandomly selected cats were not relied upon for rate of bird returns in this paper because such studies may be biased toward cats with relatively high rates of return. Also, because individual cats differ widely in rates and types of prey returned, with a small proportion of cats typically accounting for a large proportion of prey returns (e.g., Barratt 1998, Woods et al. 2003, Tschanz et al. 2011), studies with few cats are unlikely to provide representative rates of return even if randomly selected. Questionnaires that asked owners to estimate past prey returns for their cats may give inflated numbers, relative to rates of prey returns determined by recording prey returns as they occurred (Barratt 1998, Tschanz et al. 2011), though not always (Gillies and Clout 2003). As a result, questionnaire-based studies restricted to owners' memory of past prey returns were not relied upon for rate of kill calculations in our research.

Several studies of cat predation were conducted year-round, or else sampled in all seasons. For other studies that sampled only one or two seasons, results were extrapolated to a full year based on the average proportion of birds returned per month in five year-round studies (Fig. 1). In general, bird

returns were highest in spring and summer, though there was a minor peak in midwinter in some studies because birds were sometimes more readily available than other prey at that time (Churcher and Lawton 1987, Paltridge et al. 1997, Paltridge 2002, van Heezik et al. 2010).

Fig. 1. Seasonal distribution of bird returns by pet cats, averaged across five year-round temperate-zone studies (Churcher and Lawton 1987, Barratt 1997, Flux 2007, van Heezik et al. 2010; C. Fiore and K. B. Sullivan, *unpublished manuscript*). Data from the southern hemisphere were offset by six months.



Based on studies listed in Table 3, the return rate for urban outdoor pet cats in Canada was assumed to be between 0.6 and 6.7 birds per year per cat, with a midpoint of 2.8. That is, the rate was assumed to have a 50% probability of being between 0.6 and 2.8, and a 50% probability of being between 2.8 and 6.7.

Birds brought home per rural outdoor pet cat per year (BpR):
Few reliable estimates exist for rate of birds returned by rural pets (Table 3). In this study, the low end of the range chosen for rural pets was set at the midpoint for urban/suburban pets (2.8 birds returned/yr/outdoor pet); Lepczyk et al. (2004) reported only a 20% higher rate of prey returns from rural vs. urban/suburban pets in Michigan. The high end of the range was set at five times the urban midpoint (14 birds returned/yr/outdoor pet) based on data from Eberhard (1954), adjusted downward to convert kills from stomach samples to prey returns. The 2.8 to 14 bird returns per year range is lower than suggested by Coleman and Temple (1996) for rural cats in Wisconsin (low rate 5.6 birds/yr, medium rate 23, high rate 110), however once an adjustment is added to convert bird returns to birds killed (see below), the range for rural kills is similar to Coleman and Temple's low and medium rates. Their high rate appears to be based on some of the studies excluded here because of small nonrandom samples of cats.

Adjustment for birds killed by pets vs. returned and detected by owners (Adjust):
The number of birds returned and collected by owners is not a complete record of birds killed by their cats, for several reasons. Cats may eat some prey in the field without bringing them home. Toner (1956) estimated that out of four study cats, one brought home all its prey, another brought back about half, and the other two hunted but did not bring any prey home. C. Fiore and K. B. Sullivan, (*unpublished manuscript*) analyzed scat samples to show that 21% of the time, cats ingested birds without owner knowledge. Prey brought home may also escape detection by owners, for example when scavenged by other animals. George (1974) used a correction factor of 2 to offset undetected or scavenged prey, based on a comparison of prey returns when monitored continuously versus an average rate of monitoring. Some animals brought home and assumed to have been killed by pet cats may have been killed by other means, e.g., collisions with cars or buildings. Kays and DeWan (2004) circumvented these shortcomings of prey returns by observing hunting cats directly; they found the rate of kills by outdoor pet cats was 3.3 times as high as numbers of prey brought home, and this 3.3x factor has been used by others to adjust prey returns to prey killed (Baker et al. 2005, 2008, Maclean et al. 2008, Thomas et al. 2012). However, sample sizes were limited (60 prey returned home, 4 kills observed directly during 31 hunts over 181 hours). Loyd et al. (2013) used collar-mounted video cameras to increase samples of prey captured (n = 39) and found that pet cats brought home 23% of prey. Krauze-Gryz et al. (2012) found that predation rate for all prey types was 11.4 times higher when based on scats and stomach samples than from prey returns; their raw data for birds suggest a 5.8x adjustment. In this paper we applied an adjustment of 2.0 to 5.8 for birds killed by pet cats but not detected by owners, bracketing results of the most comprehensive studies above (George 1974, Kays and DeWan 2004, Krauze-Gryz et al. 2012, Loyd et al. 2013).

Birds killed per feral cat (KpF):
Most studies of feral cat diets were based on stomach/digestive tract samples, sometimes supplemented by scat samples and energetic demand calculations. Predation rates for feral cats listed in Table 3 were calculated under the assumption that one stomach sample or one scat sample represents one day's worth of prey eaten by a cat. This may result in an underestimate of birds killed because prey are largely digested after 12 hours (Hubbs 1951), cats produce more than two scats per day on average (Jackson 1951), and birds may be underrepresented in scats (Davis 1957).

Dietary studies from oceanic islands were excluded from Table 3; predation rates on islands with seabird colonies can be very high (up to several birds/day/cat, Keitt et al. 2002, Peck et al. 2008) because of a very high reliance on seabirds in the diet, so are not likely to be representative of rate of bird kills on the mainland. And as yet there is no evidence of

Table 3. Rates of birds returned or killed by cats, calculated from data provided in listed studies, adjusted to a year-round rate where data were seasonal.

