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PROFILE

Natural History Traits Associated with Detecting Mortality Within Residential Bird Communities: Can Citizen Science Provide Insights?

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Abstract Cat predation of birds in residential landscapes is ephemeral, unpredictable, and spatially dispersed, and thus requires many person-hours to observe. We sought to identify whether specific behaviors, traits, or feeding ecologies of birds contribute to their probability of cat-caused mortality around residences across temperate North America. In addressing this question, we evaluated citizen science data with respect to peer-reviewed species accounts (Birds of North America, BNA). Using information on cat predation from the BNA, we found that species that glean their prey from the ground or breed in nest boxes were three times more likely to be depredated by cats, while birds that hawk were over two times less likely to become cat prey than would be predicted by random chance. Data from citizen science sources also showed that birds using nest boxes had increased susceptibility to cat predation, as did those that use feeders and that glean from foliage. We caution that observations of predation by citizen science volunteers may be biased towards detection at feeders. Future research should focus on developing volunteer survey techniques for improving estimates of bird mortality rates and sources.

Keywords Domestic cat · Predator-prey interactions · Urbanization · Birdfeeders · “My Yard Counts” · “PredatorWatch”

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Introduction

Human-dominated lands can have conservation value (Rosenzweig 2003). In residential ecosystems, people have the collective potential to strongly influence bird population dynamics, directly or indirectly, intentionally or unintentionally, through landscaping, bird feeding, and pet ownership practices (Lepczyk and others 2004; Cooper and others 2007; Lerman and Warren 2011). Given the significant potential and relatively low public cost of backyard conservation efforts, their impacts are worthy of investigation (Evans and others 2005).

Bird population densities increase along a gradient of urbanization, a surprising phenomenon that has been attributed to relaxed predation pressure and higher amounts of food resources in urban settings (Shochat 2004; Shochat and others 2010). Yet, even though populations of specific bird species are greater in urban settings, species richness is dramatically lower with urbanization (Shochat and others 2010). Thus, species vary greatly in their population response to urbanization. The current role of predation in shaping bird population size and community composition around residences is equivocal. For example, some studies have found higher nest predation rates in urban settings (Balogh and others 2011; Jokimä ki and Huhta 2000; Thorington and Bowman 2003), whereas other studies have not (Rodewald and others 2011; Gering and Blair 1999;

Ryder and others 2010). Compounding interpretation of past predation studies is recent research illustrating that avian productivity can be decreased merely by the prey's perception of predation risk, without direct lethal effects (Zanette and others 2011).

In attempting to understand the differential species response to urbanization, there are several reasons for attention on domestic cats as predators of wild birds. First, domestic cats are strongly associated with residential settings, and can occur in high densities (Liberg and others 2000). Hawkins and others (2004) found that almost twice as many resident bird species were detected in surveys of areas without cat colonies than areas with cat colonies, and focal species, including California quail (*Callipepla californicus*) and California thrashers (*Toxostoma redivivum*), were absent (or virtually absent) from areas with cat colonies. Second, there are well-documented and severe impact of feral cats on island avifauna (e.g., King 1985) and exorbitant mainland estimates derived from extrapolation from small numbers of local bird deaths attributed to cats (e.g., 217 million birds/year in Wisconsin reported by Coleman and others 1997; two bird deaths by cats/winter/residence reported by Dunn and Tessaglia 1994). Third, cats have a propensity to kill more birds than they consume (i.e., surplus killing, Peck and others 2008). These reasons have led conservation advocacy organizations, such as the American Bird Conservancy (1997, 2007), to list cats as a leading cause of bird species extinctions, second only to habitat destruction.

