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Preliminary Analysis of the Effects of Non-target Supplemental Feeding on Camera Trap Captures of Small Mammals in Central Georgia

Raena McCown
University of Georgia, Raena.McCown@uga.edu

Travis Cunningham
Georgia College & State University, travis.cunningham@bobcats.gcsu.edu

Alfred J. Mead
Georgia College & State University, al.mead@gcsu.edu

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PRELIMINARY ANALYSIS OF THE EFFECTS OF NON-TARGET SUPPLEMENTAL FEEDING ON CAMERA TRAP CAPTURES OF SMALL MAMMALS IN CENTRAL GEORGIA

Raena McCown[1,2]
Travis Cunningham[2]
Alfred J. Mead[2]*
[1]College of Agriculture and Environmental Sciences
University of Georgia
Athens, GA 30602
[2]Department of Biological and Environmental Sciences
Georgia College & State University
Milledgeville, GA 31061
*corresponding author
al.mead@gcsu.edu

ABSTRACT

Supplemental bird feeding is a widespread hobby throughout western culture. Although it brings joy to many people, bird feeding has been shown to have potentially negative effects on local bird populations and small mammalian species. To study the differences in local occurrence of native small mammalian species around bird feeders and in more distant settings, six camera traps were placed in a rural residential area in Putnam County, Georgia. Three cameras were placed facing bird feeders and three placed a minimum of 60 m away from the feeders. Species presence was recorded three days a week from 12:00 am Monday to 12:00 am Thursday between 11 November 2019 and 29 January 2020. We recorded 5,073 images of mammals during the 36 days: gray squirrels (4,264), eastern chipmunks (458), raccoons (113), Virginia opossums (65), domestic cats (54), white-tailed deer (36), gray foxes (35), field mice (22), armadillos (11), eastern cottontail rabbits (11), and domestic dogs (4). Pair-wise t-tests indicate a greater frequency of image-captures of gray squirrels, chipmunks, raccoons, opossums and cats near the feeders compared to the area away from the feeders. Foxes and deer were imaged more frequently in the area away from the feeders. Not only do bird feeders contribute to a higher visitation frequency in certain species such as gray squirrels and raccoons, species known to depredate bird nests, the elevated densities of birds and mammals in the area also attract more predators such as domestic/feral cats. This study suggests that future research is needed to investigate the effects of bird feeders on the behavior of small mammals and the magnitude to which excess predation at supplemental bird feeders affects the community structure.

Keywords: supplemental feeding, small mammals, camera trap capture frequency, Georgia

INTRODUCTION

Recreational bird watching is a common pastime throughout the United States. According to the most recent data from the U.S. Fish & Wildlife Service (Carver 2019), there were 45 million bird watchers (birders) in the U.S. in 2016, with 39 million of these birders enjoying the activity around their homes. Many birders enhance their chances of seeing birds by using supplemental bird feeding stations. In the 2016 survey, birders reported spending $8,874,978,000 on wildlife-watching equipment which included bird food, bird feeders, bird houses, bird baths, binoculars, cameras, and field guides. Besides the recreational value, backyard bird feeding also offers unique research opportunities, and could lead to an enhanced societal conservation ethic (Jones and Reynolds 2008). Although it brings joy to many people and plays a vital role in avian conservation efforts (Ewen et al. 2014), there are negative effects associated with supplemental bird feeding (Jones and Reynolds 2008). Supplemental bird feeding has been linked to increased local abundance of non-native bird species resulting in the restructuring of urban avian communities to the detriment of native species (Galbraith et al. 2015), and a higher prevalence of infectious diseases (Wilcoxen et al. 2015). Positive effects include improved body condition and innate immune defense (Wilcoxen et al. 2015), increased survival of juvenile and adult migratory birds (Seward et al. 2013), extended breeding season and increased clutch size (Bonnington et al. 2014, Boutin 1990, Prevedello et al. 2013), and in some cases, a long term increase in bird diversity in some communities (Plummer et al. 2019). In many instances, actively feeding birds displace a portion of the supplemental feed from feeders onto the ground below where many ground feeding avian species make use of the displaced seeds. However, once on the ground, small mammals have access to the feed (Reed and Bonter 2018) and actively compete with birds for the resource (Bonnington et al. 2014). Some small mammals such as gray squirrels (*Sciurus carolinensis*) and raccoons (*Procyon lotor*), attracted to an area by the available grain, may influence local avian populations through nest predation (Bonnington et al. 2014, DeGregorio et al. 2016, Moller 1983).