Birds/Cat/yr	Method	Study	Location	Excluded
Urban / Suburban Outdoor Pet Cats				
0.6	pr	Baker et al. 2008	Bristol, UK	
1.6	pr	Kays and DeWan 2004	Albany, NY	
1.8	pr	Tschanz et al. 2011	Finstersee, Switzerland	
2.8	pr	Barratt 1997, 1998	Canberra, Australia	
2.8	pr	Gillies and Clout 2003	Auckland City, NZ	
3.4	pr	C. Fiore and K. B. Sullivan, *unpublished manuscript*	Wichita, KS	
4.0	pr	Mitchell and Beck 1992	Henrico County, VA	Xn
5.6	pr	Churcher and Lawton 1987	Felmersham, UK	
6.3	pr	van Heezik et al. 2010	Dunedin, NZ	
6.7	pr	Woods et al. 2003	Great Britain	
13	pr	Crooks and Soulé 1999	San Diego, CA	Xq
13	pr	Flux 2007	Lower Hutt, NZ	Xn
15	pr	Calver et al. 2007	Perth, Australia	Xb
24	pr	Lepczyk et al. 2004	southeast Michigan	Xq
Rural Outdoor Pet Cats				
23	pr	Mitchell and Beck 1992	Virginia	Xn
28	pr	Lepczyk et al. 2004	southeast Michigan	Xq
31	st	Eberhard 1954	Pennsylvania	
41	pr	Bradt 1949	Michigan	Xn
5.6, 23, 110	est	Coleman and Temple 1996	Wisconsin + literature	see text
Feral Cats				
24	st	Parmalee 1953	eastcentral Texas	
27	st	Coman and Brunner 1972	Victoria, Australia	
30+	st,sc	Hutchings 2003	Victoria, Australia	
44	st	Errington 1936	rural Wisconsin	
48	st	McMurray and Sperry 1941	Oklahoma	
51	st	Eberhard 1954	Pennsylvania	
64	sc,st	Llewellyn and Uhler 1952	Patuxent, MD	
153	st	Nilsson 1940, as cited in Hubbs 1951	Willamette Valley, OR	
192	st	Hubbs 1951	Sacramento Valley, CA	

Method: based on prey returned to owner (pr), stomach samples (st), scat analyses (sc), or estimates based on existing literature (est).
Excluded (X): Studies were not relied upon if they were based on a very small number of cats (Xn), were based on questionnaires asking for past numbers of birds killed (Xq), were purposely biased toward prolific hunters (Xb), or were from island studies (not listed in table).

significant predation on seabird colonies in Canada. Many of the studies of feral cat diet in Table 3 are more than 50 years old, and may overrepresent rural areas relative to urban/suburban landscapes where many feral cats are found currently. Studies that included a residential neighborhood (McMurray and Sperry 1941) and a garbage dump (Hutchings 2003) were within the range of bird kills from other studies (Table 3). For application in Canada, a range of 24 to 64 birds per year was selected on the assumption that the two highest rates observed in mainland studies (153 and 192 bird kills/yr) would be unlikely to apply to a broad range of feral cats across Canada.

Sensitivity of estimates to variance in individual parameters

Multiple linear regressions (GLM procedure, SAS Institute 2003) were used to identify parameters that contributed most to variance in mortality estimates across all 10,000 iterations, as measured by R^2 values, with bird mortality estimates as the dependent variable. Separate regressions were run for total birds killed (all parameters included), and for birds killed by pet cats (feral cat parameters excluded).

Note that this assessment of sensitivity directly reflects the range and magnitude of plausible values chosen for each parameter above, based on published studies to date.

Identification of vulnerable bird species in Canada

House cats are opportunistic predators that eat a wide variety of prey, often relying on whatever prey are most abundant (Coman and Brunner 1972, Fitzgerald 1988). However, not all birds are equally available to cats. Published literature was reviewed to examine characteristics of species most susceptible to predation by cats elsewhere in the world, especially in cases where there was evidence of population

impacts. These characteristics were then used to identify bird species in Canada that have potential for similar impacts.

Birds are a more important part of the diet of cats on islands than on continents (Fitzgerald 1988). Birds nesting on oceanic islands are particularly vulnerable to introduced populations of feral cats (reviewed by Nogales et al. 2004), especially ground- and burrow-nesting seabirds. In Canada, there is no evidence currently that predation by feral cats is an issue on oceanic islands with bird colonies (D. Bertram, A. Gaston, M. Hipfner, J. McKnight, G. Robertson, C. Weseloh, B. Whittam, *personal communication*). Cats may not be able to survive on most of these islands because of cold winter weather and/or insufficient alternative sources of food to sustain a year-round population. Nevertheless, it is possible that some of the most southerly islands could sustain cat populations in future, so birds nesting there have been included as potentially vulnerable.

