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The Effects of Habitat Fragmentation on Avian Mobbing Behavior

Jada T. Daniels

THE EFFECTS OF HABITAT FRAGMENTATION ON AVIAN MOBBING BEHAVIOR

by

JADA DANIELS

(Under the Direction of C. Ray Chandler)

ABSTRACT

Habitat fragmentation has negative effects on bird species diversity, as well as reproductive success of some species. However, there is little comparative information on the effect it may have on bird behavior. For example, small forest fragments are likely to have fewer bird species and individuals. This may limit the success of mobbing as an antipredator behavior because mobbing success depends on recruiting other birds to the group. This possibility has never been tested. The objective of my study is to quantify the effects of forest size on mobbing behavior in forest-dwelling birds. Mobbing behavior was elicited in 100 randomly selected forest patches ranging in size using a model owl as a focal point. The results show that the probability of birds participating in a mobbing event increases as forest size increase ($p = 0.002$). The latency at which birds respond to a predator vocalization decreases as the forest size increases ($p = 0.007$). However, forest size had no effect on the intensity of the mobbing event, the probability of birds making alarm calls, the number of individuals participating, or the number of species participating in the mobbing event ($p = 0.097$, $p = 0.952$, $p =0.1987$, $p =0.1983$). Additionally, no mobbing events were observed in forests fragments below 0.97 hectares, suggesting that this may near a threshold forest size at which mobbing behaviors can no longer be supported.

INDEX WORDS: Habitat fragmentation, Mobbing, Avian behavior, Passerine, Forest size, Habitat loss

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by

JADA DANIELS

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by
JADA DANIELS

Major Professor: C. Ray Chandler

Committee: Alan Harvey
Steve Vives

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DEDICATION

First, I would also like to thank my family. My parents, Joanie and Kevin Daniels, have always supported and motivated me over the years. Thank you for encouraging me to pursue what makes me happy in life. To my siblings, Kris and Justice Daniels, who have put up with long days, dog-sitting, and listening to my many breakdowns. To my friends, Megan Siefert, Sarah Batchelor, Maribel Hernandez, Parrish Duncan, and Mason Moore I could not have finished this project without your help. You have all supported me in ways I didn't know I needed. I appreciate you all so much.

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CHAPTER 1

INTRODUCTION

Habitat loss is the world's leading cause of the loss of biodiversity (Latimer and Zuckerberg 2020, Ambrose 2020). It can manifest in ways such as habitat degradation, habitat destruction, and habitat fragmentation. Habitat fragmentation is defined as the process of dividing a habitat into smaller, discontinuous habitats (Fischer and Lindenmayer 2007). This means decreasing the habitat size and increasing the degree of isolations (Andren 1997). As the human population increases, the amount of available habitat for wildlife species continues to decrease (Herkert 1994). Habitat fragmentation centers around large continuous areas of habitat being disrupted into smaller less continuous habitats, usually due to human disturbances and development (Herkert 1994). This has been known to decrease species occupancy and abundancy, as well as scatter resources needed for survival (Wilcove et al. 1986, Wiens 1995). Over time, these the effects of fragmentation tend to multiply, eventually leaving the remaining habitat scattered into "forest islands" with little to no connectivity (Andreassen et al. 1998). The surrounding non-forest land causes an increase in edge habitat, further reducing the usable forest size (Cadenasso and Pickett 2001). Habitat fragmentation exponentially increases the distance between remaining fragments and original habitat (Andren 1999).

Animal behavior links habitat condition, habitat fragmentation, and occupancy (Lonsdorf 2007, Castro-Arellano et al. 2009). The effects that habitat fragmentation have on animal behavior is understudied. Mobbing is a widespread behavior observed across multiple taxa such as fish, mammals, and birds (Hurd 1996). Avian mobbing is the corporate vocal and physical display by small birds towards a larger potential predator (Chandler and Rose 1988). It usually occurs under risky situations when a predator is present. Mobbing is intended to distract,

intimidate, or remove a predator from a given area (Curio 1978). It includes a wide range of behaviors such as vocalizations, warning calls, swooping, and even physical attacks (Slagsvold 1984; Gehlbach and Leverett 1995). It can serve to defend nests from predators, protect territory, teach offspring, or even to recruit other conspecifics and non-conspecifics to join the mob (Langham et al. 2006).

In forest-dwelling birds, it is common to see a multi-species congregation cooperatively work towards driving a predator away (Cully and Ligon 1976). Participants in the mobbing event use vocalizations and visual displays to share the location and risk posed by the predator (Sordahl 1990). Many species such as Tufted Titmouse, Carolina Chickadees, and Northern Mockingbirds are known to initiate mobbing by relaying cues across forest patches to gain recruitments for the mobbing event (Gelbach 2002). The mobbing events can be dependent upon many factors related to both the predator (e.g., identity, age, abundance, activity: Gelbach and Leverett 1995) and the prey (e.g., number of recruitments, breeding status, body mass, sociability: Hurd 1996; Berziņš et al. 2010). Habitat conditions also play a vital role in the success of the mobbing event (Shedd 1983). The amount of cover available for birds can alter their willingness to participate in the mobbing event (Fallow et al. 2013, Sieving et al. 2004). Less cover means an increase in risk, whereas more cover is a decrease in risk (Bélisle and St. Clair 2002). Overall, the patch size can affect the number of birds that are willing to join the mobbing congregation, thus threatening the success of the mobbing event. As the number of birds that are able to be recruited for the mobbing event increase, the chances of a mobbing event being successful also increases (Chandler and Rose 1988).

Mobbing also comes with a cost; participating in a mobbing event can result in death for the bird (Marzluff et al. 2015). There is also a great deal of energy that goes into these events,

higher stress levels, and less time spent taking care of offspring or themselves (Montgomerie and Weatherhead 1988). However, with high cost comes high reward. The main benefit is having the removal of a predator, increasing the birds' own chances of survival (Caro 2005). Other benefits include cultural transmission of predator recognition for offspring and younger generations, and a higher chance of survival for offspring (Flasskamp 1994).

Some of the well-known effects of habitat loss and degradation include an increase in nest predation, a decrease in abundance and a decrease in diversity (Balmford and Long 1994). Impacts on behavioral aspects, such as mobbing, are not as well-known. The ability to pass between habitats to participate in mobbing events has a big influence on the number of recruits available (Sieving et al. 1996). The presence of woody debris and shrubbery can also be a defining factor when attempting to create an assemblage for mobbing (Gentry et al. 2019, Gobeil and Villard 2002). Without adequate cover, many species will not risk participating in the mobbing (Hendrichensen et al. 2006).

One of the most crucial variables affecting the success of mobbing is recruitment (Altmann 1956). Habitat fragmentation has been shown to negatively influence species abundance, occupancy, and species interactions (Villard and Metzger 2014). Many under-story passerine birds are absent from smaller habitat patches. Studies have shown that smaller forested areas experience population declines (Lynch and Whitcomb 1978, Robbins 1979, Leck et al. 1988, Askins and Philbrick 1987, Johnston and Hagan 1992). Species that show declining population trends are more likely to occur in areas with high habitat loss as opposed to species with increasing or stable population trends (Fahrig 1997). As forests are fragmented, fewer birds are available or willing to join in the mobbing event (Magrath and Bennett 2012). Therefore, we would predict an increase in latency to form mobbing groups as forest size gets smaller.

My study seeks to provide insight into how habitat fragmentation may affect mobbing behavior and options available to forest birds. These data may also be used for conservation efforts to preserve and protect wildlife. Habitat fragmentation is a global threat to biodiversity (Debinski and Holt 2000). At the extreme there may be forests sizes below which mobbing is not a viable behavior. However, this possibility has never been tested. Thus, the objective of this study is to quantify the effects of forest size on mobbing behavior in songbirds. Three main questions will be addressed: (1) Does the number of birds attracted to mobbing assemblages vary with forest fragment size? (2) Does the latency or intensity of mobbing vary with forest fragment size? (3) Is there a fragment size below which no mobbing takes place? These questions will be answered by experimentally inducing mobbing events (using an artificial owl and tape-recorded owl vocalizations) inside forest patches varying in size. I will quantify the latency of mobbing birds to respond, the number of individuals responding, and their intensity and closeness of response. These data will provide insight into how habitat fragmentation may affect and change the mobbing responses available to forest birds. By understanding the effect that habitat fragmentation can cause on behavioral options, we can begin understanding the benefit of reversing these affects.

CHAPTER 2

METHODS

Study Sites

Playback experiments in forests were conducted between March 2021 and July 2021 within 9 counties in Georgia [Appling, Bulloch, Candler, Emmanuel, Jeff-Davis, Montgomery, Tattnall, Toombs, Treutlen] (Figure 1, Figure 2). All sites were located within the coastal plain region of Georgia (Figure 1). This area is a matrix of agricultural fields and forests dominated by pines (*Pinus spp.)* and oaks (*Quercus spp*.). Patch sizes range from a few dozen square meters to hundreds of hectares. This provides an ideal landscape to test how the size of forest fragments affects the frequency and intensity of avian mobbing.

The sites did not differ significantly enough in landscape composition to justify further classification. Sites selected on public lands (city parks, state parks, wildlife management areas) and via permission from private landowners. All sites were patches of intact forest separated by at least 50m of non-forest or scrub habitat from other patches. Forests patches range in size from 0.07 – 2157.5 ha (Appendix 1). Sites were measured using Google Earth 2019 and its provided measuring tool.

Playback Protocol

Mobbing behavior was elicited by placing a mounted plastic simile of an Eastern Screech Owl (*Megascops asio*) on a 2-m wooden pole at least 100 m from the habitat edge, or in the center of the patch for sites that could not accommodate 100 m (Chandler and Rose 1988). Within 10 m of each sampling point, a location for model deployment was chosen that met three criteria for vegetation to set up the experiment: (1) the forest canopy within a 10-m radius was generally closed, (2) there was perching substrate

within a 2-m radius in the understory (1–5 m above ground), and (3) vegetation within a 15-m radius was not too dense and allowed for observation.