Nevertheless, consistent strong evidence that domestic cats are a conservation threat to mammals or birds on mainlands is limited (e.g., Crooks and Soule 1999; Baker and others 2005; Beckerman and others 2007; Dauphine and Cooper 2009). Studies have described domestic cats as generalist and opportunistic predators (Pearre and Maass 1998; Coman and Brunner 1972), both in terms of time and habitat location (Barratt 1997), meaning they will kill a prey item if they encounter it. Use of the term 'opportunistic' to describe cat predatory behavior has led some cat advocates to claim that cats kill species that are abundant and therefore cause minimal impacts. Yet, Cresswell and others (2003) pointed out that cats are stalking predators, only opportunistic in the sense that they stalk and will be more likely to take the non-vigilant individuals. They can also use a sit-and-wait style with similar consequences (Fitzgerald and Turner 2000). If stalking and/or sit-and-wait results in cats taking species in proportion to availability, then they may reduce the most common species in the local bird community (Barratt 1997; Dunn and Tessaglia 1994). On the other hand, if cats prefer certain types of species, or if certain types of species are less vigilant, then they could negatively impact populations of rare species as well. Furthermore, as Barratt (1997) points out, the latter is likely for predators such as cats because they likely show no numerical response to fluctuations in prey abundance. Finally, it remains unclear whether bird mortality from cat predation is compensatory (producing no consequences to overall population) or additive (impacts populations; Balogh and others 2011) and this may differ by species. Yet, predators at high densities can influence prey populations directly through mortality (Baker and others 2005; van Heezik and others 2010) and through sub-lethal effects such as decreasing the preys' reproductive performance and/or overwinter survival (Beckerman and others 2007).

Unfortunately, incorporating cat predation into models of avian populations in residential settings is challenging because of the difficulty in distinguishing bird movements from cumulative, yet dispersed, mortality events. Citizen science, such as when residents participate in scientific research, can be an excellent means of monitoring rare and unpredictable events over large geographic areas and significant time spans (Cooper and others 2007, 2012; Silvertown 2009). Research on urban/suburban cat predation with data collection by residents may hold promise for several reasons. First, citizen science methods can provide an amount of cumulative observation-hours as to make the collection of information on rare events tractable. Second, the main sources of detection bias, variation in effort and habitat-specific visibility, could translate into lower and less variable bias around residences (Dickinson and others 2010). Specifically, detection of cat predation may be greater around residences, because effort is high and habitats are typically open, and less variable among uniform residences (compared to forested or pastoral landscapes where detectability varies among habitat patches and with distance from the road (Buckland and others 1993)). On the other hand, causes of mortality that are spatially static, such as flight strikes into windows or wind turbines, can be monitored using robust, constant-effort protocols, with experiments to evaluate search efficiency and detectability (Osborn and others 2000). To date, few, if any, protocols that incorporate effort or detectability have been developed for monitoring ephemeral, spatially dispersed, and temporally unpredictable events such as cat predation.

In lieu of systematic monitoring, we sought to utilize extensive, but haphazard, documentation of cat predation in relation to avian natural histories. Our first goal was to determine whether certain bird behaviors and natural history traits influenced the susceptibility to cat depredation. Our predictive hypotheses were: Cat predation is influenced by (a) birds' use of human structures (feeders and nest boxes make birds more predictable in space, and thus could lead to higher rates of predation by cats using a sit-and-wait predatory style), (b) birds' foraging strategies (ground-gleaning species are susceptible to cats because they stalk on the ground), and (c) bird size (smaller birds are more susceptible to cat predation as in Dunn and Tessagila 1994). Our second goal was to evaluate the potential for citizen science to address research questions about cat predation in residential settings. To do so, we compared analyses based on peer-reviewed compilations (Birds of North America, Poole 2005) with analyses based on citizen science data, with the expectation of reaching similar conclusions from each source.

Methods

Mortality Data Collection

We used data collected with a Citizen Science methodology via two schemes: My Yard Counts (MYC), administered by the Cornell Lab of Ornithology, and PredatorWatch (PW), administered by the American Bird Conservancy. Participants submitted observations via online surveys (www.surveymonkey.com). My Yard Counts was a short-term pilot project that assessed factors affecting bird species richness and abundances around 283 residences in the spring and summer seasons (March through September in 2007). PredatorWatch is an on-going survey, from which we used data submitted from 15 December 2006 to 14 December 2007. PredatorWatch data consisted of over 300 reports of cats killing birds from 146 residences. After excluding species associated with water, we retained 232 North American bird species that appeared on checklists in residential areas of participants in My Yard Counts. We collated data from species accounts in the Birds of North America (BNA; Poole 2005), a peer-reviewed series that synthesizes literature with experts authoring accounts for each North American species. We categorized each species as susceptible to cat predation (yes/no) based on information in the subsection “Predation” in the “Behavior” section, which is where predators of the species were listed.

