

INFLUENCE OF ROADS AND LANDSCAPE FEATURES ON THE SPATIAL ECOLOGY
AND MORTALITY OF OCELOTS IN SOUTH TEXAS

A Thesis
by
ANNMARIE BLACKBURN

Submitted to the College of Graduate Studies
Texas A&M University-Kingsville
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2020

Major Subject: Range and Wildlife Management

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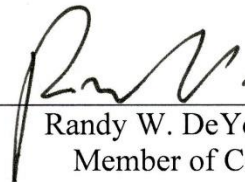
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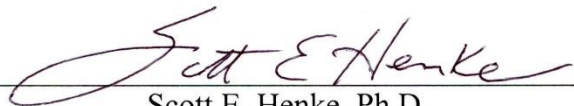
Michael E. Tewes, Ph.D.
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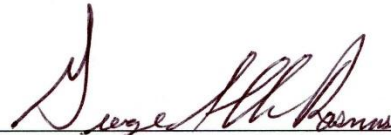
Humberto L. Rerotto-Baldivieso, Ph.D.
Member of Committee



Randy W. DeYoung, Ph.D.
Member of Committee



Scott E. Henke, Ph.D.
Chair of Department



George Allen Rasmussen, Ph.D.
Vice President for Research and Graduate
Studies

August 2020

ABSTRACT

Influence of Roads and Landscape Features on the Spatial Ecology and Mortality of
Ocelots in South Texas
(August 2020)

AnnMarie Blackburn, B.S., University of California Santa Barbara

Chairman of Advisory Committee: Dr. Michael E. Tewes

Urban development is the leading cause of habitat loss, replacing natural areas with infrastructure and road networks. Roads can negatively impact wildlife populations through habitat fragmentation, decreased landscape connectivity, and wildlife-vehicle collisions. Ocelots (*Leopardus pardalis*) are a federally endangered felid, with the sole breeding populations in the United States restricted to the Lower Rio Grande Valley of South Texas, an area of extensive anthropogenic expansion. Vehicle collisions are the highest sources of mortality for ocelots in Texas. Mitigation strategies, such as wildlife crossing structures, have been implemented throughout South Texas in the last 3 decades to combat the negative effects of roads on the ocelot populations. However, there has only been 1 documented case of an ocelot using a road crossing structure. The goal of my project was to analyze ocelot landscape use and response to road networks to inform potential locations for future road crossing structures designed for ocelot recovery. I examined the landscape structure surrounding ocelot-vehicle collision sites to understand the relationship between the spatial structure of land cover and where ocelots are

struck by vehicles. I also examined the landscape structure surrounding wildlife crossing structures implemented for ocelot use to understand potential reasons ocelots may not use the structures. Lastly, I evaluated the relationship between biological and road-related factors and ocelot mortality risk, to determine which factors contribute to the probability of mortality from vehicle collision. Results from this study will improve conservation efforts for the endangered ocelot by illustrating the need for strategies to mitigate vehicle collisions and improve landscape connectivity. These results can be used for the placement of future road crossing structures more likely to be used by ocelots.

PREVIEW

ACKNOWLEDGEMENTS

I thank my graduate committee chair, Dr. Michael Tewes, and my committee members, Dr. Humberto Perotto-Baldivieso and Dr. Randy DeYoung, for their guidance and support throughout the course of this research. I am also thankful for Dr. David Wester, who has provided an immeasurable amount of statistical help for this project. You all have contributed to my growth as a research scientist and wildlife professional.

I thank the Texas Department of Transportation, especially Dr. John Young, Jr., for their funding and support, data, and advice. I thank the U.S. Fish and Wildlife Service for providing ocelot road mortality data, without which this project could not have been completed. I am appreciative of the financial tuition assistance through scholarships and awards from Mr. Rene Barrientos, the South Texas Quail Coalition, and the Amanda Whitaker scholarship.

