A SURVEY FOR POTENTIAL PREDATORS OF THE GOLDEN-CHEEKED WARBLER (*DENDROICA CHRYSOPARIA*) IN RELATION TO DIFFERENT EDGES AT THE BALCONES CANYONLANDS PRESERVE

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ABSTRACT

A SURVEY FOR POTENTIAL PREDATORS OF THE GOLDEN-CHEEKED WARBLER (*DENDROICA CHRYSOPARIA*) IN RELATION TO DIFFERENT EDGES AT THE BALCONES CANYONLANDS PRESERVE

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The Golden-cheeked Warbler (*Dendroica chrysoparia*), an endangered neotropical migrant, has a restricted breeding range in central Texas. Because of their sensitivity to habitat loss, fragmentation, and limited breeding habitat, the City of Austin, federal, and county agencies purchased tracts of land known as the Balcones Canyonlands Preserve. My study addressed the presence or absence of potential predators of the Golden-cheeked Warbler in different edge types at three sites in the Balcones Canyonlands Preserve. I identified predatory mammals, birds, and snakes using track plate stations, point counts, and visual observations. Five mammalian predators and six avian predators were identified. No snakes were observed. Urban edges as opposed to man-made and natural edges had greater predator activity. Urbanization and

fragmentation will continue to increase with human population growth; it is important to develop conservation strategies to protect the habitat of the Golden-cheeked Warblers.

CHAPTER 1

INTRODUCTION

The Golden-cheeked Warbler, *Dendroica chrysoparia* (here after, GCWA), is an endangered neotropical migrant that nests exclusively in central Texas. This species winters in highlands of southern Mexico, Guatemala, Honduras, and Nicaragua at elevations ranging from 1,500 to 3,000 m (Ladd and Gass 1999). During winter, GCWAs occupy pine forest, pine-oak forest, and sometimes deciduous forests (Pulich 1976, Ladd and Gass 1999). In the early spring migration, GCWA arrives in the Edwards Plateau, Llano Uplift, and Lampasas Cut Plain of central Texas about 11 March (Ladd and Gass 1999). Suitable breeding habitat consists of Ashe juniper-oak woodlands on limestone hills and canyons. More specifically, nesting habitat contains mature Ashe juniper (*Juniperus ashei*), Texas oak (*Quercus buckleyi*), and plateau live oak (*Quercus fusiformis*) (Ladd and Gass 1999). Other factors affecting GCWA nesting habitat include high density of trees, closed canopy coverage, and large tracts of land (Pulich 1976, Ladd 1985, Ladd and Gass 1999). GCWAs migrate south to wintering sites during mid – June to late July (Ladd and Gass 1999).

The decline of this species is a result of urbanization and loss of habitat (Pulich 1976, Engles and Sexton 1994). Like most Neotropical songbirds, the GCWA is not a successful edge species with best productivity survival in large, continuous forest tracts (Ladd and Gass 1999). Due to extensive habitat loss, habitat fragmentation, and decline of populations, the U.S. Fish and Wildlife Service added the GCWA to the Endangered Species List in 1990. To preserve habitat and increase the GCWA population, the City of Austin, Travis County, and US Fish and Wildlife Service purchased parcels of land known as the Balcones Canyonlands Preserve (here after, BCP). Though suitable breeding habitat for the GCWA occurs in the BCP, it is highly fragmented due to the piece meal purchase of a series of tracts with some contiguous and others isolated. As a result, some tracts are near housing developments or other types of property with many being replete with natural and man-made edges (Ladd and Gass 1999).

In urban areas, household pets and nuisance animals contribute to higher predation rates on birds (Wilcove 1985). Because parts of BCP lands are adjacent to residential neighborhoods, domestic cats (*Felis catus*) pose a potential threat to birds. Besides mortality from urban and suburban cats, the presence of cats alone can cause detectable stress on songbirds (Friesen 1995 et al., Coleman et al. 1997). Common raccoons (*Procyon lotor*), Virginia opossums (*Didelphis virginiana*), coyotes (*Canis latrans),* squirrels *(Sciurus sp.),* and striped skunks (*Mephitis mephitis*) are predators on eggs and nestling songbirds (Wilcove 1985, Miller et al. 1998, Dijak 2000). These small mammals along with squirrels (*Sciurus*) have higher densities in areas with an edge effect (Wilcove 1985). Due to anthropogenic food sources, various man-made structures, and decreased emigration/immigration, populations of common raccoons reach much higher densities along urban/suburban edges (Prange et al. 2003).

Larger birds such as Blue Jays (*Cyanocitta cristata*), Brown-headed Cowbirds (*Molothrus ater*), Western Scrub Jays (*Aphelocoma coerulescens*), American Crow (*Corvus brachyrhynchos*), owls, hawks, and grackles are nest predators on songbirds (Wilcove 1985, Engels and Sexton 1994). Davidson (1993) observed Common Grackles (*Qiuscalus quiscula*) preying upon and killing 39 adult passerine species in an 80-h period. Engels and Sexton (1994) found predation on birds increased in areas surrounded by urban neighborhoods with the introduction of new predators into GCWA habitat (Engels and Sexton 1994). Nesting in fragmented woodlots with edges makes GCWAs and their eggs more susceptible to predation and nest parasitism (Wilcove 1985).

Since multiple edges and edge effect have been created in the suburban location of BCP land, it is important to determine whether GCWAs are under additional stress by predation or the presence of predators (Leopold 1933). The objectives of my study were to (1) identify potential predators of the GCWA on the BCP, (2) determine species diversity along man-made, natural, and urban edges, and (3) determine species composition of edges and interior forest.

CHAPTER 2

STUDY AREA

My study sites were located on three adjacent tracts of land in the City of Austin's Bull Creek Unit of the BCP. The BCP is located in Travis County on the eastern edge of the Jollyville Plateau. The Jester-Burris (here after, Jester) tract consists of 119 ha. The Ivanhoe tract, 381 ha, is adjacent to and west of Jester. The 3M mitigation tract, 87 ha, is adjacent to the southern section of the Jester tract.

The southwestern boundary of the Jester tract is a suburban neighborhood, while undeveloped tracts of land form the other boundaries. The tract contains many ravines that drain into the upper portion of Bull Creek. Plateaus on this tract are 296 m amsl (above the mean sea level), and tributary bottoms are about 213 m amsl. The Jester tract is primarily an Ashe juniper woodland with a mixture of plateau live oak, Texas oak, shin oak (*Quercus sinuata var. breviloba*), and cedar elm (*Ulmus crassifolia*). Understory woody vegetation consists of Texas persimmon (*Diospyros texana*) and mountain laurel (*Sophora secundiflora*). Woody vegetation in the lowland/riparian zone includes eastern cottonwood (*Populus deltoides* var. *deltoids*), American elm (*Ulmus americana*), Chinaberry (*Sapindus drummondii*), American sycamore (*Platanus occidentalis*), and black willow (*Salix nigra*). There is moderate to heavy browsing of woody vegetation by white-tailed deer (*Odocoileus virginianus*). The habitat on the tract is considered GCWA habitat. In 1996, 8 GCWA territories and 6 partial territories occurred on the tract and those adjacent to it (Balcones Canyonlands Preserve 1998).

The Ivanhoe tract has remained somewhat undisturbed and wooded for over 30 years. Many edges exist within Ivanhoe. A housing development occurs at the eastern boundary, a man-made edge created by a power line corridor is the northern boundary, while a meadow forms an edge near the center of the property. A steep canyon of West Bull Creek divides Ivanhoe. The elevation is slightly over 305 m amsl in the southwestern portion of the tract, while the lowest point is just below 185 m amsl in the West Bull Creek valley. Through time the vegetative composition has remained relatively the same. The community is dominated by mature Ashe juniper with a mixture of deciduous trees, specifically elms and oaks. The meadow currently is being invaded by young Ashe juniper (Balcones Canyonlands Preserve 1998). As on Jester, many GCWA surveys have been conducted on this tract. Currently, a 40.5 ha study plot for GCWA population monitoring is located on Ivanhoe.

