East Collier County Wildlife Movement Study
SR 29, CR 846, and CR 858 Wildlife Crossing Project

Final Report

Purpose of Study:

To determine candidate sites for wildlife crossing structures to maintain/restore large-scale functional landscape connectivity for Florida panthers and other wildlife by monitoring and analyzing wildlife movement patterns along the SR 29, CR 846, and CR 858 highway corridors adjacent to designated stewardship areas.

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EXECUTIVE SUMMARY

Roads are one of the greatest threats to wildlife worldwide. Especially in areas with high traffic volume, wildlife crossing structures are needed at carefully selected locations along roads in order to allow wildlife to successfully cross highways and maintain connectivity and gene flow within and among populations. Design of crossing structures can benefit from data on unsuccessful crossing locations (i.e., roadkills), but whenever possible should be combined with data on successful crossing locations (i.e., from radio-tracking or tracking stations such as graded paths) and a broader look at the landscape context of the crossing, including the adjacent topography, vegetation, and land use.

South Florida has experienced explosive growth over the last 25 years with conversion of agriculture and wildlands to residential and urban developments. Population increase over the next three decades is projected to average 29%. Consequences that accompany such growth include construction of new roads and widening of existing alignments, increases in traffic volume, increases in invasive species, rapid levels of habitat loss and fragmentation that threaten the integrity and functionality of critical habitat corridors, and loss of native biodiversity. Evidence of these impending effects is demonstrated by the increase in road mortality of Florida panthers and black bears on rural roads in Collier County. Since 2000, the road mortality rate of Florida panthers on rural roads in Collier County has quadrupled relative to previous decades. Loss of habitat has put a great strain on the survival of many imperiled species, especially the Florida panther.

The Rural Lands Stewardship Program (RLSP) was developed in Florida under the Rural Land Stewardship Act of 2001. The Act was implemented to target land preservation in rural and agricultural lands through innovative development while reducing urban sprawl. In 2002 a Rural Land Stewardship Area (RLSA) was designated in the northeastern portion of Collier County, which contains approximately 200,000 acres of wilderness and rural agricultural lands. The plan in this RLSA is to preserve 90,000 acres of environmentally sensitive land and maintain approximately 75,000 acres of agricultural land over the next 25 years through market-driven forces. Two primary corridors were designated by as Habitat Stewardship Areas under this program and include restrictions on development and land use. Concessions given to landowners in exchange for these designations include allowances for increased development densities outside the stewardship areas. The habitat corridors designated in the Collier County RLSP were also targeted as priority habitat areas by the Southwest Florida Regional Planning Council in the 2010 Regional Future Land Use Plan and by the U.S. Fish and Wildlife Service in the South Florida Multi-species Recovery Plan. The FWS identified these as key landscape linkages for conservation of the Endangered Florida panther, connecting protected habitat areas to the north and south. Based on the results of our preliminary study, we discuss the efficacy of the RLSP and potential threats to functional habitat connectivity for the Florida panther and other species by recently proposed developments within the RLSA. We also make recommendations for corridor improvements and road crossings to ameliorate these impacts.

The four stretches of road in our study area where wildlife mortality is of greatest concern are CR 846 east and west of Immokalee, CR 858 from Oil Well Grade Road east to the Hendry County line, and SR 29 north and south of CR 858. We used a comprehensive approach that employed

several methods to determine candidate sites for wildlife crossing by monitoring and analyzing wildlife movement patterns along the SR 29, CR 846, and CR 858 highway corridors adjacent to designated stewardship areas. These methods included roadkill and track surveys, comparison of roadkill and track data to assess capacity of existing structures to facilitate safe movement for certain small wildlife species, and deployment of infra-red camera stations at selected sites to monitor large animal highway crossing or approach events. We also synthesized existing data from radio telemetry, roadkill reports, and other studies, especially for the Florida panther and Florida black bear. We emphasize, however, that our results are preliminary, as they are based on less than one year of new data collection.

For all road sections, we recorded 67 different species from roadkills, tracks, and cameras, categorized by faunal groups that included American alligator, birds, carnivores, ungulates, domestic animals, meso-mammals, small mammals, frogs, snakes, turtles, and river otter. A total of 136 tracks and 73 photos (focal species only: bobcat, coyote, deer, panther, turkey, and wild pig) and 333 roadkills (all species) were recorded. Seasonal peaks in roadkill and track observations were inconsistent. Roadkill was most abundant in December-January, April, and July, whereas tracks were most abundant in March.

We recorded no new roadkills of panthers in our study; however, previous data indicate that many panthers have been killed on these roads over previous decades. Of particular note are eight panther roadkills (including three in close proximity to one another) along CR 846 East between 1993 and 2006. An additional panther roadkill was reported from this stretch of road in December 2006, as this report was being completed; however, we have not been able to obtain precise location data. CR 846 East is a significant hotspot for Florida panther and roadkill in general. Most notable tracks recorded in our study on this stretch were Florida panther on five separate dates in April and May 2006. These tracks occurred in the same road segments as previously recorded panther roadkills. Another Florida panther track was recorded along CR 846 East near a camera station in June 2006, near the location of a January 2006 panther roadkill.

Based on roadkill, track, telemetry, and landscape information, six significant crossing areas (landscape linkages) exist along CR 846 East. All these are corridors of native vegetation (mostly wetlands, pinelands, and palm hammocks) within the agricultural matrix. The most critical for Florida panther is the Okaloacoochee Slough and adjacent upland buffers. Panther roadkills have also been recorded along CR 846 West on either side of the Camp Keais Strand, within important upland buffer areas. Several black bear roadkills are also recorded from this general area. Significantly, we obtained photographs of an uncollared panther in this area, in the upland buffer just east of Camp Keais Strand, in March and April 2006.

Significant wildlife crossing areas on CR 858 include the area east of CR 29 in the vicinity of the Okaloacoochee Slough and adjacent upland buffers. The central portion of CR 858 has recorded panther roadkills, and we found a panther track in January 2006 along this stretch. Telemetry data also indicate regular crossings in much of this area, which requires major restoration in order to improve functional connectivity. Also important is the western section of CR 858 along the Camp Keais Strand and adjacent upland buffers. Significant restoration is required to create upland buffers adjacent to the strand to improve the functionality of this corridor. The intersection with Oil Well Grade Road also needs to be shifted west outside of the upland buffer zone.

Other hotspots for Florida panther roadkills are along certain segments of SR 29. Four Florida panther roadkills have been recorded along the north section of SR 29 between 2003 and 2005, and eight panther roadkills were recorded along the south section of SR 29 between 1980 and 2003 (including six in close proximity). Several black bear roadkills are also recorded from these stretches of SR 29. An important wildlife crossing area along the north section of SR 29 would connect the Florida Panther National Wildlife Refuge to the Okalacoochee Slough corridor. Significant restoration is required on the west side of the road to create upland buffers adjacent to the cypress wetlands along with conversion of some of the citrus groves to improve functional connectivity of this corridor. Along the south section of SR 29, natural movement corridors are fragmented not only by the road but also by a parallel deep-water canal and by mining activities. Major restoration is also needed in this area to restore functional connectivity for wildlife.

To summarize, based on roadkill locations and other data analyzed in this study, we identified significant sections of each roadway that should be considered for retrofits to reduce road mortality and increase road permeability:

- CR 846 east: Okaloacoochee Slough including adjacent upland buffers and two secondary travel corridors each to the west and east of the slough.
- CR 846 west: Camp Keias Strand and adjacent upland buffers and the large cypress corridor to the east.
- CR 858 east: the Okaloacoochee Slough (and adjacent upland buffers) is the central feature of concern.
- CR 858 central: road segments 2-28 constitute an important panther crossing area between the Florida Panther NWR and the Okaloacoochee Slough. As with CR 846 west, the Camp Keais Strand is an important crossing area for Florida panther and black bear, among other species.
- SR 29 north: contains a significant crossing area as part of the corridor connecting the Florida Panther NWR and the Okaloacoochee Slough; though we recorded few roadkills, portion of this area appear important for key species.
- SR 29 south: much of this stretch was not specifically monitored due to road conditions, but is considered a potentially important travel area for the Florida panther and other wildlife, and should be addressed as such.

We found no significant relation between season and rainfall with number of roadkills, contrary to findings reported by previous researchers. However, our results were biased by an insufficient sampling period (8 months) to capture seasonal variation or interannual variability in rainfall (dry and wet years) necessary to determine differences by year or season.

Significant retrofitting of highways is needed to increase functional connectivity for wildlife in the study area. Current bridge/culvert configurations are inadequate to provide necessary levels of permeability for wildlife in the bisected conservation area. Existing structures were designed for hydrological needs, not wildlife accessibility; they conveyed water and were flooded and impassable to terrestrial-based species over the entire study period. We recorded significant numbers of roadkills adjacent to four of these structures. Moreover, planning of wildlife crossings at these sites is complicated by the presence of canals parallel to the roadways. Earthen ramps that cross canals have been used at previously constructed wildlife underpasses on SR 29 and I-75. Several types of structures will be needed to accommodate the diversity of species (terrestrial and aquatic) found across the upland-wetland gradient.

The following factors should be considered in improving the permeability to wildlife of the CR 846, CR 858, and SR 29 corridors within the RLSA:

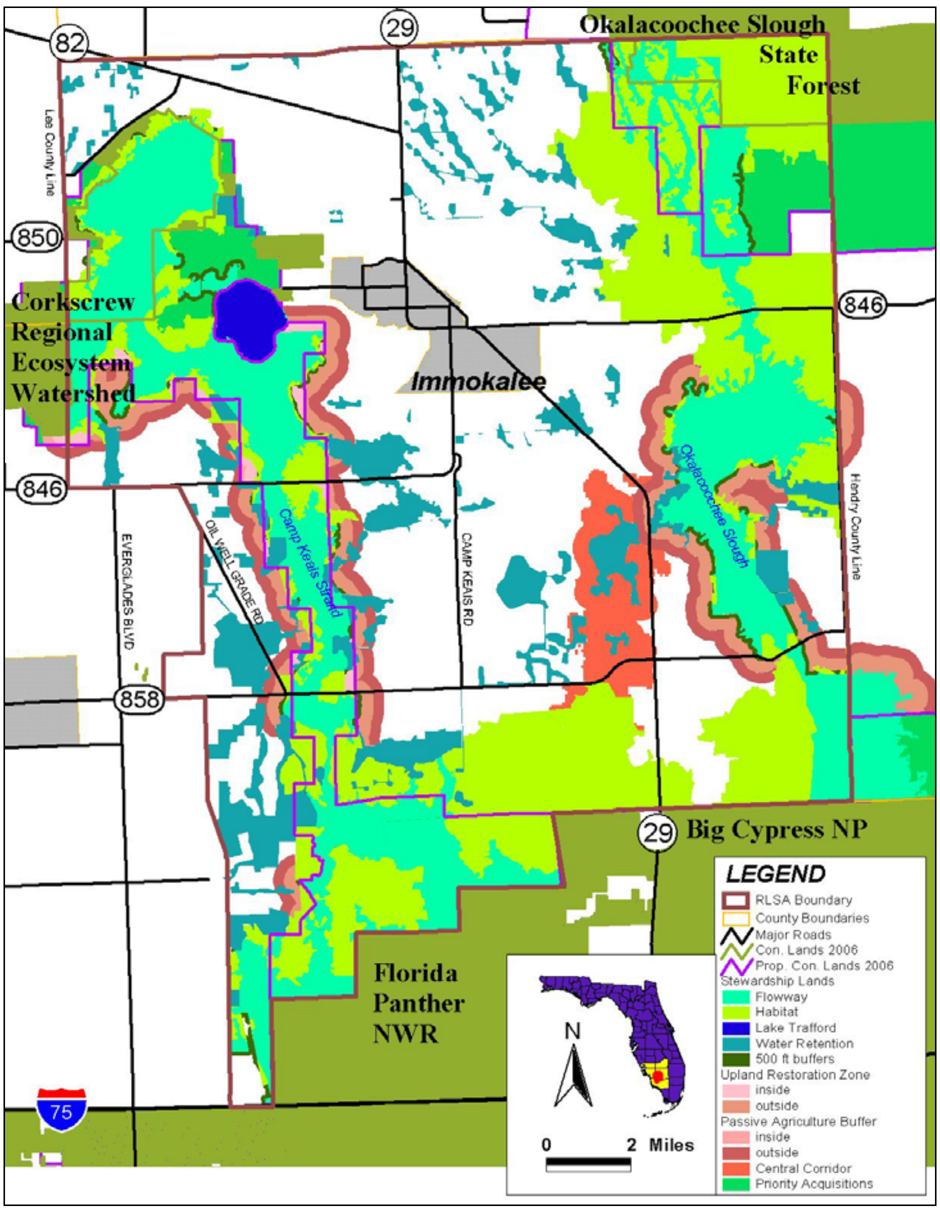
- Context sensitivity—vegetation along road consistent with surrounding habitat
- Environmental variability—provide for terrestrial passage at semi-aquatic sites during periods of high water levels
- Directional fencing—funnel wildlife through passages and away from road surface
- Berming—reduce effects of traffic noise and lights
- Topography—road should be designed to “fit into” the landscape (e.g., minimize alteration in slope of underpass/ overpass approaches)
- Substrate—consistent with adjacent area
- Lighting—reduce tunnel effects by increasing openness value (height*width/length) and providing light penetration in medians of divided highways
- Human presence—reduce human access associated with crossing sites

To improve habitat connectivity within the RLSA, we propose a system of culverts, bridges, and barrier fences to reduce roadkills and increase the permeability of each road for wildlife. Specific recommendations for each stretch of road are included in the Discussion section of this report. Our recommendations are meant to optimize habitat connectivity (this includes restoration of disturbed or altered portions of habitat corridors at critical landscape linkages) and significantly reduce barrier effects of roads to wildlife movement. The recommended dimensions of specific structures are similar to wildlife-use thresholds generated from an extensive culvert monitoring conducted for FDOT and are consistent with recommendations from studies elsewhere.

We discuss the risks to species of road widening. Two-lane and four-lane highways produce varying negative effects on wildlife in adjacent areas. The intensity of these effects depends on road and verge width and traffic volume. If traffic volume is equal, two-lane highways generally produce more roadkills, but are more permeable. Four-lane highways would have fewer roadkills, but are known to be aversion zones for many animal species and therefore create greater habitat and population fragmentation. Widening of highways also potentially magnifies negative edge effects.

Three critical components are necessary to establish a functionally connected reserve system—core habitat areas of sufficient size, connecting habitat corridors of sufficient width between core habitat areas, and buffers that protect the interior quality of the primary network features (core areas and linkages). Buffers serve to reduce negative edge effects for interior species sensitive to human activities, provide additional habitat for species less sensitive to human activities, allow for establishment of natural gradients from wet to dry habitats required by many species for sustainable breeding populations, allow for spatial response (e.g., escape potential) to natural disturbance (flood and fire), and in this study region would provide travel corridors of upland habitat for those species that may not be able to move through the existing wetland corridors.

Since there are few, if any, current regulatory mechanisms to establish or protect upland habitat buffers, the Rural Land Stewardship Program seems an ideal platform to implement this strategy for habitat conservation. The study area currently contains several large habitat areas (Florida Panther NWR, Big Cypress NP, CREW lands, Okalaocoochee Slough SF) patchily connected by extensive wetland corridors (Camp Keais Strand and Okalaocoochee Slough). As in most parts of Florida, the paved road network in the study area is fairly dense and is expected to increase. Road impacts such as roadkills, fragmentation, and isolation are critical issues that will need to be addressed in plans to protect habitat connectivity. We recommend and portray in a map (below) "Conceptual Design Improvements to the Rural Land Stewardship Habitat Corridors" that include a tiered-buffer design and the addition of a central travel corridor, with particular reference to the needs of the Florida panther.



Implementation of this conceptual design would require restoration of some agricultural areas to native habitat types. We also suggest acquisition of significant areas adjacent to Big Cypress NP, Okalaocoochee Slough SF, and CREW lands to increase size of these core areas

The landscape in the study area currently consists of significant habitat corridors and portions of core habitat areas within an agricultural matrix. Efforts are being made to control and manage impending growth and development, yet major risks still exist with regard to roads and proposed large developments. Increased levels of development will dictate increased width of existing roadways (and possible construction of new roads) to accommodate increasing traffic levels. All these activities threaten to cause further fragmentation and loss of remaining habitat areas and associated native biodiversity. Recommendations provided herein, based on data collected in this study as well as previous studies on Florida panther and black bear, include addition of wildlife crossing structures and conceptual additions to the designated stewardship zones. These measures are intended to improve overall habitat connectivity within the study area and promote sustainability of rare and common native wildlife species.

Introduction

Background Information

Population growth and development.

South Florida has experienced explosive growth over the last 25 years with conversion of agriculture and wildlands to residential and urban developments (Main et al. 1999, Meegan and Maehr 2002, Kautz et al. 2006). Population growth in Collier County is shown in Fig. 1; growth over the past 3 decades averaged 89%. The Bureau of Economic and Business Research (BEBR) estimated the population in 2004 at 306,186. Population increase over the next three decades is projected to average 29%. Under provisions of the current Collier County Comprehensive Plan, a buildout of 797,000 people is expected. Consequences that accompany such growth include construction of new roads and widening of existing alignments, increases in traffic volume, increases in invasive species, rapid levels of habitat loss and fragmentation, and loss of native biodiversity. Czech et al. (2000) identified non-native species, urbanization, and agriculture as the three leading causes of endangerment for American species listed by the U.S. Fish and Wildlife Service (FWS).

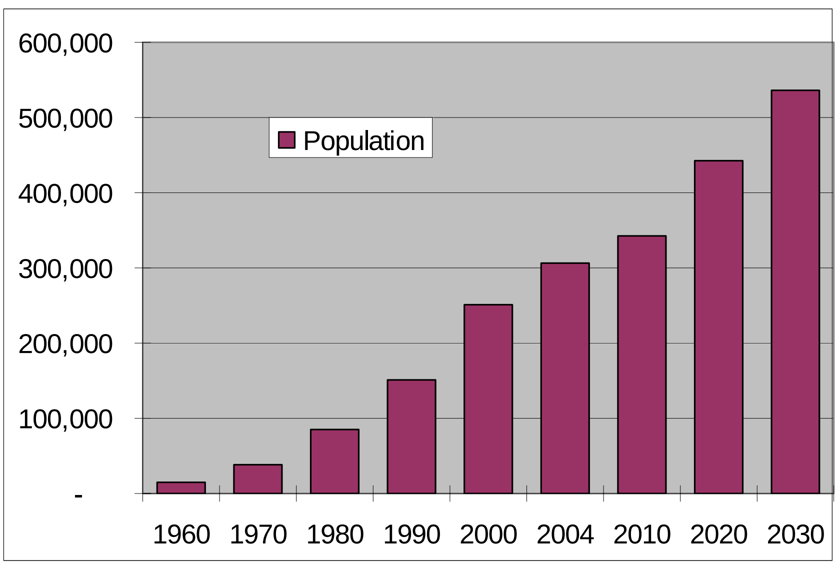


Figure 1. Population growth in Collier County, Florida (sources: U.S. Census Bureau and BEBR).

Evidence of these impending effects is demonstrated by the present increase in the road mortality rate of Florida panthers (*Puma concolor coryi*) and black bears (*Ursus americanus floridanus*) on rural roads in Collier County (Fig. 2). Since 2000, the road mortality rate of Florida panthers on rural roads in Collier County has quadrupled in relation to previous decades, primarily due to increased levels of development, agricultural activities, traffic, limited habitat availability, and increased population size.

The locations along the four roads where wildlife mortality is the greatest concern are CR 846 east and west of Immokalee, CR 858 from Oil Well Grade Road east to the Hendry County line, and SR 29 north and south of CR 858. Because of the rural nature of the area, traffic volume data are limited (except for SR 29), yet what is available indicates significant increases in volume contributing to higher incidences of wildlife collisions. From 2001 to 2005, traffic volume (average annual daily traffic- AADT) on SR 29 (south of CR 858) increased by 70% (to 2,800 vehicles/day in 2005) (data source: Florida Department of Transportation- FDOT). Traffic volume on CR 846 (2 mi east of Everglades Blvd) increased by 19% (to 6,115 vehicles/day in 2005) over the same period (Frye 2005). Compounding the effects of increased traffic volume is vehicle speed. Speed limit on all these sections of road is 55 mph or higher.

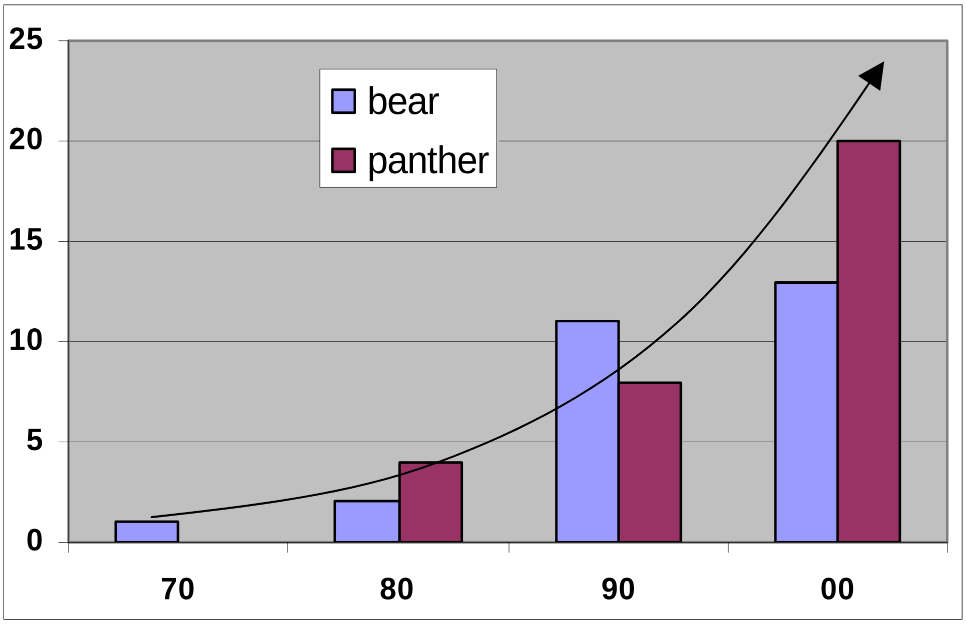


Figure 2. Recorded vehicle collisions on east Collier rural roads by decade (Panthers – through 2005 and Bears – through 2004). Data Source: Florida Fish and Wildlife Conservation Commission.

Growth management and planning.

Loss of habitat has put a great strain on the survival of endangered species, especially the Florida panther (Fergus 1991, Main et al. 1999, Meegan and Maehr 2002). Managers have had limited resources and options to purchase or preserve land that would help ensure the survival of the Florida panther. Typically land is either acquired with public funds or conservation easements are negotiated with private landowners. These methods are not always compatible with landowner needs or wants (Main et al. 1999). Another option that wildlife managers and county officials have looked into is Resource Conservation Agreements (RCA), an incentive-based program that provides landowners with compensation for development potential in exchange for conserving and managing wildlife habitat (Main et al. 1999).

Main et al. (1999) reviewed the costs of managing public lands (preserves and refuges) for the Florida panther, conservation easements, and the implementation of RCAs on approximately 200,000 hectares of priority panther habitat. Their analysis highlighted the cost effectiveness of RCAs, which were found to be similar in cost to maintaining public lands. Conservation easements were 200-300% more expensive and land acquisition was 200-400% more expensive than RCAs.

Rural Land Stewardship Program and Collier County.

The Rural Lands Stewardship Program (RLSP) was developed in Florida under the Rural Land Stewardship Act of 2001, and is another type of RCA. The Act was implemented to target land preservation in rural and agricultural lands through innovative development while reducing urban sprawl. Development can be accomplished through a system of "Transferable Land Use Credits," where landowners are provided equity for the natural resources on their land. Landowners receive credits that can be utilized in areas of planned development (Demers 2003, D'alessandro 2006a).

There are many short articles and government-related websites regarding RLSPs and how they conceptually work (Scott 2003, Reynolds and Jenkins 2004, D'alessandro 2006a). Few articles provide specific examples on amount of money needed, negotiations with landowners, or conflict resolution. Demers (2003) provided the best explanation on how the Act works with examples and monetary figures. Several important elements go into the establishment of an RLSP. They include determining an appropriate location for a stewardship area, dividing the area into credit "sending" and credit "receiving" areas, assigning "transferable rural land use credits" to the sending area, transferring credits from sending to receiving areas, using credits to promote appropriate development in the receiving area, and promoting the rural economic base while protecting environmental resources in the sending areas. Keys to effective resource protection under an RLSP include:

- Availability of reliable data/information for use in evaluation and designation of critical natural resources
- Ensuring land use and permitting decisions (for receiving/sending areas) are based on scoring systems developed within a scientific peer review framework
- Incorporation of policies/restrictions that ensure protection of designated areas
- Designation of appropriate areas (receiving sites) where towns and villages will be built
- Public participation and oversight of implementation

This is a simple overview of how RLSPs are developed and function. Rural lands stewardship overlays are generally based on considerable amounts of resource data and may include complicated scoring matrices. Additional detail on RLSPs may be obtained from sources used in this summary (Demers 2003, Scott 2003, Reynolds and Jenkins 2004, D'alessandro 2006a), the Florida Department of Community Affairs, and the Florida Chapter of the American Planning Association websites.

In 2002 a Rural Land Stewardship Area (RLSA) was designated in the northeastern portion of Collier County (Fig. 3), which contains approximately 200,000 acres of wilderness and rural agricultural lands (Scott 2003, Pruetz 2005, D'alessandro 2006a). The plan in this RLSA is to preserve 90,000 acres of environmentally sensitive land and maintain approximately 75,000 acres of agricultural land over the next 25 years through market-driven forces (Demers 2003, Scott 2003). Two primary corridors were designated by Collier County as Habitat Stewardship Areas and include restrictions on development and land use. Concessions given to landowners in exchange for these designations include allowances for increased development densities outside the stewardship areas. Specific mechanisms used in the Collier County program can be found at the Collier County Planning Department website.

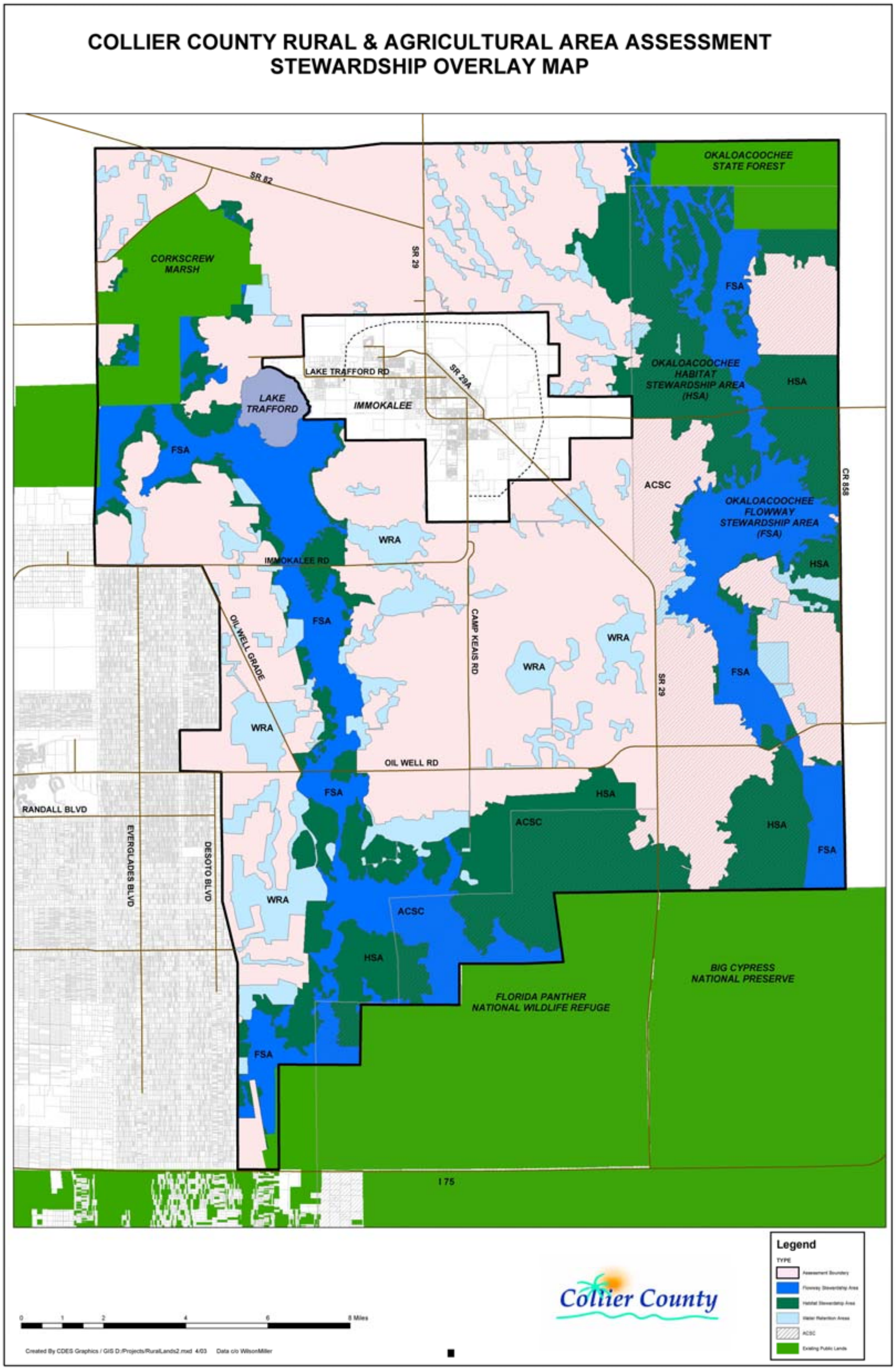


Figure 3. Collier County rural lands stewardship overlay map.

The habitat corridors designated in the Collier County RLSP were also targeted as priority habitat areas by the Southwest Florida Regional Planning Council in the 2010 Regional Future Land Use Plan (Fig. 4) and by the FWS in the South Florida Multi-species Recovery Plan (Fig.5, FWS 1999). The FWS identified these as key landscape linkages for conservation of the Endangered Florida panther connecting protected habitat areas to the north and south.

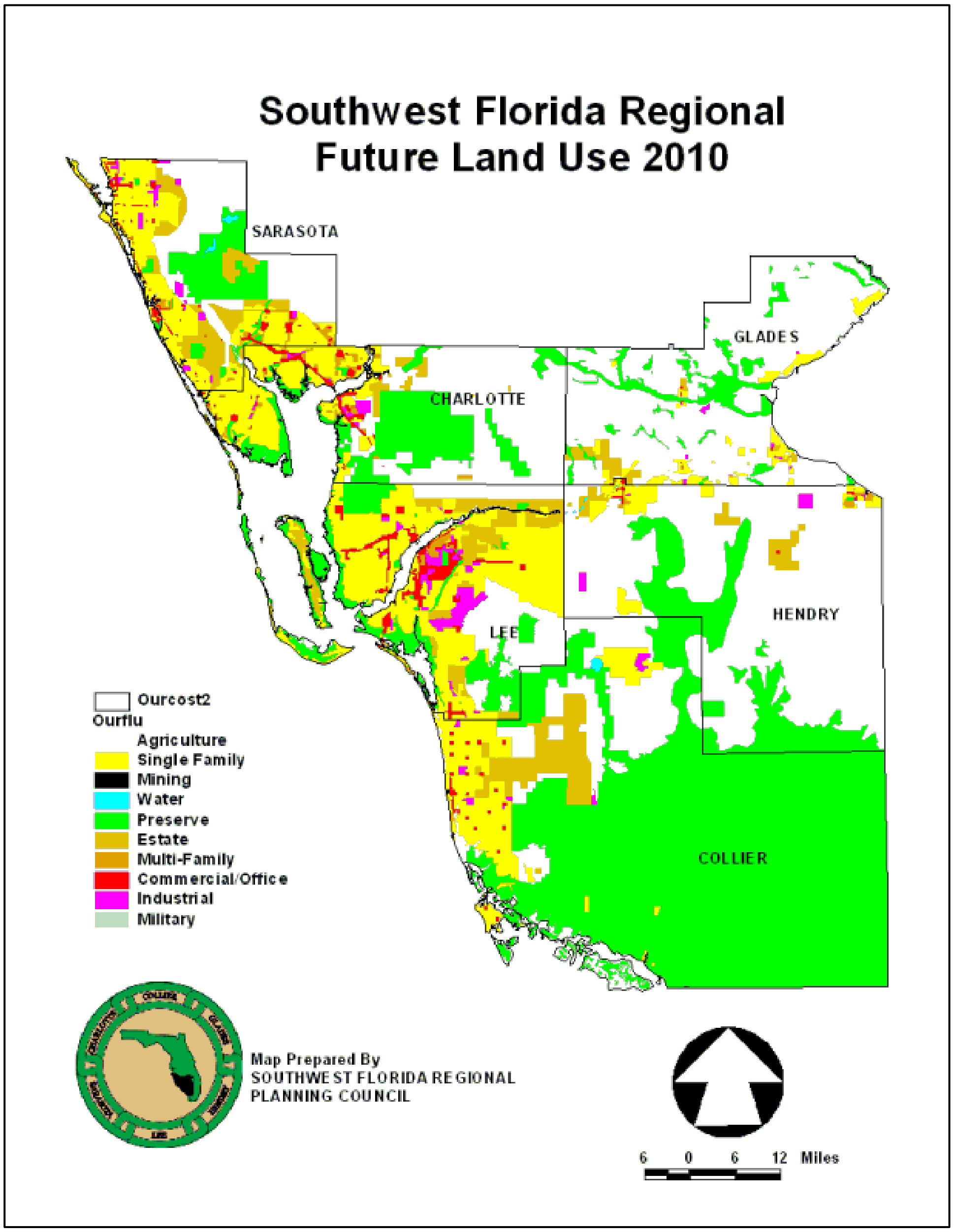


Figure 4. Southwest Florida Regional Future Land Use 2010 map.

Population growth in the county has resulted in rapid levels of habitat loss and fragmentation that threaten the integrity and functionality of these critical habitat corridors. Associated with rapid development in the rural areas of the county is the construction of new roads and widening of existing alignments. Based on the results of this study, we discuss the efficacy of the RLSP and potential threats to functional habitat connectivity for the Florida panther and other species by recently proposed developments within the RLSA and make recommendations for corridor improvements and road crossings to ameliorate these impacts.

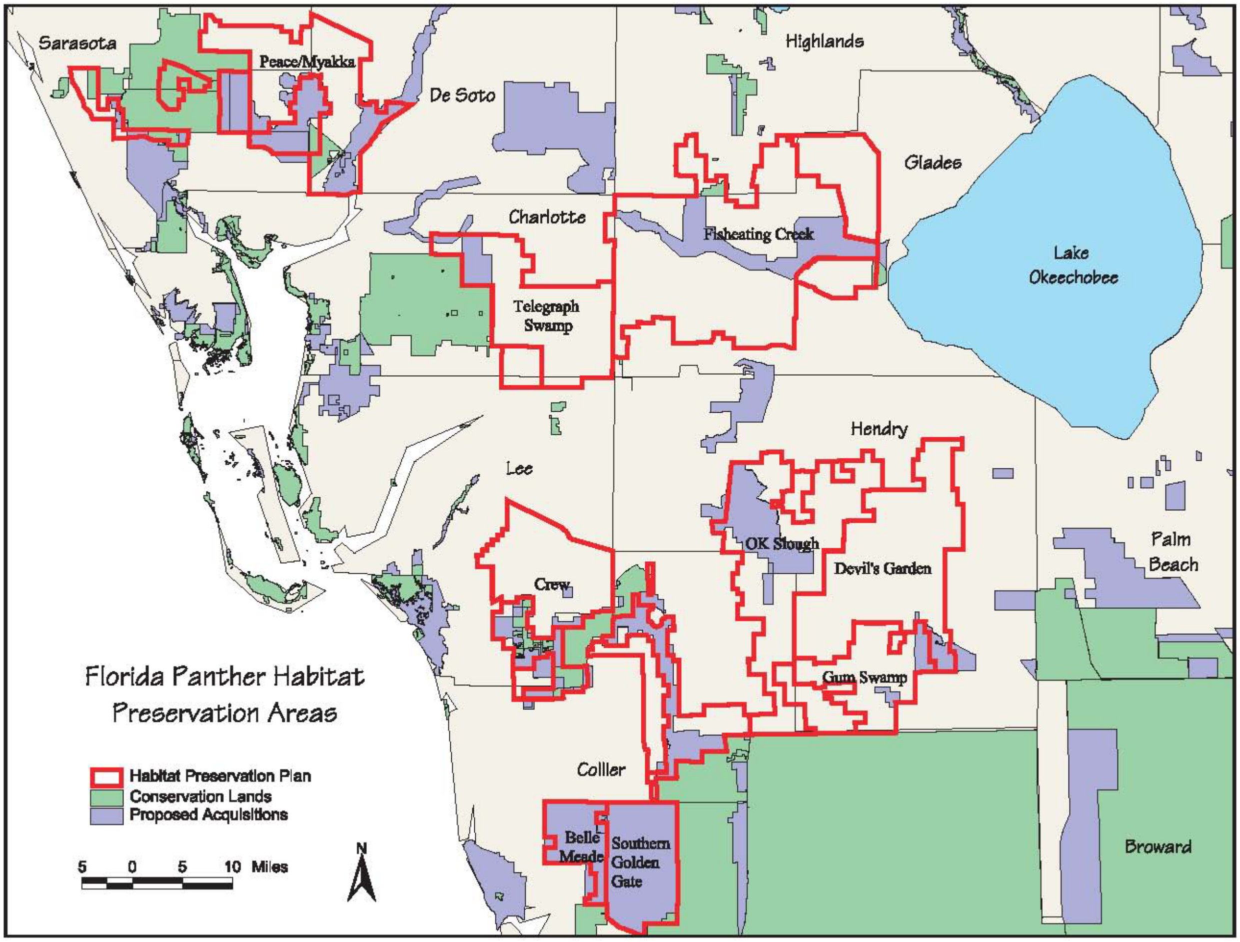


Figure 5. Florida panther habitat preservation areas (Fig. 3 from FWS 1999).

Literature Review

Roads and habitat connectivity.

Connectivity is well accepted among conservation planners as a critical consideration in the design of reserve networks and multiple-use landscapes (Noss and Cooperrider 1994). Corridors (variably called landscape linkages, connectors, greenways, and other terms) are the most popular means to achieve connectivity. The empirical literature on this topic, though still sparse, is growing rapidly and generally supports the notion that well-designed corridors function to provide demographic connectivity between populations (Beier and Noss 1998). One special type of connectivity is that which enables animals to move across roads.

Roads are one of the greatest threats to wildlife worldwide (Noss and Cooperrider 1994, Trombulak and Frissell 2000). It is widely recognized by biologists that crossing structures are needed in many cases to allow wildlife to successfully cross highways and maintain connectivity and gene flow within and among populations (Forman et al. 2003). A number of studies have discussed methods for determining appropriate locations for crossing structures. For example, GIS-based habitat models for species of interest, data on roadkill locations, radiotelemetry, remote camera photos, known migratory paths of animals, and animal signs such as tracks, can identify useful sites for highway crossing structures (Singer and Doherty 1985, Foster and Humphrey 1995, Scheick and Jones 1999, Smith 1999, Clevenger et al. 2002, Henke et al. 2002, Lyren and Crooks 2002, Main and Allen 2002, Smith and Voigt 2005).

Design of crossing structures can benefit from data on unsuccessful crossing locations (i.e., roadkills), but whenever possible should be combined with data on successful crossing locations (i.e., from radio-tracking or tracking stations) and a broader look at the landscape context of the crossing, including the adjacent topography, vegetation, and land use. Concentrations of roadkills may represent areas where many individuals are also crossing successfully, or alternately, may represent only unsuccessful crossings (for example, where there is a break in a fence). Roadkills are typically spatially aggregated, and often occur closer to vegetation cover and farther from wildlife crossings than stretches of highway with few roadkills (e.g., Clevenger et al. 2002, Main and Allen 2002).

Culverts and other structures not designed for wildlife movement may nevertheless be used by wildlife, especially when suitable habitat for the species in question exists on either side of the highway (Ng et al. 2004). However, poorly designed crossings, such as small or flooded culverts, are not used by some animals (Beier 1993) or may concentrate animal crossings and create roadkill hotspots (Main and Allen 2002). For example, in southwest Florida Main and Allen (2002) documented a peak in roadkills in close proximity to a canal crossing. In southern California bobcats and coyotes preferred to cross roads rather than use culverts; however, culvert use increased early in the night, during heavy traffic, and if they contained less water (Tigas et al. 2002). In Texas, use of culverts by bobcats was positively related to the openness ratio (width x height/length) of the culvert and the amount of vegetation adjacent to the culvert. Fences erected to funnel wildlife toward culverts did not increase overall use of culverts, but may have increased use of the high-quality culverts (Cain et al. 2003). On U.S. Highway 441 across Payne's Prairie in Alachua County, Florida, a year-long study of wildlife mortality was conducted prior to the construction by FDOT of a barrier wall and underpass system (ecopassage). This study, which documented significant mortality, especially for amphibians and reptiles (Smith and Dodd 2003) was followed by a post-construction survey, which showed a significant positive effect of the barrier wall and culvert. For example, whereas 2,411 roadkills were recorded in the 12 months prior to construction, only 158 animals were killed in the 12 months after construction (in both cases excluding hylid treefrogs) (Dodd et al. 2004).

Foster and Humphrey (1995) found Florida panthers, bobcats, deer, raccoons, bears, and alligators, in addition to other species (e.g., wading birds and humans) using underpasses below I-75 in South Florida that were constructed to mitigate impacts of the highway on panthers. Studies elsewhere have shown that small and medium-sized mammals and many species of amphibians and reptiles use concrete culverts and drainage tunnels (Hunt et al. 1987, Brehm 1989, Dexel 1989, Norden 1990, Ng et al. 2004). In Colorado, two major transportation corridors (I-25 and US-85) were studied to identify species crossing the highways and to better understand habitat connectivity needs across those areas (Henke et al. 2002). This study looked at surrounding public lands and documented movement through existing structures and across the highway. Using remotely sensed data to identify lynx habitat and model probable lynx dispersal routes across US-85, the optimal sites for locating crossing structures can be identified.

Smith (1999) assessed potential interfaces between major roads and priority ecological conservation areas for future mitigation (e.g., lengthening existing bridges and enlarging culverts, constructing new wildlife underpasses) within the Florida ecological network. Wildlife and transportation experts determined elements that were used to prioritize sites for the location of underpasses: chronic roadkill sites; known migration/movement routes (including juvenile dispersal, mating season movements and normal home range activity); identified hot spots of focal species activity; designated greenways; presence of listed species; identified strategic habitat conservation areas; existing and proposed conservation lands, riparian corridors; and potential to be included in proposed road improvement project. Likely travel routes were determined using topographic gradients, watercourses or riparian corridors, and habitat ecotones. The data reflecting these elements were assigned base values and multipliers and combined in an additive manner, which resulted in a final layer that reflected cumulative impact of each road segment. The areas identified as highest priority for mitigation were regionally and nationally significant conservation areas and important riparian corridors.

Despite these promising studies, knowledge of the effectiveness of various designs for wildlife-crossing structures is extremely limited (Transportation Research Board 2002), in part because studies of wildlife crossings must deal with a large number of potentially confounding variables, including differences in behavior and response to crossings among various species, variation in human activity in the vicinity of the crossing, density of crossing structures, and other factors (Clevenger and Waltho 2005). Species of vertebrates differ in their requirements and behavioral preferences for crossings, such that a given crossing will be permeable to some species but not to others, potentially causing changes in predator-prey relationships and other community- or ecosystem-level properties (Clevenger and Waltho 2000). Techniques to minimize wildlife mortality on highways (for example, fencing) may conflict with measures to reduce population fragmentation (Cain et al. 2003). In any case, it has become clear that maintaining connectivity across roads for multiple species requires a diversity of crossing structures of mixed designs and size classes (Clevenger and Waltho 2005).

Monitoring of crossings needs to be drastically upgraded in order to provide reliable guidance to transportation planners (Forman et al. 2003). Monitoring should encompass existing structures and structures in the design or construction phase, and should include structures designed as wildlife crossings as well as culverts, enhanced culverts and other pathways under or over highways that various species may use. Importantly, monitoring of crossing structures, roadkills, and successful crossings of highways must encompass multiple species (e.g., amphibians and reptiles as well as mammals), because different structures and landscape/habitat conditions promote movement of different taxa. In addition, crossing structures designed for wildlife should be multi-functional and also include consideration of hydrological connectivity and other ecological processes.

The Florida panther: overview.

The Florida panther historically ranged throughout the southeastern United States (Comiskey et al. 2002, Schrader-Frechette 2004). Estimates put the Florida population at approximately 500 animals at the beginning of the twentieth century (Comiskey et al. 2004, Ogden et al. 2005). Since that time, hunting, persecution, and land-use change (e.g., urbanization, agriculture, and rural development) have reduced the Florida panther population to one remnant area in south Florida (Meegan and Maehr 2002, Schrader-Frechette 2004, Gross 2005, Odgen et al. 2005).

The Florida panther utilizes a variety of habitats for its survival and reproductive needs (Comiskey et al. 2002, Comiskey et al. 2004, Odgen et al. 2005). Panthers use forests, marshes, grasslands, scrub, and agricultural lands (Maehr 1990, Maehr and Cox 1995, Comiskey et al. 2002, Kautz et al. 2006). The only habitat type that they tend to avoid is mangrove swamp (Maehr and Cox 1995, Comiskey et al. 2002). Panthers prey on a variety of animals; but white-tailed deer (*Odocoileus virginianus*) is probably the most important prey species (Maehr and Cox 1995, Kilgo et al. 1998, Comiskey et al. 2002, MacDonald-Beyers and Labisky 2005, Ogden et al. 2005).

The social structure of the Florida panther population is similar to western cougar populations in that females tend to have smaller home range sizes than males and tend to disperse shorter distances from their natal range (Cramer and Portier 2001, Maehr et al. 2002). Males have larger home ranges and travel longer distances to find mates (Maehr et al. 2002). Average home range sizes for males range from 416.5-650 km^2. Females range from 156.1-396 km^2 (Maehr and Cox 1995, Comiskey et al. 2002, Kautz et al. 2006). The population structure consists of a distribution of mutually exclusive males with large home ranges overlapping with females and their closely related offspring. This leads to a successful breeding structure (Ogden et al. 2005). Successful colonization of new areas usually occurs when females leave their natal areas and occupy new habitat (Comiskey et al. 2002).

Hundreds of articles have been written regarding the Florida panther and its management, habitat use, distribution, and genetics since it was listed as an Endangered species.

Florida panther genetics.
The Florida panther has been protected under the Endangered Species Act since its inception in 1973 (Gross 2005, Hedrick 2005, Pimm et al. 2006). Even under Federal protection, population viability remained low (population estimates between 30- 50 individuals in the 1990s), due in part to loss of habitat and human encroachment (Maehr 1990, Fergus 1991, Comiskey et al. 2004, Creel 2006, Kautz et al. 2006,). The population exhibited signs of reduced genetic variation due to inbreeding: low sperm viability, male sterility, heart defects, kinked tails, and cowlicks (Hedrick 2005, Pimm et al. 2006). In 1995, managers proposed a controversial project to help save Florida panthers by introducing eight female cougars *P. c. stanleyana* from Texas to try to bolster the genetic stock of the Florida population (Maehr and Caddick, 1995, Rhymer and Simberloff 1996, Hedrick 2005, Stokstad 2005, Pimm et al. 2006).

Eight female Texas cougars were introduced to the Florida population in 1995. Five of the females bred and subsequently produced 20 kittens (Pimm et al. 2006). Pimm et al. (2006) conducted research on the panthers after their introduction. They found that kitten hybrid survivorship was higher, adult female hybrid mortality rate was lower, adult male hybrids had shorter life spans, and hybrids expanded their ranges. In 1983 there were approximately 30 known panthers and by 2003 there were an estimated 87.

In terms of bolstering population numbers, the transplants and introgression of Texas cougars into the Florida population was successful. What has not been determined is whether it was genetic or demographic responses driving the population increase (Maehr et al. 2002, Creel 2006, Maehr et al. 2006).

The findings by Pimm et al. (2006) generated a scientific debate as to the validity and interpretation of their study. Numerous responses and editorials were written to scientific journals (Stokstad 2005, Creel 2006, Maehr et al. 2006, Mills 2006, Pimm et al. 2006). At issue was the Pimm et al. (2006) data analysis, model application (maximum likelihood models), and the fact that demographic factors were ignored as a possible explanation to the increased population size or geographic expansion (Creel 2006). Maehr et al. (2006) describe their misgivings regarding the development and interpretation of the model, absence of credible spatial analyses, and misleading demographic information. They argue that Pimm et al. (2006) did not analyze the genetics over multiple generations, which would seem important in determining whether introgression had taken place. In conclusion, Maehr et al. (2006) offered suggestions to better understand the effects of genetic intervention by reanalyzing survivorship and reproductive rates, introducing genetic components to track genes, linking habitat use and preferences to panther distribution and survival, and conducting monitoring over a sufficient period of time.

Florida panther habitat use and management.
As available panther habitat has shrunk a variety of research papers have been written on habitat use by panthers. These help managers decide which is the most important habitat to protect.

Maehr and Cox (1995) identified important habitat types used by Florida panther based on a subset of telemetry data. They found that panthers used a disproportionate amount of forest type, specifically hardwood hammock, mixed hardwood swamp, and cypress swamp in their home range. They also concluded that panthers were more likely to use and occupy areas of preferred forest type >500 hectares and were less likely to cross non-forested areas > 90 meters. They recommended that areas with high amounts of these forest types be protected, such as the areas in and around Florida Panther National Wildlife Refuge (FPNWR). Subsequent papers regarding habitat associations (Pearlstine et al. 1995, Kerkhoff et al. 2000, Cramer and Portier 2001, Maehr and Deeson 2002, Meegan and Maehr 2002) and policy decisions were based on these conclusions (Comiskey et al. 2002, Comiskey et al. 2004, Shrader-Frechette 2004, Gross 2005).

Shortly after the FWS called for a scientific review team to analyze 25 years of data and thousands of pages from articles and journals (Gross 2005), papers criticizing the methods and analysis of Maehr and Cox (1995), Meegan and Maehr (2002), and Maehr and Deeson (2002) began to appear in peer-reviewed articles (Comiskey et al. 2002, Comiskey et al. 2004, Shrader-Frechette 2004, Gross 2005, Kautz et al. 2006).

At issue was that Maehr and Cox (1995) relied on daytime telemetry locations for an animal that was thought to be nocturnal; also spatial uncertainty in radiotelemetry and vegetation maps was not acknowledged. Maehr and Cox (1995) undervalued telemetry data (40%) in areas (particularly swampland) thought to be unsuitable for panther habitat (Comiskey et al. 2002, Comiskey et al. 2004, Shrader-Frechette 2004, Gross 2005). Many of the critics pointed out that after the successful translocation and subsequent breeding of female Texas cougars into the Florida panther population in 1995, panthers were now being found in areas that were once deemed unsuitable, such as Big Cypress National Preserve (BCNP) and Everglades National Park (ENP). Prior to the introgression program where Texas cougars were translocated, home ranges in the BCNP and ENP were quite large, lending to the rationale that those areas were less suitable for panthers. After the introgression, Comiskey et al. (2002) demonstrated that panther home range size in BCNP and ENP were similar in size to panthers in more forested areas.

In their critique of the Maehr and Deeson (2002) Panther Habitat Evaluation Model, Comiskey et al. (2002, 2004) disagreed with the basic tenets that panthers are forest-obligate animals (utilizing only specific forest types). Comiskey et al. (2002) analyzed all telemetry locations and the mean error associated with those locations, field observations where panther sign was obtained, home range data, and land-cover maps. The results of their analysis indicated that panthers were not explicitly forest-oriented, and that they exploited a variety of landscapes for their survival. Panthers typically used forests for resting, hunting, and denning, but did not use forest exclusively.

More recent models have applied the lessons learned from the scientific debates on panther habitat utilization. Using compositional and Euclidean distance analyses, Kautz et al. (2006) determined relative importance of different land-cover types and patch size in habitat selection by panthers. These findings were combined with radiotelemetry records, home range overlaps, land use/land cover data, and satellite imagery to delineate Primary and Secondary habitat protection zones. Kautz et al. (2006) suggest that these habitat zones could support a population of 80–94 panthers that would likely persist and remain stable for 100 years.

Based on quantitative landscape assessments, Thatcher et al. (2006) developed a Mahalanobis distance (D^2) habitat model, using 4 anthropogenic variables and 3 landscape variables to identify prospective sites for Florida panther reintroduction within the historic range. Nine potential reintroduction sites of sufficient size to support a panther population were found. This model was also applied at fine scales to evaluate amount of effective habitat at each site (dispersal distance for female panthers was a key consideration). These model results were compared to expert-assisted models that included other considerations (e.g., area of public lands, livestock density). Anthropogenic factors heavily influenced results of each approach.

Florida panther movements relative to roads.