Thanks also to my friends and fellow graduate students for their support. Specifically, I thank Amanda Veals, Jane Anderson, and Levi Heffelfinger. I would not have been able to complete this project without your advice and guidance. I also thank the faculty and staff of the Caesar Kleberg Wildlife Research Institute for the education and assistance I have received during my time as a graduate student at Texas A&M University-Kingsville.

Finally, I would like to thank my family for their love and encouragement, and for supporting me while I follow my passion.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

This work was supervised by a thesis committee consisting of Dr. Michael Tewes, Dr. Humberto Perotto-Baldivieso, and Dr. Randy DeYoung of the Department of Rangeland and Wildlife Sciences.

The data analyzed for Chapters 1 and 3 were provided by Dr. John Young, Jr. from the Texas Department of Transportation, and the U.S. Fish and Wildlife Service, and analyses were conducted in part by Dr. Perotto-Baldivieso and Dr. Wester of the Department of Rangeland and Wildlife Sciences. The data analyzed in Chapter 2 were provided by Dr. Tewes, and analyses were conducted in part by Levi Heffelfinger of the Department of Rangeland and Wildlife Sciences.

All other work conducted for the thesis was completed by the student independently.

Funding Sources

This work was also made possible by the Texas Department of Transportation under Grant Number 57-8XXIA005. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Texas Department of Transportation.

NOMENCLATURE

AADT	Annual Average Daily Traffic
AI	Aggregation Index
ED	Edge Density
ENN	Euclidean Nearest Neighbor
LPI	Largest Patch Index
LANWR	Laguna Atascosa National Wildlife Refuge
LRGV	Lower Rio Grande Valley
MPA	Mean Patch Area
PD	Patch Density
PLAND	Percent Land Cover
PMDI	Palmer Modified Drought Index

TABLE OF CONTENTS

	Page
ABSTRACT.....	iii
ACKNOWLEDGEMENTS.....	v
CONTRIBUTORS AND FUNDING SOURCES	vi
NOMENCLATURE	vii
TABLE OF CONTENTS.....	viii
LIST OF TABLES.....	x
LIST OF FIGURES	xiii
CHAPTER I. LANDSCAPE PATTERNS OF OCELOT-VEHICLE COLLISION SITES	1
Methods.....	5
Results.....	9
Discussion	12
References.....	15
CHAPTER II. CONSEQUENCES OF ROAD DENSITY AND ACTIVITY ON THE OCELOT.....	36
Methods.....	41
Results.....	45
Discussion	47
References.....	50

	Page
CHAPTER III. COMPARATIVE LANDSCAPE ANALYSIS OF OCELOT CROSSING	
STRUCTURES AND OCELOT-VEHICLE COLLISION SITES	72
Methods.....	75
Results.....	80
Discussion.....	82
References.....	86
VITA.....	99

PREVIEW

LIST OF TABLES

TABLE	Page
<p>1.1 Dates of ocelot-vehicle collisions, LANDSAT satellite imagery data acquisition, and LANDSAT instrument (TM = Thematic Mapper; OLI = Operational Land Imager) used to quantify spatial scale of landscape features on ocelot-vehicle collisions in South Texas, U.S.A. during 1984 to 2017</p>	26
<p>1.2 Significant differences in median woody cover structure between ocelot-vehicle collision sites from South Texas, U.S.A. during 1984 to 2017 and paired random road locations detected by Wilcoxon sign-rank tests. Sign indicates the direction of the difference relative to vehicle collision sites. (+ collision sites significantly greater than random locations, - collision sites significantly lower than random locations, 0 no significant difference). Results of the sign test (<i>p</i>-value) relative to vehicle collision sites also given.</p>	30
<p>1.3 Significant differences in median herbaceous cover structure between ocelot-vehicle collision sites from South Texas, U.S.A. during 1984 to 2017 and paired random road locations detected by Wilcoxon sign-rank tests. Sign indicates the direction of the difference relative to vehicle collision sites. (+ collision sites significantly greater than random locations, - collision sites significantly lower than random locations, 0 no significant difference). Results of the sign test (<i>p</i>-value) relative to vehicle collision sites also given</p>	31

