NON-INVASIVE ASSESSMENT OF BLACK BEAR MOVEMENTS AND ABUNDANCE RELATIVE TO U.S.98 WITHIN THE AUCILLA WILDLIFE MANAGEMENT AREA

BY:

STEPHANIE L. SIMEK, PAUL S. KUBILIS, SANDRA A. JONKER, THOMAS H. EASON

DECEMBER 2005

FINAL REPORT CONTRACT BD568

Completed for the Florida Department of Transportation and Florida Fish and Wildlife Conservation Commission

Metric Conversion Table

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Non-Invasive Assessment of Black Bear Movements and Abundance Relative to U.S.98 Within the Aucilla Wildlife Management Area		5. Report Date December 30, 2005 6. Performing Organization Code
7. Author(s) Stephanie L. Simek, Paul S. Kubilis, Sandra A. Jonker, Thomas H. Eason		8. Performing Organization Report No.
9. Performing Organization Name and Address Florida Fish and Wildlife Conservation Commission 620 South Meridian Street Tallahassee, FL 32399		10. Work Unit No. (TRAIS) 11. Contract or Grant No. BD-568
12. Sponsoring Agency Name and Address Florida Department of Transportation 605 Suwannee Street, MS30 Tallahassee, FL 32399		13. Type of Report and Period Covered Final Report May 2003 – May 2004 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract:

Transportation related deaths (roadkill) are the primary mortality factor that Florida Fish and Wildlife Conservation Commission (FWC) has documented for the Florida black bear (*Ursus americanus floridanus*) statewide since 1976. During the period of December 2001 to March 2002 six black bears were killed on a section of U.S. 98 within the Aucilla Wildlife Management Area (Aucilla WMA) in southeastern Jefferson County, Florida. The objective of this study is to assess the movements (number and locations of black bear crossings) and abundance of black bears in the study area relative to U.S. 98 within the Aucilla WMA and adjacent lands in southeastern Jefferson County. The study is designed to: 1) Generate an estimate for the black bear population in the Aucilla area, 2) Assess the effect of roadkill on the local black bear population, and 3) Assess specific road crossing locations and rates correlated with various parameters. Population estimate calculations using program CAPTURE failed to provide a reliable estimator due to small generated sample size, low recapture rates, few new captures, and model closure violation. The approximate density (0.097) was based on the number of black bears identified through genetic analysis (n=48) (May 2003-May 2004). These results indicate a moderately high rate of genetic drift during a period of relative genetic isolation. Habitat differences, intersecting roads, and seasons have an effect on black bear crossing rates, however; none of the tested variables had an effect on black bear roadkill. There is an increased occurrence of black bear crossings at intersecting roads and there is no correlation between black bear crossings and roadkill. There were 28 roadkill black bears recorded during September 1983 - December 2004, with the majority occurring in the Fall within the effective sampling area. Two roadkill occurred during the study period. Recommendations are provided to address elevated crossing and roadkill activity concurrently for all seasons. These include specific wildlife crossings, habitat manipulations, signage and visual stimuli, and road improvements for the study interval of U.S. 98 as well as considerations for other roads in the area including U.S. 19 and SR 59. These measures would facilitate the apparent black bear movement within the Aucilla area and toward coastal resources found in the St. Marks area and adjacent lands. Additionally, these conservation measures may significantly decrease bear mortality, increase driver safety, and benefit multiple species while ensuring connectivity to conservation lands for this expanding population of genetically distinct black bears. Additionally, recommendations are provided for current and projected road projects in collaboration with private and state agencies and organizations.

17. Key Word	18. Distribution Statement
Black bear, Ursus floridanus, roadkill, population, U.S. 98, Florida, DNA analyses, wildlife crossings, abundance, movement	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
		68	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACKNOWLEDGEMENTS

The authors would like to thank the Florida Department of Transportation for providing funding for this study. A special thank you to David Ziegler and Vicki Sharpe for their cooperation and support in black bear conservation measures. We would like to thank Kim Annis, Randy King, Jenny Novak, Jena Perdue, Morgan Wilbur, Chris Wynn, Christine Yannett, and the many volunteers for their dedicated work on this project. We would like to thank our team members Walt McCown and Brian Scheick for their contributions to this project. We would also like to thank Mark Endries for his assistance with the GIS component of this project. In addition, we would like to extend our gratitude to our cooperators on this project: St. Marks National Wildlife Refuge and their biologists Joe Rineman and Robin Wills, St. Joe Timberland Company (Flint Rock Wildlife Management Area), private landowners who provided access to their properties, and Krispy Kreme Doughnuts. In addition, we would like to extend many thanks to the staff at Wildlife Genetics International for their time and expertise. We would like to thank Kipp Frohlich, Tim O'Meara, Walt McCown, Vicki Sharpe, Brian Scheick, and Chris Wynn for their reviews of this report.

EXECUTIVE SUMMARY

Introduction

Transportation related deaths (roadkill) are the primary mortality factor that Florida Fish and Wildlife Conservation Commission (FWC) has documented for the Florida black bear (*Ursus americanus floridanus*) statewide since 1976. Increasing numbers of roadkill alone cannot provide the basis for conclusions regarding black bear populations. Other factors such as increased public awareness, more accurate documentation of roadkill, and human and black bear population changes in certain areas may influence the apparent increase of the number of roadkill. Road characteristics (i.e., roadside habitat, intersecting roads, elevation, etc.) may impact black bear movement.

Previous research (Dixon 2004) has suggested that black bears located in the Aucilla area may be a subpopulation of the Apalachicola population. During the period of December 2001 to March 2002 six black bears were killed on a section of U.S. 98 within the Aucilla Wildlife Management Area (Aucilla WMA) in southeastern Jefferson County, Florida. Previous research has identified the U.S. 98 study interval as a principal roadkill area (Simek et al. in press, Gilbert and Wooding 1996) using roadkill data from 1976 to 2004 and 1976 to 1995 respectively. Additionally, Smith et al (1998) and Schaefer and Smith (2000) identified segments along the U.S. 98 study interval as high priority highway ecological zones. Therefore, an accurate population estimate of black bears in the vicinity of the Aucilla WMA, together with the frequency and locations of black bear crossings along U.S. 98, is needed to assess the impact of this highway on the black bear population in the Aucilla area and evaluate the future needs for improved habitat connectivity features.

Objective

The objective of this study is to assess the movements (number and locations of black bear crossings) and abundance of black bears in the study area relative to U.S. 98 within the Aucilla WMA and adjacent lands in southeastern Jefferson County. The study is designed to:

- Generate an estimate for the black bear population in the Aucilla area,
- Assess the effect of roadkill on the local black bear population, and
- Assess specific road crossing locations and rates correlated with various parameters.

Study Area

The study area is a segment of U.S. 98, which is located in the Aucilla WMA and adjacent lands that include portions of St. Marks National Wildlife Refuge, Flint Rock Wildlife Management Area, and private lands in Jefferson County, Florida. The study area extends approximately 5km north and 7.8km south and approximately 1.3km west and 9km east of the intersection of U.S. 98 and SR 59 (490.54km^2). The study area is located within three major drainage basins (Aucilla, Hosford Branch, and Pinhook).

METHODS

Genetic sampling techniques (using DNA from black bear hair follicles captured in hair snares) and mark-recapture equations were used to estimate the Aucilla black bear population (Paetkau 2004, White et al. 1982, White et al. 1978). In May 2003, 30 population hair snares were established and monitored from May through September 2003. Population hair snares were set during 4 sampling periods (10-14 days each) comprised of 2 sampling sessions each, for a total of 8 sessions. Each sampling period was separated by a 5 to 7 day period of no baiting and

no sampling to deter individual black bears from staying at a single hair snare. Additionally, to document black bear movement across U.S. 98, 24 crossing snares were established in May 2003 and monitored from May 2003-May 2004.

A dirt trail transect approximately 3m wide along 9.5km of U.S. 98 within the study area was monitored once a week for the presence of black bear tracks to record black bear crossings from May 2003 through May 2004. We documented characteristics of all crossing sites, including location, direction of travel, size of tracks, date, and vegetative cover.

Black bear roadkill occurrences within the study area were queried from existing FWC data during the study period (May 2003 to May 2004) and a separate query of the data was conducted to examine all roadkill occurrences over time within the study area (September 1983 - December 2004). The impact of roadkill on the Aucilla black bear population was calculated using the proportion of roadkill in relation to the abundance estimate derived from the DNA analysis for the study area.

Program CAPTURE (White et al. 1978) was used to calculate a within-year population estimate for the study period. A density estimate for the study area population was calculated based on the number of captured black bears. Black bear tracks observed on each of 46 observation days (n=46 weeks) were used to calculate black bear crossing rates on the study interval of U.S. 98. The 46 observation days represented 273 cumulative days of observation along U.S. 98. Crossing data (n=84 crossings) observed from May 2003 to May 2004 were used in the analyses.

Using Arc View GIS, the study interval of U.S. 98 was divided into meter segments and the locations of black bear tracks observed alongside U.S. 98 were referenced to these nearest points (i.e., meter-marks). Habitat type frontage boundaries, intersecting road buffer frontage boundaries, road elevation, and relative degree of road curvature were also referenced to meter-marks on U.S. 98 so that habitat and road characteristics could be appropriately matched with black bear track locations.

Crossing rates were calculated for thirty-eight 250m sections of U.S. 98 starting at the east side of SR 59 and heading east. Rates were calculated for the entire study period and separately for each of the following 3 black bear activity seasons: Winter (January 1 to April 30), Summer (May 1 to August 31), and Fall (September 1 to December 31).

The effects of elevation, relative degree of road curvature, presence or absence of intersecting roads, and dominant roadside habitat type on 250m section crossing rates and roadkill rates were assessed separately for each black bear activity season and across all black bear activity seasons combined.

Black bear roadkill data during the study interval (May 2003 to May 2004) and from September 1983 to December 2004 were categorized within the effective study area by sex, age class, and season. The percent impact of annual and seasonal roadkill on the estimated population was determined within the study area from May 2003 to May 2004 and September 1983 to December 2004.

RESULTS

During the study 3,406 hair samples were collected from population (n=1,069) and crossing (n=2,337) snares. The success rate of identifying individual black bears from genetic sampling was 76%. Both crossing (100%) and population (60%) snares were successful at capturing hair samples. The sex ratio of the population snare sample was 57% females and 43% males and the sex ratio for the crossing hair sample was 35% females and 65% males.

Population estimate calculations using program CAPTURE failed to provide a reliable estimator due to small generated sample size, low recapture rates, few new captures in the 3rd (11.4% and n=1) and 4th (10.4% and n=1) sampling periods, and model closure violation. As a result, CAPTURE estimated 46 black bears within the study area which is less than the total number of black bears captured and identified through genetic sampling (n=48). Based on the failure of the CAPTURE estimation, the actual number of individual black bears (n=48) captured in both the population and crossing snares was used to derive an approximate density (0.097) for this study period. These results indicate a moderately high rate of genetic drift during a period of relative genetic isolation.

The results from this study have demonstrated that habitat differences, intersecting roads, and seasons have an effect on black bear crossing rates, however; none of the tested variables had an effect on black bear roadkill. There is an increased occurrence of black bear crossings at intersecting roads and there is no correlation between black bear crossings and roadkill.

There were a total of 28 roadkill black bears recorded during September 1983 - December 2004, within the effective sampling area. Two of these roadkill occurred during the study period (May 2003 to May 2004). The sex ratio of roadkill bears was skewed towards females and the age ratio was skewed towards younger bears. It is difficult to assess the impacts of roadkill on this area since we were unable to determine a true population estimate. The majority (n=16, 57%) of documented roadkill from September 1983 through December 2004 occurred during the Fall (September – December).

Study Limitations : This study includes data collection and analyses limitations. The study area based on extrapolated home ranges was inadequate to generate an appropriate sample size. Only having completed one field season of data collection limited the usefulness of the results. A low number of identified bears, low recapture and few new captures in the 3rd and 4th sampling periods, and model closure violation were additional limitations.

RECOMMENDATIONS

Therefore, to address elevated crossing and roadkill activity concurrently for all seasons, wildlife crossings should be considered at the 1km-3km and 5.5km-7.5km segments of the study interval of U.S. 98. FDOT engineers will need to conduct on-site evaluations of these segments to determine whether to install underpasses or overpasses based on the existing environmental conditions (i.e., excess runoff, water inundation, elevation, etc.). Location of the placement of the wildlife crossings is critical to the success of these crossings (Land and Lotz 1996, Walker and Baber 2003). These structures would facilitate the apparent black bear movement within the Aucilla area and toward coastal resources found in the St. Marks area and adjacent lands. Additionally, these conservation measures may significantly decrease bear mortality, increase driver safety, and benefit multiple species while ensuring connectivity to conservation lands for this expanding population of genetically distinct black bears.

Findings of this study agree with recommendations 8 and 9 identified for FDOT District 3 by Schaefer and Smith (2000). Recommendation 8 suggests replacing the existing box culvert with a wildlife underpass and wildlife fencing 1 mile (1.6km) east of the junction of SR 59/U.S. 98. Recommendation 9 suggests replacing existing pipe culvert with a wildlife underpass 1 mile (1.6km) west of the SR 59/U.S. 98 intersection. As this study has demonstrated that intersecting roads are an effect to crossing behavior by black bears, purchasing land surrounding intersections to reduce development and increase habitat availability for black bears, as suggested by Schaefer and Smith (2000), may facilitate crossings by black bears at intersections. However,

manipulating the habitat surrounding intersections may not be beneficial to black bears since intersections have been shown to have an effect on black bear crossings in this study. Increasing black bear crossings at these locations could potentially cause a significant effect of roadkill that was not apparent in this study. In recommendation 7 Schaefer and Smith (2000) recommend installing a black bear wildlife underpass and associated fencing at 2.2 miles (3.5km) east of the SR 59/U.S. 98 intersection on the curve. The Aucilla study and Simek et al. (in press) recognize this segment of U.S. 98 as an area for consideration to reduce black bear mortality. However, due to the seasonal movement of bears, roadkill, the associated frontage, intersecting roads, and the fact that road curvature does not have an effect on crossings, a recommendation from this study is to place the wildlife crossing centered between 2.0km and 2.9km east of the SR 59/U.S. 98 intersection and install fencing 1.6km east and west of the crossing. Fencing should be at least 3meters above the ground, buried 0.5meter underground, and include a 1 meter barb wire overhang at the top. The segment identified in recommendation number 6 (Schaefer and Smith 2000) would place 2 wildlife bridges/culverts at 0.5mi (0.8km) to 1.3mi (2.1km) west of the Aucilla river. The results from this study however, suggest that road improvement such as wildlife crossings should be centered approximately 6.5km east of SR 59/ U.S. 98 intersection or 3km west of the Aucilla River. In addition, landscape manipulation can be used to direct wildlife species to wildlife crossings, provide connectivity to conservation areas, and deter black bears from approaching roadside segments.

The study interval of U.S. 98 and the segment of U.S. 19 (east of CR 259/U.S. 19 intersection and west of CR 257/U.S. 19 intersection) northeast of Aucilla have a high number of recorded black bear roadkill and are identified principal roadkill areas (Simek et al. in press). Therefore, a recommendation from this study is to address both segments of U.S. 98 and U.S. 19 at the same time with respect to implementing wildlife crossings and roadway improvements. Modifications for U.S. 19 may include extending high level wildlife fencing and replacing small culverts with wildlife underpasses (Schaefer and Smith 2000). Improving both these sections of U.S. 98 and U.S. 19 at the same time would have a greater impact on minimizing bear mortality within the Aucilla and Wacissa drainage basins. Although there are few recorded roadkill on SR 59, if development and improved road networks are planned for this and the surrounding area, then precautions and mitigation measures for wildlife, and especially the black bear, must be taken into account on all roads in the area (i.e., direct impacts, cumulative effects, and secondary effects).

A recommendation to address the correlation of intersecting roads and black bear crossings is to implement visual stimuli such as caution lights and signs at intersections. Any existing signs along the study interval should be updated and missing signs should be replaced. This would be beneficial to warn drivers of the occurrence of black bear crossings. In addition, signs and reduced speed zones should be implemented at segments of the road where roadkill occurs, and in the Fall temporary variable message boards can be employed to alert drivers to heightened black bear activity.

Findings and recommendations from this report can assist FDOT with the current replacement of the Aucilla River Bridge Project and future projected road manipulation projects. FDOT can use models such as Smith et al. (1998) to integrate FDOT road projects with state conservation lands and greenway projects, scenic byway developments, FWC species and habitat management goals, etc., as well as minimize impacts on black bears and other wildlife species and determine projected mitigation requirements. FDOT should take a proactive role in

considering long term plans in this area as no land changes are currently planned to connect conservation lands.