Panthers prefer large contiguous habitat areas where few major highways are present (Maehr and Cox 1995). Previous studies (Van Dyke et al. 1986, Belden and Hagedorn 1993) had found that other pumas avoided establishing home ranges in areas with high hard-surfaced road density; but lightly traveled roads such as dirt roads and trails were common within home ranges. Crossings of heavily-traveled roads were rare. Maehr (1997) found that female panthers rarely established home ranges bisected by highways, and maternal dens were located at distances of one kilometer or greater from highways.

A key to expansion of the panther population is by successful dispersal to new unoccupied habitat areas; roads confound these movement events. Maehr et al. (2002) studied dispersal of 27 individual panthers. Results showed that male dispersal was longer (mean=68.4 km), more exploratory, and of higher risk (e.g., encounters with roads and other human development features) than that of females (mean=20.3 km). They found that although the population exhibits the behavioral ability to colonize nearby vacant ranges, females have yet to do so, which prevents successful colonization of new habitat areas. Thus underscores the need to establish and maintain sufficiently wide and safe habitat corridors, connecting important breeding habitat areas, which are suitable for dispersal of females. Maehr et al. (2002) suggest that successful dispersal to these areas could be facilitated by habitat restoration and translocation of females. Kautz et al. (2006) created least-cost path models to identify important landscape linkages. A primary concern was to delineate a “dispersal zone” to accommodate future panther dispersal outside of south Florida.

All plans to establish linkages must contend with an ever increasing network of roads and traffic that jeopardize successful dispersal. Vehicle collisions (n=94) were the primary cause of mortality of Florida panther between March 1978 and June 2006. Prior to 1998 incidents with vehicles occurred less than 2 times per year. From 1998 – 2006 vehicle collisions averaged 7 per year. Recall that population size began to increase appreciably after female Texas cougars were introduced in 1995; this led directly to more individuals searching for new home ranges increasing the probability of encountering roads. Sexual variation in collisions was n=55 for males and n=37 for females; recall Maehr et al. (2002) regarding dispersal. Vehicle collisions resulting in the death of subadult panthers (0 to 3 years) of both sexes exceeded all other forms of subadult mortality combined. Mortality types recorded include vehicle collisions, intraspecific aggression, disease/health, shooting, capture related, and unknown. Of all recorded mortality and injuries, vehicle collisions accounted for 49%.

Florida panther road mortality and injury since 1997 (n=63) were greatest in Collier County (n=40, 63%), followed by Hendry County (n=13, 21%) and Dade and Highlands (n=2 each, 3%) counties. Recent panther mortality and injury (since 1997) was greatest on SR 29 (n=15, 33%) and CR 846 (n=14, %), and US 41 (n=10, %). Alligator Alley (the portion of I-75 connecting Naples to Ft. Lauderdale) once had the highest number of road mortalities; wildlife underpasses have dramatically reduced vehicle collisions. Three deaths occurred in 2004 in an area where underpasses were not installed.

Considerations Specific to Northeast Collier County

Two projects of concern in the Collier County RLSA are the development of the Catholic University and town of Ave Maria and the proposed town of Big Cypress (Scott 2003, D’alessandro 2006b). Ave Maria, when finished, would contain about 4,000 acres of development (11,000 homes) including a university for 6,000 students, hotels, shops, schools, medical facilities, schools, playing fields, and two golf courses (Scott 2003, Staats 2006). The development would contribute to conserving 17,000 acres of agricultural and environmentally sensitive lands (Scott 2003). Ave Maria is situated near Camp Keais Strand (Gross 2005), a landscape feature considered an important corridor connecting Florida panther habitat. If Big Cypress is approved, it would be a large development, containing 25,000 homes including a town on Oil Well Road (CR 858) and eight smaller communities interconnected by trails. About

8,000 acres would be developed and 14,000 preserved —an additional 13,000 environmentally sensitive acres outside the district would also be preserved (Cepero 2006).

CR 846 and 858 and SR 29 in the RLSA are currently 2-lane alignments with adjacent parallel canals. The traffic volume on each of these roads is relatively low to moderate. Due to these impending projects, the County proposes to widen CR 858. Other new roads are proposed, including a potential six-lane highway from Immokalee Road (CR 846) south along the eastern side of Golden Gate Estates to I-75 (Cepero 2006). Increased traffic on existing rural roads will certainly be associated with these development projects.

Increased road widths and traffic will result in more roadkills of some species and greater aversion to crossing of the road by others (thus increased habitat fragmentation and population subdivision). Strategically placed crossing structures can partially offset these effects by increasing permeability of the road for wildlife. Currently, cross-drainage conveyances such as culverts and bridges along these road segments provide limited opportunities for wildlife movement under the roadways. Those that do exist are primarily flow-ways limiting use by terrestrial organisms.

It is with respect to these impending projects and the need for additional data on roadkill and wildlife movement patterns along the road right-of-way to evaluate functional connectivity associated with the habitat stewardship areas, that we conducted this research project.

The objectives of this research were:

- To conduct roadkill, tracking, and camera studies to determine current movement patterns of Florida panther and other wildlife in relation to the highway and to assess each road’s current and potential impacts to movement and habitat connectivity.

- To assemble existing information and study results and conduct analyses that will help evaluate functional connectivity of designated habitat stewardship areas and determine potential locations of wildlife crossings within the RLSA.

Methods

Study Area

We investigated wildlife mortality associated with vehicle traffic along three rural highways in northeast Collier County, CR 846 (Immokalee Road), CR 858 (Oil Well Road), and SR 29 (Fig. 6). Specific sections of these roads monitored included:

- CR 846 right-of-way (near Okaloacoochee Slough), beginning at Immokalee City Limits and ending at Hendry County Line (approximately 7.5 mi), and southwest of Immokalee (in vicinity of Camp Keais Strand), specifically east from Oil Well Grade Road (approximately 5.5 mi);
- CR 858 right-of-way (Okaloacoochee Slough to Camp Keais Strand), specifically from Hendry County Line to Oil Well Grade Road (approximately 13.5 mi);
- SR 29 right-of-way north of Florida Panther NWR (approximately 8 mi).

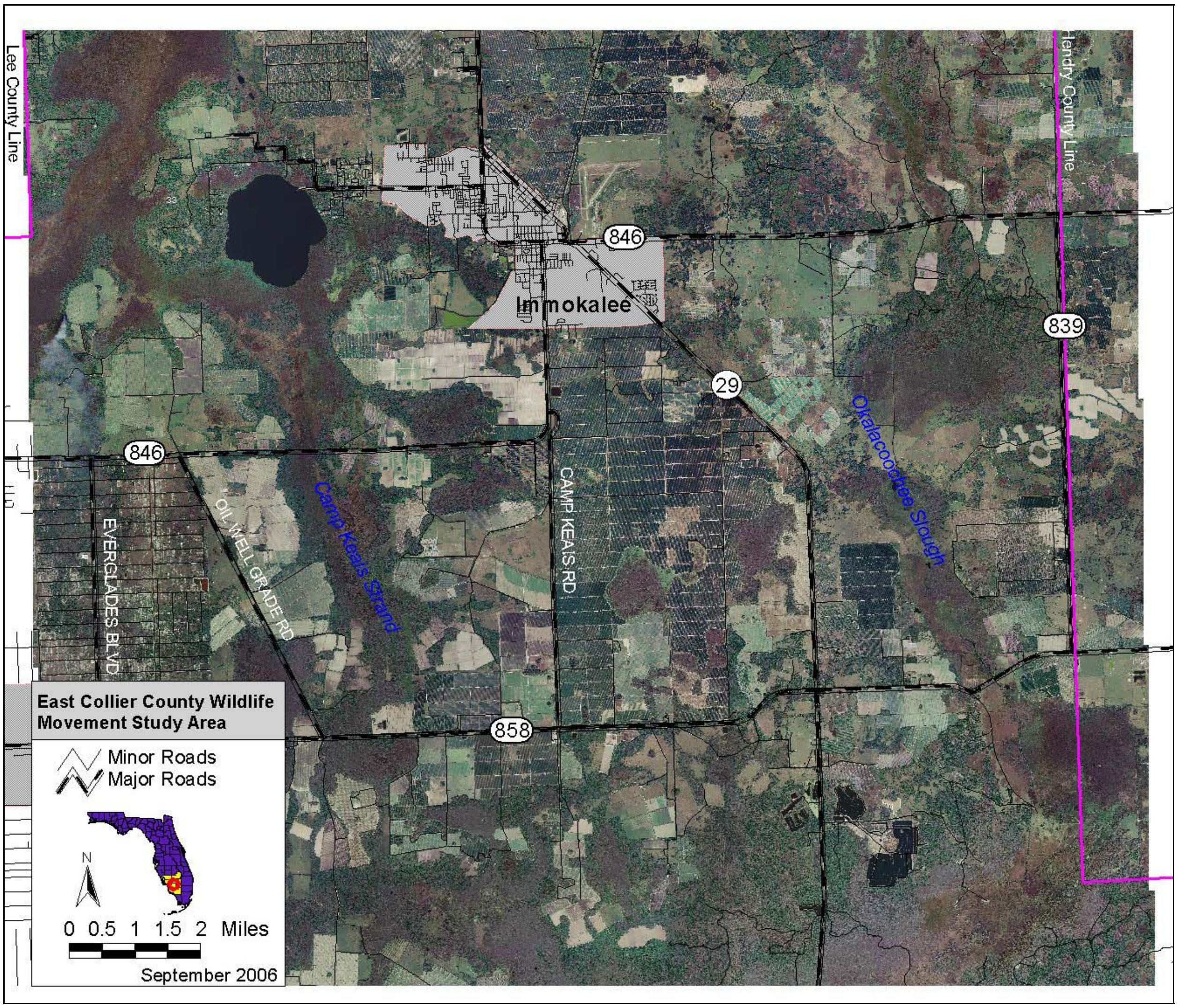


Figure 6. Northeast Collier County Study Area.

Field Activities

Our field procedures included roadkill and track surveys and the use of infra-red triggered camera stations (camera traps). We monitored for all wildlife roadkill on the road surface and immediate shoulder (3 times per week from December 2005 to May 2006 and once per week from June-August 2006) on 1) a 7-mile section of CR 846 from the Immokalee City Limits to Hendry County Line and a 4-mile section southwest of Immokalee east from Camp Keais Grade Road in the vicinity of Camp Keais Strand, 2) CR 858 from Hendry County Line west to Oil Well Grade Road, and 3) SR 29 from 3 miles north of CR 858 south to the Florida Panther National Wildlife Refuge boundary (Fig. 7). When encountered as part of the overall route for checking roadkill, large animal roadkills were recorded outside of these target areas. Surveys were conducted by vehicle, driving 40 mph or less. We recorded date, GPS location, species, sex and approximate age (if discernable), traffic lane direction, and animal direction of travel (if discernable). Recorded roadkills were then marked with orange paint to avoid double counting.

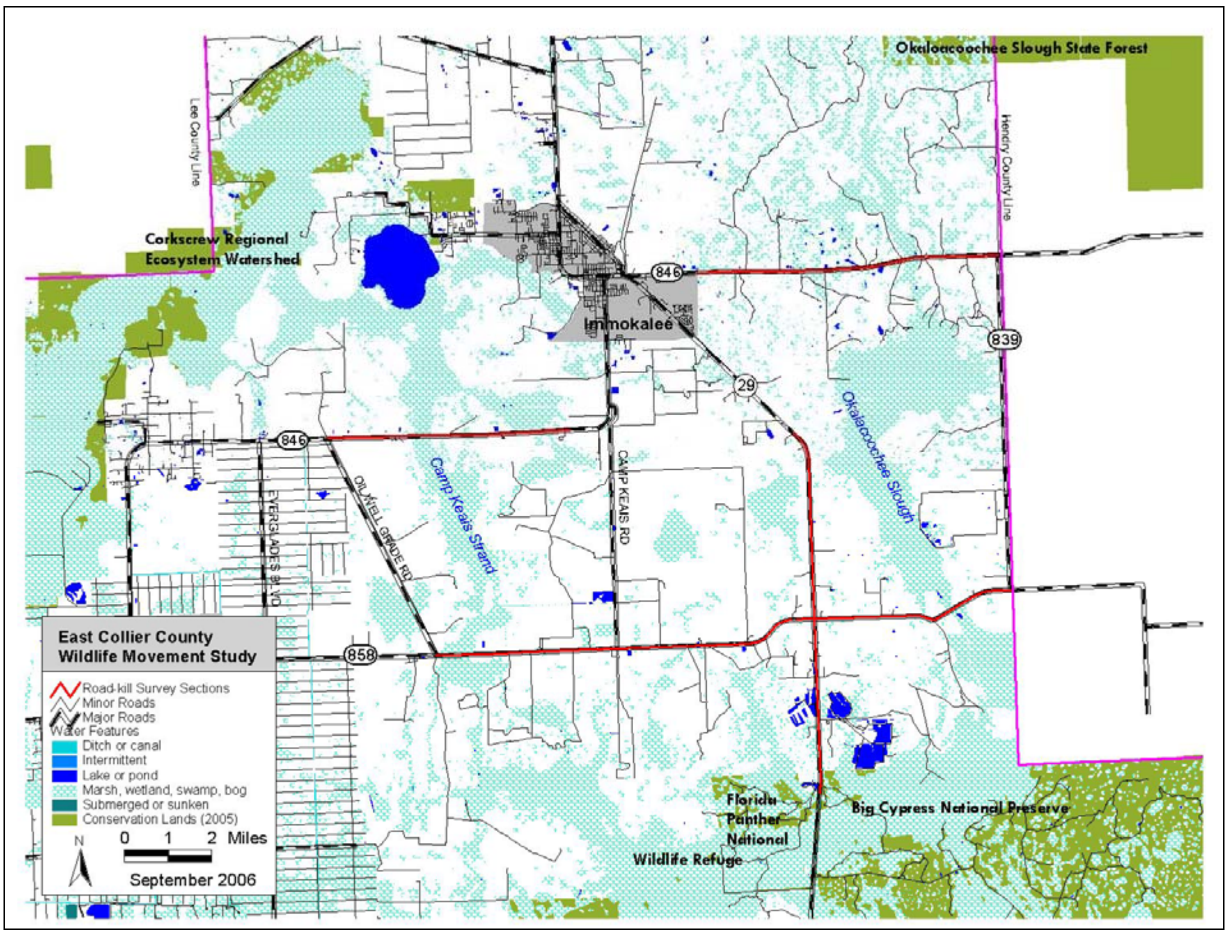


Figure 7. Location of Roadkill Surveys (in red). Large animal roadkills were also documented along roads throughout the study area on an opportunistic basis.

Ideally, it would have been preferable to conduct track monitoring for crossing events over entire sections of CR 846 east and west of Immokalee (Fig. 7). Insufficient resources prevented this approach. Instead, track transects and camera trapping stations were used in combination to obtain satisfactory coverage of road crossings by wildlife along each road section. Sites with camera stations were selected from within the roadkill monitoring areas shown in Fig. 7 and in other areas where corridors of forest or other appropriate habitat intersected the road sections of interest. Prior locations of Florida panther and black bear roadkills and telemetry points also contributed to selection of track transects and camera stations.

Wildlife track monitoring was conducted (3 times weekly from December 2005 through March 2006, 2 times weekly April-May 2006, and once weekly June-August 2006) on graded paths along the right-of-way at selected locations adjacent to the road surface (Fig. 8). Track paths were prepared within the mowed maintenance area (parallel to and approximately 2-5 m from the pavement), first by treating with herbicide to kill existing vegetation. Second, each track path was disced and tilled to loosen soil and vegetation. Finally, each track bed was raked to remove dead vegetation and stones to create a smooth, readable surface. Each track path was approximately 1-m wide and varied in length depending on each location. An ATV with a harrow was used to maintain transects and to check for tracks. We checked track paths for larger organisms of these taxa-- mammal, bird, snake, and turtle tracks. We recorded date, GPS location, species (to nearest taxa), and animal direction of travel (if discernable).

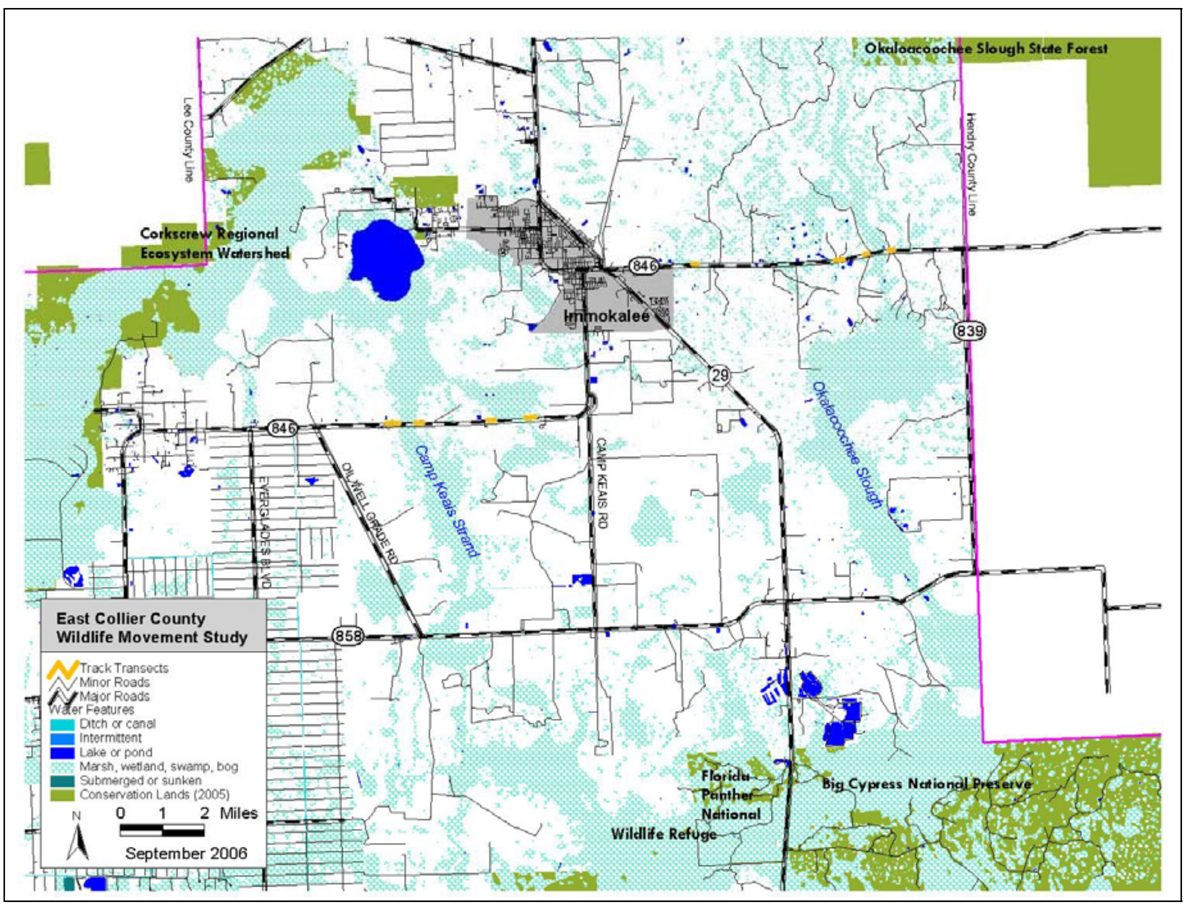


Figure 8. Location of Track Monitoring Stations (in yellow).

Remote infra-red camera stations were deployed at selected sites (Fig. 9) to monitor road crossings and approach events by large animals. Sites selected included game trails, areas near former roadkill or telemetry locations, or where track monitoring was not feasible (e.g., poor soil conditions). Thirteen original camera stations were deployed in January 2006, and six additional sites were established in April (2) and June (4) of 2006 and checked through August 2006. Generally, cameras were mounted parallel to the ground approximately 2 ft high (or at strategic angles to target specific crossing paths). Camera traps were not baited. These were checked once weekly to remove stored photographs and replace low batteries. We used *Bushnell Trail Scout Pro* digital cameras and recorded date, species, and animal direction of travel (if discernable).

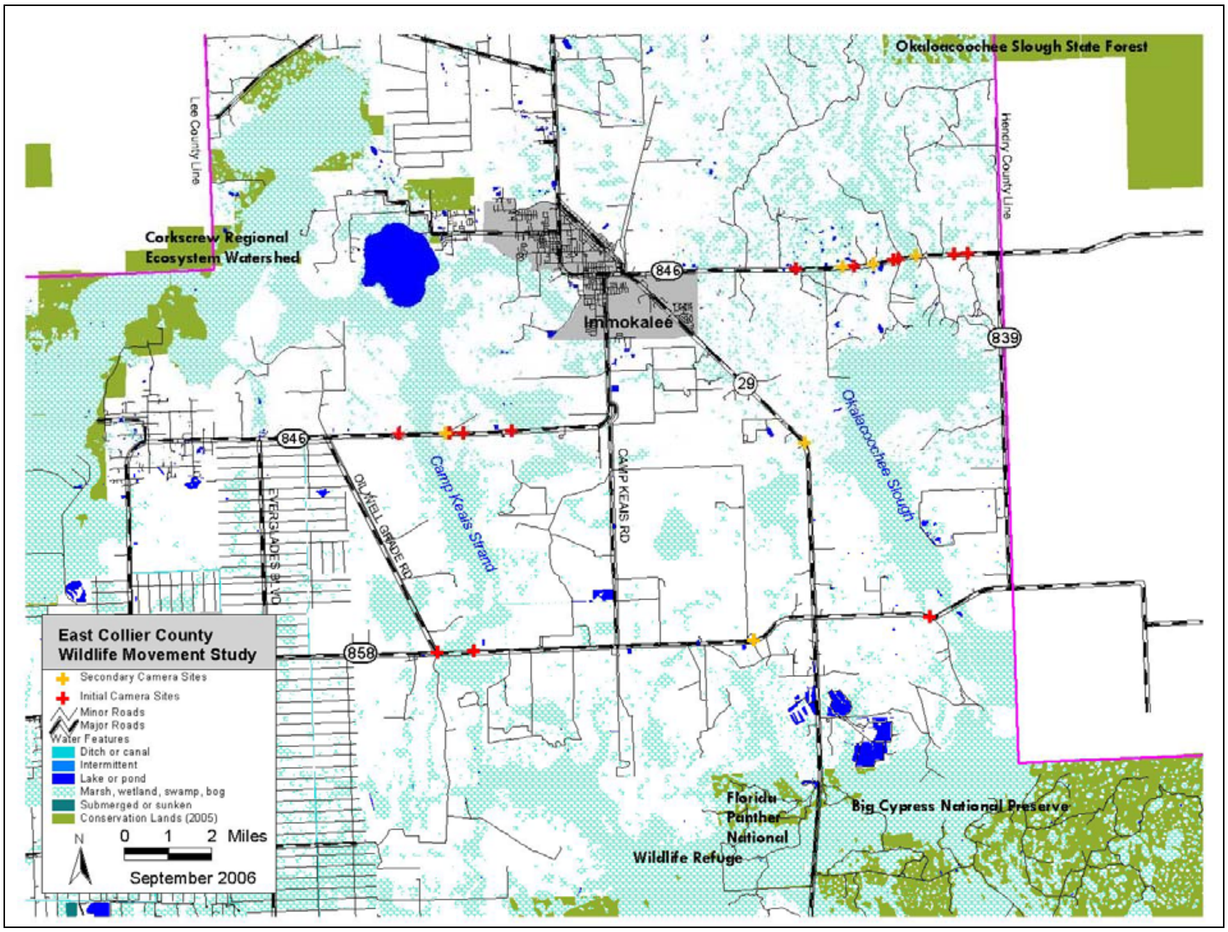


Figure 9. Location of Camera Monitoring Stations (red and yellow crosses).

Analysis

Analysis of field data includes use of GIS information and results from previous telemetry, tracking, and roadkill studies conducted by Florida Fish and Wildlife Conservation Commission and other agencies. Because of the short duration of field data collection, only descriptive statistics could be performed.

In addition to field studies, we conducted a simple comparative analysis of previous conservation planning efforts that defined critical landscape features and habitat areas for Florida panther and other imperiled wildlife in northeast Collier County. Data layers examined included Florida Fish and Wildlife Conservation Commission (FWC) strategic habitat conservation areas (SHCAs), the Florida Ecological Network (greenways), Florida Managed Natural Areas (existing public conservation lands), Florida Forever Lands (proposed public conservation lands), Florida Natural Areas Inventory (FNAI) Priority Habitat Areas, hydrography 1:24,000, FWC land cover (2003) native upland communities, the primary and secondary habitat zones from the Florida panther MERIT sub-committee, FWC roadkill and telemetry data for Florida panther and black bear, and Florida Element Occurrence Natural Heritage Program data (recorded locations of listed, rare or imperiled species). These conservation planning elements were compared within the boundary of the Rural Lands Stewardship Area (RLSA). The Collier County Rural Lands Stewardship Program designated stewardship zones (habitat stewardship areas, flow-way stewardship areas, and water retention areas) are included in this comparative analysis.

The FWC SHCAs were based on habitat needs for 124 vertebrate species designated as listed, rare, or imperiled (Kautz and Cox and 2000). The Florida Ecological Network (greenways) was developed for the Florida Greenways Commission and Florida Department of Enviromental Protection by the University of Florida and identified priority conservation areas and linkages for a statewide connected system of habitats (Hoctor et al. 2000). The Florida Managed Natural Areas data layer represents all current public and private conservation lands (FNAI 2006). This includes Federal, State, local, and privately managed natural areas. Florida Forever lands include all proposed conservation lands designated by the Florida Board of Trustees (FNAI 2006). These generally represent areas targeted for public acquisition as priority conservation areas. FNAI priority habitat areas include places on the landscape that would protect both the greatest number of rare species and those species with the greatest conservation need (FNAI 2006). The hydrography coverage (source: USGS) includes all water features such as wetlands, natural open water bodies, man-made impoundments, and canals. The 2003 land cover data (30 m resolution) created by FWC included 24 different land cover classes within the study area; all native upland communities were extracted from this dataset including pinelands, mixed pine-hardwood forest, hardwood hammocks and forests, cabbage palm-live oak hammock, cypress/pine/cabbage palm, dry prairie, shrub, and brushland. The primary and secondary habitat zones for the Florida panther were based on a model of landscape components important to Florida panther habitat conservation (Kautz et al. 2006). It was based on radiotelemetry records, home range overlaps, land use/land cover data, and satellite imagery. The results comprise a landscape mosaic considered sufficient to maintain a self-sustaining population. FWC provided roadkill and telemetry point data from previous and ongoing studies of Florida panther and black bear. The Florida element occurrence data includes records of listed, rare and imperiled species, natural communities, and unique geologic and landscape features maintained by FNAI as part of the Florida Natural Heritage Program. These records date back to the late 1800s.

Results

Combined Site Results

For all road sections (n=7) we recorded 67 different species (Table 1). These were categorized by faunal groups that included American alligator, birds (n=29), carnivores (n=5), ungulates (n=2), domestic animals (n=2), meso-mammals (n=3), small mammals (n=4), frogs (n=2), snakes (n=11), turtles (n=7), and river otter.

Table 1. Species recorded at all study sites.

Group name	Common name	Scientific name	Roadkill	Track	Photographs/Live Observation
Crocodilian	American alligator	*Alligator mississippiensis*	x		x
Birds	American kestrel	*Falco sparverius*	x		
	anhinga	*Anhinga anhinga*	x		
	barred owl	*Strix varia*	x		
	black vulture	*Coragyps atratus*	x		
	black-crowned night heron	*Nycticorax nycticorax*	x		
	brown thrasher	*Toxostoma rufum*			x
	cattle egret	*Bubulcus ibis*			x
	Chuck Will's widow	*Caprimulgus carolinensis*	x		
	common moorhen	*Gallinula chloropus*	x		
	eastern meadowlark	*Sturnella magna*	x		
	eastern screech owl	*Otus asio*	x		
	European starling	*Sturnus vulgaris*	x		
	gray catbird	*Dumatella carolinensis*	x		
	great blue heron	*Ardea herodias*	x		
	great egret	*Casmerodius albus*	x		
	green heron	*Butorides virescens*	x		
	heron	*Egretta spp.*	x		
	marsh wren	*Cistothorus palustris*	x		
	mourning dove	*Zenaida macroura*	x		
	northern cardinal	*Cardinalis cardinalis*	x		x
	owl	*Strigidae*			x
	perching bird	*Avian*			x
	red shouldered hawk	*Buteo lineatus*	x		
	red-winged blackbird	*Agelaius phoeniceus*	x		
	sandhill crane	*Grus canadensis*	x		x
	snowy egret	*Egretta thula*	x		
	turkey vulture	*Cathartes aura*	x		
	wild turkey	*Meleagris gallopavo*		x	x
	wood stork	*Mycteria americana*			x
Carnivores	bobcat	*Lynx rufus*	x	x	x
	coyote	*Canis latrans*	x	x	x
	grey fox	*Urocyon cinereoargenteus*	x		
	Florida panther	*Puma concolor c.*	x	x	x
	Florida black bear	*Ursus americana fl.*		x	

Table 1. continued.

Group name	Common name	Scientific name	Roadkill	Track	Photographs/Live Observation
Domestic*	cow	*Bovidae*			x
	dog	*Canis familiaris*	x		x
Frogs	frog	*Anuran*	x		
	pig frog	*Rana grylio*	x		
Meso-mammals*	nine-banded armadillo	*Dasypus novemcinctus*	x		
	raccoon	*Procyon lotor*	x		x
	Virginia opossum	*Didelphis virginiana*	x		x
River otter	river otter	*Lutra canadensis*	x	x	x
Small Mammals*	marsh rabbit	*Sylvilagus palustris*	x		x
	rabbit	*Sylvilagus spp.*	x		
	rat	*Muridae*	x		x
	E. gray squirrel	*Sciurus carolinensis*	x		
Snakes	black racer	*Coluber Constrictor*	x		
	brown water snake	*Nerodia taxispilota*	x		
	corn snake	*Elaphe guttata*	x		
	Florida cottonmouth	*Agkistrodon piscivorus c.*	x		
	E. diamondback rattlesnake	*Crotalus adamanteus*	x		
	Florida scarlet snake	*Cemophora coccinea c.*	x		
	common garter snake	*Thamnophis sirtalis s.*	x		
	pigmy rattle snake	*Sistrurus miliarus*	x		
	snake	*Serpentes*	x	x	
	water snake	*Nerodia spp.*	x		
	yellow rat snake	*Elaphe obsoleta q.*	x		
Turtles	Florida box turtle	*Terrapene carolina b.*	x		
	Florida cooter	*Chrysemys floridana f.*	x		
	Florida red-bellied turtle	*Chrysemys nelsoni*	x		
	common snapping turtle	*Chelydra serpentina*	x		
	Florida softshell turtle	*Trionyx ferox*	x		
	striped mud turtle	*Kinosternon bauri*	x		
	turtle	*Testudines*	x	x	
Ungulates	white-tail deer	*Odocoileus virginianus*	x	x	x
	wild pig	*Sus scrofa*	x	x	x

* numerous tracks from species in these groups were observed but not recorded.

Figures 10 and 11 display the total tracks/photos and roadkills, respectively, recorded from all sites. A total of 136 tracks and 73 photos (focal species only: bobcat, coyote, deer, panther, turkey, and wild pig) and 333 roadkills (all species) were recorded. Of tracks/photos, deer were found most frequently (n=121), followed by bobcat (n=21), pig (n=18), turtles (n=13), coyote (n=11), Florida panther and turkey (n=10 each), snake (n=2), river otter (n=2), and black bear (n=1). For recorded roadkills, meso-mammals were most common (n=115), followed by birds (n=110), snakes (n=35), turtles (n=17), alligator (n=5), river otter (n=10), small mammals and ungulates (n=9 each), carnivores and frogs (n=5 each), and domestic animals (n=3). Noteworthy roadkills included raptors (n=21), vultures (n=58), wading birds (n=13), sandhill crane (n=1), Florida box turtle (n=1), snapping turtle (n=3), and E. diamondback rattlesnake (n=1).

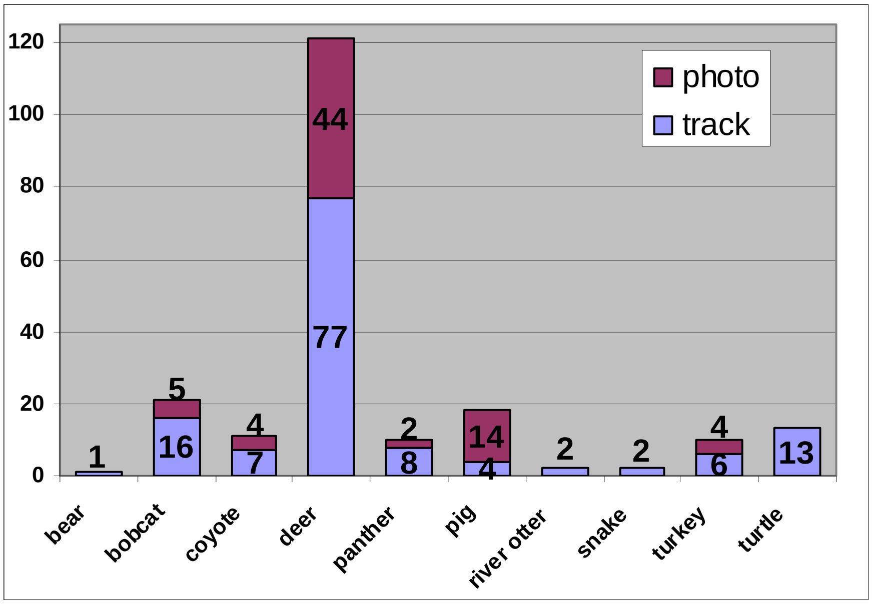


Figure 10. Total number of tracks/photos recorded by species, Dec 05 – Aug 06.

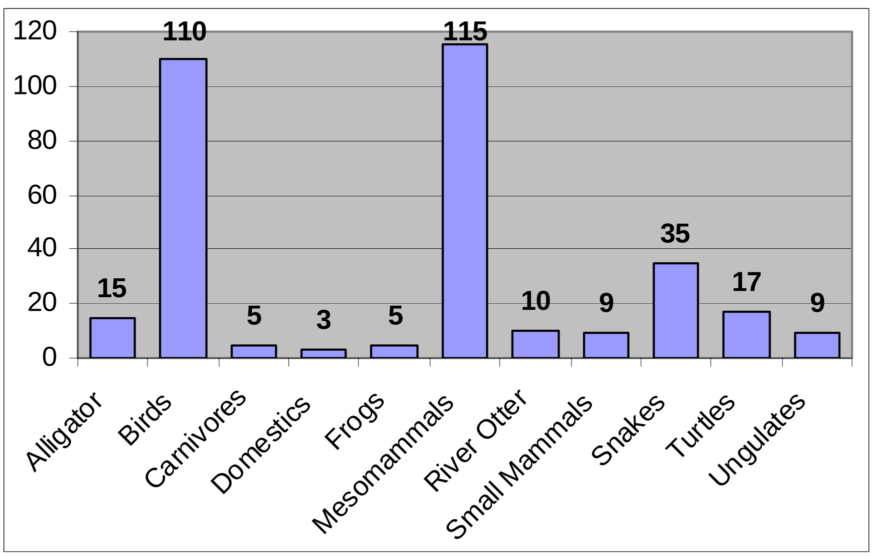


Figure 11. Total number of roadkills recorded by group, Dec 05 – Aug 06.

Seasonal peaks in roadkill and track observations were inconsistent (Fig.12). Roadkill was most abundant in December-January, April and July. Tracks were most abundant in March. Previous studies (Smith et al. 2005, Smith and Voigt 2005, Smith et al. 2005) conducted in Florida exhibited consistent seasonal peaks in spring and late summer for both tracks and roadkills.

Several factors are at play that explain the inconsistent trends; first, roadkill and tracks were monitored 3 times per week from December to May (tracks- twice per week in April and May) and only once per week from June to August, thus the lower numbers in summer months; second, several track paths still required preparation work from January-February, as such, fewer tracks were recorded during this period; third, substrate consistency was very poor on the CR

846 west transects, which severely reduced our ability to read tracks; and finally, rainfall during the study period was below average by 1.7 in per month and was 3 in or more below normal from June – August. Therefore, very few herptiles were recorded during this study. Herptiles represented a major component in previous studies (Smith et al. 2005, Smith and Voigt 2005, Smith et al. 2005) and were expected to here also, especially given the dominant presence of canals and wetlands throughout the landscape. Interannual variability in precipitation dictates that multi-year studies are needed to obtain consistent data that reflects accurate movement patterns and presence of wildlife, especially among amphibians and reptiles.

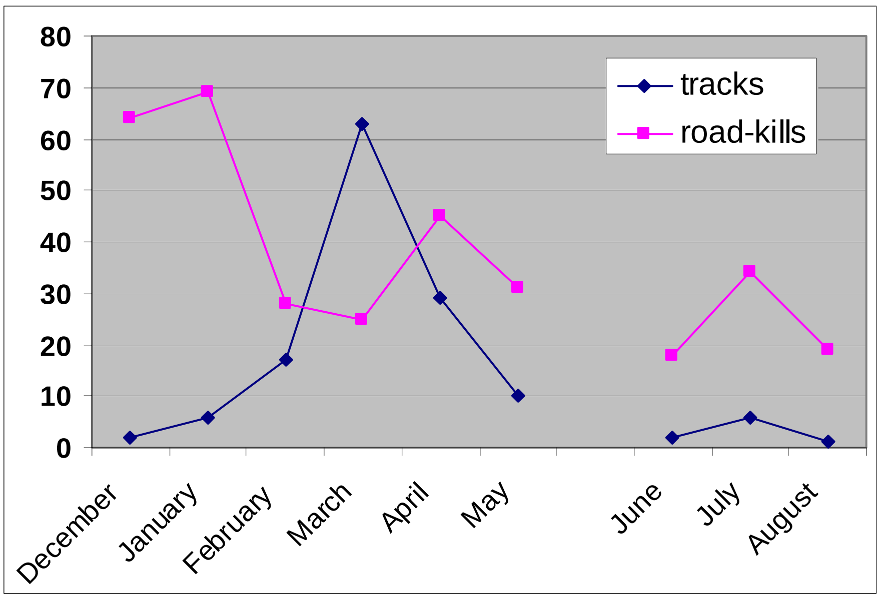


Figure 12. Seasonal Variation in Roadkill and Track Records.

Spatially, we counted 114 separate track records on CR 846 east transects (n=4) and 22 separate track records on CR 846 west transects (n=4); track transect locations are shown in Fig. 8. Track data are included in Appendix A. Due to poor substrate conditions at the west transects, far fewer tracks were recorded. Dry silty sand frequently reduced our ability to accurately read presence and type of tracks; substrate at the east transects was much better, a loamy sand that held track form longer. Because of these differences, we could not accurately compare differences in species presence/absence or perceived abundance between east and west transects.

Tracks were divided by species by road section in Fig. 13; deer were far more abundant than any other species at the east transects. All species types were found in the east except Florida black bear and domestic dog. Florida panther, bobcat, coyote, deer, and turtles were recorded at both east and west road sections. Locations of Florida black bear and panther tracks are consistent with previous roadkill and telemetry data.

General spatial distribution of roadkills included 7 separate road sections (Figs.7 and 13). We found the greatest number of roadkills on CR 846 (100 – east, 81 – west). CR 858 was divided into three sections—east, central, and west. Roadkills were evenly distributed among these sections with 32, 27, and 31, respectively. For SR 29, 15 roadkills were found north of CR 858, and 47 roadkills were found south of CR 858. Roadkill data can be found in Appendix B and camera data are located in Appendix C.

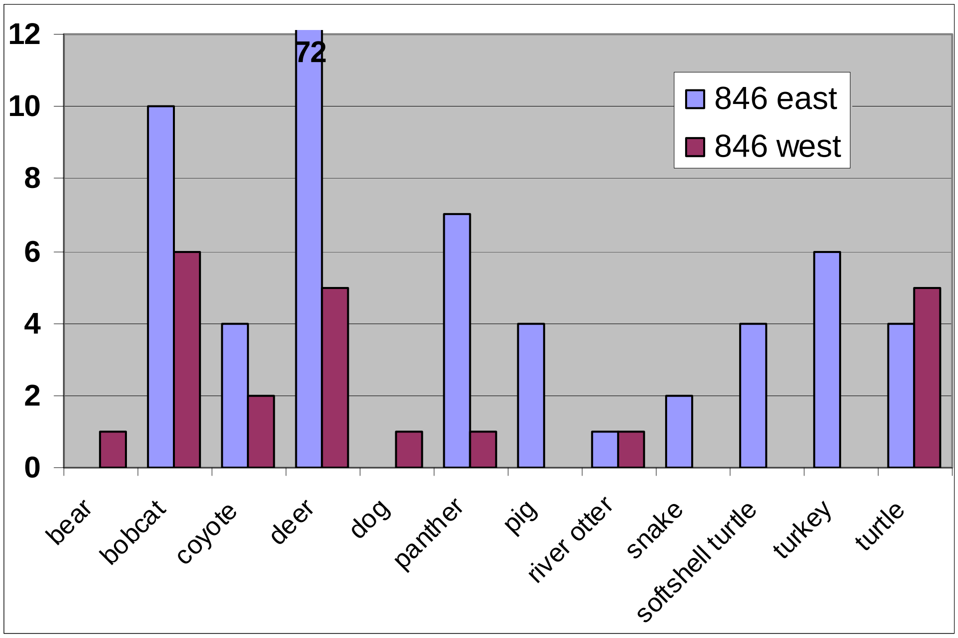


Figure 13. Tracks recorded by type and by road section (refer to Fig. 8 for site map).

Examined by type and by road section (Fig. 14), recorded roadkills exhibit some basic patterns. Alligators were found on all road sections except SR 29 north (this section is adjacent to citrus groves on the west and a steep-walled canal on the east); since canals are adjacent to all these roads this was expected. Birds were common on all road sections; raptors and scavengers were most common and were likely killed while foraging for carrion on the road. Few carnivores were found on any road section. River otters were found in similar numbers as alligators; from observations they commonly used the canals adjacent to roads as habitat. Together with their poor mobility on land, this placed them at high risk from vehicle collisions when crossing the road. More than twice as many ungulate roadkills were found on eastern road sections than on western road sections or SR 29. The category “other mammals” includes meso-mammals, small mammals, and domestic mammals (see Table 1); this was the most abundant group, commonly found on CR 846, CR 858, and SR 29 south.

Turtles, snakes, and frogs were found most often along road sections near wetlands (CR 846 east and west, CR 858 east and west, and SR 29 south). Conspicuously underrepresented among this group were anurans (n=5); as previously mentioned, lack of rainfall probably contributed to their absence. Also of note, no lizards and only one rodent were recorded. These two groups are rarely found (Smith et al. 2005, Smith and Voigt 2005, Smith et al. 2005); because of their physical size, their movements are more constrained by roads, and if they do decide to cross they do not persist on the road very long after death (probably disintegrated by vehicle tires or collected by carrion feeders).

We tested for effect of land cover type on roadkill locations. Because of small sample sizes, we placed species in three groups—mammals, herpetofauna, and birds; land cover types (from FWC

2003 land cover) were consolidated from 24 classes to five classes—agriculture, open wetlands, forested wetlands, open uplands, and forested uplands (Table 2). The Chi-square test of association (non-independence) showed no relation between roadkills and land cover type ($\chi^2 = 9.085$, $p = 0.335$). Factors affecting this result might include small sample sizes, short duration of surveys, presence of canals adjacent to all road sections, and resolution/classification accuracy of land cover data source. We would expect statistically defensible patterns to emerge with longer study duration.

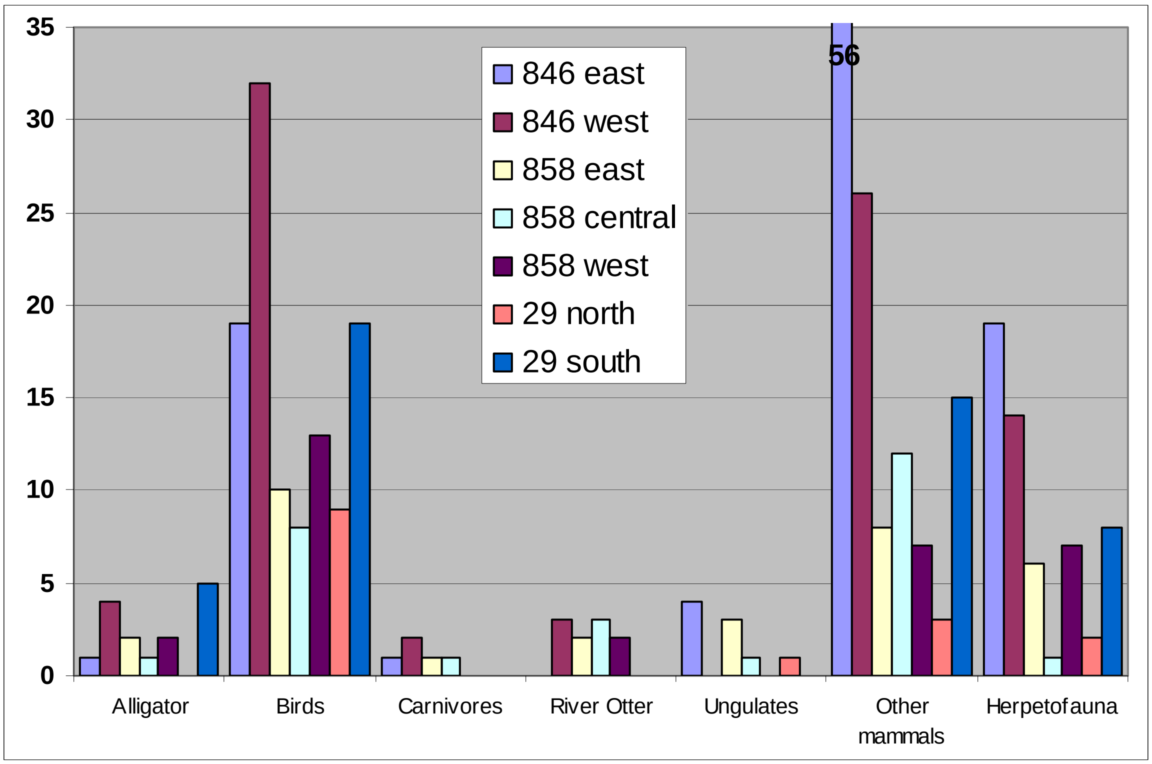


Figure 14. Roadkills recorded by type and by road section (refer to Fig. 7 for site map).

Table 2. Roadkill type by general land cover class.

	Agriculture	Forested Uplands	Forested Wetlands	Open Uplands	Open Wetlands
Herpetofauna	18	15	13	6	22
Birds	28	16	16	17	33
Mammals	46	27	16	29	35
Alligator	3	2	1	1	8
Snakes	7	9	6	5	10
Turtles	6	4	6	0	1
Frogs	2	0	0	0	3
Carnivores	2	1	0	1	1
River Otter	4	1	1	1	3
Domestics	5	0	0	0	0
Mesomammals	33	18	13	24	27
Small Mammals	0	5	1	1	2
Ungulates	2	2	1	2	2

CR 846 East Site Results

Each road section monitored was partitioned into 100-m segments for analysis. This was used to determine spatial frequency distributions for roadkills on each road. The frequency distribution for roadkills on CR 846 east is shown in Fig. 15. Despite only 100 total roadkills recorded, 75% of these are concentrated in eight spatial clusters, at road segments 1-2 (6%), 6-9 (7%), 38-42 (8%), 44-50 (14%), 59-65 (11%), 68-70 (5%), 75-82 (19%), and 99-100 (5%). All roadkills and respective 100-m segments for CR 846 east are shown above the 2004 digital ortho-photograph of the area in Fig. 16. Specific locations of roadkills by taxonomic group for this road section are shown in a series of maps in Appendix D.

Eight Florida panther roadkills have been recorded along this section of CR 846 between December 1993 and January 2006 (Appendix D – Map D6). (Note: an additional panther roadkill on this stretch of CR 846 was reported in December 2006, as this report was being completed. However, we have not been able to obtain specific location data.) Location of 5 of the 8 panther roadkills are within four of the road segment clusters described above (1-2, 44-50, 59-65, and 68-70). Of particular note are three panther roadkills that occurred in close proximity to one another in road segment clusters 59-65 and 68-70. This is a significant hotspot for Florida panther and roadkill in general.

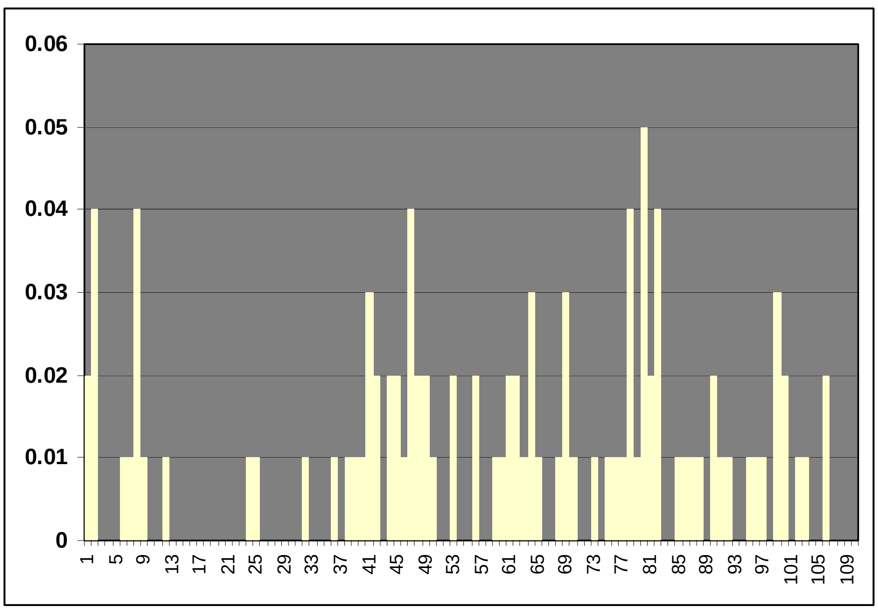


Figure 15. Frequency distribution for roadkills recorded on CR 846 east (numbers on x-axis represent 100-m road segments, see Fig.17)**.**

Other significant roadkills include white-tailed deer (road segments 9 and 88), alligator (road segment 56), and raptors (road segments 36, 44, 59, 64). See other species and their locations in Appendices B and D.

Tracks were recorded in four separate transects on CR 846 east (Fig. 17). Thirty tracks were recorded in the first transect (road segments 8-9). At the second transect (road segments 62-65) we recorded 22 tracks. At the third transect (road segments 73-75) 11 tracks were recorded. The fourth transect (road segments 82-85) had the greatest number of tracks recorded (n=46).

Most notable tracks recorded were Florida panther within road segments 63 - 65 (see Appendices A and D – Map D10) on five separate dates between April 14th and May 24th 2006. These tracks occurred in the same road segments as previously recorded panther roadkills. Another Florida panther track was recorded in road segment 105 near a camera station on June 15th 2006 near the location (road segment 96) of a January 2006 panther roadkill.

Several deer and wild pig tracks were recorded in all four transects, at least one bobcat was recorded at each transect, one river otter was recorded at road segment 8, wild turkey tracks were recorded on three separate occasions in road segment 9, turtle tracks were recorded in road segments 8 and 62-65, and snake tracks were recorded in road segments 64 and 65. For numbers and locations of each species refer to Appendices A and D.