Among mainland populations of birds, species that nest or forage on or near the ground tend to be overrepresented in cat prey relative to other birds (Mead 1982, Dunn and Tessaglia 1994, Coleman and Temple 1996, Lepczyk et al. 2004; C. Fiore and K. B. Sullivan, *unpublished manuscript*); studies have documented significant impacts on survival or abundance of some of these species (Crooks and Soulé 1999, FFWCC 2003, Hawkins et al. 2004, Winter and Wallace 2006, Balogh et al. 2011). Birds that are found in or near residential neighborhoods or farms, or that frequent bird feeders, are also likely to be found among prey of house cats (Dunn and Tessaglia 1994, Coleman and Temple 1996, Lepczyk et al. 2004, Maclean et al. 2008), with some species existing in 'sink' populations (mortality not sustainable without immigration) where cat densities are high (Churcher and Lawton 1987, Baker et al. 2005, 2008, van Heezik et al. 2010, Balogh et al. 2011). Because pet cats tend not to penetrate far into forests (Kays and DeWan 2004), birds of interior forests are less likely to be vulnerable to cat predation even if nesting or foraging on the ground. For instance, cats were not among 12 predators filmed at 42 Wood Thrush (*Hylocichla mustelina*) nests in fragmented forests of southern Ontario despite proximity to farms and residential developments (L. Friesen, *personal communication*). The same is likely true of birds nesting in wetlands, though birds at the edges of marshes may be vulnerable (Winter and Wallace 2006). Pet cats showed a preference for small birds at feeders (Dunn and Tessaglia 1994, median wt ~20g, 75% of prey between ~14 and 42g) but did catch several Mourning Doves (weight ~119g); feral cats on the other hand will often catch and eat larger birds such as adult ducks and game birds (Hubbs 1951, Fitzgerald 1988), up to about their own body mass in size (Paltridge et al. 1997).

To match Canadian bird species to the characteristics above, data on species' preferred habitat(s), nest height, and foraging height were obtained from a 2008 version of the Canadian Wildlife Service WILDSPACE database (see Wong et al. 2003). Body weights were based on Dunning (1984). Species often present in urban or suburban landscapes were identified from a list compiled for the 2009 U.S. State of the Birds Report (NABCI 2009). Birds whose populations are considered "at risk" in Canada were those assessed as Endangered, Threatened, or Special Concern by COSEWIC (2012).

Species were excluded if they did not have at least 25% of their Canadian range or population in southern Canada, as determined using the PIF population estimates database (RBMO 2007, Blancher et al. 2007) and NatureServe digital range data (Ridgely et al. 2007). Species were considered vulnerable to nest predation if their average nest heights were 2m or less, excluding birds nesting mainly on cliffs, or within wetlands, forests, or alpine habitat. Island ground-nesting birds were considered separately. Birds considered vulnerable while foraging on the ground during the breeding season excluded forest birds. An index of species reliance on bird feeders in winter was based on the proportion of birds of each species reported by feeder-watchers vs. by field observers during Christmas Bird Counts (CBC). This proportion was standardized among counts relative to the proportion of 28 reference species at feeders during the same counts, to adjust for differences among counts in the amount of effort devoted to feeder vs. field observations. Species with an index of ≥ 0.5, and a body mass < 150g were included as potentially vulnerable to cat predation. CBC data for birds seen by feeder-watchers were provided by count compilers from 32 CBC circles across Canada for this analysis; full count data were downloaded from the Audubon CBC web page (http://web4.audubon.org/bird/cbc/hr/index.html).

RESULTS

Estimated cat numbers and kill of birds

Urban pet cats are estimated to contribute only about one-sixth of the kill of birds in Canada (Table 4), despite comprising about half of all house cats. Feral cats on the other hand likely kill many more birds than pet cats despite their lower numbers (roughly 25% of cats, 59% of kills).

Estimates of total annual kill of birds by house cats ranged from 105 to 348 million per year (95% of estimates), with 56% of estimates between 150 and 250 million (Fig. 2, Table 4).

Sensitivity of mortality estimates to parameter estimates

Estimates of total bird mortality across all cats were most sensitive to the values selected for numbers and predation rate of feral cats in each iteration (Figures 3, 4a). Total kill was insensitive to the range in number of pet cats in Canada (Figure 4b) because this value is relatively precisely known, and to the rural to urban ratio in number of cats per household (Figure 3).

Table 4. Estimates of cats and birds killed by cats in Canada, based on parameter values in Table 3. Values are medians across 10,000 iterations, with 95% range of estimates in parentheses.

	All Cats	Urban Pets	Rural Pets	Feral Cats
Number of Cats (Millions)	11.3 (9.8-12.8)	5.9 (5.5-6.4)	2.6 (2.3-2.9)	2.8 (1.5-4.1)
		53% (46-60)	23% (19-27)	25% (15-33)
Number of Outdoor Cats (M)	7.5 (5.4-9.6)	3.3 (2.4 - 4.2)	1.4 (1.0-1.9)	2.8 (1.5-4.1)
		44% (34-55)	19% (14-24)	37% (23-52)
Birds Killed (Millions)	204 (105-348)	35 (7-109)	42 (12-102)	116 (49-232)
		17% (4-43)	21% (7-44)	59% (30-84)

Fig. 2. Estimates of the number of birds killed per year by cats in Canada, shown as a frequency distribution across all iterations (see Methods).

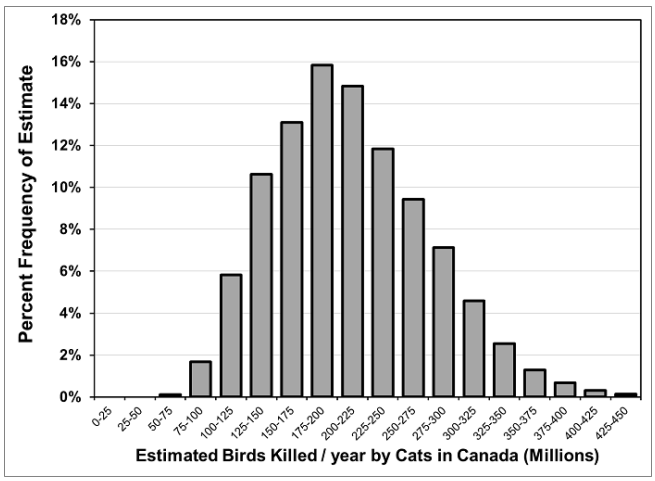


Fig. 3. Relative sensitivity of total bird kill estimates to the range of values used for individual parameters, as measured by % of variance in kill explained in a regression model (R^2).