Wooded uplands occupy the north and northwest portions of the 3M tract, while the southern portion consists of many wooded ravines. Two tributaries of Bull Creek occur on this study site. Elevation ranges from 656–940 feet amsl. The current vegetation on 3M is very similar to the vegetation that existed in aerial photographs taken in 1951. Over 74% of the 3M tract has deciduous-Ashe juniper woodlands creating about 65 ha of what is considered excellent GCWA habitat. Of the 65 ha, 51 ha are woodlands located on slopes greater than 15%. Currently there is a major power line corridor creating a man-made edge within the site (Balcones Canyonlads Preserve 1998).

CHAPTER 3

MATERIALS AND METHODS

The edges examined in this study were already in place at the BCP. The two primary edges of interest on the BCP are the urban and man-made edges. The urban development edge allowed me to determine if negative impacts were encroaching onto the preserve. Transects were perpendicular to the urban edge, which began in residents' backyards. They were located on the Jester tract of land. Likewise, the man-made edge was created by the electric power company to provide a corridor for power lines. These man-made edges are maintained regularly. Transects beginning at this edge were located within the Ivanhoe and 3M study locations. Lastly, the natural edge was used as a control; it allowed a comparison between an unaltered edge vs. an altered edge. The natural edge was created by a meadow habitat and oak-juniper forest habitat coming together. All of the natural edge transects were located on the Ivanhoe tract. All transects were located perpendicularly to the edges; thus, creating either an urban, man-made, or natural gradient. Having points on the edge as well as along gradients allowed a comparison to be made of the predator presence between the edge of GCWA habitat and within GCWA habitat.

I established fifteen, 300-m transect lines ≥ 200 m apart at Ivanhoe, 3M, and Jester tracts. Each transect had 3 point stations spaced at 150 m. Five transects, beginning at fences belonging to residents, extended perpendicular to housing developments off Jester Blvd, thus creating an urban gradient (Fig. 1). Five transects

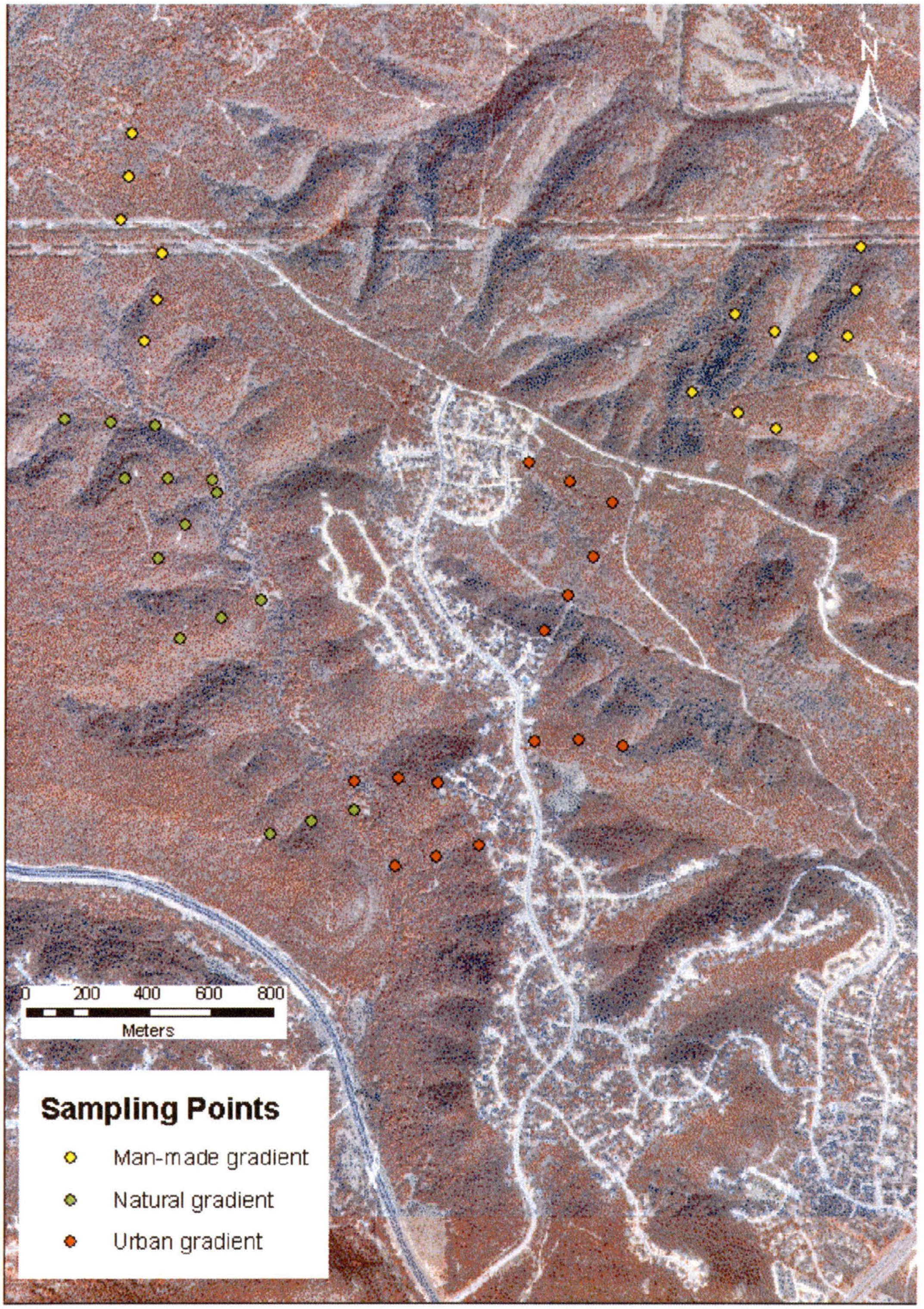

Figure 1. Location of sampling points along three gradients (urban, man-made, and natural) on the Balcones Canyonlands Preserve in Austin, Texas during March – August 2004 and 2005.

located within the Ivanhoe and 3M sites extended perpendicular from power line easements into the interior forest (Fig. 1). Five transects were located at the edge of meadows, within the Ivanhoe tract, and stretched into a forest, thus creating a natural gradient (Fig. 1). I collected track plate station data and point counts on transects between March-July 2004 and 2005.

I used a modified version of the California Fish and Game baited track plate box to determine the presence or absence of mammalian predators (Zielinski and Kucera 1995). Track plate boxes were rectangular wooden boxes 50 cm in height, 81.3 cm in length, and 48.3 cm in width. At the entrance, a 1-mm aluminum plate, 48.2 cm by 27.9 cm served as a toner receptacle. The tracking board behind the receptacle was a removable piece of 1-mm thick aluminum, 48.2 cm by 43.2 cm, with white, adherent contact paper. A slot 10.2 cm in length at the rear of the box formed a bait receptacle. The bait receptacle was enclosed by 0.16 cm^2 hardware cloth. Sardines were used as bait (Schemnitz 1996). I used copy toner instead of soot or talcum powder as a tracking medium for mammalian footprints (Zielinski and Kucera 1995, Belant 2003). Toner has proven to be safe, inexpensive, and easy to use in the field (Belant 2003).

Track plate stations were placed at 0 m, 150 m, and 300 m on 3 randomly selected transects within each edge area. During 2004 data collection, each track plate station had 1 box that was left for 20 trap-days. I checked each station every other day until the twentieth day. Three boxes were rotated among stations. This study design resulted in no replication; therefore adjustments were made in the following season. In 2005, each track plate station had 1 track box that was left at the station for 10 trap-days. Two more boxes were added to the rotation, thus 5 boxes were rotated among stations. During both seasons, I checked each track plate station on the day after baiting and every other day until the tenth day. I then relocated it to another station. I checked stations every other day for mammal activity, removed tracked contact paper, replaced contact paper, and replenished toner and bait. This process was repeated 5 times for each edge gradient. I placed an Avery sheet protector over footprints on the contact paper. Overlaying footprints with Avery protectors allowed me to make photocopies and computer scans of footprints; thus, a permanent digital record was compiled for future reference or educational purposes. It also allowed me to precisely measure footprints without causing any alterations. I identified animal tracks using Scats and Tracks of the Southeast (Halfpenny and Bruchac 2002) and Petersons Field Guides: Animal Tracks (Murie 1974).