Behavioral Traits

We used the BNA to categorize natural history traits. Visiting feeders and using nest boxes were dichotomous variables (yes, no). Foraging height was categorized as low (regularly on or <5 m from ground), medium-low (regularly 5–10 m from ground), medium (regularly 10–15 m above ground), medium-high (regularly 15–20 m) and high (regularly in tree tops, >20 m). Body weights were compiled from Dunning (1984) for males and females. Foraging technique categories were derived from Ehrlich and others (1988) and up to 3 of the categories were assigned to each species. Bath use and nesting height were found to be highly correlated with other variables and were excluded from further analysis. We also eliminated variables that were exceedingly rare among residential bird species (swoops, hover and pursuit).

Statistical Analysis

We used logistic regression to examine the relationship between domestic cat predation and bird natural history traits with cat prey as a dichotomous response variable. Logistic regression measured the influence of avian foraging styles, habits, and average mass on the likelihood that a residential bird species will be detected and reported as cat prey. We calculated variable inflation factors (VIF) to quantify the severity of any remaining multicollinearity. All variables had low VIF scores (<3) and thus were retained.

We employed an information theoretic approach (Burnham and Anderson 2002) to evaluate the plausibility of alternative regression models. To predict the influence of life history variables on the probability of becoming cat prey, we created two global models, one for each data source (BNA and citizen science), with identical fixed effects. Each global model included variables for human structures (feeder and nestbox use), variables related to foraging styles (ground gleaning, hawking, foliage gleaning, bark gleaning, aerial pursuit, and hover and gleaning), foraging height, and body size. To evaluate the goodness-of-fit of the global models, we used a Hosmer-Lemeshow test (Hosmer and Lemeshow 1989) and examined the Pearson Chi-Square residuals for outliers.

We created four additional models to reflect alternative hypotheses about the primacy of natural history traits, or use of backyard structures, while controlling for body mass, on bird susceptibility to predation (Table 1). The “human structures” model (take by sit-and-wait cat predators is influenced by bird use of residential structures and resources) included feeder and nest box use and body mass. The “foraging styles” model (bird loss to stalking cat predators is influenced by bird foraging styles) included ground gleaning, aerial pursuit, foliage gleaning, and body mass. The “foraging height” model (predation is primarily influenced by bird foraging height) included foraging height and body mass. A “combination” model (predation on birds is influenced by a combination of human structures and foraging styles) included feeder and nestbox use as well as ground gleaning, hawking, foliage gleaning, and body mass.

We used Akaike’s Information Criteria (AIC, Akaike 1973), and Akaike weights (Burnham and Anderson 2002), to evaluate the relative fit of each model. The precision of the best-fitting model was assessed using leave-one-out cross validation, which estimates out-of-sample model performance as described by (Fukunaga and Kessel 1971) and provides a measure of overall predictive ability (Efron

Table 1 Hypotheses and associated candidate logistic regression models

Candidate models	Hypothesis	Candidate model
Global		Feeder use Nestbox use Mass Foraging height Ground glean Hawk Foliage glean Bark glean Aerial pursuit Hover and glean
Human structures	Take by predators is influenced by bird use of residential structures and resources	Feeder use Nestbox use Mass
Foraging styles	Bird loss to predators is influenced by bird foraging on or near the ground, by hovering to forage, and by smaller mass (each allow birds to become easy prey)	Ground glean Aerial pursuit Foliage glean Mass
Foraging height	Predation is determined by availability of birds as prey which can be influenced by forage height or appropriate size	Forage height Mass
Combination (Human structures and foraging styles)	Predation on birds is influenced by a combination of human structures and foraging styles	Feeder use Nestbox use Ground glean Hawk Foliage glean Mass

1983). The cross validation procedure omits one observation from the data, fits the regression model with the remaining $n-1$ observations and estimates the probability of becoming cat prey for the omitted observation using the fitted model. Cross validation is appropriate for estimating the predicted error rate of a model (Brieman and Spector 1992) and should provide a measure of the ability of the residential bird model to estimate cat predation under similar conditions. A cut-off value of 0.5 was used in the cross validation process, thus any probability greater than 0.5 indicates Yes (Cat Prey) while $P < 0.5$ was estimated as No (not cat prey). All statistical analysis and calculations were conducted in R (The R Foundation 2009).