A final recommendation would be to repeat this study for a minimum of 2 years as well as genetically analyze the remaining hair samples from this original study. Further study should encompass a larger area and include habitat north and south of both U.S. 98 and U.S. 19 to document black bear movements in this localized corridor relative to these major roadways.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS v

EXECUTIVE SUMMARY vi

LIST OF TABLES xii

INTRODUCTION 14
Objective 15

STUDY AREA 16

METHODS 16
Data Collection for Black Bear Population Estimate 16
Data Collection for Black Bear Crossings and Disk Transect 18
Data Collection for Roadkill Impacts 19
Data Analysis for Black Bear Population Estimate 20
Data Analyses for Black Bear Crossings and Disk Transect 21
Data Analysis for Roadkill Impacts 24

RESULTS 25
Black Bear Population Estimate 25
Black Bear Crossing Snares and Disk Transect 26
Roadkill Impacts 30

DISCUSSION 31

RECOMMENDATIONS 36

LITERATURE CITED 40

LIST OF TABLES

Table 1. Minimum grid area and associated parameters required to sample a minimum of 50 black bears for the Aucilla black bear populations in Jefferson County, Florida. 44

Table 2. U.S. 98 road features, crossing rates, and roadkill rates summarized by 250m section in the Aucilla study area in Jefferson County, Florida. 45

Table 2 continued. U.S. 98 road features, crossing rates, and roadkill rates summarized by 250m section in the Aucilla study area in Jefferson County, Florida. 46

Table 2 continued. U.S. 98 road features, crossing rates, and roadkill rates summarized by 250m section in the Aucilla study area in Jefferson County, Florida. 47

Table 2 continued. U.S. 98 road features, crossing rates, and roadkill rates summarized by 250m section in the Aucilla study area in Jefferson County, Florida. 48

Table 2 continued. U.S. 98 road features, crossing rates, and roadkill rates summarized by 250m section in the Aucilla study area in Jefferson County, Florida. 49

Table 3. Association between quantitative road features and 250m section crossing or roadkill rates in the Aucilla study area in Jefferson County, Florida. 50

Table 4. Association between quantitative road features and the probability of observing at least 1 crossing or at least 1 roadkill in 250m section in the Aucilla study area in Jefferson County, Florida. 51

Table 5. Comparison of black bear crossing and roadkill rates among groups of 250m sections defined by various characteristics of the U.S. 98 study interval in Jefferson County, Florida. 52

Table 6. Comparison of the percent of 250m sections having at least 1 black bear crossing or at least 1 roadkill among groups of sections defined by various characteristics of the U.S. 98 study interval in Jefferson County, Florida..... 53

Table 7. Comparison of 250m section monthly crossing rates among black bear activity seasons in the Aucilla study area in Jefferson County, Florida 54

Table 8. Number of Florida black bear roadkill by sex and age class for the Aucilla study area in Jefferson County, Florida from September 1983 through December 2004. 55

LIST OF FIGURES

Figure 1. Location of Aucilla study area in Jefferson County, Florida during May 2001-September 2003. 56

Figure 2. Diagram of barbed wire hair snare enclosure used to collect black bear hair samples. 57

Figure 3. Locations of black bear population and crossing hair snares in the Aucilla study area in Jefferson County, Florida from May 2003-May 2004. 58

Figure 4. Florida black bear crossings per month along U.S. 98 in Jefferson County, Florida during all activity seasons combined from May 2003-May 2004 59

Figure 5. Florida black bear crossings per month along U.S. 98 in Jefferson County, Florida during the winter activity season (January 1-April 30). 60

Figure 6. Florida black bear crossings per month along U.S. 98 in Jefferson County, Florida during the summer activity season (May 1 – August 31). 61

Figure 7. Florida black bear crossings per month along U.S. 98 in Jefferson County, Florida during the fall activity season (September 1 – December 31). 62

Figure 8. Florida black bear crossings per month along U.S. 98 in Jefferson County, Florida during all activity seasons combined from 1983-2004. 63

Figure 9. Population hair snares successfully frequented by black bears in the Aucilla study area in Jefferson County, Florida. 64

Figure 10. Crossing snares successfully frequented by black bears in the Aucilla study area in Jefferson County, Florida. 65

Figure 11. Population and crossing hair snares successfully frequented by black bears in the Aucilla study area in Jefferson County, Florida. 66

Figure 12. Seasonal monthly crossing rates by 250m section of U.S. 98 in Jefferson County, Florida ("hairs" represent locations of crossings and roadkills). 67

Figure 13. Monthly crossing rates and roadkills per decade by 250m section of U.S. 98 in Jefferson County, Florida ("hairs" represent crossing and roadkill locations). 68

Figure 14. Recommended locations for consideration to reduce black bear mortality on the study interval of U.S. 98 in Jefferson County, Florida. 69

INTRODUCTION

Transportation related deaths (roadkill) are the primary mortality factor that Florida Fish and Wildlife Conservation Commission (FWC) has documented for the Florida black bear (*Ursus americanus floridanus*) statewide since 1976. There has been an increase in roadkill during the last 10 years (1994 n=47, 2004 n=129), with a peak in 2002 when 132 black bears were killed. The roadkill data collected over time suggests parallel increases in transportation-related mortality and human population growth. Vehicular collisions with black bears not only present a public safety threat, but roadkill can impact black bear populations (Servheen et al. 1998). Some land managers have expressed concern that high roadkill numbers may be symptomatic of early stages of habitat fragmentation or represent human created barriers across important landscape linkages (Ruediger et al. 1999, Servheen et al. 2003). In order to assess the potential impact of roadkill as a mortality factor, information about the size and health of black bear populations sustaining roadkill is needed. Increasing numbers of roadkill alone cannot provide the basis for conclusions regarding the black bear population. Other factors such as increased public awareness, more accurate documentation of roadkill, and human and black bear population changes in certain areas may influence the apparent increase of the number of roadkill. Additionally, road characteristics (i.e., roadside habitat, intersecting roads, elevation, etc.) may impact black bear movement.

There are 6 core and 2 smaller, more remnant black bear populations in Florida (Eglin, Apalachicola, Osceola, Ocala, St Johns, Big Cypress, Chassahowitzka, and Glades/Highlands). Previous research (Dixon 2004) has suggested that black bears located in the Aucilla area may be a subpopulation of the Apalachicola population. During the period

of December 2001 to March 2002 six black bears were killed on a section of U.S. 98 within the Aucilla Wildlife Management Area (Aucilla WMA) in southeastern Jefferson County, Florida. In 2001 this section of highway ranked third in importance out of fifteen statewide black bear roadkill "chronic" areas based on an analysis by Gilbert et al (2001). Recent analyses of roadkill data conducted by FWC using more restrictive parameters, has also identified this section of U.S. 98 as a principal roadkill area (3 or more roadkill bear /1mile) using data from 1976-2004 (Simek et al. in press). Numerous studies assessing black bear populations as well as the impact of roads on black bear populations have been conducted through out Florida (Wooding and Hardisky 1988, Seibert 1993, Land 1994, Roof and Wooding 1996, McCown et al. 2004, Simek et al. 2005); however, none have been conducted in or around the Aucilla WMA. Therefore, an accurate population estimate of black bears in the vicinity of the Aucilla WMA, together with the frequency and locations of black bear crossings along U.S. 98, is needed to assess the impact of this highway on the black bear population in the Aucilla area and evaluate the future needs for improved habitat connectivity features.

Objective

The objective of this study is to assess the movements (number and locations of black bear crossings) and abundance of black bears in the study area relative to U.S. 98 within the Aucilla WMA and adjacent lands in southeastern Jefferson County. The study is designed to:

- Generate an estimate for the black bear population in the Aucilla area,
- Assess the effect of roadkill on the local black bear population, and

- Assess specific road crossing locations and rates correlated with various parameters.

STUDY AREA

A segment of U.S. 98 is encompassed within the study area, which is located in the Aucilla WMA and adjacent lands that include portions of St. Marks National Wildlife Refuge, Flint Rock Wildlife Management Area, and private lands in Jefferson County, Florida (Figure 1). The study area extends approximately 5km north and 7.8km south and approximately 1.3km west and 9km east of the intersection of U.S. 98 and SR 59. Effective sampling area was 490.54km^2. The study area is located within three major drainage basins (Aucilla, Hosford Branch, and Pinhook). The habitat within the study area primarily consists of hardwood swamps (*Quercus spp*.) interspersed with mixed wetland forest (*Cyrilla racemiflora, Acer spp., etc.*) and pinelands (*Pinus elliottii*) interspersed with cypress swamps (*Taxodium spp*.). There are scattered shrubs and brushlands (*Serenoa repens*, *Quercus myrtifolia, etc.)* through out the area (FWC 2004). In addition, the majority of the habitat within the study area ranks high on the FWC Integrated Wildlife Habitat Ranking System (2001). This system ranks habitat for wildlife on a scale from 1 (low) to 10 (high) with respect to suitability of habitat quality for wildlife (Endries 2003).

METHODS

Data Collection for Black Bear Population Estimate

Genetic sampling techniques (using DNA from black bear hair follicles captured in hair snares) and mark-recapture equations were used to estimate the Aucilla black bear population (Paetkau 2004, White et al. 1982, White et al. 1978). For population estimation,

White et al. (1982) suggests to calculate the minimum area that would sustain 50 black bears (Table 1). The equation provides a calculation of the effective sampling area that includes the sampling grid and buffering perimeter, which is based on the average summer home ranges for males and females combined (Simek et al. 2005). Since no prior research had been performed in the Aucilla area, the home range size and densities for this population were calculated based on an interpretation of the known home ranges and densities for the Florida black bear populations in Apalachicola and Osceola (Dobey et al. 2002, Siebert 1993, Logan 1998). The Apalachicola and Osceola black bear populations were used due to their proximity to Aucilla. In addition, the densities of these two populations appeared similar based on observational information.

Once the study area was defined, a systematic grid of 30 equally sized cells was created. Maximum grid spacing to assure that at least 4 hair snares were located within an average female summer home range was determined using a method developed by White et al. (1982) (Table 1). Using data from the Apalachicola and Osceola black bear populations, the maximum grid cell spacing for the Aucilla study area was 4.15km^2. Final size and placement of the grid depended upon access, previous knowledge of well-known black bear occurrences within the population, and adjustments to unique local circumstances.

The total area of each hair snare ranged between 10-30 m^2. Each snare was constructed by anchoring 2 strands of standard 4-prong barbed wire at 25cm and 50cm above the ground around 4-6 perimeter trees (Figure 2). To ensure that black bears would enter through the barbed wire corral and leave tufts of hair on the barbs, a lure of corn and pastries was placed on the ground in the center of each snare and hung at least 8 feet above the center of the snare. When snares could not be placed on level ground, measures were taken to

preclude black bears from crawling under the lower wire without leaving hair samples by filling depressions under the wire to level the ground with dirt, logs, or debris.

In May 2003, 30 population hair snares were established (one in each grid cell) and monitored from May through September 2003 (Figure 3). Following the same criteria as Simek et al. (2005) (in order of importance), the final placement of hair snares were determined within each grid cell: 1) in areas of known black bear use (based on field sign), 2) along typical black bear travel routes (creeks, drainages, and other land features), 3) where logistically feasible, and 4) proximity to the center point of each grid cell. For population estimation, hair snares were set during 4 sampling periods (10-14 days each) comprised of 2 sampling sessions each, for a total of 8 sessions. Each sampling period was separated by a 5 to 7 day period of no baiting and no sampling to deter individual black bears from staying at a single hair snare.

Tufts of hair collected from an individual barb were considered a single sample. A ranking method, based on sample quality, was developed based on the following criteria: Rank 0 for samples with less than 5 hair follicles, Rank 1 for samples with 5 to 10 hair follicles, Rank 2 for samples with 11 to 25 hair follicles, and Rank 3 for samples with 26 or more hair follicles. Data were collected for each sample and recorded on individual coin envelopes including study area, date, sample number, category, and identifiers for cell, sampling period, site, snare side, wire, and barb.

Data Collection for Black Bear Crossings and Disk Transect

Crossing Snares: Using the same site, snare, and sampling design as the population snares, 24 crossing snares were established in May 2003 and monitored from May 2003-May

2004 to document black bear movement across U.S. 98. These snares were located 600-800 meters apart, approximately 500 meters north and south of U.S. 98 (Figure 3). The crossing snares began at the intersection of U.S. 98 and SR 59 and ended on the west side of the Aucilla River. Four of the crossing snares also served as population snares.

Disk Transect: A dirt trail transect approximately 3m wide along 9.5km of U.S. 98 within the study area was monitored once a week for the presence of black bear tracks to record black bear crossings from May 2003 through May 2004. We documented characteristics of all crossing sites, including location, direction of travel, size of tracks, date, and vegetative cover. The track transect was cleared either by plowing, dragging, or rain (usually performed on the most recent observation day). Black bear tracks crossing the track transect and ending at the road pavement were recorded as a single crossing. All locations of black bear tracks were documented using Global Positioning Systems (GPS). Tracks separated by greater than 3m or tracks derived from different directions were recorded as individual black bears. Multiple tracks from one black bear were individually recorded but grouped under one single identification number. An observed set of tracks was considered to represent one black bear crossing except when it was apparent that multiple sets of tracks indicated a female black bear traveling with cubs, in which case the multiple track sets were counted as a single black bear crossing.

Data Collection for Roadkill Impacts

Black bear roadkill occurrences within the study area were queried from existing FWC data during the study period (May 2003 to May 2004). In addition, a separate query of the data was conducted to examine all roadkill occurrences over time within the study area

(September 1983 - December 2004). Additionally, roads were identified within the study area using a major roads shapefile created by Florida Department of Transportation (FDOT) and available from the Florida Geographic Data Library (version 3.0). Roads included in the shapefile for analysis were Interstates, State Highways, County Highways, Highway access ramps, and major local and forest roads. The impact of roadkill on the Aucilla black bear population was calculated using the proportion of roadkill in relation to the abundance estimate derived from the DNA analysis for the study area.

Data Analysis for Black Bear Population Estimate

Using optimal sub-sampling methods described by Simek et al. (2005) and McCown et al. (2001), 300 random sub-samples from the population snares (Ranking of samples: Rank 0 = 49; Rank 1 = 165; Rank 2 = 59; Rank 3 = 27) and 150 random sub-samples from the crossing snares (Ranking of samples: Rank 0 = 7; Rank 1 = 85; Rank 2 = 40; Rank 3 = 18) were selected. Once selected, hair samples were sent to Wildlife Genetics International, Ltd. Nelson, British Columbia for genetic analyses. Each hair sample was analyzed to 7 loci to determine the sex and individual identity of each black bear (Paetkau 2004).

Capture histories were constructed for each individual black bear during each sampling period, and mark-recapture methodology was used to derive an abundance estimate. Black bears were considered as unmarked on their initial visit to a hair snare and as marked on subsequent visits to any hair snare. Program CAPTURE (White et al. 1978) was used to calculate a within-year population estimate for the study period. A density estimate for the study area population was calculated based on the number of captured black bears.

Data Analyses for Black Bear Crossings and Disk Transect

Black bear tracks observed on each of 46 observation days (n=46 weeks) were used to calculate black bear crossing rates on the study interval of U.S. 98. Five of the total 51 weeks during the study interval were not checked due to inclement weather. The observation period for the track sets counted on each observation day was considered to be the number of days elapsed between the clearing of the transect and the current observation day. Considered in this manner, the 46 observation days represented 273 cumulative days of observation along U.S. 98. Crossing data (n=84 crossings) observed from May 2003 to May 2004 were used in the analyses. Direction of road crossing implied by a track set was noted whenever possible. Direction could not be determined for 19% (16 of 84) of the observed individual black bear crossings.

Using Arc View GIS, the study interval of U.S. 98 was divided into meter segments and the locations of black bear tracks observed alongside U.S. 98 were referenced to these nearest points (i.e., meter-marks). Habitat type frontage boundaries, intersecting road buffer frontage boundaries, road elevation, and relative degree of road curvature were also referenced to meter-marks on U.S. 98 so that habitat and road characteristics could be appropriately matched with black bear track locations.

Crossing rates were calculated for thirty-eight 250m sections of U.S. 98 starting at the east side of SR 59 and heading east. Rates were calculated for the entire study period and separately for each of the following 3 black bear activity seasons: Winter (January 1 to April 30), Summer (May 1 to August 31), and Fall (September 1 to December 31). Crossing rates were standardized to monthly crossing rates per 250m section using the cumulative number of observation days overall and for each season: 273 days (overall), 104 days (Winter), 70

days (Summer), and 99 days (Fall). Converting the number of black bear tracks per day to the number of black bear tracks per month was calculated as follows: (# tracks / # days) x (365 days / 12 months) = # tracks / month. This adjustment was based on 12 months of surveying so that 273 days of surveying equaled 8.98 months. Roadkill rate per decade was also calculated for each 250m section using locations of black bear roadkills recorded along the study interval of U.S. 98 from September 1983 to December 2004.