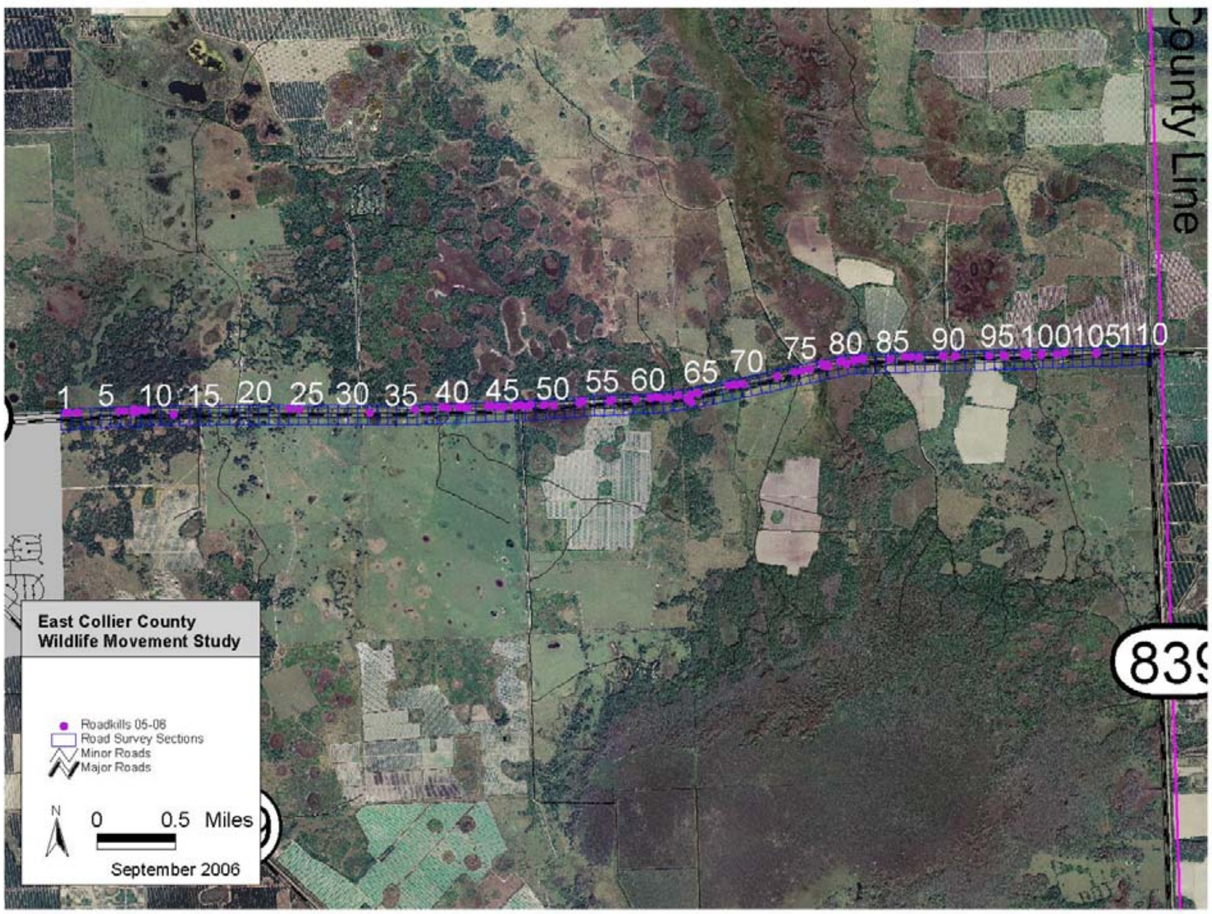


Figure 16. All roadkills recorded on CR 846 east partitioned into 100-m road segments.

Nine cameras were placed within this section of CR 846 (Fig. 18). Camera nos. 1 and 2 were placed next to a farm access road on the south side of CR 846 at road segment 48. The site was characterized by oak scrub, palm hammock, and freshwater marsh. One camera (no. 3) was placed in a remnant pineland/palm hammock site at the edge of a farm field on the south side of

CR 846 in road segment 58. This remnant was associated with a small wetland corridor connected to the south to Okaloacoochee Slough. Two cameras (no. 4 and 5) were located on the south side of the road at each end of a track transect at the upland-wetland interface on the west side of Okaloacoochee Slough (road segments 72 and 74). Camera no. 6 was located adjacent to a dirt access road (road segment 95) on the south side of CR 846 along a strip of native vegetation abutting a farm field. Camera no. 7 was placed at an access road (road segment 99) to a pasture alongside a narrow strip of pinelands adjacent to a freshwater marsh on the south side of CR 846. Camera no. 8 was located at the junction of two pastures on the south side of CR 846 (road segment 105); the pastures were divided by a strip of native vegetation, the camera was placed on a trail adjacent to a ditch. Camera nos. 1 and 2 were monitored from January to April 2006; camera nos. 3 – 8 were monitored from January to August 2006.

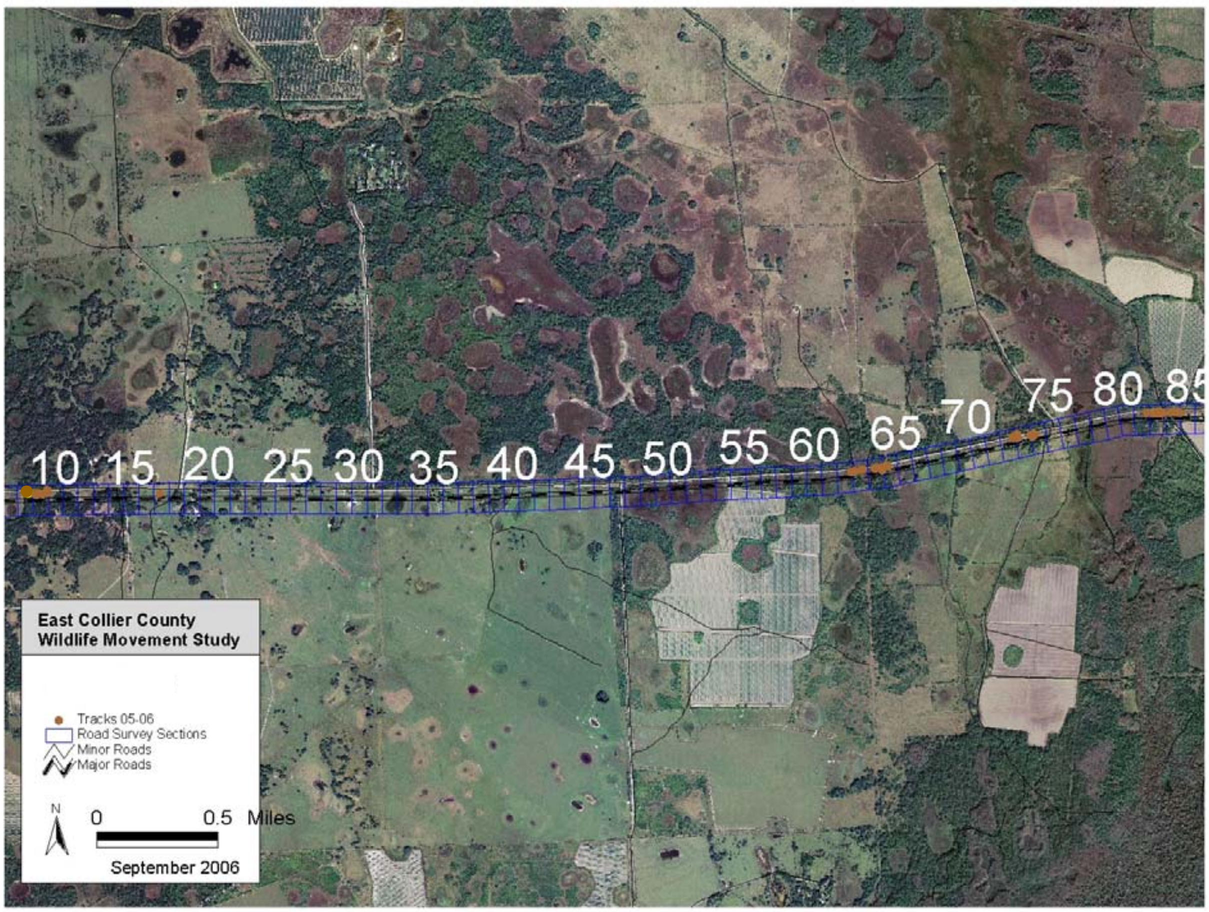


Figure 17. All tracks recorded on CR 846 east partitioned into 100-m road segments.

Camera 1b was placed in a strip of pinelands (road segment 53) across the road from a deer trail on the north side of CR 846. Camera 2b was placed at the east end of a track transect (road segment 64) near the location of observed panther tracks and a previously recorded panther roadkill. Camera 5b was situated 150 m west of a track transect (road segment 80) adjacent to a forested remnant on the east side of the Okaloacoochee Slough. Camera nos. 1b and 2b were monitored from April to August 2006; camera no. 5b was monitored from June to August 2006.

All photographic records are included in Appendix C. No photographs were recorded from camera nos. 1b and 2b. Camera no. 1 only recorded photographs of two cows and one deer. Camera no. 2 photographed raccoon (n=4), deer (n=1), cows (n=4), and an owl (n=1). Only one deer was recorded by camera no. 3. Photographs from camera no. 4 included deer (n=6), raccoon (n=1) and cows (n=3). Nineteen photographs were taken by camera no. 5; these included deer, raccoon and opossum. Twenty-three photographs were captured by camera no. 6; species recorded include deer, bobcat, raccoon, coyote, turkey, sandhill crane, and pig. Only one deer was captured by camera no. 7. Forty-three photographs were taken at the site of camera no. 8; most significant species recorded include deer, bobcat, pig, and turkey. Camera no. 5b recorded one raccoon and a brown thrasher.

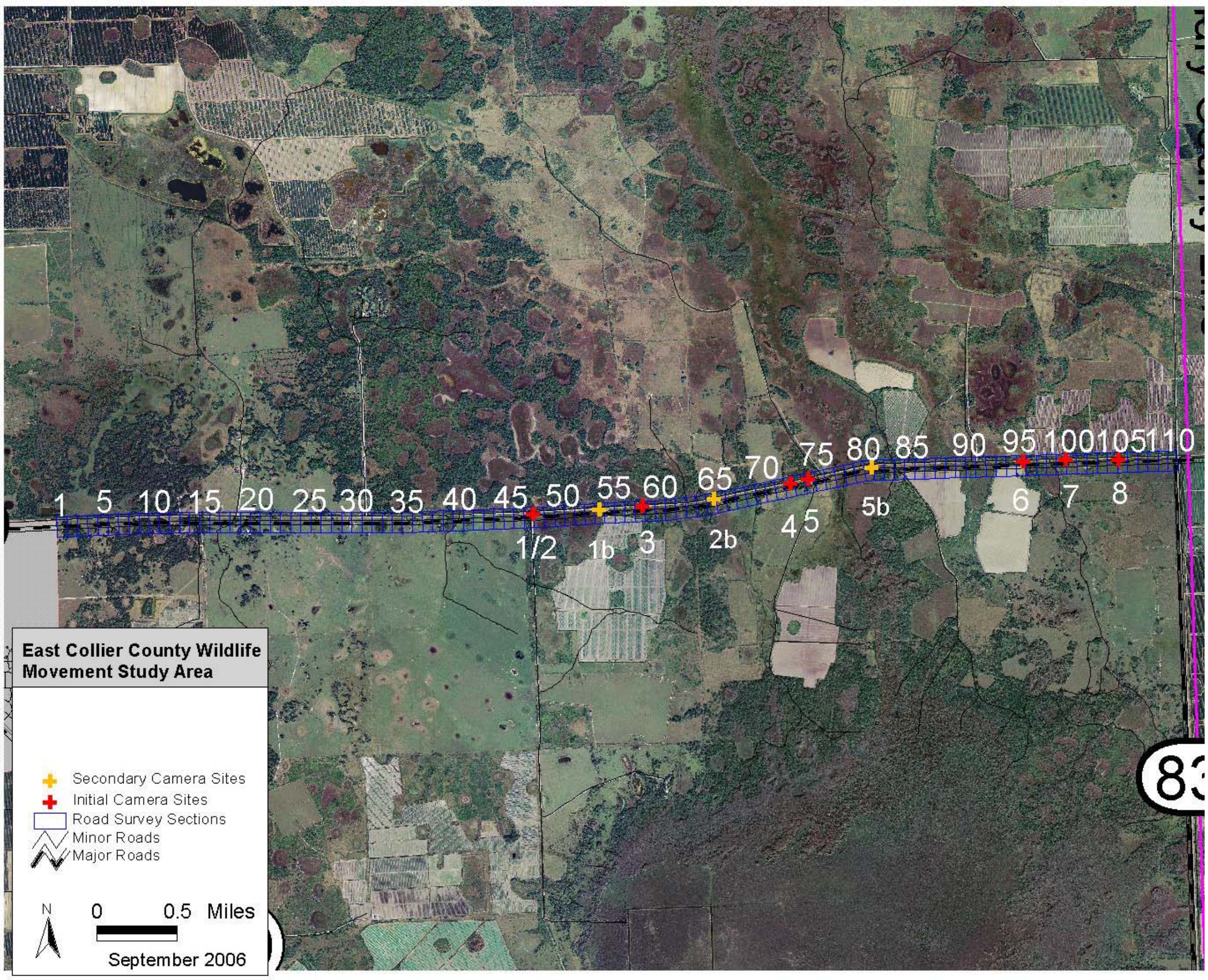


Figure 18. Location of camera stations on CR 846 east.

Based on roadkill, track, telemetry, and landscape information, there are six significant crossing areas (landscape linkages) apparent along this section of CR 846, at road segments 1-15, 44-55, 58-70, 74-85, 89-93, and 95-102. All these are corridors of native vegetation (mostly wetlands, pinelands. and palm hammocks) amongst the agricultural matrix. The most critical for Florida panther is the Okaloacoochee Slough and adjacent upland buffers between road segments 74 and 85.

CR 846 West Site Results

The frequency distribution for roadkills on CR 846 west is shown in Fig. 19. Only 81 total roadkills were recorded; in addition to the small sample size, locations are spatially dispersed. Four potential clusters (that represent 68% of roadkill records) are apparent, but more data should be collected to confirm them (Fig. 19). These spatial clusters occur at road segments 37-45 (27%), 50-58 (10%), 68-74 (7%), and 79-87 (24%). All roadkills and respective 100-m segments for CR 846 west are shown above the 2004 digital ortho-photograph of the area in Fig. 20.

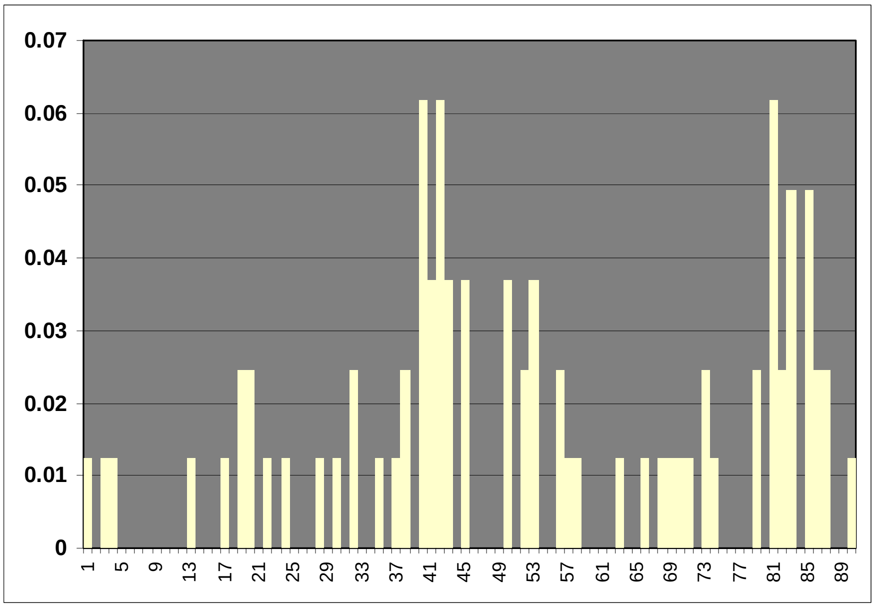


Figure 19. Frequency distribution for roadkills recorded on CR 846 west (numbers on x-axis represent 100-m road segments, see Fig. 20).

Another cluster was expected at road segments 30-32 (the upland buffer from Camp Keais Strand), yet these segments only represent 3% of the data. In addition, we anticipated an abundance of amphibians within the wetland segments (32-40, 52-53, and 70-85), but due to lack of rainfall, frog movements were extremely low resulting in the absence of roadkills. Specific locations of roadkills by taxonomic group for this road section are shown in a series of maps in Appendix E.

Two Florida panther roadkills were recorded along this section of CR 846, one in January and one in June of 2003 (Appendix E – Map E1). Location of each panther roadkill was on either side of the Camp Keais Strand in road segments 31 and 41. This corresponds to one roadkill data cluster identified above (37-45) and the predicted roadkill cluster (30-32). Both sites are important upland buffer strips adjacent to either side of the Camp Keais Strand.

In addition, six Florida black bear roadkills have been recorded here (Appendix E – Map E1). These occurrences are as follows: road segment 27 (Jan 1991), road segment 64 (Jan 2004), road segment 77 (Nov 1992), road segment 78 (Jan 2001), road segment 82 (Nov 1992), and road segment 88 (Aug 1994). The black bear found at segment 27 was 400 m from the panther found at road segment 31. The latter four black bear roadkills were found in or near the large roadkill cluster 79-87, the site of a large forested wetland.

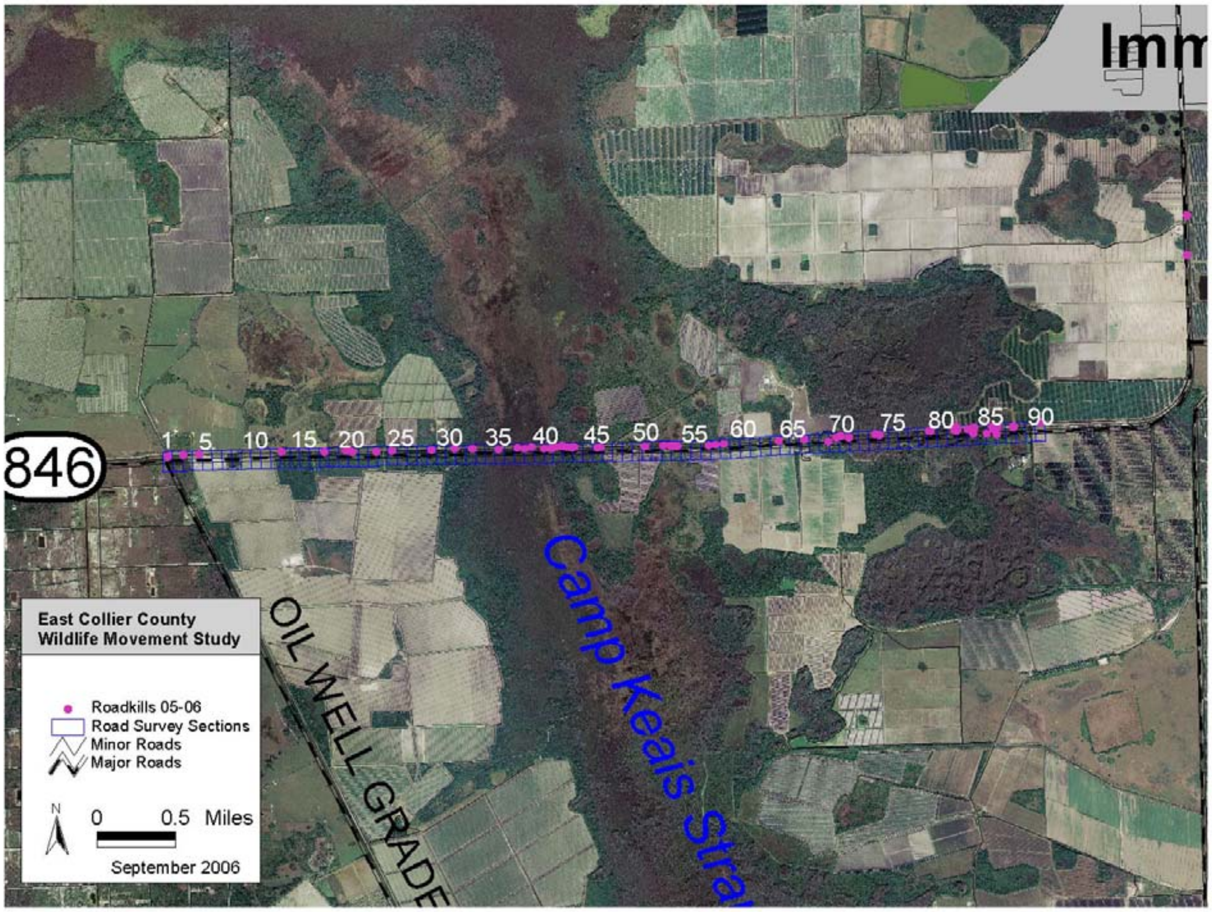


Figure 20. All roadkills recorded on CR 846 west partitioned into 100-m road segments.

Other significant roadkills include gray fox (road segment 38), bobcat (road segment 90), river otter (road segment 40, 63, and 83), alligator (road segments 24, 28, and 45x2), snapping turtle (road segment 53), E. diamondback rattlesnake (road segment 81), FL scarlet snake (road segment 30), and raptors (road segments 38, 50, 68, 74, 79, 83, 85, and 87). See other species and their locations in Appendices B and E.

Tracks were recorded in four separate transects on CR 846 west (Fig. 21). Only one bobcat track was recorded in the first transect (road segments 29-31). At the second transect (road segments 41-45) we recorded 4 significant tracks. At the third transect (road segments 68-69) 6 tracks were recorded. The fourth transect (road segments 82-85) had the greatest number of tracks recorded (n=11). Poor substrate (consisting of soft silt and limerock aggregate from the road bed) and dry weather conditions resulted in very poor performance at these transects. The consistency was such that tracks would not hold their shape or form. Our limited budget combined with the length of each transect precluded bringing in other substrate.

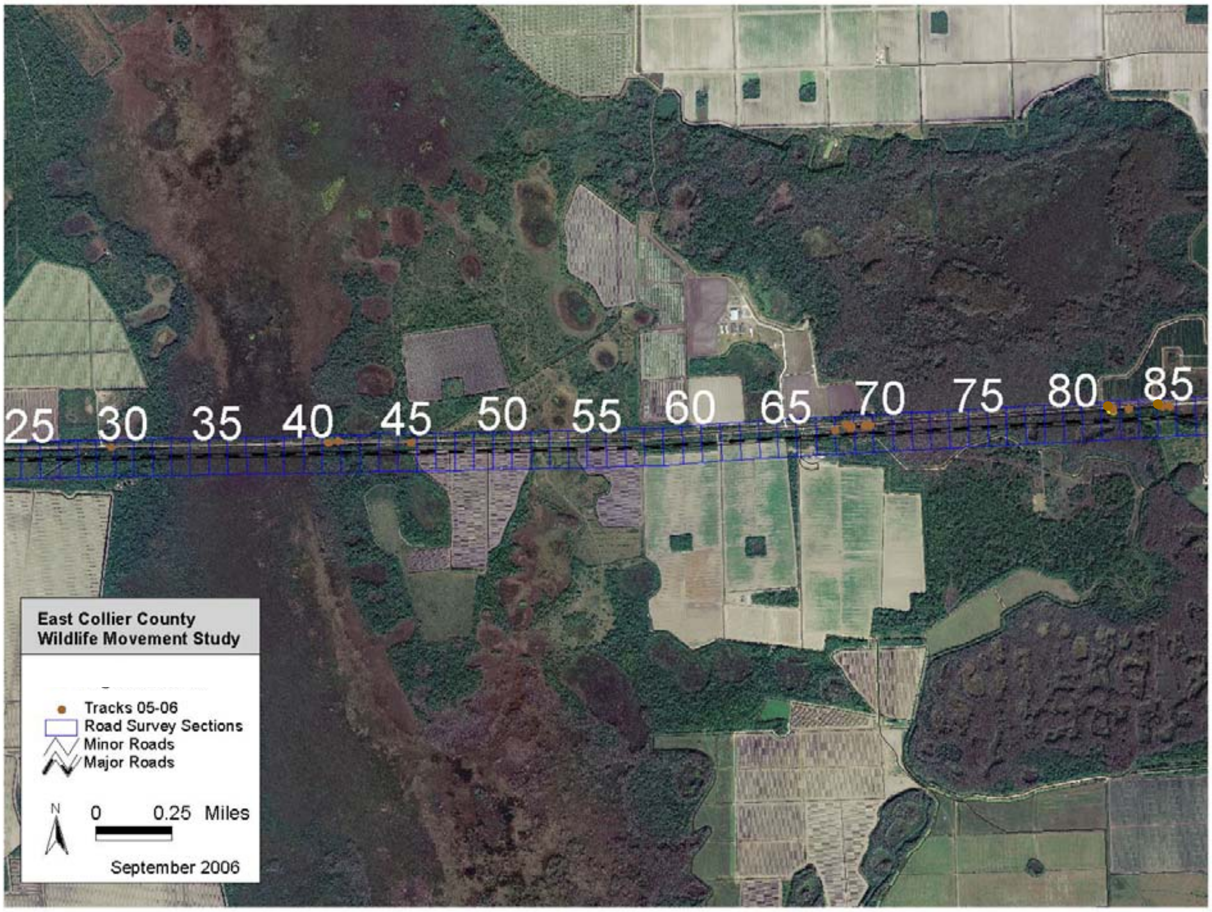


Figure 21. All tracks recorded on CR 846 west partitioned into 100-m road segments.

Most notable tracks recorded were Florida panther in road segment 45 on March 24th 2006 and Florida black bear in road segment 41 on March 9th 2006 (see Appendices A and E – Map E6). The black bear track was observed in the same road segment as a previously recorded panther roadkill (in 2003).

Other tracks recorded included five deer in the 4th transect, one and four bobcat tracks at transects 1 and 3 respectively, one river otter at road segment 45, and turtles in road segments 68, 82-83, and 85. For numbers and locations of each species refer to Appendices A and E.

Six cameras were placed within this section of CR 846 (Fig. 22). Camera no. 12 was aimed across a dirt access road on the south side of the road at road segment 28. Two cameras (no. 13 and 13b) were located on the south side of the road in the corner of a pasture at the upland-wetland interface on the east side of Camp Keais Strand (road segment 45). Camera nos. 14 and 15 were placed at pasture gates on the south side of the road at road segments 47 and 52, respectively. These two cameras were situated at access points adjacent to or across from native vegetation. Camera no. 16 was located on a primitive trail on the northside of CR 846 alongside the wetland-upland ecotone. Camera nos. 12, 14, and 15 were monitored from January to June 2006; camera nos. 13 and 16 were monitored from January to August 2006; and camera no. 13b was monitored from April to August 2006.

All photographic records are included in Appendix C. No photographs were recorded from camera nos. 12 and 16. Camera nos. 14 and 15 only recorded photographs of cows. Camera no. 13 was more productive (20 total photographs). Most significant photos included panther, bobcat, and coyote. An uncollared panther was photographed on March 29th and April 2nd 2006 (Appendix C). Camera no. 13b recorded one wild turkey.

Three significant wildlife crossing areas (landscape linkages) are present along this section of CR 846, the Camp Keias Strand (and adjacent upland buffers) from road segment 29-45, a minor linkage from road segment 51 to 55, and the large forested wetland (and adjacent upland buffers) at road segments 67-87.

CR 858 East Site Results

The frequency distribution for roadkills on CR 858 east is shown in Fig. 23. Only 32 total roadkills were recorded, reducing the ability to determine possible spatial patterns. The diagram displays a dispersed pattern. Possible roadkill clusters may exist located at road segments 6 (9%), 22-23 (6%), 35-42 (24%), 51-62 (36%), and 75 (9%). These clusters would account for 84% (n=27) of the roadkills observed on this section of CR 858.

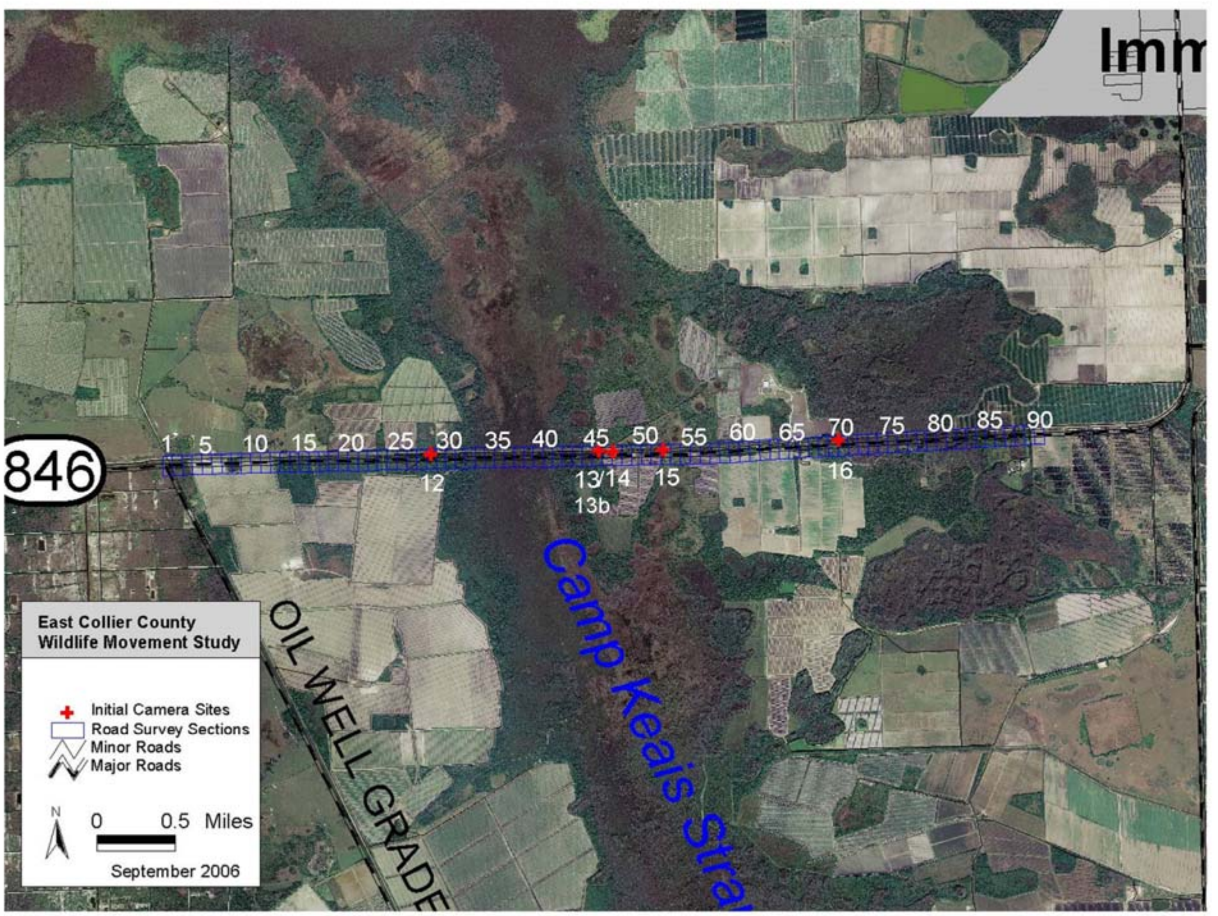


Figure 22. Location of camera stations on CR 846 west.

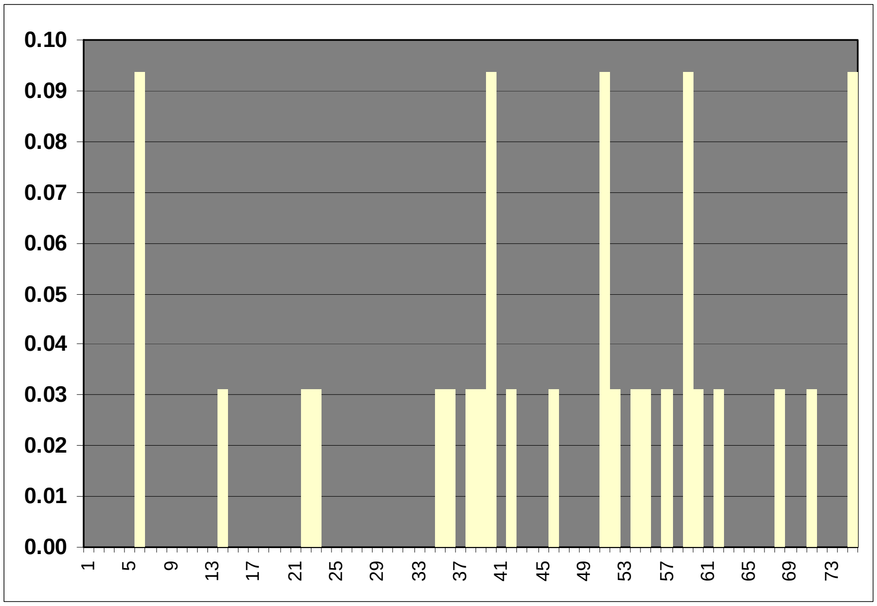


Figure 23. Frequency distribution for roadkills recorded on CR 858 east (numbers on x-axis represent 100-m road segments, see Fig. 24).

All roadkills and respective 100-m segments for CR 858 east are shown above the 2004 digital ortho-photograph of the area in Fig. 24. Specific locations of roadkills by taxonomic group for this road section are shown in a series of maps in Appendix F.

One Florida panther vehicle-related injury occurred along this section of CR 858 in road segment 15 in June 1987 (Appendix F – Map F6). Other significant roadkills included river otter (road segments 4 and 40), alligator (road segments 22 and 51), and wading birds including great blue heron and great egret (road segments 51, 54, 57, and 60). See other species and their locations in Appendices B and F.

The area near the Okaloacoochee Slough and canal (road segments 40-57) is surrounded by open marsh that provides excellent foraging grounds for aquatic-dependent terrestrial wildlife such as alligator, river otter, and wading birds. The pavement and right-of-way along this section is narrow and the road bed is elevated. This provides limited visibility for motorists, poor escape potential for wildlife crossing the road, and angles that direct wading bird flight paths into traffic.

A camera (no. 9) was placed at the entrance to a FWS mitigation property on the north side of CR 858 at road segment 44 (Fig. 25). This was near along the western ecotone of the Okaloacoochee Slough. It was aimed across the trail so that animals traveling down the trail would be photographed. The trail was monitored from January to August 2006. Photographs included 13 whitetail deer and one bobcat. Dates and times are shown in Appendix 3.

One significant wildlife crossing area (landscape linkage) is present along this section of CR 858, the Okaloacoochee Slough (and adjacent upland buffers) from road segment 35-62. Significant restoration is required to create upland buffers adjacent to the slough to improve the functionality of this corridor.

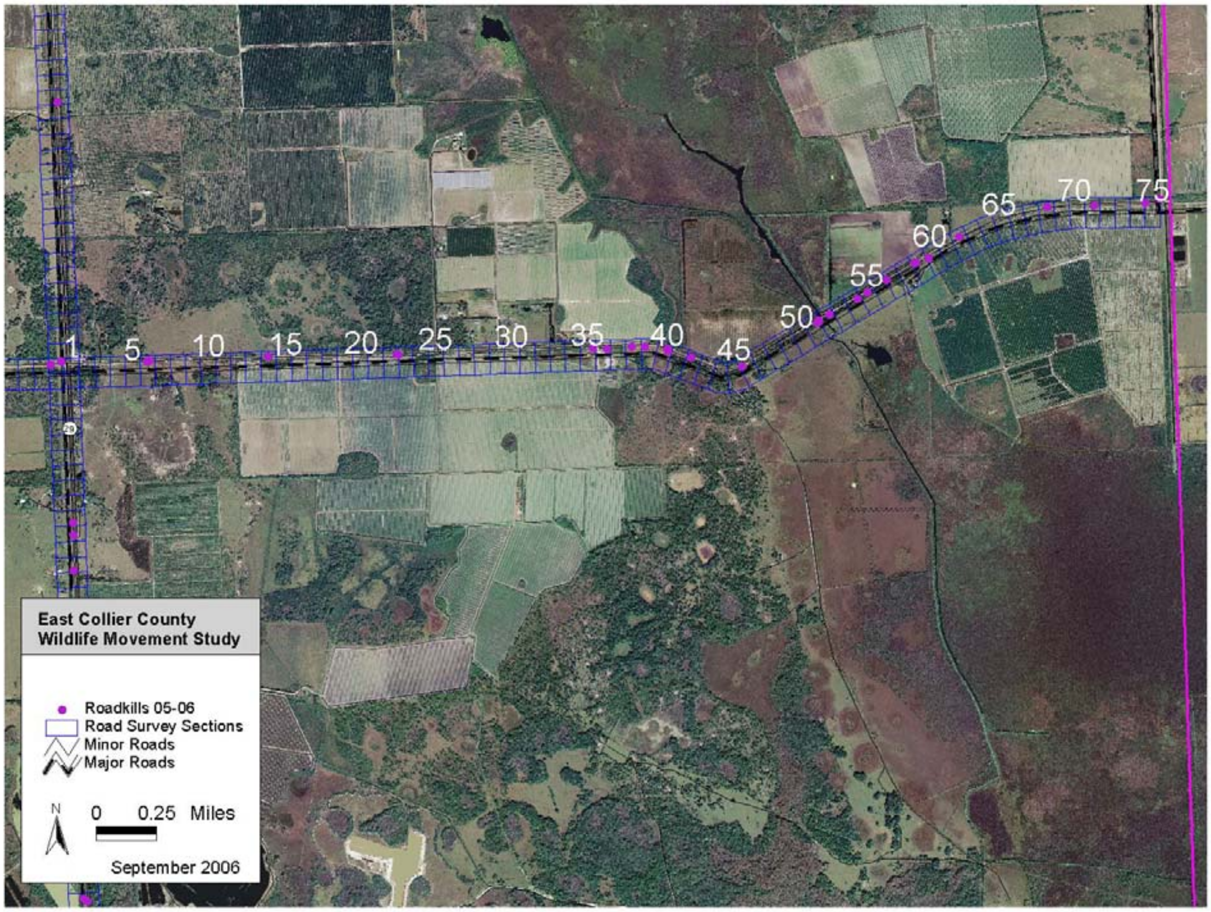


Figure 24. All roadkills recorded on CR 858 east partitioned into 100-m road segments.

CR 858 Central Site Results

The frequency distribution for roadkills on CR 858 central is shown in Fig.26. Only 29 total roadkills were recorded, limiting our ability to determine possible spatial patterns. The diagram displays a dispersed pattern. Possible roadkill clusters may exist at road segments 1 (14%), 20-26 (33%), and 44-49 (16%). These clusters would account for 63% (n=18) of the roadkills observed on this section of CR 858.

All roadkills and respective 100-m segments for CR 858 central are shown above the 2004 digital ortho-photograph of the area in Fig. 28. Specific locations of roadkills by taxonomic group for this road section are shown in a series of maps in Appendix G.

Two Florida panther roadkills were recorded along this section of CR 858, one in November 2003 and one in February 2000 (Appendix G – Map G6). Location of each panther roadkill (road segments 22 and 25, respectively) was on a curve within a native pineland crossing area. This corresponds to one roadkill data cluster identified above (road segments 20-26).

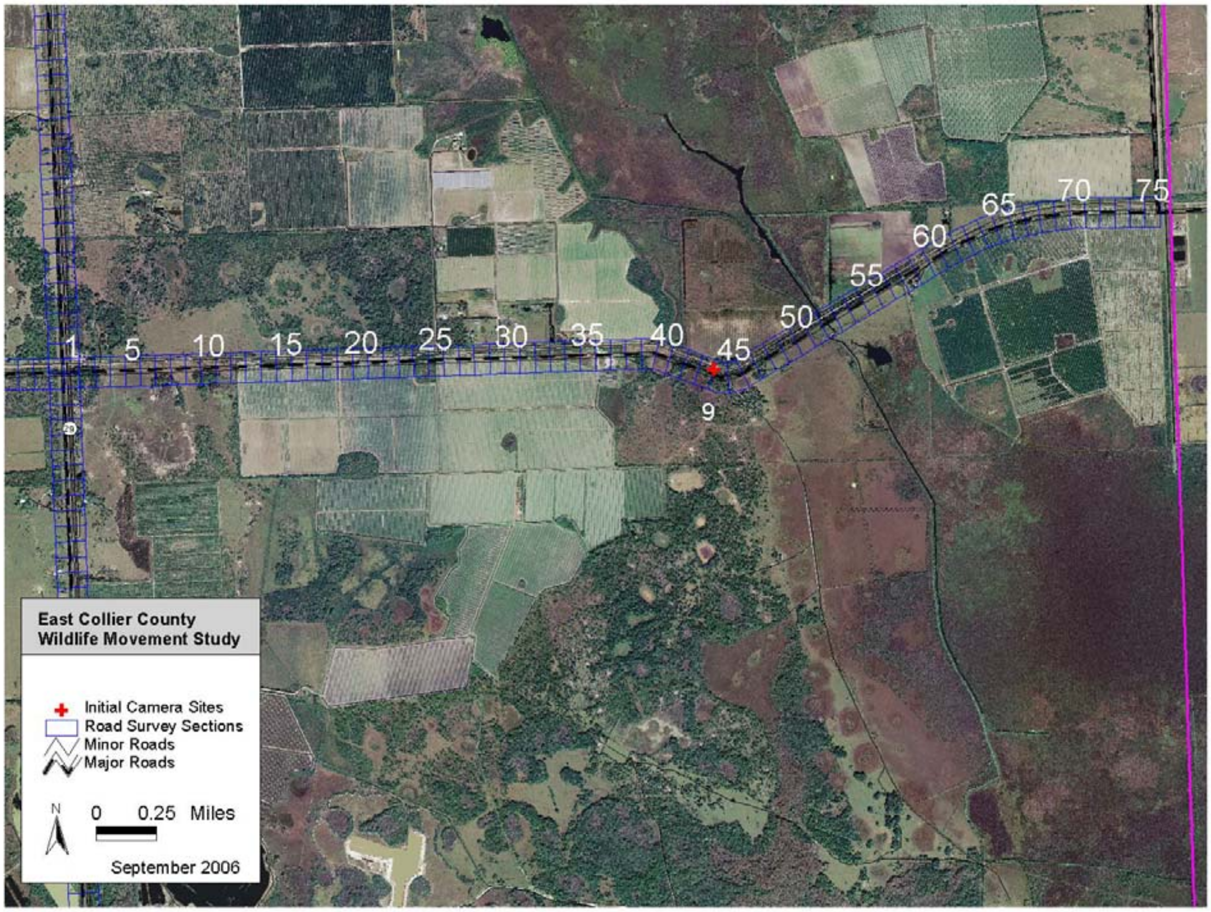


Figure 25. Location of camera station on CR 858 east.

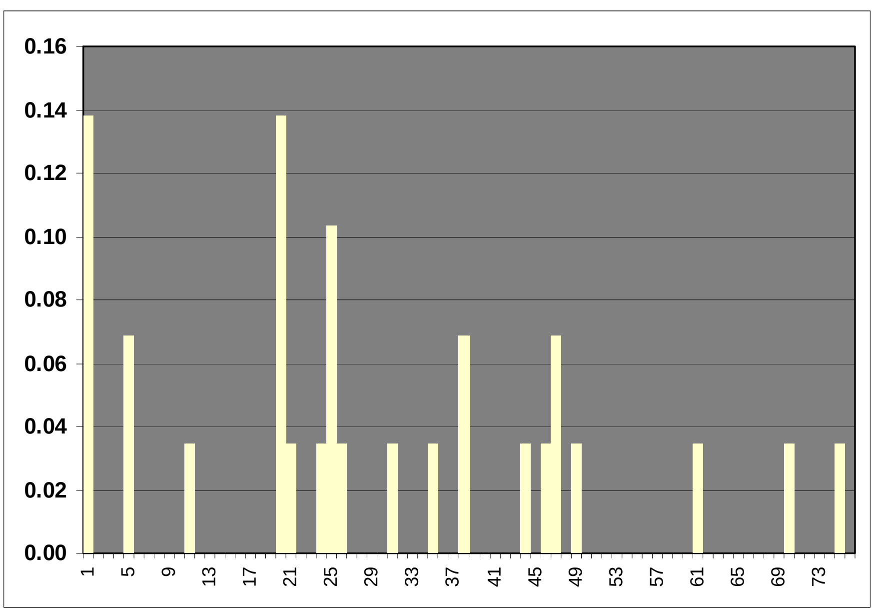


Figure 26. Frequency distribution for roadkills recorded on CR 858 central (numbers on x-axis represent 100-m road segments, Fig. 27).

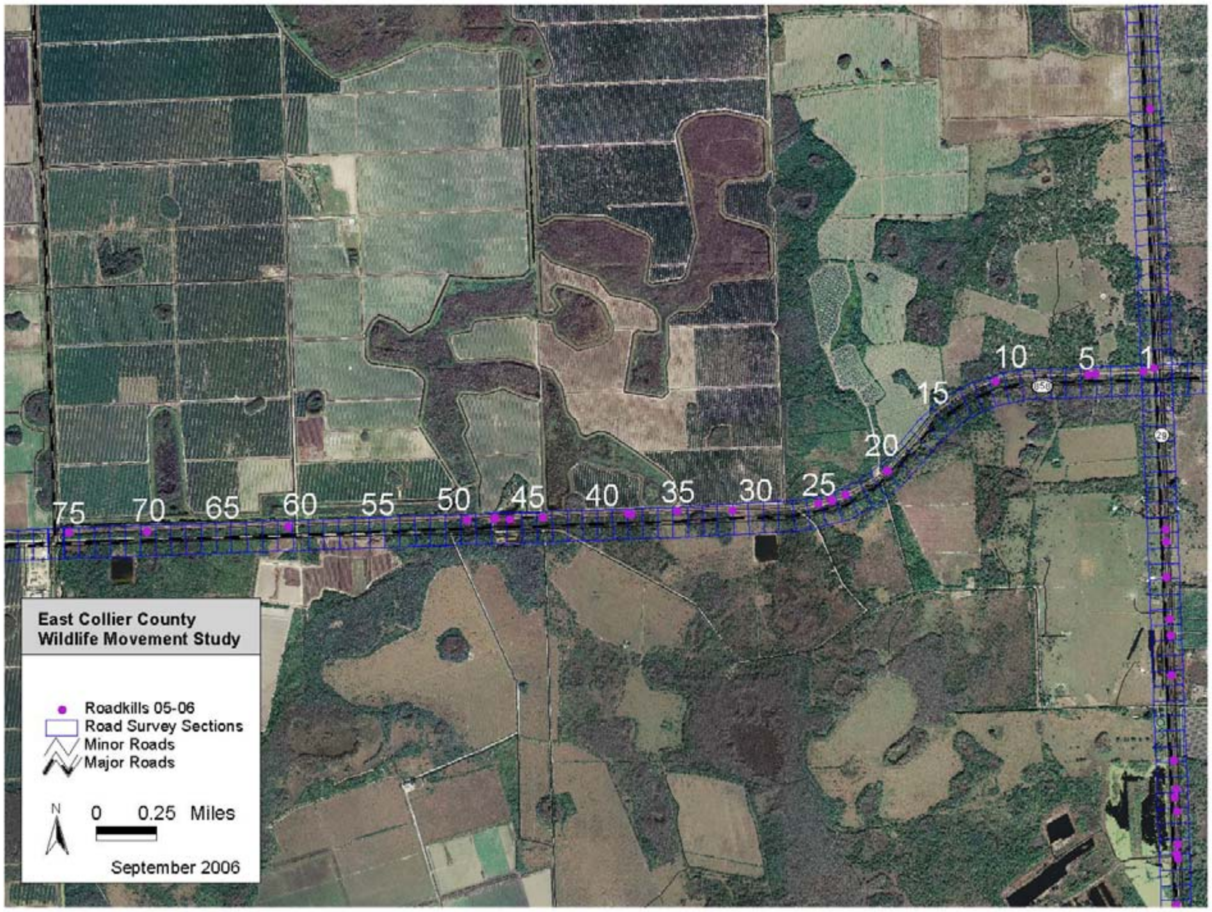


Figure 27. All roadkills recorded on CR 858 central partitioned into 100-m road segments.

Other significant species with roadkills included white-tailed deer (road segment 25), alligator (road segment 20), river otter (road segments 20, 35, and 61), and two raptors (road segment 38). See other species and their locations in Appendices B and G.

One Florida panther track was observed in the southside swale at road segment 26 on January 30th 2006 where a secondary camera station (no. 10b) was later established (Fig. 28). This was near the location (road segment 25) of the February 2000 panther roadkill (Appendix G – Map G6). It was placed on the south side of CR 858 aimed across a deer trail perpendicular to the road so that animals traveling on the trail would be photographed. The trail was monitored from June to August 2006. No photographs were recorded.

This section of CR 858 is highly fragmented, yet several "fingers" of native vegetation still exist and wildlife crossings (landscape linkages) are present along this section of CR 858. Though we recorded few roadkills, many potential wildlife crossings occur within road segments 1-28 and 37-53. The most important is road segments 1-28 where Florida panther crossings are apparent (based on telemetry, track, and roadkill data), especially within road segments 10-28 (the curved section of the road) where driver visibility is reduced and panther roadkills have already occurred. Significant restoration is required to reintegrate this area and improve the functionality of this corridor.

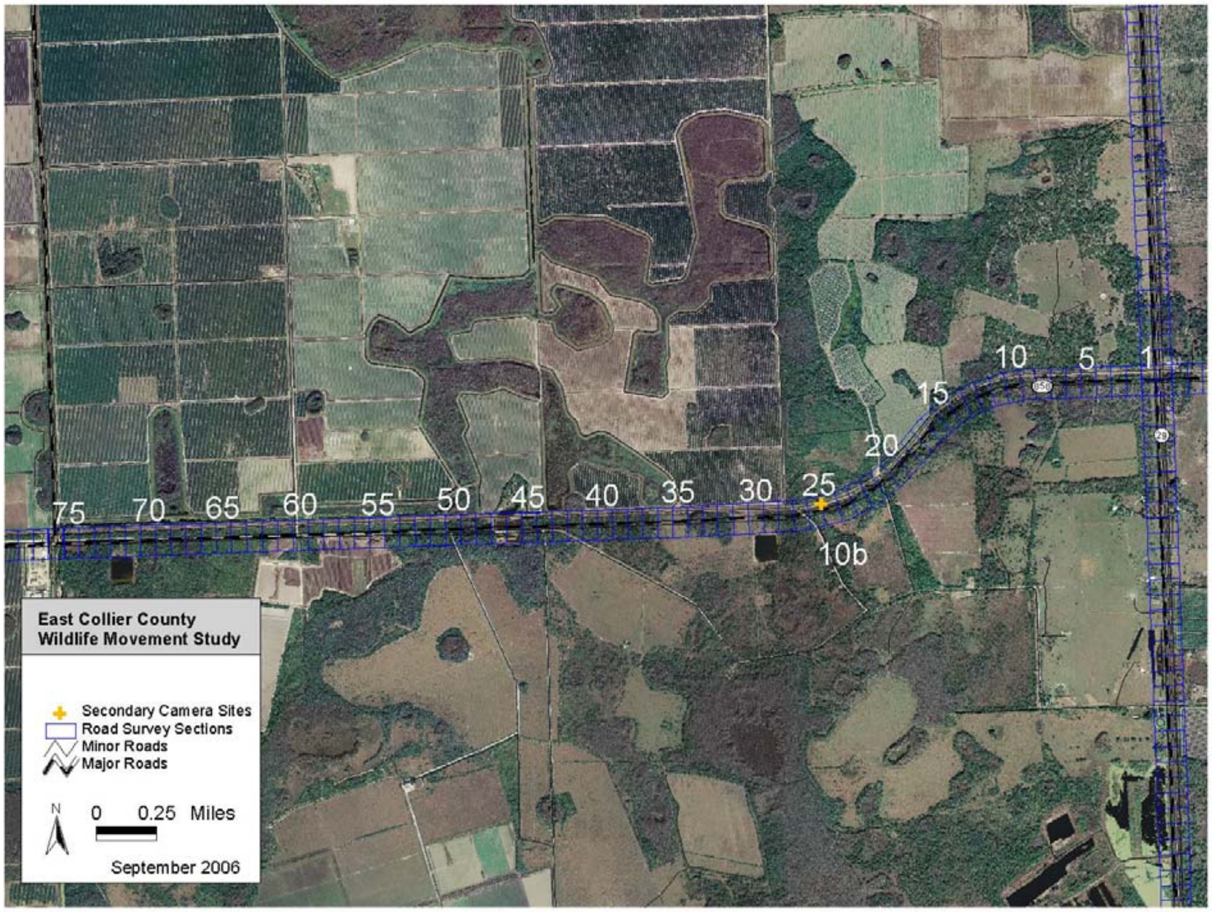


Figure 28. Location of camera station on CR 858 central.

CR 858 West Site Results

The frequency distribution for roadkills on CR 858 west is shown in Fig. 29. Only 31 total roadkills were recorded, limiting our ability to determine possible spatial patterns. One certain and two potential roadkill clusters were identified at road segments 24-26 (n=9), 42-47 (n=8), and 62-66 (n=11). These clusters account for 90% of the roadkills observed on this section of CR 858.

All roadkills and respective 100-m segments for CR 858 west are shown above the 2004 digital ortho-photograph of the area in Fig. 30. Specific locations of roadkills by taxonomic group for this road section are shown in a series of maps in Appendix H. We expected more roadkills at road segment 52 where the edge of the Camp Keais Strand is continuous on both sides of the road; however, more roadkills occurred east of this point along a 1,200-m section where the wetland on the south side is opposite agricultural fields on the north side.

No previous roadkill of Florida panther or black bear have been recorded along this section of CR 858. Other significant roadkills included river otter (road segments 64 and 66), alligator (road segment 42 and 65), and raptors including barred owl and kestrel (road segments 45). See other species and their locations in Appendices B and H.