To interpret the logistic regression estimates for the best models, we calculated Odds Ratios for each model parameter ($e^{\text{coefficient estimate}}$). The precision of model coefficients was assessed by calculating the 95 % confidence intervals (based on a t-statistic with $n-1$ df). Confidence intervals containing zero resulted in inconclusive results since imprecision in the parameter estimate clouded the nature of the relationship (positive or negative). We used predicted log odds (=intercept coefficient + (each parameter coefficient estimate*value of 1 or 0)) to calculate the probability of a bird with these characteristics becoming cat prey as $=1/(1 + e^{(-\text{log odds})})$.

Results

Through the two citizen science schemes, information on bird mortality was contributed from 429 residential properties across the US and Canada (a representative sample of North American residences assuming a 95 % Confidence Interval and 5 % error). Data from both surveys indicate that cats kill a wide range of wild bird species (Appendix 1) and the species varied in their natural history traits (Fig. 1).

The BNA-derived data identified more species as depredated by cats than did the citizen science-derived data (Appendix 1). In the BNA, 82 of 232 species accounts (35 %) specifically mentioned predation by cats, while 55 species (24 %) were reported as victims of cat predation in citizen science schemes. Citizen science data included only one species—northern flicker—that was not noted in BNA as vulnerable to cat predation. For BNA and citizen science data sources, the combination model, which included common foraging styles and use of human structures, was the best-fit logistic regression model. Interpreting the Akaike weights, the combination model was 24 times (0.96/0.04) and 9 times (0.90/0.10) more probable than the next best model, using BNA and citizen science data, respectively, than the next best model, which was the global model containing all predictor variables (Table 2).

Based on BNA data, the confidence intervals for ground gleaning and box use indicate that these variables had the greatest influence on susceptibility to cat predation (Table 3). The Odds Ratio revealed that ground gleaning birds and birds that used cavities were almost 3 times (2.95, 2.89, respectively) more likely to be at risk of cat predation. Ground gleaning birds include species such as: Dark-eyed Junco, Song Sparrow, Eastern Towhee, House Wrens, American Robin, Gray Catbird, and Brown Thrasher. The BNA estimates predicted a 48 % chance that a bird that uses a cavity will become cat prey, this increased to 73 % if a bird uses a bird box and ground gleaning foraging strategy. Common cavity nesters and nest box users in our sample include: Carolina Wren, Black-capped Chickadee, House Sparrow, and Eastern Bluebirds. Birds that forage by hawking, such as Eastern Wood-peewee, Willow

Table 2 BNA results; predictor variables, number of parameters (K), AIC, ΔAIC, and Akaike weights for the set of BNA and citizen science models predicting the influence of bird life history characteristics on cat predation of residential birds

	K	AIC	ΔAIC	Wi
BNA models				
Combination (Human structures and foraging styles)	6	272.35	0	0.96
Global	11	278.62	6.27	0.04
Foraging styles	5	287.65	15.31	0.00
Human structures	4	299.71	27.36	0.00
Foraging height	3	305.96	33.61	0.00
Citizen science models				
Combination (Human structures and foraging styles)	6	222.61	0	0.90
Global	11	227.02	4.41	0.10
Human structures	4	233.74	11.13	0.00
Foraging styles	5	242.32	19.71	0.00
Foraging height	3	260.02	37.42	0.00

Table 3 Model results for the best logistic regression model predicting residential bird susceptibility to cat predation based on data from the BNA

Parameter	Estimate	SE	Odds ratio	Upper CI	Lower CI
BNA					
Intercept	−1.15	0.38		−0.40	−1.90
Feeder use	0.11	0.35	1.12	0.80	−0.58
Box use	1.06	0.41	2.89	1.87	0.26
Ground gleaning	1.08	0.36	2.95	1.78	0.38
Hawks	−1.10	0.36	0.33	−0.40	−1.80
Foliage gleaning	0.15	0.30	1.17	0.75	−0.44
Citizen science					
Intercept	−3.39	0.57		−2.27	−4.50
Feeder use	1.28	0.44	3.58	2.13	0.42
Box use	1.34	0.44	3.81	2.20	0.48
Ground gleaning	0.78	0.40	2.18	2.18	−0.02
Hawks	−0.17	0.40	0.84	0.84	−0.96
Foliage gleaning	1.09	0.37	2.98	2.98	0.38

Flycatcher, and Eastern Phoebe, were less likely to be depredated by cats (Table 3). Based on BNA data, other predictors (bird feeder use and foliage gleaning) appeared to be related to cat predation though their confidence intervals included zero and thus the precise nature of the relationship could not be determined.

