RED-TAILED HAWK (*BUTEO JAMAICENSIS*) PRESENCE ALONG ROADSIDE CORRIDORS IN RELATION TO URBAN ENVIRONMENT CHARACTERISTICS IN AUSTIN, TEXAS

THESIS

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RED-TAILED HAWK (*BUTEO JAMAICENSIS*) PRESENCE ALONG ROADSIDE CORRIDORS IN RELATION TO URBAN ENVIRONMENT CHARACTERISTICS IN AUSTIN, TEXAS

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The Red-tailed Hawk (*Buteo jamaicensis*) is a species that has shown a positive ability to adapt and populate urbanized environments in some U.S. cities while displaying a negative ability to adapt in others. The purpose of this study was to determine if Red-tailed Hawk occupancy was affected by differing characteristics of urbanization along roadway corridors in Austin, Texas.

A population of Red-tailed Hawks in Austin, TX appears to have adapted to roadway corridors and can be seen year-round. The detection and occupancy probabilities of this raptor species on different roadways were analyzed using program PRESENCE. Occupancy was modeled as constant, a function of the roadway median and a function of urbanization, while detection was modeled as constant and function of seasonality. The model selected estimated occupancy as a function of presence of a median and detection as changing among seasons. However, this model's AIC weight is not significant enough to indicate Red-tailed Hawk occupancy and detection were solely based upon these functions. Further research into differing urbanization characteristics such as traffic flow, median dynamics, vegetative components of the median, as well as prey availability and abundance might lead to a clearer understanding of occupancy and detection of Red-tailed Hawks.

CHAPTER I

INTRODUCTION

As natural habitat is lost to the increasing effects of urbanization, diversity and abundance of many avian species will be substantially impacted by a reduction in prey availability and perching, nesting, and roosting sites (Brooke and Birkhead 1991). Specialist species are the most severely affected by human disturbance, habitat alteration, habitat fragmentation, and habitat loss (Jullien and Thiollay 1996). The effects of habitat loss and expansion of urbanized landscapes on different hawk species abundance have been largely negative in urban areas in Colorado (Berry et al. 1998), Ohio (Dykstra et al. 2001), and Baja Mexico (Rodriguez-Estrella et al. 1998). However, there are conflicting results concerning the correlation between raptor abundance and urbanization in different regions of the United States. Bosakowski and Smith (1997) reported Red-tailed Hawks (*Buteo jamaicensis*) were more common within urban areas of New Jersey, but Smallwood et al. (1996) found the species avoided human settlements in Sacramento, California. For most raptor species, however, which naturally maintain large home ranges and low densities, the effects of habitat loss and alteration are compounded (Berry et al. 1998). Most raptor species are highly sensitive within areas of urbanization (Berry et al. 1998). Some raptor species, however, are becoming more adept at using urbanized areas that retain ecologically important characteristics (Bird et al. 1996) and have benefited from man-made disturbances (Olendorff 1984). In some cases a small proportion of hawk species in a given geographical area might require habitat that is more urbanized (Olendorff 1984). Swainson's Hawks (*Buteo swainsoni*), which prefers open grassland habitat, are now nesting in populated cities in Saskatchewan where they did not previously nest (James 1992). The Red-tailed Hawk appears more sensitive to the proximity of people, but displays remarkable adaptable characteristics within an urbanized landscape (Bosakowski and Smith 1997). A small population of Red-tailed Hawks even adapted over time to the disturbance of low-level flyovers by helicopters (Andersen et al. 1989).

The Red-tailed Hawk is the most common diurnal raptor in North America and is a year-round resident in the southern United States (Preston and Beane 1993, Clark and Wheeler 2001). This species is a generalist predator that prefers small mammals and rodents but is very plastic in diet eating small reptiles, amphibians, birds, and carrion (Steenhof and Kochert 1988). It also displays diet-switching behavior changing from their preferred prey, when density of preferred prey is low, to alternative prey (Steenhof and Kochert 1988). Cully (1991) reported Red-tailed Hawks numbers did not change significantly during an epizootic plague in a New Mexico Gunnison's prairie dog (*Cynomys gunnisoni*) population that was the primary food source. Grant et al. (1991) found depression of cottontail (*Sylvilagus* sp) populations, the primary prey of Red-tailed Hawks in Utah did not affect Red-tailed Hawk numbers. Red-tailed Hawks inhabit both wooded and open spaces, especially along wooded edges where perching sites are abundant (Clark and Wheeler 2001).