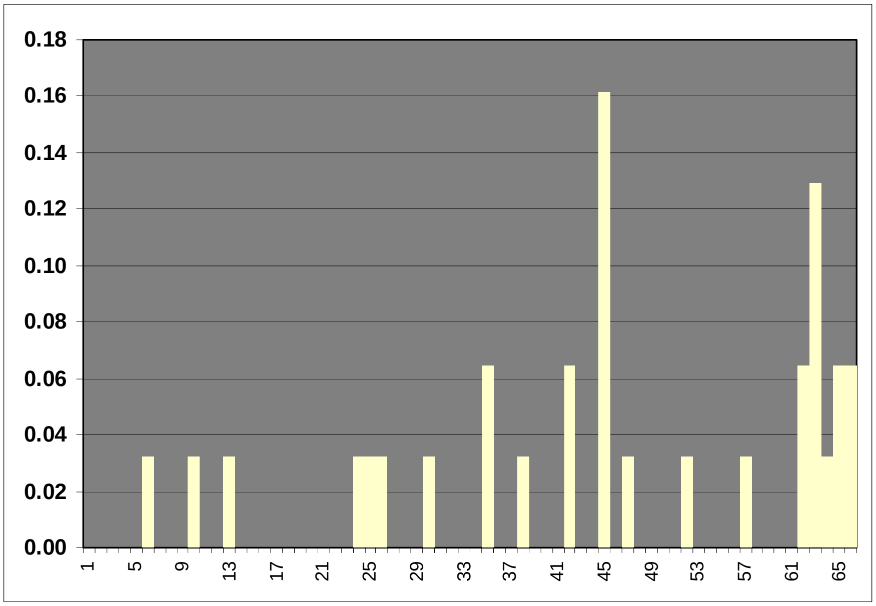


Figure 29. Frequency distribution for roadkills recorded on CR 858 west (numbers on x-axis represent 100-m road segments, Fig. 30).

Figure 30. All roadkills recorded on CR 858 west partitioned into 100-m road segments.

Two cameras were placed within this section of CR 858. Each camera was located at the upland-wetland interface on either side of the Camp Keais Strand (Fig. 31). Each camera was aimed across adjacent dirt farm roads so that animals traveling down the roads would be photographed. Camera no. 10 was on the northside of CR 858 and camera no. 11 was on the southside of CR 858. The farm roads were monitored from January to June 2006. No photographs were recorded.

Figure 31. Location of camera stations on CR 858 west.

One significant wildlife crossing area (landscape linkage) is present along this section of CR 858, the Camp Keais Strand (and adjacent upland buffers) from road segment 34-66. Significant restoration is required to create upland buffers adjacent to the strand to improve the functionality of this corridor. The intersection with Oil Well Grade Road also needs to be shifted west outside of the upland buffer zone.

SR 29 North Site Results

The frequency distribution for roadkills on SR 29 north is shown in Fig. 32. Only 13 total roadkills were recorded, not enough data to determine possible spatial patterns. Significant roadkills included white-tailed deer (road segments 41), snowy egret (road segment 59), FL box turtle (road segment 40), and raptors including barred owl and red-shouldered hawk (road segments 43 and 60). See other species and their locations in Appendices B and I.

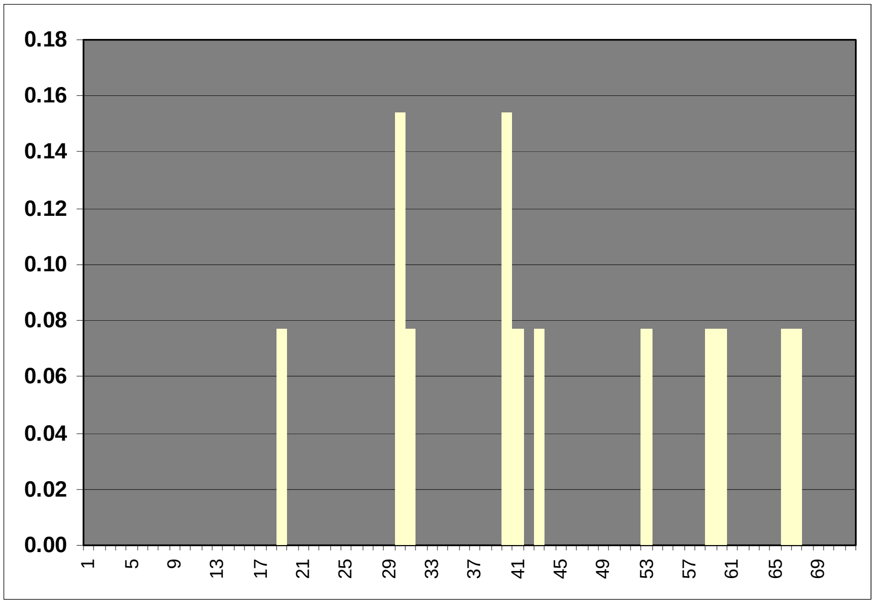


Figure 32. Frequency distribution for roadkills recorded on SR 29 north (numbers on x-axis represent 100-m road segments, see Fig. 33)**.**

All roadkills and respective 100-m segments for SR 29 north are shown above the 2004 digital ortho-photograph of the area in Fig. 33. Specific locations of roadkills by taxonomic group for this road section are shown in a series of maps in Appendix I.

We expected to find one roadkill cluster at road segments 54-72 (Fig. 33). This area is characterized by a long sweeping curve in the road surrounded by pinelands and palm hammocks (Owl Hammock) and connected to the Okaloacoochee Slough to the east and cypress-dominated wetlands to the west. Four roadkills (birds) were recorded in this section of the road.

Four Florida panther roadkills have been recorded along this section of SR 29 between May 2003 and June 2005 (Appendix I – Map I3). These were found within road segments 65 (December 2004 and June 2005), 42 (October 2004), 33 (June 2003), and 25 (May 2003). In addition, one black bear roadkill was recorded at road segment 70 in October of 1997. Location of 2 of the panther roadkills and the black bear roadkill are within the predicted roadkill cluster at road segments 54-72. This is a significant hotspot for Florida panther, black bear, and roadkill in general.

A camera was placed near the wooden bridge over the canal adjacent to SR 29 at the curve by Owl Hammock (Fig. 35). This was near where two Florida panther roadkills were found (Appendix I – Map I3). It was aimed across the trail so that animals traveling down the trail would be photographed. The trail was monitored from May to August 2006. No photographs were recorded.

An important broad wildlife crossing area (landscape linkage) is present along this section of SR 29, from road segments 45-72, which connects the Florida Panther National Wildlife Refuge to the Okaloacoochee Slough corridor. Significant restoration is required on the west side of the road to create upland buffers adjacent to the cypress wetlands along with conversion of some of the citrus groves to improve functional connectivity of this corridor.

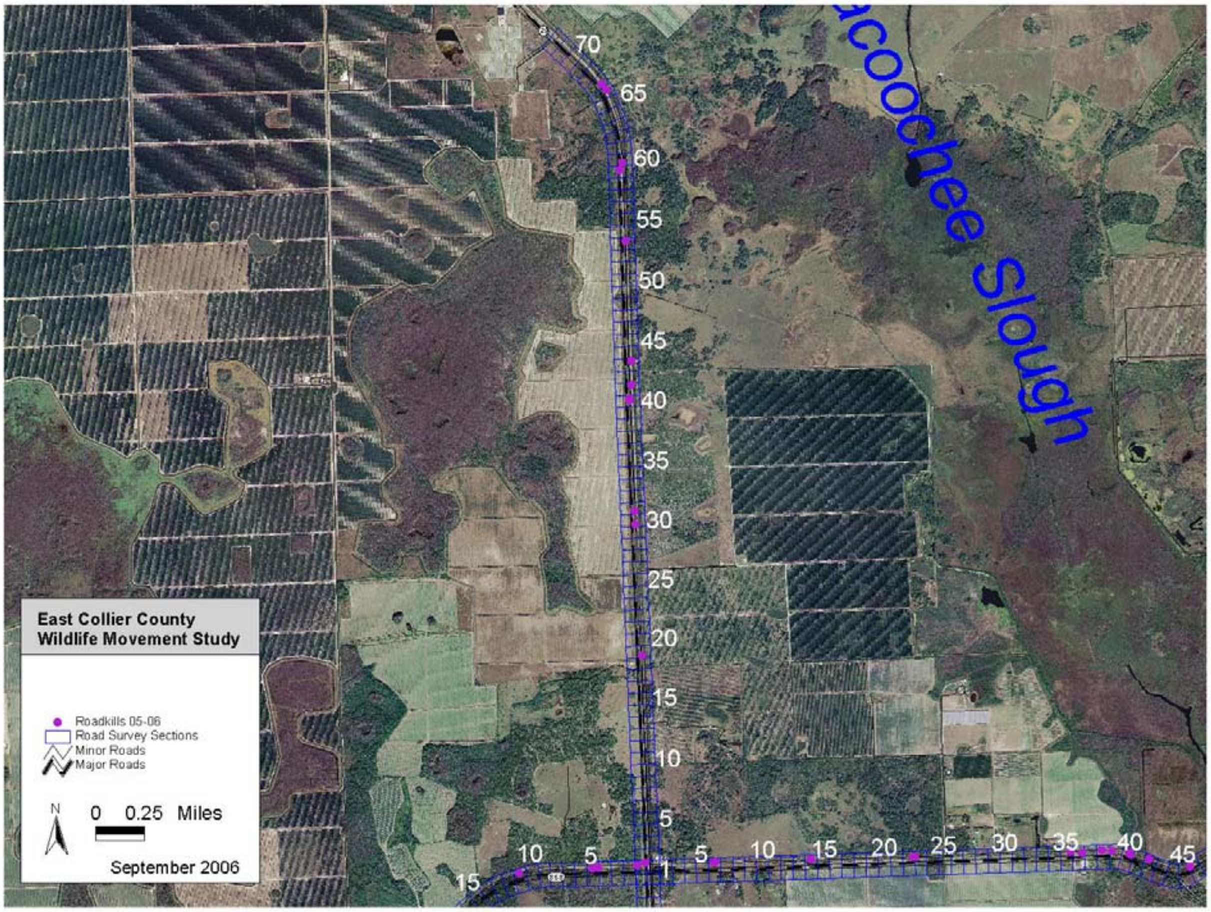


Figure 33. All roadkills recorded on SR 29 north partitioned into 100-m road segments.

<u>SR 29 South Site Results</u>

The frequency distribution for roadkills on SR 29 south is shown in Fig. 35. Despite only 47 total roadkills recorded, 68% of these are concentrated in three spatial clusters, at road segments 27-32 (16%), 35-39 (21%), and 53-61 (31%). All roadkills and respective 100-m segments for SR 29 south are shown in the 2004 digital ortho-photograph of the area in Fig. 36. Specific locations of roadkills by taxonomic group for this road section are shown in a series of maps in Appendix J.

Eight Florida panther roadkills have been recorded along this section of SR 29 between February 1980 and 2003 (Appendix J – Map J3). Locations and dates are as follows: May 2001 (road segment 37), February 2003 (road segment 38), February 1980 (road segment 41), December 1987, November 1992, and March 1994 (road segment 43), July 2002 (road segment 51), and February 1991 (road segment 63). Of particular note are the six panther roadkills that occurred in close proximity to one another in road segments 37-41 and 43. This is a significant hotspot for Florida panther and roadkill in general.

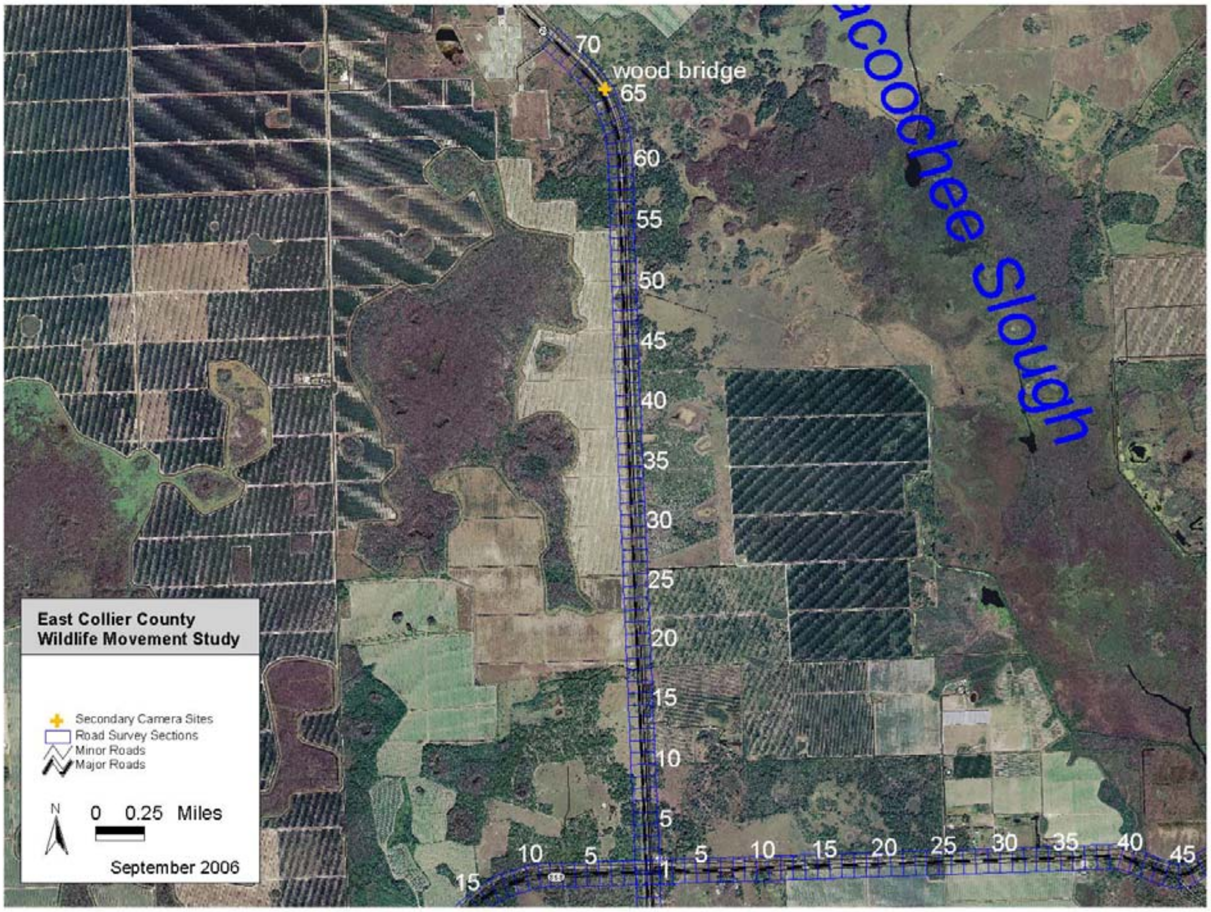


Figure 34. Location of camera station on SR 29 north.

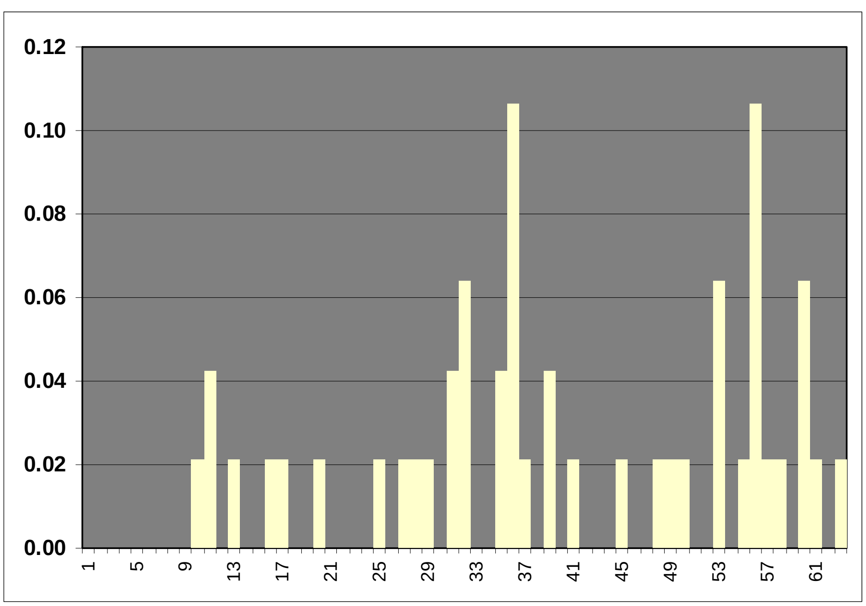


Figure 35. Frequency distribution for roadkills recorded on SR 29 south (numbers on x-axis represent 100-m road segments, see Fig. 36).

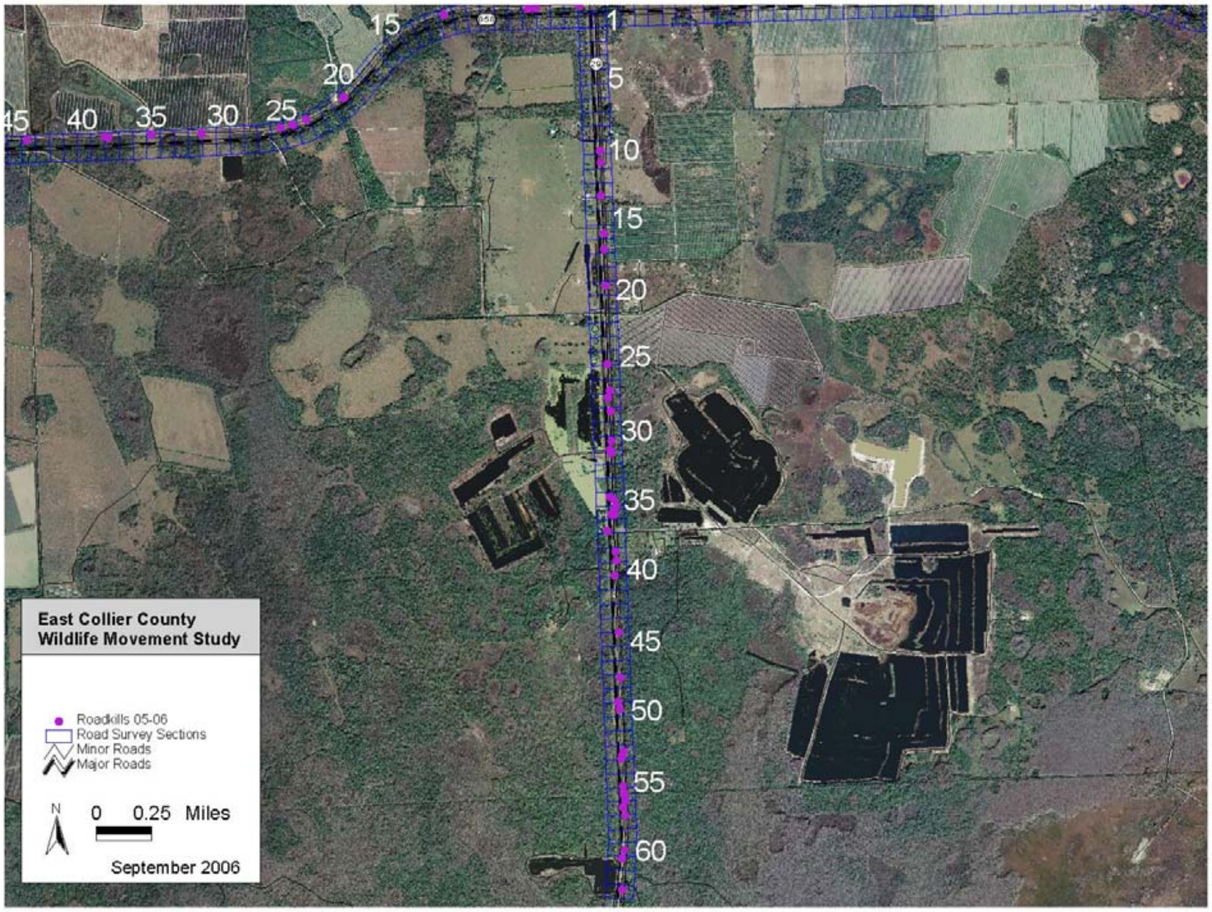


Figure 36. All roadkills recorded on SR 29 south partitioned into 100-m road segments.

Three Florida black bear roadkills have also been recorded on this section of SR 29 (Appendix J – Map J3). Locations and dates are as follows: October 1997 (road segment 35), May 2004 (road segment 42), and November 2000 (road segment 50). Two of these roadkills (road segments 42 and 50) are adjacent to Florida panther roadkill sites and the third (road segment 35) is within one of the identified roadkill clusters (road segment 35-39).

Other significant roadkills included alligator (road segments 11, 27, 29, 35, and 60), snapping turtle (road segment 32 x 2), great egret (road segment 39), and raptors including barred owl and red-shouldered hawk (road segments 20, 35, and 58). See other species and their locations in Appendices B and J.

SR 29 bisects high-quality habitat from road segments 25 to 63. This area is an extension of the Florida Panther National Wildlife Refuge and Big Cypress National Preserve to the south. It is fragmented not only by the road, but the presence of a parallel deep-water canal and the Sunniland Mine complex. Road crossings by many species of wildlife including Florida panther and black bear appear common. It is important to increase the permeability of the road in this area and to minimize disturbance by mining activities.

Comparative Analysis of Conservation Planning Data Layers Defining Critical Landscape Features and Habitat Areas

We supplemented the data collected in our field study with data from previous and ongoing telemetry studies and previous conservation planning studies to evaluate the extent of landscape coverage (including priorities for landscape linkages) and potential protection of habitat for the Florida panther and other imperiled wildlife in northeast Collier County under the Rural Lands Stewardship Program.

We compared conservation planning data layers (FWC SHCAs, greenways, existing public conservation lands, proposed public conservation lands, FNAI Priority Habitat Areas, hydrography 1:24,000, FWC land cover – native upland communities, and the primary and secondary habitat zones from the Florida panther MERIT committee) with the Collier County Rural Lands Stewardship Program designated stewardship zones (habitat stewardship areas, flowway stewardship areas, and water retention areas). Spatial extent of each of these data layers are shown in the map set in Appendix K. The purpose of this comparison was to determine how closely conservation zoning under the Rural Lands Stewardship Program corresponds to conservation priorities identified in previous conservation planning exercises, especially with respect to the Florida panther. Our comparison is preliminary.

Our comparative analyses include landscape coverage (area) offered by the various data layers (Table 3) and number and percentage of key data points included within the area of each data layer (Table 4) within the RLSA. Key data points included general roadkills and tracks collected in our field study, Florida panther and black bear roadkills and telemetry locations (provided by FWC), and FNAI element occurrences (recorded locations of imperiled species). Maps depicting locations of this point data are found in Appendix K.

Overall ranks of major data elements in Table 3 by total area and percent coverage are as follows: 1) panther MERIT final, 2) FNAI priority habitat – all, 3) ecological greenways, 4) FWC SHCAs – all, 5) panther SHCA, 6) bear SHCA, 7) stewardship areas – all, and 8) public conservation lands – all. Regarding the total area of wetlands/water resources protected the major data elements can be ranked as follows: 1) panther MERIT final, 2) FNAI priority habitat – all, 3) ecological greenways, 4) stewardship areas – all, 5) FWC SHCAs – all, 6) panther SHCA, 7) bear SHCA, and 8) public conservation lands – all. For protection of native upland communities the data elements order of rank are: 1) FNAI priority habitat – all, 2) panther MERIT final, 3) ecological greenways, 4) FWC SHCAs – all, 5) panther SHCA, 6) stewardship areas – all, 7) bear SHCA, and 8) public conservation lands – all. The stewardship areas consistently rank four or lower out of eight datasets, meaning that they offer less protection to key biological features.

When components of these datasets are compared with regard to total area, wetlands and uplands coverage (Table 3), the panther primary zone ranks first, the FNAI habitat priorities 3-4 ranks second, and the FWC SHCA priorities 1-2 ranks third in all cases. The flow-way stewardship areas also rank third for wetland/water resource protection. Data elements that rank fourth for total area, wetlands and uplands coverage are panther secondary zone, proposed conservation lands and habitat stewardship areas, respectively. Habitat stewardship areas rank fifth and sixth in total area and wetlands coverage, respectively. FWC SHCA priorities 3-4 rank fifth for wetland and upland area protected; and sixth for total area protected. FNAI habitat priorities 1-2 rank sixth for uplands area protected. Amount of area for all three of these categories within public ownership consistently rank 9^{th} – 10^{th} out of eleven data sub-elements included in the analysis. Other sub-elements included in these area rankings are water retention areas and 500 ft upland buffers; the former ranked 7^{th} – 8^{th} for the three categories while the latter ranked 11^{th} for all three categories. Consider that the analysis in Table 3 only looks at quantity not quality of habitat protected.

Table 3 also includes data on the total area and percentage of each data element contained within the stewardship area types (habitat, flow-way, water retention) and 500 ft upland buffers. Comparing the overall stewardship areas to each major element, it includes: 1) 50% of the panther MERIT final model results (65% of the designated primary zone), 2) 63% of the panther SHCA, 3) 51% of the black bear SHCA, 4) 85% of all public conservation lands (89% of existing lands and 84% of proposed lands), 5) 60% of the ecological greenways, 6) 50% of FWC SHCA priorities 1-6 (76% of priorities 1-2 and 35% of priorities 3-4), and 7) 53% of FNAI habitat priorities 1-6 (85% of priorities 1-2 and 61% of priorities 3-4). In all cases, the stewardship areas fall short of the total area designated by other conservation planning study results. Breakdown by each component of the stewardship areas is shown in Table 3. Of note, each component of the stewardship areas contains less than 35% of the area within other major data elements (except all existing/proposed public lands within the flow-way – 48%).

While Table 3 presents a quantitative comparison of area, Table 4 also provides qualitative indicators (specifically locations of listed, rare, and imperiled species). The same data layers as presented in Table 3 were compared with relation to presence of roadkill and track point data from our 2005-06 surveys, panther roadkills, bear roadkills, panther telemetry locations, bear telemetry locations, and element occurrence record locations (see Appendix K). Ranks of major data elements in Table 4 by number of roadkills (n=333) contained therein was as follows: 1) panther MERIT final (97%), 2) ecological greenways (95%), 3) FNAI priority habitat – all (94%), 4) FWC SHCAs – all (89%), 5) panther SHCA (70%), 6) bear SHCA (50%), 7) stewardship areas – all (46%), and 8) public conservation lands – all (15%).

The number of tracks (n=136) found within each major data element was as follows: 1) panther MERIT final, FNAI priority habitat – all, and ecological greenways (n=136, 100%), 2) FWC SHCAs – all (n=132, 97%), 3) panther SHCA (n=102, 75%), 4) stewardship areas – all (n=92, 68%), 5) bear SHCA (n=22, 16%), and 6) public conservation lands – all (n=5, 4%).

Each major data element contained the following percent of panther (n=28) and black bear (n=13) roadkills, respectively: 1) panther MERIT final (96%, 100%), 2) FNAI priority habitat – all (93%, 100%), 3) ecological greenways (93%, 85%), 4) FWC SHCAs – all (79%, 92%), 5) panther SHCA (71%, 85%), 6) stewardship areas – all (50%, 54%), 7) bear SHCA (46%, 85%), and 8) public conservation lands – all (4%, 8%). A large number of telemetry points were recorded for both panther (n=8089) and bear (n=515) within the RLSA. The percent of these contained in each data element from Table 4 includes: 1) panther MERIT final, FNAI priority habitat – all, and ecological greenways (100% of both), 2) FWC SHCAs – all (94%, 98%), 3) panther SHCA (87%, 86%), 4) stewardship areas – all (91%, 76%), 5) bear SHCA (48%, 82%), and 6) public conservation lands – all (23%, 31%).

Finally, each data element is compared against presence of element occurrence locations (n=65). The most were contained in FNAI priority habitat – all (95%), panther MERIT final (94%), ecological greenways (91%), FWC SHCAs – all (85%), stewardship areas – all (78%), panther SHCA (74%), bear SHCA (72%), and public conservation lands – all (29%). Consider that most of this area is privately owned, wildlife surveys and element occurrence records are scarce.

Components of these datasets were also compared with regard to roadkills, tracks, telemetry locations, and element occurrence locations (Table 4), as will be discussed further in the Discussion section.

Table 3. Matrix comparing conservation planning data layers with the Collier County Rural Lands Stewardship Program designated stewardship zones.

	total area	open water/ wetlands	upland native com-munities	panther MERIT final	panther primary zone	panther secondary zone	panther shca	bear shca	public cons lands all	public cons lands exist	public cons lands prop	ecol. green-ways	FWC - SHCAs all	FWC - SHCAs priority 1-2	FWC - SHCAs priority 3-4	FNAI - Priority Habitat all	FNAI - Priority Habitat p1-p2	FNAI - Priority Habitat p3-p4	steward-ship areas - all	habitat steward-ship areas	flowway steward-ship areas	water retention areas	500 ft upland buffers
RLSA total area	**85871**	0.31	0.18	0.97	0.73	0.24	0.56	0.51	0.24	0.06	0.18	0.77	0.72	0.38	0.19	0.90	0.08	0.64	0.49	0.22	0.18	0.09	0.01
Open water/wetlands	26642	**26642**	0.00	0.99	0.92	0.07	0.70	0.46	0.42	0.13	0.29	0.93	0.78	0.51	0.20	0.98	0.16	0.79	0.84	0.19	0.51	0.15	0.01
Upland native communities	15281	0	**15281**	0.96	0.87	0.09	0.75	0.53	0.27	0.07	0.20	0.91	0.85	0.57	0.20	0.98	0.12	0.81	0.62	0.43	0.08	0.11	0.01
Panther MERIT final	83025	26463	14629	**83025**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	0.22	0.19	0.09	0.01
panther primary zone	62515	24472	13275	-	**62515**	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65	0.30	0.25	0.10	0.01
panther secondary zone	20510	1991	1354	-	-	**20510**	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.00	0.00	0.05	0.00
Panther shca	48360	18609	11490	-	-	-	**48360**	-	-	-	-	-	-	-	-	-	-	-	0.63	0.28	0.24	0.11	0.01
Bear shca	43932	12150	8172	-	-	-	-	**43932**	-	-	-	-	-	-	-	-	-	-	0.51	0.19	0.21	0.11	0.01
Public cons lands all	20635	11107	4153	-	-	-	-	-	**20635**	-	-	-	-	-	-	-	-	-	0.85	0.35	0.48	0.02	0.01
public cons lands exist	5148	3482	1057	-	-	-	-	-	-	**5148**	-	-	-	-	-	-	-	-	0.89	0.41	0.48	0.00	0.00
public cons lands prop	15487	7625	3096	-	-	-	-	-	-	-	**15487**	-	-	-	-	-	-	-	0.84	0.33	0.48	0.03	0.02
Ecological greenways	66347	24659	13956	-	-	-	-	-	-	-	-	**66347**	-	-	-	-	-	-	0.60	0.28	0.23	0.10	0.01
FWC - SHCAs all	61803	20739	12957	-	-	-	-	-	-	-	-	-	**61803**	-	-	-	-	-	0.55	0.24	0.20	0.11	0.01
FWC - SHCAs priority 1-2	32855	13643	8674	-	-	-	-	-	-	-	-	-	-	**32855**	-	-	-	-	0.76	0.37	0.28	0.12	0.01
FWC - SHCAs priority 3-4	16724	5259	3021	-	-	-	-	-	-	-	-	-	-	-	**16724**	-	-	-	0.35	0.07	0.15	0.13	0.01
FNAI - Priority Habitat all	76918	25984	15006	-	-	-	-	-	-	-	-	-	-	-	-	**76918**	-	-	0.53	0.24	0.20	0.09	0.01
FNAI - Priority Habitat p1-p2	7187	4264	1792	-	-	-	-	-	-	-	-	-	-	-	-	-	**7187**	-	0.85	0.46	0.36	0.03	0.01
FNAI - Priority Habitat p3-p4	55323	21156	12453	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**55323**	0.61	0.26	0.22	0.12	0.01
Stewardship areas - all	41551	22432	9498	41446	40323	1123	30401	22280	17544	4563	12981	40042	33996	24994	5912	40468	6098	33753	**41551**	0.45	0.38	0.18	0.00
habitat stewardship areas	18528	4954	6572	18478	18469	9	13441	8309	7197	2117	5080	18454	14911	11999	1212	18093	3325	14528	18528	**18528**	0.00	0.00	0.00
flowway stewardship areas	15646	13459	1219	15607	15607	0	11531	9160	9912	2446	7466	15001	12561	9168	2513	15111	2581	12405	15646	0	**15646**	0.00	0.00
water retention areas	7377	4020	1707	7362	6247	1115	5429	4811	435	0	435	6587	6523	3827	2187	7263	193	6820	7377	0	0	**7377**	0.00
500 ft upland buffers	812	141	208	812	812	0	554	414	266	18	248	812	687	441	177	759	83	579	0	0	0	0	**812**

Notes. 1) top row represents percent of area of each element within the RLSA; 2) lower level of matrix contains overlap in area (ha) between elements; upper level of matrix contains percentage of area of each data layer within the RLSA designated stewardship areas (row value/diagonal value).

Table 4. Number and percentage of key data points included within the area of each conservation data layer.

	roadkills (2005-6)	%	tracks (2005-6)	%	panther roadkills (1972-2006)	%	bear roadkills (1976-2004)	%	panther telemetry pts (1981-2004)	%	bear telemetry pts (1986-1998)	%	element occurrence locations (through Aug 2005)	%
RLSA total area	333		136		28		13		8089		515		65	
Open water/wetlands	59	0.18	23	0.17	1	0.04	4	0.31	3326	0.41	207	0.40	40	0.62
Upland native communities	85	0.26	74	0.54	7	0.25	5	0.38	3550	0.44	209	0.41	17	0.26
Panther MERIT final	324	0.97	136	1.00	27	0.96	13	1.00	8087	1.00	515	1.00	61	0.94
panther primary zone	312	0.94	136	1.00	27	0.96	11	0.85	8053	1.00	514	1.00	58	0.89
panther secondary zone	12	0.04	0	0.00	0	0.00	2	0.15	34	0.00	1	0.00	3	0.05
Panther shca	233	0.70	102	0.75	20	0.71	11	0.85	7041	0.87	445	0.86	48	0.74
Bear shca	166	0.50	22	0.16	13	0.46	11	0.85	3914	0.48	422	0.82	47	0.72
Public cons lands all	50	0.15	5	0.04	1	0.04	1	0.08	1872	0.23	159	0.31	19	0.29
public cons lands exist	0	0.00	0	0.00	0	0.00	0	0.00	179	0.02	2	0.00	4	0.06
public cons lands prop	50	0.15	5	0.04	1	0.04	1	0.08	1693	0.21	157	0.30	15	0.23
Ecological greenways	316	0.95	136	1.00	26	0.93	11	0.85	8063	1.00	513	1.00	59	0.91
FWC - SHCAs all	296	0.89	132	0.97	22	0.79	12	0.92	7629	0.94	503	0.98	55	0.85
FWC - SHCAs priority 1-2	161	0.48	99	0.73	11	0.39	1	0.08	6676	0.83	362	0.70	37	0.57
FWC - SHCAs priority 3-4	89	0.27	32	0.24	9	0.32	10	0.77	656	0.08	122	0.24	12	0.18
FNAI - Priority Habitat all	312	0.94	136	1.00	26	0.93	13	1.00	8081	1.00	513	1.00	62	0.95
FNAI - Priority Habitat p1-p2	24	0.07	0	0.00	5	0.18	1	0.08	2965	0.37	168	0.33	6	0.09
FNAI - Priority Habitat p3-p4	262	0.79	136	1.00	20	0.71	11	0.85	5100	0.63	339	0.66	55	0.85
Stewardship areas - all	154	0.46	92	0.68	14	0.50	7	0.54	7328	0.91	392	0.76	51	0.78
habitat stewardship areas	104	0.31	43	0.32	14	0.50	2	0.15	4922	0.61	204	0.40	12	0.18
flowway stewardship areas	37	0.11	42	0.31	0	0.00	0	0.00	1949	0.24	117	0.23	30	0.46
water retention areas	13	0.04	7	0.05	0	0.00	5	0.38	457	0.06	71	0.14	9	0.14
500 ft upland buffers	11	0.03	0	0.00	0	0.00	0	0.00	39	0.00	14	0.03	1	0.02

Discussion

This discussion includes a summary of our results and sections on highway retrofitting and habitat corridor planning.

Summary of Results

This section provides a summary of the findings of the various research activities conducted in the project. The application of these findings is discussed with regard to adverse impacts of the roads and potential changes that may occur if road widening takes place. Most roadkill, track, and photographs will be discussed with reference to the road partition grids in the site maps in Appendix L.

Roadkill summary

During the period December 2005-August 2006, we found 333 roadkilled individual animals on 34.5 mi of 2-lane county and state roads in the RLSA. There were 59 identifiable species (Table 1 and Appendix B). The majority were meso-mammals followed by birds (Fig.11).

Significant locations of roadkills by road section/road segment (Appendix B) include:

- CR 846 east (1-2, 6-9, 38-42, 44-50, 59-65, 68-70, 75-82, and 99-100),
- CR 846 west (30, 37-45, 50-58, 68-74, and 79-87),
- CR 858 east (6, 15, 22-23, 35-42, 51-62, and 75),
- CR 858 central (1, 20-26, and 44-49),
- CR 858 west (24-26, 42-47, and 62-66),
- SR 29 north (12, 25, 32-33, 40-43, 59-60, 65, and 70, and 89), and
- SR 29 south (27-32, 35-41, 43, 51, 53-61, and 63).

Based on these roadkill locations and other data analyzed in this study, we identified significant sections of each roadway that should be considered for retrofits to reduce road mortality and increase road permeability:

- CR 846 east: Okaloacoochee Slough including adjacent upland buffers (road segments 73-85), and two secondary travel corridors each to the west (road segments 46-54 and 59-70) and east (road segments 90-93 and 96-110) of the slough.
- CR 846 west: Camp Keias Strand and adjacent upland buffers (road segments 28-57) and the large cypress corridor to the east (road segments 64-90).
- CR 858 east: the Okaloacoochee Slough (and adjacent upland buffers) is the central feature of concern, specifically road segments 35-60.
- CR 858 central: road segments 2-28 constitute an important panther crossing area between the Florida Panther NWR and the Okaloacoochee Slough. As with CR 846 west, the Camp Keais Strand is an important crossing area for Florida panther and black bear, among other species; key road segments identified include 38-66.
- North SR 29: contains a significant crossing area as part of the corridor connecting the Florida Panther NWR and the Okaloacoochee Slough; though we recorded few roadkills, the area between road segments 33-70 appear important for key species.

- SR 29 south: the area between road segments 25 and 63 were not specifically monitored due to road conditions, but is considered a potentially important travel area for the Florida panther and other wildlife, and should be addressed as such.

We found no significant relation between season and rainfall with number of roadkills, contrary to findings reported by Smith et al. (2005), Smith and Voigt (2005), Main and Allen (2002), Bernardino and Dalrymple (1992), Smith (1996), or Dodd et al. (1989). However, our results were biased by an insufficient sampling period (8 mos) to capture seasonal variation or interannual variability in rainfall (dry and wet years) necessary to determine differences by year or season.

Track summary

We recorded a total of 136 sets of tracks (Fig. 10, Appendix A); key species included whitetail deer (n=77), bobcat (n=16), turtles (n=13), Florida panther (n=8), wild turkey (n=6), river otter (n=2), and black bear (n=1). Because transects were proximal to the paved surface, we assumed that travel direction of tracks oriented perpendicular to the pavement was indicative of a crossing by that animal. Even so, we prefer to document these as predicted crossings rather than confirmed crossings for at least two reasons. Tracks may not correspond to successful crossings because: 1) some crossing attempts are probably aborted, and 2) some faunal groups monitored use the right-of-way for foraging or scavenging (Smith et al. 2005, Smith and Voigt 2005). Predicted crossings for species by road segment nos. are shown in Table 5.

Table 5. Predicted Crossing Locations of Key Species from Tracks Recorded on Sand Transects.

Species	CR 846 Road Section and Segment No.
Panther	E (63-65, 105), W (45)
Bear	W (41)
Bobcat	E (8-9, 64, 75, 83-84), W (29, 68-69, 85)
Coyote	E (9, 63-65), W (41, 68)
White-tailed Deer	E (8-9, 17, 63-65, 73, 75, 82-85), W (82, 85)
River Otter	E (8), W (45)
Turtles	E (8, 62-65), W (68, 82-83, 85)
Snakes	E (64-65)
Turkey	E (9)

Note: refer to Appendices D and E for map locations.

As with roadkill, significant hotspots of activity are evident. We identified track hotspots for Florida panther and black bear, turkeys, white-tail deer, and meso-carnivores. In most instances these correspond to the same road segments identified as roadkill hotspots. For alligator, river otter, snakes, and turtles, we suspect our track data severely underestimates abundance and locations of road crossings. We expect many more crossings occur within and adjacent to the wetlands and canals. Our coverage for tracks was not continuous over each road section or moisture gradient, thus we likely missed many of these species in our track surveys; poor quality of substrate also played a role in missing possible crossings by some of these organisms.

Camera station (traps) summary

A total of 73 photographs (Fig. 10, Appendix C) were taken of focal species including whitetail deer (n=44), bobcat (n=5), wild turkey (n=4), and Florida panther (n=2). Because cameras were placed on fence posts or trees on the outside of the road right-of-way we cannot determine with any confidence whether road crossings by these animals occurred at these locations. As such, the data can only be used as an indicator of activity at that location by each species recorded. Records by camera locations (road segment nos.) are shown in Table 6.

Table 6. Photographs of Key Species by Camera Location.

Species	CR 846 Road Section and Segment No.	CR 858 Road Section and Segment No.
Panther	W (45)	
Bobcat	E (95, 105), W (45)	E (44)
Coyote	E (95), W (45)	
White-tailed Deer	E (48, 58, 72, 74, 95, 99, 105)	E (44)
Turkey	E (95, 105), W (45)	

Note: refer to Figs. 18, 22, and 25 for map locations.

The photographic evidence supports the roadkill and track data; significant hotspots of activity (camera locations) include road segment no. 45 on CR 846 west, road segments no. 72, 74, 95 and 105 on CR 846 east, and road segment no. 44 on CR 858 east.

<u>Highway Retrofit Recommendations</u>

Current bridge/culvert configurations are inadequate to provide necessary levels of permeability for wildlife in the bisected conservation area. Existing structures were designed for hydrological needs, not wildlife accessibility; they conveyed water and were flooded and impassable to terrestrial-based species over the entire study period. We recorded significant numbers of roadkills adjacent to four of these structures (Okaloacoochee Slough and a canal 1000 m west—CR 846 and Camp Keais Strand—CR 846 and CR 858). Moreover, planning of wildlife crossings at these sites is complicated by the presence of canals parallel to the roadways. Earthen ramps that cross canals have been used at previously constructed wildlife underpasses on SR 29 and I-75. Several types of structures will be needed to accommodate the diversity of species (terrestrial and aquatic) found across the upland-wetland gradient.

The following factors (from Smith 2003) should be considered in improving the permeability to wildlife of the CR 846, CR 858, and SR 29 corridors within the RLSA:

- Context sensitivity—vegetation along road consistent with surrounding habitat
- Environmental variability—provide for terrestrial passage at semi-aquatic sites during periods of high water levels
- Directional fencing—funnel wildlife through passages and away from road surface
- Berming—reduce effects of traffic noise and lights
- Topography—road should be designed to "fit into" the landscape (e.g., minimize alteration in slope of underpass/ overpass approaches)

- Substrate—consistent with adjacent area
- Lighting—reduce tunnel effects by increasing openness value (height*width/length) and providing light penetration in medians of divided highways
- Human presence—reduce human access associated with crossing sites

To improve habitat connectivity within the RLSA, we propose a system of culverts, bridges, and barrier fences to significantly reduce roadkills and increase the permeability of each road for wildlife in the area. Our recommendations are meant to optimize habitat connectivity (this includes restoration of disturbed or altered portions of habitat corridors at critical landscape linkages) and significantly reduce barrier effects of roads to wildlife movement. Recommended dimensions of structures are similar to wildlife-use thresholds generated from an extensive culvert monitoring project conducted for FDOT by Smith (2003) and consistent with structure preferences identified by Clevenger et al. (2001), Hewitt et al. (1998), and Boarman and Sazaki (1996).

Wildlife Crossing Structure Recommendations

CR 846 east

We recommend installing wildlife underpasses on CR 846 east (road segments 47, 63, 76, 84, and 95) (see Appendix L). Locations at road segments 47, 63, and 95 represent secondary habitat corridors (consisting of a combination of hardwood hammock, pinelands, dry prairie, mixed wetland forest, cypress swamp, freshwater marsh, and improved pasture) on either side of the Okalaocoochee Slough. **Some habitat restoration is needed in portions of these corridors**. The primary corridor, the Okalaocoochee Slough, requires restoration to reestablish upland habitat buffers on either side of the wetlands; wildlife underpasses are proposed within these buffers (road segments 76 and 84).

Minimum dimensions of wildlife underpasses should be 7.4-m wide x 2.5-3.0-m tall (Fig. 37). We base this recommendation on landscape features, roadkills, tracks, and photos of white-tail deer and carnivores, particularly Florida panther. Because these underpasses would be designed specifically for wildlife, we strongly recommend an internal height of no less than 2.5 m to facilitate use by large mammals, e.g., bobcats, white-tailed deer, and black bear. **Approaches to these structures need to be landscaped with native shrubs and groundcover vegetation, and final elevation within the structure and the adjacent approaches needs to be higher than adjacent areas to prevent pooling of water and buildup of sand and silt within the structure**. This type of structure has proven functional for a wide variety of wildlife species (Smith 2003).

Figure 37. Example of proposed 7.4-m wide wildlife underpass design.

We recommend conversion of a pipe culvert at road segment 69 (Appendix L) that conveys water from a canal under CR 846 to an enlarged box culvert. This structure should be capable of allowing flow of water as well as facilitating movement by terrestrial wildlife. **A recommended minimum width of 5 m and height of 2.5 m would be necessary for potential use by Florida panther**. Configurations might include use of ledges for dry passage or a multi-culvert design that has one central cell for water passage and adjacent cells at higher elevation to accommodate movement by terrestrial wildlife. All of these designs have been applied in Florida. This site is located near the middle of a cluster of three Florida panther roadkills. The area is characterized by freshwater marsh and mixed wetland forest.

New culvert crossings are proposed for road segments 50, 53, 60, 82, 91, and 101 (Appendix L). Sites at road segments 50, 53, 60, and 82 are characterized by freshwater marsh, shrub swamp, and pinelands. Mainly associated with wetlands, their primary function is to increase permeability for aquatic and wetland-dependent species such as river otter, alligator, turtles, snakes, and frogs. **Recommended minimum dimensions for structures at road segments 50, 53, 60, and 82 include a width of 3 m and height of 2 m**.

Road segments 91 and 101 are characterized by a mosaic of freshwater marsh, hardwood swamp, pinelands, hardwood hammock, and dry prairie. The structures placed at these sites would accommodate both terrestrial and wetland-dependent species. **We recommend box culverts 3-m wide x 2-m tall at road segments 91 and 101**. The culverts should also be three-sided (concrete walls and ceiling, natural soil floor). If erosion at the entrances is a concern, rip-rap should not be used (Smith 2003); if soil substrates cannot be maintained, then the approaches should be paved with porous concrete or tiles. These structures are targeted toward reptiles, amphibians, small mammals, and meso-carnivores.

CR 846 west

On CR 846 west we suggest installing wildlife underpasses at road segments 30-31 and 41 (Appendix L). Locations at road segments 30-31 and 41 represent upland habitat buffers on either side of the Camp Keais Strand; these sites consist of a combination of pinelands, mixed wetland forest, and freshwater marsh. **Some habitat restoration is needed at this location. These are the most critical sites where underpasses are needed to improve connectivity at the core of this habitat corridor. Minimum dimensions of wildlife underpasses should be 7.4-m wide x 2.5-3.0-m tall (Fig. 37)**. We base this recommendation on landscape features, roadkills, and tracks and photos of white-tail deer and carnivores, particularly Florida panther and black bear. Because these underpasses would be designed specifically for large wildlife (e.g., bobcats, white-tailed deer, Florida panther, and black bear), we strongly recommend an internal height of no less than 2.5 m. The same design criteria (e.g., landscaping, elevation, substrate consistency) as previously mentioned needs to be adhered to.

New box culvert crossings are proposed for road segments 34, 52-53, 69, 73, 78, and 82-83 (Appendix L). Road segments 69 and 82-83 occur in upland buffers of a secondary corridor (a large wetland 3000 m east of Camp Keais Strand); habitat types at these locations include freshwater marsh, cypress swamp, and citrus. **To improve function of this part of the corridor, the citrus groves that border the cypress swamp should be restored to native pinelands**. This would restore ecological processes that normally would occur across this wetland-upland gradient. It would also promote continued use of this area by black bear, based on previous roadkill and telemetry data. The structures placed at road segments 69 and 82-83 would accommodate both terrestrial and wetland-dependent species including black bear. **We recommend box culverts 4-m wide x 3-m tall**. The culverts should also be three-sided (concrete walls and ceiling, natural soil floor). All design criteria (e.g., landscaping, elevation, substrate consistency) as previously mentioned applies.

A box culvert is also recommended as a secondary habitat corridor at road segments 52-53 , which exists between two large wetland features (Camp Keais Strand and the large cypress swamp 3000 m east). Habitat types at road segments 52-53 consist of a combination of mixed wetland forest, freshwater marsh, and row/field crops. **Some upland habitat restoration is needed at road segments 52-53 adjacent to the wetlands in this corridor. We recommend installation of a box culvert with minimum dimensions of a width of 3 m and height of 2.5 m**. This structure is targeted toward reptiles and amphibians, small mammals, deer, and meso-carnivores (e.g., bobcat, fox, coyote).

We recommend culvert structures at road segments 34, 73 and 78, which are characterized by freshwater marsh, cypress swamp, shrub swamp, and pinelands. Mainly associated with wetlands, the primary function of structures at these road segments is to increase permeability for aquatic and wetland-dependent species such as river otter, alligator, turtles, snakes, and frogs. **Recommended minimum dimensions for these structures include a width of 3 m and height of 2 m**.

CR 858 east

We propose construction of wildlife underpasses (5-m wide x 2.5-m tall) at road segments 43 and 55 (Appendix L); habitat composition at each site is shrub swamp, pinelands, dry prairie, shrub, and brushland—road segment 43 and mixed wetland forest, shrub swamp, freshwater marsh, dry prairie, pinelands, and citrus—road segment 55. This recommendation is based on existing landscape configuration and future need as traffic volume increases. Currently, traffic volume is around 350 AADTs (average annual daily trips, based on last known reading by FDOT in 2001); as a result, the need is not imminent.

More importantly, we recommend establishment of upland habitat buffers adjacent to the Okalaocoochee Slough on CR 858 east. Presently, agricultural fields abut the wetland in many areas leaving narrow discontinuous strips of upland vegetation. Telemetry data shows that Florida panther prefer to cross CR 858 just west of SR 29 rather than continuously along the Okalaocoochee Slough corridor. **This area has been designated as the primary corridor for latitudinal movement by panthers; it is therefore important to restore the native upland habitats along this corridor**.

Canals along the wetland basin (between road segments 50-56) have led to considerable roadkills of wading birds (Appendix B). The height of the roadbed above the canals combined with trajectory of flight paths in/out of these water features contributes to vehicle collisions with birds. Although we cannot suggest any immediate solution to this problem, it is worth recognizing the potential for loss of rare/listed species (given the presence of species such as wood stork, black-crowned night heron, glossy/white ibis, great egret, and snowy egret in the area).

CR 858 central

We propose construction of one wildlife underpass at road segment 25 (Appendix L). Habitat types at this site include pinelands, hardwood hammocks and forest, dry prairie, hardwood/cypress swamp, and freshwater marsh. **Minimum dimensions of the wildlife underpass should be 7.4-m wide x 2.5-3.0-m tall (Fig. 37)**. We base this recommendation on landscape features and roadkill and telemetry data for Florida panther and black bear at this site. A significant curve at this site contributed to two Florida panther roadkills; problems caused by the road's geometry would be cancelled by construction of an underpass here. Because this underpass would be designed specifically for large wildlife (e.g., bobcats, white-tailed deer, Florida panther, and black bear), we strongly recommend an internal height of no less than 2.5 m. The same design criteria (e.g., landscaping, elevation, substrate consistency) as previously mentioned needs to be adhered to.

Of equal importance to the crossing structure is restoration of upland habitat types (e.g., pinelands) in this corridor. This linkage between the Florida Panther NWR and the Okalaocoochee Slough has been highly degraded by intensive agriculture, primarily citrus groves (Appendix L).

New culvert crossings are proposed for road segments 6, 43, and 49 (Appendix L). Road segment 6 is within the primary portion of this "central corridor" and therefore should be able to accommodate large wildlife such as deer, black bear, or panther. **For the structure at road segment 6 we recommend the following dimensions: 5-m wide x 2.5-m tall; this location is characterized by mixed wetland forest, freshwater marsh, pinelands, and hardwood swamp.**

Road segments 43 and 49 are within minor habitat corridors. Culverts (recommended width of 3 m and height of 2 m) placed at these locations would facilitate safe travel primarily for species such as bobcat, fox, coyote, river otter, alligator, turtles, snakes, and

frogs. Habitat types at these locations include freshwater marsh, cypress/hardwood swamp, mixed wetland forest, dry prairie, and pinelands.

CR 858 west

We recommend construction of wildlife underpasses (12.3-m wide x 3-m tall, see example in Fig. 38) at road segments 51-52 and 65-66 (Appendix L); habitat composition at these sites is mixed wetland forest, freshwater marsh, cypress/pine/cabbage palm, pinelands, and row/field crops. This recommendation is based on existing landscape configuration and future need as traffic volume increases. Current traffic levels (2005) at the nearest monitoring station (east of Big Cypress Elementary School) is 6,788 AADTs. This value has increased 60% since 2001. This section of CR 858 is planned to be four-laned and traffic will increase dramatically with the development of Ave Maria and Big Cypress. Given the proposed wider configuration, a wider crossing structure is required here.