Conversely, based on citizen science data, foliage gleaning and using bird feeders and nest boxes had the greatest influence on susceptibility to cat predation (Table 3). Using citizen science data, the probability that a bird species using a bird box will become cat prey was 11 %, and this increased to 32 % if the bird used a box and feeder, and 58 % if the bird used a box, feeder and foliage gleaning foraging strategy. Leave-one-out cross validation conducted for the best fitting model produced a prediction error rate of 33 % for the BNA cat prey model and 22 % for the Citizen Science cat prey model. This moderately low proportion of predictions that were wrong indicates the best model for each is fairly precise.

Discussion

Species Vulnerability

Not all bird species were equally vulnerable to predation by cats. We found that the likelihood of becoming cat prey varied among bird species, and that particular behavioral and natural-history characteristics were associated with predation risk. The susceptibility of a bird species to cat predation increased with their use of human structures, as well as use of ground gleaning and foliage gleaning strategies for foraging. Both sources of data highlight the vulnerability of guilds of birds that spend time on or near the ground and those that nest in cavities or nest boxes. These findings reflect the common stalking behavior and sit-and-wait hunting strategies of domesticated cats. In addition to drastic effects of habitat reduction, the low richness of urban bird communities may represent the 'ghost of predation past" (Shochat 2004), a scenario in which only a small group of cat-resistant species currently persist in urban ecosystems. Yet, some backyard birds, like the ground-gleaning Mourning dove (*Zenaida macroura*), remain common despite characteristics that make them susceptible to cat predation. The susceptibility of ground-gleaning species and their prevalence in residential systems points to the likelihood that source-sink metapopulation dynamics may characterize residential bird populations (van Heezik and others 2010). The influence of nest boxes, and whether they could serve as ecological traps in residential settings due to heightened exposure to predation remains unclear.

Observation Bias

Results from the BNA and citizen science sources differed in highlighting feeder use as a characteristic of birds more susceptible to cat predation. The information in the BNA differed from citizen science in some aspects, such as providing a more comprehensive list of depredated bird species, having been built over longer time period and through synthesis of gray and published literature. Nevertheless, the BNA data was only partially based on studies and experiments, but largely on opportunistic observations, just like the citizen science data. The most important differences between the BNA and citizen science data may be that citizen science data were primarily from residential landscapes, while the BNA sources were based on observations and studies from diverse habitats.

Based on observations reported by participants in the citizen science scheme, Project FeederWatch, Dunn and Tessaglia (1994) recorded a similar number of avian species around feeders as victims of cat and raptor predation, though 92 % of all victims in their study were accounted for by 10 bird species, 7 of which were reported as taken by cats. The primary foraging mode of 5 of the 7 was ground gleaning, and for the remaining 2 species, their primary mode was foliage gleaning while their secondary mode was ground gleaning. In their study, cat predation was more common at sites that offered bird food on the ground. Yet, cat predation was not related to flock size of particular species at feeders, whereas hawks were more likely to take prey with greater flock sizes (Dunn and Tessaglia 1994). Other studies suggest feeders do not increase risk of cat predation to birds. For example, Woods and others (2003) found the presence of bird feeders to be associated with lower levels of predation by domestic cats in the UK. Feeders may lower predation risk because of group vigilance (Popp 1988, Waite 1987) and/or reduced foraging time limiting exposure to predators (Jansson and others 1981). Our results suggest that the potential influence of feeders warrants further research, though a plausible reason for the different results between BNA and the citizen science dataset is that feeder use increased detection of predation events by backyard bird watchers. A potential observation bias in the citizen science datasets speaks to the need for protocols that include estimates of participant effort, methods to standardize effort related to detecting evidence of predation, and methods to concurrently monitor living bird abundance in a use (depredated) versus availability framework as in Dunn and Tessaglia (1994). We found, for example, that ground-foraging and cavity-nesting species were three-times more likely to be reported as killed by cats, but if these types of species are three-times more common around residences, then cat predations would reflect what was most common.