1.4 Significant differences in median bare ground cover structure between ocelot-vehicle collision sites from South Texas, USA during 1984 to 2017 and paired random road locations detected by Wilcoxon sign-rank tests. Sign indicates the direction of the difference relative to vehicle collision sites. (+ collision sites significantly higher than random locations, - collision sites significantly lower than random locations, 0 no significant difference). Results of the sign test (p -value) relative to vehicle collision sites also given.	32
2.1 Definitions of variables used in Cox proportional hazards regression modeling to evaluate influence of roads and other variables on ocelot mortality risk for 59 ocelots from 1982 to 2001 on the Laguna Atascosa National Wildlife Refuge in South Texas, U.S.A.....	62
2.2 A portion of competing models from model selection results using the Cox proportional hazards regression to predict biological and road-related variables influencing ocelot mortality risk based on 59 ocelots monitored from 1982 to 2001 on the Laguna Atascosa National Wildlife Refuge in South Texas, U.S.A.	68
2.3 Standardized estimates of scaled and centered covariates, robust standard errors (SE), hazard ratios, and 95% confidence intervals for the top model from the Cox proportional hazards regression predicting risk to ocelots based on 59 ocelots from 1982 to 2001 on the Laguna Atascosa National Wildlife Refuge in South Texas, U.S.A.....	70
3.1 Significant differences in median woody cover structure between ocelot-vehicle collision sites from South Texas, U.S.A. during 1984 to 2017 and ocelot road crossing structures detected by Kolmogorov-Smirnov tests. Sign indicates the direction of the difference	

relative to vehicle collision sites. (+ collision sites significantly greater than random locations, - collision sites significantly lower than random locations, 0 no significant difference). Results of the sign test (p -value) relative to vehicle collision sites also given.	94
3.2 Significant differences in median herbaceous cover structure between ocelot-vehicle collision sites from South Texas, U.S.A. during 1984 to 2017 and ocelot road crossing structures detected by Kolmogorov-Smirnov tests. Sign indicates the direction of the difference relative to vehicle collision sites. (+ collision sites significantly greater than random locations, - collision sites significantly lower than random locations, 0 no significant difference). Results of the sign test (p -value) relative to vehicle collision sites also given.	96

LIST OF FIGURES

FIGURE	Page
1.1 Cameron, Kenedy, and Willacy counties of South Texas, U.S.A. This region contains the solely known resident breeding populations of ocelots in the U.S., which are genetically isolated into 2 subpopulations.....	24
1.2 Locations of 26 ocelot-vehicle collision locations during 1984 to 2017 in Cameron and Willacy counties of South Texas, U.S.A. The cluster of road-kills to the north come from the Ranch Population of ocelots, the group to the south come from the Refuge Population.	25
1.3 Example of multi-buffer system used to analyze landscape structure surrounding ocelot-vehicle collision locations in South Texas, U.S.A. during 1984 to 2017. Each road mortality and random road location consists of 11 buffers increasing in size by a radius of 150 m	28
1.4 Median values of woody vegetation structure between 26 ocelot-vehicle collision sites that occurred in South Texas, U.S.A. during 1984 to 2017 and their paired random road locations. Metrics of landscape structure were compared at 150 m intervals. Standard error bars were estimated by bootstrapping. Asterisks indicate significant differences based on Wilcoxon signed-rank tests.....	29
1.5 Median values of woody vegetation structure between vehicle collision sites of male and female ocelots that occurred in South Texas, U.S.A. during 1984 to 2017. Metrics of landscape structure were compared at 150-m intervals. Standard error bars were estimated	