The owl model and a camouflaged JBL Clip 2 Bluetooth Speaker were then set up for the vocalization playback on top of a 2 m wooden pole, making sure the model was not covered by vegetation. At each sampling point, two concentric circular plots with a 2-m and 10-m radius were measured. Distances of 2 m and 10 m from the model were marked in four ordinal directions with 8-cm pieces of flagging tape to provide visual aid for data collection and designate the space within 2 m of the owl model and the cylindrical space within a 10-m radius of the model. A buffer period of 5 minutes after experimental setup was placed to ensure that birds would not be affected by the presence of the observers. The vocalization played for 10 minutes with a trill song repeating every 5 and 7 seconds and was started via Bluetooth.

Two cameras were set up to record the mobbing event. A Cabela's Wildgame Innovation Trail Cam was used as a motion sensor on a 3-picture burst when motion was detected while also recording the entire 10-minute vocalization. This allowed movement detection to ensure accuracy of latency data. An iPad Pro (11-inch, 3rd generation) was also used to record the mobbing event. This allowed playbacks to ensure accuracy of individual and species counts. Both cameras were placed at the perimeter of the mobbing event (10 m from stimulus) on opposite sides (Figure 3). For every mobbing event, two observers were present on alternating sides of the cameras, and opposite from each other. Observers recorded the number and species of birds that participating in the mobbing event from an inconspicuous location, 15 m from the stimulus (Figure 3). We waited 5 minutes after setting up the experiment to play the owl vocalization to ensure no human disturbances would affect the birds' responses. All mobbing events were conducted between 1000 and 1400 on days without rain or strong wind. All

fieldwork was conducted within the months of March to July to minimize potential effects of seasonal variation in mobbing (Chandler and Rose 1988).

Recording Analysis

Video footage from both cameras was watched 5 additional times to ensure accuracy of individual count and species counts. The Merlin Bird ID app by The Cornell Lab was used to verify species identities. Sound recordings of each mobbing event were also analyzed using the Merlin Bird ID app by The Cornell Lab to match songs and alarm calls with species.

Statistical Analysis

The data were analyzed using JMP Pro 16. Binary response variables, such as prevalence, alarm calls, and intensity were analyzed using a logistic regression model. Other factors, such as latency, the number of individuals, and the number of species were analyzed using a linear regression model.

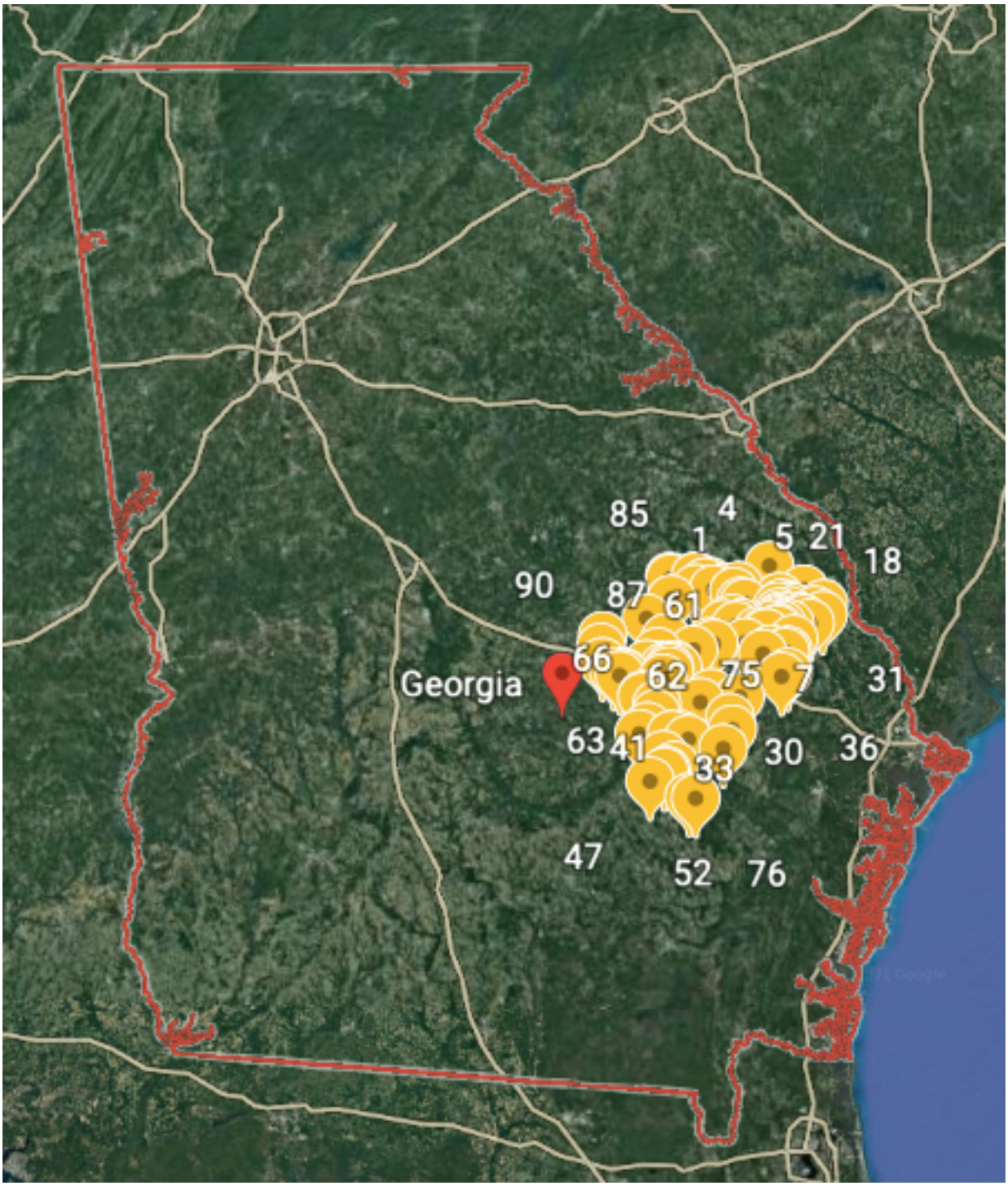

Figure 1: Site location of all 100 forest patches within the state of Georgia.

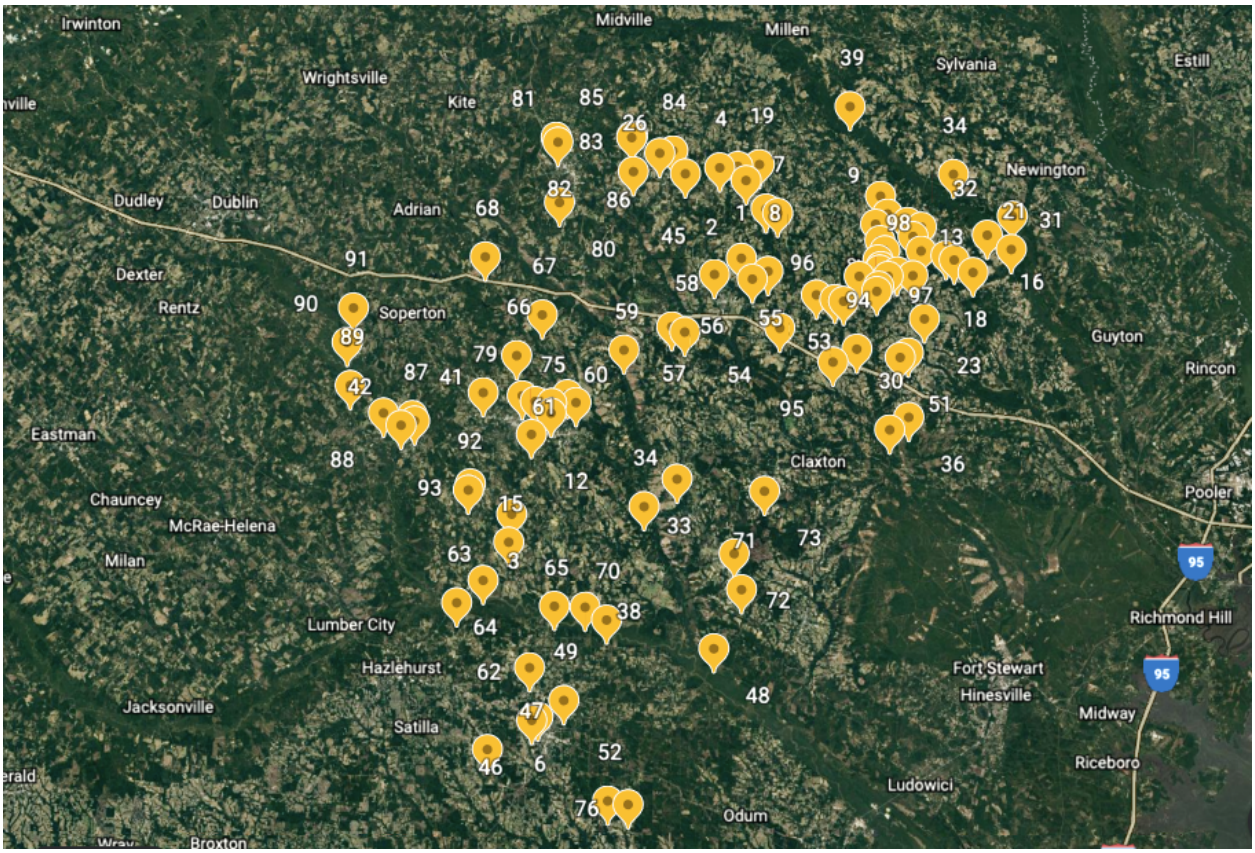

Figure 2: Sites where mobbing events were elicited. Each site is labeled with a number which corresponds to the coordinates and acreage in Appendix 1.