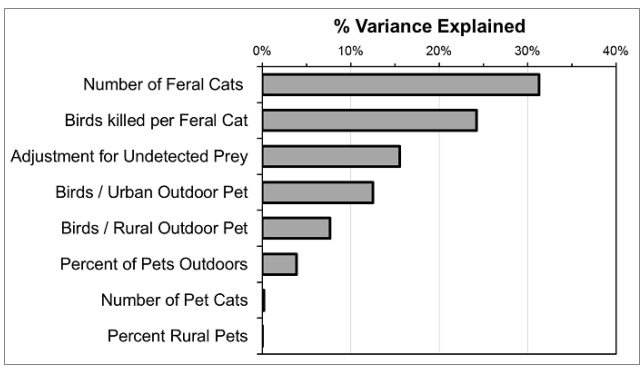


Fig. 4. Relationship between estimates of total birds killed in Canada vs. values used for: a) number of feral cats (R^2 = 0.313); and b) number of pet cats (R^2 = 0.005). Each point represents one of 10,000 iterations, with fitted linear trend line.

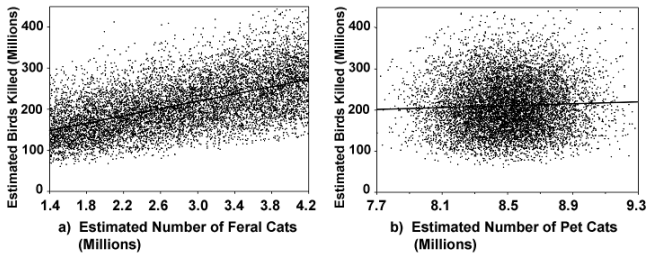
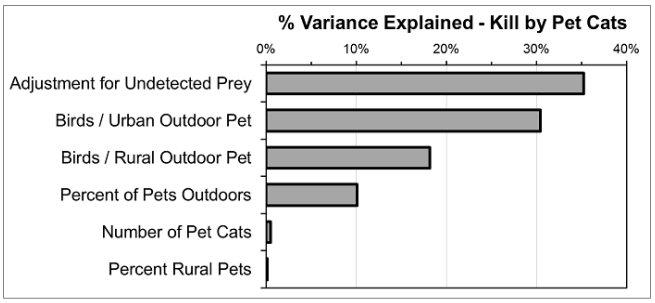


Fig. 5. Relative sensitivity of bird kill estimates for pet cats to the range of values used for individual parameters, as measured by % of variance in kill explained in a regression model.



After excluding feral cat parameters, estimates of birds killed by pet cats were about equally sensitive to variance in the adjustment factor used to convert birds returned home to birds killed, and the rate at which birds were returned by outdoor urban pets (Figure 5).

Table 5. Number of species in southern Canada with characteristics that make them vulnerable to predation by cats. See Appendix for list of species.

Vulnerability Factor	Species	At Risk[†]	Species Examples
Average Nest Height ≤ 2m	69	21	Piping Plover (*Charadrius melodus*), Song Sparrow (*Melospiza melodia*), Bobolink (*Dolichonyx oryzivorus*)
- on Islands	10	2	Cassin's Auklet (*Ptychoramphus aleuticus*), Roseate Tern (*Sterna dougallii*)
Ground Forager (breeding)	62	18	Killdeer (*Charadrius vociferus*), Mourning Dove (*Zenaida macroura*), Eastern Meadowlark (*Sturnella magna*)
Regular use of winter feeders	31	0	Blue Jay (*Cyanocitta cristata*), Dark-eyed Junco (*Junco hyemalis*), American Goldfinch (*Spinus tristis*)
Any of the above	115	23	

[†]At Risk = species assessed by Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Endangered, Threatened, or Special Concern to 2012.

Potentially vulnerable species

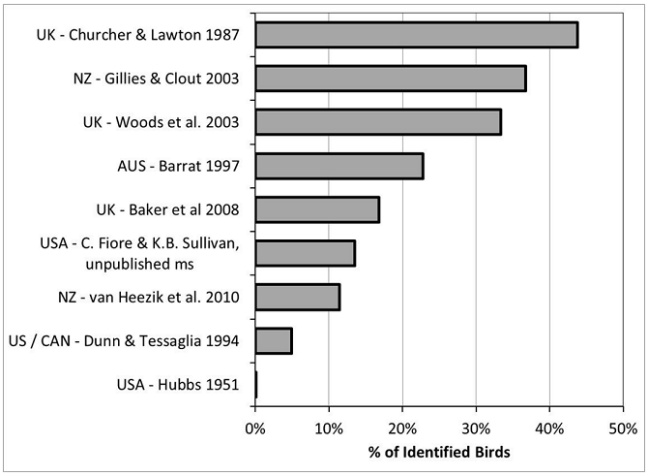
Of 461 bird species that regularly occur in Canada, 115 (25%) were identified as potentially vulnerable to cat predation on the basis of presence in southern Canada, and nesting and foraging characteristics (Table 5, Appendix 1). Forty of these species (9%) are often present in urban or suburban landscapes, where impacts of high cat densities on bird populations have been demonstrated elsewhere, so may be the most likely to suffer similar impacts in Canada. Ten species (2%) breed in burrows or on the ground on islands in southern Canadian waters, so are potentially vulnerable to cat predation, though cats are not currently known to be a problem on these islands.