by bootstrapping. Asterisks indicate significant differences based on Kolmogorov-Smirnov tests.....	33
1.6 Median values of herbaceous vegetation structure between vehicle collision sites of male and female ocelots that occurred in South Texas, U.S.A. during 1984 to 2017. Metrics of landscape structure were compared at 150-m intervals. Standard error bars were estimated by bootstrapping. Asterisks indicate significant differences based on Kolmogorov-Smirnov tests.....	34
1.7 Median values of bare ground vegetation structure between vehicle collision sites of male and female ocelots that occurred in South Texas, U.S.A. during 1984 to 2017. Metrics of landscape structure were compared at 150-m intervals. Standard error bars were estimated by bootstrapping. Asterisks indicate significant differences based on Kolmogorov-Smirnov tests.....	35
2.1 Map of the 2 isolated ocelot populations of South Texas, USA. The larger Ranch Population resides on private ranchlands in Kenedy and Willacy counties (hashed polygon). The Refuge Population resides in and around the Laguna Atascosa National Wildlife Refuge in Cameron County (filled polygon).....	61
2.2 Map of road types surrounding the Laguna Atascosa National Wildlife Refuge in Cameron County, Texas (blue polygon). Dashed black lines represent unpaved roads (e.g., soil, gravel). Green lines represent low-volume roads (<1,000 cars/day), and orange lines represent high-volume roads (>1,000 cars/day).....	64

2.3 Number of ocelot fatalities within each year from 1982 to 2001 based off 26 radio-collared ocelot mortality events from the Laguna Atascosa National Wildlife Refuge in South Texas, U.S.A.....	65
2.4 The average road density within annual home range (A) and distance from center of annual home ranges to the nearest road (B) of 59 ocelots monitored on the Laguna Atascosa National Wildlife Refuge in South Texas from 1982–2001. Box plots represent the distribution of values of the density and distance variables of each road type. The green box depicts the range of values of unpaved roads (e.g., soil, gravel), the orange depicts the range of values of low-volume roads (<1,000 cars/day), and the purple depicts the range of values of high-volume roads (>1,000 cars/day). Black crosses represent the average value throughout the study area.....	66
2.5 Annual survival curves from the Kaplan-Meier estimator of 59 ocelots with 95% confidence intervals of resident and transient ocelots from the Laguna Atascosa National Wildlife Refuge in South Texas, U.S.A. from 1982 to 2001. The solid red line is the mean annual survival estimate of resident ocelots with the 95% confidence interval shown by the light red shading. The solid blue line is the mean annual survival estimate of transient ocelots with the 95% confidence interval shown by the light blue shading	67
2.6 The effect of increasing density of high-volume roads (>1,000 annual average daily traffic volume) within home range of ocelots on the risk of mortality (i.e., hazard ratio) based on 59 ocelots monitored from 1982 to 2001 in South Texas, U.S.A. Estimates were derived from 500 simulations, where values of covariates from the top model were	

randomly extracted from a multivariate distribution. Light blue lines represent each simulated iteration of the effect of high-volume roads on hazard ratios across the levels of observed high-volume road densities. The solid black line represents population mean effect of high volume roads on ocelot hazard ratios	69
2.7 Top performing predictor of the probability of mortality from vehicle collision based on 26 ocelot fatalities from the Laguna Atascosa National Wildlife Refuge in South Texas, U.S.A. monitored from 1982 to 2001. The effect of density of low-volume roads (<1,000 annual average daily traffic volume) within home range was positively related to the probability of roadkill. The dotted red lines indicate the 95% confidence interval.....	71
3.1 Districts of Texas, U.S.A. defined by the Texas Department of Transportation. The 3 southernmost districts are Laredo, Corpus Christi, and Pharr, which contain wildlife crossing structures designed to mitigate ocelot-vehicle collisions. Ocelot crossing structures have been built in these 3 districts since the 1990s, however several have been constructed within the past 5 years with more to be constructed in the future.....	92
3.2 Map depicting the locations of 26 ocelot-vehicle collisions (stars) that occurred from 1984 to 2017 and locations of 56 ocelot road crossing structures (triangles) throughout the southernmost 3 districts of Texas, U.S.A. defined by the Texas Department of Transportation. Ocelot crossing structures have been built since the 1990s and planned into the future.....	93
3.3 Median values of woody vegetation structure between 26 ocelot-vehicle collision sites that occurred in South Texas, U.S.A. from 1984 to 2017 and 56 ocelot crossing structures. Metrics of landscape structure were compared at 150-m intervals. Standard	