I analyzed the number of footprints using a Kruskal-Wallis Analysis of Variance to determine (a) if significant differences existed between mammals detected at the 3 tracts, (b) if significant differences existed between mammals detected at 0 m, 150m, and 300 m, (c) if there was significant differences in the rate of detection between and within edges, and (d) compared mammal activity in 2004 and 2005 season of trapping. The Kruskal-Wallis Analysis of Variance analysis was used because of low sample size and non normal distributions.

I conducted point counts at 0 m, 150 m, and 300 m along the same transects to identify potential nest parasites and predatory birds of the GCWA. The natural history of the GCWA as well as information from previous studies were used to classify avian predators and brood parasites. Three of 5 transects were randomly selected from each type of gradient, which made up one round. Therefore each sampling round consisted of

9 transects (3 points per transect). Counts lasted 12 min at each point. I allowed 2 min for birds to acclimate to my presence; all predatory and parasitizing birds were recorded in the remaining 10 min. Birds were recorded within about a 75 m radius. Birds were identified by sight or vocalization (Bibby et al. 2003). I did not record the distance or direction of birds. During the 2004 season, surveys were conducted in 3 time interval classes: 0600 h-1100 h, 1100 h-1600 h, and 1600 h-2100 h. Two rounds of sampling occurred within each time interval class. I used Kruskal-Wallis test to determine the likelihood that observed patterns could have been produced by random sampling variabilities. There was no difference in the detection of each species at point count stations by time of day (S-Plus 2001, Insightful Corp., Seattle, Washington). Ninety-seven percent of the Kruskal-Wallis tests were insignificant; therefore, data were pooled to create a larger sample size. Because time was irrelevant during the first field season, all point counts during 2005 were conducted between sunrise and 1200 h. I conducted 5 survey rounds between March-July 2005.

I once again used the Kruskal-Wallis Analysis of Variance to determine the likelihood of patterns between species present at edges and/or if differences between species detected at the edge and 300 m could have been produced by random sampling variability (S-Plus 2001, Insightful Corp., Seattle, Washington).

To determine the presence of potential reptilian predators, I used walking transects and incidental sightings of snakes large enough to be an arboreal predator of GCWAs. Other field researchers at these sites took notes of their incidental sightings of snakes as well.

CHAPTER 4

RESULTS

Mammalian Predators

In 630 trap-days (180 days in 2004 and 450 in 2005), I identified a total of 5 potential mammalian predators using track plate stations. The species detected included common raccoon (*Procyon lotor*), feral/domestic cat, common gray fox (*Urocyon cineroargenteus*), Virginia opossum, ringtail (*Bassariscus astutus*), and *Canis* sp. During both seasons, common raccoons were the most frequently detected species on BCP. At the urban edge raccoons were detected 14 of 20 days during 2004. Likewise, at the urban edge in 2005, they were detected during all 5 tracking sessions (100%). On the other hand, the utility edge and natural edge had only 1 common raccoon detection (20%). In season 1, common raccoons were also detected at a lower frequency at the man-made and natural edge. No difference was detected in the proportion of common raccoons at the 3 edges ($\chi^2 = 2.0$, df = 2, P = 0.36). The rate of detection for common raccoons decreased along the urban edge (1.0, 0.8, 0.4) and natural edge (0.2, 0, 0). However, this decreasing pattern was not seen along man-made gradient (Fig. 2).

More detections of feral/domestic cats occurred along the urban edge than the utility or natural edge (Fig. 3). During 2004, feral/domestic cats were only detected at the edge; resulting in, a decrease of detections along the urban gradient. Likewise in 2005, the urban edge had a 0.6 proportion of detections, but the detection rate decreased to 0.2

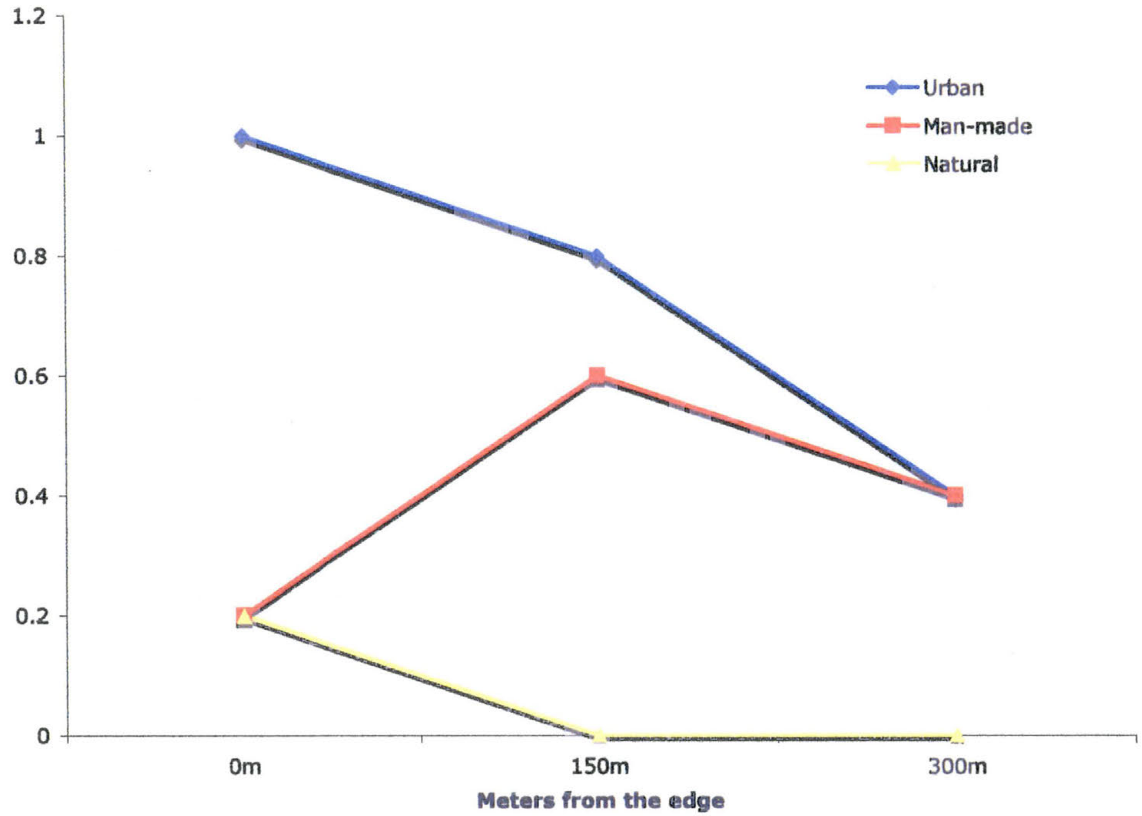

Figure 2. The proportion of raccoons detected along three gradients (urban, man-made, and natural) on the Balcones Canyonlands Preserve in Austin, TX during March – August 2005.