Twenty-three species at risk in Canada (COSEWIC 2012) are among the potentially vulnerable species in Table 5; all of these birds nest on or close to the ground in open landscapes in southern Canada, two on islands. Only one (Barn Swallow, *Hirundo rustica*) is frequently present in urban and suburban landscapes. Predation by cats is mentioned as a concern in status reports or recovery plans for at least 10 of these species, though in no case are house cats listed as the primary threat to population viability.

Three seabirds that breed elsewhere are among birds at risk in Canada; cats are listed as a threat to two of them on breeding grounds elsewhere (Pink-footed Shearwater, *Puffinus creatopus*, COSEWIC 2004*b*; Black-footed Albatross, *Phoebastria nigripes*, COSEWIC 2007), and were formerly present on the breeding grounds of the third (Short-tailed Albatross, *Phoebastria albatrus*, COSEWIC 2003).

Nine of the 115 potentially vulnerable birds are introduced species in Canada. House Sparrows (*Passer domesticus*) are frequently found in studies of house cat diet; in nine studies involving many cats and bird kills (excluding one study outside the range of House Sparrows in western Australia), House Sparrows accounted for 0 to 44% of birds identified among cat prey items (Figure 6). Their proportion in cat prey tended to be lower in North American studies (< 15% in 3 studies) than in the United Kingdom, New Zealand, or Australia, though more studies would be needed to confirm this tendency. European Starlings (*Sturnus vulgaris*) were also documented as cat prey in several studies, though typically in much lower numbers, topping out at a maximum of 17% of identified birds in a Kansas study (C. Fiore and K. B. Sullivan, *unpublished manuscript*). Other introduced birds in Canada were found much less frequently among cat prey in these same studies.

Fig. 6. House Sparrows as a percent of identified birds in house cat diet from nine studies. All studies included at least 60 identified birds and at least 40 cats.



DISCUSSION

Birds killed by cats in Canada

Estimates presented here suggest a very substantial mortality of birds, with roughly 100-350 million birds killed annually by 5-10 million outdoor cats. This range encompasses Guthrie's (2009) estimate of more than 165 million birds killed by free-roaming cats in Canada, though some of the details

behind the estimates are different (Guthrie's estimate apparently did not include kills by feral cats, and thus must have assumed a higher average predation rate by free-roaming pet cats than in the current estimate).

The most recent estimate of birds killed by cats in the United States (1.4-3.7 billion/year, Loss et al. 2013) is an order of magnitude higher than Canadian estimates in Table 4, similar to the difference in human populations (nine times higher in the United States than Canada, U.S. Census Bureau 2011, Statistics Canada 2011*b*). However, Loss et al. used a more conservative adjustment for prey killed but not returned to owners (1.2-3.3 vs. 2.0-5.8 in this study), otherwise the difference in bird mortality between countries would have been larger. A major reason for higher mortality estimates in the U.S. is the much larger number of feral cats (conservatively estimated at 30-80 million, Loss et al. 2013) vs. in Canada (1.4-4.2 million, Table 1).

In contrast, Woods et al. (2003) estimated that 27.1 (25.1-29.2) million birds were killed by 9 million cats in Great Britain between April and August, which on first glance appears to be a substantially lower total kill than estimated for Canada despite a similar number of cats, and a larger human population. However, if this British estimate is extrapolated to a full year (60% of annual kill during April to August, Fig. 1), adjusted to account for prey killed but not detected by pet owners, included predation rates specific to feral cats (assuming 10-15% of British cats are feral, Harris et al. 1995, Woods et al. 2003, with feral cats killing four times as many prey as pet cats, Liberg 1984), and extrapolated from an average rate of prey returns rather than geometric means, then the estimate of birds killed annually in Great Britain would be 150-550 million, at least as high as in Canada.

Pet ownership in Canada (33-38% of households with pet cats, CAHI 2007, Perrin 2009) and the U.S. (33%, APPA 2011) tends to be higher than across Europe (25% of households with pet cats, FEDIAF 2010) or in Australia (25%, CAHI 2007). However pet cats are ten times more numerous across Europe (85 million, FEDIAF 2010) than in Canada, and feral cat numbers are estimated to be much more abundant in Australia (12 million, New South Wales Government 2011) than in Canada, so that substantial kills of birds are likely in those regions as well.

Sensitivity of estimates

There is no guarantee that the actual rate of bird kills by cats in Canada is within the range of values applied in this study (Table 1), particularly because the data on prey returns are not from Canada, and numbers of feral cats are very crudely estimated. Until data are available from well-designed studies representing various regions and rural/urban situations in Canada, it will be difficult to be much more definitive. Current estimates would be most improved with better knowledge of feral cat numbers and the prey they take because the plausible range of values for their numbers and predation rate are wide, and predation rate is relatively high. However, data on predation rates by pet cats in Canada would also be very helpful. Robust measures of the proportion of undetected prey in studies of prey returns by pets are needed to substantiate the few estimates provided in the literature, particularly to estimate undetected proportion of bird prey.

What-if scenarios

It is possible that the range of values used in the current estimates is too high or too low for the Canadian situation. For example, the majority of studies relied on for predation rate of feral cats (Table 3) are over 50 years old and so may not represent the types of landscapes in which feral cats are most found today, in Canada or elsewhere. If predation rate by feral cats is restricted to four times the rate of pet cats, as in Liberg's (1984) Swedish study, the median total mortality estimated for feral cats in Canada is reduced by 14%.