Forman and Alexander (1998) considered roadside ecology as an understudied field with varied functional ecological roles as a conduit, barrier (filter), habitat, source, and sink in the environment. Factors affecting these roles are corridor width, connectivity, and usage intensity or degree of traffic flow along these corridors (Forman and Alexander 1998). These corridors also create an edge effect because of the fragmentation of land around them (Forman and Alexander 1998). Very little research has addressed the effects of roadside ecology and differing degrees of urbanization on diurnal raptor abundance (Forman and Alexander 1998). There are currently populations of Red-tailed Hawks along roadway corridors in Austin, Texas in areas consisting of urbanized environments. The objectives of my research were to determine whether the number of artificial perching sites, presence or absence of a roadway median, vegetative characteristics of the median, as well as the degree of urbanization surrounding these roadways affect Red-tailed Hawk presence along roadway corridors.

CHAPTER II

MATERIALS AND METHODS

STUDY AREA

My study occurred along roadways within the City of Austin, Texas encompassing Travis, Blanco, and Williamson counties. Austin is located on the border of the Texas Hill Country along the Balcones Fault Escarpment. The lengths and number of point count sites associated with roadway corridors were Mopac Expressway (39.43 km), Capital of Texas Highway 360 (20.12 km), Highway 620 (28.81 km), Southwest Parkway (10.94 km), Interregional Highway 35 (8.37 km), and Hamilton Pool Road (34.44 km). Six different roadway corridors and 32-point count sites were within the study area (Fig. 1).

DATA ACQUISITION

Data for hawk presence were acquired for one year, from May 2007 to April 2008, through point counts along the six roadway corridors. The corridors of interest were chosen because of the number of sightings of Red-tailed Hawks observed in reconnaissance of the region and their parallel distribution that would reduce the opportunity for double counting.