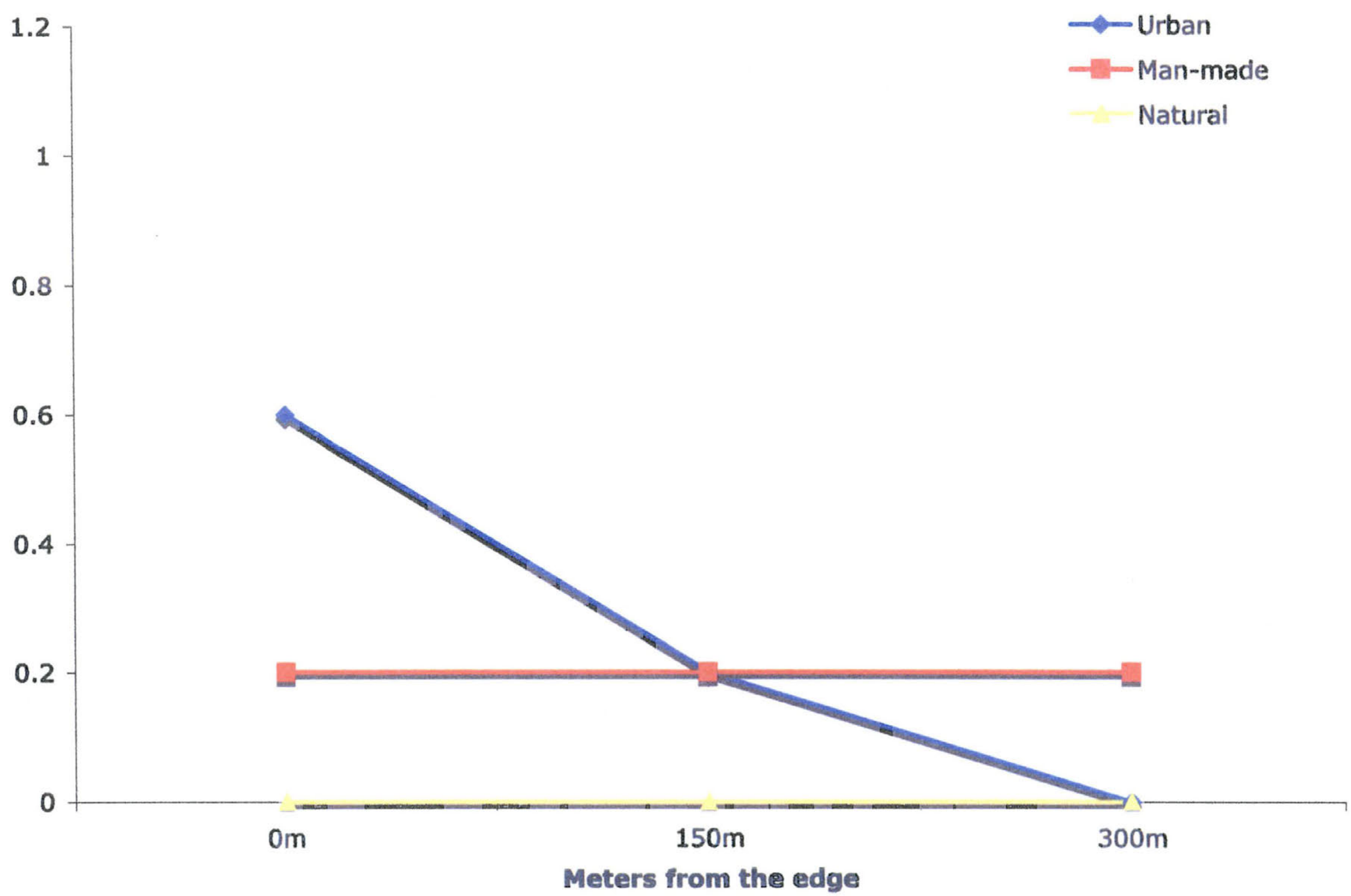

Figure 3. The proportion of feral/domestic cats detected along three gradients (urban, man-made, and natural) on the Balcones Canyonlands Preserve in Austin, Texas during March – August 2005.

at 150 m into the BCP with 0 detections at 300 m. Within the man-made and natural edge, the proportion of feral/domestic cat detections remained the same. The natural edge had the lowest detection (0 in 2004 and 2005), and detections at the utility edge were similar (0 in 2004 and 0.2 in 2005). There was no significant difference in the detections of cats between the 3 different edges ($\chi^2 = 2.0$, df = 2, $P_{cat} = 0.3679$). Also, there was no significant difference in the proportion of cats detected along the urban gradient ($\chi^2 = 2.0$, df = 2, $P_{cat} = 0.36$).

In 2004 ringtails were not detected at the urban or natural edge. They were, however, detected at the man-made edge on one occasion. Ringtails were detected at 150 m along the urban and natural gradient once. Similarly in 2005, ringtails were detected during 2 of 5 tracking sessions at the urban edge, 1 of 5 times at the utility edge, and 0 of 5 times at the natural edge (Fig. 4). There were no significant differences in the proportion of ringtails detected at the different edges ($\chi^2 = 2.0$, df = 2, P = 0.3679). There was little to no change observed among the edges and over the 3 gradients in both the Virginia opossum and the common gray fox. During 2004, Virginia opossum was detected on 2 of the 20 days at 0 m, 1 of 20 days at 150 m, and it was not detected at 300 m of the urban edge. It was also detected 1 out of 20 days at both the man-made and natural edge. It was not detected at any other location during 2004. During 2005, along the urban gradient the opossum had a proportion of detection of 0.4 at both 0 and 150 m. At 300 m it was only detected 1 of the 5 trapping sessions. The opossum was not detected at the edge; however, it was detected 1 out of the 5 tracking sessions at both 150 m and 300 m along the man-made edge. Along the natural gradient, the opossum was only detected 1 out of 5 at 300 m.

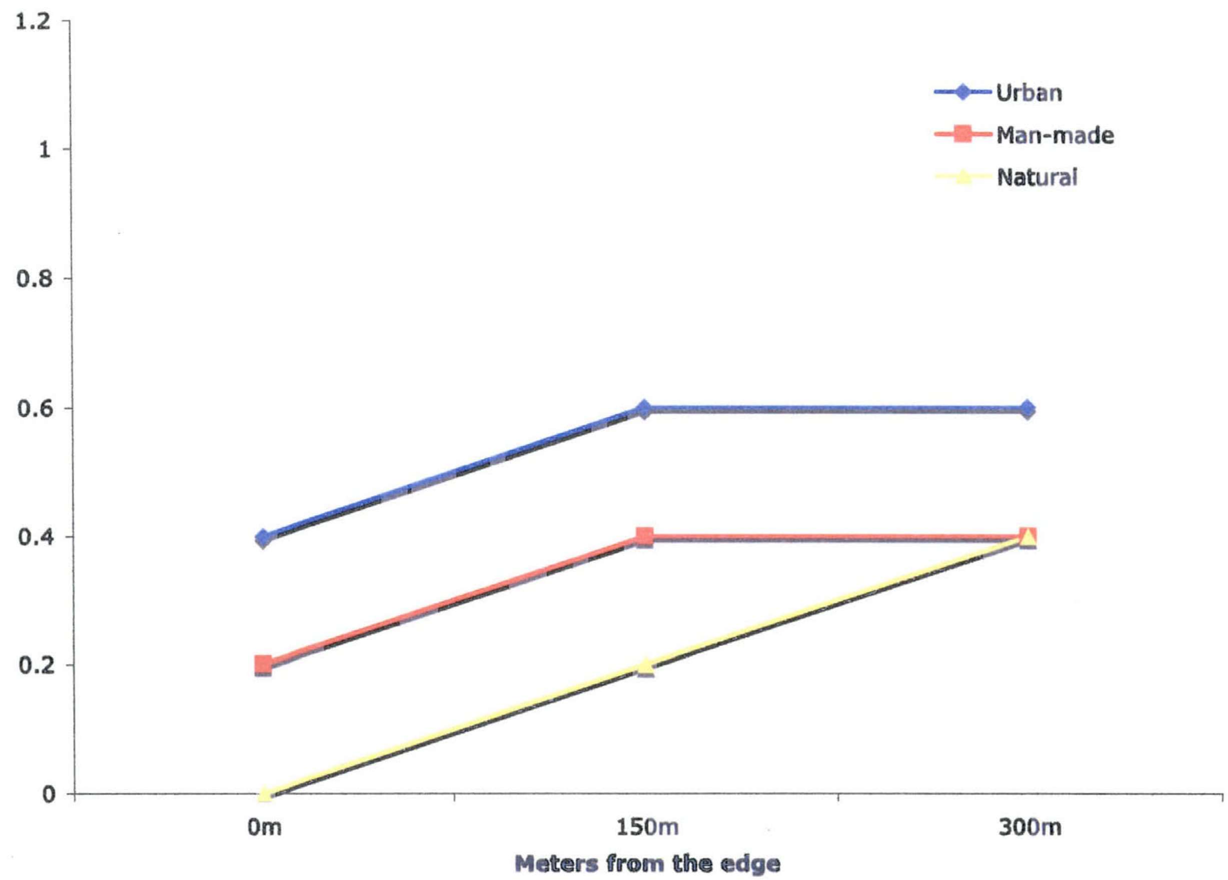

Figure 4. The proportion of ringtails detected along three gradients (urban, man-made, and natural) on the Balcones Canyonlands Preserve in Austin, Texas during March – August 2005.