Road elevation along U.S. 98 was determined using a 30m resolution USGS digital elevation model (DEM) of Florida Arc View grid coverage. Point elevations along U.S. 98 were averaged within 250m sections to generate a mean elevation attribute for each section. Possible factors that can attribute to the location of roadkill may include a driver's line of sight, which can be affected by the degree of road curvature, and safe braking distances (McCown et al. 2004). Degree of curvature of U.S. 98 was determined by considering the point of view of a driver moving at 60 mph in either an east or west direction along U.S. 98. Under normal circumstances, a safe braking distance for such a driver would be approximately 100m (Transportation Research Institute 1997). At each meter-mark on U.S. 98, the difference between the bearing of the driver relative to the next meter-mark and the bearing relative to the 100th meter-mark in a given direction was calculated, and these point-wise bearing differences were then averaged within 250m sections to generate a mean relative curvature attribute for each section. Separate mean attributes were calculated for movement from east to west and from west to east. Each 250m section along U.S. 98 was also classified with regard to the presence or absence of intersecting dirt roads or trails (no paved roads intersected U.S. 98 within the interval of road used in the study) (Figures 4-8).

Dominant roadside habitat type was determined for each 250m section using the 30m resolution FWC 2003 Vegetation and Land Cover Map generated from LandSat imagery. After 5-cell majority smoothing of the GIS coverage using Arc View Spatial Analyst, 4 habitat types were observed to occur along the study interval of U.S. 98: pinelands (PL), cypress swamp (CS), mixed wetland forest (MWF), and hardwood swamp (HS). The habitat with the longest frontage boundary on both sides of a 250m section was considered to be the dominant habitat type for that section (Table 2 and Figures 4-8).

Statistical Methods: Statistical analysis of crossing and roadkill rates was restricted to the use of univariate data analysis methods due to the low number of observed black bear crossings (n=84), the relative low number of recorded historic roadkills on the study interval of U.S. 98 (n=21), and the low number of 250m sections of U.S. 98 available for analysis (n=38). Additionally, no black bear crossings were observed in 32% of the 250m sections (12 of 38). These sections occurred intermittently on straight as well as curved sections of the interval with varying habitat types along the interval frontage. Additional data may be needed to determine pattern effect of measured variables that can account for no black bear crossings along these 12 sections. The effects of elevation, relative degree of road curvature, presence or absence of intersecting roads, and dominant roadside habitat type on 250m section crossing rates and roadkill rates were assessed separately for each black bear activity season and across all black bear activity seasons combined.

Crossing and roadkill rates were each conceptualized and analyzed as both ordinal and binary outcome variables. The ordinal ranks of 250m section crossing and roadkill rates were analyzed using nonparametric methods. The Spearman rank correlation coefficient (analogous to the Pearson correlation coefficient; Hollander and Wolfe 1973) was used to

determine if higher rates were associated with either higher or lower elevation or relative degree of road curvature. The Wilcoxon rank sum test (analogous to the independent-sample t-test; Hollander and Wolfe 1973) was used to determine if rates differed ordinally between groups of 250m sections defined by the presence or absence of intersecting roads. To assess ordinal differences in rates among groups of 250m sections defined by dominant habitat type, the Kruskal-Wallis rank sum test (analogous to 1-way ANOVA, Hollander and Wolfe 1973) was employed. The Friedman rank sum test (analogous to 1-way repeated measures ANOVA; Hollander and Wolfe 1973) was used to assess ordinal differences in crossing rates among black bear activity seasons while accounting for within-section correlation among seasons.

In analyzing crossing and roadkill rates as binary outcome variables, 250m sections were classified into 2 groups defined by the presence or absence of at least one observed crossing or at least one recorded roadkill in a 250m section. Logistic regression (Harrell 2001) was used to determine if higher or lower elevation or relative degree of roadside curvature was associated with a higher probability that a 250m section would yield at least 1 observed black bear crossing or at least 1 recorded roadkill. The Fisher exact test (Rosner 1995) was used to compare the proportion of 250m sections yielding at least 1 observed black bear crossing or at least 1 recorded roadkill between groups of sections defined by the presence or absence of intersecting roads or by dominant habitat type.

Data Analysis for Roadkill Impacts

Black bear roadkill data during the study interval (May 2003 to May 2004) and from September 1983 to December 2004 were categorized within the effective study area by sex,

age class, and season. For comparison to statewide research (Simek et al. 2005), seasons were defined as follows for this analysis: Winter: January 1 – February 29; Spring: March 1 – April 30; Summer: May 1 – August 31; and Fall: September 1 – December 31. The percent impact of annual and seasonal roadkill on the estimated population was determined within the study area from May 2003 to May 2004 and September 1983 to December 2004.

RESULTS

During the study 3,406 hair samples were collected from population (n=1,069) and crossing (n=2,337) snares. A total of 450 hair samples (from both population (n=300) and crossing (n=150) snares) were submitted for genetic analyses. Twenty-four percent (n=108) of the samples lacked suitable material for DNA extraction, produced insufficient data to establish individual identity, or contained a mixture of DNA from 2 or more individuals and therefore were omitted from the analyses. Therefore, the success rate of identifying individual black bears from genetic sampling was 76%. There were 2 black bears captured only in the crossing snares, 31 black bears captured only in the population snares, and 15 black bears captured in both the population and crossing snares. Both crossing (100%) and population (60%) snares were successful at capturing hair samples (Figures 9-11). The sex ratio of the population snare sample was 57% females and 43% males and the sex ratio for the crossing hair sample was 35% females and 65% males.

Black Bear Population Estimate

Population estimate calculations using program CAPTURE failed to provide a reliable estimator due to small generated sample size, low recapture rates, few new captures

in the 3rd (11.4% and n=1) and 4th (10.4% and n=1) sampling periods, and model closure violation. As a result, CAPTURE estimated 46 black bears within the study area (selecting the Model with time and behavior effects), which is less than the total number of black bears captured and identified through genetic sampling (n=48) in both the population (n=46) and crossing snares (n=2). Therefore, the population estimate generated through CAPTURE was not used in further analyses. Based on the failure of the CAPTURE estimation, the actual number of individual black bears (n=48) captured in both the population and crossing snares was used to derive an approximate density (0.097) for this study period. Even though the Aucilla study area is within the Apalachicola black bear population primary range, the individual black bears captured in this study are genetically distinct from their neighbors in Apalachicola National Forest. (however, one of the identified individuals' origins are likely from the Apalachicola and not the Aucilla bear population). These results indicate a moderately high rate of genetic drift during a period of relative genetic isolation. The genetic isolation of the Aucilla black bear population is similar to the isolation among the Ocala, Osceola, and Apalachicola black bear populations. However, this isolation is less than the distinction reported between the Chassahowitzka and Glades/Highlands black bear populations (Dixon 2004).

Black Bear Crossing Snares and Disk Transect

Effect of elevation on crossing and roadkill rates: Minimal change in elevation along the U.S. 98 study interval was observed. Starting at the western end of the study interval and moving eastward, the average elevation per 250m section was 5m above sea level for the first 18 sections (4.5km), then 4m above sea level for the next 2 sections

(0.5km), and finally 3m above sea level for the last 18 sections (4.5km). Therefore, the maximum change in elevation along the U.S. 98 study interval was only 2m.

For each black bear activity season and for the 3 seasons combined, no significant rank correlation was observed between road elevation and 250m black bear crossing or roadkill rates. Similarly, no significant association was observed between road elevation and the probability that a 250m section would yield at least 1 black bear crossing or at least 1 roadkill (Table 3).

Effect of road curvature on crossing and roadkill rates: Although there are 2 significant curves along the U.S. 98 study interval, their geographic scale is such that change in the relative degree of curvature along U.S. 98 was minimal. The maximum mean relative curvature per 250m section for the western curve was 1.9 degrees going from west to east and 2.1 degrees from east to west. Maximum mean relative curvature for the eastern curve was 2.3 degrees from west to east and 2.1 degrees from east to west.

For each black bear activity season and for the 3 seasons combined, no significant rank correlation was observed between relative road curvature in either direction and 250m black bear crossing or roadkill rates. Similarly, no significant association was observed between relative road curvature in either direction and the probability that a 250m section would yield at least 1 black bear crossing or at least 1 roadkill (Table 4).

Effect of intersecting roads on crossing and roadkill rates: Intersecting dirt roads or trails were present in 13 of the 38 (34%) 250m sections in the U.S. 98 study interval. Comparison of crossing rate ranks between groups of sections defined by the presence or absence of intersecting roads yielded a significant ordinal difference in rates in the Winter black bear activity season only. Winter crossing rate ranks were significantly higher in

sections where intersecting roads were present (Wilcoxon rank sum p=0.00). To illustrate the difference, the mean monthly crossing rate for sections with intersecting roads was 0.5, compared to a mean monthly rate of 0.0 for sections without intersecting roads (Table 5).

Comparison of the proportion of 250m sections having at least 1 observed black bear crossing between sections with and without intersecting roads yielded significant differences for Winter, Summer, and all seasons combined (Fisher exact test p=0.00, 0.04, and 0.03 respectively). In all cases, the section group with intersecting roads had a higher proportion of sections with at least 1 black bear crossing than the section group without intersecting roads. The percentages were 38% vs. 0% for Winter, 77% vs. 40% for Summer, and 92% vs. 56% for all seasons combined (Table 6).

Neither roadkill rate ranks nor the proportion of sections containing at least 1 recorded roadkill differed significantly between groups of sections defined by the presence or absence of intersecting roads (Tables 5 and 6).

Effect of dominant habitat type on crossing and roadkill rates: The classification of 250m sections by dominant habitat type yielded 19 pinelands (PL) sections, 4 mixed wetland forest (MWF) sections, and 15 hardwood swamp (HS) sections. PL sections were more common on the western side of the U.S. 98 study interval, while HS sections were more common on the eastern side. Comparison of crossing rate ranks among groups of sections defined by dominant habitat type yielded a significant ordinal difference in rates in the Summer black bear activity season only. Summer crossing rate ranks were significantly higher in PL and MWF sections in comparison to HS sections (Kruskal-Wallis rank sum p=0.04). To illustrate the differences, the mean monthly black bear crossing rates for PL and

MWF sections were 0.57 and 0.54 respectively, compared to a mean monthly rate of 0.17 for HS sections (Table 5).

Similarly, comparison of the proportion of 250m sections having at least 1 observed black bear crossing between PL, MWF, and HS sections yielded significant differences for the Summer activity season only (Fisher exact test p=0.04). The PL and MWF sections were somewhat similar, having 68% and 75% of sections respectively with at least 1 black bear crossing, compared to HS sections, which had only 27% of sections with at least 1 black bear crossing (Table 6).

It is possible that the significantly lower proportion of HS sections with at least 1 black bear crossing during the Summer activity season might be explained by the lower occurrence of intersecting roads in HS sections (27% HS vs. 39% non-HS). Therefore, 250m sections were reclassified into 4 groups, defined as HS sections with intersecting roads (HS+R), HS sections without intersecting roads (HS-R), non-HS sections with intersecting roads (NHS+R), and non-HS sections without intersecting roads (NHS-R). The proportion of sections among these 4 groups that had at least 1 black bear crossing during the Summer activity season differed significantly (Fisher exact test p=0.01). The observed percentages for these 4 section groups are as follows: HS+R (50%), HS-R (18%), NHS+R (89%), and NHS-R (57%). Thus in HS sections, at least 1 black bear crossing was more likely to occur in sections with intersecting roads than without (50% vs. 18%). Similarly, non-HS sections with intersecting roads were more likely to have at least 1 crossing than non-HS sections without intersecting roads (89% vs. 57%). For sections with intersecting roads, HS sections were less likely to have at least 1 black bear crossing compared to non-HS sections (50% vs. 89%). This is also true for sections without intersecting roads (18% vs. 57%). Thus it

appears that the tendency of HS to lower the likelihood that sections will have at least 1 black bear crossing during the Summer activity season is independent of the tendency for intersecting roads to increase the likelihood that sections will have at least 1 black bear crossing during the Summer season (Table 6).

Neither roadkill rate ranks nor the proportion of sections containing at least 1 recorded roadkill differed significantly among groups of sections defined by dominant habitat type (Tables 5 and 6).

Effect of black bear activity season on crossing rates: The Friedman rank sum test indicated that 250m section crossing rate ranks differed among the 3 black bear activity seasons (p=0.00). To illustrate the differences, the mean monthly crossing rates for Winter, Summer, and Fall were 0.16, 0.41, and 0.23 respectively (Table 7, Figure 12 and 13).

Association between crossing rates and roadkill rates: There was no significant rank correlation observed between 250m section crossing rates and corresponding roadkill rates. Similarly, neither the roadkill rate ranks nor the proportion of sections having at least 1 recorded roadkill differed significantly between sections that had no observed black bear crossings and sections that had at least 1 observed black bear crossing (Tables 3, 4, 5, and 6).

Roadkill Impacts

There were a total of 28 roadkill black bears recorded during September 1983 - December 2004, within the effective sampling area (including U.S. 98 (n=27) and SR 59 (n=1)). Two of these roadkill occurred during the study period (May 2003 to May 2004) (Table 8). Of the 28 roadkill, 11 (39%) were juveniles (6 females, 5 males), 9 (32%) were adults (7 females, 1 male, 1 unknown), 7 (25%) were cubs (3 females, 4 males), and one was

an unknown age class female. During the study period there were 2 roadkills; one female juvenile in the Fall and one female juvenile in the Spring. It is difficult to assess the impacts of roadkill on this area since we were unable to determine a true population estimate. However, if we use the number of black bears captured, the two incidents of roadkill documented during the study period within the effective sampling area, represent 4.2% roadkill impact of the minimum population size of 48. The majority (n=16, 57%) of documented roadkill from September 1983 through December 2004 occurred during the Fall (September – December).

Study Limitations : This study includes data collection and analyses limitations. The study area based on extrapolated home ranges was inadequate to generate an appropriate sample size. Only having completed one field season of data collection limited the usefulness of the results. A low number of identified bears, low recapture and few new captures in the 3rd and 4th sampling periods, and model closure violation were additional limitations.

DISCUSSION

The data generated from this study suggests that the smaller population of black bear within the Aucilla area is expanding. Evidence to support this inference of the data include the low number of captures and recaptures, population model failure, genetic drift and isolation, and the documented sex and age ratio of roadkill.

The sudden spike in roadkill in 2001, as compared to the average of 1-3 roadkill/year pre and post 2001, could also be an indicator or the result of a growing population. This spike in roadkill occurred in the Fall which is typical based on recorded roadkill in this area

over time. Data since 1983 indicates the sex ratio of black bear roadkill in this area is skewed towards females. The population sex ratio generated from the genetic data from this study indicates a similar skew. The age class distribution reflects a higher number of young bears in the roadkill, which suggests that there may be a relatively high reproductive rate in this area.

Recent research regarding black bear range and distribution indicates female presence and reproduction occurring within and adjacent to the Aucilla study area (Simek et al. 2005). Two findings from these analyses; a female skewed sex ratio and low recapture rates, may suggest that we are underestimating this particular population's home range size due to factors such as using an extrapolated home range estimate (average of Apalachicola and Osceola), behavioral responses to food availability, quality of habitat, and other characteristics. Therefore, the study area used for this analysis may not have been large enough to accurately capture and represent the black bear population in the area.

The area has high quality habitat and is also a corridor to coastal resources. Smith et al. (1998), using a GIS decision-based model, identified habitat along this corridor of U.S. 98 as critical habitat which connects conservation lands along the Big Bend Region with the St. Marks National Wildlife Refuge and Aucilla WMA area. Localized food productivity and the high quality habitat will influence black bear reproduction. With high reproduction, higher roadkill mortality might be expected, especially of the younger age classes. This is illustrated in the demographic data which indicate that a high number of females, juveniles, and cubs are being impacted by roadkill. Other roads in the effective sampling area did not demonstrate a similar spike in roadkill in 2001 as documented on U.S. 98. One roadkill was recorded on SR 59, however this area has not been identified as a principal roadkill area

(Simek et al. in press). U.S. 19 northeast of Aucilla WMA, similar to U.S. 98, has also been identified as a principal roadkill area (Simek et al. in press) and appears to be an area of concern that FDOT may want to consider for mitigation conservation measures for black bear.

Habitat, as a food and cover source, is a factor in influencing black bear crossings in the summer. As the data have demonstrated, pinelands, mixed wetland forest, and intersecting roads contribute to crossing locations in this area. Although elevation did not have an effect along the study interval of U.S. 98, this does not preclude that the interval itself may be lower (i.e., located in low-lying wetlands) than the surrounding area, which may possibly explain the higher number of roadkill along this study interval of U.S. 98.