Evidence that rural pet cats kill more birds on average than urban pets is based on relatively few reliable studies, those that included many randomly selected cats and excluded feral cats (see Table 3 and Methods). If predation rate by rural pets is assumed to equal predation rate of urban pets, then estimates of total birds killed drop by 8-23%, to a range of 80-319 million.

Cold and snow may lessen winter predation rates in Canada more than indicated by the temperate studies summarized in Figure 3. If cat predation on birds is assumed to be negligible during the four months of December through March, total kill would be reduced by 24%, with a 95% range of birds killed of 80-265 million. Winter kill is not likely to be truly negligible in Canada given Dunn and Tessaglia's (1994) results, but this scenario helps put a lower bound on the impact of assuming a lower winter predation rate.

Predation rates based on questionnaire surveys were excluded from consideration ("Xq" in Table 3) given evidence that they are less reliable than collection of prey. If questionnaire data are included, then the upper range of values used in predation rate by pets (Table 1) would be increased, resulting in a 97% increase in the median estimate of birds killed by pet cats per year. Similarly, if the upper limit on predation rate by feral cats (Table 1) is increased to include the two studies with highest rates in Table 3, then the median estimate of birds killed by feral cats would increase by 35%.

These what-if scenarios do not change the overall conclusion that there is a high level of bird mortality from house cats. Even at the low end of these estimates and scenarios, predation by house cats remains as probably the largest human-related source of bird mortality in Canada. Collisions with vehicles, buildings, and transmission lines appear to be the only other human-related sources of avian mortality that together approach the same order of magnitude (Calvert et al. 2013).

Potentially vulnerable species

The current estimates of birds killed per year by cats translate to roughly 2-7% of birds in southern Canada, assuming there are roughly 5.2 billion birds in southern Canada, based on an average density of 450 breeding pairs/km², derived from the Canadian Breeding Bird Census database (Kennedy et al. 1999), stratifying bird densities by ecoregion, and assuming a juvenile to adult bird ratio of 3 to 1 (Calvert et al. 2013).

At that level of annual mortality, it is reasonable to expect there may be consequences for bird populations. Most evidence that cats are a cause of range-wide declines and extinctions of bird species comes from oceanic islands, where ground-nesting colonies of birds evolved in the absence of cats and other predators for millennia prior to introduction of cats. Of 10 island-nesting species identified as potentially vulnerable along southern coastlines of Canada (Appendix 1), at least two have experienced problems from feral cats elsewhere: Cassin's Auklets (*Ptychoramphus aleuticus*) were extirpated by introduced cats from several nesting islands in Mexico (Mills et al. 2005), and Roseate Terns (*Sterna dougallii*) suffered significant feral cat predation in some years in coastal New York state (Gochfield et al. 1998). However, there is no evidence that cats are a significant problem for these species on Canadian islands, despite studies of seabirds and their predators on several islands. Thus vulnerability of these island-nesting species to cat predation does not currently translate into population concerns in Canada.

Birds that nest and/or forage on the ground in open habitats in southern Canada are also potentially at risk to cat predation, given studies elsewhere that have measured unsustainably high local predation rates or other impacts of cats on bird populations nesting or foraging on or near the ground (Churcher and Lawton 1987, Crooks and Soulé 1999, Hawkins et al. 2004, Baker et al. 2005, 2008, van Heezik et al. 2010, Balogh et al. 2011). A common factor in each of these studies was a high density of cats, far exceeding the combined density of native carnivores (Crooks and Soulé 1999, Woods et al. 2003, Baker et al. 2008) and often exceeding the density of bird species taken as prey (Beckerman et al. 2007, Baker et al. 2008).

Of the 115 bird species identified as potentially vulnerable in Canada (Table 5), 40 are often present in urban or suburban landscapes (Appendix 1) and thus possibly at most risk. Five of these species are introduced in Canada, and this raises the question of whether impacts of cat predation are absorbed mainly by introduced species that are present in large numbers in urban settings. House Sparrows in particular are often an important prey of house cats (Fig. 6), and this may be true in Canada as well. Non-native birds tend to be a greater part of cat diets in fully urban areas than in urban fringe (Gillies and Clout 2003). Nevertheless, the proportion of introduced birds in cat kills in the United States tended to be well below 50% of birds killed (Fig. 6; Crooks and Soulé 1999).

Thirty-one species were identified as potentially vulnerable to cat predation because of high use of feeders in winter and relatively small body mass (Table 5, Appendix 1). Dunn and Tessaglia (1994) thought that the bird-feeding environment did not expose birds to higher predation than the nonfeeder environment, largely because volunteer feeder-watchers tended to report low numbers of bird captures per feeding site per winter. However, it is difficult to evaluate this result without an estimate of the proportion of kills that feeder-watchers detected, or at least the proportion of time that feeders were watched. Woods et al. (2003) found that pet cats in Great Britain brought home fewer bird prey at houses that supplied bird food relative to houses that did not feed birds, however their study took place in spring and summer. Churcher and Lawton (1987) found that birds formed a higher proportion of prey in severe winter weather. Taken together, there is no strong evidence to date of population impacts among birds most vulnerable to winter predation at bird feeders, though more detailed study would be needed to demonstrate a lack of local population impacts.