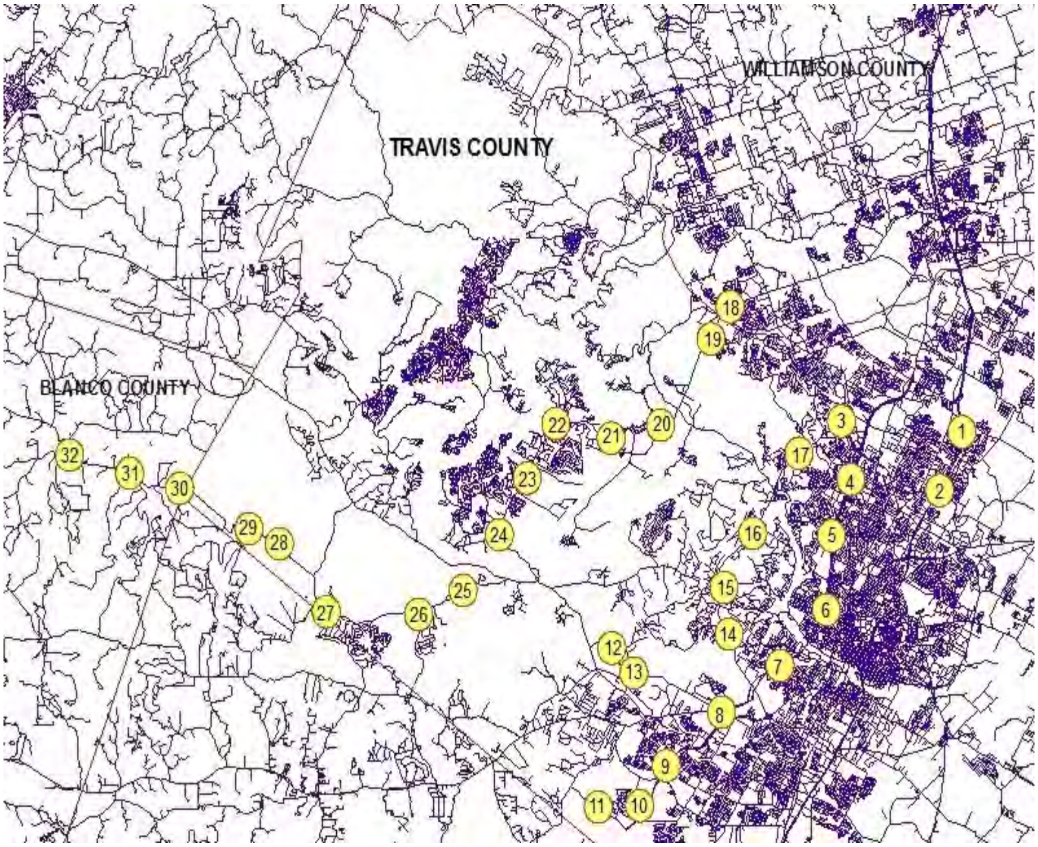

Figure 1. Map of roadways and sample sites within Travis, Blanco, and Williamson counties, Texas. The roadways and sample sites are indicated as: IHN 35 (sites 1-2), Mopac Expwy (sites 3-11), Southwest Pkwy (sites 12-13), Capital of Texas Hgwy 360 (sites 14-17), Hgwy 620 (sites 18-24), and Hamilton Pool Rd (sites 25-32). Darker blue areas are considered impervious or urbanized and red lines indicate county borders.

A rural corridor (Hamilton Pool Road) was chosen to represent a low degree of urbanization and another (IHN 35) was chosen to represent a high degree of urbanization. The other corridors represent an array of different levels of urbanization and perceived hawk presence. The length of each corridor was determined using an odometer and separated into 2-km segments. In circumstances where an intersection between corridors occurred, a 1-km length of corridor extending in all directions from the intersection was excluded from the total length of the corridor and not used in analyses. This 1-km buffer in each direction reduced the probability of double counting and ensured urbanization characteristics did not overlap for each point count.

I used statistical software (‘R’ 2.3.1) to randomize point counts and produce the random order for each sampling session. This random order, eight sites per day for four days was followed for two consecutive sessions (one month) and then a new random order was used for the next two sessions. Each sampling site session consisted of a 5-min point. Red-tailed Hawk presence was verified by observing a hawk either perching or flying along the roadway. All sampling occurred in the morning, beginning within 1h after sunrise and continued until all eight sampling sites were visited, usually by 11:00 am. This time period was selected because reconnaissance showed increased visibility in the morning due to perching by hawks.

Red-tailed Hawks have been observed perching and hunting from utility poles (Clark and Wheeler 2001) and were observed utilizing artificial perch sites during morning point counts. The numbers of artificial perching sites (telephone poles, light poles, signs) located directly on either side of the roadway and on the median were analyzed as a possible attractant to sample sites affecting Red-tailed Hawk occupancy. Artificial perch sites were counted for 1 km in both directions from each sampling site. Two observers, driver and passenger, counted artificial perch sites with the passenger counting the right side and median while the driver counted the left side of the road. The route was then driven in reverse with each individual counting the side(s) not counted on the first pass. The mean of the two different counts was then calculated to determine the number of artificial perch sites for each sample site. Perch site totals were placed into categories (0-50, 51-100, 101-150, 151-200, 201-250, and >250) to reduce the effect of observer bias and reflect a varying range of artificial perch sites along survey routes.

During a few morning point counts Red-tailed Hawks were observed hunting successfully along medians of the roadway corridors. Although the type of prey could not be identified, it was apparent that prey was present on these roadway medians. Presence of a roadway median was analyzed to determine affects on Red-tailed Hawk occupancy. Median presence was categorized as binary values as present (1) or absent (0) regardless of size. I also observed that not all the roadway medians contained the same vegetative characteristics. To determine if different vegetative characteristics affected Red-tailed Hawk occupancy, I generally characterized and recorded each median’s vegetation as containing only grass (1), containing grass and trees (2), containing only trees (3), and no vegetation due to no median (0).