error bars were estimated by bootstrapping. Asterisks indicate significant differences based on Kolmogorov-Smirnov tests.....	95
3.4 Median values of herbaceous vegetation structure between 26 ocelot-vehicle collision sites that occurred in South Texas, U.S.A. from 1984 to 2017 and 56 ocelot crossing structures. Metrics of landscape structure were compared at 150-m intervals. Standard error bars were estimated by bootstrapping. Asterisks indicate significant differences based on Kolmogorov-Smirnov tests.....	97
3.5 Histogram depicting the distance between each of the 56 ocelot crossing structures to the nearest ocelot-vehicle collision site in South Texas, U.S.A. Seventeen crossing structures occurred within 5 km of an ocelot-vehicle collision, while 12 occurred beyond 180 km from the nearest ocelot-vehicle collision site.....	98

CHAPTER I

LANDSCAPE PATTERNS OF OCELOT-VEHICLE COLLISION SITES¹

ABSTRACT Road networks can negatively impact wildlife populations through habitat fragmentation, decreased landscape connectivity, and wildlife-vehicle collisions, thereby influencing the spatial ecology and population dynamics of imperiled species. The ocelot (*Leopardus pardalis*) is a federally endangered wild felid in South Texas, with a high mortality rate linked to vehicle collisions. This study examined the spatial structure of land cover in relation to ocelot road mortality locations. I quantified the spatial distribution of land cover types at 26 ocelot-vehicle collision sites in South Texas that occurred from 1984–2017. I compared landscape metrics of woody, herbaceous, and bare ground cover types across multiple spatial scales at roadkill locations to those from random road locations, and between male and female ocelots. Road mortality sites consisted of 13–20% more woody cover than random locations. Woody patches at road mortality sites were 7.1–11% larger (2.4 ha) closer to roads, and spaced 10–16 m closer together at distances farther away from roads compared to random locations. Percent woody cover was the best indicator of ocelot-vehicle collision sites; there were no differences in woody cover between male and female road mortality locations. These findings suggest that ocelots are likely struck by vehicles while crossing between habitat patches. Roads that bisect areas of woody cover have negative impacts on ocelots by increasing habitat fragmentation and vulnerability to vehicle collisions. These results can be used to inform the placement of future crossing structures or other mitigation strategies, thus reducing ocelot-vehicle collisions.

¹ Formatted to Landscape Ecology

KEY WORDS landscape ecology, ocelot, road mortality, wildlife-vehicle collisions, wildlife crossing structures.

Roads can negatively impact survival and movements of wildlife, including reptiles and amphibians (Marsh et al. 2005; Shephard et al. 2008), birds (Laurance et al. 2005), and mammals (Oxley et al. 1974; Groot Bruinderink and Hazebroek 1996). Negative impacts may be direct, due to vehicle collisions and physical barriers to movement, or indirect, when roads act as functional barriers that reduce gene flow and reproductive success (Harris and Scheck 1991; Forman and Alexander 1998; Smith and Dodd 2003; Riley 2006; Litvaitis et al. 2015). Roads are often the principal threat to successful dispersal of wildlife within urban areas (Forman and Alexander 1998), and vehicle collisions have become an increasing source of wildlife mortality as transportation infrastructure increases because of urban sprawl (Forman et al. 2003). Road mortality has impacted population demographics of species of conservation concern (e.g., Kerley et al. 2002; Cypher et al. 2009), and population sizes of threatened or endangered species, including the Florida panther (*Puma concolor coryi*) and Key deer (*Odocoileus virginianus clavium*; Evink et al. 1996; Land and Lotz 1996). However, little research has evaluated how the spatial structure of landscape features around roads influences vehicle collisions. This information is critical for the conservation of imperiled species.