Cat densities can also be high in rural situations where there are concentrations of feral and/or free-roaming pet cats associated with barns and farming operations, typically established for pest control. For example, Coleman and Temple (1993) reported densities up to 44 cats/km² in rural Wisconsin, though this is still well below cat densities in urban situations (often over 200 cats/km², van Heezik et al. 2010). Ground-nesting grassland birds are potentially at risk in this landscape, though to date no detailed studies have assessed impacts of cats on local bird populations in rural landscapes. Studies using video cameras in several grassland/agricultural landscapes in the U.S. did not find cats to be an important predator at bird nests (Klug et al. 2010). Among ground-nesting birds that have been listed by COSEWIC as at risk in Canada, status reports of prairie-nesting populations named cats as a known threat for 3 of 11 species, whereas cats were named as a threat for 3 of 4 species of grass and scrub-nesting birds restricted mainly to British Columbia. Together these results suggest that the risk of population-level impacts in rural Canadian landscapes may vary regionally, depending to a large extent on local cat densities, and may often be lower than for birds feeding or nesting on the ground in urban and suburban landscapes.

Because most bird species in Canada are migratory, including most species that are potentially vulnerable to cat predation, many birds will be subject to additional cat predation after they leave Canada, particularly as they migrate through and/or winter in the U.S., where numbers of pet cats and especially feral cats are much higher. Thus the proportion of Canada's birds killed by cats will be higher than estimated above using predation rates in Canada alone.

CONCLUSION

Despite a dearth of Canadian data on predation by cats, it is clear from the numbers of house cats in Canada and predation rates elsewhere that the number of birds killed by cats each year is very large, probably the largest human-related source of bird mortality in Canada. This rate of mortality is likely to increase in future, if recent increases in cat numbers are an indication (Coleman and Temple 1993, Clarke and Pacin 2002, Maclean et al. 2008, CFHS 2009, though pet cat numbers have declined in Australia, Chaseling 2001). Because cat predation is likely to remain a primary source of bird mortality in Canada for some time, studies are needed to assess impacts on bird populations and effectiveness of mitigative measures.

Responses to this article can be read online at:
http://www.ace-eco.org/issues/responses.php/557

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Appendix: Bird species potentially vulnerable to cat predation in Canada (see text for details): nests on islands (Isl), nests low (Low), forages on ground (Grnd), high use of feeders (Fdr), body mass (Mass, g), frequents urban/suburban landscapes (Urb), COSEWIC status (COS; XT=Extirpated, E=Endangered, T=Threatened, SC=Special Concern, ( ) indicates 1 or more subspecies / populations).

Species	Latin Name	Isl	Low	Grnd	Fdr	Mass	Urb	COS	Int
Double-crested Cormorant	*Phalacrocorax auritus*	Y				1,679			
Laughing Gull	*Leucophaeus atricilla*	Y				325			
Ring-billed Gull	*Larus delawarensis*	Y				519			
California Gull	*Larus californicus*	Y				609			
Roseate Tern	*Sterna dougallii*	Y				110		E	
Ancient Murrelet	*Synthliboramphus antiquus*	Y				206		SC	
Cassin's Auklet	*Ptychoramphus aleuticus*	Y				188			
Rhinoceros Auklet	*Cerorhinca monocerata*	Y				520			
Horned Puffin	*Fratercula corniculata*	Y				619			
Tufted Puffin	*Fratercula cirrhata*	Y				779			
Blue-winged Teal	*Anas discors*		Y			386			
Northern Pintail	*Anas acuta*		Y			1,011			
California Quail	*Callipepla californica*		Y	Y		173	Y		Y
Northern Bobwhite	*Colinus virginianus*		Y	Y		178		E	
Chukar	*Alectoris chukar*		Y	Y		578			Y
Gray Partridge	*Perdix perdix*		Y	Y		390			Y
Ring-necked Pheasant	*Phasianus colchicus*		Y	Y		1,135			Y
Greater Sage-Grouse	*Centrocercus urophasianus*		Y	Y		2,468		(XT,E)	
Sharp-tailed Grouse	*Tympanuchus phasianellus*		Y	Y		885			
Piping Plover	*Charadrius melodus*		Y	Y		55		(E,E)	
Killdeer	*Charadrius vociferus*		Y	Y		97	Y		
Mountain Plover	*Charadrius montanus*		Y	Y		108		E	
American Oystercatcher	*Haematopus palliatus*		Y	Y		632			
Black Oystercatcher	*Haematopus bachmani*		Y	Y		648			
Willet	*Tringa semipalmata*		Y			215			
Upland Sandpiper	*Bartramia longicauda*		Y	Y		170			
Long-billed Curlew	*Numenius americanus*		Y	Y		587		SC	
Marbled Godwit	*Limosa fedoa*		Y			371			
American Woodcock	*Scolopax minor*		Y	Y		198			
Glaucous-winged Gull	*Larus glaucescens*		Y	Y		1,010			
Mourning Dove	*Zenaida macroura*		Y	Y	Y	119	Y		
Burrowing Owl	*Athene cunicularia*		Y	Y		155		E	
Common Poorwill	*Phalaenoptilus nuttallii*		Y			52			
Willow Flycatcher	*Empidonax traillii*		Y			13			
Loggerhead Shrike	*Lanius ludovicianus*		Y	Y		47		(E,T)	