Like the opossum, there were not any distinct patterns observed in the detections for gray foxes. During 2004, the gray fox was only detected at 150 m along the natural edge; it was detected 2 out of the 20 tracking days. In 2005, the gray fox was detected only 1 out of the five tracking sessions at 150 m along the man-made gradient. It was also detected 1 out of the 5 tracking sessions at 150 m and 300 m along the natural edge.

Though there were no significant differences between the 3 edges for the 5 mammals, there was a difference in the number of days required for detecting the first species ($\chi^2 = 10.70$, df = 2, P = 0.004). The average number of days for detection of the first species at the urban edge was 2.4 (SE = 0.40) and 9.2 ($SE_{man\text{-}made} = 0.48$, $SE_{natural} = 0.80$) days at both the man-made and natural edge. The average number of days until the first detection increased along the urban gradient from 2.4 days at the edge to 4.8 (SE = 1.01) days at 150 m to 7.2 (SE = 1.20) days at 300 m ($\chi^2 = 8.17$, df = 2, P = 0.01). However, along the man-made and natural edge gradients, there were no differences in the number of days until detection ($\chi^2_{man\text{-}made} = 2.43$, df = 2, $P_{man\text{-}made} = 0.29$; $\chi^2 = 1.08$, df = 2, $P_{natural} = 0.58$). In 2004, the days until detection resembled the results of 2005 along the urban edge. At the urban edge a detection occurred on the 2nd day as well as every day following. Along this gradient, the days until the first detection decreased as distance from the edge increased. At 150 m the first day of detection occurred on the 6th day and at 300 m mammal activity did not happen until the 18th day. However, there was little pattern seen along the man-made and natural gradient; detection was sporadic and less predictable during 2004. A mammal was first detected at the edge of the meadow on day 18, day 4 at 150 m, and none detected at 300 m . Likewise, at the man-made edge detection did not occur until the 16th day at the edge, none at 150 m, and 1 detection occurred on the 14^{th} day at 300 m. The patterns between 2004 and 2005 were comparable in that the urban gradient during both seasons illustrated a distinct pattern; whereas, the man-made and natural gradients did not show an obvious pattern.

Avian Parasites and Predators

Six avian species were observed: Brown-headed Cowbird, Blue Jay, Western Scrub Jay, Great-tailed Grackle (*Quiscalus mexicanus*), American Crow, and Common Grackle. When graphing the proportion of observations of avian species, I saw no obvious trends or differences among the American Crow or Great-tailed Grackle. There was a slight difference in the proportion of Western Scrub Jays detected at the urban edge (Fig. 5) but no significant difference in number of observations between edges ($\chi^2 = 3.16$, df = 2, $P_{edges} = 0.20$). From 2004 to 2005, there was a slight decrease in the proportion of Western Scrub Jays detected along the urban gradient; furthermore, there was no significant difference in point counts along the urban gradient ($\chi^2 = 3.60$, df = 2, P = 0.16). Data for the man-made and natural gradients showed no obvious trends ($\chi^2_{man\text{-}made} = 1.3$, df = 2 $P_{man\text{-}made} = 0.52$; $\chi^2_{natural} = 0.25$, df = 2, $P_{natural} = 0.88$).

During both 2004 and 2005, there were a greater proportion of Brown-headed Cowbirds detections at the utility and urban edges. There was 1 Brown-headed Cowbird detection at the meadow's edge in 18 visits in 2004 and no detections in 2005. No Brown-headed Cowbirds were detected at the 150 m and 300 m stations; all detections were at points on the edge (Fig. 6). There was no significant differences in the proportion of Brown-headed Cowbirds detections between the 3 edges ($\chi^2 = 2.27$, df = 2, P = 0.31); however, detections along the urban gradient were very close to significant ($\chi^2 = 4.8$, df = 2, P = 0.09). On the other hand, no significant results existed along the man-made and natural gradients ($\chi^2_{man\text{-}made} = 2.0$, df = 2, $P_{man\text{-}made} = 0.36$; $\chi^2_{natural} = 2.0$, df = 2, $P_{natural} = 0.36$).