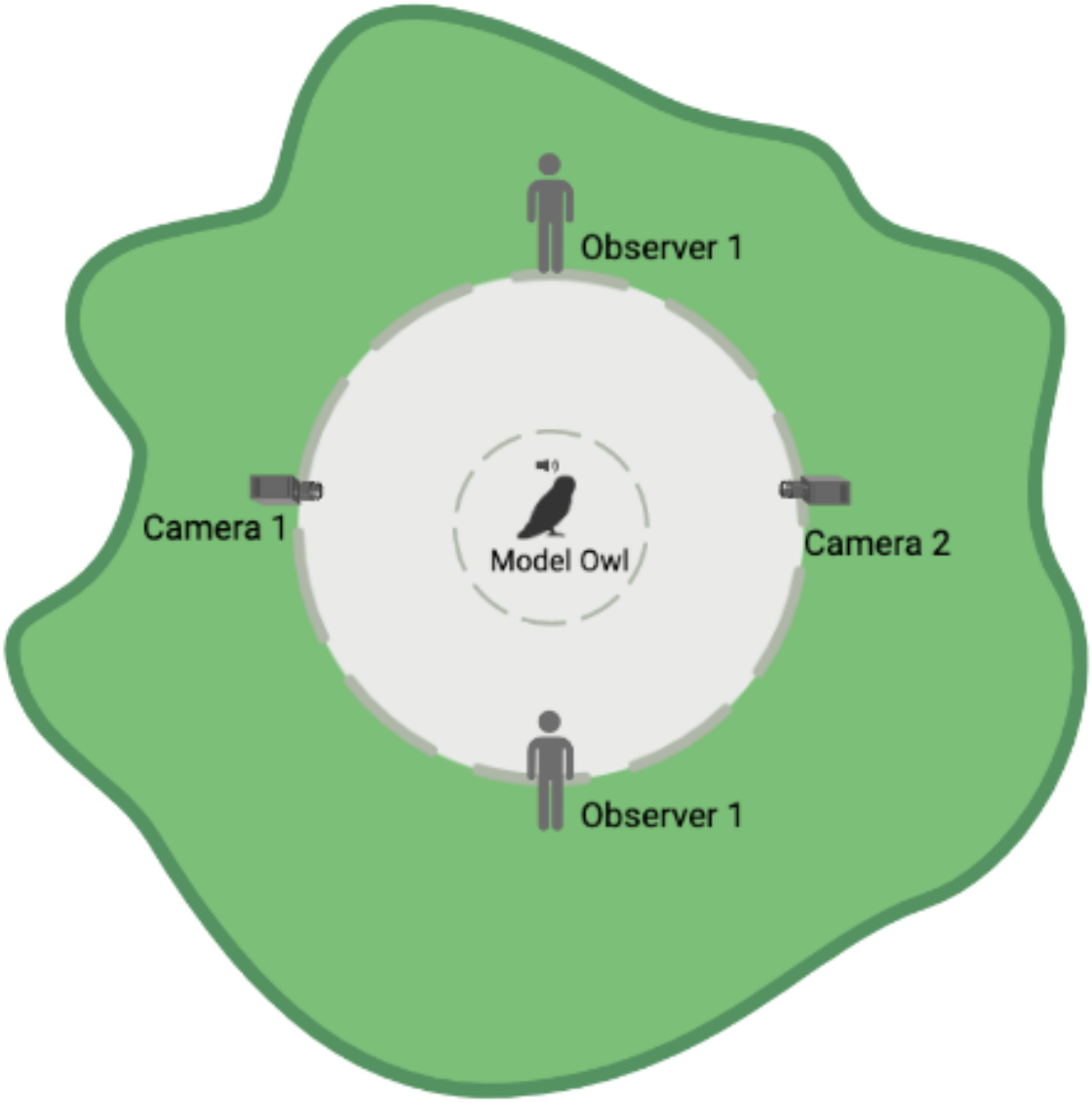

Figure 3: Diagram of experimental set-up.

Table 1: Variables used to quantify mobbing behaviors.

Measurement	Aspect of Scoring	Definition	Score Range
Prevalence	Presence	Whether at least one participating individual came within the 10m range of the model.	0 or 1
Latency*	Presence	Time from the beginning of the focal sampling to when the first bird appears within the 10m range during the 10-minute playback period.	0 – 10
Intensity**	Proximity	Whether participating individuals approached within 2m of the model and attempted to encounter the model.	0, 1, 2, or 3
Alarm Calling	Vocalization	Whether the participating individuals produced harsh scolding calls during the focal sampling.	0 or 1

*Latency was rounded to the nearest whole minute

**Scores for each intensity aspect involve integers between 0 and 3 representing zero intensity (i.e., mobbing event did not occur), low intensity (i.e., mobbing event occurred, but no individuals came within 2 m of the model), medium intensity (i.e., mobbing event occurred, at least one individual came within 2 m of the model), and high frequency (i.e., mobbing event occurred, at least one individual came within 2 m of the model, at least one individual attempted to make contact with the model).

CHAPTER 3
RESULTS

I conducted mobbing trials at 100 forested sites in south Georgia. Mobbing occurred at 89 sites (89%). The probability that mobbing occurred increases as fragment size increased (Figure 4). The smallest forest sizes (0.07 and 0.34 ha) exhibited no mobbing behaviors and mobbing events always occurred in forest patches over 400 ha. The odds of a mobbing group assembling in a forest patch increased by 1.71 for every hectare.

The majority of successful trials had birds come within 2 m of the model owl but did not attempt to make physical contact with the model (52/100 forest patches, 58.4% of successful trials). Of the remaining 37 successful trials, 31 trials had no birds enter the 2-m radius (34.8%), and 6 trials had birds attempt or succeed to make physical contact with the model owl (6.7%) (Figure 5). Overall, there was no significant relationship between in forest fragment size and the level of intensity of mobbing event (Figure 6).

Because birds in larger forest fragments were more willing to participate in mobbing events, I expected larger forest fragments to have a lower latency. The mean latency over all successful mobbing trials was 1.69 minutes (± 0.17 SE), and smaller forest fragments had a lower latency than larger forest fragments (Figure 7). Out of the 89 successful mobbing trials, 68 mobbing events included alarm calls from one or more species (76.4%). I also observed no significant effect of forest size on presence of alarm calls (Figure 8).

Overall, the mobbing trials recruited a total of 773 individuals, 769 of which were passerine birds (99.5%). I saw an average of 7 individuals (Mean = 7.73 individuals, ±0.56 SE per mobbing trial (Figure 9). Fragment size did not affect the number of individuals (Figure 10), or the number of species (Figure 11) responding to the mobbing event. I observed 47 species throughout all the mobbing trials, 44 of those being understory passerine birds (Figure 12). Of

the 100 mobbing trials we saw the largest frequency in species such as Northern Cardinal (62%), Tufted Titmouse (55%), Brown-headed Nuthatch (36%), and Carolina Wrens (36%) (Figure 13). The mean for species across all trials was 3.97 (± 0.29 SE).

Across all 100 forest patches, we saw no mobbing behaviors being exhibited in forest patches below 0.97 hectares and always experienced mobbing behaviors in forest patches over 400 hectares.

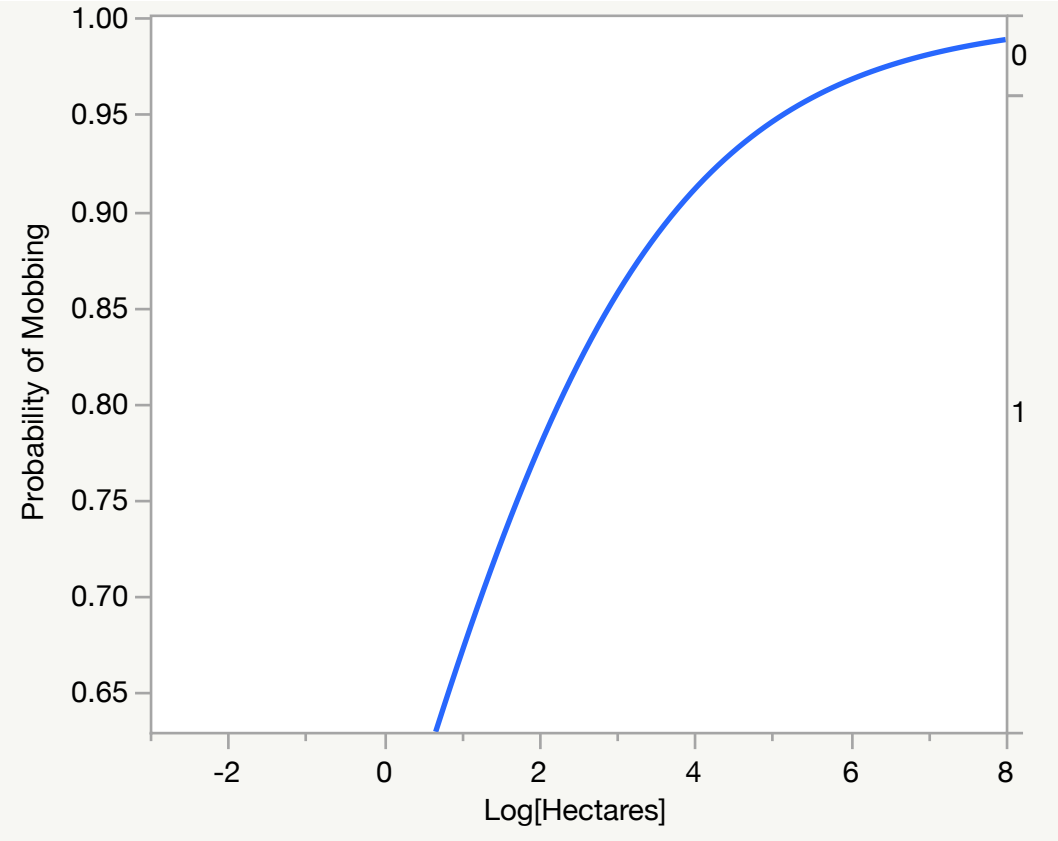

Figure 4: Size significantly affects the probability that mobbing occurs in a forest fragment. (G= 9.5, P = 0.002, R^2 = 0.137, Odds Ratio = 1.71).