White-eyed Vireo	*Vireo griseus*	Y			11			
Sky Lark	*Alauda arvensis*	Y	Y		40			Y
Horned Lark	*Eremophila alpestris*	Y	Y		31		(E)	
Barn Swallow	*Hirundo rustica*	Y			19	Y	T	
Rock Wren	*Salpinctes obsoletus*	Y	Y		17			
Carolina Wren	*Thryothorus ludovicianus*	Y		Y	21	Y		
House Wren	*Troglodytes aedon*	Y			11	Y		
Sedge Wren	*Cistothorus platensis*	Y	Y		9			
American Robin	*Turdus migratorius*	Y			77	Y		
Gray Catbird	*Dumetella carolinensis*	Y	Y		37	Y		
Northern Mockingbird	*Mimus polyglottos*	Y	Y		49	Y		
Sage Thrasher	*Oreoscoptes montanus*	Y	Y		43		E	
Brown Thrasher	*Toxostoma rufum*	Y	Y		69			
Sprague's Pipit	*Anthus spragueii*	Y	Y		25		T	
Cedar Waxwing	*Bombycilla cedrorum*	Y		Y	32	Y		
Chestnut-collared Longspur	*Calcarius ornatus*	Y	Y		19		T	
McCown's Longspur	*Rhynchophanes mccownii*	Y	Y		23		SC	
Golden-winged Warbler	*Vermivora chrysoptera*	Y			9		T	
Blue-winged Warbler	*Vermivora cyanoptera*	Y			8			
MacGillivray's Warbler	*Geothlypis tolmiei*	Y			10			
Chestnut-sided Warbler	*Setophaga pensylvanica*	Y			10			
Prairie Warbler	*Setophaga discolor*	Y			8			
Yellow-breasted Chat	*Icteria virens*	Y			25		(E,E)	
Spotted Towhee	*Pipilo maculatus*	Y	Y		40	Y		
Eastern Towhee	*Pipilo erythrophthalmus*	Y	Y		41			
Clay-colored Sparrow	*Spizella pallida*	Y	Y		12			
Brewer's Sparrow	*Spizella breweri*	Y	Y		10			
Field Sparrow	*Spizella pusilla*	Y	Y		13			
Vesper Sparrow	*Pooecetes gramineus*	Y	Y		26		(E)	
Lark Sparrow	*Chondestes grammacus*	Y	Y		29			
Lark Bunting	*Calamospiza melanocorys*	Y	Y		38			
Savannah Sparrow	*Passerculus sandwichensis*	Y	Y		23		(SC)	
Grasshopper Sparrow	*Ammodramus savannarum*	Y	Y		17			
Baird's Sparrow	*Ammodramus bairdii*	Y	Y		18		SC	
Henslow's Sparrow	*Ammodramus henslowii*	Y	Y		13		E	
Song Sparrow	*Melospiza melodia*	Y		Y	21	Y		
Lazuli Bunting	*Passerina amoena*	Y			16			
Indigo Bunting	*Passerina cyanea*	Y	Y		15			
Dickcissel	*Spiza americana*	Y	Y		27			
Bobolink	*Dolichonyx oryzivorus*	Y	Y		42		T	
Eastern Meadowlark	*Sturnella magna*	Y	Y		89		T	

Western Meadowlark	*Sturnella neglecta*	Y	Y		98			
Brewer's Blackbird	*Euphagus cyanocephalus*	Y	Y		63	Y		
American Goldfinch	*Spinus tristis*	Y		Y	13	Y		
Rock Pigeon	*Columba livia*		Y		542	Y		Y
Eurasian Collared-Dove	*Streptopelia decaocto*		Y		200	Y		Y
Blue Jay	*Cyanocitta cristata*		Y	Y	87	Y		
American Crow	*Corvus brachyrhynchos*		Y		448	Y		
Canyon Wren	*Catherpes mexicanus*		Y		11			
Bewick's Wren	*Thryomanes bewickii*		Y		10	Y		
Eastern Bluebird	*Sialia sialis*		Y		32			
Mountain Bluebird	*Sialia currucoides*		Y		29			
European Starling	*Sturnus vulgaris*		Y		82	Y		Y
Northern Cardinal	*Cardinalis cardinalis*		Y	Y	45	Y		
Common Grackle	*Quiscalus quiscula*		Y		114	Y		
Brown-headed Cowbird	*Molothrus ater*		Y		44	Y		
House Finch	*Carpodacus mexicanus*		Y	Y	21	Y		
House Sparrow	*Passer domesticus*		Y	Y	28	Y		Y
Red-bellied Woodpecker	*Melanerpes carolinus*			Y	62	Y		
Downy Woodpecker	*Picoides pubescens*			Y	27	Y		
Hairy Woodpecker	*Picoides villosus*			Y	66	Y		
Northern Flicker	*Colaptes auratus*			Y	128	Y		
Steller's Jay	*Cyanocitta stelleri*			Y	106	Y		
Black-capped Chickadee	*Poecile atricapillus*			Y	11	Y		
Mountain Chickadee	*Poecile gambeli*			Y	11	Y		
Chestnut-backed Chickadee	*Poecile rufescens*			Y	10	Y		
Bushtit	*Psaltriparus minimus*			Y	5	Y		
Red-breasted Nuthatch	*Sitta canadensis*			Y	10	Y		
White-breasted Nuthatch	*Sitta carolinensis*			Y	21	Y		
Varied Thrush	*Ixoreus naevius*			Y	78			
American Tree Sparrow	*Spizella arborea*			Y	20			
White-throated Sparrow	*Zonotrichia albicollis*			Y	26			
White-crowned Sparrow	*Zonotrichia leucophrys*			Y	29	Y		
Dark-eyed Junco	*Junco hyemalis*			Y	20	Y		
Pine Grosbeak	*Pinicola enucleator*			Y	56			
Purple Finch	*Carpodacus purpureus*			Y	25	Y		
Common Redpoll	*Acanthis flammea*			Y	13			
Hoary Redpoll	*Acanthis hornemanni*			Y	13			
Pine Siskin	*Spinus pinus*			Y	15	Y		
Evening Grosbeak	*Coccothraustes vespertinus*			Y	59			