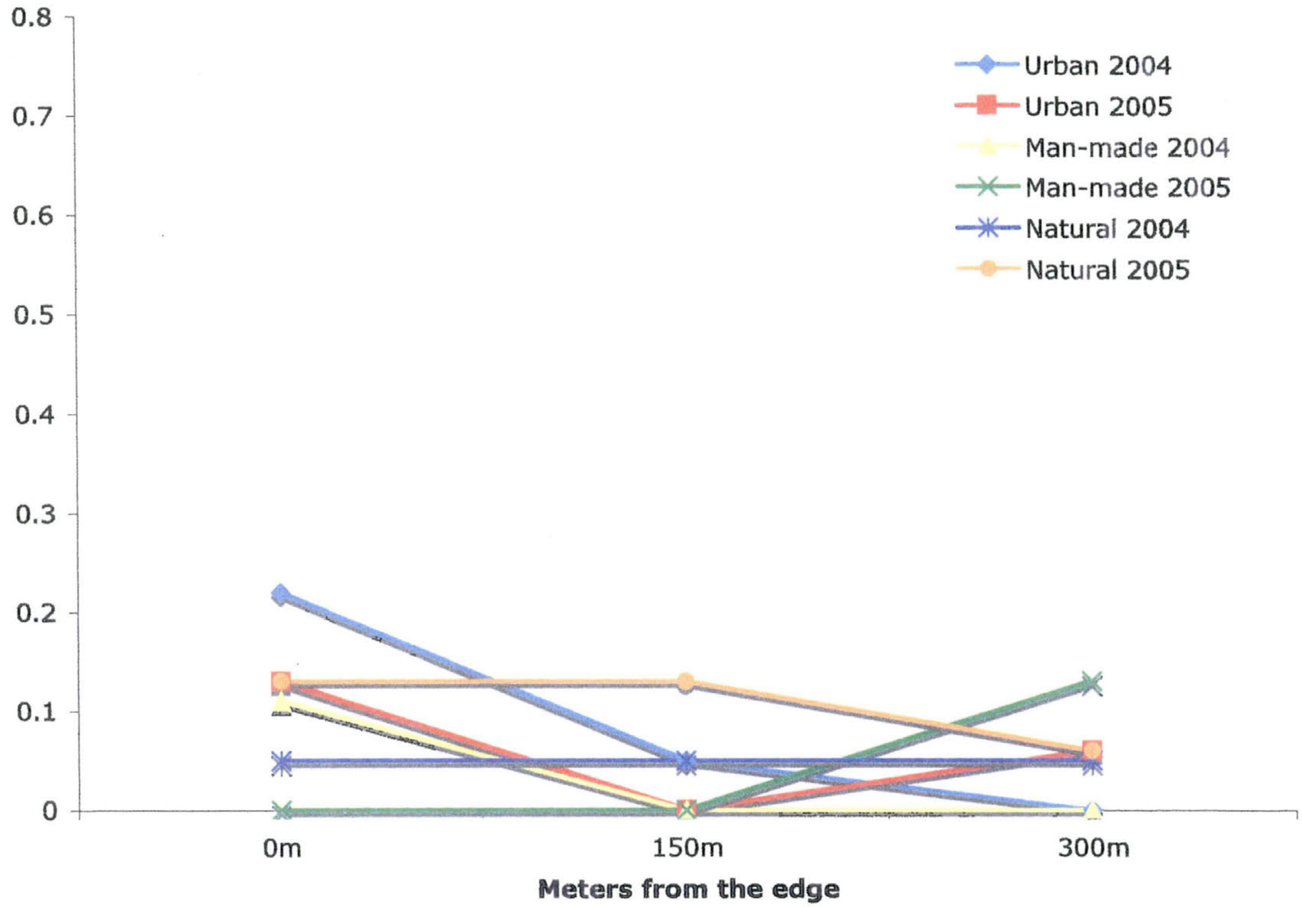

Figure 5. The proportion of Western Scrub Jays detected along three gradients (urban, man-made, and natural) on the Balcones Canyonlands Preserve in Austin, Texas during March – August 2004 and 2005.

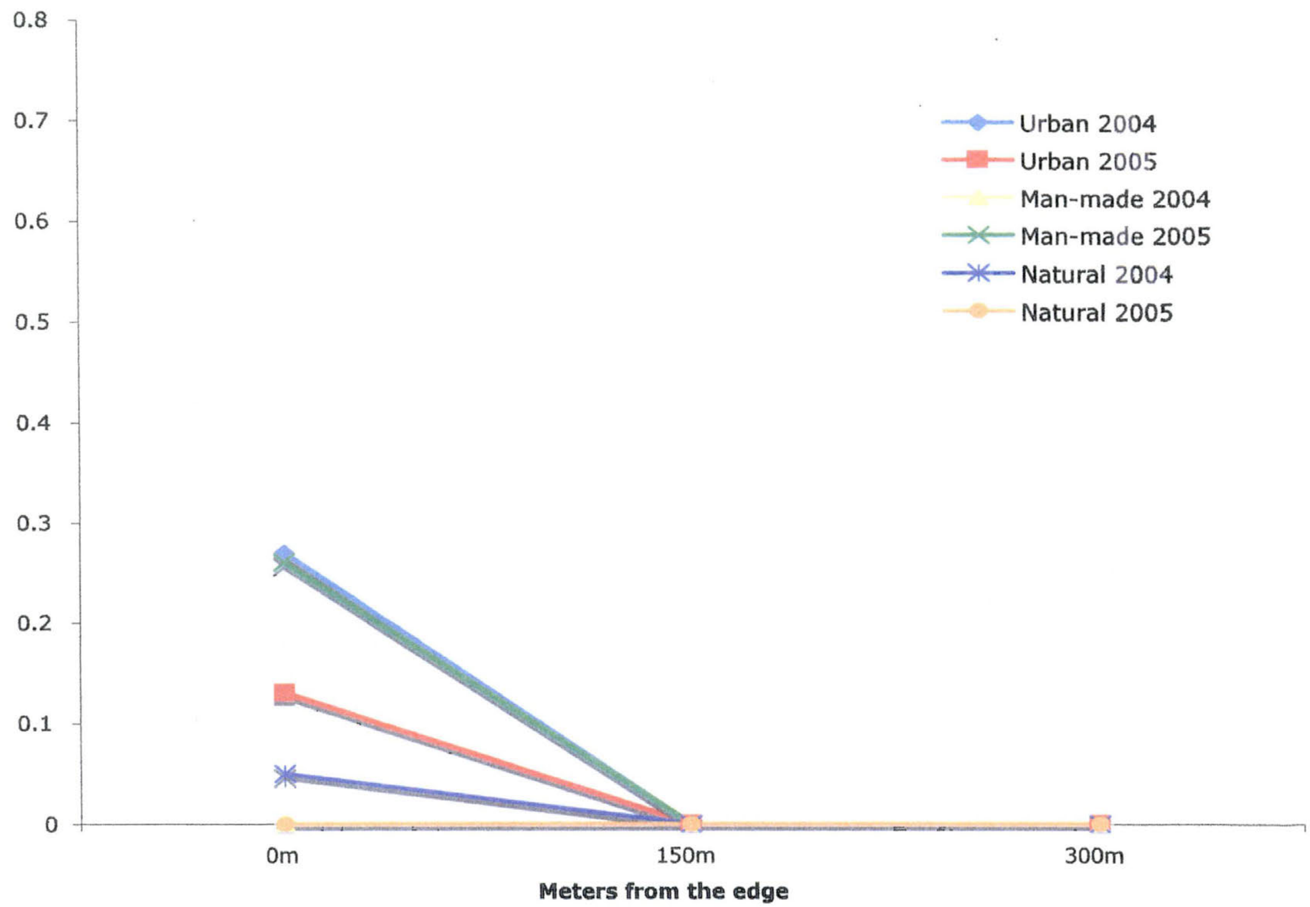

Figure 6. The proportion of Brown-headed Cowbirds detected along three gradients (urban, man-made, and natural) on the Balcones Canyonlands Preserve in Austin, Texas during March – August 2004 – 2005.

There was little fluctuation in detections of Blue Jays between edges and between points, with the exception of the urban edge during 2005. Along all 3 edges the proportion of detections ranged from 0-0.11; however, in 2005 the urban edge proportion increased to 0.4 (Fig. 7). Despite the increase in detections, a Kruskal-Wallis ANOVA indicated no significant difference between the 3 edges ($\chi^2 = 1.59$, df = 2, P = 0.451). Furthermore, the incidence of Blue Jays along all 3 gradients was insignificant ($\chi^2_{urban} = 2.9$, df = 2, $P_{urban} = 0.23$; $\chi^2_{man-made} = 2.0$, df = 2, $P_{man-made} = 0.36$, $\chi^2_{natural} = 1.25$, df = 2, $P_{natural} = 0.53$).

Lastly, I observed Common Grackles more frequently during 2004 and 2005 at the urban edge than any of the other edges (0.61, 0.46). Detections at the utility and natural edges ranged from 0-0.27 (Fig. 8). The differences between the 3 edges were almost significant ($\chi^2 = 3.42$, df = 2, P = 0.18). With a larger sample size, there could have possibly been significant differences. The proportion of detections declined from the edge (0 m) to points 300 m into the preserve along all edge gradients. The greatest declines occurred during both 2004 and 2005 from 0 m (0.61, 0.46) to 300 m (0.11, 0) along the urban gradient. Even though there appeared to be a widespread difference in detections, the results remained insignificant ($\chi^2 = 3.71$, df = 2, P = 0.15). The decline along the natural gradient was more gradual; however results were similar and almost significant values ($\chi^2 = 4.70$, df = 2, P = 0.09). Furthermore, detections of common Grackles along the man-made gradient were sporadic ($\chi^2 = 0.32$, df = 2, P = 0.85).