The results from this study have demonstrated that habitat differences, intersecting roads, and seasons have an effect on black bear crossing rates, however; none of the tested variables had an effect on black bear roadkill. The increased occurrence of crossings at intersections suggests that black bears may be using these roads as travel corridors. Additionally, the lack of correlation between these 2 variables (crossings and intersections) during the Fall, indicates that black bears are traveling throughout the area during this heightened foraging period. These findings are in direct contrast with the results described by McCown et al. (2004) for black bear movement in association with SR 40 in Ocala National Forest. McCown et al. (2004) also found in their study that elevation and road curvature (e.g., SR 40 had a greater degree of curvature than the study interval of U.S. 98) had an effect on black bear roadkill. However, the results of this study failed to demonstrate an effect of any of the tested variables on roadkill. Although not tested in this study, other variables such as driver speed, driver awareness, road congestion, and traffic volume should

be examined as they may be contributing factors. Additionally, there was no relationship between black bear crossings and the number of black bear roadkill along the study interval of U.S. 98. The independence of these two variables may be random or this may further emphasize that other factors are contributing to the occurrence of roadkill.

Previous research has identified the U.S. 98 study interval as a principal roadkill area (Simek et al. in press, Gilbert and Wooding 1996) using roadkill data from 1976 to 2004 and 1976 to 1995 respectively. Additionally, Smith et al. (1998) and Schaefer and Smith (2000) identified segments along the U.S. 98 study interval as high priority highway ecological zones. The results from these studies identify the study interval of U.S. 98 as an area of concern with the most significant priority sites for black bear conservation. The fine-scale approach used in the Aucilla study identifies the entire 9.5km segment of U.S. 98 as having alternating peaks of crossing and roadkill activity. Crossings occurred more frequently during the months of May through August and roadkill occurred more frequently in the Fall. Therefore, the results of this study suggest that mitigation and efforts to minimize roadkill mortality should occur to address bear movement through out the year (seasonally) with specific short term efforts focused in the Fall. Even though crossings occur more frequently during the summer months, crossings did not appear indicative of projected roadkill, and increased roadkill in the Fall may be a result of behavioral factors due to the Fall being a period of increased black bear activity. Additionally, it is important to note that there are unreported cases of black bear roadkill that are not accounted for in these analyses. The CAPTURE Program failed to produce a reliable population estimate; however, the Program selected models based on time and behavior as effects on the population estimate. This

suggest the short study time frame and the apparent habitat use and movement of black bears within this area could be contributing factors.

The low number of black bears captured may suggest a small population however, as discussed before; the limitations of this study may be influencing this result. The percent roadkill impact (4.2%), based on the number of black bears captured (n=48), appears to be relatively high within the limitations of the study; however; it is difficult to determine what level of roadkill this population can sustain due to the lack of a population estimate. Although this percentage is similar to annual roadkill impact documented in the Apalachicola (3.16%, population range: 438-695) and Eglin (3.28%, population range: 63-101) study areas as reported in previous research (Simek et al. 2005), the population numbers among populations may not be comparable. If the generated population estimate was higher, the percent roadkill impact would be lower and would have less of an effect on population viability. However, the data from this study are not robust and therefore, it is difficult to determine the role that roadkill may have on the long term black bear population viability in Aucilla. The density estimate for Aucilla is comparable to the Big Cypress black bear population density (0.97) (Simek et al. 2005); however, the percent roadkill impact is less (1.92%). Therefore, the density, use, and/or type of road(s) may have a greater effect on roadkill rates than the black bear population density.

The Apalachicola and Aucilla black bear populations have diverged genetically from each other (Dixon 2004). Immigration to the Aucilla population is uncertain at this time however, habitat, land use features, and roadkill may be influencing the population structure and isolation from Apalachicola. There may be movement along the Big Bend area or along the drainage basins north to or south from Georgia. As discussed before, U.S. 98 and U.S. 19

have both been identified as principal roadkill areas (Simek et al. in press). This may be further evidence that there is a north or southward movement between the Aucilla area and lands north of Aucilla.

Additionally, several factors such as dispersal, competition, relocation, roadkill, etc. can impact the population structure of bears (Stoen et al. 2005). Roadkill can impact the social structure of wildlife (Paquet and Callaghan 1996), for example by altering dispersal behavior or by removing alpha individuals or certain sex and age classes. This forces a restructure of the distribution of animals on the landscape and the population social hierarchy (Stoen et al. 2005). Home ranges of females and their offspring can shift as a result of roadkill. It is has been documented that adult males will dominate over females and younger age classes (Miller et al. 2003, Koene et al. 2002). Due to the dominant male behavior, younger bears may be forced to move out of resident bear home ranges and therefore may be more susceptible to impact by roadkill. This effect may be compounded when examining lower black bear population numbers and high roadkill mortality rates, therefore, this needs to be taken into account when managing black bear populations.

RECOMMENDATIONS

Therefore, to address elevated crossing and roadkill activity concurrently for all seasons, wildlife crossings should be considered at the 1km-3km and 5.5km-7.5km segments of the study interval of U.S. 98 (Figure 14). FDOT engineers will need to conduct on-site evaluations of these segments to determine whether to install underpasses or overpasses based on the existing environmental conditions (i.e., excess runoff, water inundation, elevation, etc.). Location of the placement of the wildlife crossings is critical to the success

of these crossings (Land and Lotz 1996, Walker and Baber 2003). These structures would facilitate the apparent black bear movement within the Aucilla area and toward coastal resources found in the St. Marks area and adjacent lands. Additionally, these conservation measures may significantly decrease bear mortality, increase driver safety, and benefit multiple species while ensuring connectivity to conservation lands for this expanding population of genetically distinct black bears.

Findings of this study agree with recommendations 8 and 9 identified for FDOT District 3 by Schaefer and Smith (2000). Recommendation 8 suggests replacing the existing box culvert with a wildlife underpass and wildlife fencing 1 mile (1.6km) east of the junction of SR 59/U.S. 98. Recommendation 9 suggests replacing existing pipe culvert with a wildlife underpass 1 mile (1.6km) west of the SR 59/U.S. 98 intersection. As this study has demonstrated that intersecting roads are an effect to crossing behavior by black bears, purchasing land surrounding intersections to reduce development and increase habitat availability for black bears, as suggested by Schaefer and Smith (2000), may facilitate crossings by black bears at intersections. However, manipulating the habitat surrounding intersections may not be beneficial to black bears since intersections have been shown to have an effect on black bear crossings in this study. Increasing black bear crossings at these locations could potentially cause a significant effect of roadkill that was not apparent in this study. In recommendation 7 Schaefer and Smith (2000) recommend installing a black bear wildlife underpass and associated fencing at 2.2 miles (3.5km) east of the SR 59/U.S. 98 intersection on the curve. The Aucilla study and Simek et al. (in press) recognize this segment of U.S. 98 as an area for consideration to reduce black bear mortality. However, due to the seasonal movement of bears, roadkill, the associated frontage, intersecting roads,

and the fact that road curvature does not have an effect on crossings, a recommendation from this study is to place the wildlife crossing centered between 2.0km and 2.9km east of the SR 59/U.S. 98 intersection and install fencing 1.6km east and west of the crossing. Fencing should be at least 3meters above the ground, buried 0.5meter underground, and include a 1 meter barb wire overhang at the top. The segment identified in recommendation number 6 (Schaefer and Smith 2000) would place 2 wildlife bridges/culverts at 0.5mi (0.8km) to 1.3mi (2.1km) west of the Aucilla river. The results from this study however, suggest that road improvement such as wildlife crossings should be centered approximately 6.5km east of SR 59/ U.S. 98 intersection or 3km west of the Aucilla River. In addition, landscape manipulation can be used to direct wildlife species to wildlife crossings, provide connectivity to conservation areas, and deter black bears from approaching roadside segments.

The study interval of U.S. 98 and the segment of U.S. 19 (east of CR 259/U.S. 19 intersection and west of CR 257/U.S. 19 intersection) northeast of Aucilla have a high number of recorded black bear roadkill and are identified principal roadkill areas (Simek et al. in press). Therefore, a recommendation from this study is to address both segments of U.S. 98 and U.S. 19 at the same time with respect to implementing wildlife crossings and roadway improvements. Modifications for U.S. 19 may include extending high level wildlife fencing and replacing small culverts with wildlife underpasses (Schaefer and Smith 2000). Improving both these sections of U.S. 98 and U.S. 19 at the same time would have a greater impact on minimizing bear mortality within the Aucilla and Wacissa drainage basins. SR 59 has not been identified as a principal roadkill area and currently has few recorded roadkill bear. However, if development and improved road networks are planned for this area, precautions and mitigation measures for wildlife, and especially the black bear, must be

taken into account on all roads in the area (i.e., direct impacts, cumulative effects, and secondary effects).

A recommendation to address the correlation of intersecting roads and black bear crossings is to implement visual stimuli such as caution lights and signs at intersections (Figure 13). Any existing signs along the study interval should be updated and missing signs should be replaced. This would be beneficial to warn drivers of the occurrence of black bear crossings. In addition, signs and reduced speed zones should be implemented at segments of the road where roadkill occurs as identified in Figure 13. In the Fall temporary variable message boards can be employed to alert drivers to heightened black bear activity.

Findings and recommendations from this report can assist FDOT with the current replacement of the Aucilla River Bridge Project and future projected road manipulation projects. FDOT can use models such as Smith et al. (1998) to integrate FDOT road projects with state conservation lands and greenway projects, scenic byway developments, FWC species and habitat management goals, etc., as well as minimize impacts on black bears and other wildlife species and determine projected mitigation requirements. FDOT should take a proactive role in considering long term plans in this area as no land changes are currently planned to connect conservation lands.

A final recommendation would be to repeat this study for a minimum of 2 years as well as genetically analyze the remaining hair samples from this original study. Further study should encompass a larger area and include habitat north and south of both U.S. 98 and U.S. 19 to document black bear movements in this localized corridor relative to these major roadways.

LITERATURE CITED

Dixon, J. D. 2004. Conservation genetics of the Florida black bear. Thesis. University of Florida, Gainesville, FL.

Dobey, S., D. V. Masters, B. K. Scheick, J. D. Clark, M. R. Pelton, and M. Sunquist. 2002. Population ecology of black bears in the Okefenokee-Osceola ecosystem. Final Report.

Eason, T. H., S. L. Simek, and D. Zeigler. 2001. Statewide assessment of road impacts on bears in Florida. Research Work Plan. Florida Fish and Wildlife Conservation Commission.

Endries, M., T. Gilbert, and R. Kautz. 2003. Mapping wildlife needs in Florida: The integrated wildlife habitat ranking system. Proceedings of the International Conference on Ecology and Transportation, Lake Placid, NY. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC.

Florida Fish and Wildlife Conservation Commission. 2004. Florida vegetation and land cover-2003: GIS data CD. Office of Environmental Services.

Florida Fish and Wildlife Conservation Commission. 2001. Integrated wildlife habitat ranking system project CD. Office of Environmental Services.

Foran, D., S. Minta, and K. Heinemeyer. 1997. DNA-based analysis of hair to identify species and individuals for population research and monitoring. *Wildlife Society Bulletin* 25(4):840-847.

Gilbert, T., R. Kautz, T. Eason, R. Kawula, and C. Morea. 2001. Prioritization of statewide black bear roadkill problem areas in Florida. Proceedings of the International Conference on Ecology and Transportation, Keystone, CO. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC. pp574-579.

Gilbert., T and J. Wooding. 1994. Chronic Roadkill Problem Areas for Black Bear in Florida. Florida Game and Fresh Water Fish Commission.

Gilbert, T. and J. Wooding. 1996. An overview of black bear roadkills in Florida 1976-1995. Florida Game and Fresh Water Fish Commission.

Harrell, F.E. 2001. Regression Modeling Strategies: with Applications to Linear Models, Logistic Regression, and Survival Analysis. Springer-Verlag New York, Inc., New York.

Hollander, M. and D.A. Wolfe. 1973. Nonparametric Statistical Methods. John Wiley & Sons, Inc., New York.

Koene, P., J. Ardesch, A. Ludriks, E. Urff, L. Wenzelides, and, V. Wittenberg. 2002. Interspecific and intrasepcific social interactions among brown bears and wolves in an enclosure. *Ursus:* 13: 85-93.

Land, E.D. and M. Lotz. 1996. Wildlife crossing designs and use by Florida panthers and other wildlife in Southwest Florida. Proceedings of the transportation related wildlife mortality seminar. FDOT Environmental Office, Tallahassee, Florida.

Land, E.D., D. S. Maehr, J. C. Roof, and J. W. McCown. 1994. Southwest Florida black bear distribution, movements, and conservation strategies. Florida Game and Fresh Water Fish Commission, Tallahassee.

McCown, W., P. Kubilis, T. Eason, and B. Scheick. 2004. Black bear movements and habitat use relative to roads in Ocala National Forest. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, Final Report. FDOT Contract # BD-016.

McCown, J.W., T.H. Eason, and M.W. Cunningham. 2001. Black bear movements and habitat use relative to roads in Ocala National Forest. Final Report. Fl. Fish and Wildlife Conservation Commission. Tallahassee.

Miller, S. D., R.A. Sellers, and J.A. Keay. 2003. Effects of hunting on brown bear cub survival and litter size in Alaska. *Ursus* 14(2):130-152.

Paetkau D. 2004. The optimal number of markers in genetic mark-recapture studies. Journal of Wildlife Management 68: 449452.

Paquet, P. and C. Callaghan. 1996. Effects of linear developments on winter movements of gray wolves in the Bow River Valley of Banff National Park, Alberta. Proceedings of the transportation related wildlife mortality seminar. FDOT Environmental Office, Tallahassee, Florida.

Pollock, K. H., J. D. Nichols, C. Brownie, and J. E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildlife Monograph 107. .

Roof, J. and J. Wooding. 1996. Evaluation of S.R. 46 wildlife crossing. Florida Cooperative Fish and Wildlife Research Unit, U. S. Biological Service Technical Report No. 54.

Rosner, B. 1995. Fundamentals of Biostatistics (4th edition). Duxbury Press, New York.

Ruediger, B., J. Claar, and J. Gore. 1999. Restoration of carnivore habitat connectivity in the Northern Rockies. Proceedings of the International Conference on Ecology and Transportation, Missoula, MT. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC.

Schaefer, J.M. and D.J. Smith. 2000. Ecological characterization of identified high priority highway-ecological interface zones including the inventory and evaluation of existing Florida Department of Transportation highway facilities within these zones. Final report, contract no. B-B120, task #1 (amendment no. 3). Florida Department of Transportation, Tallahassee, FL.

Seibert, S. 1993. Status and management of black bears in Apalachicola National Forest. Final Report, Study 7551. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Servheen, C., R. Shoemaker, and L. Lawrence. 2003. A sampling of wildlife use in relation to structure variables for bridges and culverts under I-90 between Alberton and St. Regis, Montana. Proceedings of the International Conference on Ecology and Transportation, Lake Placid, NY. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC. P331-352.

Serveheen, C, J. Waller, and W. Kasworm. 1998. Fragmentation effects of high speed highways on Grizzly bear populations shared between the United States and Canada. Proceedings of the International Conference on Ecology and Transportation, Ft. Myers, Fl. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC.

Simek, S.L., S.A. Jonker, and M.J. Endries. In press. Evaluation of principal roadkill areas for Florida black bear. Proceedings of the International Conference on Ecology and Transportation, San Diego, CA. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC.

Simek, S.L., S.A. Jonker, B.K. Scheick, M.J. Endries, and T.H. Eason. 2005. Statewide assessment of road impacts on bears in six study areas in Florida from May 2001-Septemebr 20003. Final Report Contract BC-972, completed for the Florida Department of Transportation and Florida Fish and Wildlife Conservation Commission.

Smith, D.J., L.D. Harris, and F.J. Mazzotti. 1998. Highway-wildlife relationships (development of a decision-based wildlife underpass road project prioritization model on GIS with statewide application). Final Report FDOT Contract Number B9943.

Stoen, O.G., E. Bellemain, S. Saebo, and J. E. Swenson. 2005. Kin-related spatial structure in brown bears (*Ursus arctos*). Presentation/abstract 16th International Conference on Research and Management. Riva del Garda, Italy. September 27-October 1.

Transportation Research Institute, 1997. Stopping sight distance and decision sight distance. Discussion Paper No. 8A, Oregon Department of Transportation, Salem OR.

Walker, G. and J.A. Baber. 2003. Wildlife use and interactions with structures constructed to minimize vehicle collisions and animal mortality along State Road 46, Lake County, Florida. Final Report for FDOT Contract Number BD162.

White, G. C., D. R. Anderson, K. P. Burnham, and D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, LA 8787-NERP, Los Alamos, New Mexico, USA.

White, G. C., K. P. Burnham, D.L. Otis, and D. R. Anderson. 1978. User's Manual for Program CAPTURE. Utah State University Press, Logan, Utah.

Wooding, J. and T. Hardisky. 1988. Black bear habitat study. Final Performance Report, Study Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Table 1. Minimum grid area and associated parameters required to sample a minimum of 50 black bears for the Aucilla black bear populations in Jefferson County, Florida.