Figure 38. Example of proposed 12.3-m wide wildlife underpass design.

Just as important as the wildlife underpass on CR 858 west is establishment of upland habitat buffers adjacent to the Camp Keais Strand. Presently, agricultural fields abut the wetland on both sides leaving only narrow discontinuous strips of upland vegetation. Telemetry, roadkill, track, and photographic data show that Florida panther and black bear still use this corridor. This area is the only landscape linkage connecting the Florida Panther NWR to the CREW lands; it is therefore important to restore the native upland habitats along this corridor to increase use by Florida panther and black bear. **In conjunction with the proposed site of the underpass in road segments 65-66 and restoration of adjacent upland habitat buffers, we suggest moving the intersection with the dirt access road (Oil Well Grade Road) approximately 0.25 mi west. We further propose culverts within the wetland basin at road segments 56 and 60 to increase permeability of the widened roadway for aquatic and wetland-dependent species such as river otter, alligator, turtles, snakes, and frogs. Recommended minimum dimensions for these structures are a width of 3 m and height of 2 m**. Amount of light available within culverts can help counter tunnel effects. This is critical on four-lane highways. Certain amphibian species will not use culverts when sufficient light is not present (Krikowski 1989). **These culverts should include lighting grates within the median and on the shoulders to maximize light penetration**.

Disturbance to vegetation and natural substrates needs to be minimized during construction. Prior to construction, surveys should be performed to determine if any fossorial animals occur in these areas, which would suggest a need to minimize disturbance to soil and leaf litter. Although we recognize that the process of construction will inevitably cause some damage, these comments are provided to bring attention to the precarious nature of the sites.

Lastly, wildlife surveys should be performed on the wetland corridor about 0.5 mi west of Camp Keais Strand; though this was not part of our study, telemetry data suggests that this corridor may be used by Florida panther and black bear. If this is the case, with increased traffic the potential for collisions could occur at this site if proper pre-planning is not performed.

SR 29 north

We propose construction of wildlife underpasses at road segments 41, 53, and 64-65 (Appendix L). This recommendation is based on current telemetry and roadkill data that show Florida panther and black bear still use this central corridor. Habitat types at these sites include pinelands, dry prairie, hardwood/cypress swamp, mixed wetland forest, freshwater marsh, unimproved pasture, and citrus groves. **Minimum dimensions of the wildlife underpasses at road segments 41 and 64-65 should be 7.4-m wide x 2.5-3.0-m tall (Fig. 37)**. Roadkills of Florida panther and black bear have occurred at or near each of these sites. Because these underpasses would be designed specifically for large wildlife (e.g., bobcats, white-tailed deer, Florida panther, and black bear), we strongly recommend an internal height of no less than 2.5 m.

A smaller culvert is also warranted at road segment 53, where activity by collared Florida panthers and black bears has been recorded. **For this structure we recommend the following dimensions: 5-m wide x 2.5-m tall; capable of accommodating passage by large wildlife such as deer, black bear, or panther on two-lane roads.** The same design criteria (e.g., landscaping, elevation, substrate consistency) as previously mentioned would apply.

We also recommend the conversion of an existing culvert at road segment 59 (Appendix L) that conveys water from a canal under SR 29 to an enlarged box culvert. This structure should be capable of allowing flow of water as well as facilitating movement by terrestrial wildlife. **A recommended minimum width of 5 m and height of 2.5 m would be necessary for potential use by Florida panther**. Configurations might include use of ledges for dry passage or a multi-culvert design that has one central cell for water passage and adjacent cells at higher elevation to accommodate movement by terrestrial wildlife. This site is located within a cluster of Florida panther and black bear telemetry locations. The area is characterized by freshwater marsh, mixed wetland forest, pinelands, dry prairie, and unimproved pasture.

Of equal importance to the crossing structures is restoration of upland habitat types (e.g., pinelands) in this corridor. This linkage between the Florida Panther NWR and the Okalaocoochee Slough has been highly degraded by intensive agriculture, primarily citrus groves (Appendix L). What remains are habitat nodes on the west side of the road that no longer have continuous links to native habitat areas on the east side of the road. Connections are disrupted by conversion to citrus groves; we recommend restoring these natural connections.

SR 29 south

We propose construction of wildlife underpasses at road segments 39, 50, and 63 (Appendix L). Habitat types in this area include pinelands, hardwood hammocks and forest, dry prairie, cypress/pine/cabbage palm, hardwood/cypress swamp, shrub marsh, mixed wetland forest, freshwater marsh, and open water. **Minimum dimensions of the wildlife underpasses should be 7.4-m wide x 2.5-3.0-m tall (Fig. 37)**. We base this recommendation on landscape features and roadkill and telemetry data of Florida panther and black bear throughout this area (and roadkill data collected in 2006). Because this underpass would be designed specifically for large wildlife (e.g., bobcats, white-tailed deer, Florida panther, and black bear), an internal height of no less than 2.5 m is required. The same design criteria (e.g., landscaping, elevation, substrate consistency) as previously mentioned should be applied.

This part of SR 29 bisects the Florida Panther NWR and Big Cypress NP. Telemetry studies show that this area is central to the maintenance of existing populations of Florida panther and black bear in southwest Florida. As such, consideration should be given with regard to the disposition of mining activities in the area. Upon closing of this mine, pre-mining upland and wetland habitat types (e.g., pinelands) should be restored.

New culvert crossings are proposed for road segments 27, 31, and 56 (Appendix L). **These crossings are recommended to increase permeability of the road for small and meso-mammals, and reptiles and amphibians; minimum dimensions: 3.0-3.5-m wide x 2.0-2.5-m tall.** Habitat types at these locations include open water, freshwater marsh, cypress/hardwood swamp, mixed wetland forest, hardwood hammocks and forest, and pinelands. The structures placed at road segments 27 and 31 would primarily serve aquatic and wetland-dependent species; at road segment 56, use by a variety of terrestrial and wetland-dependent species is anticipated.

Fencing

On all road sections, between all these structures, we recommend construction of a 2.5-m minimum height barrier fence with 0.7-m high herptile-excluding mesh-screen (or alternative material) at the base of the fence. The mesh screen should extend below the ground surface to prevent any openings. Fencing should terminate at all culvert and bridge openings to aid in funneling wildlife through the crossing structures. **One-way gates/earthen ramps may be needed to allow escape for wildlife trapped in the fenced enclosure within the right-of-way (see Bank et al. 2002). If the proposed extent of fencing is not feasible, then we recommend that fencing extend at least 500 m in each direction from the structure**.

Even with these measures the long-term effects of road widening may be detrimental and can take decades to determine (Findlay and Bourdages 2000). **Following construction we recommend that funding be earmarked to monitor crossing structure performance and population stability of focal species in and around the RLSA**.

<u>**Planning Considerations**</u>

To preserve the character of the RLSA we strongly support a context-sensitive approach to land-use planning and highway design (see Moler 2002, Gesing 2003). Okalaocoochee Slough and Camp Keais Strand represent critical habitat connections between the Florida Panther NWR/Big Cypress NP and the Corkscrew Regional Ecosystem Watershed and Okalaocoochee Slough SF. These linkages face severe threats from urban development and highway expansion. Resource agencies need to monitor proposed developments and future highway upgrades on CR 858 and CR 846, as well as other proposed new roads in the RLSA and engage themselves in local government planning to protect this area.

Two-lane vs. Four-lane configuration: aversion factors and negative edge effects

Two-lane and four-lane highways produce varying negative effects on wildlife in adjacent areas. The intensity of these effects depends on road and verge width and traffic volume. If traffic volume is equal, two-lane highways generally produce more roadkills, but are more permeable (Smith 2003). Four-lane highways would have fewer roadkills, but are known to be aversion zones for many animal species and therefore create greater habitat and population fragmentation (Carr and Pelton 1984, Garland and Bradley 1984, Smith 2003).

Langton (1989) and Tyning (1989) documented the obstruction of normal migratory patterns of amphibian populations by roads. Mortality rates increased as mobility of various species decreased (Hels and Buchwald 2001). For populations of slower-moving amphibian species (many of which occur in the area), wider, high-traffic roads become an impermeable barrier, effectively disrupting the breeding process in many cases.

Widening of highways potentially magnifies negative edge effects, including the elimination or reduction of species sensitive to noise or visual disturbance and increased presence of opportunistic meso-predators and weedy species (e.g., of birds, rodents, and omnivores) (Oxley et al. 1974, Ferris 1979, Kozel and Fleharty 1979, Wilkins 1982, Adams and Geis 1983, Garland 1984, Andrews 1990, Bennett 1991, Reijnen et al. 1995, 1997, Forman and Alexander 1998, Gibbs 1998). In summary, roads seem to increase the richness of species that are competitively advantaged in disturbed environments, while decreasing the abundance and richness of area-sensitive or forest-interior species.

Reijnen et al. (1995, 1997) attributed forest breeding birds’ aversion to road verges to reduced habitat quality (primarily caused by traffic noise, and to a much lesser extent, visual disturbance or pollutants). These studies examined the effect of proximity to roads on breeding-bird density and found a 60% reduction in species diversity in plots adjacent to roads. The threshold at which bird densities decline was the distance from the highway where traffic noise is 42 decibels (dB) or higher (Reijnen et al. 1995). We measured traffic noise levels in excess of 50 dB as far as 500 m from a two-lane road with an average of 10,100 AADTs from 2004-05 in several different land cover types, e.g., dry prairie, shrub and brushland, fallow agricultural fields, native pinelands, and forested wetlands (Smith et al. 2005). Current AADTs on roads in the RLSA are: CR 846 west – 6,115, CR 846 east – approx. 1,500, CR 858 east – less than 500, SR 29 north – 8,800, and SR 29 south – 2,800 (data sources: FDOT 2006, Collier County 2006). With road widening (as planned on CR 858), this aversion zone is expected to increase.

Increased edge can impact interior species by increasing predation from edge predators as far as 300 to 600 m into a forested patch (Norse et al. 1986). Disruption of normal behaviors such as intraspecific communication and mating success can also result, as was shown for nocturnal frogs exposed to artificial lighting (Buchanan 1993) and for anurans and birds exposed to traffic and other noise pollution (Barrass 1985, Il'ichev et al. 1995). For these reasons we discourage placement of artificial lighting along each road within the core of the Okalaocoochee Slough and Camp Keais Strand habitat corridors.

Habitat fragmentation and encroachment by secondary development

Habitat isolation and fragmentation by linear structures such as roads may have strong deleterious effects on biological diversity. Human activities threaten native biological diversity through loss of species from genetic inbreeding, elimination of large intact habitat blocks, and invasion of alien species (Harris and Gallagher 1989, Andrews 1990, Forman and Alexander 1998). Collier County is currently experiencing tremendous growth and development pressure. The landscape character is switching from one of humans in a natural landscape matrix to one of natural areas in a human-dominated landscape. The widening of CR 858 and CR 846 (or construction of proposed new roads) will almost certainly increase construction of secondary roads and residential and commercial development.

Rapid fragmentation of landscapes by roads and urbanization result in loss of normal dispersion patterns and population instability (Andrews 1990, Harris and Scheck 1991, Rosen and Lowe 1994). Prior to the construction of county and state roads and agricultural development, this area would have been a mosaic of many habitat types (e.g., continuous and isolated forested and open wetlands, mixed-pine hardwood forest, pine forests, dry prairie, palm hammocks, and hardwood hammocks and forests) that animals regularly moved through. Animals still move through the landscape, of course, but now they must attempt to cross a significant barrier (the road and parallel canals) with great risk because of the existing high traffic flow on SR 29 and CR 846 west and projected increases in traffic flow on CR 858 west. What once was a simple 35- to 80-m movement event across continuous native plant communities now involves an abrupt habitat edge consisting of many shrubs and non-native ground cover species, a variable-depth canal, a section of grass or bare ground, and a section of pavement with variable densities of high speed traffic. This presents a daunting task to slow-moving small mammals, frogs, turtles, and snakes. The result is significantly high road mortality, fewer successful crossings, and population fragmentation for those species that are not well adapted to crossing artificial landscape features. For the Big Cypress fox squirrel, a state-listed species of special concern, this means segregation of local populations. Negative effects this fragmentation may have on long-term population genetics, though unknown, may be significant.

The extent of habitat fragmentation and isolation caused by increasing road densities in developing areas is critical for determining the persistence of disturbance-sensitive species. Based on numerous studies that have documented these impacts for various species (Opdam et al. 1985, Van Dyke et al. 1986, Rodgers and Smith 1995, Bowers and Matter 1997), the best prescription for retaining disturbance-sensitive species would include conservation reserve designs that maintain contiguous or well-connected large reserves. Ideally these reserves would contain wetland-upland gradients of suitable habitat (high landscape structural complexity) and network connections that contain similar characteristics and that minimize negative edge effects (Noss and Cooperrider 1994). Although enlarging the core area of the existing public conservation areas in northeast Collier County is restricted by escalating land prices and development pressure, we recommend some critical buffers to designated landscape linkages (Camp Keais Strand and Okalaocoochee Slough) to improve the current ecological function of this area (discussion of these buffers is provided in the section on regional landscape connectivity below).

Harris and Silva-Lopez (1992) argued that faunal collapse occurs when disturbance levels are sufficient to cause fundamentally different intensities of ecological processes to prevail. Without proper management and planning, the divisive fragmentation caused by widening CR 858 (or other existing roads) or building new roads would significantly restrict natural dispersal and detract from current efforts to improve ecological flows between Florida Panther NWR and Big Cypress NP with CREW lands and Okalaocoochee Slough SF.

Florida Audubon and Florida Wildlife Federation supported the RLSA program and the first proposed development, Ave Maria because of proposed wildlife crossings, wetland conservation, and restoration (Staats 2006, Cox 2006). Despite these concessions potential ecological impacts may be significant and should be investigated. Defenders of Wildlife's opinion was that the growth plan does not sufficiently protect endangered and threatened species; some of the best remaining habitat for panthers exists within the stewardship receiving (development) area (Cox 2006). Newspaper articles and websites reviewed pertaining to the land stewardship development did not mention the potential effects on panther populations due to increased infrastructure, roads, or human conflicts. The scientific literature provides more references regarding potential effects of the development on panther populations (Comiskey et al. 2004, Shrader-Frechette 2004, Gross 2005).

Studies of reserve network design recognize road density as a critical indicator for evaluating system integrity (Noss 1995). Roads, as barriers to animal movement, are considered one of the six major determinants of functional connectivity (Noss and Cooperider 1994). The use of highway-crossing structures at intersections with greenway linkages (habitat corridors) offers a method to reduce transportation-related wildlife mortality and restore connectivity to the landscape. Recommended designs (as presented in this case) illustrate the use of wildlife crossings to permeate transport facilities (Noss 1995).

Regional landscape connectivity

Along with the encroachment of roads and development, isolation and fragmentation of ecosystems and associated wildlife populations has occurred with varying detrimental effects. Coordination between transportation agencies, resource conservation agencies, and large landowners is essential to the development of effective policies that protect ecological systems, while simultaneously providing safe and efficient transportation systems.

The statewide Greenways Network Plan or Florida Ecological Network (Hoctor et al. 2000) was designed to provide guidance for conserving valuable natural resources of Florida and to restore connectivity between core conservation reserves and other isolated conservation areas. The Okalaocoochee Slough and Camp Keais Strand function as critical habitat connections in this network between the Florida Panther NWR/Big Cypress NP and the Corkscrew Regional Ecosystem Watershed and Okalaocoochee Slough SF Area. Connecting corridors must have sufficient width to maintain interior habitat qualities that would enhance use by threatened area-sensitive species (Noss 1983, Soulé 1991, Noss and Cooperider 1994). Understanding the natural-history requirements of species being considered is essential in design of functional corridors (Burbrink et al. 1998). Design of these landscape connections is complicated by the presence of roads within and surrounding large blocks of remaining habitat.

A major objective of the Rural Lands Stewardship Program is to conserve habitat corridors between core habitat areas to the north and south. This must include the creation of functional wildlife corridors for multiple species (e.g., generalist and specialist species, wetland and upland obligates). To accomplish this objective, restoration of cleared, cultivated areas along the margin of the existing wetland corridors is necessary to provide adjacent continuous upland linkages.

Although we believe the Rural Lands Stewardship Program is moving in the right direction, it falls short of protecting the amount and location of habitats identified in the most recent study on protection of the existing panther population (Kautz et al. 2006). Specifically, it adequately protects wetlands, but omits sufficient protection for uplands in some areas adjacent to these wetland corridors. This is probably due to the existing level of degradation to adjacent uplands, which have been converted to agricultural production areas. There are also areas adjacent to Big Cypress NP and north of CR 858 identified in the panther primary zone (Kautz et al. 2006) that were excluded in the habitat stewardship areas. We are particularly concerned with the inadequacies apparent in the design of the connecting corridors. However, we believe these concerns can be alleviated by review and use of standard reserve design principles.

Based on landscape ecology principles and commonly accepted reserve design techniques discussed by Noss and Harris (1986), Adams and Dove (1989), Noss and Harris (1989), Noss and Cooperider (1994), Forman (1995), Dramstad et al. (1996) and others, three critical components are necessary to establish a functionally connected reserve system—core habitat areas of sufficient size, connecting habitat corridors of sufficient width between core habitat areas, and buffers that protect the interior quality of the primary network features (core areas and linkages). Buffers serve to reduce negative edge effects for interior species sensitive to human activities, provide additional habitat for species less sensitive to human activities, allow for establishment of natural gradients from wet to dry habitats required by many species for sustainable breeding populations, allow for spatial response (e.g., escape potential) to natural disturbance (flood and fire), and in this case would provide travel corridors of upland habitat for those species that may not be able to move through the existing wetland corridors.

Since there are few, if any, current regulatory mechanisms to establish or protect upland habitat buffers, the Rural Land Stewardship Program seems an ideal platform to implement this strategy for habitat conservation. We propose a conceptual design based on the current RLSA designations with the inclusion of tiered (or multiple) buffers (of decreasing degree of land-use intensity as you move inward). Our design (Fig. 39) includes upland buffers adjacent to the primary wetland corridors. The inner buffer is an upland habitat restoration zone (600-m wide); the outer buffer is a low intensity agricultural zone (400-m wide). Together these provide a 1,000-m zone of additional protection for the core wetland areas. The selected width is based on literature reviews of negative edge effects; 600 m is a conservative distance to reduce various negative edge effects from adjacent human land uses such as roads and development (Forman 1995). The proposed 500-ft buffers (Fig. 39) are discontinuous and would be less effective in protecting the core habitat areas and allowing unimpeded travel through the corridors by species obligated to upland habitats.

In addition, based on current roadkill and telemetry data for Florida panther and black bear we have added a central corridor that connects the Florida Panther NWR to the Okalaocoochee Slough; from the data this appears to be the preferred travel corridor between these areas. Of course, implementation of this conceptual design would require restoration of some agricultural areas to native habitat types. Lastly, we suggest acquisition of significant areas adjacent to Big Cypress NP, Okalaocoochee Slough SF, and CREW lands to increase size of these core areas (Fig. 39).

Other general measures in corridor design include the 1 to 10 rule (one unit of width for every 10 units of length) and guidance to protect an area at least 3 times the width of the edge effects. The present wetland corridors are approximately 20,000-m long, which would require a width of 2,000 m. The narrowest width of the Okalaocoochee Slough corridor is about 1,200 m at CR 858; addition of the proposed buffers would increase minimum width to approx. 2,200 m.

Total area of designated stewardship areas (flow-ways-15,656 ha, habitat- 18,528 ha, and water retention areas- 7,377 ha) was 41,551 ha. Proposed buffers (habitat restoration zone- 3,259 ha and passive agricultural zone- 2,572 ha) would add 5,831 ha. This represents approximately 14% of the total area of the existing designated stewardship areas. The central corridor would increase the overall area of designated stewardship zones by 1,673 ha.

These proposed additions are conceptual with the objective of optimizing functional habitat connectivity for Florida panthers, black bears, white-tailed deer, river otters, amphibians and reptiles, and other species of concern. This effort is meant to generate more discussion toward improving the existing design and to foster reasonable compromise between the designated stewardship zones and recent scientific studies (Kautz et al. 2006), sponsored by the U.S. Fish and Wildlife Service that request more land be set aside for Florida panther protection (Tables 3 and 4 provide general comparisons).

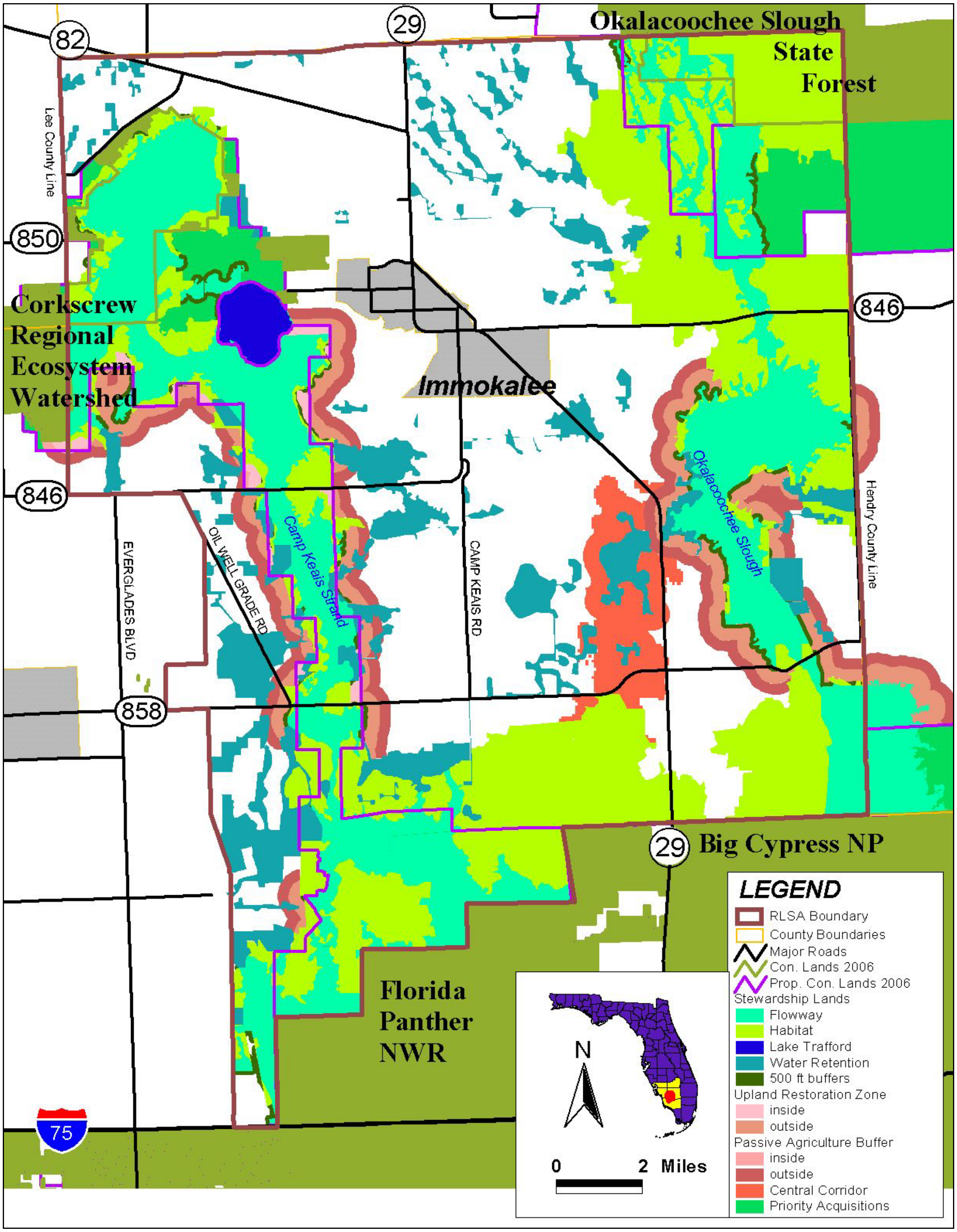


Figure 39. Conceptual Design Improvements to the Rural Land Stewardship Habitat Corridors. Elements include a tiered-buffer design and addition of a central travel corridor for Florida panther. The inner buffer is a 600 m upland restoration zone and the outer buffer is a 400 m passive agricultural zone. The central corridor is based on the areas identified in the FWC Florida panther SHCA and telemetry data.

The landscape in the study area currently consists of significant habitat corridors and portions of core habitat areas within an agricultural matrix. Efforts are being made to control and manage impending growth and development; yet major risks still exist with regard to roads and proposed large developments. Increased levels of development will dictate increased width of existing roadways (and the possibility of construction of new roads) to accommodate increasing traffic levels. All these activities threaten to cause further fragmentation and loss of remaining habitat areas and associated native biodiversity. Recommendations provided herein, based on data collected in this study as well as previous studies on Florida panther and black bear, include addition of wildlife crossing structures and conceptual additions to the designated stewardship zones. These measures are intended to improve overall habitat connectivity within the study area and promote sustainability of rare and common native wildlife species.

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Appendix A

Track data collected on right-of-way of CR 846 from Dec 2005 – Aug 2006

Appendix A. Track data.

Date	Road	Section	Segment	Species
20060320	846	E	8	bobcat
20060223	846	E	8	deer
20060227	846	E	8	deer
20060329	846	E	8	pig
20060505	846	E	8	river otter
20060412	846	E	8	soft shell turtle
20060412	846	E	8	soft shell turtle
20060111	846	E	9	bobcat
20060315	846	E	9	bobcat
20060419	846	E	9	bobcat
20060515	846	E	9	bobcat
20060302	846	E	9	coyote
20060111	846	E	9	deer
20060223	846	E	9	deer
20060223	846	E	9	deer
20060223	846	E	9	deer
20060302	846	E	9	deer
20060310	846	E	9	deer
20060322	846	E	9	deer
20060322	846	E	9	deer
20060331	846	E	9	deer
20060407	846	E	9	deer
20060407	846	E	9	deer
20060407	846	E	9	deer
20060306	846	E	9	turkey
20060315	846	E	9	turkey
20060315	846	E	9	turkey
20060515	846	E	9	turkey
20060515	846	E	9	turkey
20060515	846	E	9	turkey
20060306	846	E	17	deer
20060306	846	E	17	deer
20060306	846	E	17	deer
20060306	846	E	17	deer
20060515	846	E	62	turtle
20060414	846	E	63	coyote
20060123	846	E	63	deer
20060419	846	E	63	panther
20060421	846	E	63	panther
20060306	846	E	63	turtle
20060624	846	E	64	bobcat
20060320	846	E	64	coyote
20060405	846	E	64	deer
20060414	846	E	64	panther
20060414	846	E	64	panther
20060515	846	E	64	panther

Appendix A. Track data (continued)

Date	Road	Section	Segment	Species
20060213	846	E	64	snake
20060315	846	E	64	turtle
20060315	846	E	64	turtle
20060223	846	E	65	coyote
20060726	846	E	65	deer
20060524	846	E	65	panther
20060719	846	E	65	pig
20060317	846	E	65	snake
20060508	846	E	65	soft shell turtle
20060508	846	E	65	soft shell turtle
20060213	846	E	73	deer
20060306	846	E	73	deer
20060227	846	E	74	pig
20060306	846	E	74	pig
20060414	846	E	75	bobcat
20060213	846	E	75	deer
20060213	846	E	75	deer
20060213	846	E	75	deer
20060223	846	E	75	deer
20060414	846	E	75	deer
20060816	846	E	75	deer
20060405	846	E	82	deer
20060213	846	E	83	bobcat
20060213	846	E	83	deer
20060310	846	E	83	deer
20060310	846	E	83	deer
20060310	846	E	83	deer
20060310	846	E	83	deer
20060310	846	E	83	deer
20060310	846	E	83	deer
20060310	846	E	83	deer
20060310	846	E	83	deer
20060310	846	E	83	deer
20060313	846	E	83	deer
20060313	846	E	83	deer
20060315	846	E	83	deer
20060315	846	E	83	deer
20060315	846	E	83	deer
20060315	846	E	83	deer
20060315	846	E	83	deer
20060317	846	E	83	deer
20060317	846	E	83	deer
20060317	846	E	83	deer
20060317	846	E	83	deer
20060317	846	E	83	deer
20060317	846	E	83	deer

Appendix A. Track data (continued)

Date	Road	Section	Segment	Species
20060317	846	E	83	deer
20060317	846	E	83	deer
20060317	846	E	83	deer
20060320	846	E	83	deer
20060322	846	E	83	deer
20060322	846	E	83	deer
20060327	846	E	83	deer
20060327	846	E	83	deer
20060329	846	E	83	deer
20060405	846	E	83	deer
20060412	846	E	83	deer
20060414	846	E	83	deer
20060414	846	E	83	deer
20060414	846	E	83	deer
20060419	846	E	83	deer
20060701	846	E	83	deer
20060705	846	E	83	deer
20060213	846	E	84	bobcat
20060705	846	E	84	bobcat
20060414	846	E	84	deer
20060414	846	E	85	deer
20060615	846	E	106	panther
20060306	846	W	29	bobcat
20060309	846	W	41	bear
20060719	846	W	41	coyote
20060324	846	W	45	panther
20060414	846	W	45	river otter
20051212	846	W	68	bobcat
20060302	846	W	68	bobcat
20060412	846	W	68	coyote
20060216	846	W	68	turtle
20051212	846	W	69	bobcat
20060302	846	W	69	bobcat
20060111	846	W	82	deer
20060111	846	W	82	deer
20060111	846	W	82	deer
20060331	846	W	82	turtle
20060405	846	W	82	turtle
20060405	846	W	83	turtle
20060405	846	W	85	bobcat
20060331	846	W	85	deer
20060331	846	W	85	deer
20060405	846	W	85	dog
20060320	846	W	85	turtle

Appendix B

Roadkill data collected on CR 846, CR 858, and SR 29
Dec 2005 – Aug 2006

Appendix B. Roadkill data.

Date	Road	Section	Segment	Type	Species
20051204	29	N	19	Mesomammals	Virginia opossum
20060802	29	N	30	Birds	black vulture
20060802	29	N	30	Mesomammals	raccoon
20060802	29	N	31	Birds	black vulture
20060802	29	N	40	Birds	black vulture
20060802	29	N	40	Turtles	Florida box turtle
20060712	29	N	41	Ungulates	deer
20060809	29	N	43	Birds	red shoulder hawk
20051204	29	N	53	Birds	black vulture
20051207	29	N	59	Birds	snowy egret
20060320	29	N	60	Birds	barred owl
20060802	29	N	66	Birds	black vulture
20060701	29	N	67	Birds	black vulture
20051204	29	S	10	Mesomammals	Virginia opossum
20060423	29	S	11	Alligator	alligator
20060423	29	S	11	Mesomammals	raccoon
20060224	29	S	13	Mesomammals	Virginia opossum
20051204	29	S	16	Mesomammals	Virginia opossum
20060522	29	S	17	Birds	eastern meadowlark
20060719	29	S	20	Birds	red shoulder hawk
20060224	29	S	25	Mesomammals	Virginia opossum
20051204	29	S	27	Alligator	alligator
20051204	29	S	28	Birds	black vulture
20060701	29	S	29	Alligator	alligator
20051212	29	S	31	Snakes	water snake
20051204	29	S	31	Frogs	pig frog
20060501	29	S	32	Birds	black vulture
20051204	29	S	32	Turtles	snapping turtle
20051212	29	S	32	Turtles	snapping turtle
20060426	29	S	35	Alligator	alligator
20060213	29	S	35	Birds	barred owl
20060501	29	S	36	Birds	black vulture
20060109	29	S	36	Mesomammals	Virginia opossum
20060109	29	S	36	Mesomammals	Virginia opossum
20060522	29	S	36	Mesomammals	Virginia opossum
20060816	29	S	36	Turtles	Florida red-bellied turtle
20060320	29	S	37	Mesomammals	Virginia opossum
20060719	29	S	39	Birds	great egret
20060726	29	S	39	Snakes	yellow rat snake
20060322	29	S	41	Birds	black vulture
20051209	29	S	45	Mesomammals	9 banded armadillo
20060523	29	S	48	Snakes	brown water snake
20060426	29	S	49	Mesomammals	raccoon
20060127	29	S	50	Birds	anhinga
20060322	29	S	53	Birds	black vulture
20060109	29	S	53	Birds	turkey vulture
20060109	29	S	53	Mesomammals	Virginia opossum
20060104	29	S	55	Birds	black bird

Appendix B. Roadkill data (continued).

Date	Road	Section	Segment	Type	Species
20051209	29	S	56	Birds	black vulture
20060104	29	S	56	Snakes	black racer
20060125	29	S	56	Birds	black vulture
20060322	29	S	56	Birds	black vulture
20060125	29	S	56	Mesomammals	Virginia opossum
20060322	29	S	57	Birds	black vulture
20051207	29	S	58	Birds	barred owl
20060701	29	S	60	Alligator	alligator
20060611	29	S	60	Birds	black vulture
20060701	29	S	60	Birds	black vulture
20060327	29	S	61	Small Mammals	rat
20060719	29	S	63	Mesomammals	9 banded armadillo
20051212	846	E	1	Birds	black vulture
20051203	846	E	1	Small Mammals	marsh rabbit
20051204	846	E	2	Birds	black vulture
20060116	846	E	2	Birds	black vulture
20060116	846	E	2	Snakes	snake
20051212	846	E	2	Snakes	water snake
20060130	846	E	6	Mesomammals	Virginia opossum
20060203	846	E	6	Ungulates	pig
20051209	846	E	7	Mesomammals	Virginia opossum
20060705	846	E	8	Mesomammals	9 banded armadillo
20060324	846	E	8	Mesomammals	raccoon
20060510	846	E	8	Mesomammals	raccoon
20060426	846	E	8	Mesomammals	Virginia opossum
20060120	846	E	9	Ungulates	deer
20051212	846	E	12	Snakes	water snake
20060127	846	E	24	Mesomammals	raccoon
20060220	846	E	25	Birds	turkey vulture
20060701	846	E	32	Snakes	brown water snake
20060726	846	E	36	Birds	red shoulder hawk
20060719	846	E	38	Mesomammals	Virginia opossum
20060127	846	E	39	Mesomammals	raccoon
20060414	846	E	40	Mesomammals	Virginia opossum
20060414	846	E	41	Mesomammals	9 banded armadillo
20060223	846	E	41	Mesomammals	raccoon
20060104	846	E	41	Snakes	cottonmouth
20060719	846	E	42	Mesomammals	9 banded armadillo
20060104	846	E	42	Mesomammals	Virginia opossum
20060125	846	E	42	Birds	black vulture
20060203	846	E	44	Birds	barred owl
20060104	846	E	44	Mesomammals	Virginia opossum
20060617	846	E	45	Mesomammals	9 banded armadillo
20060130	846	E	45	Mesomammals	Virginia opossum
20060501	846	E	46	Mesomammals	Virginia opossum
20060501	846	E	47	Birds	black vulture
20060501	846	E	47	Mesomammals	9 banded armadillo
20060419	846	E	47	Mesomammals	Virginia opossum

Appendix B. Roadkill data (continued).

Date	Road	Section	Segment	Type	Species
20060501	846	E	47	Turtles	soft shell turtle
20060220	846	E	48	Mesomammals	Virginia opossum
20060522	846	E	48	Mesomammals	Virginia opossum
20060809	846	E	49	Snakes	brown water snake
20060111	846	E	49	Ungulates	pig
20060617	846	E	50	Mesomammals	raccoon
20060512	846	E	51	Alligator	alligator
20060719	846	E	53	Mesomammals	9 banded armadillo
20060519	846	E	53	Mesomammals	Virginia opossum
20060611	846	E	55	Birds	common moorhen
20060823	846	E	56	Alligator	alligator
20060123	846	E	56	Mesomammals	9 banded armadillo
20060611	846	E	59	Birds	red shoulder hawk
20051212	846	E	60	Birds	black vulture
20060125	846	E	61	Frogs	pig frog
20051212	846	E	61	Mesomammals	Virginia opossum
20060410	846	E	62	Mesomammals	Virginia opossum
20060407	846	E	62	Snakes	black snake
20060701	846	E	62	Mesomammals	9 banded armadillo
20060303	846	E	63	Mesomammals	raccoon
20060206	846	E	64	Birds	red shoulder hawk
20060515	846	E	64	Mesomammals	raccoon
20060414	846	E	64	Snakes	black snake
20060802	846	E	65	Mesomammals	9 banded armadillo
20060320	846	E	68	Mesomammals	raccoon
20060611	846	E	68	Mesomammals	9 banded armadillo
20060130	846	E	69	Birds	black vulture
20060130	846	E	69	Mesomammals	9 banded armadillo
20060421	846	E	69	Snakes	snake
20060130	846	E	70	Small Mammals	marsh rabbit
20060407	846	E	73	Mesomammals	Virginia opossum
20060123	846	E	75	Mesomammals	Virginia opossum
20060701	846	E	76	Birds	black vulture
20060617	846	E	77	Mesomammals	9 banded armadillo
20060130	846	E	78	Birds	black vulture
20060130	846	E	78	Mesomammals	raccoon
20060320	846	E	78	Mesomammals	raccoon
20060130	846	E	78	Mesomammals	Virginia opossum
20060130	846	E	79	Mesomammals	Virginia opossum
20060223	846	E	80	Birds	black vulture
20060223	846	E	80	Carnivores	coyote
20060224	846	E	80	Snakes	cottonmouth
20060224	846	E	80	Snakes	cottonmouth
20060116	846	E	80	Mesomammals	Virginia opossum
20060726	846	E	81	Small Mammals	marsh rabbit
20060405	846	E	81	Ungulates	pig
20060405	846	E	82	Birds	black vulture
20060624	846	E	82	Snakes	black racer

Appendix B. Roadkill data (continued).

Date	Road	Section	Segment	Type	Species
20060405	846	E	82	Snakes	cottonmouth
20060405	846	E	82	Turtles	Florida red-bellied turtle
20060410	846	E	85	Mesomammals	Virginia opossum
20051207	846	E	86	Birds	black vulture
20051207	846	E	87	Mesomammals	Virginia opossum
20060417	846	E	88	Ungulates	deer
20060127	846	E	90	Mesomammals	Virginia opossum
20060505	846	E	90	Mesomammals	raccoon
20060203	846	E	91	Snakes	snake
20060203	846	E	92	Mesomammals	Virginia opossum
20060515	846	E	95	Mesomammals	Virginia opossum
20060123	846	E	96	Mesomammals	Virginia opossum
20060405	846	E	97	Mesomammals	Virginia opossum
20060701	846	E	99	Mesomammals	9 banded armadillo
20060510	846	E	99	Mesomammals	raccoon
20060510	846	E	99	Mesomammals	Virginia opossum
20060313	846	E	100	Birds	black vulture
20060320	846	E	100	Birds	black vulture
20060617	846	E	102	Turtles	soft shell turtle
20060624	846	E	103	Mesomammals	raccoon
20060712	846	E	106	Birds	black vulture
20060809	846	E	106	Frogs	pig frog
20060104	846	W	1	Birds	black vulture
20051204	846	W	3	Mesomammals	raccoon
20060111	846	W	4	Mesomammals	Virginia opossum
20051203	846	W	13	Mesomammals	Virginia opossum
20060522	846	W	17	Mesomammals	Virginia opossum
20051212	846	W	19	Mesomammals	Virginia opossum
20051212	846	W	19	Mesomammals	Virginia opossum
20051203	846	W	20	Mesomammals	raccoon
20051212	846	W	20	Birds	black vulture
20060127	846	W	22	Small Mammals	marsh rabbit
20060705	846	W	24	Alligator	alligator
20051214	846	W	28	Alligator	alligator
20060317	846	W	30	Snakes	Florida scarlet snake
20060317	846	W	32	Mesomammals	Virginia opossum
20060719	846	W	32	Turtles	striped mud turtle
20051203	846	W	35	Birds	black vulture
20060424	846	W	37	Mesomammals	raccoon
20051203	846	W	38	Birds	barred owl
20060104	846	W	38	Carnivores	grey fox
20051203	846	W	40	Birds	black vulture
20060104	846	W	40	Birds	black vulture
20051207	846	W	40	Mesomammals	9 banded armadillo
20060227	846	W	40	Mesomammals	Virginia opossum
20060512	846	W	40	Mustelids	river otter
20051212	846	W	41	Birds	cat bird
20051203	846	W	41	Mesomammals	raccoon

Appendix B. Roadkill data (continued).

Date	Road	Section	Segment	Type	Species
20060130	846	W	41	Mesomammals	Virginia opossum
20060120	846	W	42	Birds	black vulture
20060405	846	W	42	Birds	Chuck Wills widow
20060405	846	W	42	Snakes	black racer
20060405	846	W	42	Snakes	pygmy rattle snake
20060405	846	W	42	Turtles	Florida red-bellied turtle
20060405	846	W	43	Birds	black vulture
20060120	846	W	43	Mesomammals	Virginia opossum
20060405	846	W	43	Turtles	Florida red-bellied turtle
20060424	846	W	45	Alligator	alligator
20060426	846	W	45	Alligator	alligator
20060617	846	W	45	Birds	marsh wren
20060104	846	W	50	Birds	hawk/owl
20051209	846	W	50	Mesomammals	Virginia opossum
20060104	846	W	50	Mesomammals	Virginia opossum
20060519	846	W	52	Birds	black vulture
20051203	846	W	52	Small Mammals	marsh rabbit
20060120	846	W	53	Birds	green heron
20051203	846	W	53	Birds	vulture
20060313	846	W	53	Turtles	snapping turtle
20060405	846	W	56	Birds	mourning dove
20060405	846	W	56	Mesomammals	raccoon
20060405	846	W	57	Birds	black vulture
20060624	846	W	58	Snakes	black racer
20060123	846	W	63	Mustelids	river otter
20060120	846	W	63	Birds	turkey vulture
20060120	846	W	63	Mesomammals	raccoon
20060624	846	W	66	Birds	black vulture
20060216	846	W	68	Birds	screech owl
20060116	846	W	69	Mesomammals	Virginia opossum
20060508	846	W	70	Mesomammals	9 banded armadillo
20051209	846	W	71	Mesomammals	raccoon
20060118	846	W	73	Birds	great blue heron
20060118	846	W	73	Mesomammals	raccoon
20060719	846	W	74	Birds	red shoulder hawk
20060313	846	W	79	Birds	barred owl
20060322	846	W	79	Frogs	frog
20051212	846	W	81	Snakes	garter snake
20051203	846	W	81	Birds	heron
20060216	846	W	81	Snakes	diamondback rattlesnake
20051203	846	W	81	Turtles	turtle
20060118	846	W	81	Turtles	turtle
20060726	846	W	82	Birds	black-crowned night heron
20060104	846	W	82	Birds	great blue heron
20060104	846	W	83	Birds	black vulture
20051203	846	W	83	Birds	barred owl
20060624	846	W	83	Birds	European starling
20051207	846	W	83	Mustelids	river otter

Appendix B. Roadkill data (continued).

Date	Road	Section	Segment	Type	Species
20051203	846	W	85	Birds	cardinal
20060106	846	W	85	Mesomammals	Virginia opossum
20051207	846	W	85	Birds	barred owl
20060203	846	W	85	Mesomammals	9 banded armadillo
20060118	846	W	86	Birds	black vulture
20060118	846	W	86	Mesomammals	raccoon
20060611	846	W	87	Birds	red shoulder hawk
20060816	846	W	87	Snakes	cottonmouth
20060405	846	W	90	Carnivores	bobcat
20060201	858	C	1	Domestics	dog
20060201	858	C	1	Domestics	dog
20051204	858	C	1	Snakes	black racer
20051204	858	C	1	Snakes	black racer
20060104	858	C	5	Birds	turkey vulture
20060104	858	C	5	Mesomammals	Virginia opossum
20060407	858	C	11	Mesomammals	Virginia opossum
20060701	858	C	20	Alligator	alligator
20060701	858	C	20	Birds	black vulture
20060701	858	C	20	Birds	black vulture
20060419	858	C	20	Mustelids	river otter
20060127	858	C	21	Mesomammals	Virginia opossum
20060512	858	C	24	Birds	sandhill crane
20060505	858	C	25	Carnivores	coyote
20060505	858	C	25	Small Mammals	rabbit
20060512	858	C	25	Ungulates	deer
20060426	858	C	26	Mesomammals	Virginia opossum
20060705	858	C	31	Mesomammals	Virginia opossum
20060111	858	C	35	Mustelids	river otter
20060111	858	C	38	Birds	red shoulder hawk
20060809	858	C	38	Birds	red shoulder hawk
20060412	858	C	44	Mesomammals	Virginia opossum
20051212	858	C	46	Birds	black vulture
20060130	858	C	47	Domestics	dog
20051212	858	C	47	Mesomammals	Virginia opossum
20060426	858	C	49	Small Mammals	squirrel
20051204	858	C	61	Mustelids	river otter
20060505	858	C	70	Birds	black vulture
20060522	858	C	75	Mesomammals	raccoon
20060213	858	E	6	Birds	black vulture
20060213	858	E	6	Ungulates	pig
20051203	858	E	14	Mustelids	river otter
20060419	858	E	22	Alligator	alligator
20060701	858	E	23	Mesomammals	raccoon
20060227	858	E	35	Snakes	black racer
20060320	858	E	36	Carnivores	coyote
20051203	858	E	38	Birds	vulture
20060331	858	E	39	Snakes	black racer
20060405	858	E	40	Mesomammals	Virginia opossum

Appendix B. Roadkill data (continued).

Date	Road	Section	Segment	Type	Species
20060104	858	E	40	Mustelids	river otter
20060104	858	E	40	Snakes	snake
20060407	858	E	46	Small Mammals	squirrel
20060217	858	E	51	Birds	great blue heron
20060104	858	E	51	Birds	black vulture
20060213	858	E	52	Birds	black vulture
20051203	858	E	54	Birds	great blue heron
20051203	858	E	57	Birds	anhinga
20060726	858	E	59	Frogs	pig frog
20060712	858	E	59	Snakes	cottonmouth
20060726	858	E	59	Turtles	soft shell turtle
20060322	858	E	60	Birds	great egret
20060320	858	E	71	Mesomammals	9 banded armadillo
20060405	858	E	75	Mesomammals	Virginia opossum
20060410	858	E	75	Mesomammals	Virginia opossum
20060410	858	E	75	Ungulates	pig
20060802	858	W	6	Birds	black vulture
20060523	858	W	10	Mesomammals	Virginia opossum
20051204	858	W	13	Mesomammals	raccoon
20060426	858	W	24	Snakes	corn snake
20060313	858	W	25	Turtles	Florida red-bellied turtle
20060125	858	W	26	Mesomammals	Virginia opossum
20060220	858	W	30	Birds	black vulture
20051203	858	W	35	Birds	black vulture
20060313	858	W	35	Birds	Black vulture
20060125	858	W	38	Turtles	Florida cooter
20060809	858	W	42	Alligator	alligator
20060104	858	W	42	Mesomammals	raccoon
20051204	858	W	45	Birds	barred owl
20051203	858	W	45	Birds	kestrel
20051203	858	W	45	Birds	vulture
20051203	858	W	45	Snakes	snake
20051203	858	W	45	Birds	black vulture
20060701	858	W	47	Snakes	cottonmouth
20060220	858	W	52	Mesomammals	raccoon
20060519	858	W	57	Mesomammals	raccoon
20060331	858	W	62	Snakes	cottonmouth
20060802	858	W	62	Turtles	striped mud turtle
20060624	858	W	63	Birds	anhinga
20060624	858	W	63	Birds	turkey vulture
20060823	858	W	64	Mustelids	river otter
20060505	858	W	65	Alligator	alligator
20060809	858	W	65	Birds	black vulture
20060611	858	W	66	Birds	black vulture
20060701	858	W	66	Mustelids	river otter

Appendix C

Photographic data collected adjacent to CR 846 and CR 858
Jan – Aug 2006

Appendix C. Photographic data.

Date	Time	Road	Section	Segment	Camera ID	Species
1/25/2006	3:57	846	E	37	1	bovine
1/26/2006	3:56	846	E	37	1	bovine
8/7/2006	5:23	846	E	37	1	deer
1/19/2006	22:14	846	E	37	2	raccoon
1/24/2006	4:36	846	E	37	2	raccoon
1/24/2006	4:36	846	E	37	2	raccoon
1/24/2006	4:36	846	E	37	2	raccoon
1/26/2006	4:02	846	E	37	2	deer
2/1/2006	9:00	846	E	37	2	bovine
2/27/2006	19:20	846	E	37	2	bovine
3/22/2006	23:41	846	E	37	2	owl
4/29/2006	23:47	846	E	37	2	bovine
5/20/2006	8:56	846	E	37	2	bovine
3/13/2006	6:26	846	E	58	3	deer
2/8/2006	18:45	846	E	73	4	deer
2/9/2006	22:45	846	E	73	4	deer
2/14/2006	0:19	846	E	73	4	bovine
2/14/2006	0:25	846	E	73	4	bovine
2/15/2006	22:55	846	E	73	4	bovine
2/15/2006	19:52	846	E	73	4	deer
2/15/2006	20:09	846	E	73	4	deer
4/10/2006	7:22	846	E	73	4	deer
4/10/2006	7:08	846	E	73	4	deer
6/24/2006	14:37	846	E	73	4	raccoon
1/23/2006	22:23	846	E	75	5	deer
1/28/2006	20:48	846	E	75	5	deer
1/30/2006	21:24	846	E	75	5	deer
1/31/2006	2:45	846	E	75	5	deer
2/17/2006	19:49	846	E	75	5	raccoon
4/11/2006	2:20	846	E	75	5	deer
7/17/2006	22:44	846	E	75	5	raccoon
8/1/2006	23:15	846	E	75	5	opossum
8/2/2006	4:39	846	E	75	5	raccoon
8/11/2006	20:37	846	E	75	5	opossum
8/13/2006	20:41	846	E	75	5	opossum
8/14/2006	21:05	846	E	75	5	opossum
8/14/2006	22:03	846	E	75	5	raccoon
8/15/2006	22:47	846	E	75	5	deer
8/15/2006	5:23	846	E	75	5	raccoon
8/17/2006	23:51	846	E	75	5	raccoon
8/18/2006	4:00	846	E	75	5	opossum
8/20/2006	22:34	846	E	75	5	raccoon
8/21/2006	2:24	846	E	75	5	raccoon
7/23/2006	14:54	846	E	80	5b	brown thrasher
7/28/2006	19:05	846	E	80	5b	raccoon
1/15/2006	17:12	846	E	94	6	deer
2/8/2006	18:01	846	E	94	6	deer
2/15/2006	15:23	846	E	94	6	bobcat

Appendix C. Photographic data (continued).

Date	Time	Road	Section	Segment	Camera ID	Species
3/25/2006	17:26	846	E	94	6	deer
7/4/2006	16:22	846	E	94	6	pig
7/12/2006	22:56	846	E	94	6	dog
7/13/2006	22:14	846	E	94	6	raccoon
7/14/2006	22:39	846	E	94	6	coyote
7/15/2006	23:41	846	E	94	6	raccoon
7/15/2006	7:49	846	E	94	6	turkey
7/16/2006	21:22	846	E	94	6	raccoon
7/16/2006	8:29	846	E	94	6	sandhill crane
7/18/2006	7:03	846	E	94	6	pig
7/28/2006	9:56	846	E	94	6	pig
7/28/2006	20:19	846	E	94	6	raccoon
7/29/2006	1:25	846	E	94	6	pig
8/2/2006	22:43	846	E	94	6	bobcat
8/3/2006	21:19	846	E	94	6	raccoon
8/4/2006	20:01	846	E	94	6	pig
8/7/2006	5:58	846	E	94	6	pig
8/7/2006	1:01	846	E	94	6	raccoon
8/7/2006	20:13	846	E	94	6	raccoon
8/21/2006	5:51	846	E	94	6	pig
1/20/2006	0:43	846	E	99	7	deer
1/14/2006	0:47	846	E	99	8	opossum
1/14/2006	3:43	846	E	99	8	opossum
1/15/2006	21:27	846	E	99	8	opossum
1/17/2006	23:19	846	E	99	8	opossum
01/18/06	18:38	846	E	99	8	opossum
1/20/2006	19:15	846	E	99	8	bobcat
1/20/2006	9:33	846	E	99	8	bovine
1/20/2006	2:26	846	E	99	8	deer
1/20/2006	7:15	846	E	99	8	pig
2/5/2006	13:56	846	E	99	8	bovine
2/6/2006	21:58	846	E	99	8	deer
3/18/2006	17:26	846	E	99	8	deer
3/22/2006	10:14	846	E	99	8	deer
3/22/2006	9:09	846	E	99	8	turkey
3/25/2006	5:28	846	E	99	8	raccoon
3/29/2006	20:32	846	E	99	8	pig
3/29/2006	5:19	846	E	99	8	pig
3/30/2006	3:38	846	E	99	8	marsh rabbit
3/31/2006	18:51	846	E	99	8	deer
4/1/2006	20:37	846	E	99	8	pig
4/1/2006	20:37	846	E	99	8	pig
4/1/2006	20:37	846	E	99	8	pig
4/1/2006	20:37	846	E	99	8	pig
4/1/2006	22:55	846	E	99	8	raccoon
4/5/2006	23:35	846	E	99	8	opossum
4/10/2006	7:20	846	E	99	8	deer
4/11/2006	23:03	846	E	99	8	deer

Appendix C. Photographic data (continued).