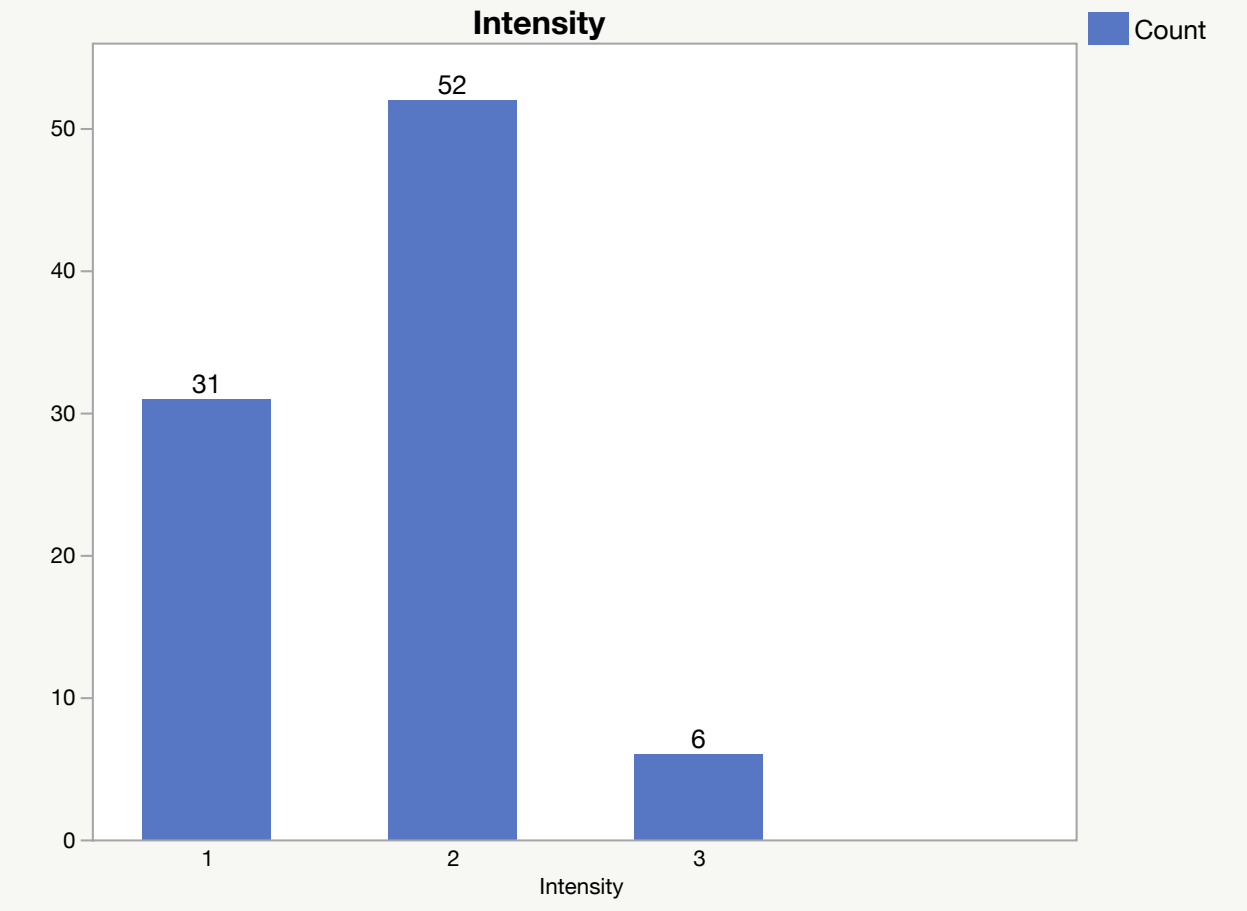

Figure 5: Intensity levels from all 100 forest patches. 52.8% of mobbing trials experienced birds within the 2-m radius, without an attempt to initiate contact with the focal owl model.

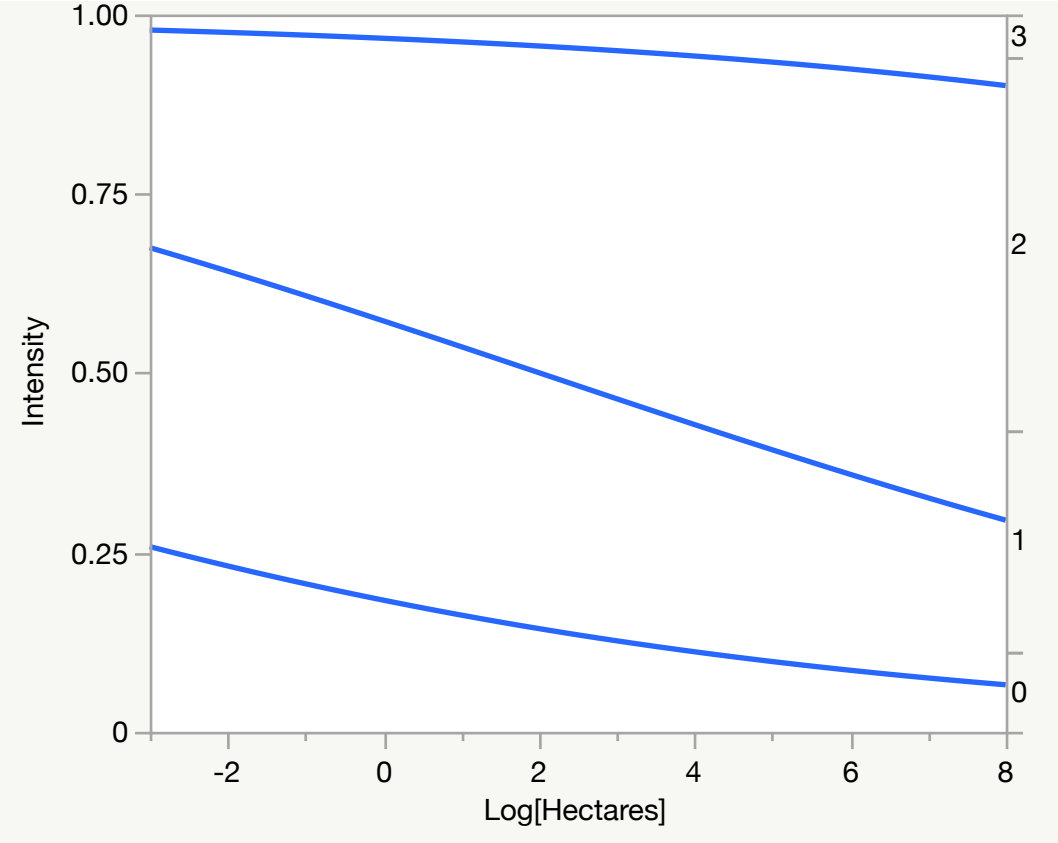

Figure 6: Size has no effect on the intensity of the mobbing event that occurs within the forest fragment ($G = 1.45$, $df = 1$, $P = 0.227$, $R^2 = 0.007$).

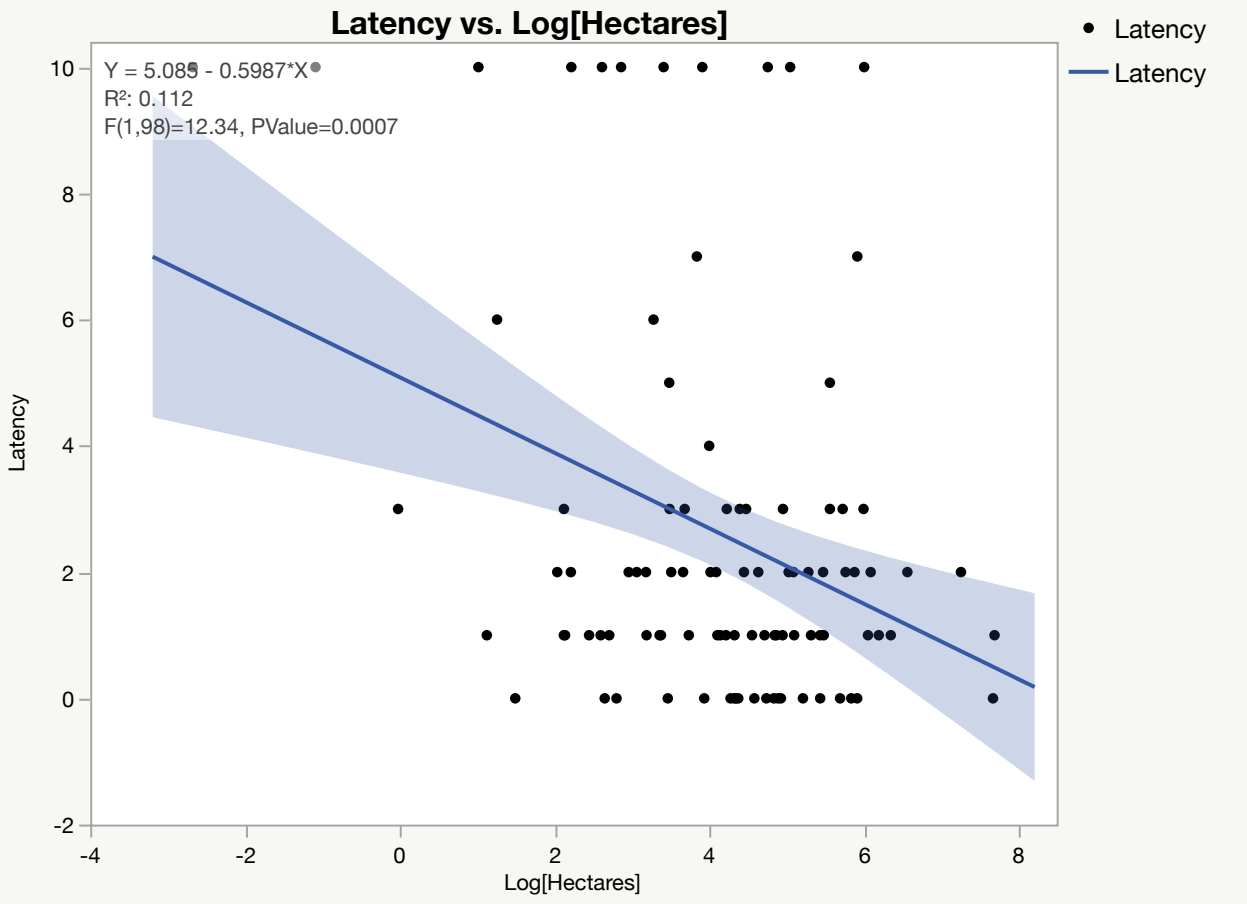

Figure 7: Birds responded quicker to predator vocalizations in larger forest fragments (Mean = 1.69 minutes, ± 0.17 SE).