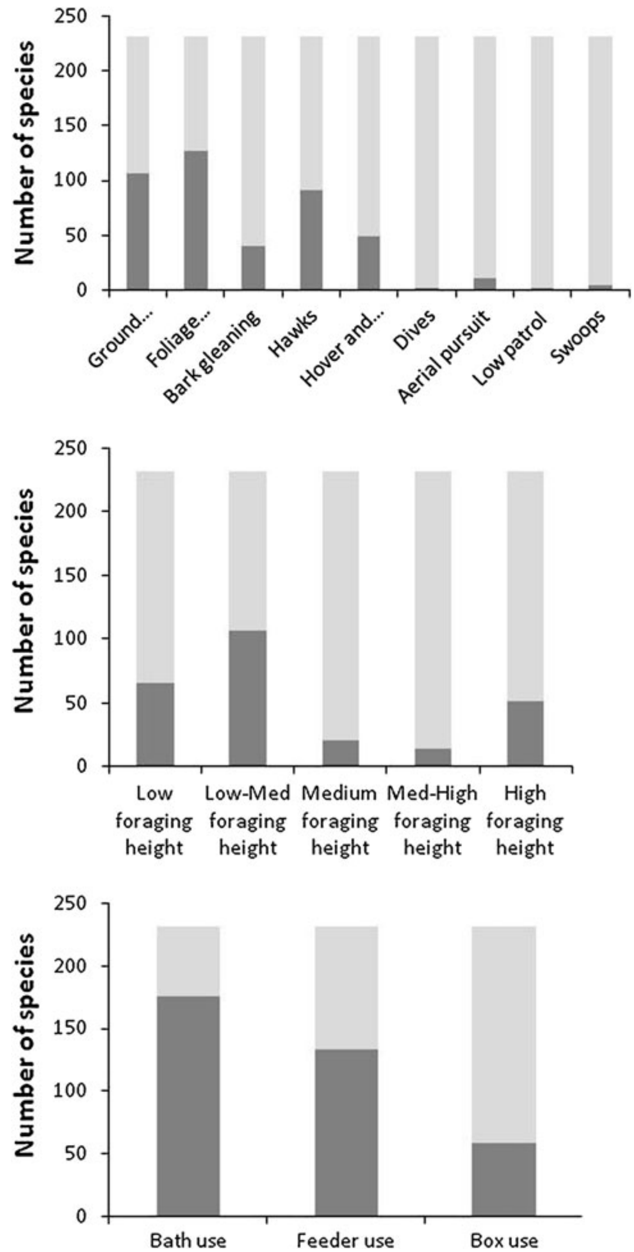

Fig. 1 Dark shade of bars indicate foraging behavior and structure use by songbird species found in residential landscapes, extracted from Ehrlich and others (1988) and Birds of North America (Poole 2005)

Implications for Citizen Science

Citizen Science serves as a multipurpose method of carrying out ecological research, informal science education, and various forms of civic involvement and community management of natural resources (Bonney and others 2009; Galloway and others 2006). Participants frequently learn about biology and natural history (Bonney and Dhondt 1997; Brossard and others 2005; Trumbull and others 2000), increase their leisure activities related to the project (Thompson and Bonney 2007), and gain greater awareness of environmental issues and of scientific processes (Trumbull and others 2000). Thus, aside from research questions that can be addressed with citizen science methods, other goals that integrate conservation outcomes, such as through informal science education about cat predation, can be met simultaneously within a citizen science framework (Cooper and others 2009).