Date	Time	Road	Section	Segment	Camera ID	Species
4/14/2006	4:41	846	E	99	8	deer
4/14/2006	1:23	846	E	99	8	deer
4/17/2006	1:35	846	E	99	8	opossum
5/16/2006	12:16	846	E	99	8	bovine
5/17/2006	9:48	846	E	99	8	bovine
5/17/2006	17:49	846	E	99	8	bovine
5/17/2006	12:33	846	E	99	8	cattle egret
5/17/2006	17:46	846	E	99	8	cattle egret
5/24/2006	9:02	846	E	99	8	bovine
5/24/2006	9:46	846	E	99	8	bovine
5/24/2006	12:33	846	E	99	8	bovine
5/24/2006	15:22	846	E	99	8	bovine
5/24/2006	14:29	846	E	99	8	cattle egret
7/13/2006	5:37	846	E	99	8	deer
7/21/2006	21:14	846	E	99	8	bovine
7/31/2006	18:41	846	E	99	8	bovine
2/9/2006	22:37	858	E	43	9	deer
7/13/2006	5:21	858	E	43	9	deer
7/16/2006	21:38	858	E	43	9	deer
7/19/2006	18:43	858	E	43	9	deer
7/20/2006	17:49	858	E	43	9	deer
7/21/2006	18:14	858	E	43	9	deer
7/23/2006	20:08	858	E	43	9	deer
8/7/2006	11:19	858	E	43	9	deer
8/10/2006	18:01	858	E	43	9	deer
8/12/2006	0:12	858	E	43	9	deer
8/12/2006	5:30	858	E	43	9	deer
8/18/2006	18:16	858	E	43	9	bobcat
8/18/2006	18:28	858	E	43	9	deer
8/18/2006	4:26	858	E	43	9	deer
1/24/2006	23:52	846	W	45	13	bobcat
1/25/2006	13:05	846	W	45	13	raccoon
2/4/2006	2:31	846	W	45	13	bovine
2/8/2006	0:43	846	W	45	13	bovine
2/8/2006	19:36	846	W	45	13	bovine
2/8/2006	19:52	846	W	45	13	bovine
2/8/2006	2:25	846	W	45	13	raccoon
2/11/2006	22:03	846	W	45	13	bovine
2/11/2006	1:47	846	W	45	13	coyote
2/12/2006	6:48	846	W	45	13	cardinal
3/1/2006	22:10	846	W	45	13	coyote
3/4/2006	13:59	846	W	45	13	perching bird
3/12/2006	1:07	846	W	45	13	coyote
3/14/2006	1:47	846	W	45	13	bovine
3/18/2006	1:03	846	W	45	13	bovine
3/23/2006	18:00	846	W	45	13	perching bird
3/29/2006	20:07	846	W	45	13	panther
4/2/2006	22:24	846	W	45	13	panther

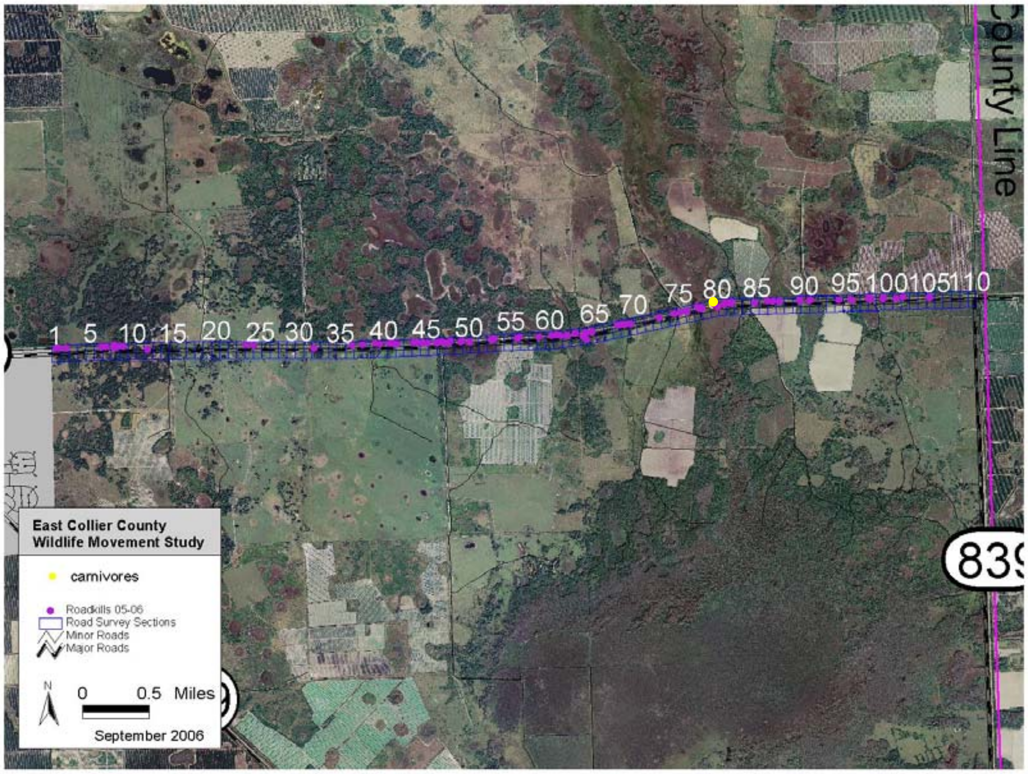
Appendix C. Photographic data (continued).

Date	Time	Road	Section	Segment	Camera ID	Species
6/24/2006	22:20	846	W	45	13	rat
6/25/2006	21:54	846	W	45	13	rat
4/20/2006	11:38	846	W	45	13b	turkey
2/1/2006	0:21	846	W	47	14	bovine
2/2/2006	0:19	846	W	47	14	bovine
2/5/2006	22:40	846	W	47	14	bovine
2/7/2006	22:34	846	W	47	14	bovine
2/7/2006	23:54	846	W	47	14	bovine
2/8/2006	0:03	846	W	47	14	bovine
5/5/2006	17:52	846	W	47	14	bovine
5/6/2006	21:06	846	W	47	14	bovine
5/8/2006	21:22	846	W	47	14	bovine
5/9/2006	18:45	846	W	47	14	bovine
5/9/2006	23:28	846	W	47	14	bovine
5/11/2006	0:19	846	W	47	14	bovine
5/12/2006	19:24	846	W	47	14	bovine
5/10/2006	0:06	846	W	52	15	bovine
5/11/2006	23:43	846	W	52	15	bovine
5/12/2006	1:08	846	W	52	15	bovine

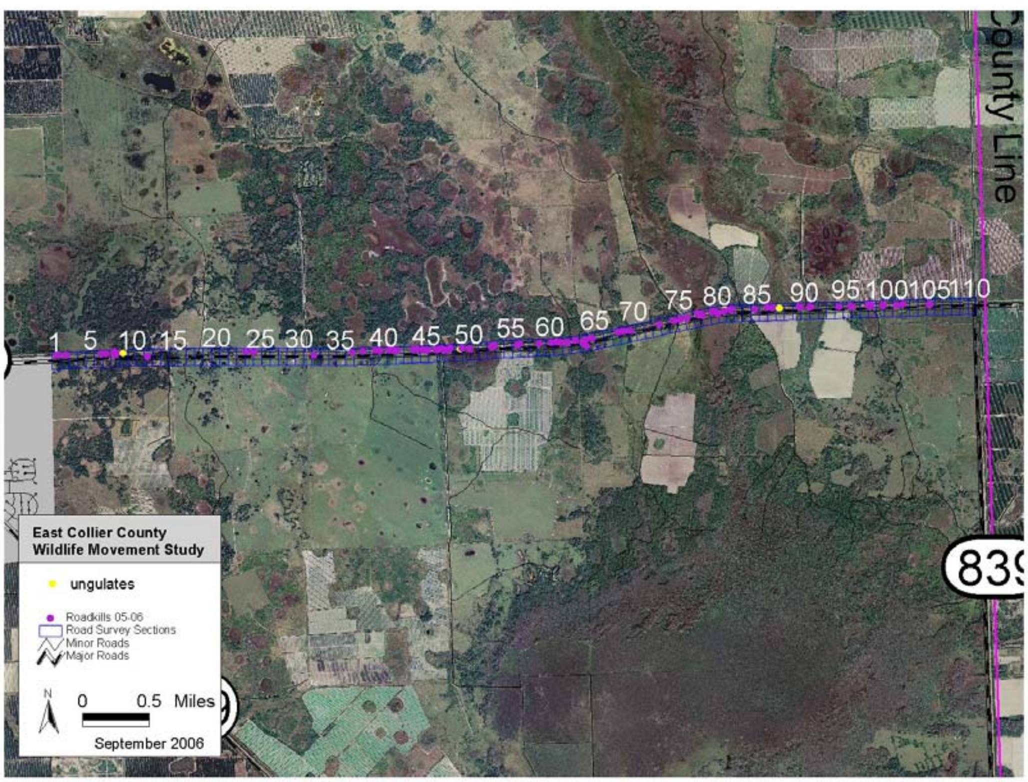

13
2006/04/02 22:24:40

Appendix D

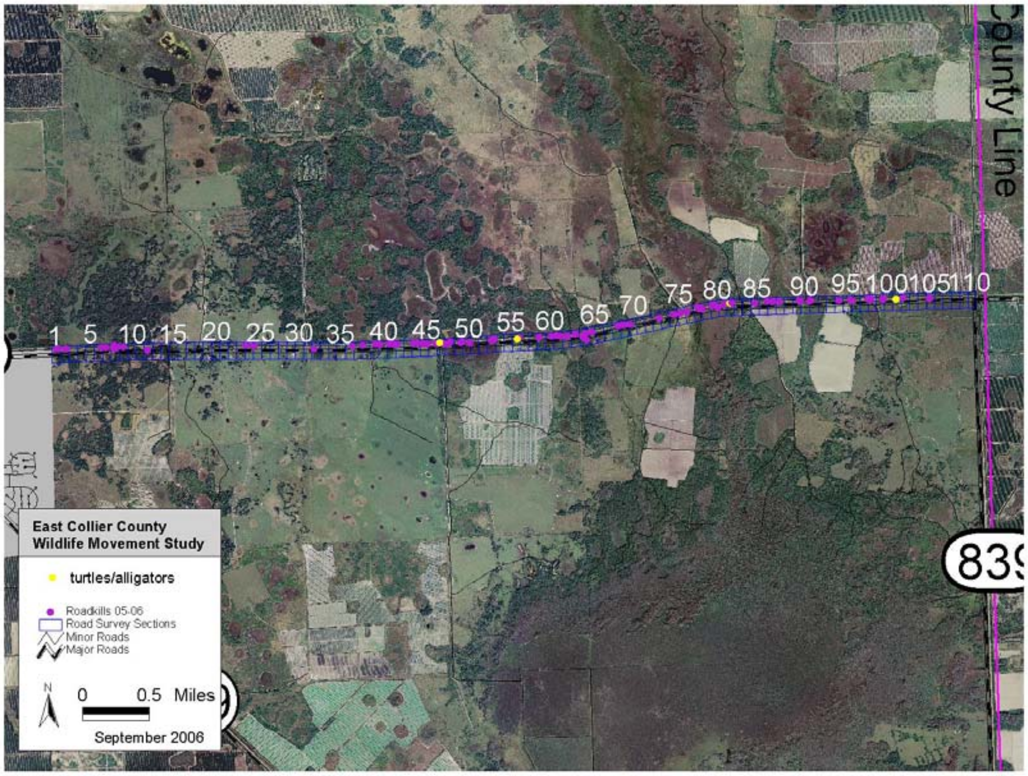
Maps of roadkill and track data for CR 846 east road section



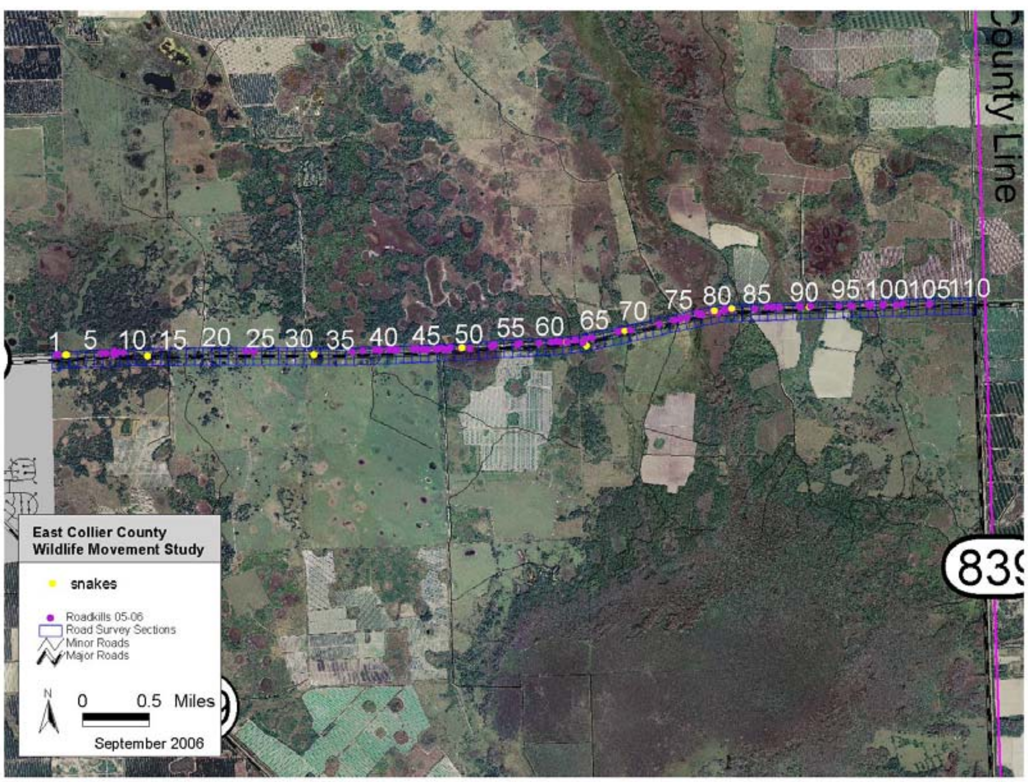
Map D1. Carnivore roadkill locations (road segment partitions equal 100 m).



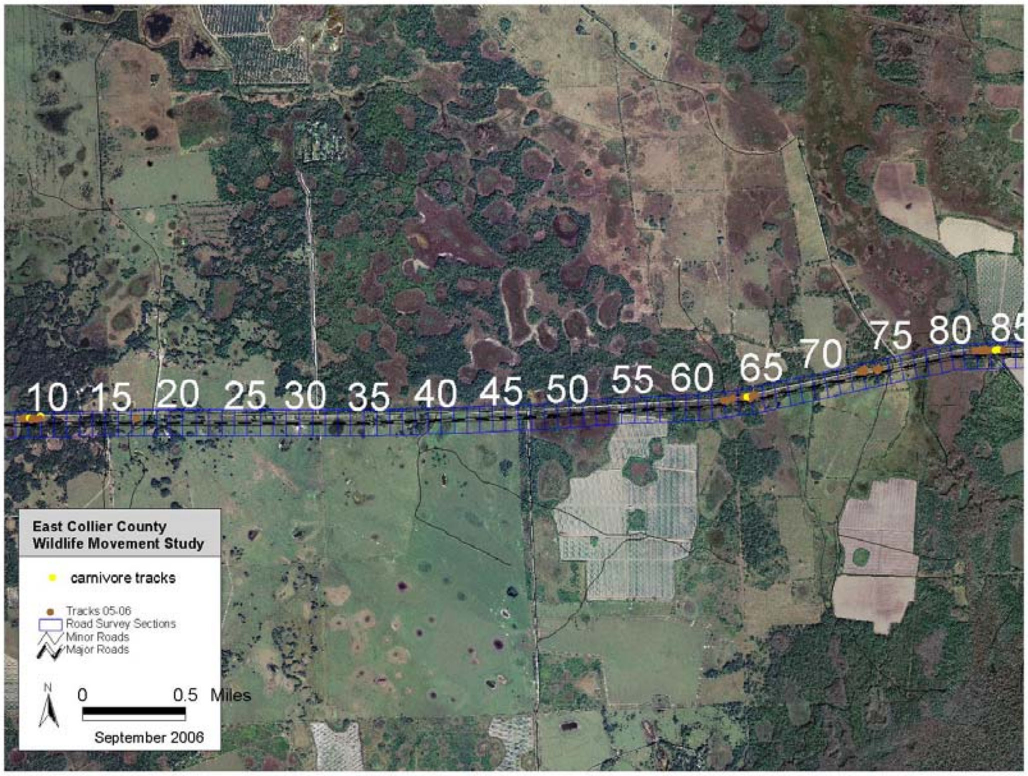
Map D2. Ungulate roadkill locations (road segment partitions equal 100 m).



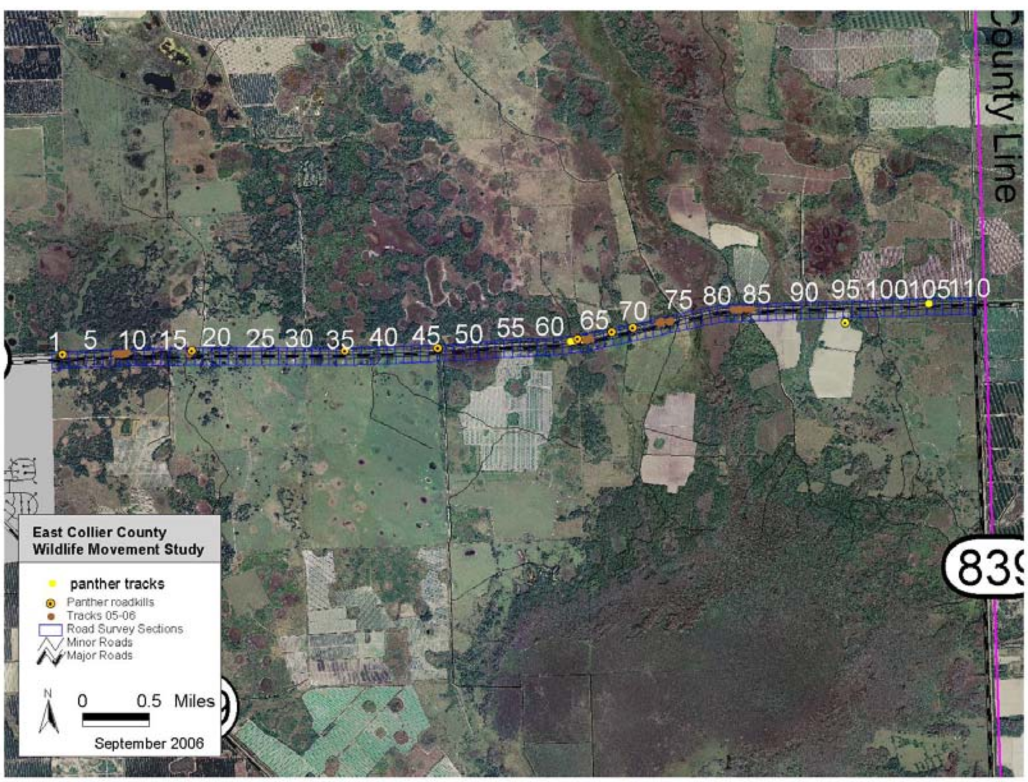
Map D3. Turtle/alligator roadkill locations (road segment partitions equal 100 m).



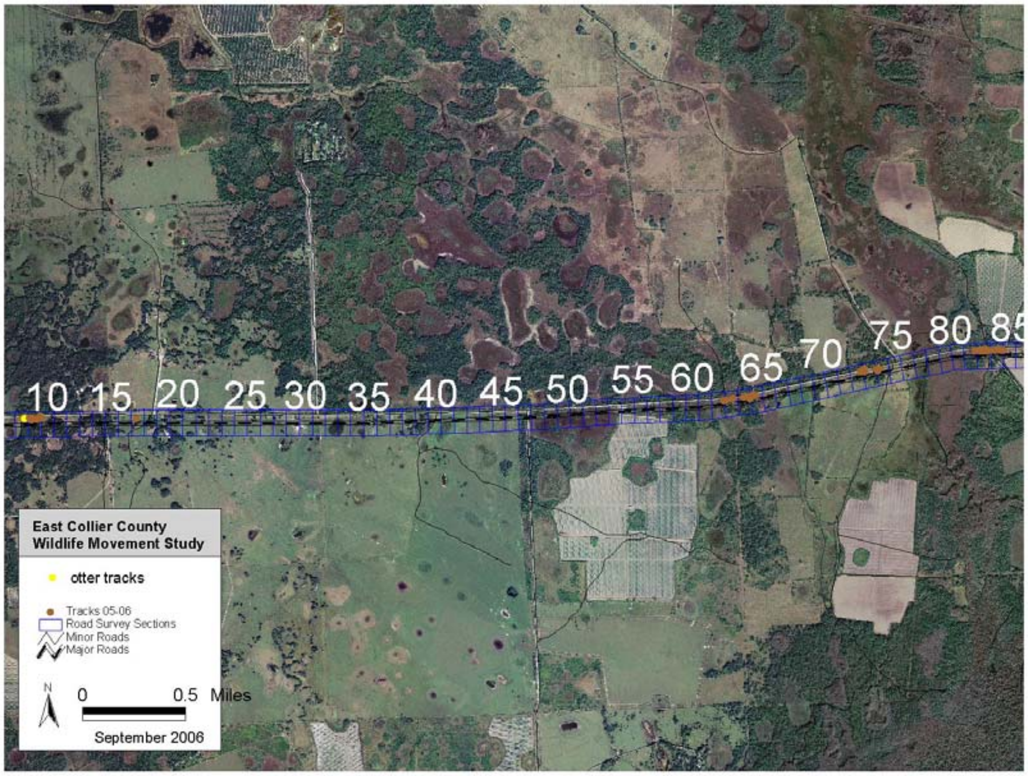
Map D4. Snake roadkill locations (road segment partitions equal 100 m).



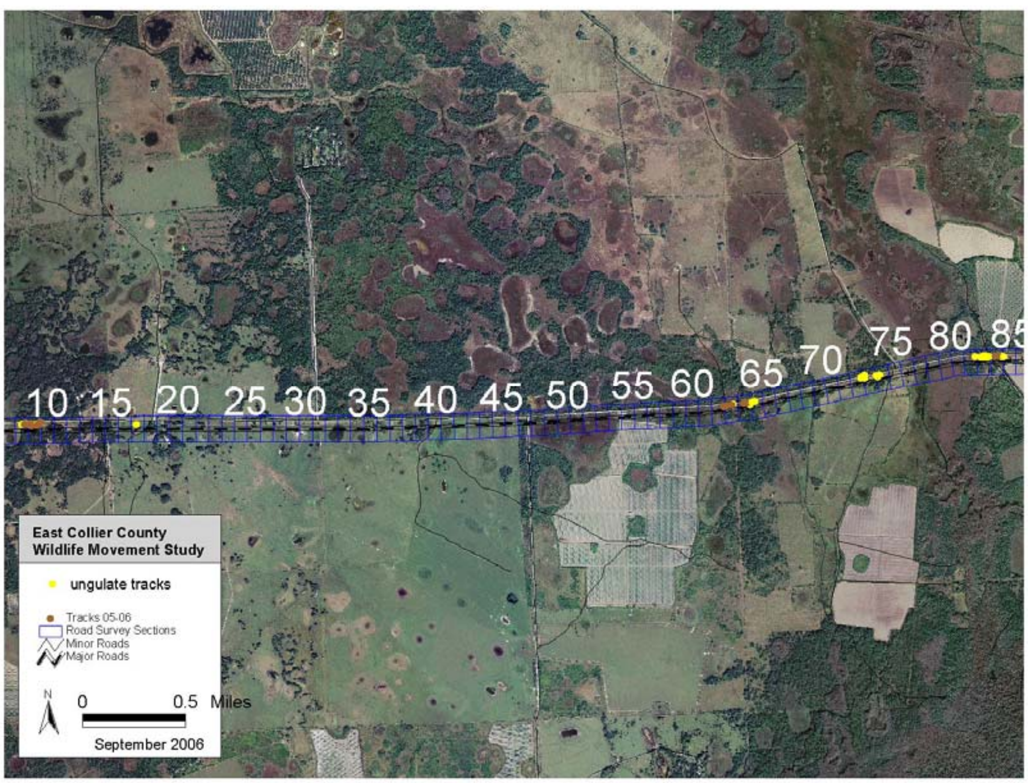
Map D5. Carnivore track locations (road segment partitions equal 100 m).



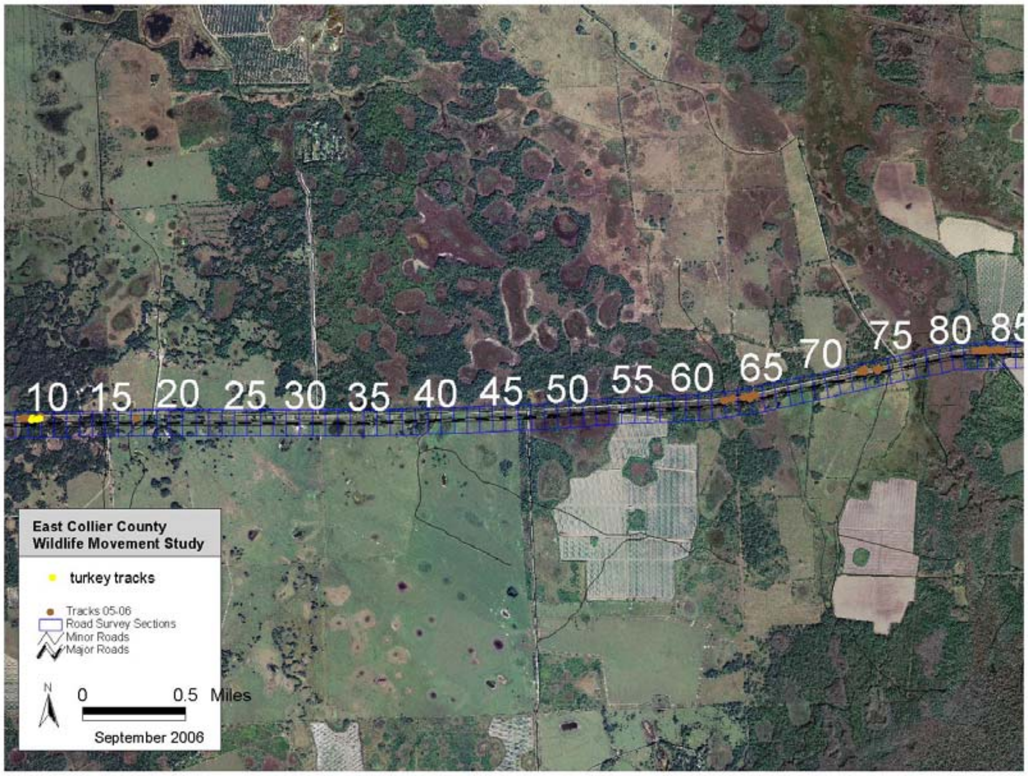
Map D6. Panther track and former roadkill locations (road segment partitions equal 100 m).



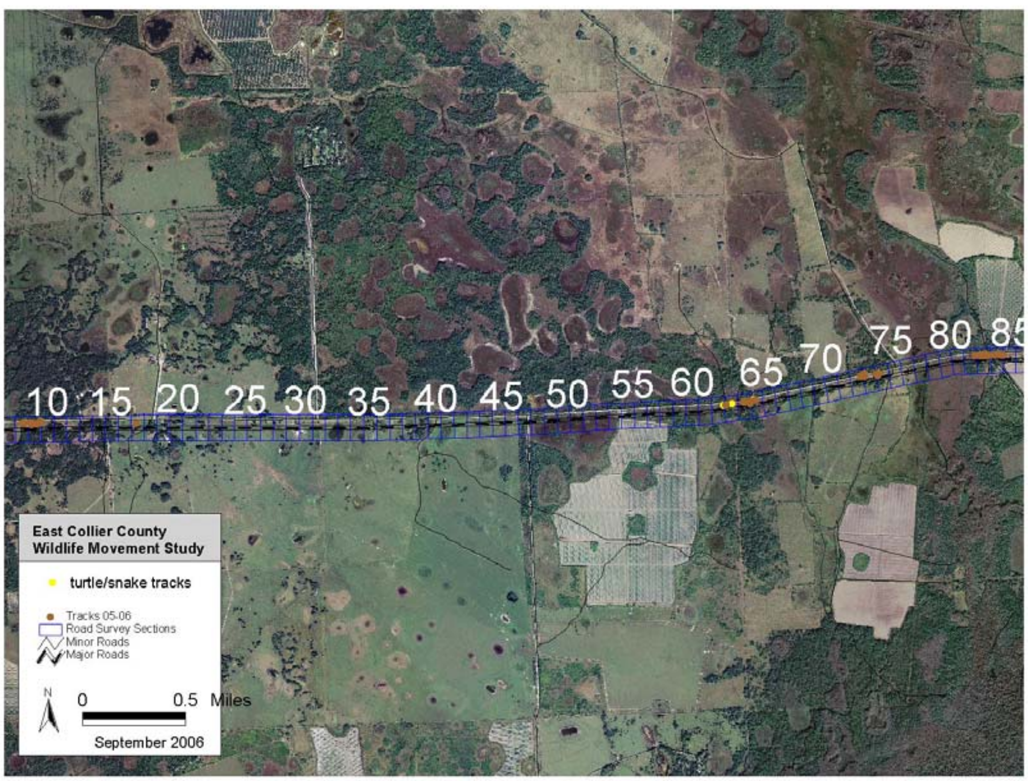
Map D7. River otter track locations (road segment partitions equal 100 m).



Map D8. Ungulate track locations (road segment partitions equal 100 m).



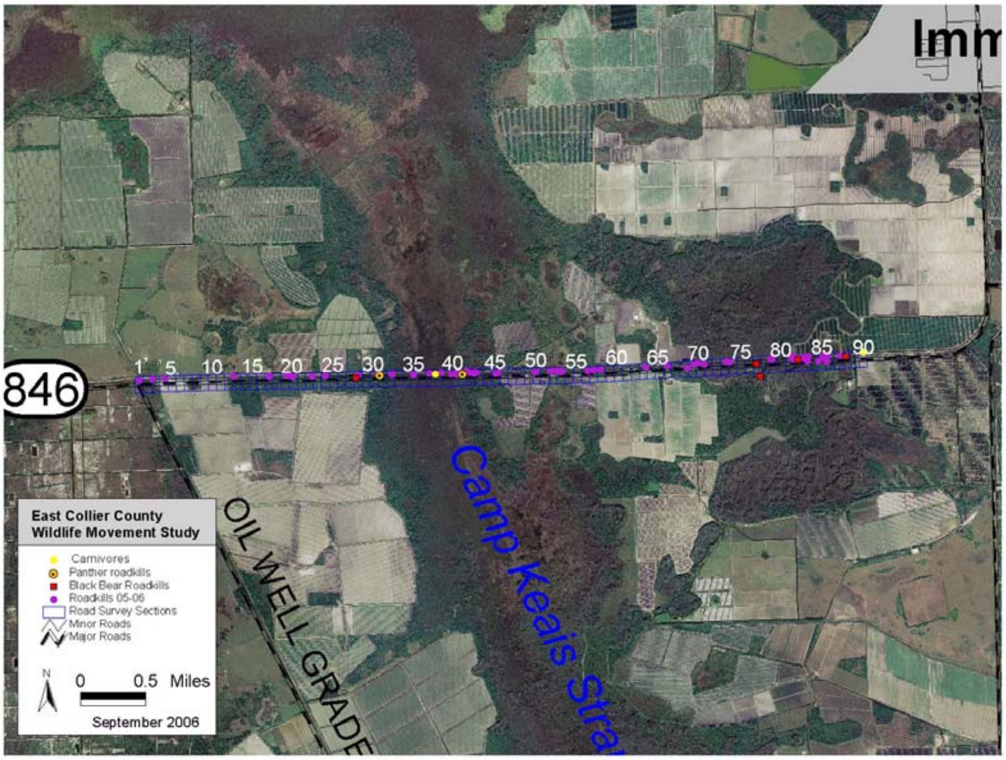
Map D9. Wild turkey track locations (road segment partitions equal 100 m).



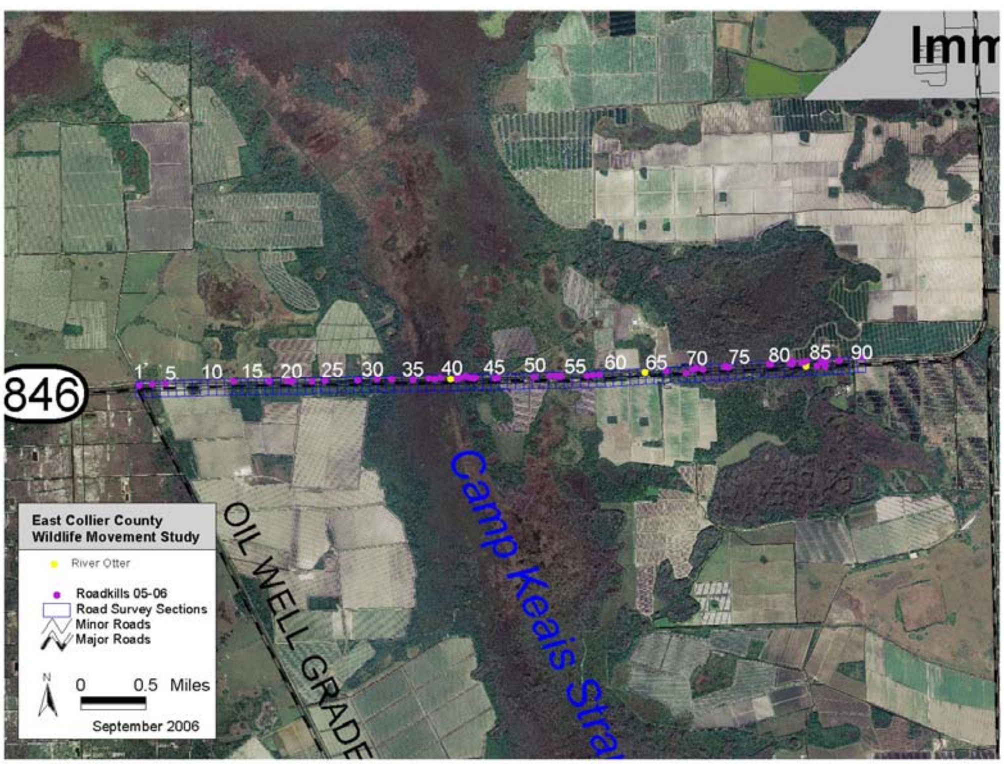
Map D10. Turtle/snake track locations (road segment partitions equal 100 m).

Appendix E

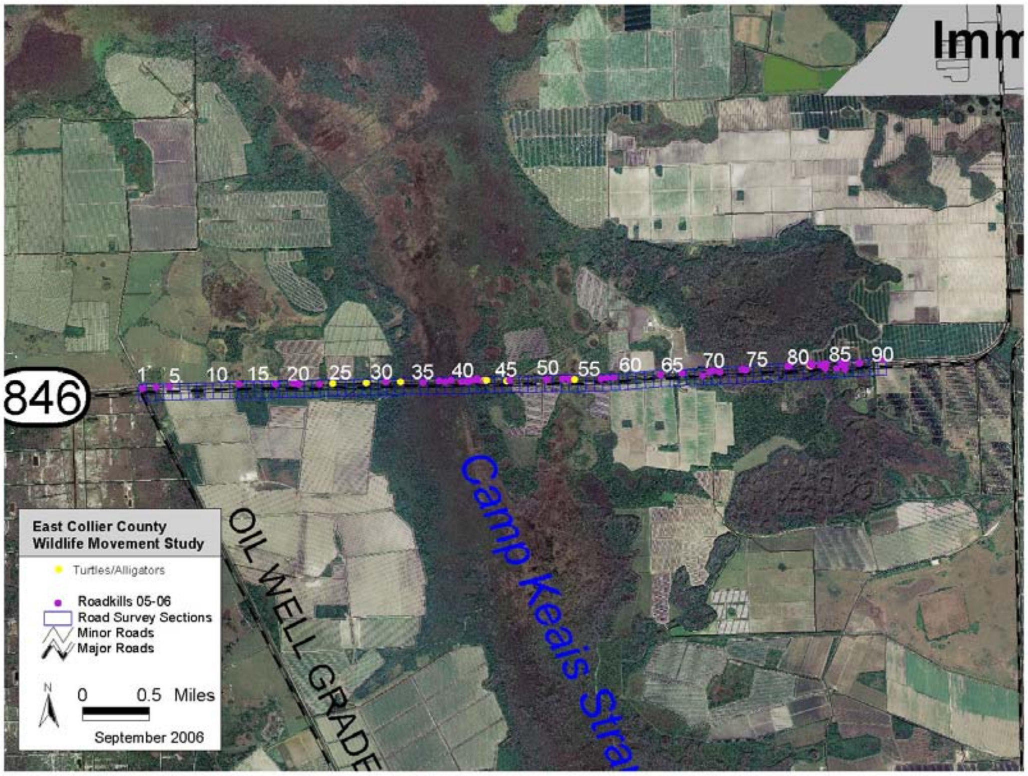
Maps of roadkill and track data for CR 846 west road section



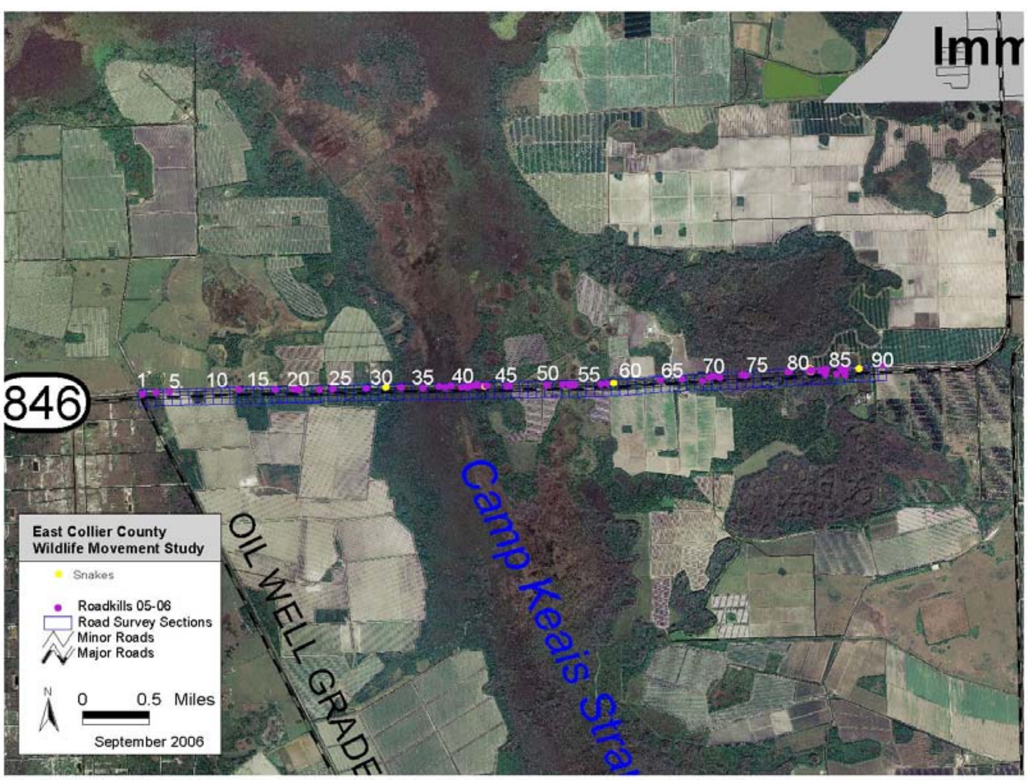
Map E1. Carnivore roadkill locations including former Florida panther and black bear records (road segment partitions equal 100 m).



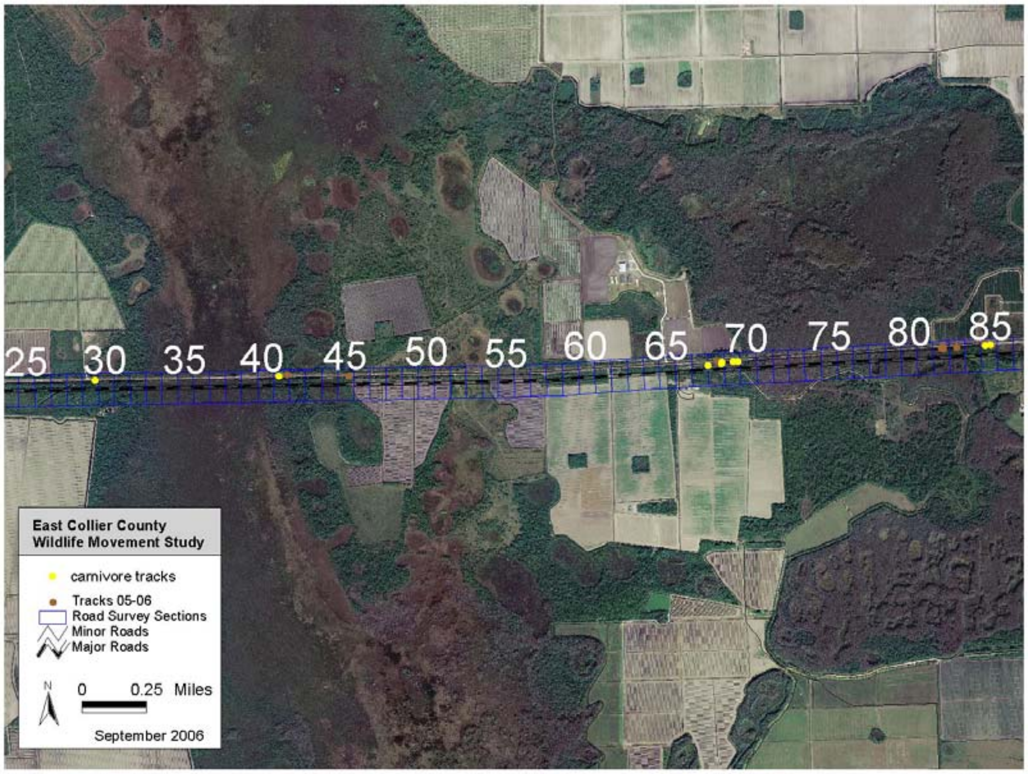
Map E2. River otter roadkill locations (road segment partitions equal 100 m).



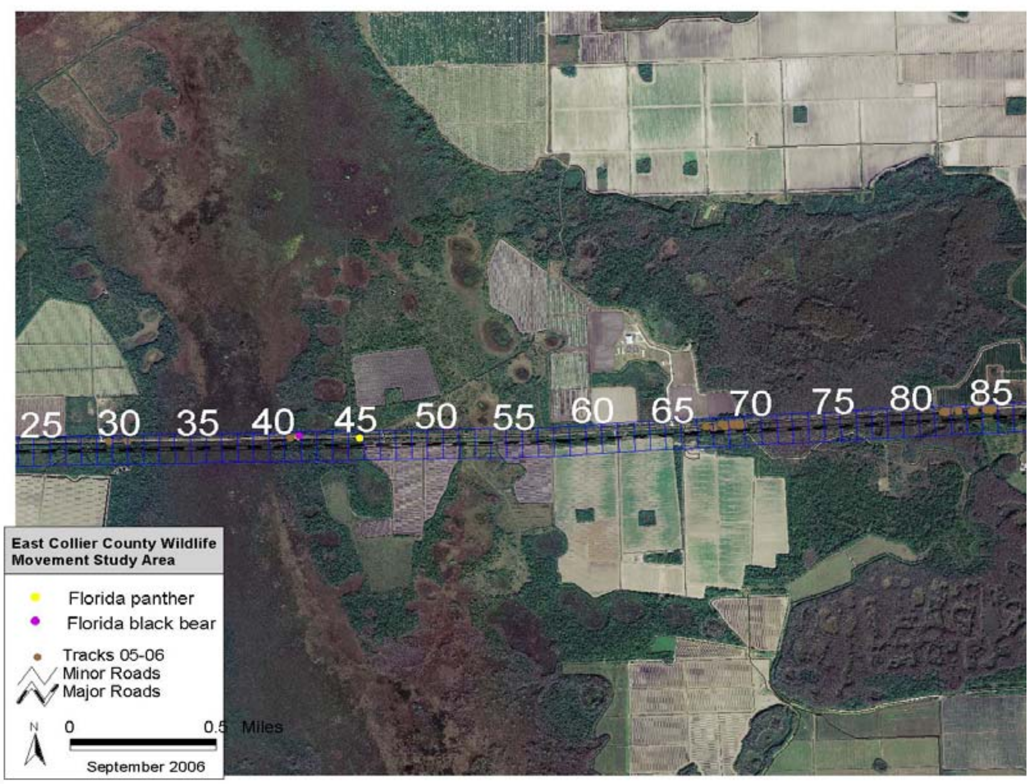
Map E3. Turtle/alligator roadkill locations (road segment partitions equal 100 m).



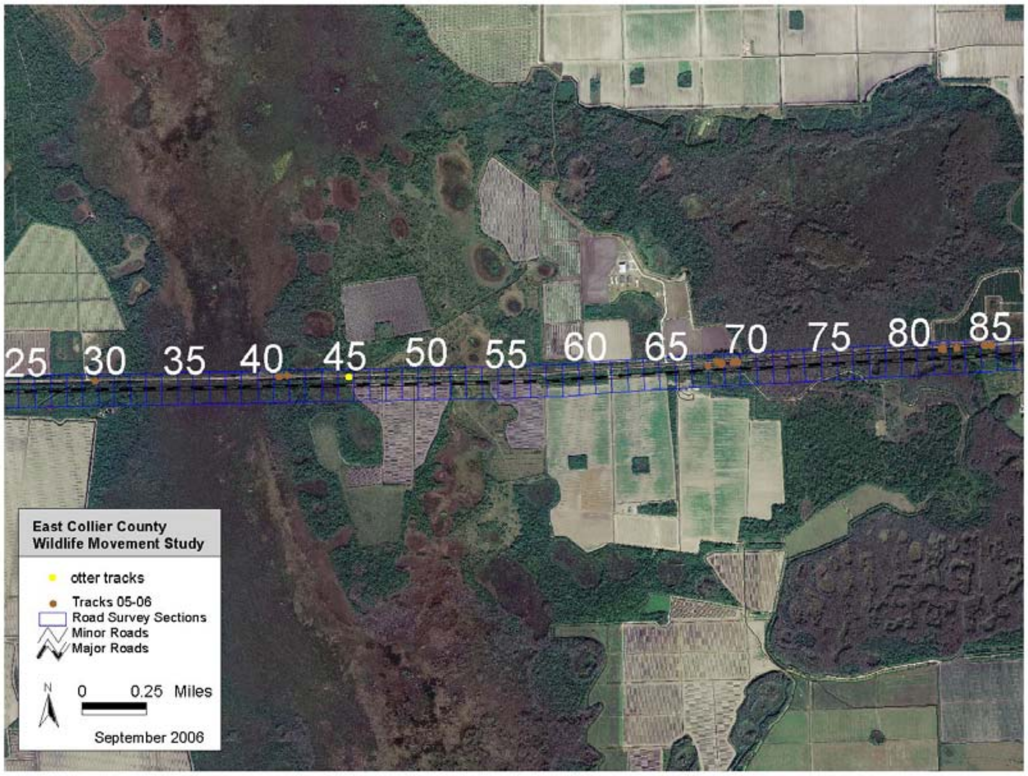
Map E4. Snake roadkill locations (road segment partitions equal 100 m).



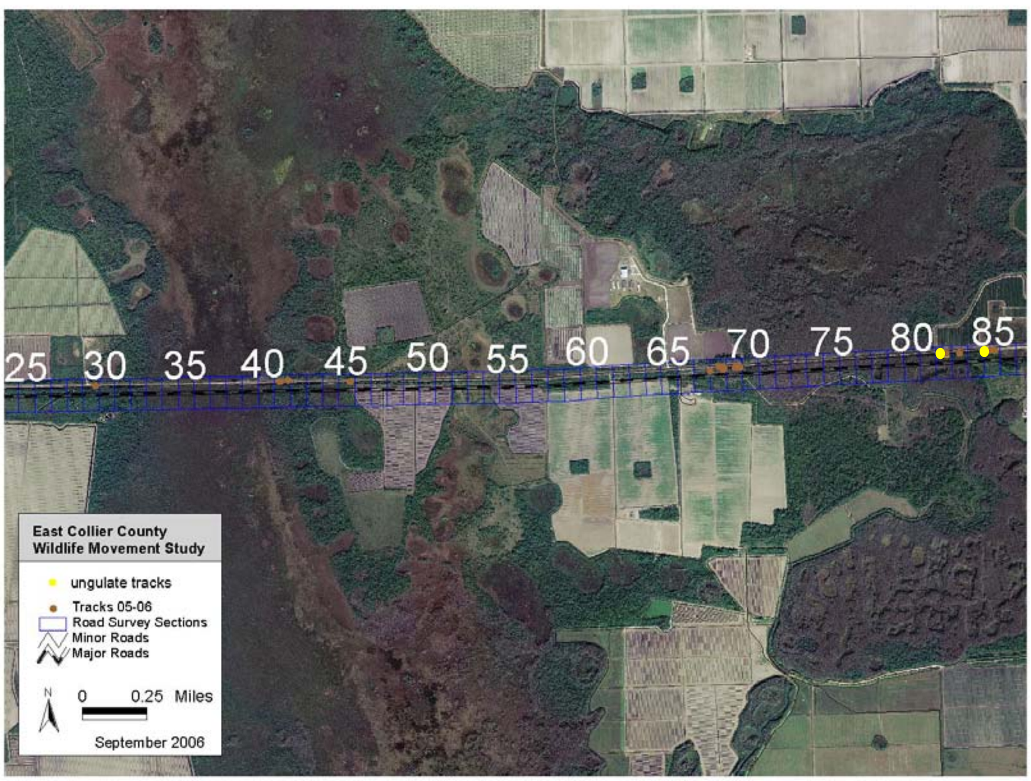
Map E5. Carnivore track locations (road segment partitions equal 100 m).



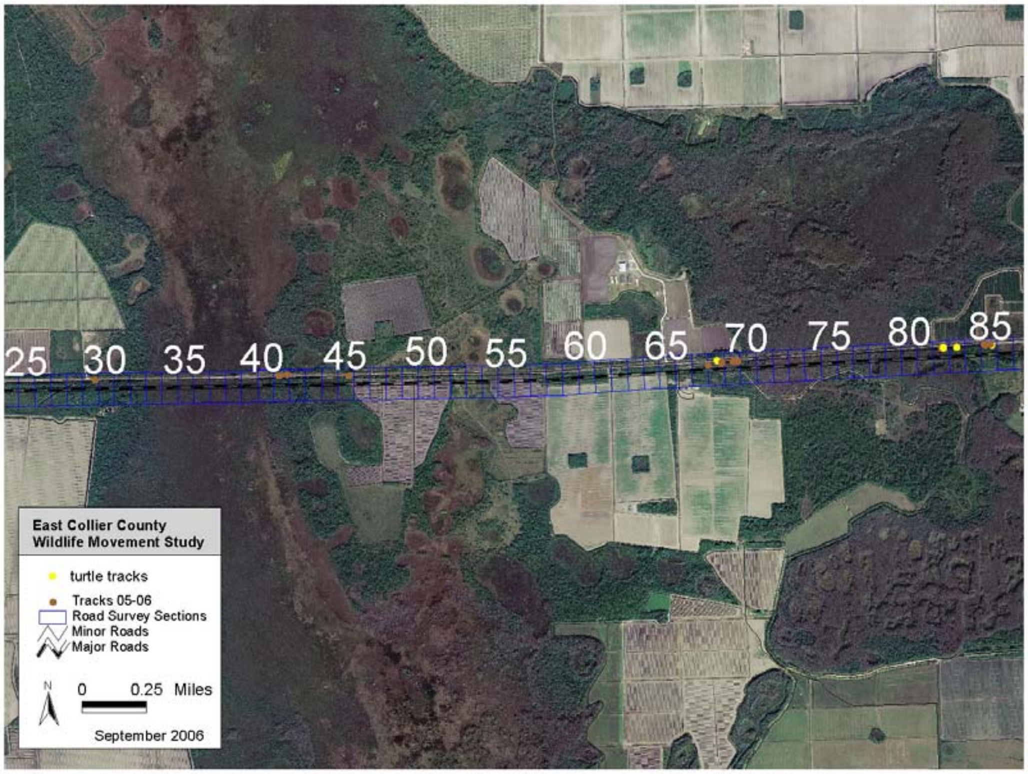
Map E6. Florida panther/black bear track locations (road segment partitions equal 100 m).