	Average summer home range	Estimated density per km[1]	Minimum Length (km)[2]	Maximum Grid Cell	Female Summer Home Range Radius (km)[1]
Aucilla	5.64	0.097	22.15	4.15	3.35

1. Derived from Dobey et al. (2002) and Siebert (1993)

2. Calculated using equation: $D \leq \sqrt{2} \times W$

3. Calculated using equation $L = \sqrt{0.8584(W_o)^2 + \frac{N}{D}} - 2W_o$

Where: D = best estimate of bear density in area,
L = length of grid row and column,
N = 50 bears (recommended minimum needed), and
W_o= average bear summer home range radius.

.

Table 2. U.S. 98 road features, crossing rates, and roadkill rates summarized by 250m section in the Aucilla study area in Jefferson County, Florida.

Section	Meters East of SR-59	Mean Elevation (meter)	Mean Relative Curvature (degree)		Intersecting Roads	Meters of Frontage on US-98 by Habitat Type				Dominant Habitat	# of crossings and crossings per month								# of Roadkills and Roadkills per Decade	
											All Seasons		Winter		Summer		Fall		All Seasons	
			W-E	E-W		PL	CS	MWF	HS		N	Rate	N	Rate	N	Rate	N	Rate	N	Rate
1	1 - 250	5	0.00	0.00	N	500	0	0	0	PL	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	251 - 500	5	0.00	0.00	Y	500	0	0	0	PL	2	0.22	0	0.00	2	0.87	0	0.00	0	0.00
3	501 - 750	5	0.00	0.00	N	500	0	0	0	PL	2	0.22	0	0.00	2	0.87	0	0.00	0	0.00
4	751 - 1000	5	0.00	0.00	N	377	123	0	0	PL	1	0.11	0	0.00	0	0.00	1	0.31	0	0.00
5	1001 - 1250	5	0.00	0.00	Y	500	0	0	0	PL	1	0.11	0	0.00	1	0.43	0	0.00	0	0.00
6	1251 - 1500	5	0.00	0.00	N	500	0	0	0	PL	5	0.56	0	0.00	4	1.74	1	0.31	0	0.00
7	1501 - 1750	5	0.00	0.00	N	500	0	0	0	PL	5	0.56	0	0.00	5	2.17	0	0.00	4	1.89
8	1751 - 2000	5	0.00	0.00	N	500	0	0	0	PL	8	0.89	0	0.00	4	1.74	4	1.23	0	0.00

Table 2 continued. U.S. 98 road features, crossing rates, and roadkill rates summarized by 250m section in the Aucilla study area in Jefferson County, Florida.

Section	Meters East of SR-59	Mean Elevation (meter)	Mean Relative Curvature (degree)		Intersecting Roads	Meters of Frontage on US-98 by Habitat Type				Dominant Habitat	# of crossings and crossings per month								# of Roadkills and Roadkills per Decade	
											All Seasons		Winter		Summer		Fall		All Seasons	
			W-E	E-W		PL	CS	MWF	HS		N	Rate	N	Rate	N	Rate	N	Rate	N	Rate
9	2001 - 2250	5	0.00	0.00	Y	500	0	0	0	PL	2	0.22	1	0.29	1	0.43	0	0.00	0	0.00
10	2251 - 2500	5	1.45	0.91	Y	402	98	0	0	PL	1	0.11	0	0.00	1	0.43	0	0.00	2	0.94
11	2501 - 2750	5	1.90	1.54	N	116	116	0	268	HS	5	0.56	0	0.00	1	0.43	4	1.23	0	0.00
12	2751 - 3000	5	1.50	1.83	N	0	0	0	500	HS	3	0.33	0	0.00	2	0.87	1	0.31	1	0.47
13	3001 - 3250	5	1.62	2.14	N	366	0	0	134	PL	1	0.11	0	0.00	0	0.00	1	0.31	2	0.94
14	3251 - 3500	5	1.71	1.65	N	500	0	0	0	PL	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
15	3501 - 3750	5	1.40	1.28	Y	500	0	0	0	PL	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
16	3751 - 4000	5	1.43	1.48	N	413	0	87	0	PL	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Table 2 continued. U.S. 98 road features, crossing rates, and roadkill rates summarized by 250m section in the Aucilla study area in Jefferson County, Florida.

Section	Meters East of SR-59	Mean Elevation (meter)	Mean Relative Curvature (degree)		Intersecting Roads	Meters of Frontage on US-98 by Habitat Type				Dominant Habitat	# of crossings and crossings per month								# of Roadkills and Roadkills per Decade	
											All Seasons		Winter		Summer		Fall		All Seasons	
			W-E	E-W		PL	CS	MWF	HS		N	Rate	N	Rate	N	Rate	N	Rate	N	Rate
17	4001 - 4250	5	1.63	1.82	N	250	0	185	65	PL	1	0.11	0	0.00	1	0.43	0	0.00	0	0.00
18	4251 - 4500	5	0.00	0.00	N	71	0	0	429	HS	0	0.00	0	0.00	0	0.00	0	0.00	2	0.94
19	4501 - 4750	4	0.18	0.18	Y	0	0	0	500	HS	1	0.11	0	0.00	1	0.43	0	0.00	1	0.47
20	4751 - 5000	4	0.00	0.00	N	0	0	0	500	HS	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
21	5001 - 5250	3	0.00	0.00	Y	444	0	0	56	PL	1	0.11	0	0.00	1	0.43	0	0.00	0	0.00
22	5251 - 5500	3	0.00	0.00	Y	500	0	0	0	PL	2	0.22	1	0.29	1	0.43	0	0.00	0	0.00
23	5501 - 5750	3	0.23	0.00	N	500	0	0	0	PL	2	0.22	0	0.00	1	0.43	1	0.31	1	0.47
24	5751 - 6000	3	2.33	1.56	Y	500	0	0	0	PL	7	0.78	1	0.29	1	0.43	5	1.54	0	0.00

Table 2 continued. U.S. 98 road features, crossing rates, and roadkill rates summarized by 250m section in the Aucilla study area in Jefferson County, Florida.

Section	Meters East of SR-59	Mean Elevation (meter)	Mean Relative Curvature (degree)		Intersecting Roads	Meters of Frontage on US-98 by Habitat Type				Dominant Habitat	# of crossings and crossings per month								# of Roadkills and Roadkills per Decade	
											All Seasons		Winter		Summer		Fall		All Seasons	
			W-E	E-W		PL	CS	MWF	HS		N	Rate	N	Rate	N	Rate	N	Rate	N	Rate
25	6001 - 6250	3	1.15	2.15	Y	160	0	340	0	MWF	18	2.01	17	4.98	1	0.43	0	0.00	1	0.47
26	6251 - 6500	3	2.03	1.20	N	0	0	500	0	MWF	2	0.22	0	0.00	2	0.87	0	0.00	5	2.36
27	6501 - 6750	3	1.40	1.94	N	0	0	436	64	MWF	4	0.45	0	0.00	2	0.87	2	0.61	0	0.00
28	6751 - 7000	3	0.87	1.17	Y	0	0	0	500	HS	3	0.33	0	0.00	2	0.87	1	0.31	0	0.00
29	7001 - 7250	3	0.00	0.00	Y	0	0	0	500	HS	1	0.11	0	0.00	0	0.00	1	0.31	0	0.00
30	7251 - 7500	3	0.00	0.00	N	0	0	0	500	HS	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
31	7501 - 7750	3	0.00	0.00	N	0	0	0	500	HS	5	0.56	0	0.00	0	0.00	5	1.54	0	0.00
32	7751 - 8000	3	0.00	0.00	N	0	0	0	500	HS	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Table 2 continued. U.S. 98 road features, crossing rates, and roadkill rates summarized by 250m section in the Aucilla study area in Jefferson County, Florida.

Section	Meters East of SR-59	Mean Elevation (meter)	Mean Relative Curvature (degree)		Intersecting Roads	Meters of Frontage on US-98 by Habitat Type				Dominant Habitat	# of crossings and crossings per month								# of Roadkills and Roadkills per Decade	
											All Seasons		Winter		Summer		Fall		All Seasons	
			W-E	E-W		PL	CS	MWF	HS		N	Rate	N	Rate	N	Rate	N	Rate	N	Rate
33	8001 - 8250	3	0.00	0.00	N	0	0	0	500	HS	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
34	8251 - 8500	3	0.00	0.00	Y	0	0	0	500	HS	1	0.11	1	0.29	0	0.00	0	0.00	1	0.47
35	8501 - 8750	3	0.00	0.00	N	0	0	0	500	HS	0	0.00	0	0.00	0	0.00	0	0.00	1	0.47
36	8751 - 9000	3	0.00	0.00	N	0	0	0	500	HS	1	0.11	0	0.00	0	0.00	1	0.31	0	0.00
37	9001 - 9250	3	0.00	0.00	N	0	0	0	500	HS	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
38	9251 - 9500	3	0.07	0.00	N	0	0	408	92	MWF	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

W – West
E - East
PL – pinelands
CS - cypress swamp
MWF - mixed wetland forest
HS - hardwood swamp
Winter - January to April
Summer - May to August
Fall - September to December

Table 3. Association between quantitative road features and 250m section crossing or roadkill rates in the Aucilla study area in Jefferson County, Florida.

		Monthly Crossing Rate				Roadkill Per Decade
Predictor	**Statistic**	**All Seasons**	**Winter**	**Summer**	**Fall**	**All Seasons**
Elevation	Spearman R[1]	0.03	-0.26	0.26	-0.12	-0.01
	P-value[2]	0.868	0.115	0.115	0.465	0.978
Curvature (W to E)	Spearman R[1]	0.22	0.09	0.20	0.20	0.24
	P-value[2]	0.194	0.572	0.232	0.235	0.154
Curvature (E to W)	Spearman R[1]	0.20	0.09	0.16	0.18	0.20
	P-value[2]	0.221	0.608	0.340	0.281	0.218
Monthly Crossing Rate	Spearman R[1]	--	--	--	--	0.11
	P-value[2]	--	--	--	--	0.503

1. Spearman R = Spearman rank correlation coefficient
2. P-value = P-value for a test that the Spearman equals 0

Table 4. Association between quantitative road features and the probability of observing at least 1 crossing or at least 1 roadkill in 250m section in the Aucilla study area in Jefferson County, Florida.

Predictor	Statistic	1+ Crossing per 250m Section				1+ Roadkill Per 250m Section
		All Seasons	Winter	Summer	Fall	All Seasons
Elevation	Odds Ratio[1]	1.17	0.43	1.45	0.86	0.99
	P-value[2]	0.660	0.123	0.266	0.661	0.983
Curvature (W to E)	Odds Ratio[1]	1.57	1.31	2.02	1.69	1.56
	P-value[2]	0.361	0.646	0.118	0.228	0.322
Curvature (E to W)	Odds Ratio[1]	1.60	1.40	1.83	1.77	1.61
	P-value[2]	0.333	0.554	0.167	0.182	0.278

1. Odds Ratio = factor change in the odds of a section having at least 1 crossing or at least 1 roadkill per unit increase in the predictor
2. P-value – Logistic regression score test p-value for association between the predictor and the probability of a section having at least 1 crossing or at least 1 roadkill

Table 5. Comparison of black bear crossing and roadkill rates among groups of 250m sections defined by various characteristics of the U.S. 98 study interval in Jefferson County, Florida.

Section Category	N	Crossings per month												Roadkill per Decade		
		All Seasons			Winter			Summer			Fall			All Seasons		
		Mean	(SE)	Median	Mean	(SE)	Median	Mean	(SE)	Median	Mean	(SE)	Median	Mean	(SE)	Median
Roads Y	25	0.34	(0.15)	0.11	0.47	(0.37)	0.00	0.40	(0.08)	0.43	0.17	(0.12)	0.00	0.18	(0.09)	0.00
Roads N	13	0.20	(0.05)	0.11	0.00	(0.00)	0.00	0.42	(0.13)	0.00	0.26	(0.09)	0.00	0.30	(0.12)	0.00
WRS P-value[1]			0.234			0.003			0.302			0.373			1.000	
Pinelands	19	0.24	(0.06)	0.11	0.05	(0.03)	0.00	0.57	(0.15)	0.43	0.21	(0.10)	0.00	0.22	(0.12)	0.00
Mixed WL Forest	15	0.67	(0.46)	0.33	1.24	(1.24)	0.00	0.54	(0.21)	0.65	0.15	(0.15)	0.00	0.71	(0.56)	0.24
Hardwood Swamp (HS)	4	0.15	(0.05)	0.11	0.02	(0.02)	0.00	0.17	(0.08)	0.00	0.27	(0.12)	0.00	1.19	(0.08)	0.00
K-W P-value[2]			0.229			0.500			0.044			0.873			0.547	
Non-HS – Roads	14	…	(…)	…	…	(…)	…	0.65	(0.20)	0.43	…	(…)	…	…	(…)	…
HS –Roads	11	…	(…)	…	…	(…)	…	0.12	(0.08)	0.00	…	(…)	…	…	(…)	…
Non HS + Roads	9	…	(…)	…	…	(…)	…	0.43	(0.07)	0.43	…	(…)	…	…	(…)	…
HS + Roads	4	…	(…)	…	…	(…)	…	0.33	0.21	0.22	…	…	…	…	(…)	…
K-W P-value[2]			…			…			0.078			…			…	
1 + Crossings	26	…	(…)	…	…	(…)	…	…	(…)	…	…	(…)	…	0.12	(0.12)	0.00
0 Crossings	12	…	(…)	…	…	(…)	…	…	(…)	…	…	(…)	…	0.33	(0.08)	0.00
WRS P-value[1]			…			…			…			…			0.039	

1. WRS P-value = Wilcoxon rank sum test p-value for a test of ordinal difference in rates between 2 groups
2. K-W P-value = Kruskal-Wallis rank sum test P-value for a test of ordinal difference in rates among 3 or more groups

Table 6. Comparison of the percent of 250m sections having at least 1 black bear crossing or at least 1 roadkill among groups of sections defined by various characteristics of the U.S. 98 study interval in Jefferson County, Florida.

	Percent and Fraction of 250m Sections with:									
	1 + Crossings								**1+ Roadkills**	
	All Seasons		**Winter**		**Summer**		**Fall**		**All Seasons**	
Section Category	**% Fraction**		**% Fraction**		**% Fraction**		**% Fraction**		**% Fraction**	
Roads Y	92.3	(12/13)	38.5	(5/13)	76.9	(10/13)	23.1	(3/13)	30.8	(4/13)
Roads N	56.0	(14/25)	0.0	(0/25)	40.0	(10/25)	40.0	(10/25)	28.0	(7/25)
FXT P-value[1]	0.030		0.003		0.043		0.473		1.000	
Pinelands	79.0	(15/19)	15.8	(3/19)	68.4	(13/19)	31.6	(6/19)	21.1	(4/19)
Mixed WL Forest	75.0	(3/4)	25.0	(1/4)	75.0	(3/4)	25.0	(1/4)	50.0	(2/4)
Hardwood Swamp	53.3	(8/15)	6.7	(1/15)	26.7	(4/15)	40.0	(6/15)	33.3	(5/15)
FXT P-value[1]	0.244		0.500		0.036		0.888		0.412	
Non-HS – Roads	…	(…)	…	(…)	57.1	(8/14)	…	(…)	…	(…)
HS –Roads	…	(…)	…	(…)	18.2	(2/11)	…	(…)	…	(…)
Non HS + Roads	…	(…)	…	(…)	88.9	(8/9)	…	(…)	…	(…)
HS + Roads	…	(…)	…	(…)	50.0	(2/4)	…	(…)	…	(…)
FXT P-value[1]	…		…		0.013		…		…	
1 + Crossings	…	(…)	…	(…)	…	(…)	…	(…)	34.6	(9/26)
0 Crossings	…	(…)	…	(…)	…	(…)	…	(…)	16.7	(2.12)
FXT P-value[1]	…		…		…		…		0.444	

1. FXT P-Value = Fisher exact test P-value for a test of difference between proportions

Table 7. Comparison of 250m section monthly crossing rates among black bear activity seasons in the Aucilla study area in Jefferson County, Florida

Bear Activity Season	**N**	**Mean**	**(SE)**	**Median**
Winter	38	0.16	(0.13)	0.00
Summer	38	0.41	(0.09)	0.43
Fall	38	0.23	(0.07)	0.00
FRS P- Value[1]		0.0003		

All Seasons	**N**	**Mean**	**(SE)**	**Median**
Crossings/month	38	0.25	(0.06)	0.11
Roadkills/decade	38	0.26	(0.09)	0.00

1. FRS P-Value = Friedman rank sum test p-value for a test of ordinal difference among groups defined by bear activity season

Table 8. Number of Florida black bear roadkill by sex and age class for the Aucilla study area in Jefferson County, Florida from September 1983 through December 2004.

Population	Female Adult	Female Juvenile	Female Cub	Male Adult	Male Juvenile	Male Cub	Adult / Unknown Sex	Female / Unknown Age	Male / Unknown Age	Total
Aucilla	7	6	3	1	5	4	1	1	0	28
Total	**7**	**6**	**3**	**1**	**5**	**4**	**1**	**1**	**0**	**28**

Figure 1. Location of Aucilla study area in Jefferson County, Florida during May 2001-September 2003.