As human populations continue to grow, residential habitats will continue to replace natural habitats. The conservation value of residential areas may need to expand beyond that of keeping common birds common, to increasing the distribution of species currently uncommon around residences. This will require well coordinated management of residential landscapes which may be promising in a citizen science framework. Our findings suggest that it is important to ask whether the diversity of residential bird communities could, and should, be increased without further research on what the impacts might be. Specifically, could removing limiting factors, by adding more diverse habitat and/or providing protection from predators, result in greater avian diversity around residences? For example, might other ground gleaners be present around residences if cat predation were diminished? On the other hand, is it wise to provide habitat for birds in residential landscapes where cats roam freely?

Fitzgerald (1990) and Jarvis (1990) cautioned against legislation or regulation of free-ranging domestic cats without data on the hunting habits and ecological impacts of cats. Conversely, noting that data on the population-level impacts of cats is difficult to obtain, Calver and others (2011) argued for application of the precautionary principle. The application of the precautionary principle in this case means taking immediate interventions to manage pet cats in order to protect birds from risks that are scientifically plausible but unproven, while awaiting definitive studies. As more recent research begins to answer questions about cat behavior and impact, some conservation organizations have become advocates for more responsible pet and feral cat management (see campaigns by the American Bird Conservancy, http://www.abcbirds.org/ and The Wildlife Society http://wildlife.org/). Encouraging minor changes in the time of day that pet cats are allowed to roam freely may benefit birds in residential areas. For example, Stracey (2011) found nest predation by cats to occur at night and Barratt (1997) noted depredation of birds was more likely in the morning. By improving our understanding of the mechanisms that influence avian sensitivity to cat predation, we can gain insights into what the avian community in residential ecosystems might look like if cat predation were minimized or eliminated. This knowledge, in concert with information on impacts of vegetation type and structure (Kress 2006; Tallamy 2009), could lead to more effective management of residential landscapes for wild birds.

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Appendix

See Table 4

Table 4 List of species depredated by cats, as documented in BNA accounts and citizen science schemes

Common name	Genus species	Cat in BNA	Cat in CS
Gray Partridge	*Perdix perdix*	1	0
Ring-necked Pheasant	*Phasianus colchicus*	1	0
California Quail	*Callipepla californica*	1	1
Gambel's Quail	*Callipepla gambelii*	–	1
Rock Pigeon	*Columba livia*	1	1
Eurasian Collared-Dove	*Streptopelia decaocto*	1	0
White-winged Dove	*Zenaida asiatica*	1	0
Mourning Dove	*Zenaida macroura*	1	1
Inca Dove	*Columbina inca*	1	1
Common Ground-Dove	*Columbina passerina*	1	0
Common Nighthawk	*Chordeiles minor*	1	0
Ruby-throated Hummingbird	*Archilochus colubris*	1	1
Anna's Hummingbird	*Calypte anna*	1	0
Rufous Hummingbird	*Selasphorus rufus*	1	1
Downy Woodpecker	*Picoides pubescens*	1	0
Northern Flicker	*Colaptes auratus*	0	1
Willow Flycatcher	*Empidonax traillii*	1	0
Eastern Phoebe			1
Say's Phoebe	*Sayornis saya*	1	0
Great Kiskadee	*Pitangus sulphuratus*	1	1
Loggerhead Shrike	*Lanius ludovicianus*	1	0