Small mammal population density is often food supply limited (Boutin 1990). Food supplementation increases small mammal density through higher rates of reproduction, survival, or immigration (Reed and Bonter 2018, Prevedello et al. 2013). However, this result is not uniform in all environments. In rural mature hardwood forests, fox squirrels (*Sciurus niger*) and gray squirrels displayed no noticeable benefit from supplemental shelled corn during winter months (Havera and Nixon 1980). When provided with supplemental food, eastern chipmunk (*Tamias striatus*) home range size decreased and population density increased (Mares et al. 1976). Red squirrels (*Tamiasciurus hudsonicus*) displayed a 3-4 times density increase when supplied with supplemental food (Sullivan 1990). Other small mammals such as raccoons (*Procyon lotor*) displayed smaller, more stable home ranges and greater local density when presented with accessible supplemental food (Prange et al. 2004, Reed and Bonter 2018).

Higher densities of rodents around feeding stations also increased disease transmission (Forbes et al. 2015). Compartmental models of disease dynamics suggest that supplemental feeding may maximize pathogen prevalence in a local population (Becker and Hall 2014). Parasites take advantage of the higher densities and spread throughout susceptible hosts congregating at supplemental feeders (Lambert and Demarais 2001). Concentrated food sources and a de-sensitivity to humans affects some rodents in other ways. Gray squirrels, fox squirrels, red squirrels, and chipmunks in urban areas with supplemental feeding stations become less sensitive to predatory risks, increasing predator-prey contact (Bowers and Breland 1996, Mares et al. 1976, McCleery 2009, Sullivan 1990, Uchida et al. 2016). Natural (avian raptors) and domestic (especially cats [*Felis catus*]) predators take advantage of supplemental feeding areas and become a limiting factor to small mammal population densities (Baker et al. 2003, Bowers and Breland 1996, Prevedello et al. 2013).

Camera traps typically consist of digital trail cameras with passive infrared motion sensors and built-in infrared nighttime illuminators. These cameras allow researchers to monitor a species' frequency of occurrence within an active camera's visual range, day or night. The validity of animal identification from camera trap photographs can be questionable, especially when observed animals are relatively small and multiple similar species from a given genus reside in the area (Meek et al. 2013). Correct identification increases when the differences between the photographed animals are obvious. Most small mammals are recognizable to genus or species but lack markings that allow the identification of an individual organism. Therefore, a major assumption of camera trap studies is the direct correlation between the frequency of images captured and the relative local abundance. In the current study, digital trail cameras were employed in a rural residential area to monitor the effects of an established supplemental bird feeding station (20 years of continuous use) on camera capture frequency of mammals near the feeders compared to nearby sites not immediately adjacent to the feeders.

MATERIALS & METHODS

The capture frequency of mammalian species was surveyed on a 0.77 hectare rural residential lot in Putnam County, Georgia (Figure 1) using automatic camera traps. The surrounding area consists of 0.40 to 2.83 hectare residential lots in a mature hardwood forest bordering Lake Sinclair. The small residential area is bordered by approximately 250 hectare of managed timberland. The owners of the study property did not have pet domestic cats, did not feed feral cats, and did not have free-ranging dogs (*Canis*