The spatial structure of land cover types can dictate animal space use, movement, and abundance (Thornton et al. 2011; Baigas et al. 2017; Marchand et al. 2017). For example, an evaluation of landscape spatial structure is useful in the assessment of habitat fragmentation for wild felids (Jackson et al. 2005; Zemanova et al. 2017). However, the relationship between landscape structure and road mortality patterns remains largely unknown for many species, particularly

those threatened or endangered. Studies suggest wildlife-vehicle collisions are often spatially aggregated (Main and Allen 2002), and occur along roadways near natural vegetation cover (Romin and Bissonette 1996; Clevenger et al. 2003). Further, many ecological patterns are influenced by elements acting at multiple spatial scales (Weins 1989; Bauder et al. 2018). The spatial scale at which a landscape feature has the strongest effect on species response (e.g., movement, abundance) is termed the “scale of effect;” although the “scale of effect” varies with the response variable, it does not always vary in a predictable manner (Jackson and Fahrig 2012; Moraga et al. 2019). Without previous multi-scale studies to base analyses of the effects of landscape structure on wildlife behavior, it is recommended to estimate the “scale of effect” empirically using a multi-scale study design (Moraga et al. 2019). Understanding landscape patterns and spatial scale associated with wildlife-vehicle collisions can inform mitigation strategies for sensitive species within a fragmented landscape.

The ocelot (*Leopardus pardalis*) is a medium-sized neotropical felid that is listed as endangered at the state and federal levels in the United States (U.S.; USFWS 1982; TPWD 2018). Fewer than 80 ocelots remain in the U.S. (Tewes 2019), divided between 2 isolated breeding populations in the eastern Coastal Sand Plain and the Lower Rio Grande Valley of Texas (Janečka et al. 2011; Janečka et al. 2016). Ocelots in this region are habitat specialists with spatial patterns strongly linked to dense thornshrub (Harveson et al. 2004). Ocelots select for areas with $\geq 75\%$ thornshrub canopy cover, with a strong preference for habitat with $> 95\%$ canopy cover (Horne et al. 2009). This dense thornshrub cover type used by ocelots is uncommon throughout the southernmost 13 counties of Texas, as an estimated $< 1\%$ of this area presently contains suitable ocelot habitat (Tewes and Everett 1986).

During the past century, the Lower Rio Grande Valley has been substantially modified by urban development and agriculture (Leslie 2016). Native woodland declined 91% between the 1930s–1980s due to the expansion of agriculture and urban development (Tremblay et al. 2005). Urban expansion in this region has increased anthropogenic infrastructure, including housing developments, shopping centers, and road networks (Tiefenbacher 2001; Lombardi et al. 2020a). As the human population of this region grows, urbanization will become the primary driver of fragmentation and loss of native habitat (Marzluff and Ewing 2001; Lombardi et al. 2020a). Vehicle collisions represent the highest source of direct mortality for ocelots in this region (Haines et al. 2005). Thus, the challenge for ocelots to survive in an increasingly fragmented landscape is further exacerbated by the development and expansion of road networks to meet urbanization demands.

Few studies have examined the spatial structure of land cover of South Texas that may influence ocelot movement and dispersal (Harveson et al. 2004; Jackson et al. 2005). The identification of patterns in the landscape structure associated with ocelot-vehicle collisions at the appropriate scale can help precisely determine critical locations where ocelots may be vulnerable to vehicle-caused mortality. This information can then be integrated into mitigation strategies. The goal of this study was to understand the scale of effect of landscape structure associated with ocelot-vehicle collisions and aid conservation planners in the development of mitigation strategies. My main objectives were (1) to quantify the spatial distribution of land cover types at ocelot-vehicle collision locations, (2) to determine the scale at which spatial patterns of land cover at ocelot-vehicle collision locations differ from landscape spatial structure across my study area, and (3) to compare spatial structure of landscape features at vehicle collision sites between male and female ocelots.