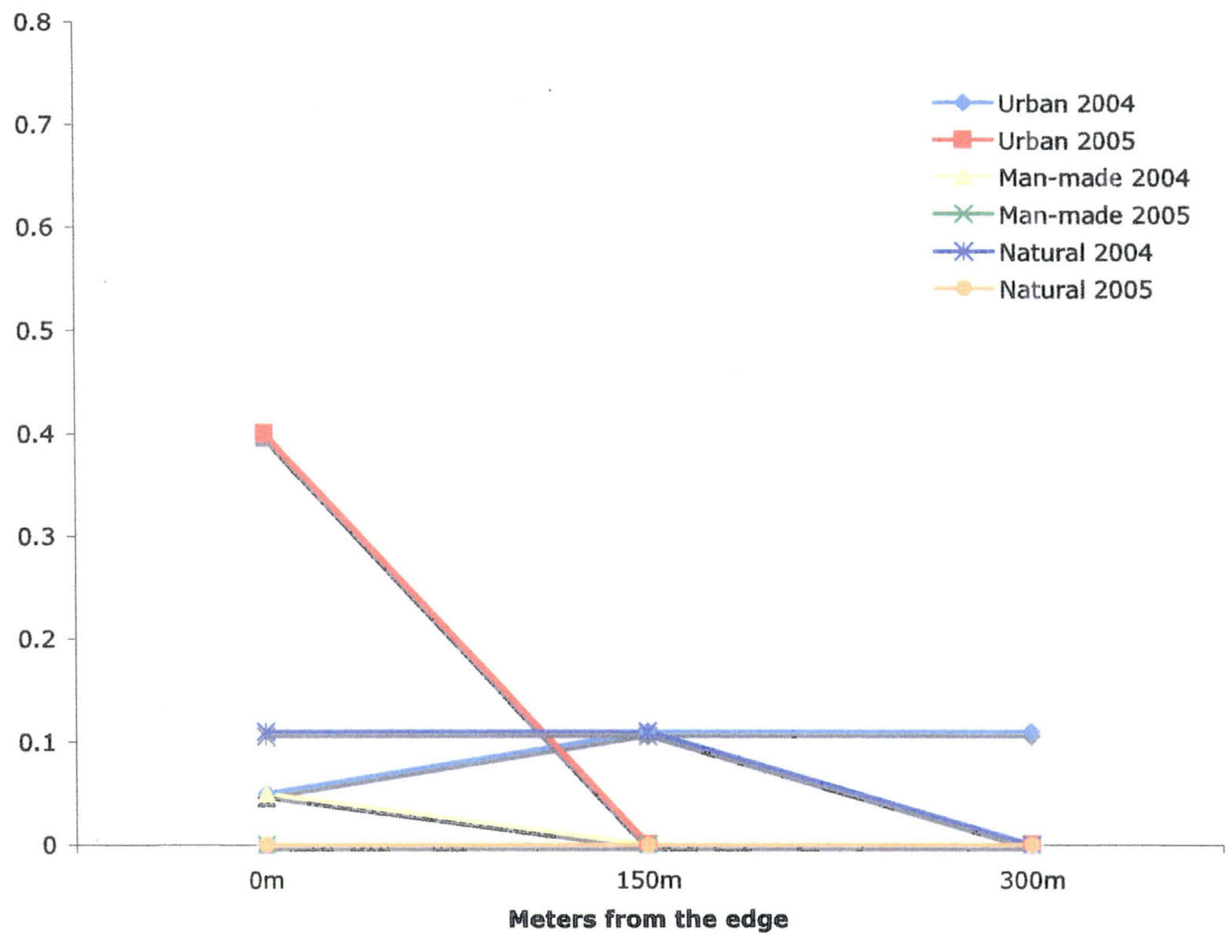

Figure 7. The proportion of Blue Jays detected along three gradients (urban, man-made, and natural) on the Balcones Canyonlands Preserve in Austin, Texas during March – August 2004 and 2005.

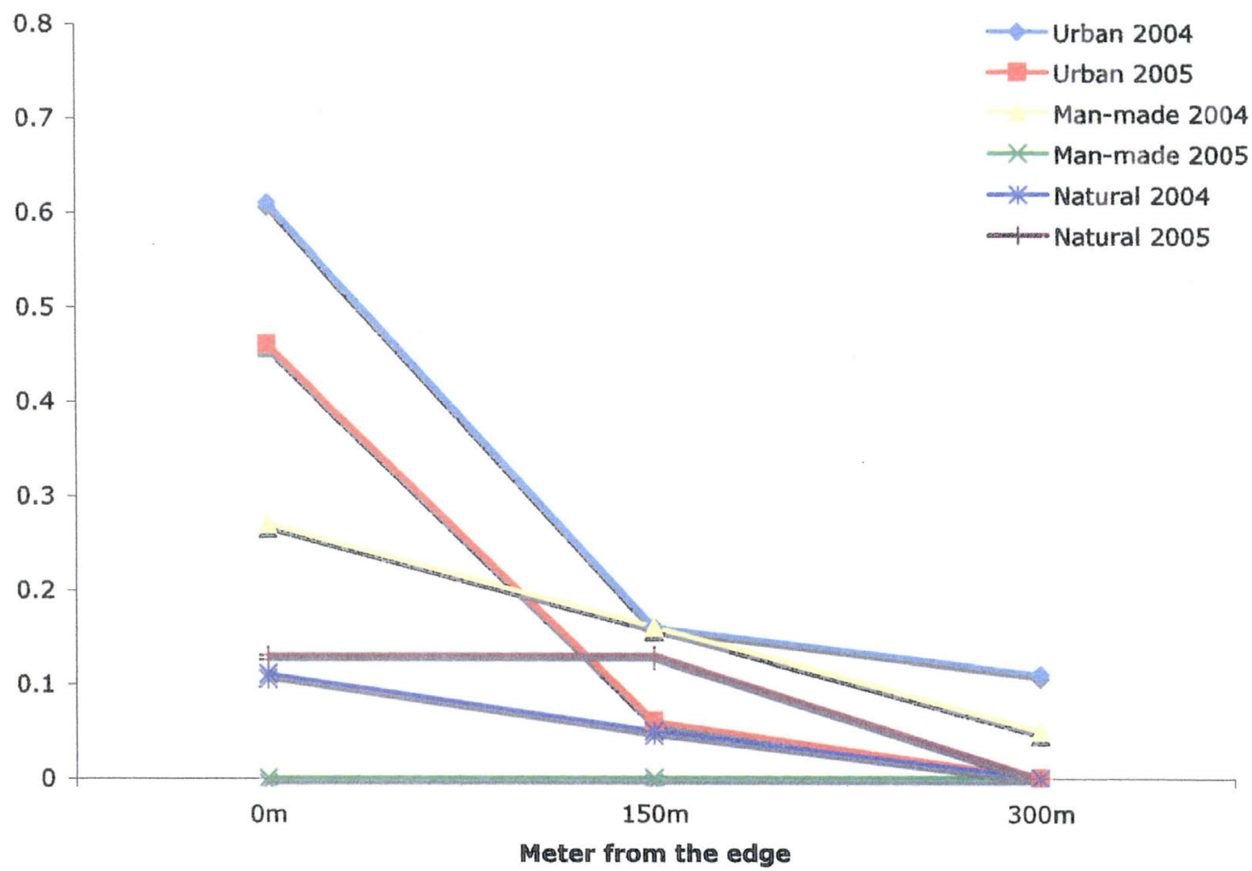

Figure 8. The proportion of Common Grackles detected along three gradients (urban, man-made, and natural) on the Balcones Canyonlands Preserve in Austin, Texas during March – August 2004 and 2005.

Reptilian Predators

No potential reptilian predators were detected along transects during either season. There were, however, incidental sightings made by other researchers that were recorded, as well as, off transect sightings. Cindy Sperry detected a Central Texas Whipsnake (*Masticophis taeniatus girardi)* on 14 April 2004. It was seen on utility transect three, 300 m into the preserve. On 15 May 2005, I detected a blotched water (*Nerodia erythrogaster transversa)* snake along a creek approximately 80 m into the preserve and 25 m off the urban transect.

CHAPTER 5

DISCUSSION

The results of my study showed no significant difference in the proportion of individual mammalian predators detected at different edges. This is not congruent with studies in the literature, which suggest a greater diversity and concentration of predators at urban or man-made edges in small woodlots (Wilcove 1985, Dijak and Thompson 2000). Common raccoons and feral/domestic cats had clear patterns among and between edges. Common raccoons were more frequently detected along the urban edge with detections everyday. At the man-made and natural edges, common raccoons were usually detected near the 8^{th} or 10^{th} day. Furthermore, only along the urban gradient was there a decrease in the proportion of detections at the edge (0 m) compared to 300 m, suggesting this species is more active at the urban edge as opposed to the forest interior. Also, there was no evidence of a decreasing rate of detection along either the natural or man-made gradient. Random detections that occurred in and along the man-made and natural gradients suggest common raccoons were just passing through or traveling to areas with food availability. I found a greater activity of common raccoons at the urban edge. Perhaps as a result of food resources, water sources, and the availability of artificial dens, common raccoon activities were greater near forest edge, agricultural areas, and areas near riparian habitats (Dijak and Thompson 2000, Prange et al. 2003). As a general rule, nest predation by medium-sized carnivores increases as proximity to the edge increases (Winter et al. 2000).