The studies mentioned in the introduction discuss the differing effects of urbanization in relation to raptor abundance across the United States. There has not been a study in Texas that examines the effects of differing degrees of urbanization on Red-tailed Hawk occupancy. To determine if a range existed within varying degrees of urbanization that were affecting Red-tailed Hawk occupancy either negatively or positively, the degree of urbanization surrounding each sampling site was determined by ArcGIS 9.2 (ESRI, Redlands, CA). Data concerning the degree of urbanization or degree to which a surface is impervious were acquired through the National Map Seamless Server at the U. S. Geological Survey website (http://seamless.usgs.gov/) via the impervious surface layer. Impervious surfaces were considered as roads, buildings, housing, and parking lots or an unnatural surface (http://seamless.usgs.gov/). Latitude and longitude coordinates of each sample site were entered into the impervious layer and a 1.0-km buffer was placed around each site. Each buffer was converted to a series of polygons to assess area. A polygon was considered impervious if it received a value of $\geq$13. I selected a value of $\geq$13 by comparing the impervious surface imagery with satellite imagery of canopy coverage (http://seamless.usgs.gov/), ground proofing each site, and becoming knowledgeable of the area of interest. The percentage of urbanization was determined by dividing the area of a polygon containing the value $\geq$13 by the total area of the polygon. Ranges in degrees of urbanization were assessed to reflect little ($\leq$10%), low (11-30%), medium-low (31-50%), medium-high (51-70%), high (71-90%), and very high ($\geq$90%).

STATISTICAL ANALYSIS

Statistical software (‘R’ 2.3.1.) was used to assess differences in artificial perch site counts between observers via paired *t*-tests and perch site preference via *t*-test. Pearson’s correlation coefficient was utilized to determine strength of relationships among urbanization characteristics (www.r-project.org). Point count data were analyzed using Program PRESENCE to determine occupancy of Red-tailed Hawks at each sample site. Urbanization characteristics resulting in a strong positive relationship ($r > 0.60$) by Pearson’s correlation coefficient were not analyzed due to similar modeling results via the Akaike Information Criteria (AIC). Urbanization characteristics displaying weaker relationships ($r \leq 60$) were assessed using the AIC to determine if Red-tailed Hawk occupancy along roadway corridors was affected by different characteristics of urbanization. Skirvin (1981) indicated detection of breeding birds may vary due to seasonal changes, and Preston and Beane (1993) reported that many northern breeding Red-tailed Hawks migrate south seeking warmer climates. Therefore, I analyzed single and multiple season models to assess if differences in occupancy probabilities (ψ) existed throughout a season or if they fluctuated seasonally. During assessment of multiple season models colonization (γ) and extinction (ε) probabilities were held constant (.) to eliminate the effects immigration and emigration might have on Red-tailed Hawk occupancy. Detection probabilities (p) for single and multiple season models were either held constant (.), assuming detection was equivalent for all sites through out the season or detection was a function of seasonality (seasonal).

Models were chosen based upon their AIC weight in comparison with other models. Results were considered significant at $P = 0.05$.

CHAPTER III

RESULTS

A total of 768 point counts were conducted in which 60 detections of Red-tailed Hawks were made by the observer. Of the 60 observations, 58 were recorded as perching and only two as flying. Of the 58 total perching observations, 56 were perching on artificial sites and two were perching on natural sites. T-test results assessing artificial and natural perching sites indicate differences in perch site preference ($t = 27.74$, $p < 2.2e\text{-}16$).

Results of the paired *t*-test indicated some, but not significant, observer bias in perch site counts ($t = 1.554$, $p = 0.06516$, Table 1). The small observer bias could be accounted for from the driver not being able to give complete attention to counting perches while maintaining focus on traffic conditions. Sample site #1 contained the most artificial perching sites ($\bar{X} = 250.5$, SE = 5.5) and sample site #12 contained the fewest artificial perching sites ($\bar{X} = 0$, SE = 0.0) (Table 1). Roadway corridor IHN-35 contained the highest number of artificial perching sites ($\bar{X} = 179$, SE = 71.5) and Southwest Parkway contained the fewest number of artificial perching sites ($\bar{X} = 15$, SE = 15.0).

Table 1. Total sum of artificial perching sites on roadway corridors in Austin, Texas. Assessed by two observers (A, B) per sample site, and mean number of artificial perches at each site.