Table 4 continued

Common name	Genus species	Cat in BNA	Cat in CS
Bell's Vireo	*Vireo bellii*	1	0
Steller's Jay	*Cyanocitta stelleri*	1	1
Blue Jay	*Cyanocitta cristata*	1	1
Western Scrub-Jay	*Aphelocoma californica*	1	0
American Crow	*Corvus brachyrhynchos*	1	0
Northwestern Crow	*Corvus caurinus*	1	0
Purple Martin	*Progne subis*	1	0
Tree Swallow	*Tachycineta bicolor*	1	0
Cliff Swallow	*Petrochelidon pyrrhonota*	1	0
Barn Swallow	*Hirundo rustica*	1	0
Carolina Chickadee	*Poecile carolinensis*	1	1
Black-capped Chickadee	*Poecile atricapilla*	1	1
Chestnut-backed Chickadee	*Poecile rufescens*	–	1
Oak Titmouse	*Baeolophus inornatus*	1	0
Tufted Titmouse	*Baeolophus bicolor*	1	1
White-breasted Nuthatch	*Sitta carolinensis*	–	1
Pygmy Nuthatch	*Sitta pygmaea*	–	1
Brown Creeper	*Certhia americana*	1	0
Cactus Wren	*Campylorhynchus brunneicapill*	1	0
Carolina Wren	*Thryothorus ludovicianus*	1	1
Bewick's Wren	*Thryomanes bewickii*	1	1
House Wren	*Troglodytes aedon*	1	1
Winter Wren	*Troglodytes troglodytes*	1	0
Golden-crowned Kinglet	*Regulus satrapa*	–	1
Eastern Bluebird	*Sialia sialis*	1	1
Western Bluebird	*Sialia mexicana*	1	0
Hermit Thrush	*Catharus guttatus*	–	1
Wood Thrush	*Hylocichla mustelina*	1	0
American Robin	*Turdus migratorius*	1	1
Varied Thrush	*Ixoreus naevius*	1	1
Gray Catbird	*Dumetella carolinensis*	1	1
Northern Mockingbird	*Mimus polyglottos*	1	1
Brown Thrasher	*Toxostoma rufum*	1	0
California Thrasher	*Toxostoma redivivum*	1	0
European Starling	*Sturnus vulgaris*	1	1
Bohemian Waxwing	*Bombycilla garrulus*	1	0
Cedar Waxwing	*Bombycilla cedrorum*	–	1
Nashville Warbler	*Vermivora ruficapilla*	1	0
Yellow-rumped Warbler	*Dendroica coronata*	–	1
American Redstart	*Setophaga ruticilla*	1	0
Common Yellowthroat	*Geothlypis trichas*	–	1
Wilson's Warbler	*Wilsonia pusilla*	1	0
Scarlet Tanager	*Piranga olivacea*	–	1
Western Tanager	*Piranga ludoviciana*	1	0
Spotted Towhee	*Pipilo maculatus*	–	1

Table 4 continued

Common name	Genus species	Cat in BNA	Cat in CS
Eastern Towhee	*Pipilo erythrophthalmus*	–	1
Canyon Towhee	*Pipilo fuscus*	1	0
California Towhee	*Pipilo crissalis*	–	1
Rufous-crowned Sparrow	*Aimophila ruficeps*	1	0
American Tree Sparrow	*Spizella arborea*	1	1
Chipping Sparrow	*Spizella passerina*	1	1
Field Sparrow	*Spizella pusilla*	–	1
Vesper Sparrow	*Pooecetes gramineus*	–	1
Savannah Sparrow	*Passerculus sandwichensis*	1	0
Fox Sparrow	*Passerella iliaca*	–	1
Song Sparrow	*Melospiza melodia*	1	1
Lincoln's Sparrow	*Melospiza lincolnii*	1	0
White-throated Sparrow	*Zonotrichia albicollis*	–	1
Dark-eyed Junco	*Junco hyemalis*	1	1
Northern Cardinal	*Cardinalis cardinalis*	1	1
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	1	1
Black-headed Grosbeak	*Pheucticus melanocephalus*	1	1
Lazuli Bunting	*Passerina amoena*	1	0
Dickcissel	*Spiza americana*	1	0
Bobolink	*Dolichonyx oryzivorus*	1	0
Red-winged Blackbird	*Agelaius phoeniceus*	–	1
Eastern Meadowlark	*Sturnella magna*	1	0
Western Meadowlark	*Sturnella neglecta*	1	0
Brewer's Blackbird	*Euphagus cyanocephalus*	1	0
Common Grackle	*Quiscalus quiscula*	1	1
Great-tailed Grackle	*Quiscalus mexicanus*	1	0
Baltimore Oriole	*Icterus galbula*	1	1
Purple Finch	*Carpodacus purpureus*	1	0
House Finch	*Carpodacus mexicanus*	1	1
Common Redpoll	*Carduelis flammea*	1	0
Pine Siskin	*Carduelis pinus*	1	1
Lesser Goldfinch	*Carduelis psaltria*	–	1
American Goldfinch	*Carduelis tristis*	1	1
Evening Grosbeak	*Coccothraustes vespertinus*	1	0
House Sparrow	*Passer domesticus*	1	1
Eurasian Tree Sparrow	*Passer montanus*	1	0
Pyrrhuloxia	*Cardinalis sinuatus*	1	0

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