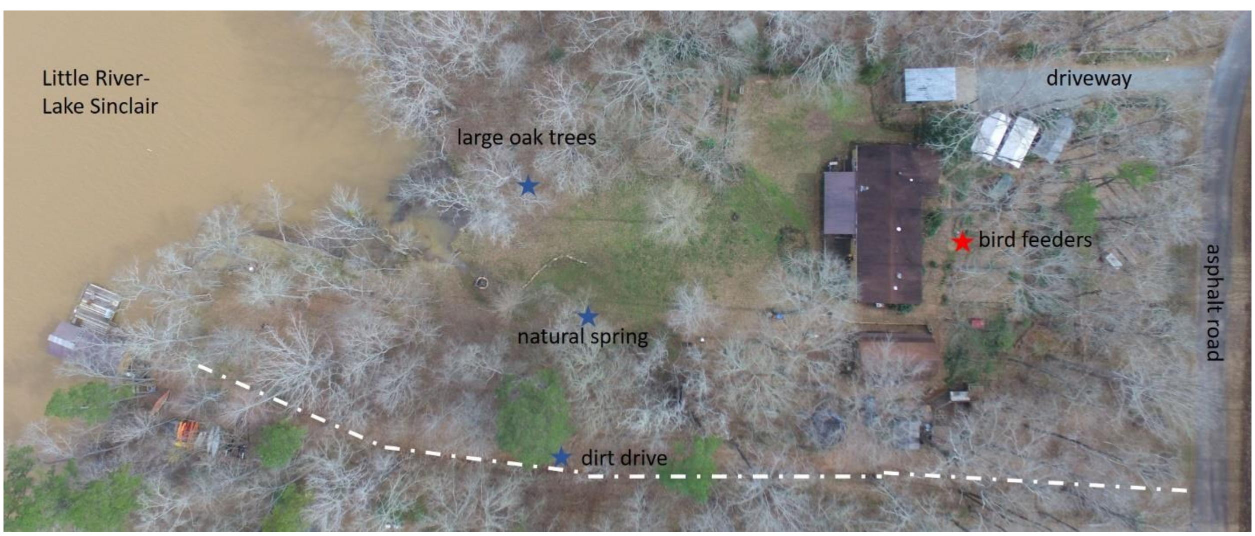

Figure 1. Aerial view of study area in Putnam County, Georgia showing the positions of camera traps (stars) used in this study. Image covers approximately 0.77 hectare. Dashed line indicates position of dirt access drive. Drone image by James Mead.

familiaris). Six BlazeVideo® SL112 digital trail cameras with passive infrared motion sensor and built-in infrared nighttime illuminator were positioned on the property. The cameras were programmed to delay a minimum of 60 seconds between successive triggers. Three cameras were placed one meter above the ground and angled slightly down in areas a minimum of 60 m away from the bird feeders: along a dirt drive, near a natural spring, and beneath large oak trees (Figure 1). Three cameras were placed around the supplemental bird feeding station (Figure 1, 2). The supplemental bird feeding station consisted of one suspended mixed birdseed feeder (Figure 2A; white proso millet [*Panicum miliaceum*], milo [*Sorghum bicolor*], wheat [*Triticum* sp.], black oil sunflower seed [*Helianthus annus*], cracked corn [*Zea mays*]), one suspended thistle seed feeder (Figure 2B; *Guizotia abyssinica*), one suspended suet cake feeder (Figure 2G; rendered beef suet, corn, white millet, oats [*Avena sativa*], sunflower meal), and one wooden post-mounted black oil sunflower seed feeder (Figure 2C). The wooden post was climbable by small mammals. One camera (Figure 2D, below bell) was mounted to capture images beneath the suspended mixed birdseed feeder, another (Figure 2E, below green) was mounted to capture images beneath the wooden post-mounted black oil sunflower seed feeder, and the third (Figure 2F, high green) was mounted to capture images of the wooden post and mounted black oil sunflower feeder.

Figure 2. Supplemental bird feeding station in a rural residential lot in Putnam County, Georgia. A) suspended mixed birdseed feeder; B) suspended thistle seed feeder; C) black oil sunflower seed feeder mounted on wooden post; D) trail camera (below bell) scanning under suspended mixed birdseed feeder; E) trail camera (below green) scanning under mounted black oil sunflower seed feeder; F) trail camera (high green) scanning wooden post and mounted black oil sunflower seed feeder; G) suspended suet cake feeder; H) spilled seed on ground; I) bird bath. Photography by Heidi Mead.

The presence of mammals was recorded three days a week from 12:00 am Monday to 12:00 am Thursday between 11 November 2019 and 29 January 2020, resulting in 36 days of observation. Every individual of each species in each image was tallied. On the occasion that a camera malfunctioned for the day, the lack of data was not included in the statistical analyses. Pair-wise t-tests of the six camera stations were utilized to analyze the statistical difference ($\alpha \leq 0.05$) in mean capture frequency for each species at each camera location. Due to the overlapping fields of view for the cameras located near the bird feeders (Figure 2), it is highly probable that, in some instances, individual animals were captured on two cameras at the same time. It must be acknowledged that the total number of captures is elevated due to this overlap.