Sample Site	Roadway	Observer A	Observer B	Mean
1	IHN-35	256	245	250.5
2	IHN-35	110	105	107.5
3	MOPAC	146	130	138
4	MOPAC	141	153	147
5	MOPAC	204	188	196
6	MOPAC	178	178	178
7	MOPAC	166	137	151.5
8	MOPAC	156	126	141
9	MOPAC	66	64	65
10	MOPAC	5	23	14
11	MOPAC	7	27	17
12	SW PKWY	0	0	0
13	SW PKWY	32	28	30
14	COT 360	96	92	94
15	COT 360	32	37	34.5
16	COT 360	56	51	53.5
17	COT 360	82	52	67
18	HGWY 620	105	109	107
19	HGWY 620	89	78	83.5
20	HGWY 620	65	61	63
21	HGWY 620	51	55	53
22	HGWY 620	72	80	76
23	HGWY 620	81	86	83.5
24	HGWY 620	75	82	78.5
25	HAM POOL	35	28	31.5
26	HAM POOL	16	16	16
27	HAM POOL	19	19	19
28	HAM POOL	27	26	26.5
29	HAM POOL	11	10	10.5
30	HAM POOL	20	13	16.5
31	HAM POOL	24	23	23.5
32	HAM POOL	17	16	16.5

The Pearson's product-moment correlation indicated relatively strong relationships between median presence and vegetation ($r = 0.721$, $P < 0.001$) as well as degree of urbanization and perching sites ($r = 0.746$, $P < 0.001$). Correlations were weak and not significant for degree of urbanization and vegetation ($r = 0.189$, $P = 0.1506$) as well as perching sites and vegetation ($r = 0.136$, $P = 0.230$). Correlations between presence of a median and perching sites ($r = 0.405$, $P = 0.0107$) and presence of a median and degree of urbanization ($r = 0.391$, $P = 0.013$) were also significant and moderately correlated. Based on the strong correlation between median presence and vegetation only one of these characteristics was analyzed using the AIC. Presence of a median is the primary characteristic by which there would be no vegetation and hence the one chosen. Conclusions were similarly drawn indicating the degree of urbanization to be the primary characteristic by assuming a more urbanized area would contain more artificial perching sites. Occupancy models were examined for each sample site as a function of median presence and / or degree of urbanization (Table 2).

The model containing occupancy as a function of median presence and detection probability as a function of seasonality resulted in the best fit among all 15 models (Table 3). The single season model that assessed occupancy as a function of both median presence and degree of urbanization and detection probability as a function of seasonality produced unreliable data and was disregarded from model assessments.

Table 2. Median presence (Y = yes, N = no), degree of urbanization (%), and vegetation type found on median (Grass, Trees, Mix-grass and trees, NA-not applicable) at sample sites on roadways in Travis, Blanco, and Williamson counties.

Sample Site	Median Presence	Degree of Urbanization	Median Vegetation
1	Y	74.47%	GRASS
2	Y	38.46%	GRASS
3	Y	70.22%	GRASS
4	Y	79.70%	GRASS
5	Y	54.31%	MIX
6	Y	39.44%	GRASS
7	Y	45.34%	GRASS
8	Y	54.29%	GRASS
9	Y	54.09%	MIX
10	Y	24.72%	MIX
11	Y	9.78%	TREES
12	Y	5.01%	TREES
13	Y	11.18%	GRASS
14	Y	35.13%	GRASS
15	Y	13.82%	GRASS
16	Y	39.26%	GRASS
17	Y	19.76%	GRASS
18	N	72.63%	NA
19	N	35.03%	NA
20	N	5.69%	NA
21	N	17.46%	NA
22	N	24.12%	NA
23	N	21.30%	NA
24	N	27.39%	NA
25	N	27.25%	NA
26	N	0.22%	NA
27	N	4.16%	NA
28	N	0.33%	NA
29	N	0.37%	NA
30	N	0.73%	NA
31	N	0.20%	NA
32	N	0.31%	NA

Table 3. Akaike Information Criteria (AIC), AIC weights (w) and number of parameters (K) of PRESENCE models analyzing Red-tailed Hawk occupancy (ψ) and detection probability (p) along roadway corridors in Austin, Texas as functions of median presence (median), degree of urbanization (urban), both (median-urban), or a constant (.). Colonization (γ) and extinction (ε) probabilities were held constant in multiple season models. Bold indicates model chosen.