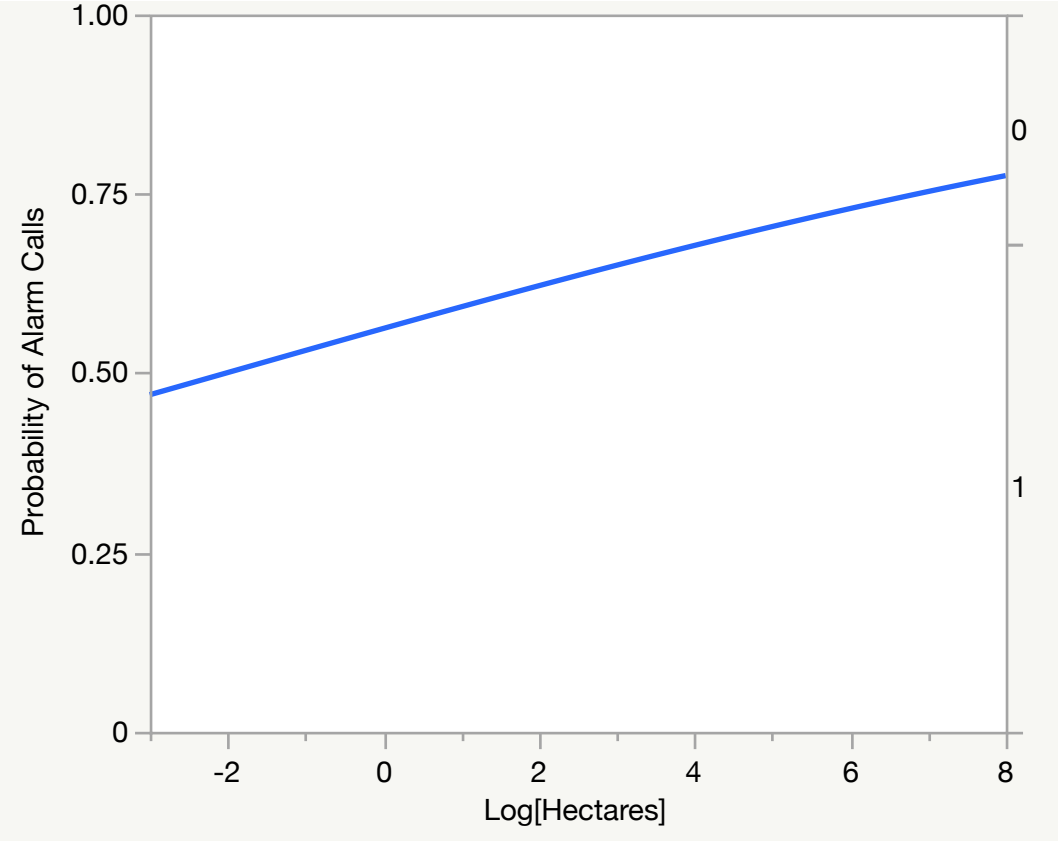

Figure 8: Fragment size had no significant effect on the probability of birds making an alarm call during the mobbing event ($G = 0.96$, $df = 1$, $P = 0.326$, $R^2 = 0.008$).

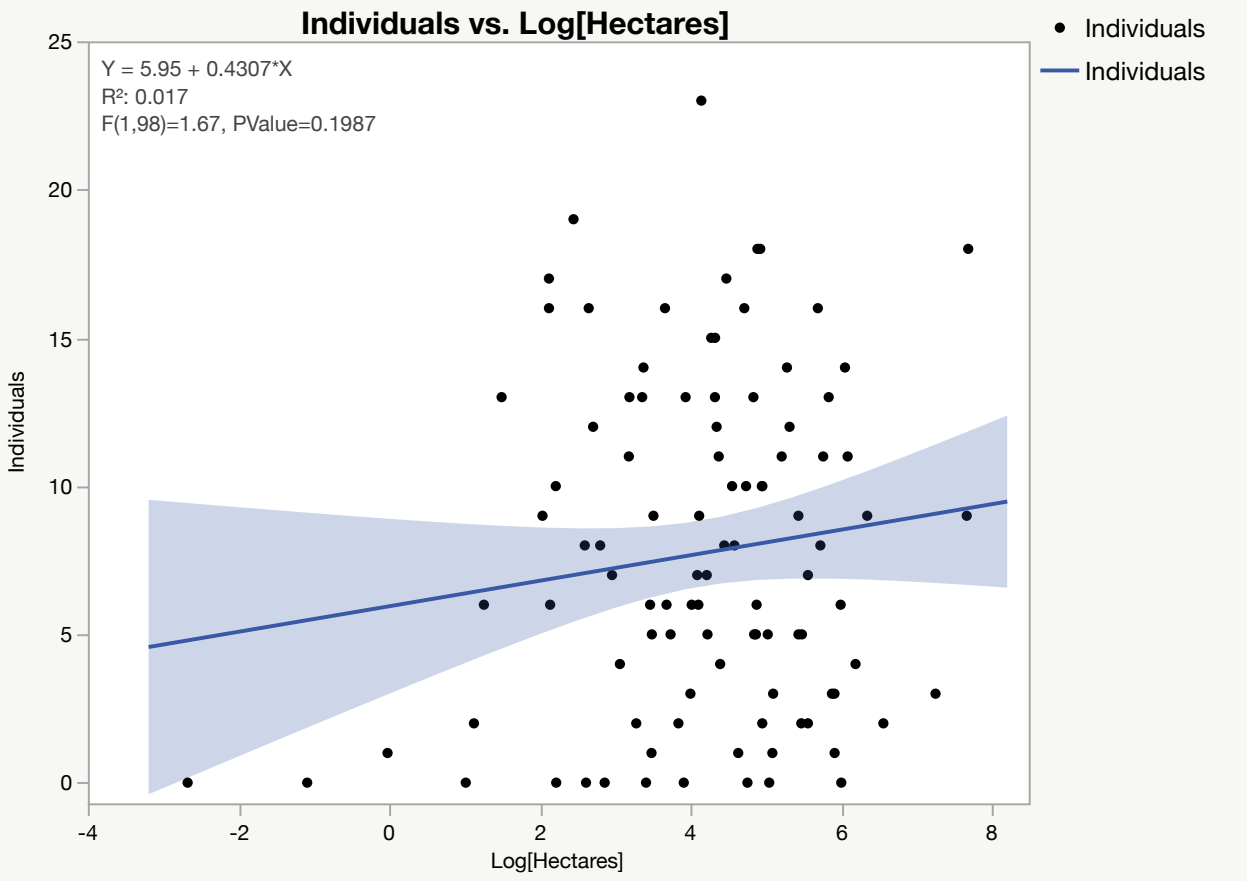

Figure 9: Size had no significant effect on the number of birds that were willing to participate in the mobbing event (Mean = 7.73 individuals, ±0.56 SE).

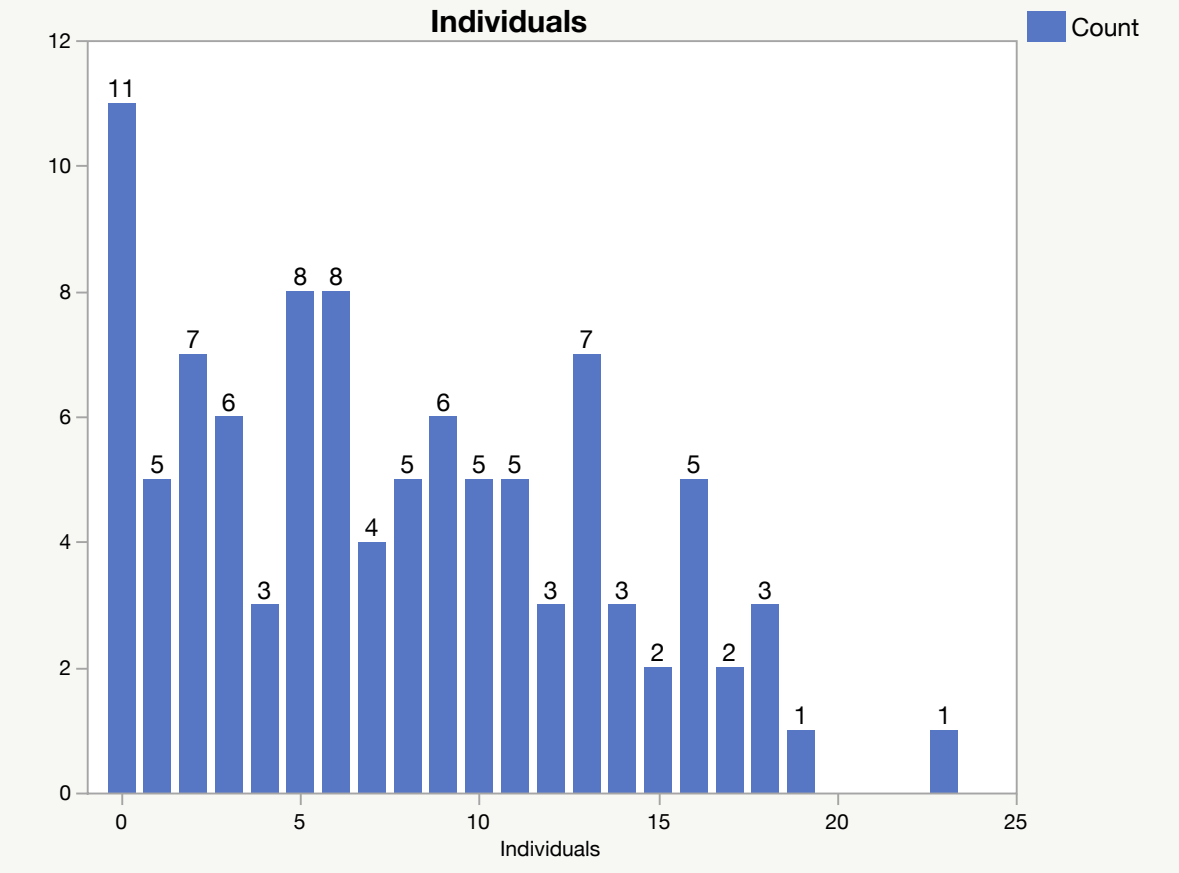

Figure 10: Distribution of the number of individuals participating in the mobbing event across forest sizes (Mean = 7.73, ±0.56 SE).