METHODS

Study area

My study area is located in the 3 southernmost coastal counties of Texas: Cameron, Kenedy, and Willacy (Fig. 1.1). Ocelots reside in 2 isolated breeding populations within these counties (Tewes and Everett 1986; Janečka et al. 2016). The southernmost ocelot population, the “Refuge Population”, occurs in and around the Laguna Atascosa National Wildlife Refuge (26.2289° N, 97.3467° W), a federally protected area in Cameron County. The northernmost population, the “Ranch Population”, occurs on private lands primarily in Kenedy and Willacy counties (Tewes 2019; Lombardi et al. 2020b). The region represents a transition zone between temperate and tropical conditions, with humid subtropical and semiarid climates, resulting in hot summers and mild winters (Leslie 2016). Rainfall fluctuates seasonally and among years, with an annual average of 660 mm (Norwine and John 2007). This region is in the Tamaulipan Biotic Province, constituting of hardwood and dense thornshrub forest. Dominant woody vegetation includes Texas ebony (*Ebenopsis ebano*), honey mesquite (*Prosopis glandulosa*), spiny hackberry (*Celtis pallida*), live oak (*Quercus virginianus*), lime prickly ash (*Zanthoxylum fagara*), huisache (*Acacia farnesiana*), and Texas lantana (*Lantana horrida*, Harveson et al. 2004; Leslie 2016).

Landscape Analysis

There were 50 recorded ocelot-vehicle collisions in the Lower Rio Grande Valley during 1982–2017. Of those records, 32 had documented geographic coordinates. The spatial accuracy of 2 road mortality locations did not fall on a road and were removed from analysis. Four ocelot-vehicle collisions were within completely urbanized areas; initial data analysis indicated these were aberrations compared to other mortality locations, thus were not included in the analyses. The final data set consisted of 26 known road mortality locations: 18 males, 7 females, and 1

unknown sex (Fig. 1.2). I defined my area of interest by generating a 10-km buffer around the aggregated road mortality locations to include a broad area available for ocelots to have used. I used 30-m LANDSAT satellite imagery that overlapped with the timeframe of known ocelot-vehicle collisions to evaluate spatial structure of land-cover features in the study area. I acquired 15 LANDSAT images taken within 2 years of each collision through the U.S. Geological Survey Global Visualization Viewer (<https://glovis.usgs.gov/>). Images consisted of 10 LANDSAT 5 Thematic Mapper scenes (1986–2010) and 5 LANDSAT 8 Operational Land Imager scenes (2014–2017; Table 1.1).

I created land-use cover maps using an unsupervised image classification (Xie et al. 2008, Lombardi et al. 2020a) in ERDAS IMAGINE 2018 (Hexagon Geospatial, Norcross, GA). I grouped each image into 4 cover classes: woody vegetation cover, herbaceous vegetation cover (i.e., non-woody), bare ground, and water. To properly address and classify urban areas, I fused layers of digitized urban areas from 1987, 1992, 2000, 2008, and 2016 based on spatial data from the U.S. Census Urban Area from the Texas Natural Resource Information System (TNRIS, Austin, TX). Cropland varied by year and season and often had similar spectral signatures to woody cover, which led to inaccurate images. Therefore, I manually digitized crop fields for each image and fused these layers to my classified imagery in addition to the digitized urban layers. Final imagery included 6 cover classes: woody, herbaceous, bare ground, water, cropland, and urban. I conducted accuracy assessments on each image by generating 200 random points across each satellite image, assigning each random point to 1 of the 6 classes, and compared the observed cover class to the expected cover class from the classified image. I used a threshold of $\geq 85\%$ accuracy for image classifications (Jensen 2016; Pulighe et al. 2016).