There was a greater detection rate of feral/domestic cats and dogs at the urban edge. Occasionally, evidence of residents' pets was seen and found on the BCP edge. For example, a domestic house cat with a collar and bell followed me about 50 m into the BCP and climbed into trees. On other occasions, dog collars were found. Lastly, a dog chased me into the BCP. Similar examples of house pets on the preserve were seen by another researcher using these same sites (Cindy Sperry personal communication). Domestic pets are getting into and using the preserve. Surveys in Wisconsin showed cat ownership has increased from approximately 30 million owners in 1970 to 60 million in 1990 (Coleman and Temple 1993).

The diet of feral cats is made up of about 70% small mammals and 20% birds (Coleman and Temple 1993). Free-ranging domestic cats, despite being fed by their owners, continue to capture prey (Coleman and Temple 1993). Cats were estimated to kill between 7.8 and 217 million birds a year in Wisconsin (Marzluff and Ewing 2001). On islands, the introduction of competitors (domestic cats) extirpated bird populations (Marzluff and Ewing 2001). In my study, points along man-made edges had a consistent proportion of detections (0.2). Though not directly located by neighborhoods, they were in close proximity, providing evidence for the small number of cats detected within this area. Three of the man-made gradient transects were more isolated from residential areas. These 3 transects had no detections of cats. I detected no cats at natural meadows farthest from housing developments. Neighborhood cats are trespassing onto the preserve. Though there may not be an abundance of cats, any activity can have an adverse effect on songbird populations sensitive to predation.

The 3 most important potential avian predators in my study were the Western Scrub Jay, Brown-headed Cowbird, and Common Grackle. These avian predators have been identified in studies on songbird predation (Wilcove 1985, Engels and Sexton 1994, Saracco and Collazo 1999, and Damude undated). Leila Gass observed a Western Scrub Jay carry a Brown-headed Cowbird and Golden-cheeked Warbler nestlings to the ground and consume them (Gass 1996). The Western Scrub Jay removed and replaced an egg that had not hatched in the nest. Later a Western Scrub Jay returned and consumed the remaining egg (Gass 1996). The detections of the Western Scrub Jay decreased slightly along the urban gradient. At the urban edge, Scrub Jays were typically seen on wooden and wire fences. Engels and Sexton (1994) noted Western Scrub Jays lack a negative correlation with the Golden-cheeked Warblers. This corvid that is historically a part of the Golden-cheeked Warbler's range probably has an impact on this songbird near urban areas in Austin. Western Scrub Jays were not as abundant as Blue Jays; however, they are typically present in urban areas of Austin and possibly have some effect on Golden-cheeked Warbler fitness (Engels and Sexton 1994).

Common Grackles are considered an avian predator. Saracco and Collazo (1999) identified bill imprints on clay egg and suggested both Common Grackles and Blue Jays were nest predators. Common Grackles are more common along forest edges rather than forest interiors (Wilcove 1985). Smaller woodlots in close proximity to urban areas also have large numbers of Common Grackles (Wilcove 1985). My results indicated urban and natural gradients had larger but non-significant numbers of Common Grackles. Potentially with a larger sample size these findings would have proven to be significant.

The Brown-headed Cowbird, a brood parasite, has increased in number because of continued fragmentation of habitat throughout the breeding grounds of many songbirds. I found an almost significant difference in detections along the urban gradient. Brown-headed Cowbird detections decreased with distance into the preserve. Engels and Sexton (1994) concluded cowbirds did not have a strong influence on habitat occupancy near urban areas. Though Engels and Sexton do not associate Brown-headed Cowbirds with urbanized areas, they are linked to small fragmented forests. Paton (1994) compiled various studies of Brown-headed Cowbird parasitism rates and found 3 of 5 studies showed parasitism declined away from edges. I did not decisively show more cowbirds in different gradients in my study. A larger sample size may have shown significant differences along the urban gradient.

I observed Brown-headed Cowbirds using power lines as a corridor. Most observations were made before or after timed point counts. It is interesting that I found no differences in detection at points along the man-made gradient. Typically cowbirds flew through and did not land on the edge. Miller et al. (1998) suggested cowbirds use open corridors as narrow as 2.5 m as routes into the interior forest to parasitize birds of the forest interior.

There were very few reptilian predators identified during my study; however, it does not mean that they did not exist. Snakes have typically been one of the primary predators in nest predation (Wilcove 1985, Paton 1994, Thompson and Burhans 2003). Snakes have been a more prevalent nest predator in field habitats as opposed to forested habitats (Thompson and Burhans 2003). In my study, snakes might have been better detected using funnel traps, night searching, or simply more intense searching under and around logs/debris.

Combining all observations and detections of mammals, birds, and snakes, I think there was clearly more activity at Jester than the other sites. Golden-cheeked Warblers do not typically nest in an urban environment; they are 40% less likely to be found in urban areas of their range (Engels and Sexton 1994). However, during the course of my study, Cindy Sperry observed GCWA family groups foraging at points on the urban edge. Therefore, having a higher concentration of potential predators at edges where GCWA forage could potentially impact recruitment in the population.

Urbanization has the greatest local effect on wildlife populations (Marzluff and Ewing 2001). It causes fragmentation in forested habitat, thus increasing the amount of edge (Blair 1996). Developing areas tend to isolate and create patchiness of undeveloped areas that contain native vegetation (Germaine et al. 1998). Isolated fragments have very high ratio of edge to forest interior (Marzluff and Ewing 2001). Not only do predation rates increase as forest size decreases, but also density and diversity of avian species decline (Friesen et al. 1995, Keyser et al. 1998, Marzluff and Ewing 2001). If subdivision of forests continues, sensitive avian species will decline and may become locally extinct (Friesen et al. 1995). Native habitats with increased edge due to fragmentation by residential areas tend to be invaded by non-native species. Non-native species (plant, mammal, and avian communities) compete with native species. Therefore, it is essential to develop innovative ways to discourage the invasion of non-native species and protect native habitat in an environment that will continue to be impacted by urban sprawl.

CHAPTER 6

CONSERVATION STRATEGIES

Urbanized land covers only about 3% of the earth (Marzluff and Ewing 2001). However, with continually increasing human population urban development will also increase. Furthermore, habitat fragmentation and human influence on habitats will not decrease. Therefore, it is essential to develop conservation strategies to maintain wildlife diversity, sensitive wildlife populations, and conserve ecologically sensitive habitat (Marzluff and Ewing 2001). With regards to GCWAs, the first step in managing fragmented land on the verge of urban sprawl is to purchase many large (preferred) or small tracts of native habitat. On reserves that have been set aside, non-native vegetation must be eliminated; thus, promoting the growth and maintenance of native vegetation (Germaine et al. 1998, Marzluff and Ewing 2001). In urban settings, enforcement of regulations limiting human use of habitat areas is essential to maintaining viable GCWA populations. Buffer zones reduce human impacts on habitats and diminish the effects of abrupt edges. Buffer areas should be fenced to minimize human activity. The development of trails for recreational use can potentially create new edges and reduce the benefits of buffers (Mazluff and Ewing 2001). Saracco and Collazo (1999) suggested buffers should extend 50 m from the boundary. My study suggests that predatory activity decreases between the edge (0 m) and 150 m into the preserve. Therefore, further studies should be performed to determine the best width for buffers on BCP land.

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