Model	AIC	w	K
ψ(median), p(seasonal)	***410.95***	***0.41***	***6***
ψ(.), p(seasonal)	413.93	0.09	5
ψ(.), γ(.), ε(.), p(.)	414.06	0.09	4
ψ(.), γ(.), ε(.), p(seasonal)	414.85	0.07	7
ψ(urban), p(seasonal)	414.85	0.06	6
ψ(median), p(.)	415.20	0.05	3
ψ(median-urban), p(.)	415.29	0.05	3
ψ(urban), γ(.), ε(.), p(.)	415.36	0.05	5
ψ(median), γ(.), ε(.), p(.)	415.72	0.04	5
ψ(urban), γ(.), ε(.), p(seasonal)	415.86	0.04	8
ψ(median), γ(.), ε(.), p(seasonal)	416.27	0.03	8
ψ(median-urban), γ(.), ε(.), p(.)	416.90	0.02	5
ψ(median-urban), γ(.), ε(.), p(seasonal)	417.07	0.02	8
ψ(urban), p(.)	419.10	0.01	3
ψ(.),p(.)	469.94	0.00	2

Figure 2 displays 95% confidence intervals for estimates of occupancy as a function of median presence ($\psi = 0.96$, SE = 0.09) and median absence ($\psi = 0.58$, SE = 0.1408). Sites 1-17 contained a median and sites 18-32 did not contain a median. Figure 3 displays 95% confidence intervals for detection probabilities for season 1 (May-Jul, $p = 0.8$, SE = 0.2), season 2 (Aug-Oct, $p = 0.16$, SE = 0.03), season 3 (Nov-Jan, $p = 0.11$, SE = 0.03), and season 4 (Feb-Apr, $p = 0.05$, SE = 0.02).

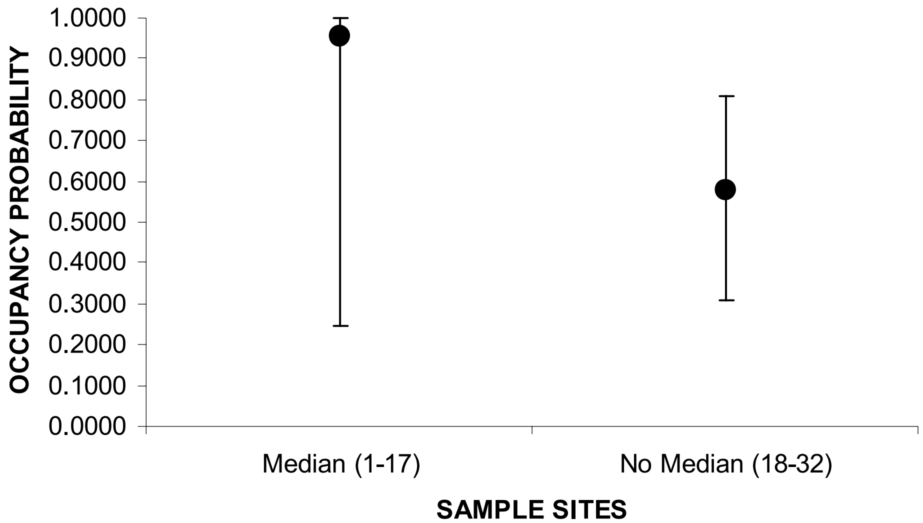

Figure 2. Occupancy probability of Red-tailed Hawks as a function of median presence and their 95% confidence intervals along roadway corridors in Austin, Texas.