Map E7. River otter track locations (road segment partitions equal 100 m).



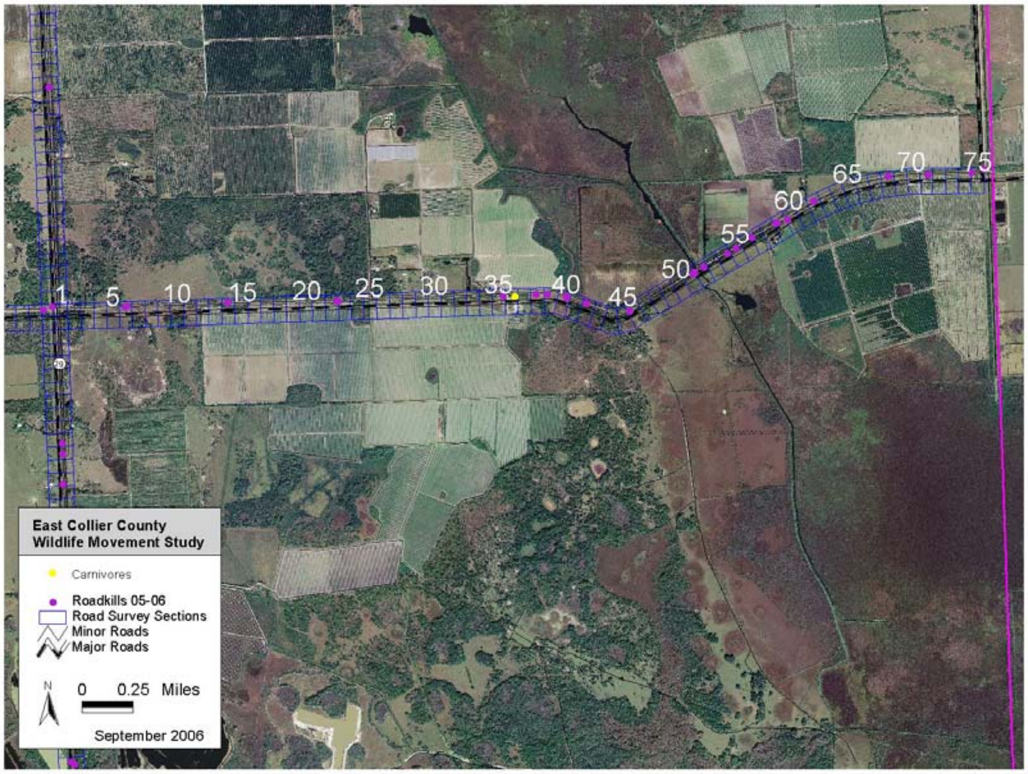
Map E8. Ungulate track locations (road segment partitions equal 100 m).



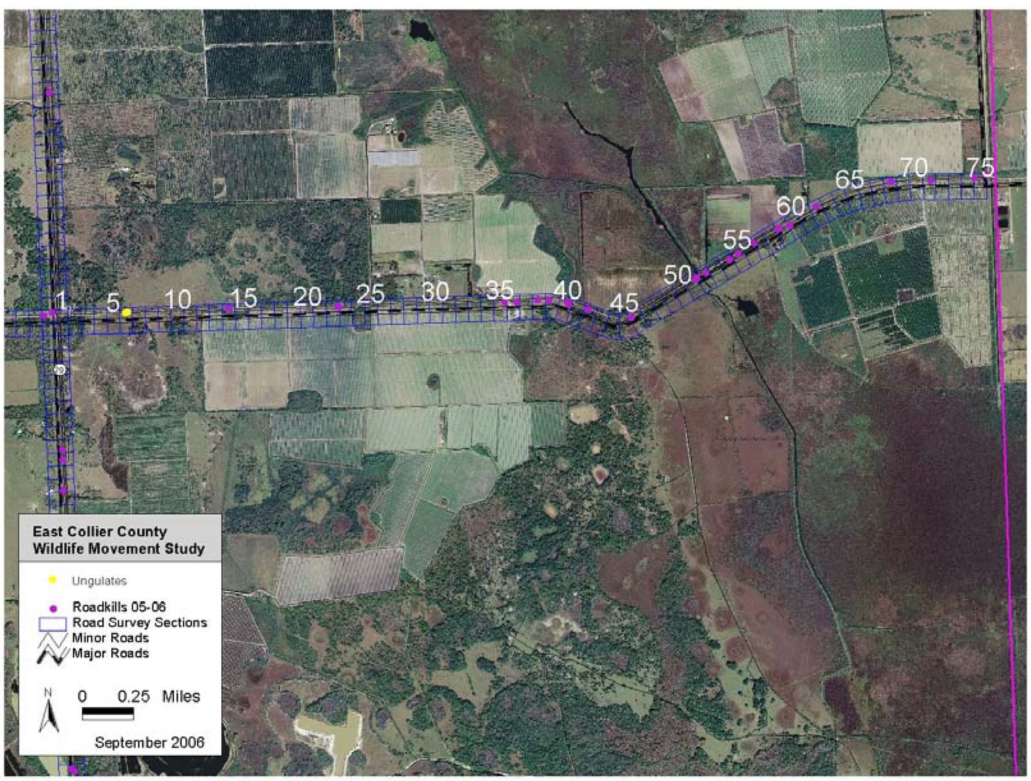
Map E9. Turtle track locations (road segment partitions equal 100 m).

Appendix F

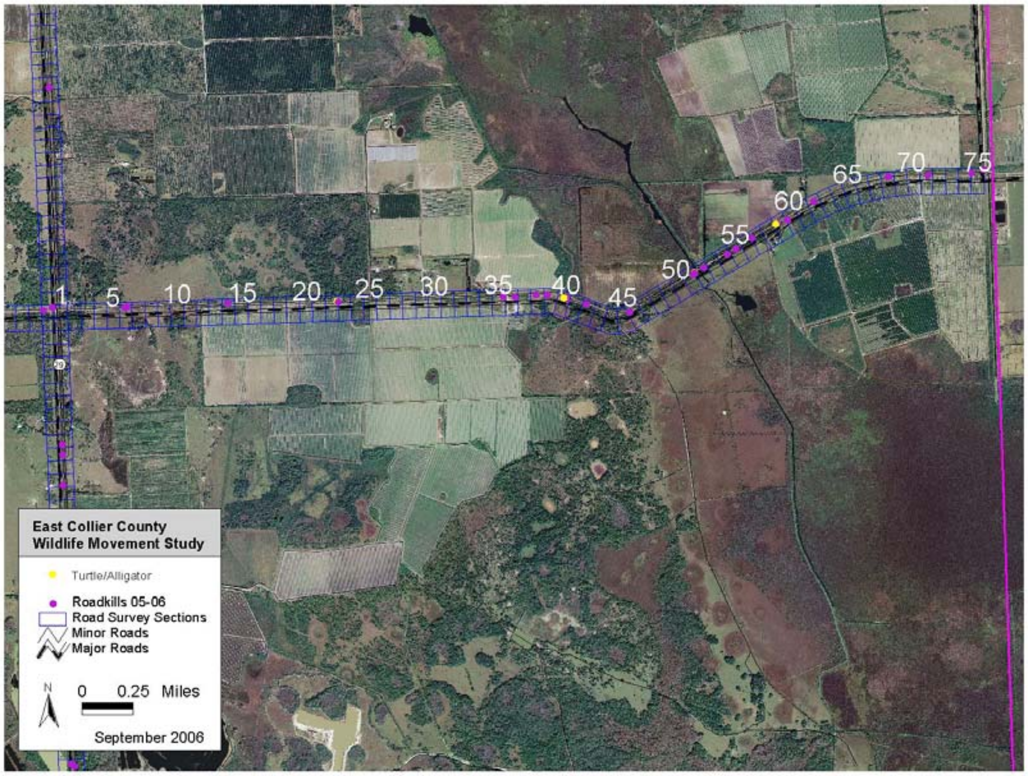
Maps of roadkill data for CR 858 east road section



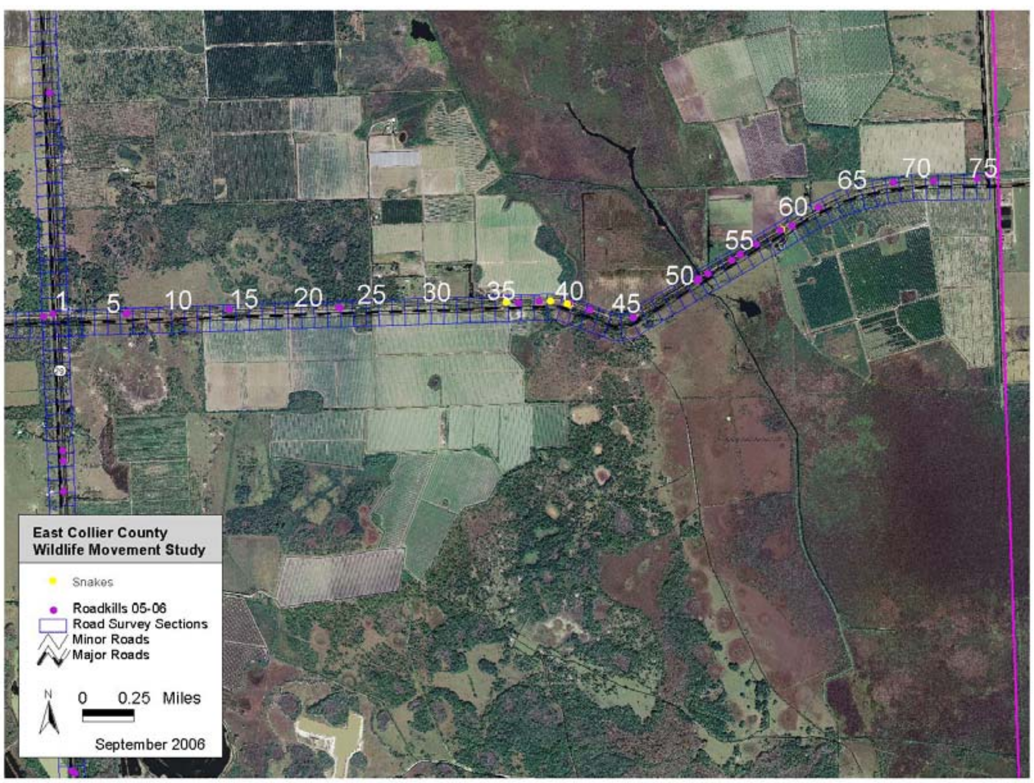
Map F1. Carnivore roadkill locations (road segment partitions equal 100 m).



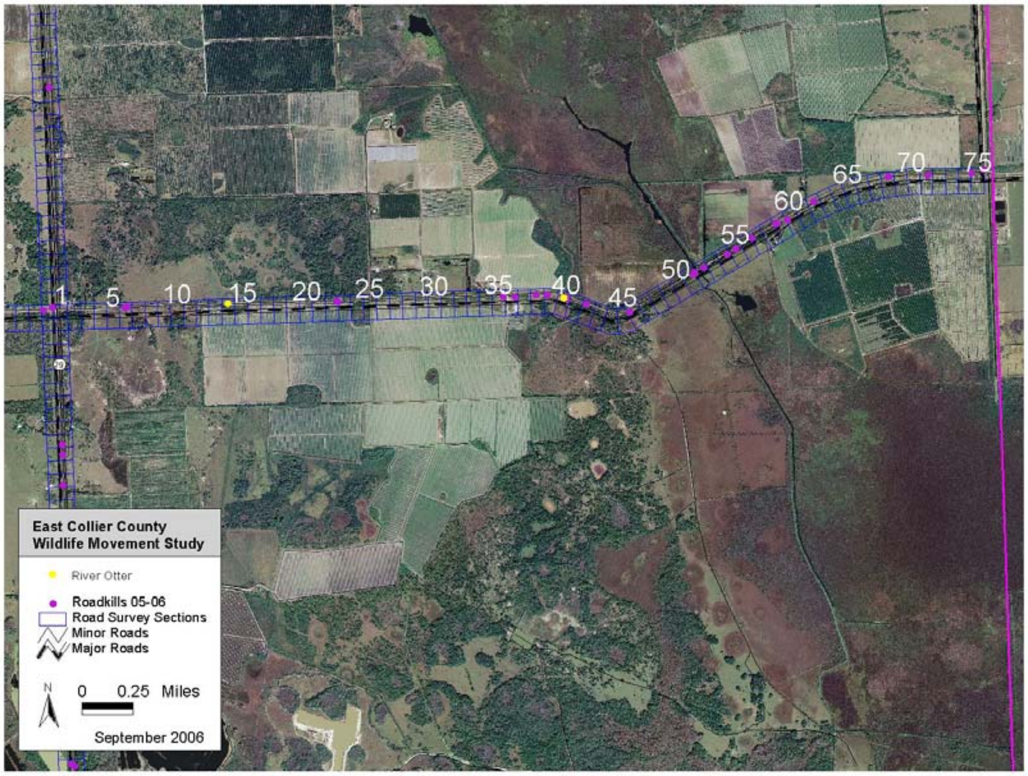
Map F2. Ungulate roadkill locations (road segment partitions equal 100 m).



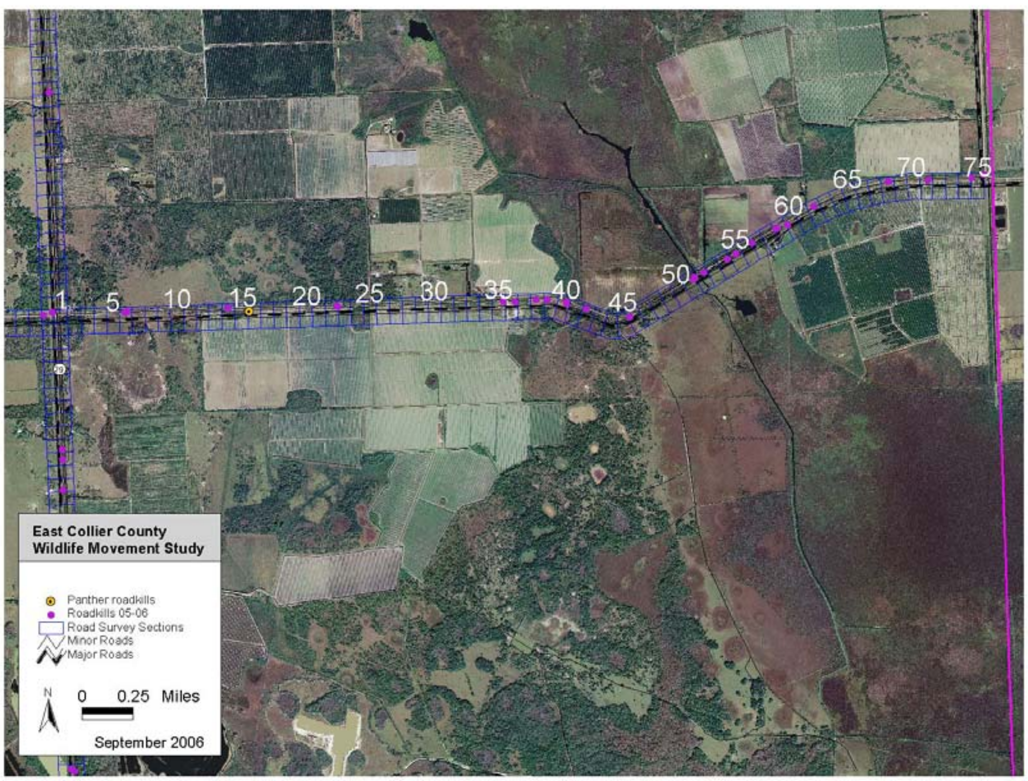
Map F3. Turtle/alligator roadkill locations (road segment partitions equal 100 m).



Map F4. Snake roadkill locations (road segment partitions equal 100 m).



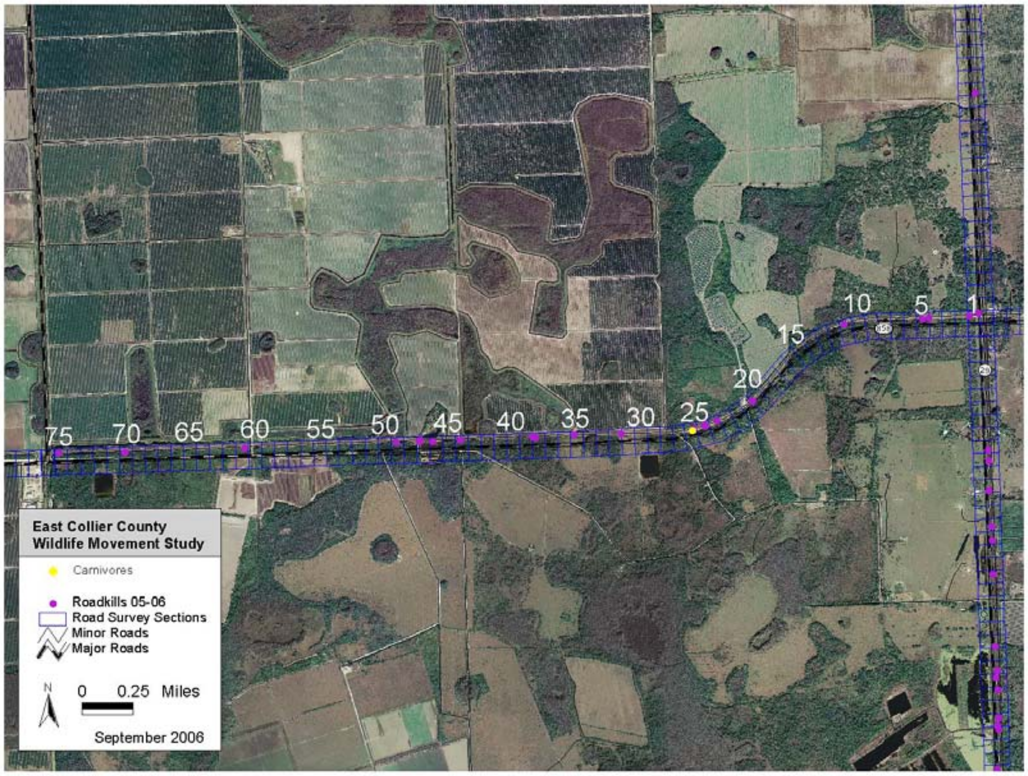
Map F5. River otter roadkill locations (road segment partitions equal 100 m).



Map F6. Former Florida Panther roadkill locations (road segment partitions equal 100 m).

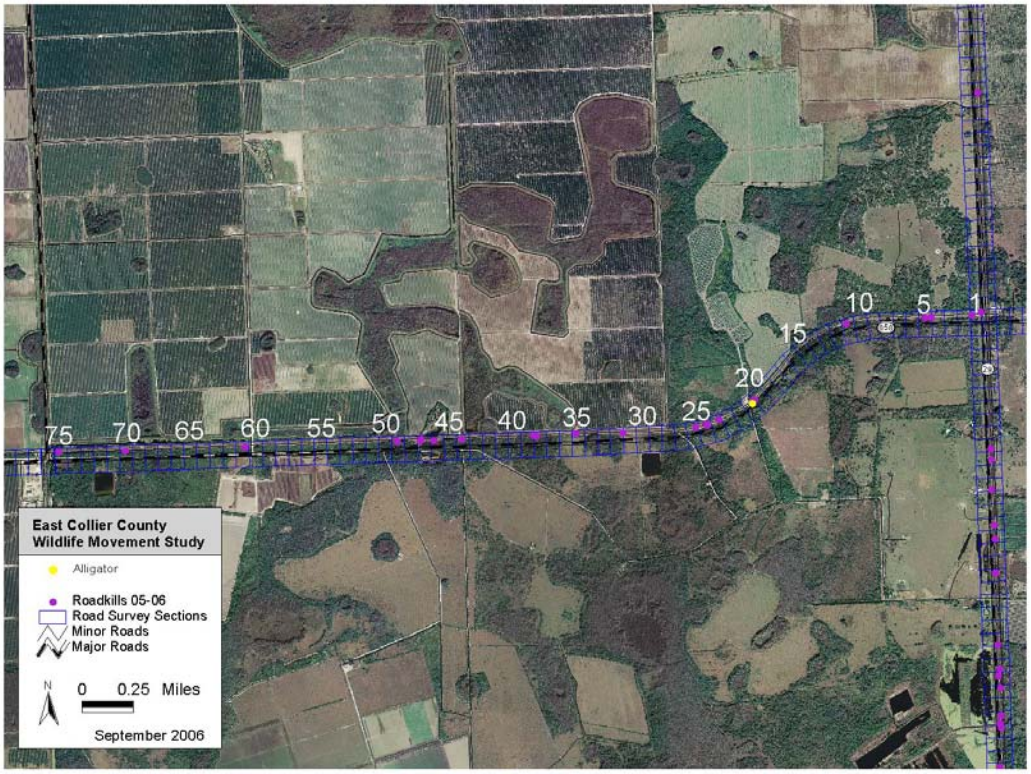
Appendix G

Maps of roadkill and track data for CR 858 central road section



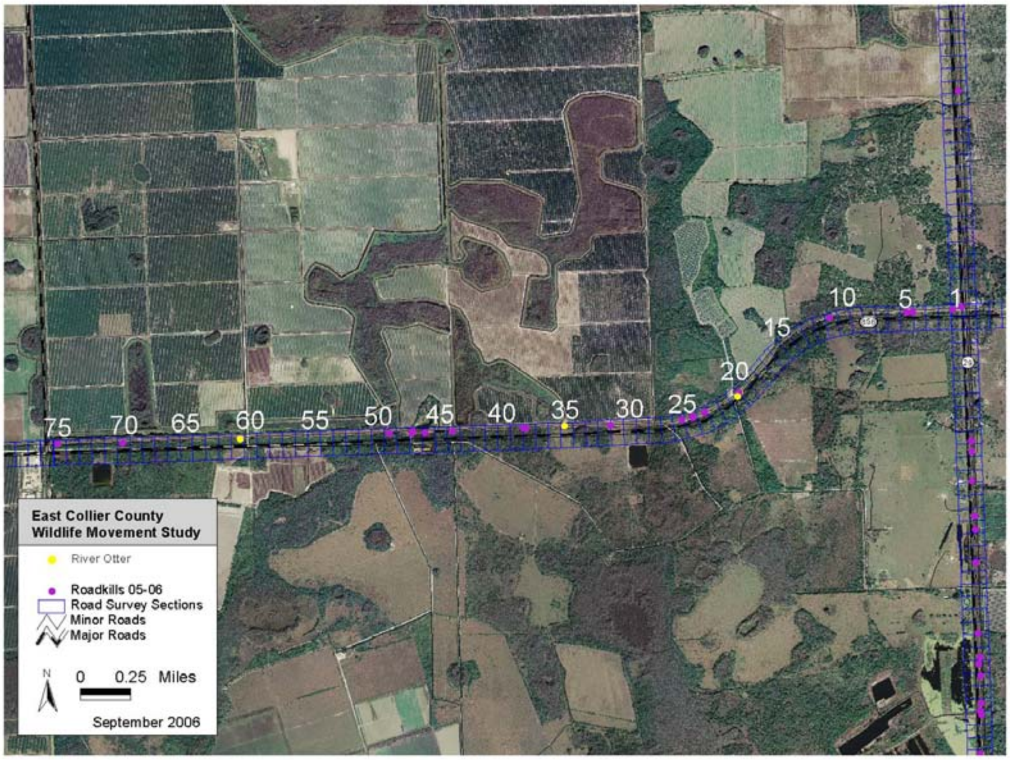
Map G1. Carnivore roadkill locations (road segment partitions equal 100 m).

Map G2. Ungulate roadkill locations (road segment partitions equal 100 m).



Map G3. Alligator roadkill locations (road segment partitions equal 100 m).

Map G4. Snake roadkill locations (road segment partitions equal 100 m).



Map G5. River otter roadkill locations (road segment partitions equal 100 m).

Map G6. Florida panther track and former roadkill locations (road segment partitions equal 100 m).

Appendix H

Maps of roadkill data for CR 858 west road section

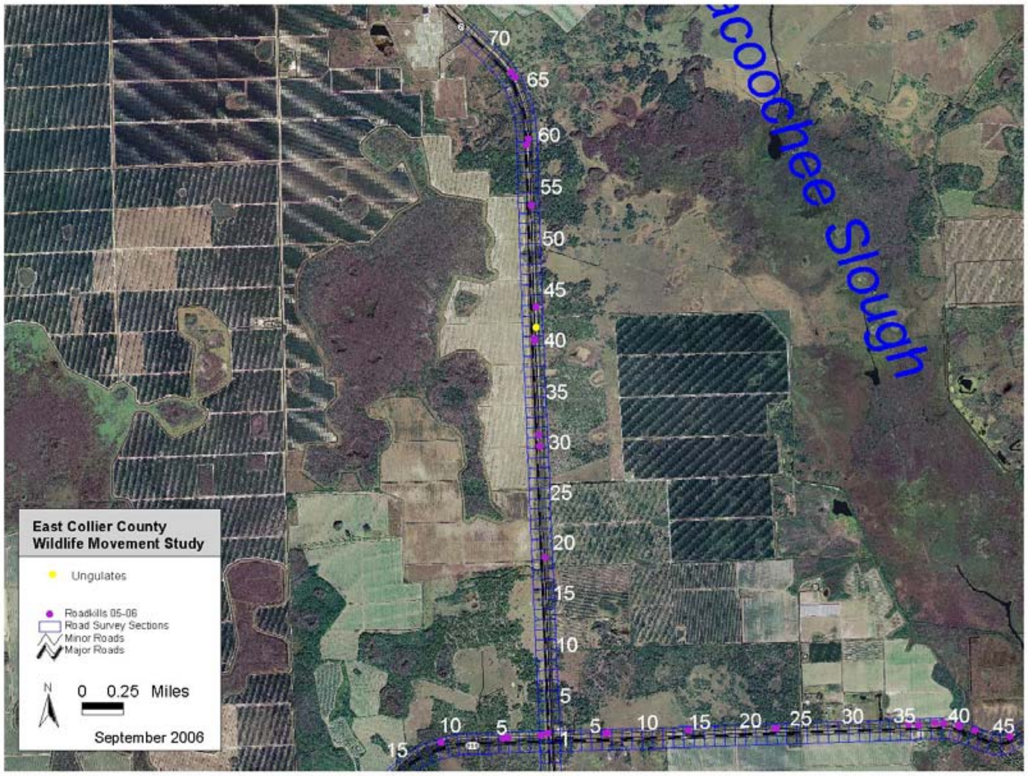
Map H1. Turtle/alligator roadkill locations (road segment partitions equal 100 m).

Map H2. Snake roadkill locations (road segment partitions equal 100 m).

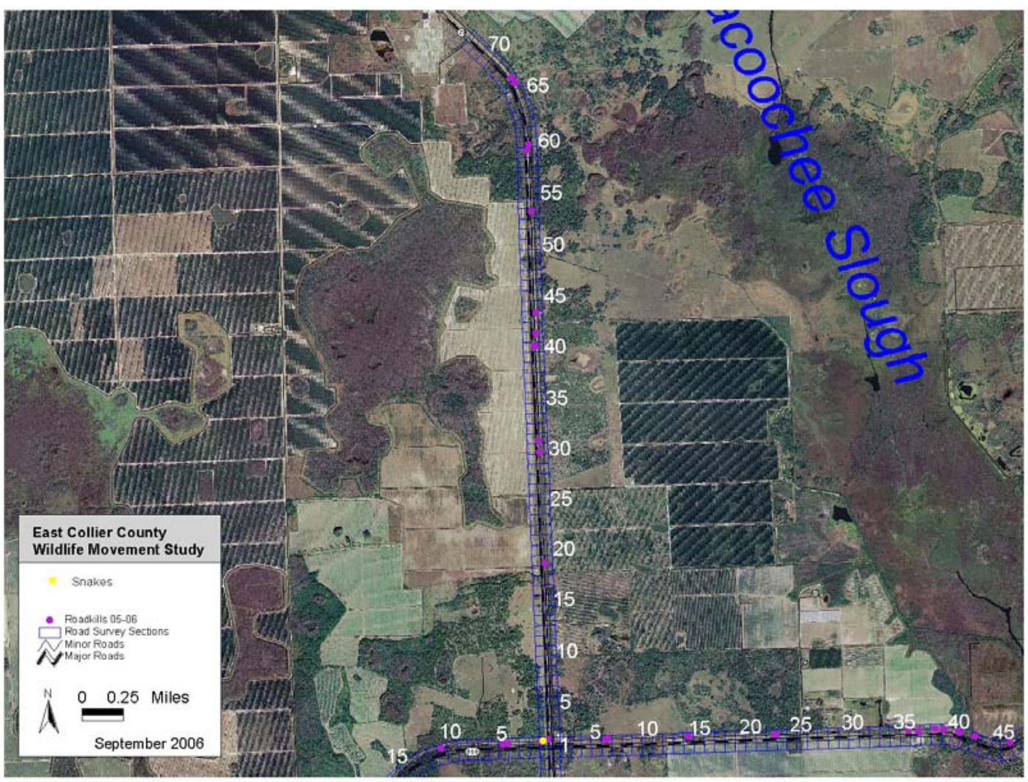
Map H3. River otter roadkill locations (road segment partitions equal 100 m).

Appendix I

Maps of roadkill data for SR 29 north road section



Map I1. Ungulate roadkill locations (road segment partitions equal 100 m).

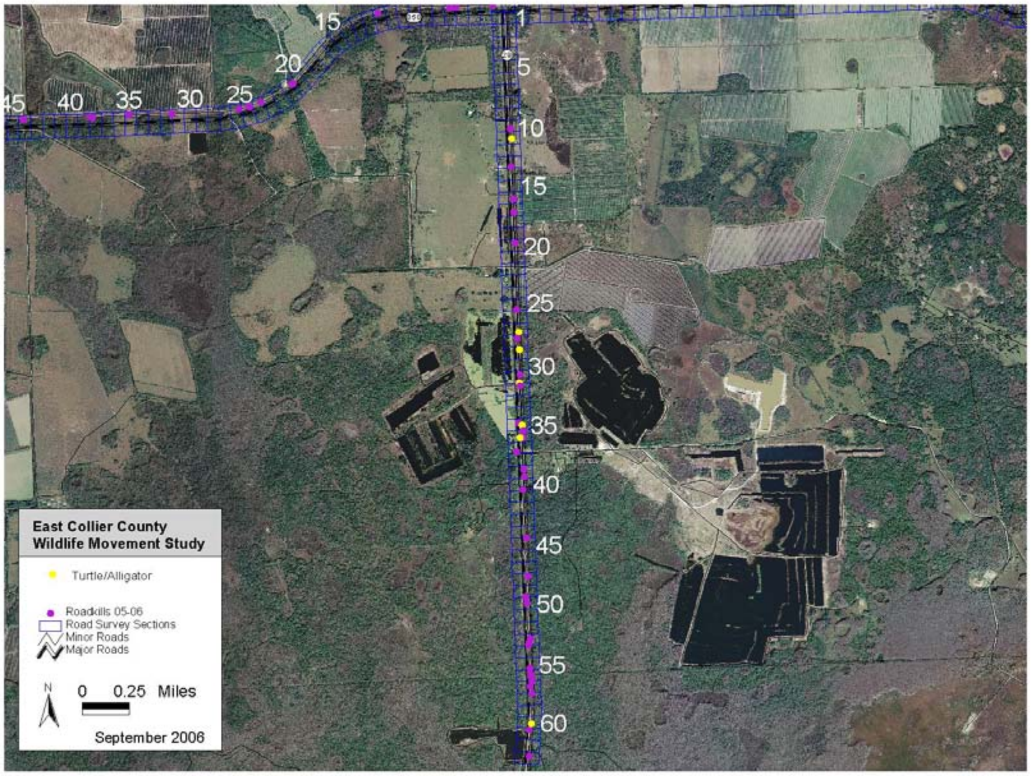


Map I2. Snake roadkill locations (road segment partitions equal 100 m).

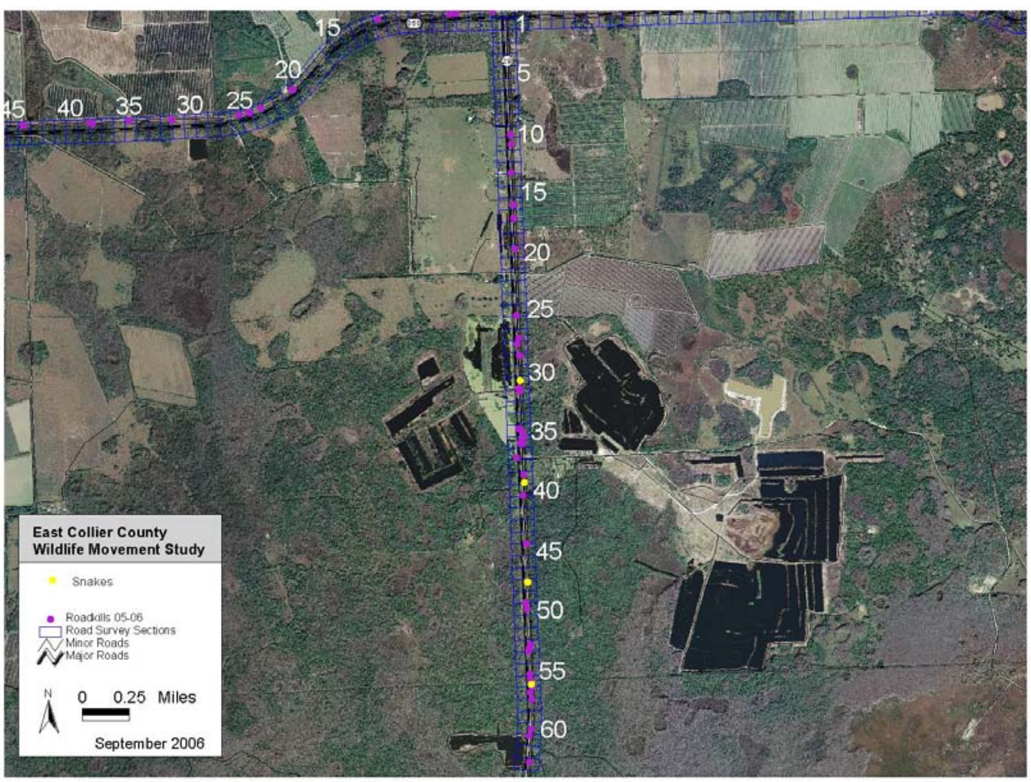
Map I3. Former Florida panther and black bear roadkill locations (road segment partitions equal 100 m).

Appendix J

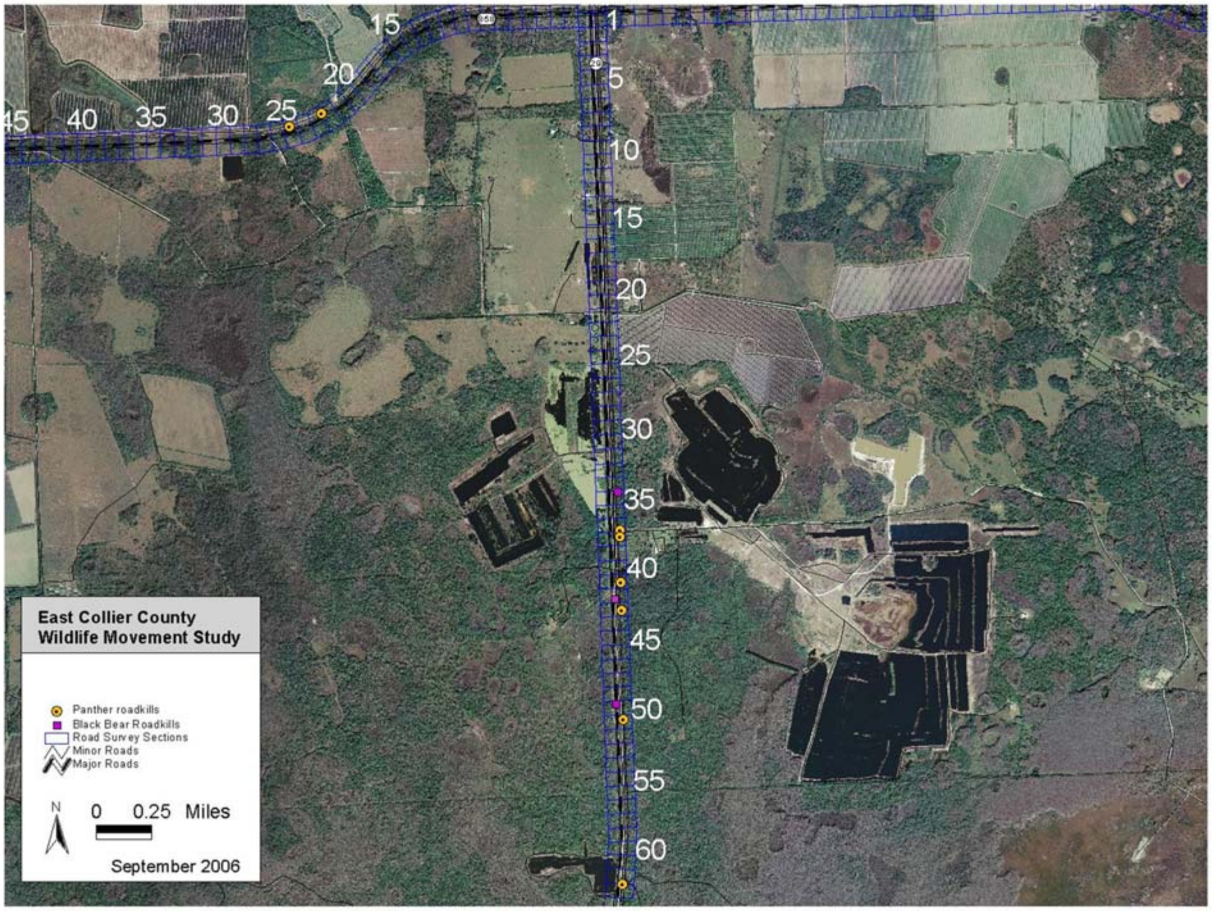
Maps of roadkill data for SR 29 south road section



Map J1. Turtle/alligator roadkill locations (road segment partitions equal 100 m).



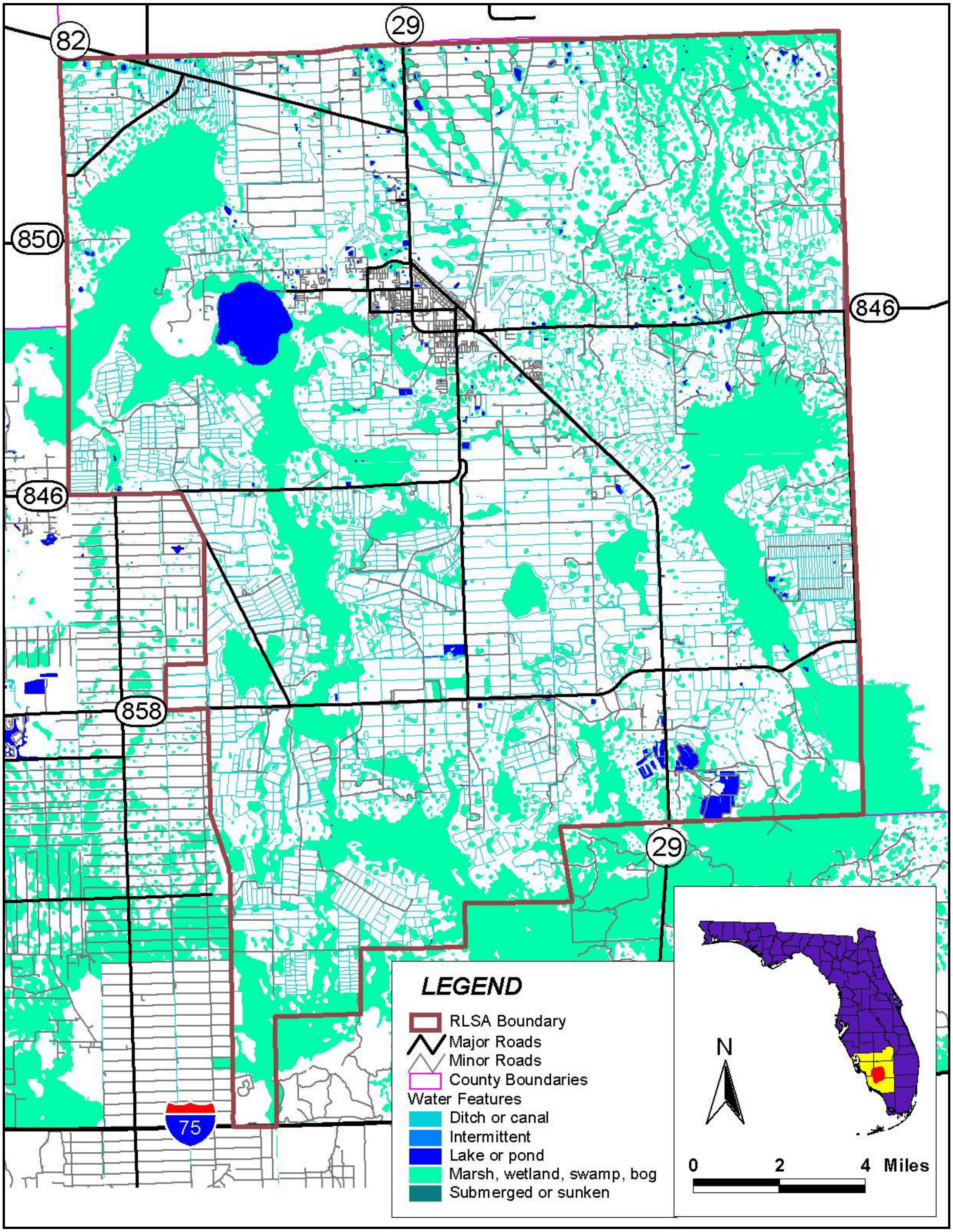
Map J2. Snake roadkill locations (road segment partitions equal 100 m).



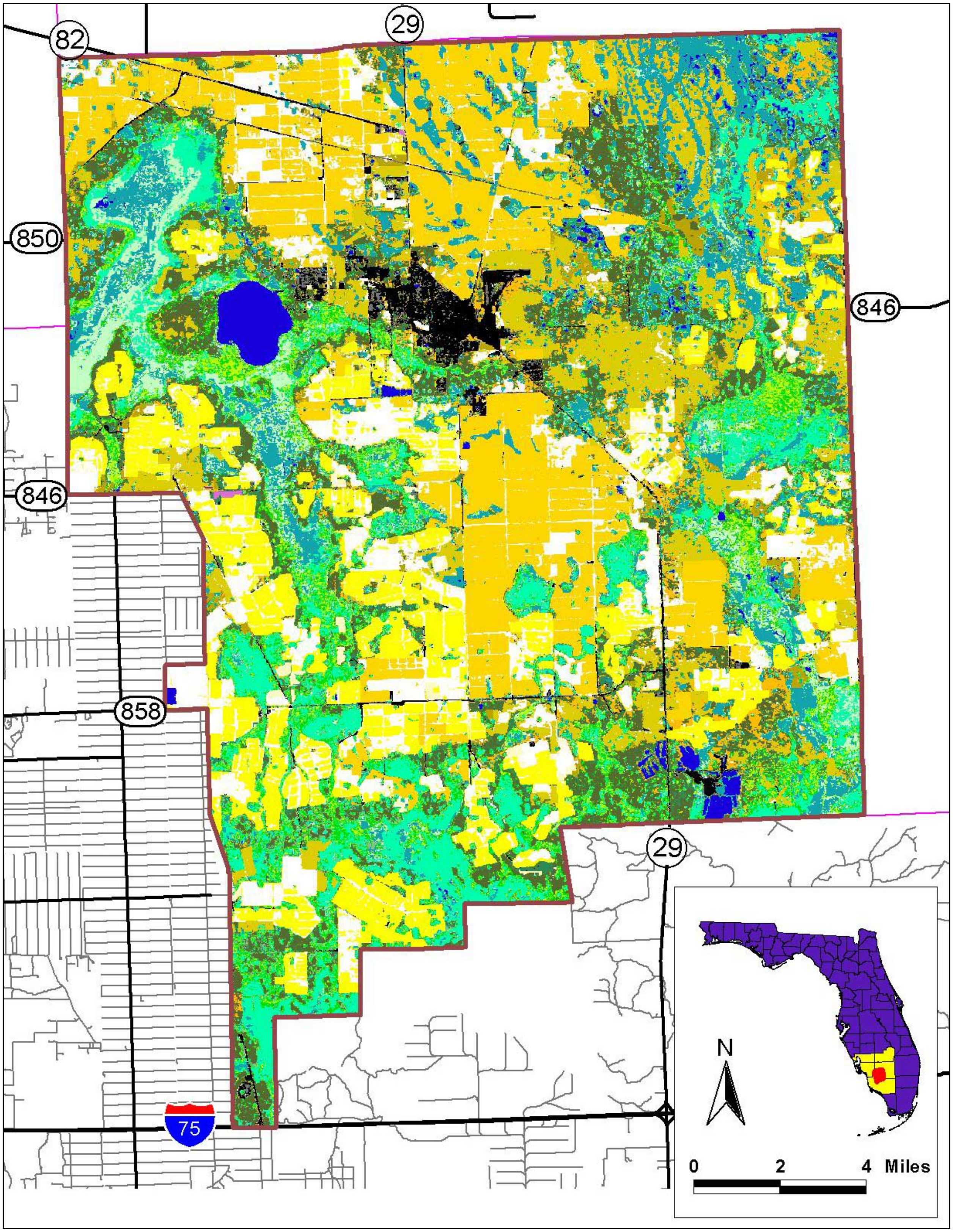
Map J3. Former Florida panther and black bear roadkill locations (road segment partitions equal 100 m).

Appendix K

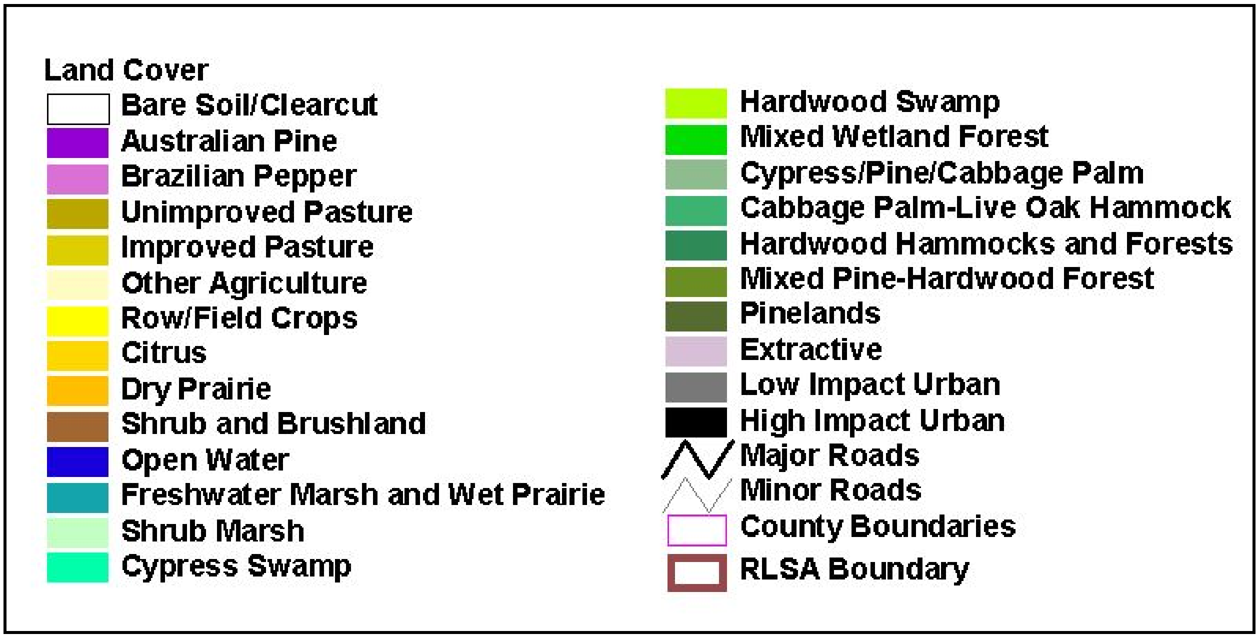
Maps of various conservation planning data layers



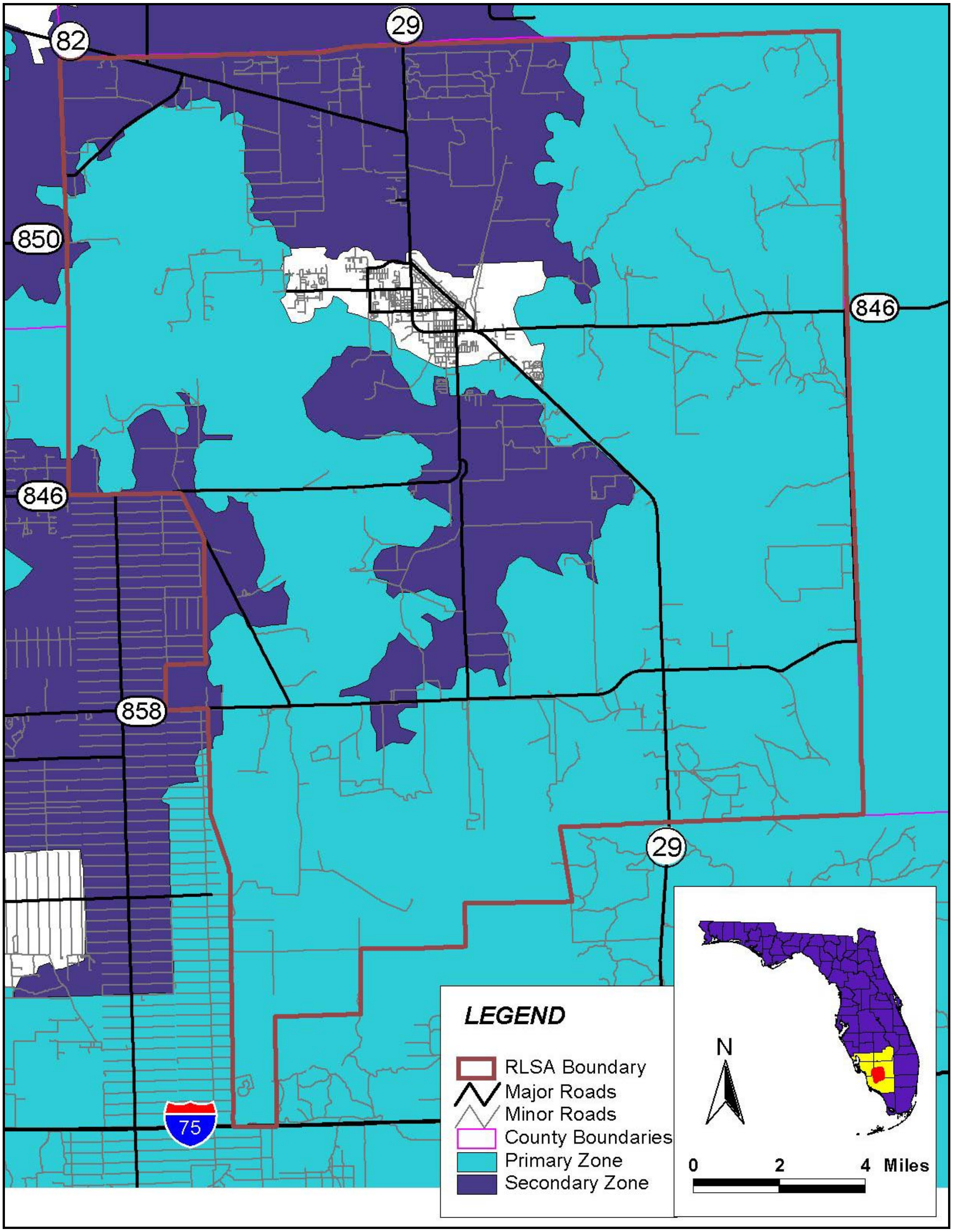
Map K1. Hydrography (1:24,000), including wetlands, open water, and man-made impoundments/canals.