RESULTS

During the 36-day study period, we recorded 5,073 mammals (Table I). Gray squirrels were the most abundant taxon in both areas. Near the feeders, multiple squirrels in the same image were common. The most abundant taxa near the feeders, following gray squirrels, were chipmunks, raccoons, opossums (*Didelphis virginiana*), cats, mice (most likely *Peromyscus*), Eastern cottontail rabbits (*Sylvilagus floridanus*), armadillos (*Dasypus novemcinctus*), white-tailed deer (*Odocoileus virginianus*), and gray foxes (*Urocyon cinereoargenteus*). No dogs were recorded near the feeders. The most abundant taxa in the area not near the feeders, following gray squirrels, were deer (13 of 35 deer were photographed in one night, 22 January 2020), foxes, opossums, cats, raccoons, armadillos, rabbits, dogs, and chipmunks. Mice were recorded only near the feeders.

The pair-wise t-tests indicate a greater frequency of image-captures of gray squirrels, chipmunks, raccoons, opossums, and cats near the feeders compared to the area away from the feeders (Table II). Foxes and deer were imaged more frequently in the area away from the feeders. For the cameras near the feeders, more photographs of cats and

Table I. Number of observations of each taxon at each camera in close proximity to a supplemental bird feeding station (Feeder) and each camera not adjacent to the feeding station (Yard) in Putnam County, Georgia. Sq = gray squirrel (*Sciurus carolinensis*), Ch = eastern chipmunk (*Tamias striatus*), Ra = raccoon (*Procyon lotor*), Op = Virginia opossum (*Didelphis virginiana*), Ca = domestic/feral cat (*Felis catus*), De = white-tailed deer (*Odocoileus virginianus*), Fx = gray fox (*Urocyon cinereoargenteus*), Mo = field mouse (most likely *Peromyscus*), Ar = nine-banded armadillo (*Dasypus novemcinctus*), Rb = Eastern cottontail rabbit (*Sylvilagus floridanus*), Dg = domestic dog (*Canis familiaris*).

	Sq	Ch	Ra	Op	Ca	De	Fx	Mo	Ar	Rb	Dg
Feeder Total	**3898**	**455**	**100**	**45**	**39**	**1**	**1**	**22**	**4**	**7**	**0**
High green	474	21	37	6	4	0	0	0	0	0	0
Below green	1592	394	40	22	0	0	0	22	0	1	0
Below bell	1832	40	23	17	35	1	1	0	4	6	0
Yard Total	**366**	**3**	**13**	**20**	**15**	**35**	**34**	**0**	**7**	**4**	**4**
Dirt drive	57	1	5	0	6	6	12	0	3	0	2
Natural spring	88	2	6	12	1	8	12	0	4	0	0
Large oaks	221	0	2	8	8	21	10	0	0	4	2
Survey Total	**4264**	**458**	**113**	**65**	**54**	**36**	**35**	**22**	**11**	**11**	**4**

armadillos were captured by the below bell camera compared to the other two cameras. More photographs were recorded by the below bell and below green cameras compared to the high green camera. For the cameras located away from the feeders, gray squirrels were more commonly photographed near the yard oaks, and opossums and cats were more abundant at the oaks compared to the dirt drive and yard spring, respectively.

A difference in gray squirrel and chipmunk behavior was observed at the supplemental feeders. Both species are typically active in the morning and evening in natural settings (Koprowski 1994), but instead were active throughout the daylight hours at the bird feeders. Some intraspecific antagonistic squirrel behavior was recorded at the bird feeders (Figure 3). Even though there was a higher frequency of squirrels and chipmunks around the feeders compared to the distant areas, the two taxa were rarely photographed together. Additionally, there was evidence of predation events near the feeders (Figure 4) during the study period, however no images of active predation were captured.

Table II. Results of pair-wise two-tailed t-tests comparing the mean number of image-captures of each taxon by each camera in Putnam County, Georgia. Significantly greater ($p \leq 0.05$) mean values are denoted for the left column variable compared to top row variable. Sq = gray squirrel (*Sciurus carolinensis*), Ch = eastern chipmunk (*Tamias striatus*), Ra = raccoon (*Procyon lotor*), Op = Virginia opossum (*Didelphis virginiana*), Ca = domestic/feral cat (*Felis catus*), De = white-tailed deer (*Odocoileus virginianus*), Fx = gray fox (*Urocyon cinereoargenteus*), Ar = nine-banded armadillo (*Dasypus novemcinctus*).