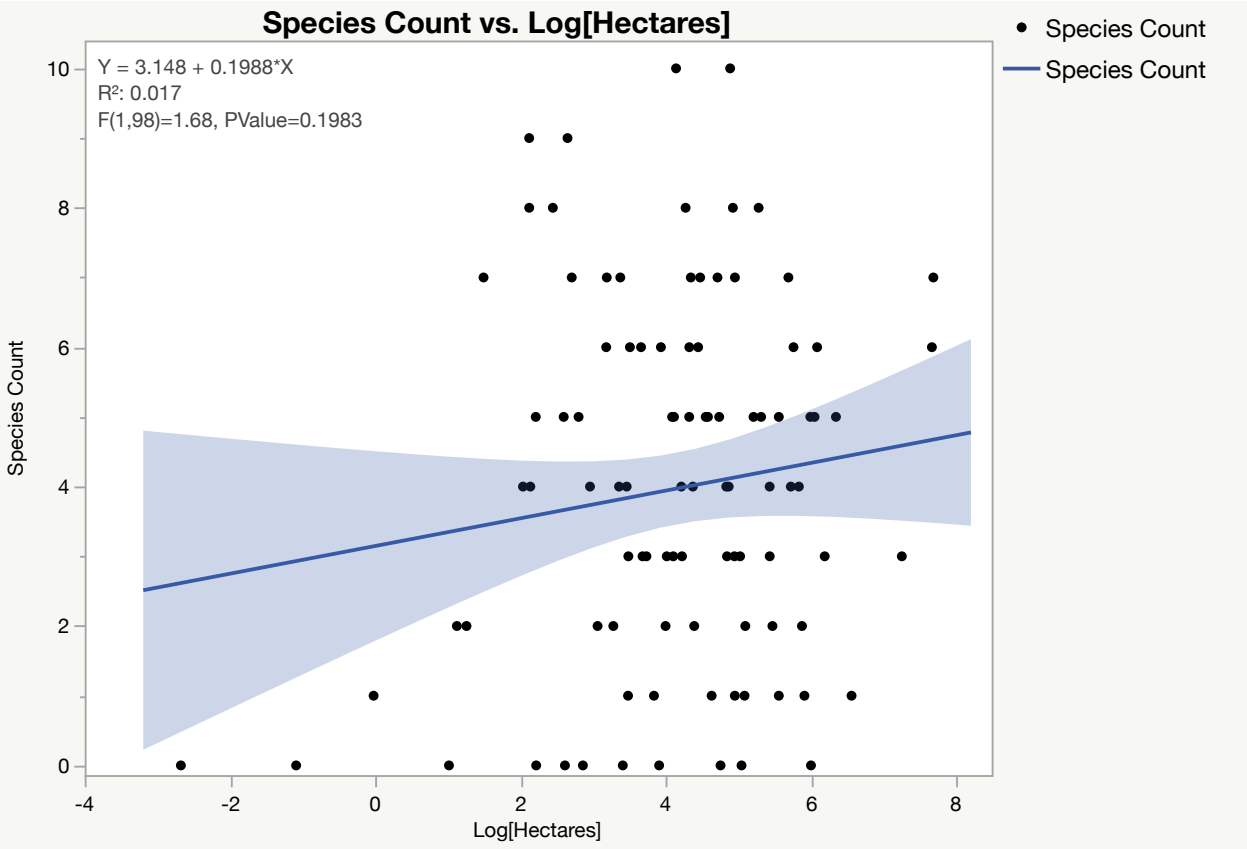

Figure 11: Size had no significant effect on the number of species that participated in the mobbing event.

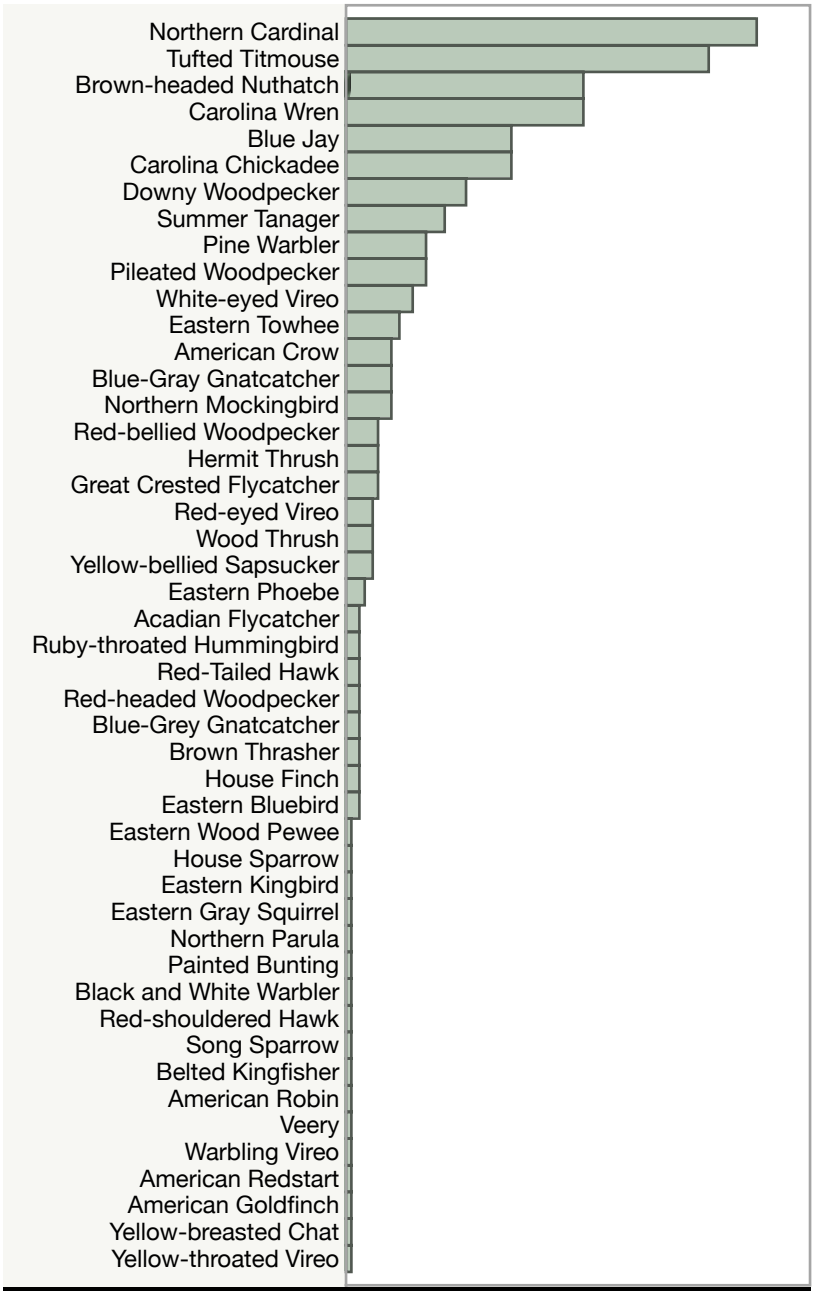

Figure 12: Frequency occurrence of species for all 100 mobbing trials. Northern Cardinals and Tufted titmice appeared the most frequently (62%, 55%).

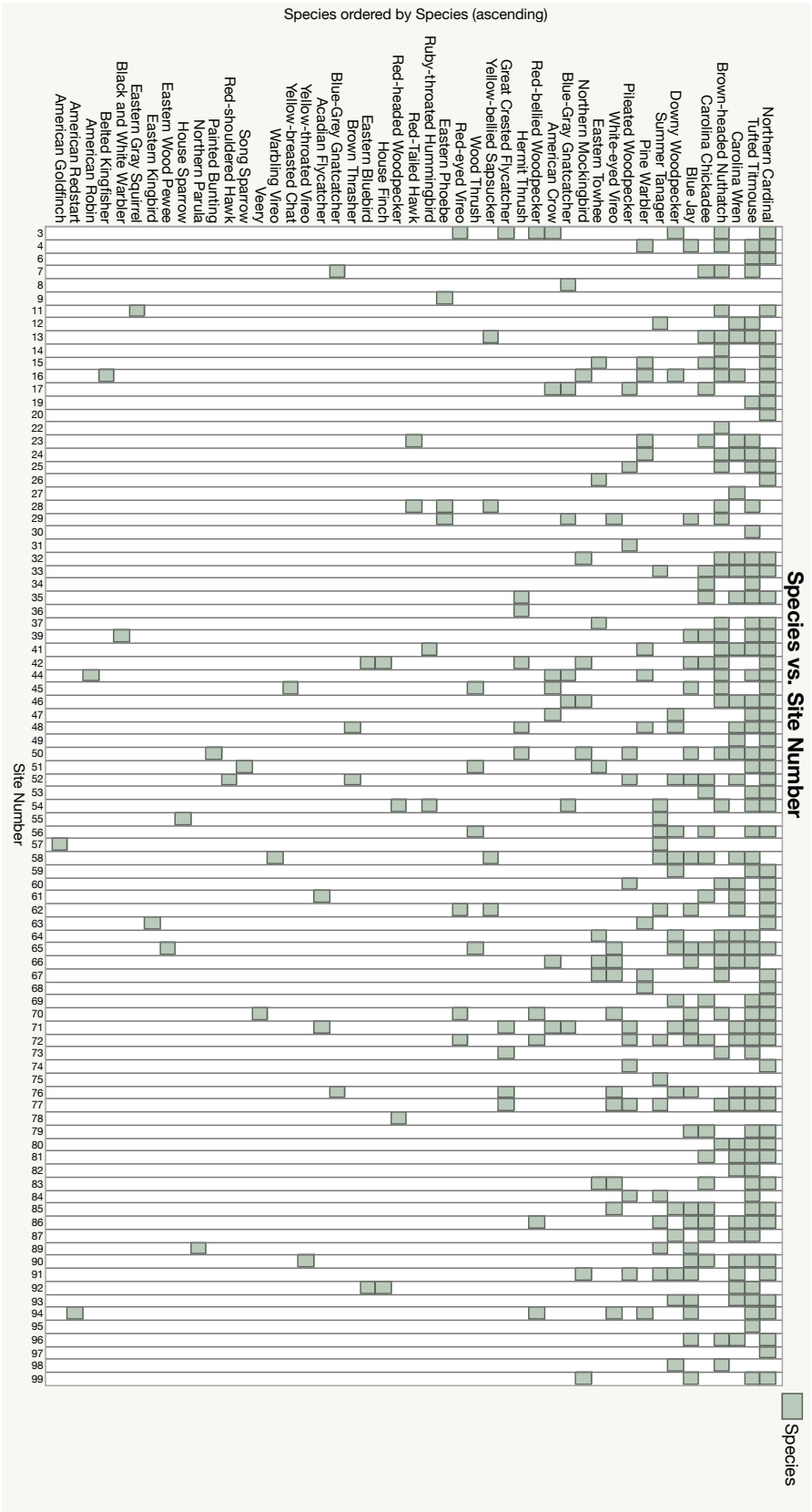

Figure 13: Species occurrence at all 100 forest patches.