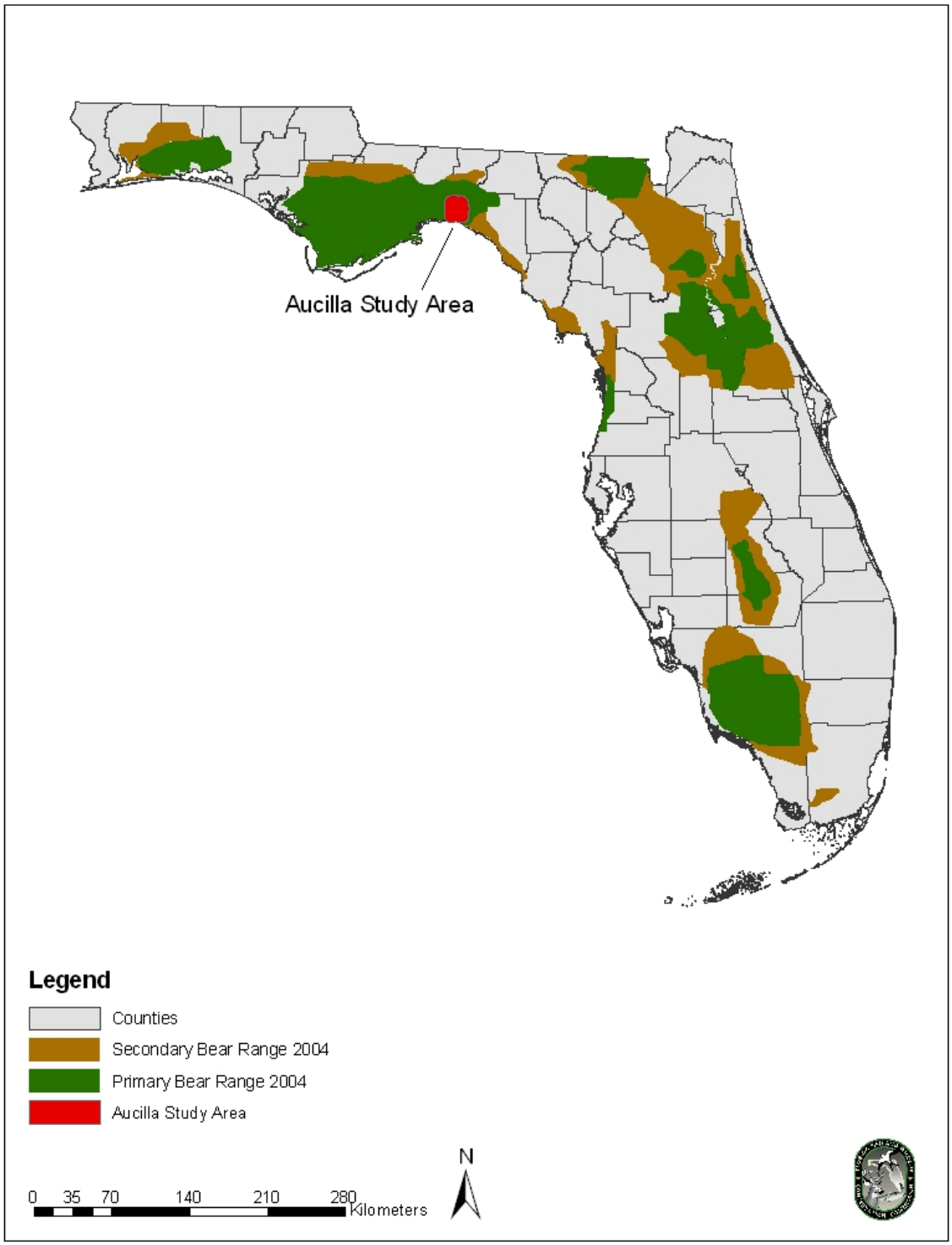


Figure 2. Diagram of barbed wire hair snare enclosure used to collect black bear hair samples.

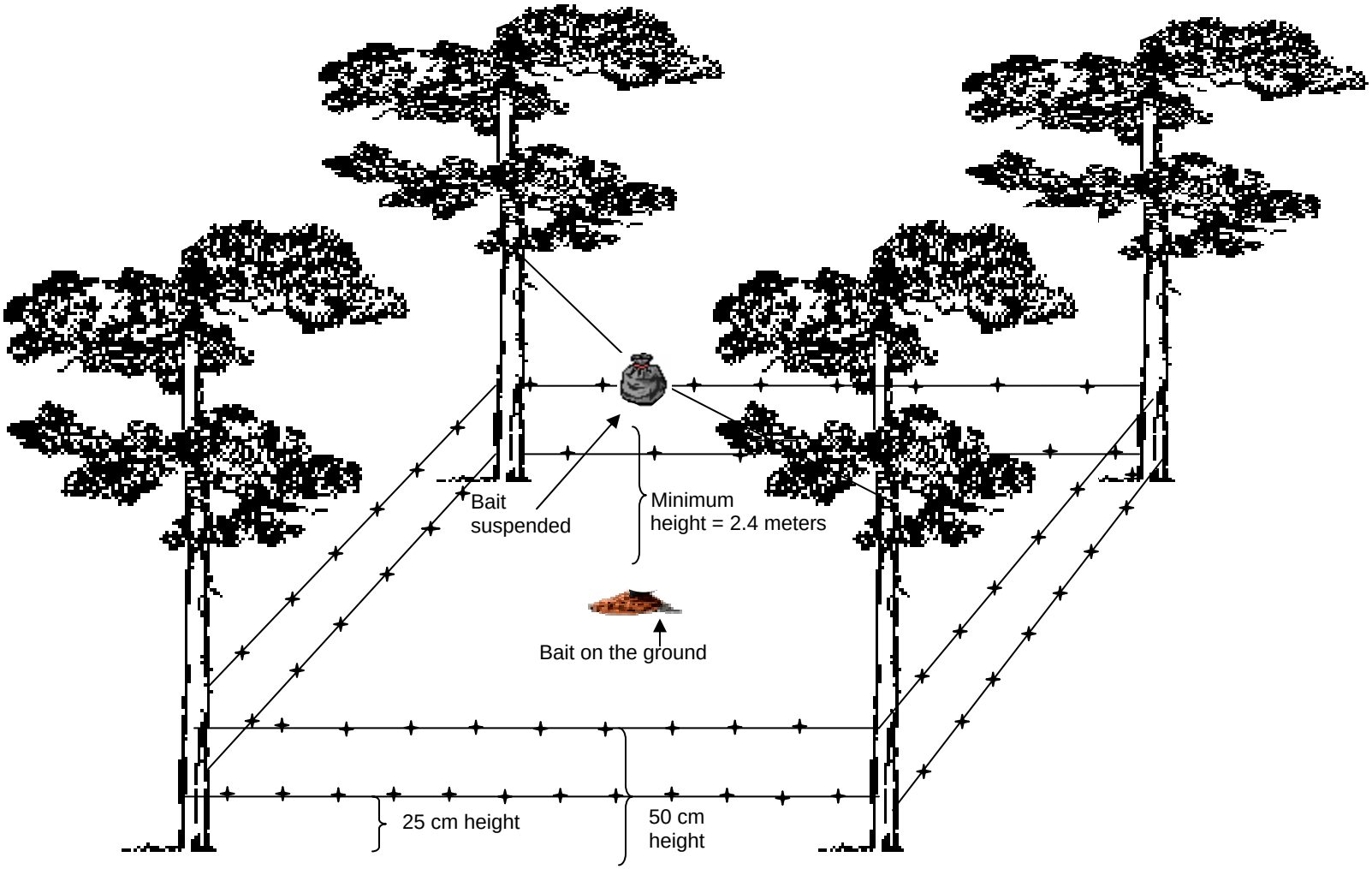


Figure 3. Locations of black bear population and crossing hair snares in the Aucilla study area in Jefferson County, Florida from May 2003-May 2004.

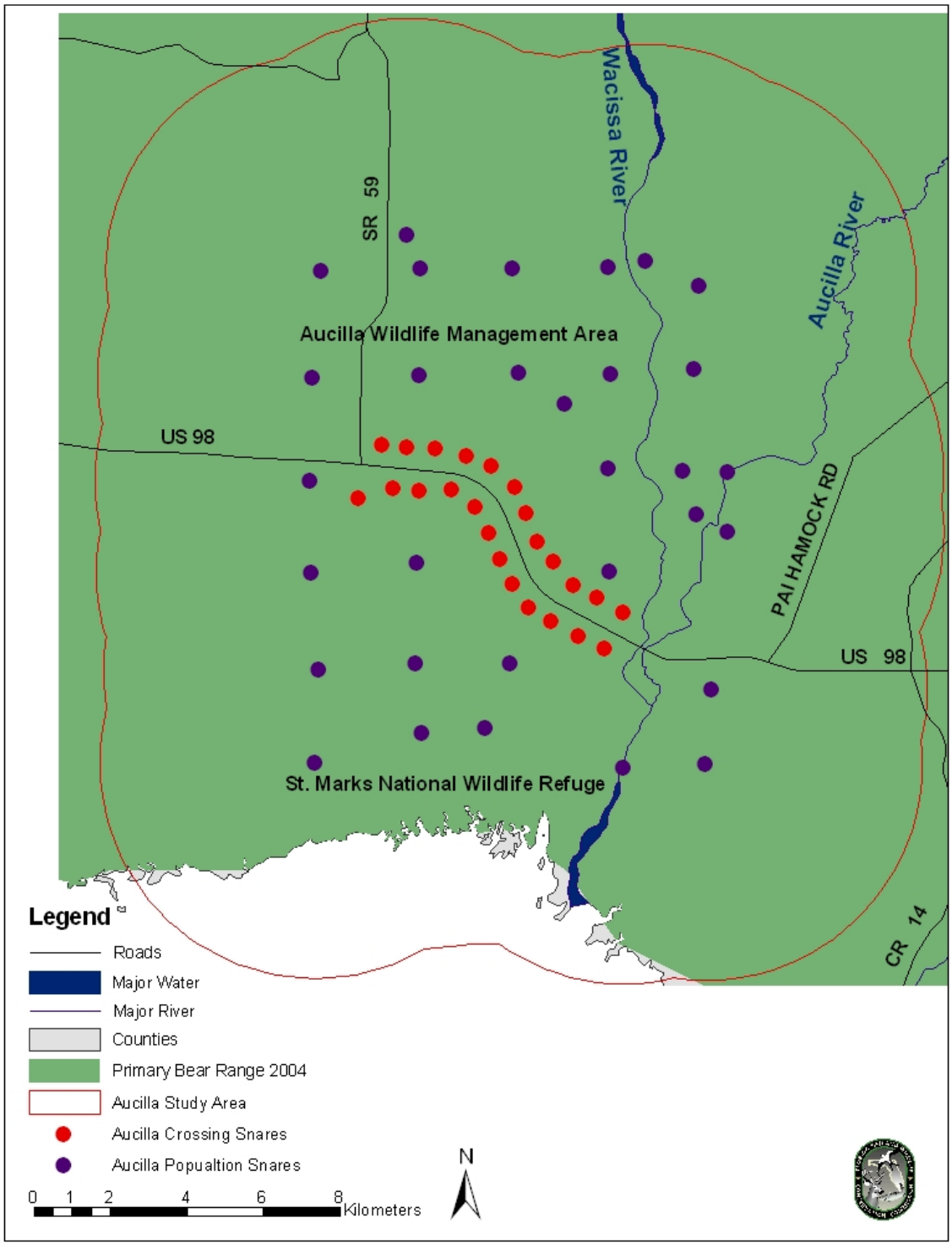


Figure 4. Florida black bear crossings per month along U.S. 98 in Jefferson County, Florida during all activity seasons combined from May 2003-May 2004

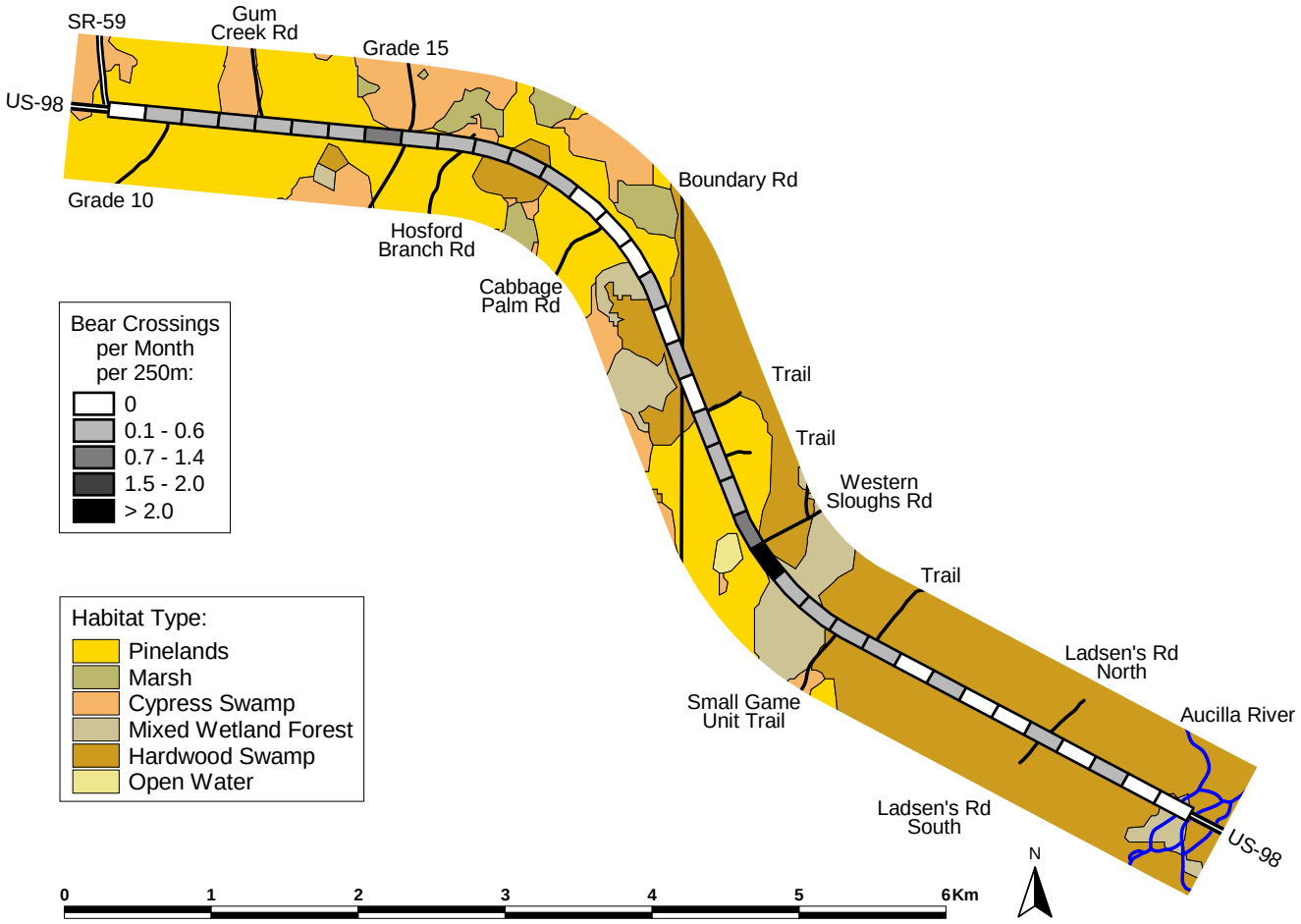


Figure 5. Florida black bear crossings per month along U.S. 98 in Jefferson County, Florida during the winter activity season (January 1-April 30).