	High Green	Below Green	Below Bell	Dirt Drive	Yard Spring	Yard Oaks
High Green	n/a	Ca	-	Sq, Ch, Ra, Op	Sq, Ra	Sq, Ra
Below Green	Sq, Ch, Op	n/a	Ch	Sq, Ch, Ra, Op	Sq, Ch, Ra	Sq, Ch, Ra, Op
Below Bell	Sq, Ch, Ca, Ar	Ca, Ar	n/a	Sq, Ch, Ra, Op, Ca	Sq, Ch, Ca	Sq, Ch, Ra, Ca, Ar
Dirt Drive	Fx	Fx, Ca	Fx	n/a	-	-
Yard Spring	Fx, De	Fx, De	Fx, De	Op	n/a	-
Yard Oaks	Fx	Fx, Ca	Fx	Sq, Op	Sq, Ca	n/a

DISCUSSION

It was no surprise that more photographs of small mammals were recorded by the cameras in close proximity to the supplement food source compared to cameras in more natural settings. In particular, squirrels and chipmunks spent a greater amount of time around the feeders. In this area, capture frequency was highest for the below bell and below green cameras compared to the high green camera. Most small mammals were utilizing the seeds on the ground rather than trying to gain seeds directly from the feeders. Squirrels, chipmunks, raccoons, and opossums utilized the climbable wooden post and were photographed on the high green feeder. The cats captured by the high green camera were not on the high green feeder, but on the ground behind the feeder. The below bell and below green totals were minimally different, and due to the positioning of these two cameras, it is likely that they frequently captured the same animals. Mice were only photographed by the below green camera, likely due to the camera being positioned low to the ground and pointing directly at the concentrated food source surrounded by plant and rock cover. It is likely that the small size of the mouse was not sufficient to trigger the other cameras if this species occurred in those fields of view. For the cameras away from the feeders, the greater abundance of squirrels near the large oaks was expected due the local concentration of acorns. The most significant finding of this study is the greater frequency of cats near bird feeders. Since cats and foxes are not seed eating mammals, the greater abundance of these species near (cats) and away (foxes) from the feeders suggests additional concentrating factors.

Many mammalian taxa are commonly observed in and around residential yards (Kays and Parsons 2014) due to the positive correlation between food availability and population density (Boutin 1990). The greater abundance of gray squirrels and chipmunks photographed at the supplemental bird feeding station in the current study agrees with the findings of previous studies (Mares et al. 1976, Reed and Bonter 2018). Within gray squirrel populations, intraspecific aggression is positively correlated and wariness is negatively correlated with local density (Parker and Nilon 2008). Intraspecific aggression may lead to a greater frequency of injury in this species (Bosch et al. 2016, Moncrief et al. 2022). We captured images of apparent aggressive interactions between squirrels below the bell feeder (Figure 3). Aggressive behavior by gray squirrels toward chipmunks beneath the bell feeder was also observed, although we did not photograph the interactions (A. Mead; personal observation). Even though gray squirrels (n = 3,898) and chipmunks (n = 455) were the two most frequently observed taxa at the bird feeding station, they were rarely photographed simultaneously. Reduced wariness in small mammals increases the likelihood of predation, particularly by domestic cats (Loss et al. 2013). Elevated densities of gray squirrels and chipmunks also increase interspecific interactions with birds and other small mammals. In addition to the direct competition with birds for spilled seed, both taxa are known to predate bird eggs and nestlings (Bailey 1923, Cain et al. 2006). The observed elevated local abundance of gray squirrels and chipmunks likely negatively affect passerines nesting in the study area (Cain et al. 2006,

Figure 3. Evidence of intraspecific aggressive behavior between gray squirrels (*Sciurus carolinensis*) near a supplemental bird feeding station in a rural residential lot in Putnam County, Georgia.

DeGregorio et al. 2016, Hanmer et al. 2016, Heske et al. 2001, Snyder 1982). Elevated local abundances also increase the likelihood of disease and parasite transmission within these species (Becker and Hall 2014, Forbes et al. 2015, Lambert and Demarais 2001).