CHAPTER 4

DISCUSSION

I found that the probability of birds mobbing a potential predator increases as forest size increases. As forest size increases, the carrying capacity of the forest will presumably increase, providing a larger number of potential recruits within a forest patch. Furthermore, in forest fragments below 0.97 hectares I observed no mobbing behaviors at all. This suggests there may indeed be a threshold forest size at which the repertoires of mobbing are lost.

I also observed a significant effect on forest size in the time that birds took to respond to a predator. As forest size increased, birds responded quicker. In larger forest fragments, birds either detected the predator more rapidly or they were more willing to engage in mobbing behavior. If the latter were true, I would expect the willingness to be reflected in other variables that were measured.

However, I did not see a significant effect of forest size on the remaining aspects of mobbing that I measured. The data does not support our overall hypothesis that the degree of fragmentation within a habitat would affect the number of individuals, species, the presence of alarm calls, and the intensity of the mobbing events. I sometimes observed large numbers of birds being recruited for mobbing events in smaller forest sizes. This could contribute to the risk factor given by Eastern Screech Owls (*Megascops asio*). A recent study showed that crows learn to recognize unique threats. Using this information, they selectively ignore associations with similar predators (Marzluff et al. 2015). They recorded higher responses in mobbing behaviors of crows to models of Red-tailed Hawks than Ospreys. Thus, suggesting that mobbing increases with the risk posed by the predator at hand. This reduction in risk posed by an Eastern Screech Owl could be attributed to their slow movement into suburban areas. Eastern Screech Owls have

shown higher nesting success rate in suburban areas than rural areas (Gehlbach 1994, 1996). Bird feeders and bird baths played a significant role in this. Owls were able to obtain prey using the bird feeders and used bird-bath water to drink and bathe, making it much easier to obtain resource needed (Gelhbach 2002, 1996). I can also attribute the lack of variation in forest size and individuals to the resilience of bird species. A 1997 study showed that short-term community responses to habitat fragmentation produced more resilient bird species. Although the study reported a decrease in resident species in isolated fragment patches, there was no decrease in species richness. It also reported no change in birds that are habitat generalists (Schmiegelow et al. 1997).

The overall latency and intensity of each mobbing event had no response in terms of forest size, making the second hypothesis null. I can attribute this to two possibilities: 1) Birds in smaller forest fragments see a larger risk in predators and are therefore more attracted to the mobbing event, thus creating a large assemblage that will mob more intensely. 2) Birds in larger forest fragments can generate larger assemblages of participating birds, therefore resulting in the intensity increasing as more recruitments join. These two ideas were believed to be mutually exclusive, but perhaps a combination is at play.

I also experienced numerous encounters of species in the family *Paridae* that are known to broadcast alarm calls and signals to recruit mobbing assemblages (Courter and Ritchison 2010, Nocera et al. 2008). Members of this family are also known to modify their alarm call to convey information about the predator and the risk it poses (Suzuki and Ueda 2013), with Eastern Screech Owls being a known predator. The study found Eastern Screech Owls to be equally as dangerous as diurnal predators, to Carolina Chickadees, but not to Tufted Titmice. During the playback experiments, titmice took longer to return to feeding after playbacks of

alarm calls given in response to a small owl than to playbacks given in response to a large hawk or a robin (Zachau and Freeberg 2012). Throughout our mobbing trials, we experienced a larger response of Tufted Titmice (55%) than Carolina Chickadees (25%).

The last goal of this project was to quantify a threshold forest size at which the repertoires of mobbing behaviors are lost, which is seen below 0.97 ha. Forest patches below that size exhibited no mobbing behaviors from the birds within them. Furthermore, forest patches above 400 ha always exhibited mobbing behaviors. This data may be used for conservation and management practices to ensure forest fragments do not fall below this threshold size to prevent future behavioral alterations of birds. The lack of significant response we see in the number of individuals and the number of species by forest size could imply that habitat fragmentation does not have a more pressing effect on the number of individuals and the number of species that are willing to participate in this mobbing events. We can also assume that only sampling each forest size once, rather than having repeated trials for each forest size could have attributed to these results.

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APPENDIX 1: THIS TABLE LISTS THE SITES WITHIN GEORGIA THAT WERE USED FOR MOBBING TRIALS. LATITUDE AND LONGITUDE ARE IN DECIMAL DEGREES.

Site	Hectares	Latitude	Longitude
1	0.07	32.491599	-81.985976
2	0.34	32.533913	-82.019997
3	14.9	32.048132	-82.413655
4	16.37	32.553039	-82.065171
5	17.37	32.429491	-81.783498
6	26.41	31.764771	-82.365395
7	31.73	32.485176	-81.966102
8	32.33	32.555117	-82.034083
9	46.18	32.483859	-81.777698
10	49.59	32.401099	-81.792873
11	55.08	32.357646	-81.870056
12	60.21	32.162153	-82.382645
13	75.12	32.392559	-81.736457
14	80.36	32.406094	-81.790586
15	97.05	32.008654	-82.417902
16	110.68	32.452062	-81.607572
17	113.31	32.279708	-81.746822
18	115.42	32.396967	-81.633661
19	126.15	32.557739	-81.996916
20	140.47	32.510320	-81.789233
21	154.09	32.430800	-81.567156
22	160.64	32.450325	-81.734803
23	181.78	32.329065	-81.718371
24	201.74	32.391714	-81.778643
25	226.86	32.471275	-81.743795
26	237.7	32.547140	-82.213706
27	257.39	32.421862	-81.679199
28	275.39	32.415450	-81.665316
29	303.56	32.377229	-81.795022
30	353.93	32.168892	-81.780239
31	400.62	32.480230	-81.563586
32	420.81	32.464303	-81.720114
33	435.88	32.098451	-82.137858
34	483.92	32.059291	-82.192815
35	564.98	32.542753	-81.662960
36	700.11	32.186536	-81.748100
37	1398.53	32.543975	-82.124304
38	2157.46	31.917447	-82.289780
39	84.83	32.644886	-81.839217

40	2.75	32.444373	-81.791626
41	33.17	32.188922	-82.583695
42	194.91	32.174795	-82.602253
43	30.07	32.468694	-81.798497
44	293.59	32.418484	-82.028634
45	50.83	32.394687	-82.074656
46	13.34	31.760198	-82.375480
47	339.06	31.719905	-82.447575
48	2115	31.859699	-82.076908
49	29.68	31.787720	-82.323347
50	8.3	32.428854	-81.721513
51	59.27	32.273052	-81.760725
52	71.38	31.649901	-82.250126
53	39.47	32.364512	-81.901343
54	140.68	32.316059	-81.964067
55	3.068	32.399148	-81.983350
56	38.66	32.387830	-82.010115
57	235.76	32.318018	-82.147295
58	24.12	32.310301	-82.125155
59	227.11	32.284116	-82.228068
60	78.85	32.192749	-82.350030
61	151.07	32.208053	-82.308299
62	9.08	31.832968	-82.380311
63	41.63	31.923205	-82.502487
64	397.28	31.954710	-82.459350
65	62.6	31.918750	-82.340623
66	136.77	32.275839	-82.409505
67	60.84	32.335260	-82.367170
68	21.26	32.420300	-82.465904
69	67.28	32.326640	-82.404895
70	87.23	31.899582	-82.254020
71	131.73	31.942126	-82.030847
72	14.06	31.992616	-82.042810
73	139.77	32.081157	-81.991800
74	54.17	32.219507	-82.322939
75	102.12	32.206975	-82.349125
76	8.3	31.645057	-82.216866
77	11.49	32.217802	-82.399112
78	0.98	32.209605	-82.376864
79	130.28	32.222117	-82.464999
80	124.9	32.501053	-82.340327
81	28.56	32.598791	-82.347481
82	3.5	32.591437	-82.341829

83	94.15	32.598222	-82.217044
84	67.94	32.579695	-82.145458
85	23.94	32.600928	-82.215619
86	76.67	32.574810	-82.168563
87	7.62	32.181007	-82.579680
88	9.13	32.192357	-82.632402
89	32.47	32.231899	-82.689920
90	315.1	32.294520	-82.697433
91	4.43	32.344720	-82.688465
92	19.15	32.082369	-82.486902
93	74.99	32.091246	-82.483636
94	29.07	32.285310	-81.833990
95	366.67	32.266540	-81.874630
96	129.09	32.355040	-81.855220
97	366.12	32.369570	-81.798480
98	162.27	32.398320	-81.763280
99	8.43	32.416010	-81.795490
100	13.57	32.391063	-81.828199

APPENDIX 2: SPECIES IDENTIFIED DURING EACH MOBBING EVENT.