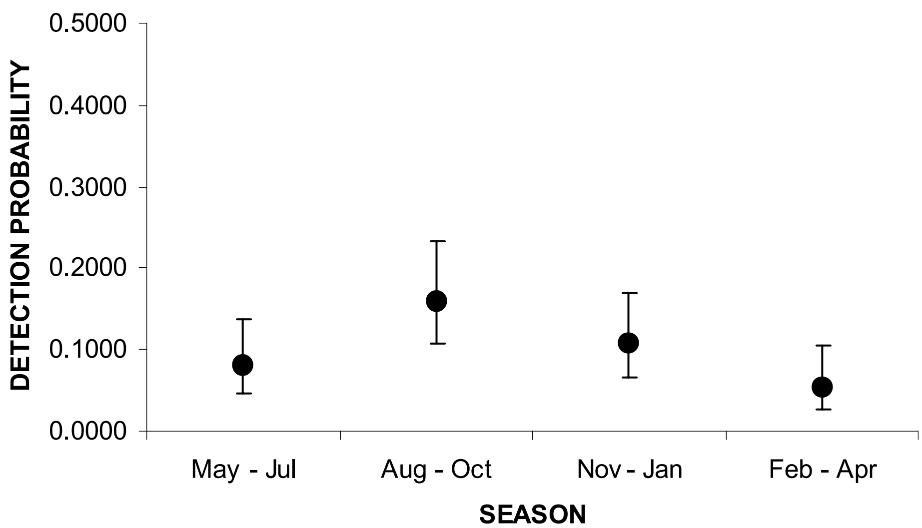

Figure 3. Detection probability of Red-tailed Hawks as a function of seasonality and their 95% confidence intervals along roadway corridors in Austin, Texas.

CHAPTER IV

DISCUSSION

Model analyses indicated that occupancy probability as a function of median presence and detection probability as a function of seasonality were the best estimators for the presence of Red-tailed Hawks in Austin, TX. Occupancy probabilities were higher with median presence than absence, but displayed large confidence intervals in comparison (Fig. 1). Detection probabilities varied seasonally with the highest detection in August-October (Fig. 2) during the peak of fall migration for Red-tailed Hawks (Allen 1993) and could explain the higher detection probability. Although this model best fits the data, the AIC weight (w = 0.41) leaves room for questions concerning occupancy.

Encroachment of urbanization into natural habitats has the greatest effects on specialist raptor species (Jullien and Thiollay 1996) due to habitat loss, alteration, and human disturbance. However, for generalist species, such as the Red-tailed Hawk, there appears to be benefits of this encroachment in areas retaining ecologically important features (Bird et al. 1996). It is unknown whether prey abundance is affecting the occupancy of this raptor species in Austin due to the ability of the Red-tailed Hawk to incorporate diet-switching behaviors (Steenhof and Kochert 1988).

Olendorff (1984) suggested that some raptor species might require a more urbanized habitat in certain geographic areas of the United States. This use of urban areas may result from the best natural habitat (source) being already occupied and roadside habitats that retain ecologically important characteristics may act as sinks. These urban areas appear to benefit the Red-tailed Hawk, a species generalist, in using a less favorable habitat.

It appears occupancy probability of Red-tailed Hawks in Austin cannot be solely assessed by the characteristics examined in this project. However, occupancy as a function of median presence is a good place to start when examining different factors leading to presence of Red-tailed Hawks. Andersen et al. (1989) viewed Red-tailed Hawks adapting to areas of intense helicopter traffic and thus should be able to adapt to areas of high traffic and noise. This characteristic of roadside ecology needs to be examined (Forman and Alexander 1998) and might play a bigger role in occupancy. Forman and Alexander (1998) also indicated that the fragmentation effects of urbanization and roadway ecosystems on occupancy probability need further study. A larger sample size would allow more focus to be placed on vegetative components, such as type, dynamic structure, and edge effect on and immediately surrounding roadways. Urban encroachment will affect natural nesting sites for all raptor species and should be examined in future research as well as abundance of artificial nesting sites to determine the effects on hawk occupancy of roadway corridors.

Factors such as median dynamics and prey abundance are research areas that might lead to stronger conclusions concerning occupancy and detection probabilities of the Red-tailed Hawk. Results from this research indicated that Red-tailed Hawks in Austin are probably adapting to roadside corridors due to a variety of factors. These factors estimating occupancy are likely biased to this geographic locale. With further research into geographically similar areas one can assess the factor(s) that contribute to Red-tailed Hawk occupancy along roadways. This information can be further used to assist in the construction of new roadways or scenic byways advancing into natural areas (i.e., Balcones Canyonland Preserve) to retain ecologically important criteria. If top carnivores are beginning to fill niches created by increasing urban sprawl, then we should use this opportunity to examine the reasons why this is occurring and adjust methods of road construction into natural habitat to allow for the highest ecological diversity possible.

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Jason inspires to work for the National Park Service and continue his education and knowledge of raptor species in the years to come.

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