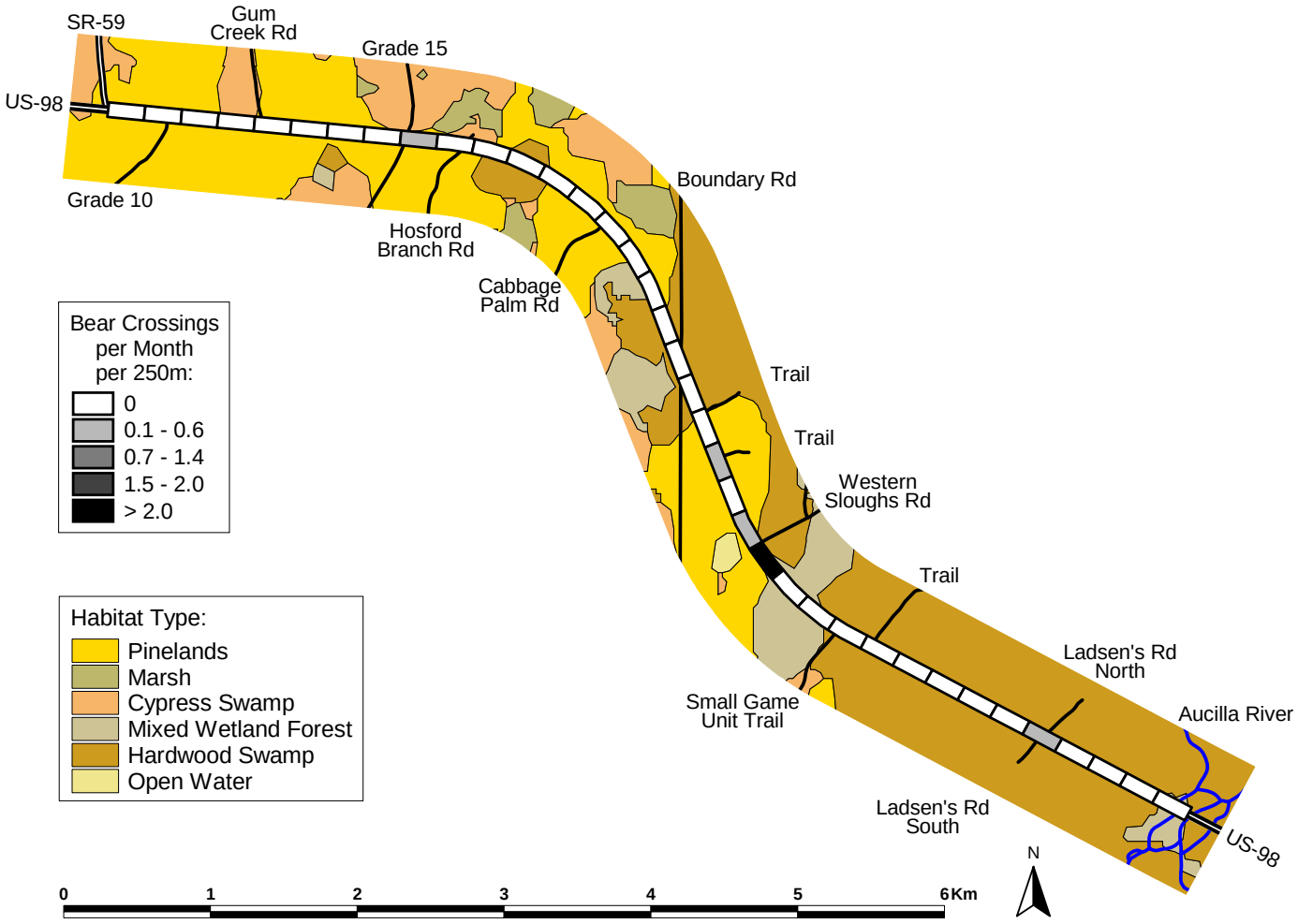


Figure 6. Florida black bear crossings per month along U.S. 98 in Jefferson County, Florida during the summer activity season (May 1 – August 31).

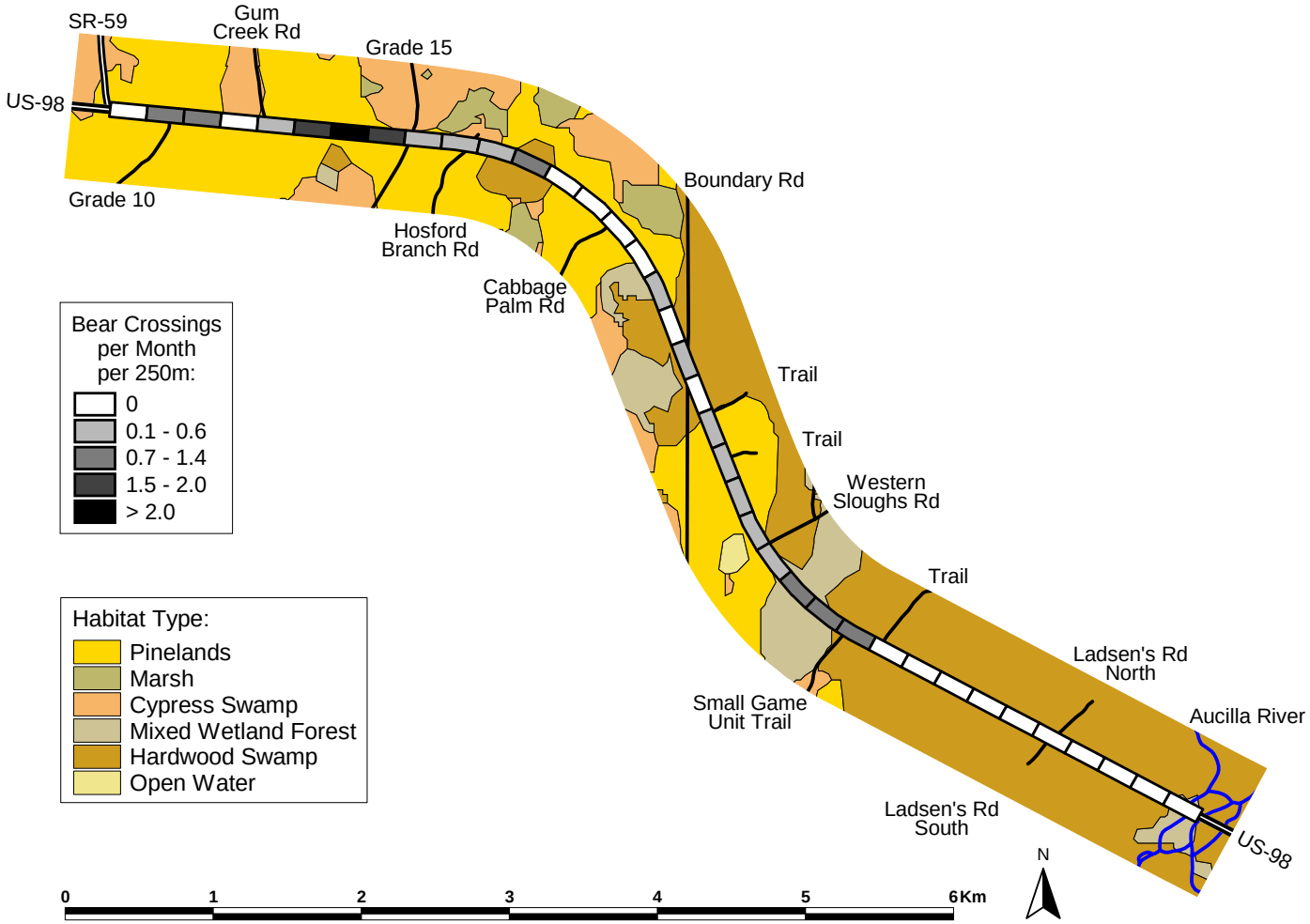


Figure 7. Florida black bear crossings per month along U.S. 98 in Jefferson County, Florida during the fall activity season (September 1 – December 31).

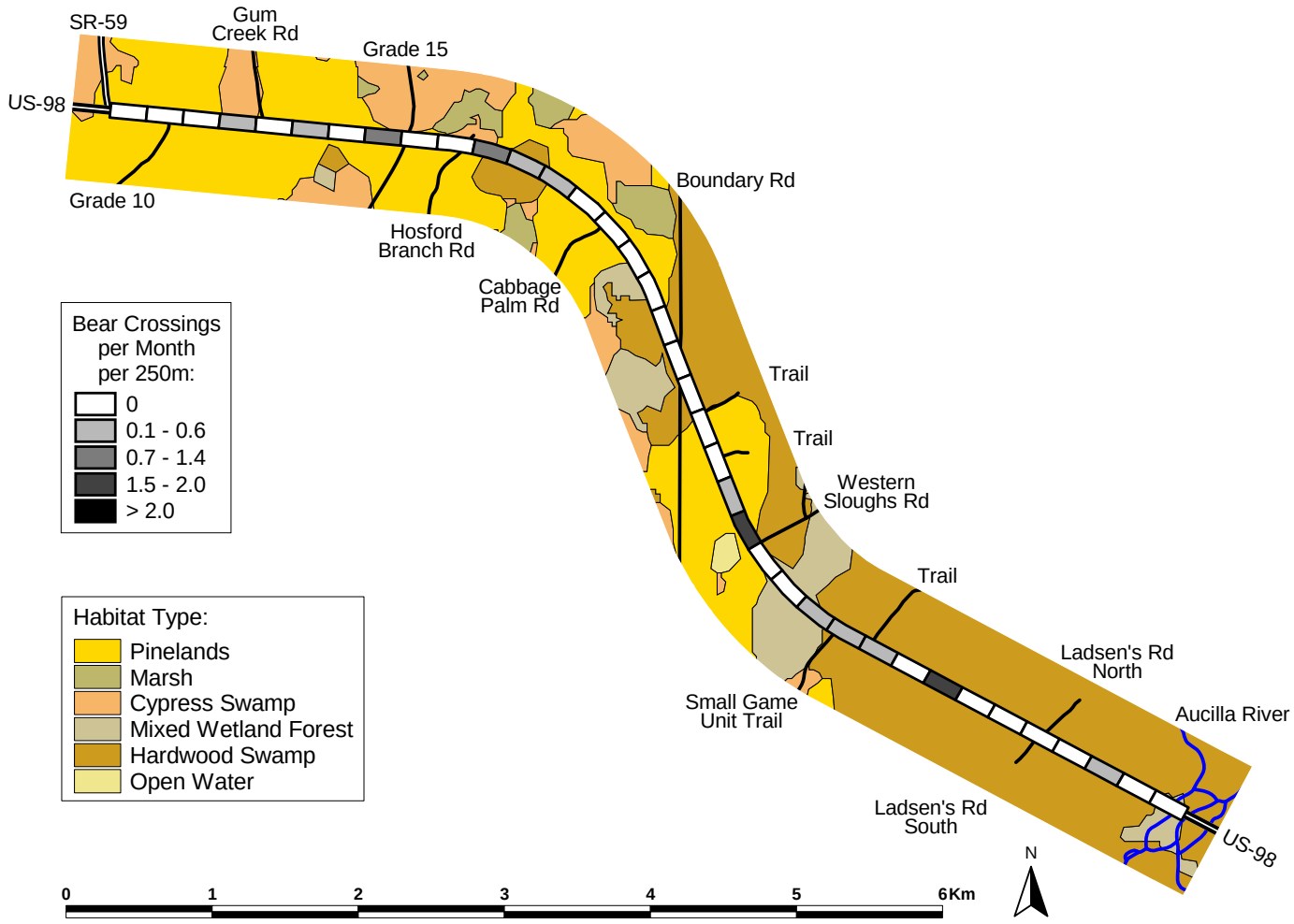


Figure 8. Florida black bear crossings per month along U.S. 98 in Jefferson County, Florida during all activity seasons combined from 1983-2004.

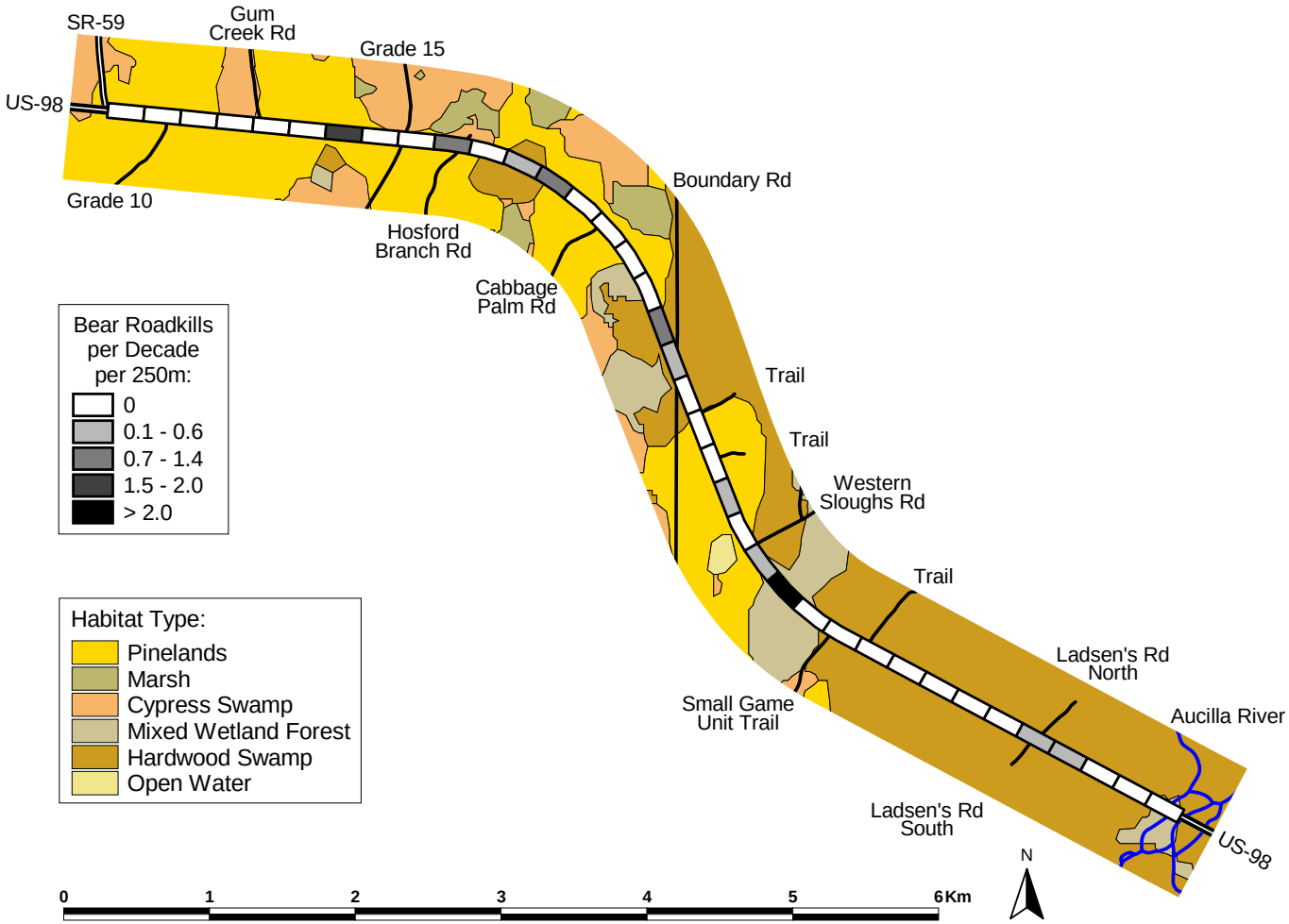


Figure 9. Population hair snares successfully frequented by black bears in the Aucilla study area in Jefferson County, Florida.

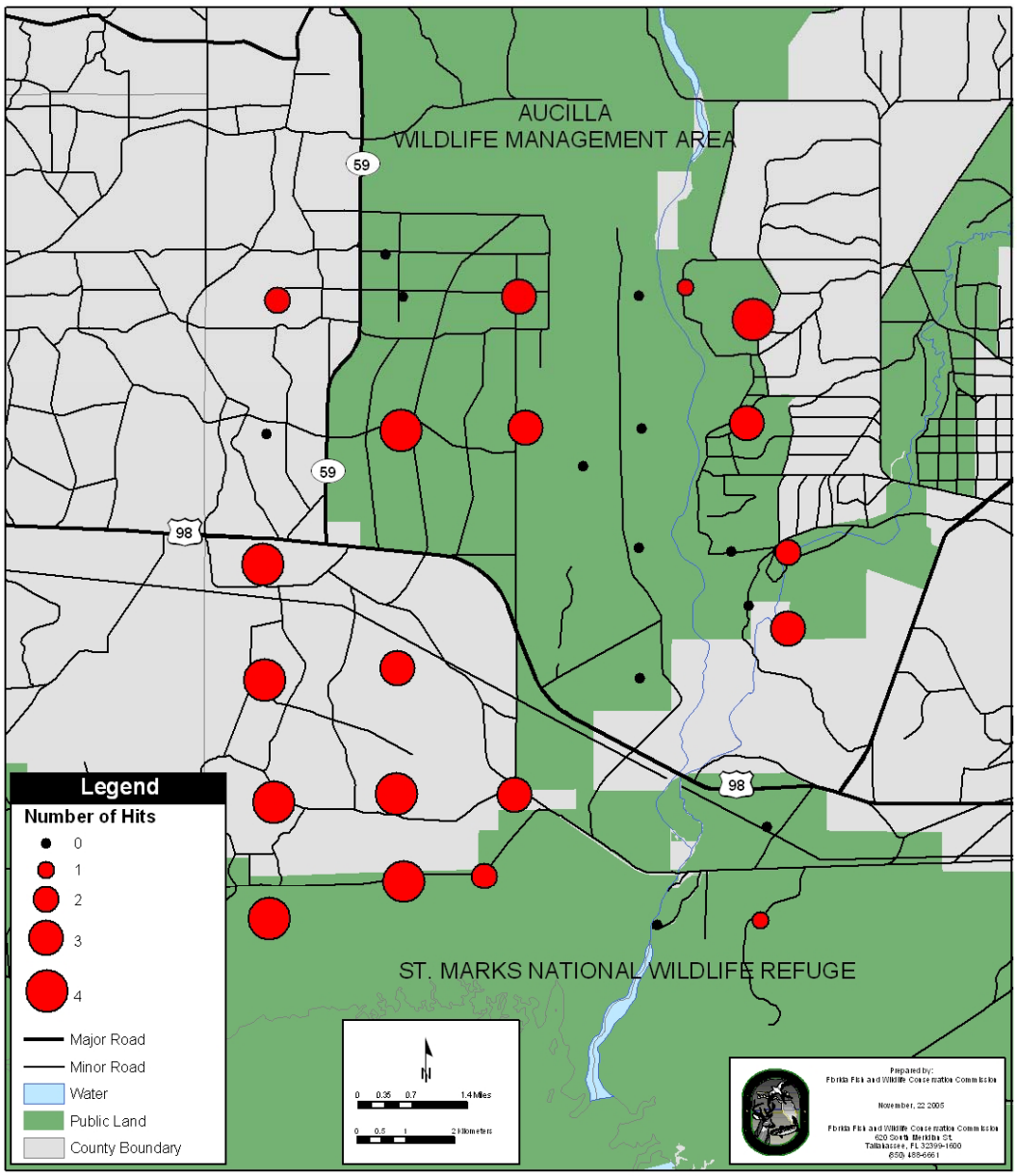


Figure 10. Crossing snares successfully frequented by black bears in the Aucilla study area in Jefferson County, Florida..