Site Number	Species
1	None
2	None
3	Great Crested Flycatcher
3	Northern Cardinal
3	Red-eyed Vireo
3	Brown-headed Nuthatch
3	Red-bellied Woodpecker
3	Downy Woodpecker
3	American Crow
4	Blue Jay
4	Tufted Titmouse
4	Brown-headed Nuthatch
4	Northern Cardinal
4	Pine Warbler
5	None
6	Tufted Titmouse
6	Northern Cardinal
7	Blue-Grey Gnatcatcher
7	Tufted Titmouse
7	Caroline Chickadee
7	Brown-headed Nuthatch
8	Blue-Grey Gnatcatcher
9	Eastern Phoebe
10	None
11	Brown-headed Nuthatch
11	Eastern Gray Squirrel
11	Northern Cardinal
12	Tufted Titmouse
12	Summer Tanager
12	Carolina Wren
13	Yellow-bellied Sapsucker
13	Carolina Wren
13	Brown-headed Nuthatch
13	Caroline Chickadee
13	Tufted Titmouse
13	Northern Cardinal
14	Brown-headed Nuthatch
14	Northern Cardinal
15	Pine Warbler
15	Northern Cardinal

15	Eastern Towhee
15	Brown-headed Nuthatch
15	Caroline Chickadee
16	Northern Cardinal
16	Pine Warbler
16	Belted Kingfisher
16	Brown-headed Nuthatch
16	Northern Mockingbird
16	Downy Woodpecker
16	Carolina Wren
17	American Crow
17	Northern Cardinal
17	Caroline Chickadee
17	Pileated Woodpecker
17	Blue-Grey Gnatcatcher
18	None
19	Tufted Titmouse
19	Northern Cardinal
20	Northern Cardinal
21	None
22	Brown-headed Nuthatch
22	Brown-headed Nuthatch
23	Red-Tailed Hawk
23	Carolina Wren
23	Caroline Chickadee
23	Tufted Titmouse
23	Pine Warbler
24	Northern Cardinal
24	Brown-headed Nuthatch
24	Tufted Titmouse
24	Pine Warbler
24	Carolina Wren
25	Pileated Woodpecker
25	Northern Cardinal
25	Tufted Titmouse
25	Brown-headed Nuthatch
26	Eastern Towhee
26	Northern Cardinal
27	Carolina Wren
28	Red-Tailed Hawk
28	Brown-headed Nuthatch
28	Yellow-bellied Sapsucker
28	Eastern Phoebe

28	Tufted Titmouse
29	Brown-headed Nuthatch
29	White-eyed Vireo
29	Eastern Phoebe
29	Blue Jay
29	Blue-Grey Gnatcatcher
30	Tufted Titmouse
31	None
31	Pileated Woodpecker
32	Brown-headed Nuthatch
32	Northern Mockingbird
32	Northern Cardinal
32	Tufted Titmouse
32	Carolina Wren
33	Tufted Titmouse
33	Northern Cardinal
33	Carolina Wren
33	Brown-headed Nuthatch
33	Caroline Chickadee
33	Summer Tanager
34	Tufted Titmouse
34	Caroline Chickadee
35	Caroline Chickadee
35	Tufted Titmouse
35	Hermit Thrush
35	Northern Cardinal
35	Carolina Wren
36	Hermit Thrush
37	Northern Cardinal
37	Tufted Titmouse
37	Brown-headed Nuthatch
37	Tufted Titmouse
37	Northern Cardinal
37	Eastern Towhee
39	Caroline Chickadee
39	Brown-headed Nuthatch
39	Black and White Warbler
39	Northern Cardinal
39	Blue Jay
39	Tufted Titmouse
40	None
41	Northern Cardinal
41	Ruby-throated Hummingbird

41	Pine Warbler
41	Tufted Titmouse
41	Brown-headed Nuthatch
41	Carolina Wren
42	Northern Cardinal
42	Brown-headed Nuthatch
42	Caroline Chickadee
42	Eastern Bluebird
42	Northern Mockingbird
42	Blue Jay
42	House Finch
42	Hermit Thrush
43	None
44	Northern Cardinal
44	Tufted Titmouse
44	Brown-headed Nuthatch
44	Pine Warbler
44	Blue-Grey Gnatcatcher
44	American Crow
44	American Robin
45	Northern Cardinal
45	Brown-headed Nuthatch
45	Wood Thrush
45	American Crow
45	Blue Jay
45	Yellow-breasted Chat
46	Northern Cardinal
46	Blue-Grey Gnatcatcher
46	Carolina Wren
46	Northern Mockingbird
46	Tufted Titmouse
46	Brown-headed Nuthatch
47	Northern Cardinal
47	Downy Woodpecker
47	American Crow
47	Tufted Titmouse
48	Northern Cardinal
48	Hermit Thrush
48	Tufted Titmouse
48	Pine Warbler
48	Downy Woodpecker
48	Brown Thrasher
48	Carolina Wren

49	Northern Cardinal
49	Carolina Wren
50	Northern Cardinal
50	Hermit Thrush
50	Northern Mockingbird
50	Blue Jay
50	Carolina Wren
50	Brown-headed Nuthatch
50	Pileated Woodpecker
50	Tufted Titmouse
50	Painted Bunting
51	Northern Cardinal
51	Song Sparrow
51	Eastern Towhee
51	Wood Thrush
51	Tufted Titmouse
52	Northern Cardinal
52	Red-shouldered Hawk
52	Carolina Wren
52	Downy Woodpecker
52	Pileated Woodpecker
52	Caroline Chickadee
52	Blue Jay
52	Brown Thrasher
53	Northern Cardinal
53	Tufted Titmouse
53	Caroline Chickadee
54	Tufted Titmouse
54	Brown-headed Nuthatch
54	Northern Cardinal
54	Red-headed Woodpecker
54	Summer Tanager
54	Blue-Grey Gnatcatcher
54	Ruby-throated Hummingbird
55	House Sparrow
55	Summer Tanager
56	Tufted Titmouse
56	Northern Cardinal
56	Downy Woodpecker
56	Summer Tanager
56	Caroline Chickadee
56	Wood Thrush
57	American Goldfinch

57	Summer Tanager
58	Tufted Titmouse
58	Blue Jay
58	Warbling Vireo
58	Summer Tanager
58	Carolina Wren
58	Yellow-bellied Sapsucker
58	Downy Woodpecker
58	Caroline Chickadee
59	Tufted Titmouse
59	Northern Cardinal
59	Downy Woodpecker
60	Brown-headed Nuthatch
60	Northern Cardinal
60	Carolina Wren
60	Pileated Woodpecker
61	Northern Cardinal
61	Arcadian Flycatcher
61	Caroline Chickadee
61	Carolina Wren
62	Carolina Wren
62	Summer Tanager
62	Northern Cardinal
62	Red-eyed Vireo
62	Yellow-bellied Sapsucker
62	Blue Jay
63	Northern Cardinal
63	Pine Warbler
63	Eastern Kingbird
64	Eastern Towhee
64	Downy Woodpecker
64	Tufted Titmouse
64	Brown-headed Nuthatch
64	Carolina Wren
65	Brown-headed Nuthatch
65	Tufted Titmouse
65	Northern Cardinal
65	Wood Thrush
65	Downy Woodpecker
65	Carolina Wren
65	Blue Jay
65	White-eyed Vireo
65	Caroline Chickadee

65	Eastern Wood Pewee
66	Eastern Towhee
66	Carolina Wren
66	Tufted Titmouse
66	American Crow
66	Brown-headed Nuthatch
66	Blue Jay
66	White-eyed Vireo
67	Northern Cardinal
67	Brown-headed Nuthatch
67	Pine Warbler
67	Eastern Towhee
67	White-eyed Vireo
68	Northern Cardinal
68	Pine Warbler
69	Tufted Titmouse
69	Caroline Chickadee
69	Downy Woodpecker
69	Northern Cardinal
70	Tufted Titmouse
70	Red-bellied Woodpecker
70	Blue Jay
70	Red-eyed Vireo
70	Brown-headed Nuthatch
70	Northern Cardinal
70	Veery
70	White-eyed Vireo
71	Tufted Titmouse
71	Great Crested Flycatcher
71	Downy Woodpecker
71	Northern Cardinal
71	Blue-Grey Gnatcatcher
71	Pileated Woodpecker
71	Acadian Flycatcher
71	Blue Jay
71	American Crow
71	Carolina Wren
72	Caroline Chickadee
72	Northern Cardinal
72	Red-bellied Woodpecker
72	Tufted Titmouse
72	Blue Jay
72	Carolina Wren

72	Red-eyed Vireo
72	Pileated Woodpecker
72	Summer Tanager
73	Tufted Titmouse
73	Brown-headed Nuthatch
73	Great Crested Flycatcher
74	Pileated Woodpecker
74	Northern Cardinal
75	Summer Tanager
76	White-eyed Vireo
76	Great Crested Flycatcher
76	Downy Woodpecker
76	Northern Cardinal
76	Blue Jay
76	Tufted Titmouse
76	Carolina Wren
76	Blue-Grey Gnatcatcher
77	Brown-headed Nuthatch
77	Northern Cardinal
77	Tufted Titmouse
77	Summer Tanager
77	Pileated Woodpecker
77	White-eyed Vireo
77	Carolina Wren
77	Great Crested Flycatcher
78	Red-headed Woodpecker
79	Northern Cardinal
79	Tufted Titmouse
79	Caroline Chickadee
79	Blue Jay
80	Northern Cardinal
80	Brown-headed Nuthatch
80	Tufted Titmouse
80	Carolina Wren
81	Tufted Titmouse
81	Northern Cardinal
81	Carolina Wren
81	Caroline Chickadee
82	Tufted Titmouse
82	Carolina Wren
83	Caroline Chickadee
83	Tufted Titmouse
83	Northern Cardinal

83	Eastern Towhee
83	White-eyed Vireo
84	Summer Tanager
84	Pileated Woodpecker
84	Tufted Titmouse
85	Tufted Titmouse
85	Downy Woodpecker
85	Blue Jay
85	Northern Cardinal
85	Caroline Chickadee
85	White-eyed Vireo
86	Tufted Titmouse
86	Northern Cardinal
86	Caroline Chickadee
86	Red-bellied Woodpecker
86	Summer Tanager
86	Carolina Wren
86	Blue Jay
87	Downy Woodpecker
87	Tufted Titmouse
87	Carolina Wren
87	Caroline Chickadee
88	None
89	Northern Parula
89	Blue Jay
89	Summer Tanager
90	Northern Cardinal
90	Caroline Chickadee
90	Tufted Titmouse
90	Blue Jay
90	Yellow-throated Vireo
90	Carolina Wren
91	Carolina Wren
91	Downy Woodpecker
91	Northern Cardinal
91	Pileated Woodpecker
91	Blue Jay
91	Northern Mockingbird
91	Summer Tanager
92	Tufted Titmouse
92	House Finch
92	Carolina Wren
92	Eastern Bluebird

93	Tufted Titmouse
93	Downy Woodpecker
93	Northern Cardinal
93	Carolina Wren
93	Blue Jay
94	American Redstart
94	White-eyed Vireo
94	Northern Cardinal
94	Tufted Titmouse
94	Blue Jay
94	Red-bellied Woodpecker
94	Pine Warbler
95	Tufted Titmouse
96	Carolina Wren
96	Brown-headed Nuthatch
96	Northern Cardinal
96	Blue Jay
97	Northern Cardinal
98	Brown-headed Nuthatch
98	Downy Woodpecker
99	Blue Jay
99	Tufted Titmouse
99	Northern Cardinal
99	Northern Mockingbird
100	None