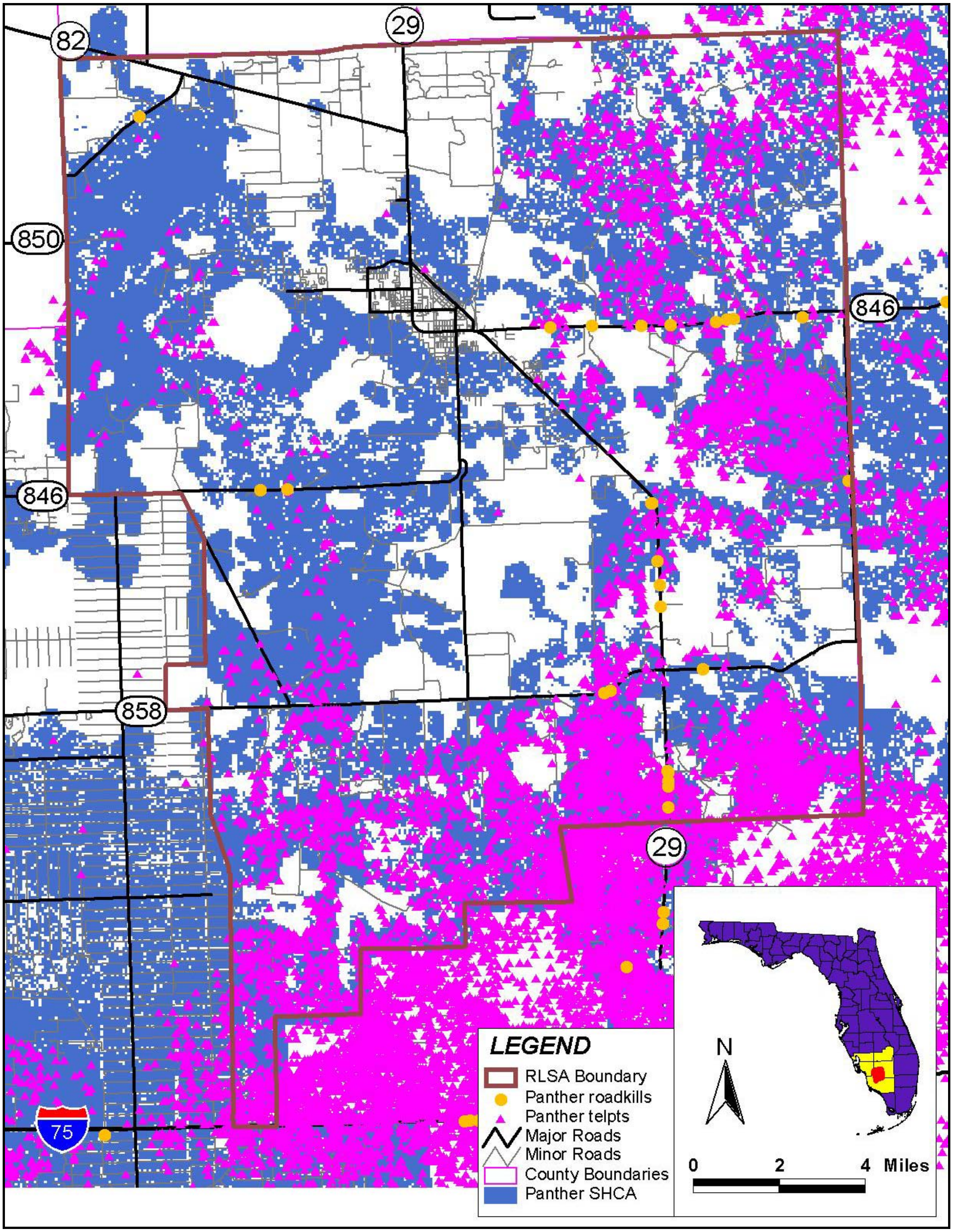
Map K2a. Florida Fish and Wildlife Conservation Commission (FWC) 2003 land cover (key shown below).



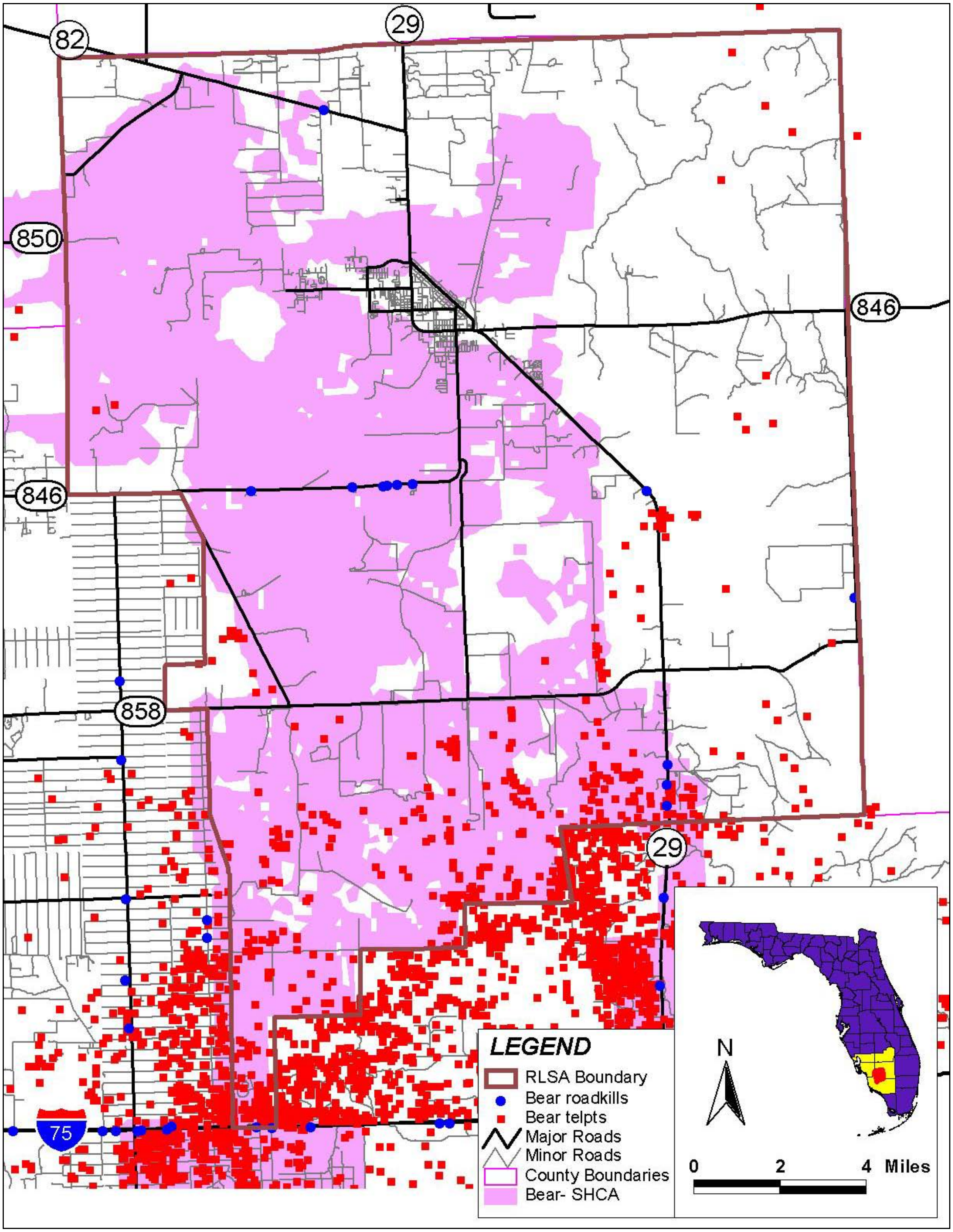
Map K2b. Florida Fish and Wildlife Conservation Commission (FWC) 2003 land cover legend.



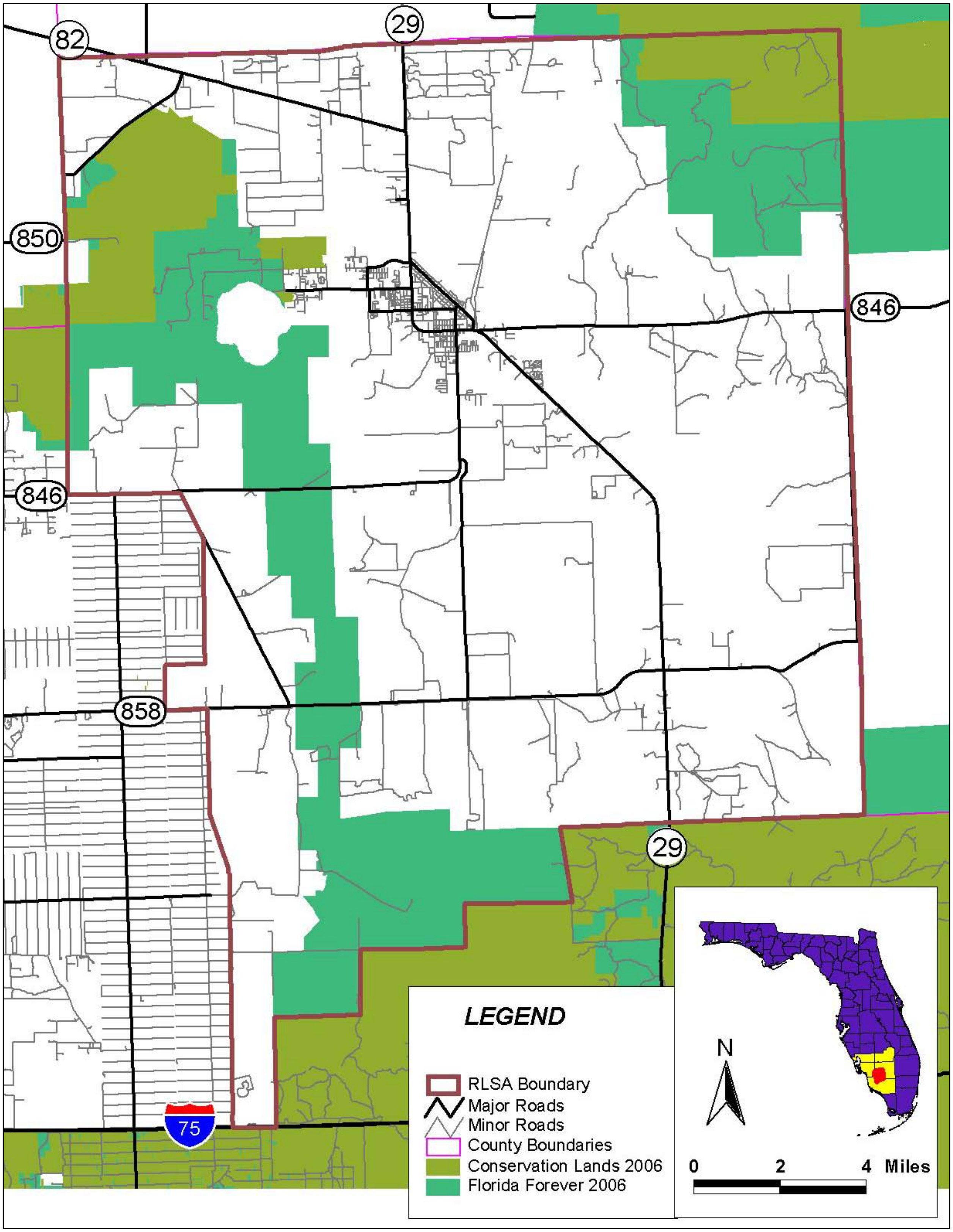
Map K3. MERIT committee model results – Florida panther primary and secondary habitat zones.



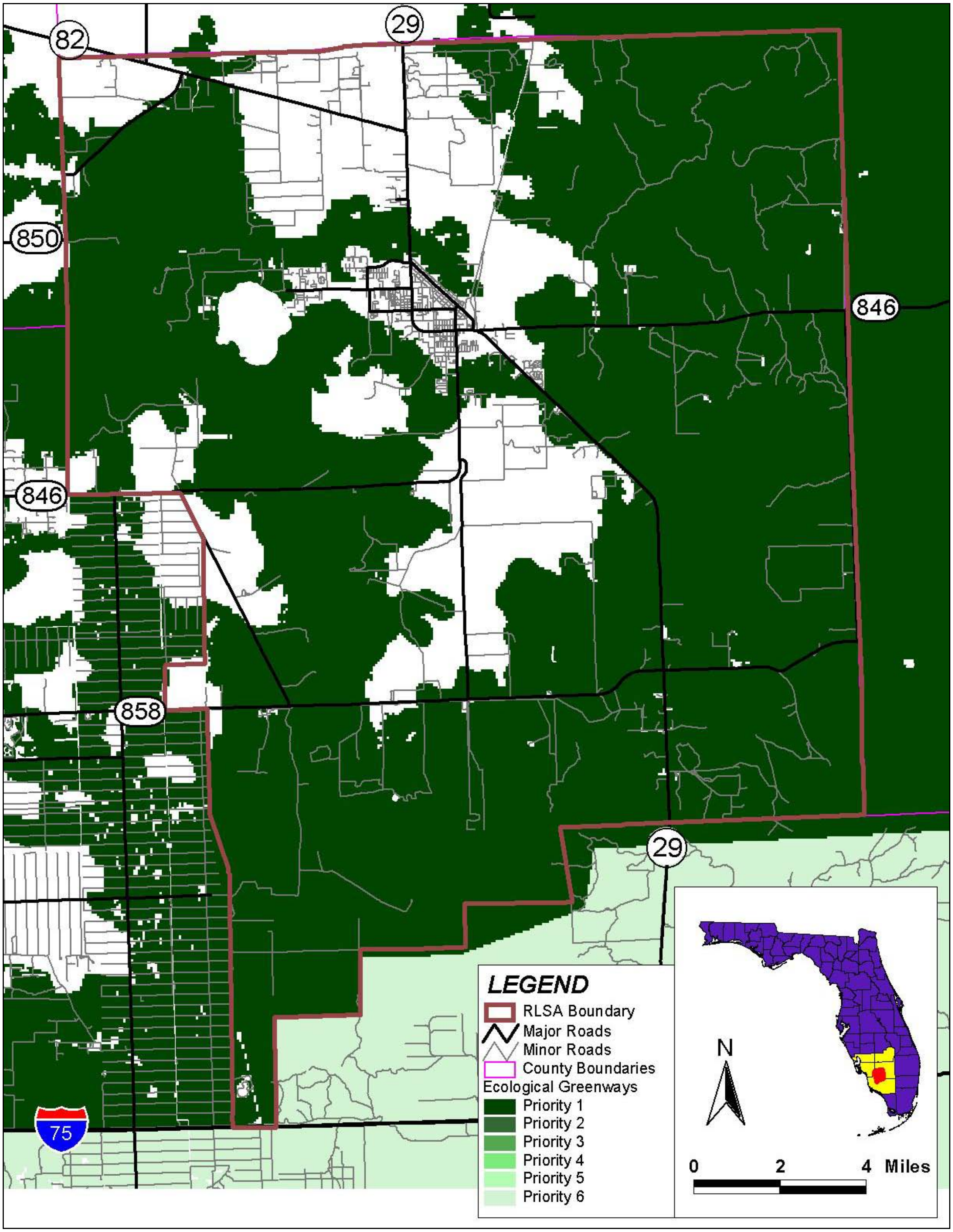
Map K4. Florida panther field data and FWC strategic habitat conservation area.



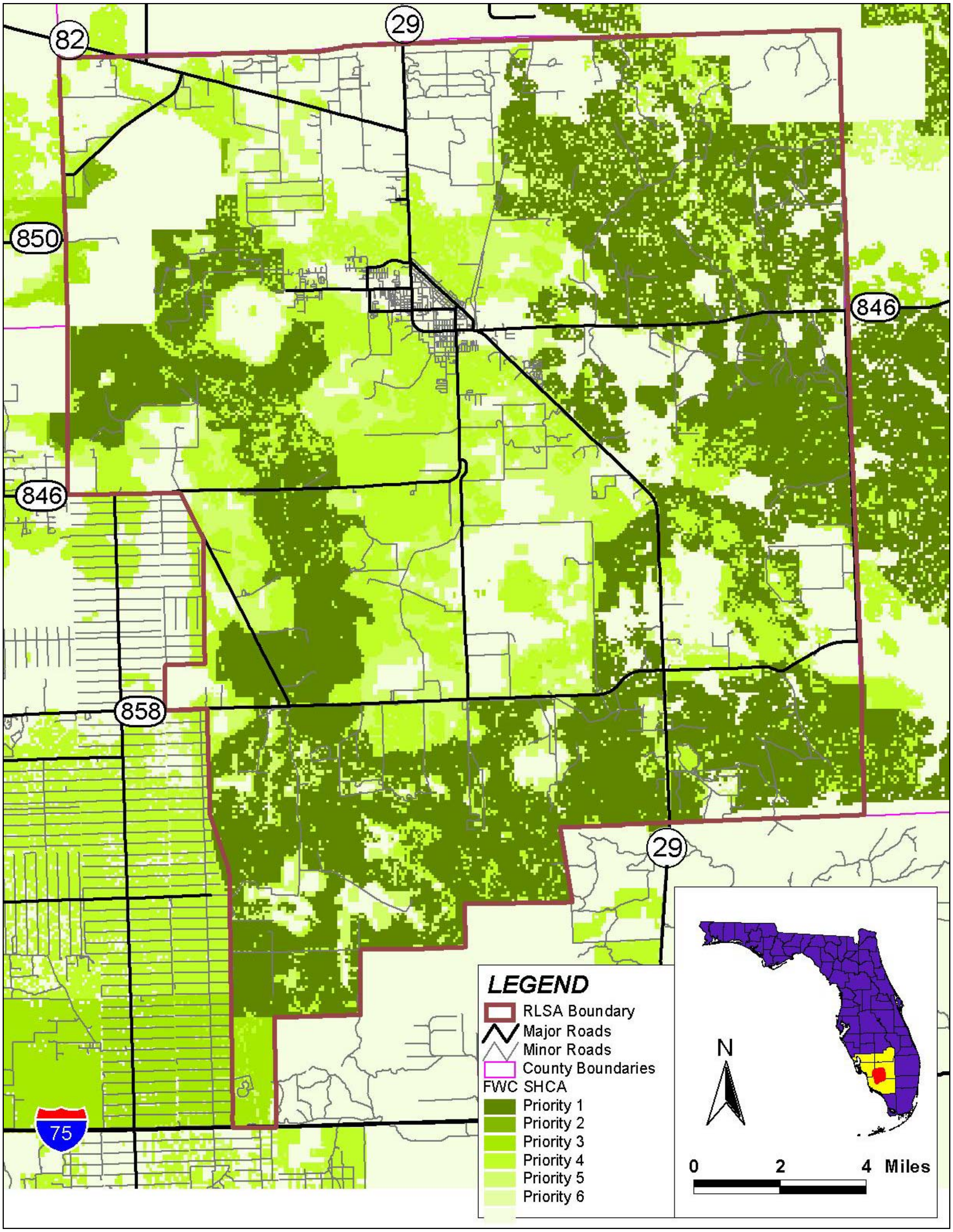
Map K5. Florida black bear field data and FWC strategic habitat conservation area.



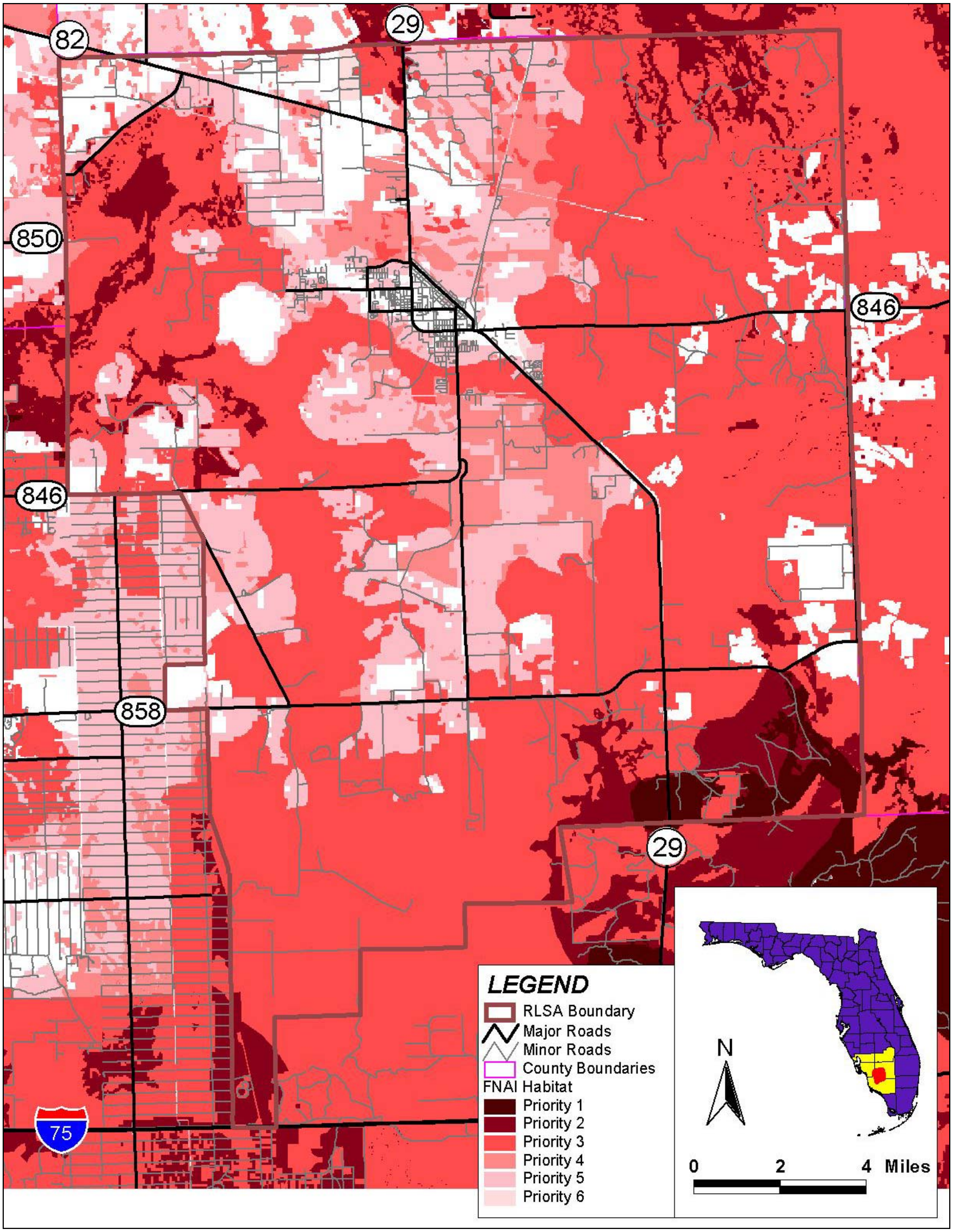
Map K6. Conservation Lands – existing (2006) and proposed (Florida Forever 06/07).



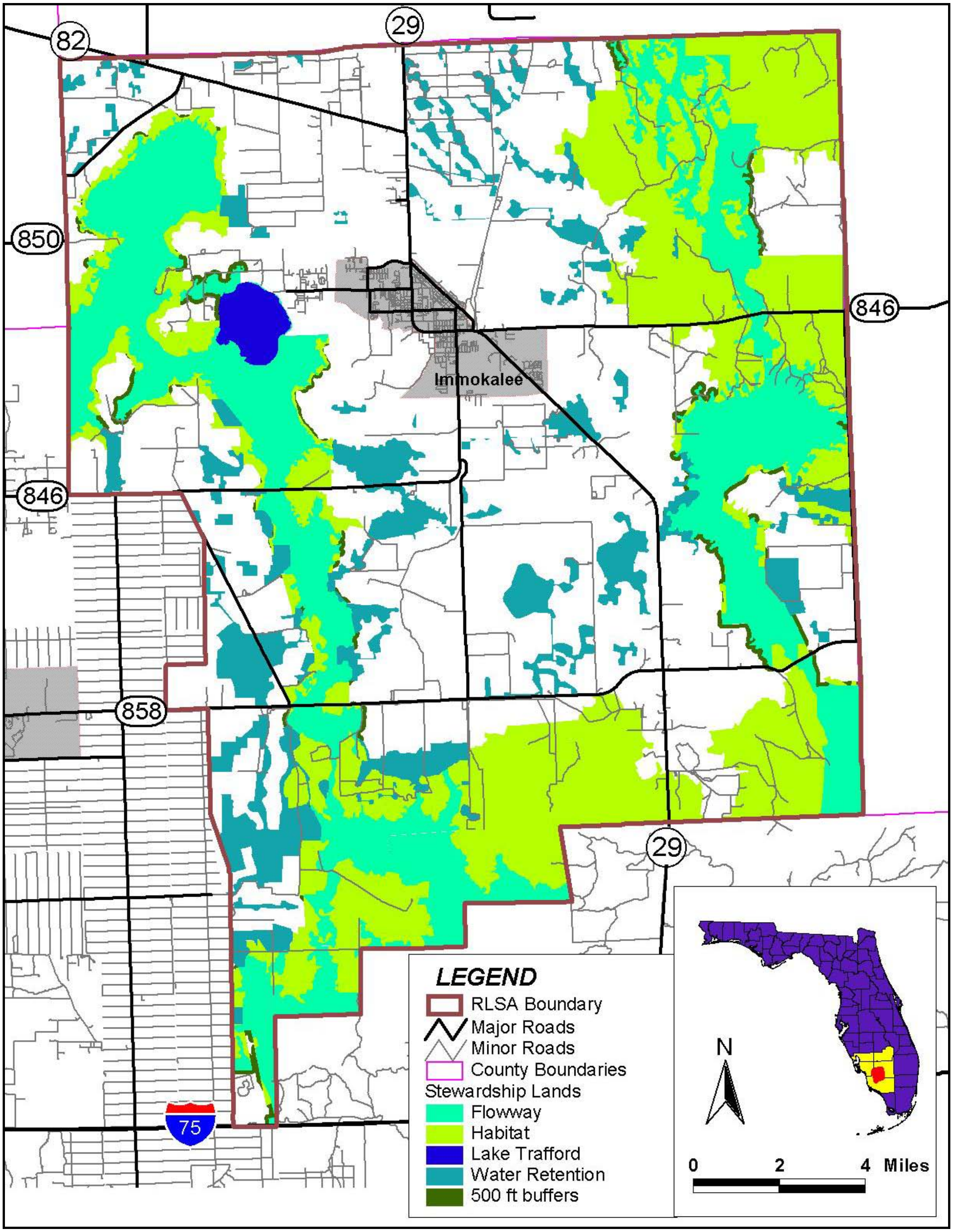
Map K7. Florida ecological network (greenways).



Map K8. Florida Fish and Wildlife Conservation Commission (FWC) strategic habitat conservation areas (SHCAs) based on 124 species-habitat models.



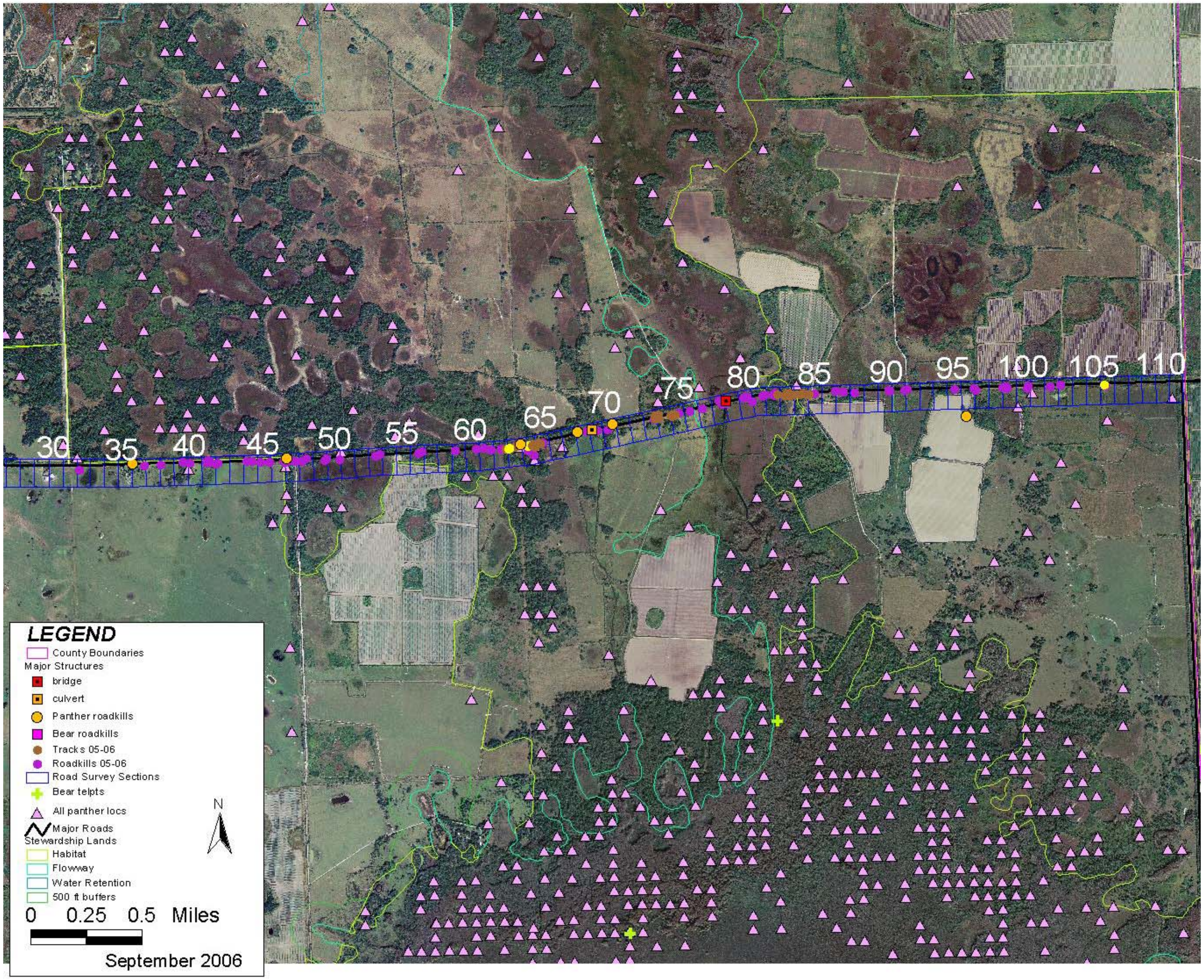
Map K9. Florida Natural Areas Inventory (FNAI) priority habitat areas.



Map K10. Collier County Rural Lands Stewardship Program – stewardship areas (habitat, flow-way, water retention and buffers).

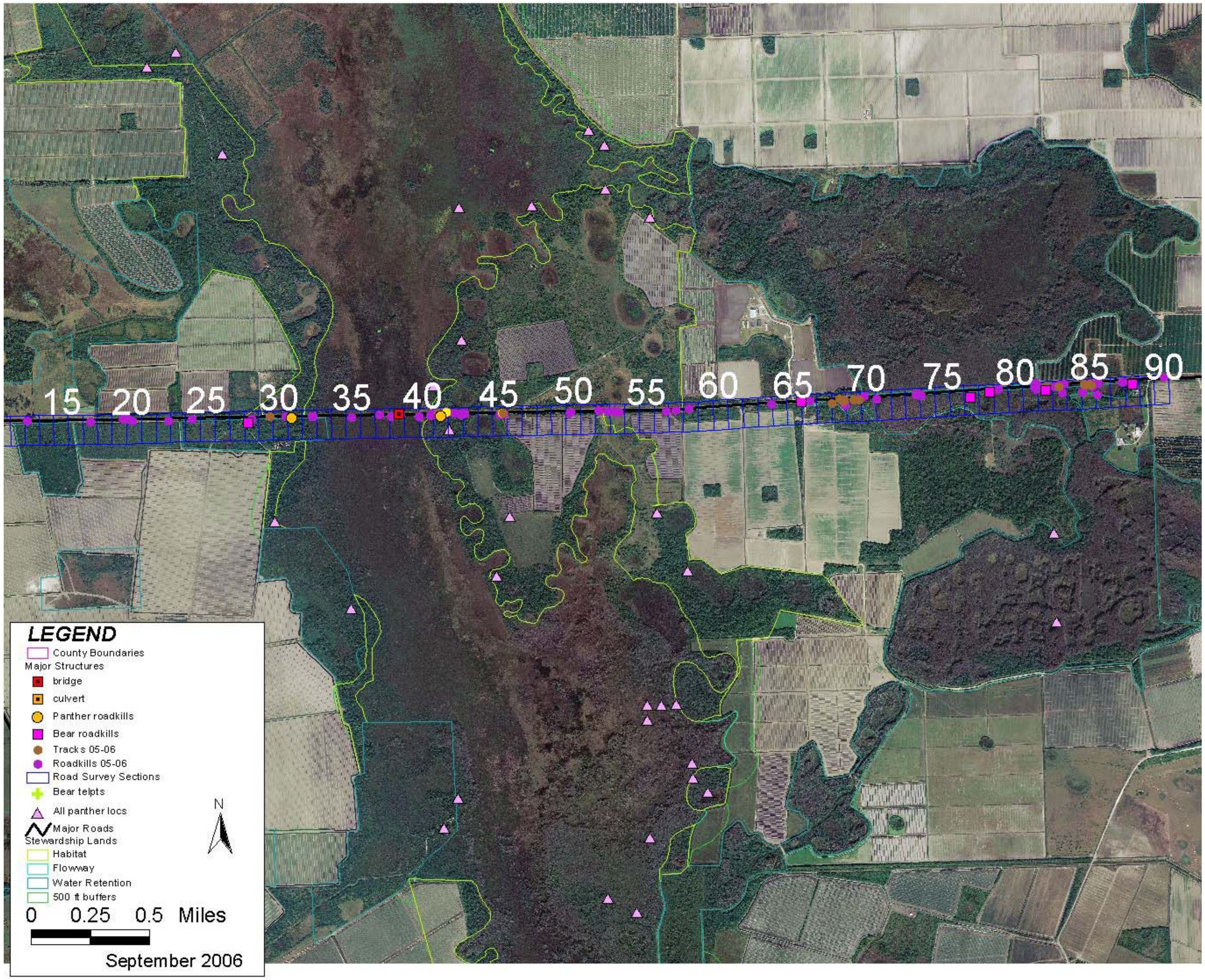
Appendix L

Maps of proposed highway retrofits to improve habitat connectivity

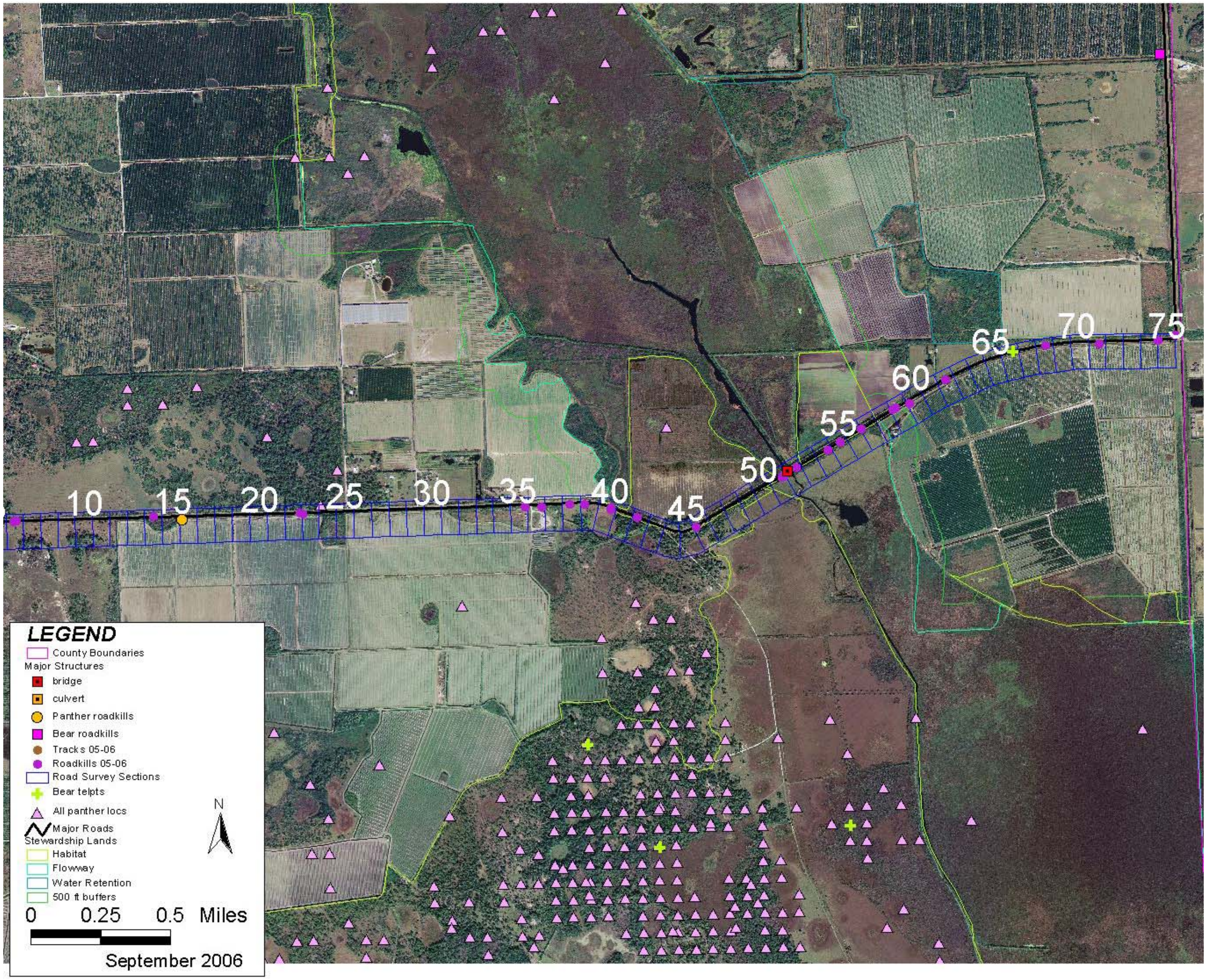


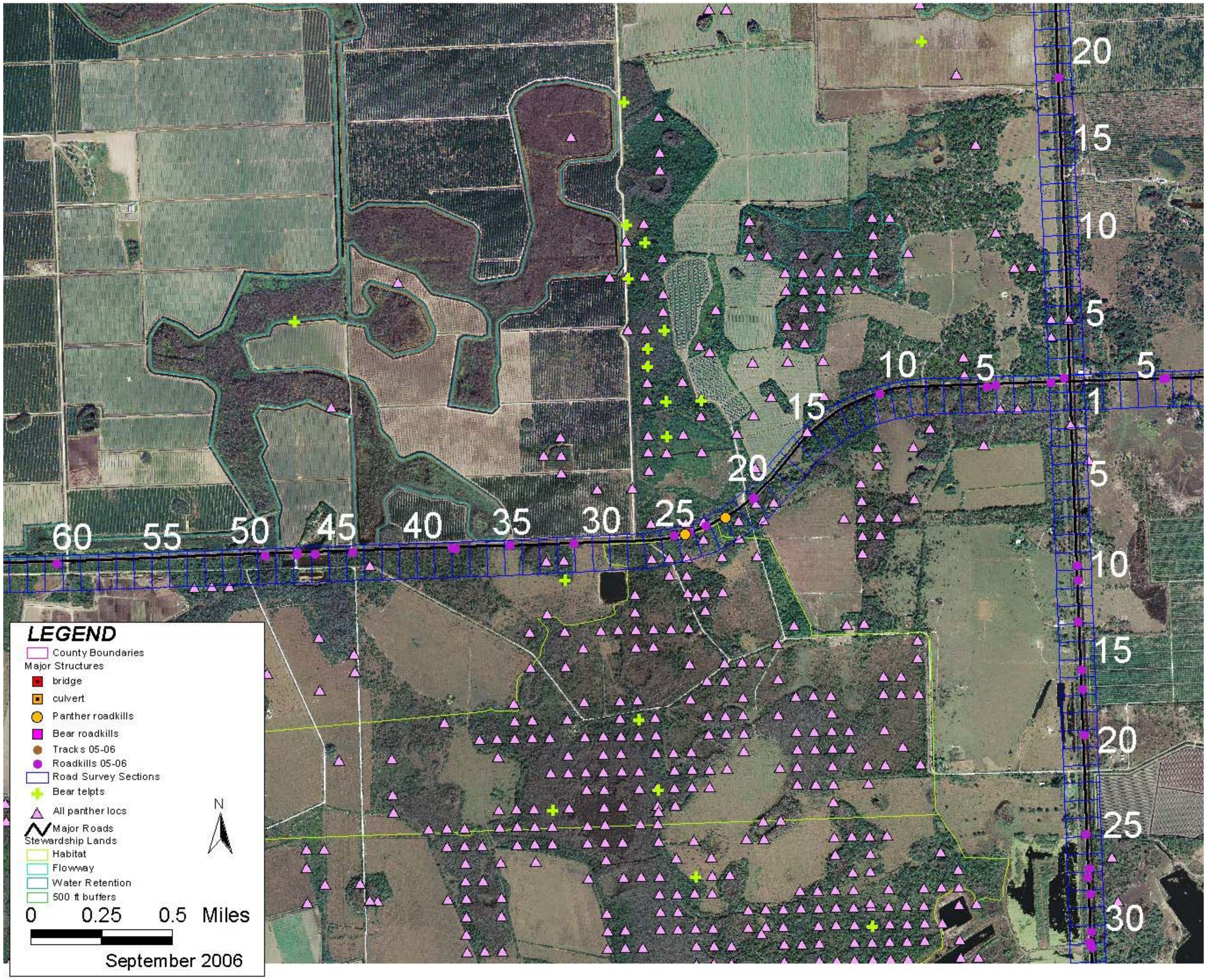
Map L.1. Proposed wildlife crossing structure locations for CR 846 east. Approximate locations for wildlife underpasses are proposed at road segments 47, 63, 76, 84, and 95. An expansion to the existing culvert is proposed at road segment 69. New culvert crossings are proposed for road segments 50, 53, 60, 82, 91, and 101.

Map L2. Proposed wildlife crossing structure locations for CR 846 west. Approximate locations for wildlife underpasses are proposed at road segments 30-31 and 41. New culvert crossings are proposed for road segments 34, 52-53, 69, 73, 78, and 82-83.



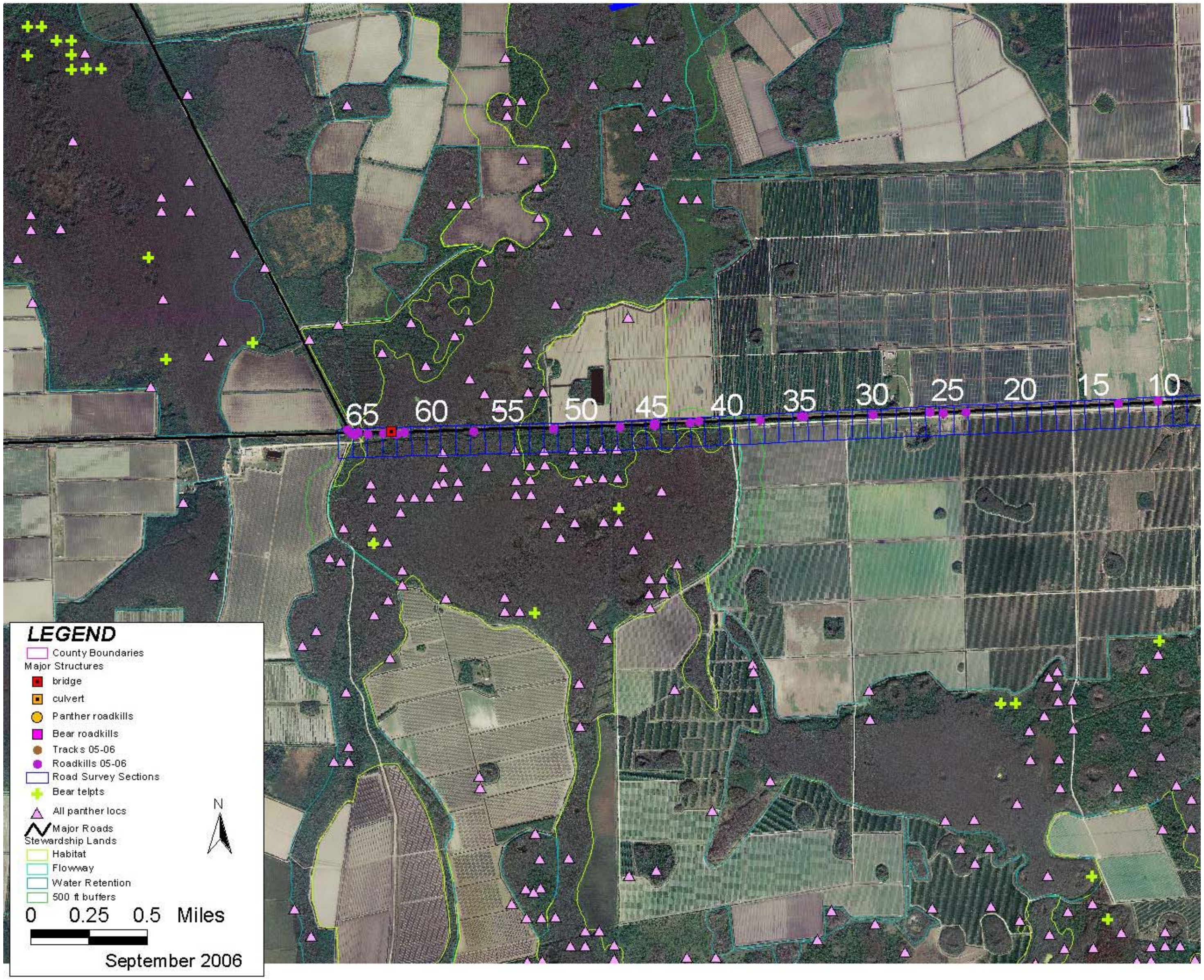
Map L3. Proposed wildlife crossing structure locations for CR 858 east. Approximate locations for wildlife underpasses are proposed at road segments 43 and 55.



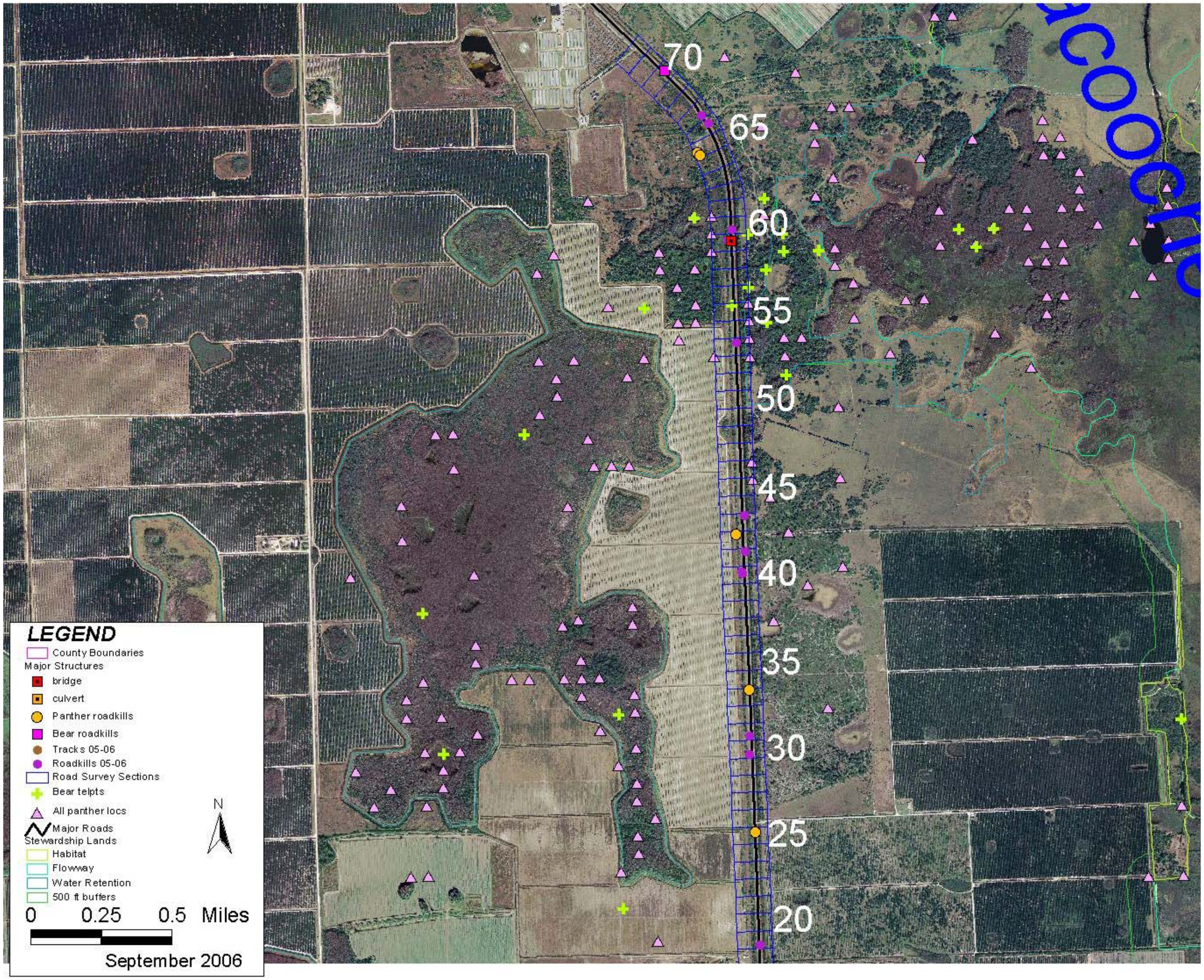


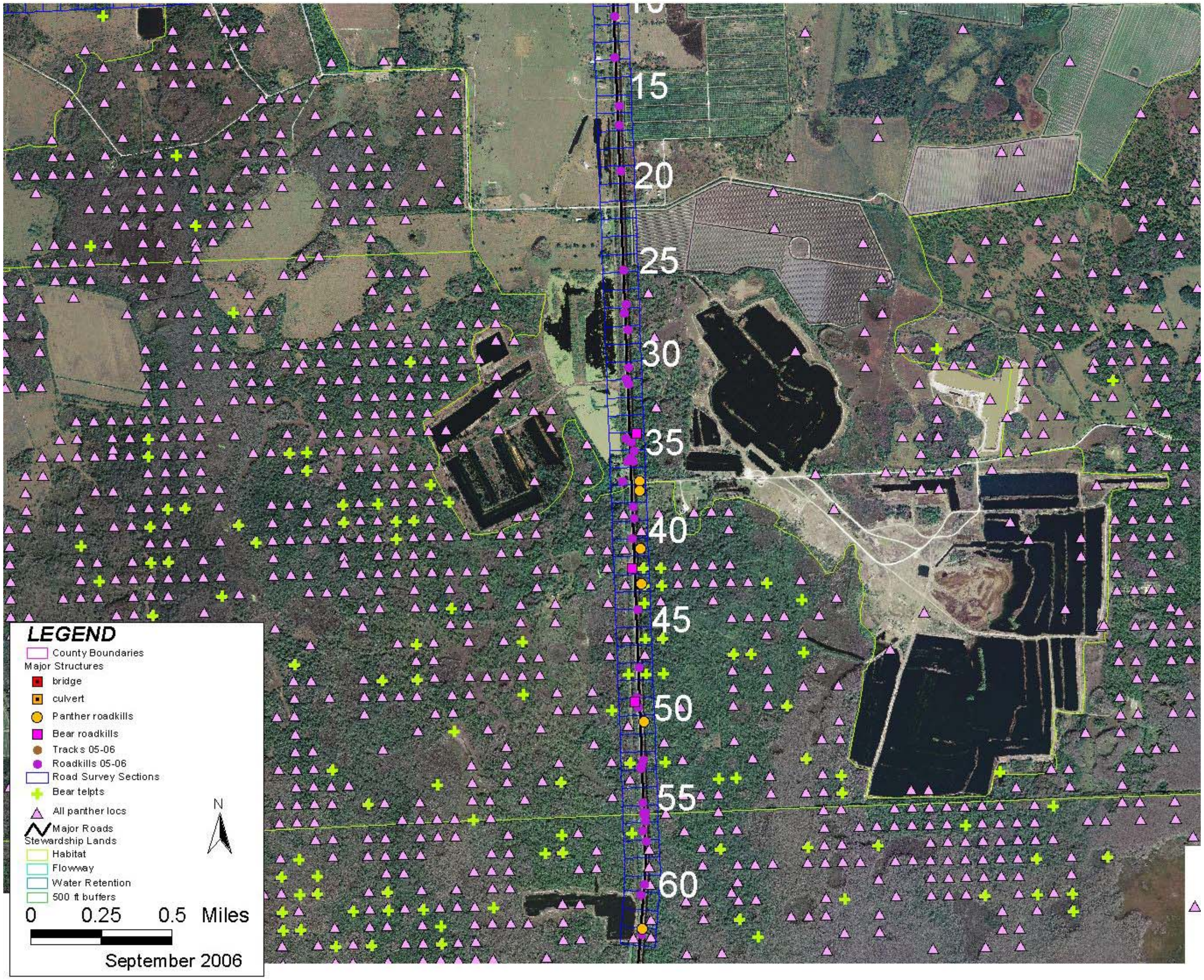
Map L4. Proposed wildlife crossing structure locations for CR 858 central. The approximate location for the proposed wildlife underpass is at road segment 25. New culvert crossings are proposed for road segments 6, 43, and 49.

Map L5. Proposed wildlife crossing structure locations for CR 858 west. Approximate locations for wildlife underpasses are proposed at road segments 51-52 and 65-66. New culvert crossings are proposed for road segments 56 and 60.



Map L6. Proposed wildlife crossing structure locations for SR 29 north. Approximate locations for wildlife underpasses are proposed at road segments 41, 53, and 64-65. An expansion to the existing culvert is proposed at road segment 59.





Map L6. Proposed wildlife crossing structure locations for SR 29 south. Approximate locations for wildlife underpasses are proposed at road segments 39, 50, and 63. New culvert crossings are proposed for road segments 27, 31, and 56.