Raccoons, opossums, and domestic cats were found in greater abundance near the feeders, while gray foxes and deer were more abundant in distant areas. Raccoons have been found in greater abundance around urban chicken coops (Kays and Parsons 2014) and supplemental feeders used for ungulates (Lambert and Demarais 2001). Being nocturnal omnivores, raccoons and opossums rarely compete directly with avian taxa for spilled seed. However, in a review of mammalian bird nest predation, raccoons and opossums were found to be the top two non-rodent predators (DeGregorio et al. 2016). Large populations of free-ranging cats have been documented in many residential areas (Elizondo and Loss 2016). The greater abundance of cats near the bird feeders in the current study most likely negatively affects the local avian and small mammal populations (Baker et al. 2003, Simpson et al. 2013). It is estimated that domestic cats, functioning as both diurnal and nocturnal predators, kill 1.4–3.7 billion birds and 6.9–20.7 billion mammals annually in the United States (Loss et al. 2013). Injury from domestic cat attack is the leading cause of gray squirrel and chipmunk admission at wildlife rescue centers (Levy et al. 2020, Loyd et al. 2017, Schenk 2017, Schenk and Souza 2014). Evidence of predation below the bell feeder (Figure 4) was observed within the time window of this study, but since it occurred during the latter part of the week when the cameras were not actively recording, we did not capture an image and were unable to determine the identity of the predators. Gray foxes and deer were the only taxa photographed more frequently in the area away from the feeders. For gray foxes, this may suggest that bird feeding stations do not concentrate prey species at the right time of day for this nocturnal predator. Additionally, the relative lack of foxes near the bird feeders may be related to this species' avoidance of baited areas (Rexford 1961). The relative lack of deer near the bird feeders may be a result of the close proximity of the feeders to the house.

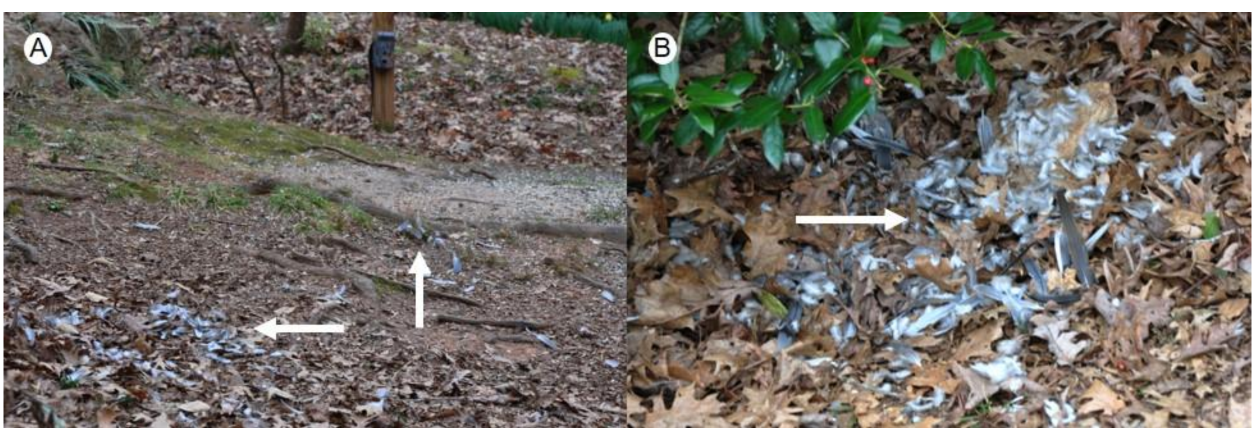

Figure 4. Evidence of predation events near a supplemental bird feeding station in a rural residential lot in Putnam County, Georgia. A) feather piles (arrows) beneath a suspended mixed birdseed feeder, digital trail camera in the background; B) feather pile (arrow) underneath a bush approximately 4.0 meters from the suspended mixed birdseed feeder. Photography by Heidi Mead.

Supplemental bird feeding stations benefit avian species by providing nutrition that may otherwise be limited in a local area. However, the greater frequencies of occurrence of gray squirrels, chipmunks, raccoons, opossums, and domestic cats around feeding stations are potentially harmful for avian species through direct competition for seeds, nest depredation, and elevated predation. Future studies should determine if feeders with spill protector saucers decrease the frequency of spilled seed, and in turn decrease the abundance of ground foraging birds and the number of gray squirrels, chipmunks, raccoons, opossums, and domestic cats at feeding stations. Additional research is needed to investigate the effects of spilled seed from bird feeders on the intraspecific and interspecific behavior of small mammals as well as the magnitude to which excess predation at supplemental bird feeders affects the community structure.

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