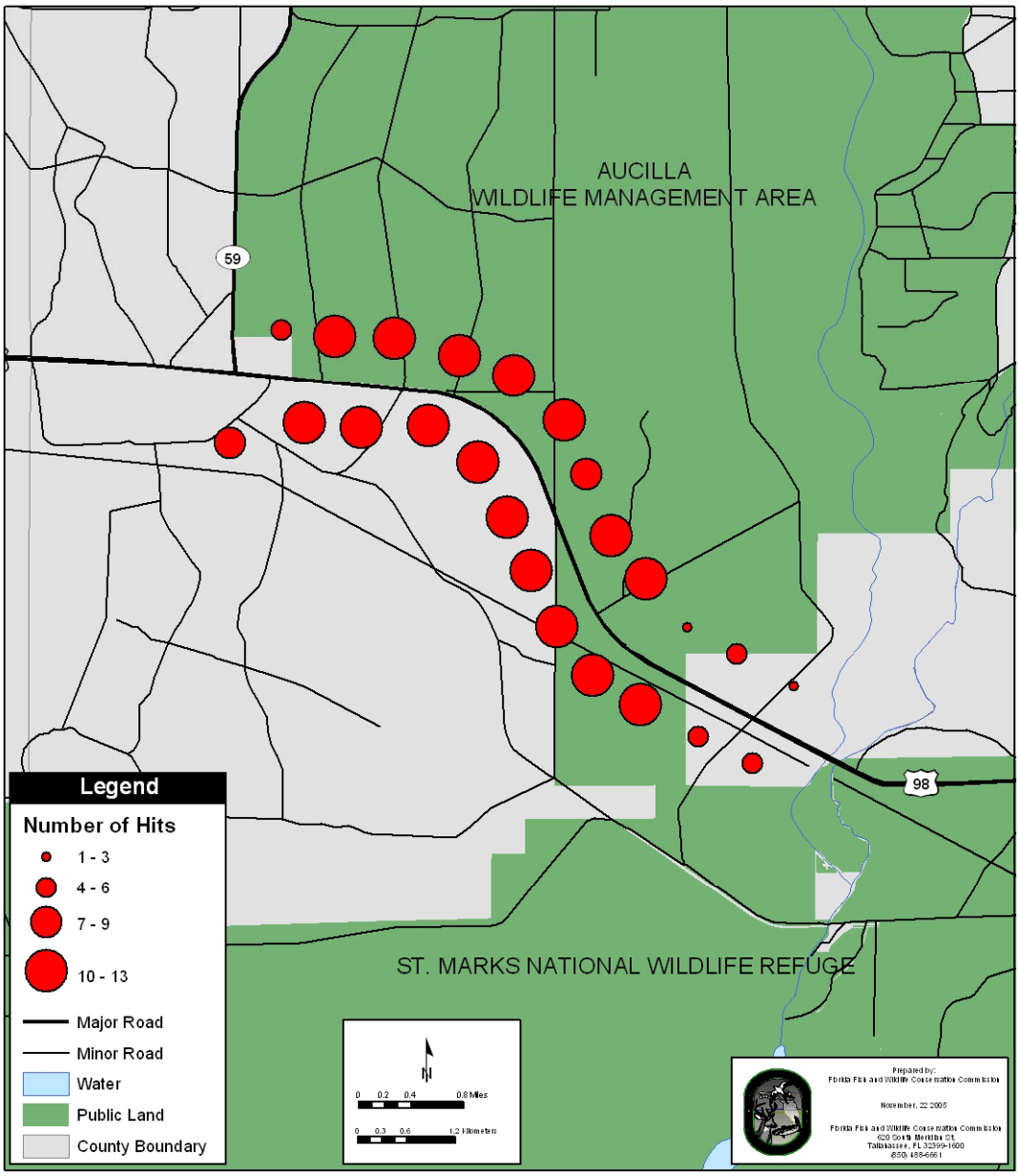


Figure 11. Population and crossing hair snares successfully frequented by black bears in the Aucilla study area in Jefferson County, Florida.

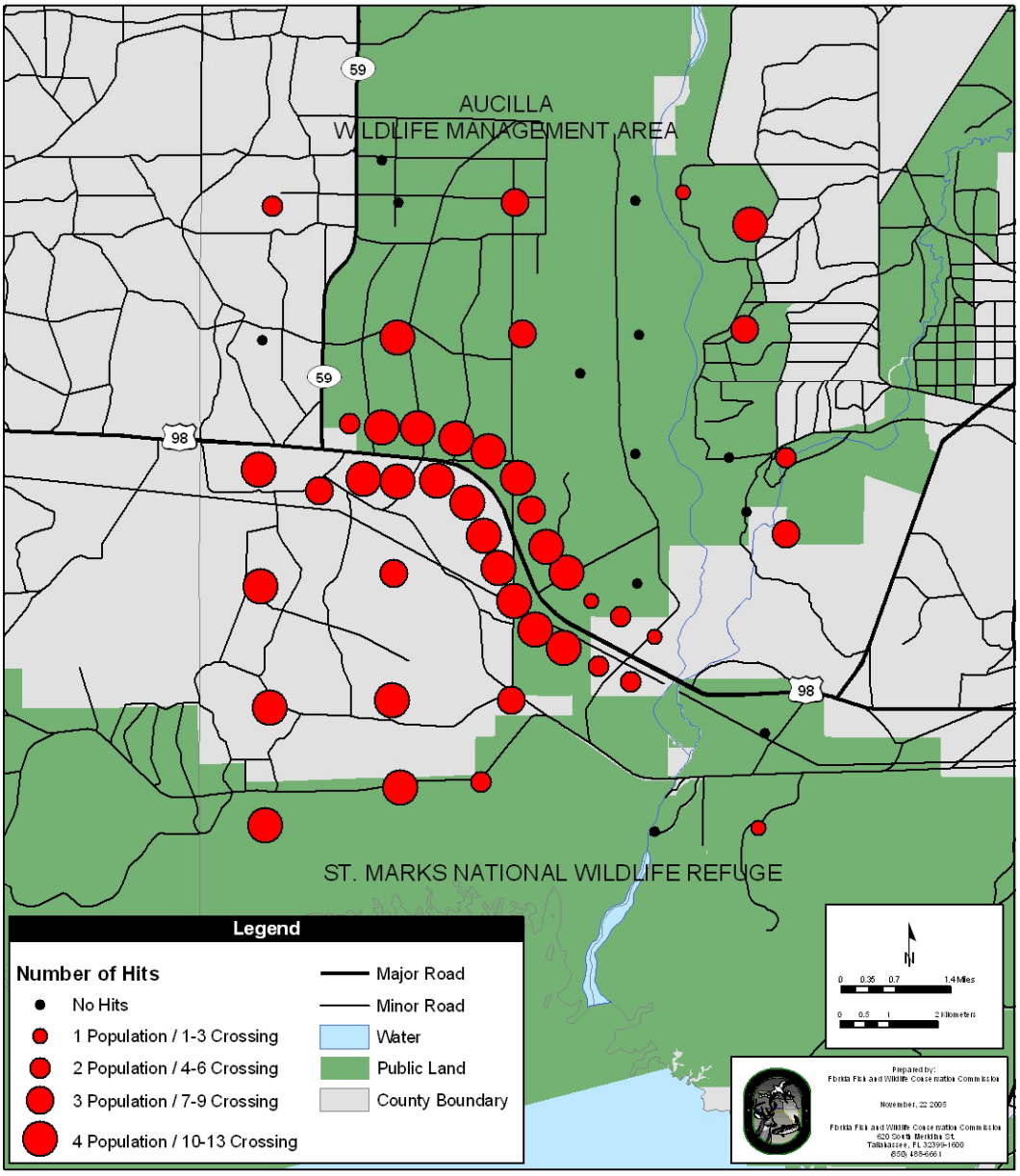


Figure 12. Seasonal monthly crossing rates by 250m section of U.S. 98 in Jefferson County, Florida ("hairs" represent locations of crossings and roadkills).

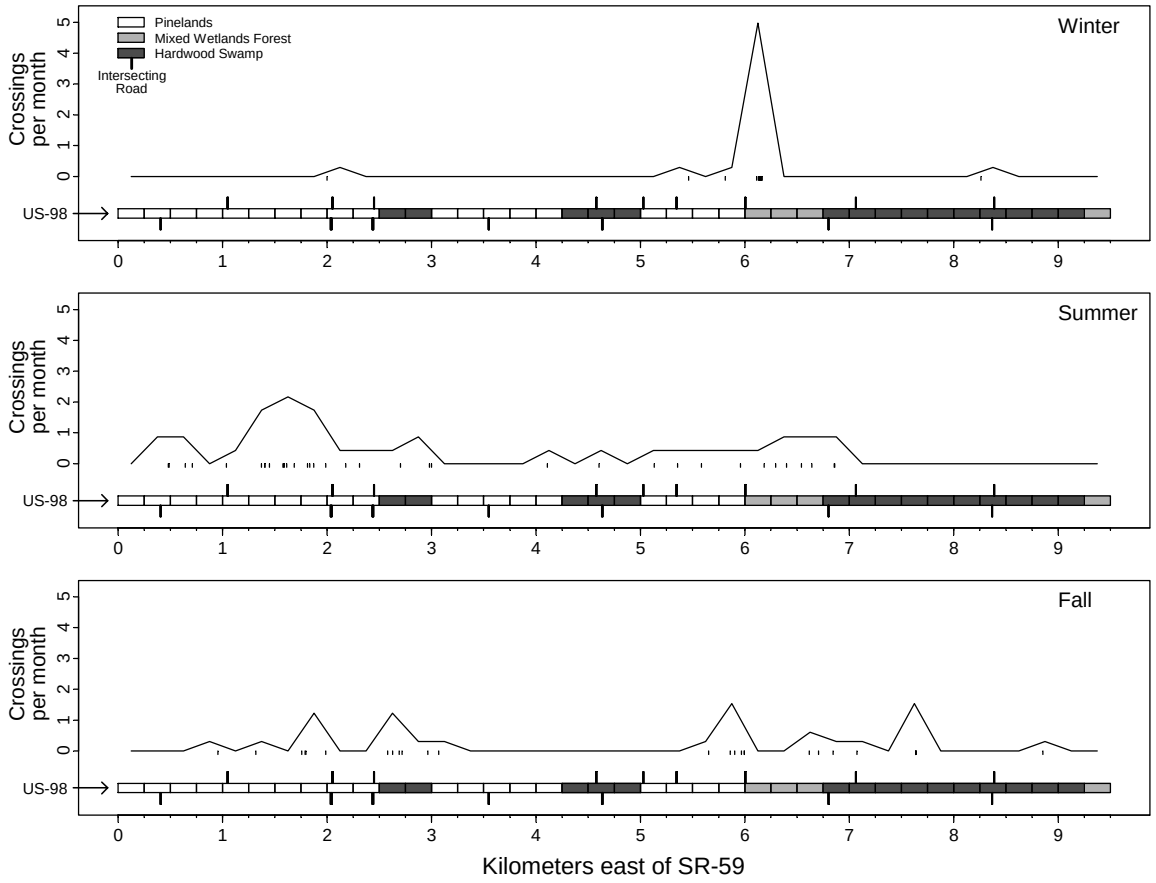


Figure 13. Monthly crossing rates and roadkills per decade by 250m section of U.S. 98 in Jefferson County, Florida ("hairs" represent crossing and roadkill locations).

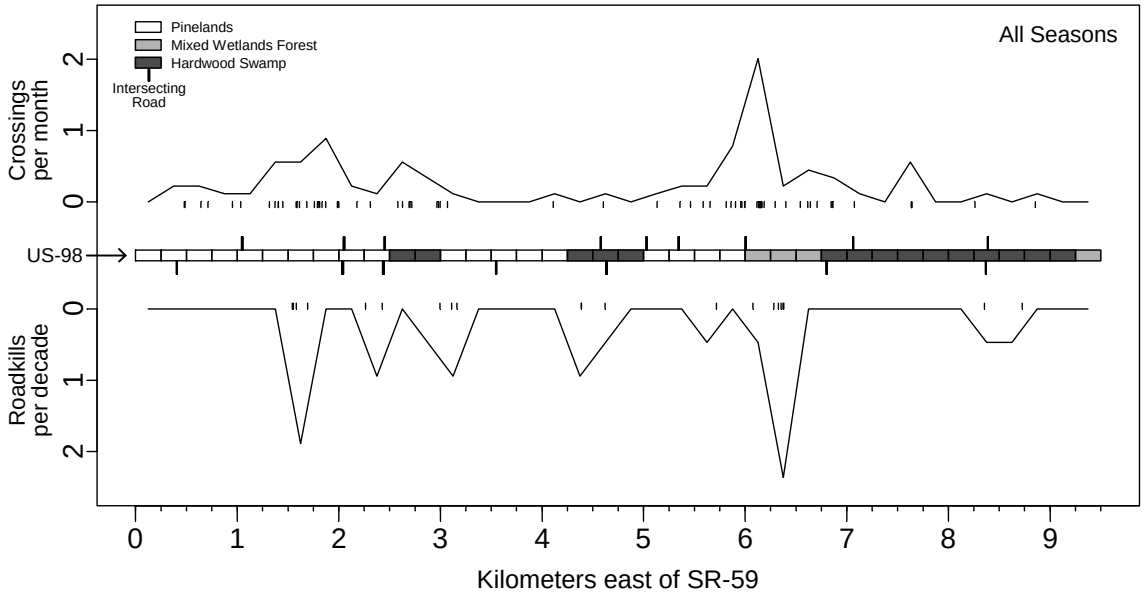
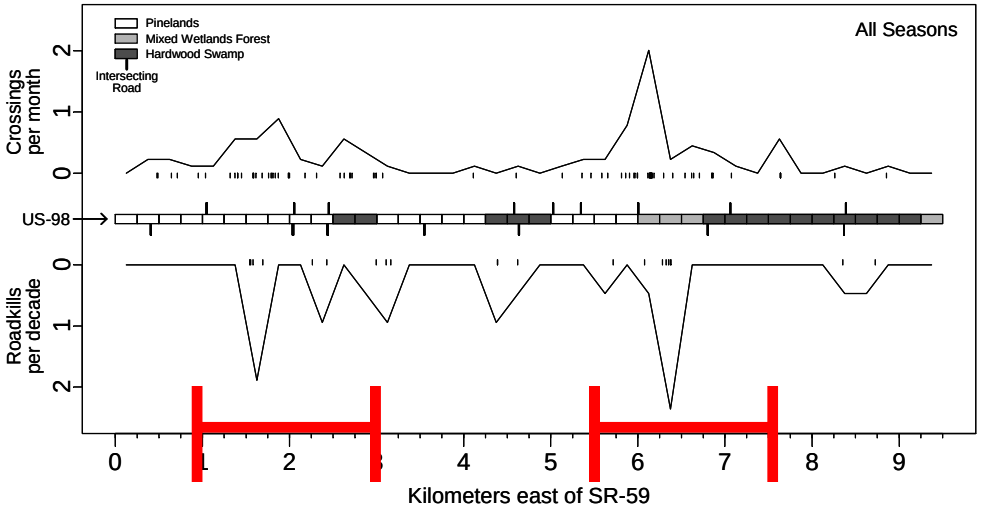


Figure 14. Recommended locations for consideration to reduce black bear mortality on the study interval of U.S. 98 in Jefferson County, Florida.



Recommended locations for consideration to reduce black bear mortality