## Title
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# Evaluation of Principal Roadkill Areas for Florida Black Bear

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**Abstract:** The high number of vehicle-bear collisions and the potential impact of these collisions on both humans and bears prompted a re-evaluation of principal roadkill areas for the Florida black bear (Ursus americanus floridanus). The Florida Fish and Wildlife Conservation Commission has documented an increasing statewide trend in the number of roadkill bears since 1976. Previous research indicates roadkills are concentrated in particular areas based on several habitat features (Gilbert and Wooding 1996). Additionally, Gilbert and Wooding (1996) suggest the areas with the largest bear populations (Apalachicola, Big Cypress, and Ocala) have accounted for the greatest number of roadkill, particularly Ocala National Forest. Most recently, Gilbert et al. (2001) prioritized "chronic" bear roadkill areas using roadkill data and habitat characteristics. A subset of black bear roadkill locations (May 2001-September 2003) was evaluated as part of a larger study focusing on several variables, including changes in patterns of principal roadkill areas. Using a simple density analysis (ESRI), principal roadkill areas were identified as those areas which have three or more roadkill instances within a distance of one mile. A one-mile buffer was established surrounding each of these identified areas to ensure that all roadkill locations were included. From the established criteria and analysis, principal roadkill areas were defined during the time frame May 2001 through September 2003. These principal roadkill areas were located in Apalachicola, Chassahowitzka, Ocala, and St. Johns. The majority of the principal roadkill areas, similar to previous research (Gilbert and Wooding 1996), were identified in Ocala. Although the results from the 2001-2003 analysis identified a number of principal roadkill areas documented by Gilbert and Wooding (1996) and Gilbert et al. (2001), several segments were no longer classified as principal roadkill areas, and a few new areas were documented. These new results prompted a re-evaluation of the data using the same time frame as Gilbert and Wooding (1996) as well as the full data set (1976-2004) to determine the causes of variation. These results identify trends in the occurrence of principal roadkill areas and determine re-occurring "chronic" areas. This evaluation provides information for managers and planners who must take direct management action in an effort to minimize road impacts on bears.

## Introduction

The Florida black bear (*Ursus americanus floridanus*) is a subspecies of the American black bear (*Ursus americanus*) and occurs primarily in Florida, with evidence of Florida bears in southern Georgia, Alabama, and Mississippi. The Florida black bear is state-listed as threatened and occurs in six core and two small, remnant populations throughout Florida (figure 1). Historically and through today, intensive resource extraction and increased human population with associated development has impacted black bear and many other wildlife populations. The Florida black bear is not legally harvested in Florida; however, the number of transportation-related deaths (roadkill) is documented and monitored by the Florida Fish and Wildlife Conservation Commission (FWC). Since 1976, the number of black bear roadkills has increased. Understanding the impact of roadkill on bears prompted a statewide assessment of road impacts on bears in Florida, which was conducted in collaboration with FWC and the Florida Department of Transportation (FDOT) from 2001-2005. Results from the study indicated that overall, road mortality rates ranged between three and eight percent per year across the six core populations. Although the impact of road mortality differed by population, the roadkill rates sustained by these six populations were similar to roadkill rates sustained by black bear populations in other eastern U.S. states (Simek et al. 2005).

The road impacts study provided the opportunity to re-evaluate principal roadkill areas in Florida. Previous research by Gilbert and Wooding (1996) and Gilbert et al. (2001) identified chronic roadkill areas as areas that have eight bear roadkill within a distance of seven miles, using roadkill data from 1976 through 1995. Using historical roadkill data and habitat characteristics, the authors identified roadkill areas that needed to be addressed using conservation measures for the Florida black bear. For the road impacts study, more restrictive criteria were established to identify principal roadkill areas (three or more roadkill bear within a distance of one mile). These criteria were established to identify groupings of bears larger than a family unit within a tighter, more specific area. To align with the road impacts study time frame, roadkill data from 2001-2003 were analyzed. These analyses, and subsequent time frame comparisons, were accomplished using a simple density analysis with Spatial Analyst in ArcGIS (ESRI, Redlands, CA). Objectives of the re-evaluation were to establish whether these "chronic" areas were still apparent or had shifted, and whether different criteria and time frames would impact results and subsequent conservation recommendations using current and previously evaluated roadkill data.

## Methods

The FWC bear roadkill data and a major roads shapefile available from the Florida Geographic Data Library (version 3.0) were used in these analyses. The major roads shapefile was created by the Florida Department of Transportation using their Roads Characteristics Inventory (RCI) dataset. Roads selected for analysis included interstates, state highways, county highways, highway access ramps, and major local and forest roads (as identified in the major roads shapefile).

The density analysis was performed in raster format with a pixel size of 30 m x 30 m. The simple density analysis creates a 2D raster grid of pixels calculating the total number of points (roadkill locations) that occurred within the search radius divided by the search area size. The resulting raster grid was reclassified to give a pixel value of one to

those areas that had a density of three or more roadkill bear within a mile; all other pixel values were given no value. The areas with a value of one were identified as Calculated Roadkill Density Areas (CRDA).

To ensure that all roadkill locations that resulted in identifying the CRDA were included in the principal roadkill area identification process, a one-mile buffer of the CRDA dataset was performed. One mile is the maximum distance a roadkill instance from the CRDA. The buffer areas are called Principal Roadkill Buffer Areas (PRBA). Combined, CRDA and PRBA define the principal roadkill areas. Some manual removal of road segments which intersected the principal roadkill areas was performed due to inaccuracies of the major road shapefile construction and appropriateness for the current analysis. These analyses were repeated to identify the "chronic" roadkill areas using the criteria outlined by Gilbert and Wooding (1996) of eight roadkill bear per seven miles.

## Results

The Gilbert methodology (8 bears/7miles) using data from 1976-1995 identified chronic roadkill areas in the Apalachicola, Ocala, Chassahowitzka, Glades Highlands, and Big Cypress black bear populations (figure 2). However, when using the current methodology of three or more bears per mile and data from 2001-2003, principal roadkill areas were identified in the Apalachicola, Ocala, Chassahowitzka, and St. Johns populations. With a few exceptions, most of the principal roadkill areas identified by both methodologies overlapped. When these two methods were overlaid, however, it became apparent that Glades Highlands and Big Cypress were no longer identified as principal roadkill areas while new areas were identified in St. Johns using the current methodology. The Gilbert methodology encompassed a much larger area, which included more roads, whereas the current methodology identified more specific principal roadkill road segments (figure 3).

Due to the differences exhibited in this first comparison, both methodologies were compared using a similar time frame (1976-1995) to determine if analyses using different time frames would impact the findings or, if, indeed, the principal roadkill areas had disappeared from Big Cypress, for example. The two methodologies identified very similar principal roadkill areas; however, the current methodology selected additional areas not found through Gilbert's method (figure 4a). Once again, Gilbert's method encompassed a larger area with a higher number of roads, whereas the current methodology selected more specific locations on fewer roads (figure 4b). Having tested the new methodology using Gilbert's time frame (1976-1995), it was now important to understand if the full database, including current data (1976-2004), would identify additional or different principal roadkill areas. Using both methodologies with roadkill data from 1976-2004, principal roadkill areas were identified in all six populations, including Eglin and Osceola, which had not been previously identified as containing principal roadkill areas (figure 5a and figure 5b).

As a result of these findings, the data from 1996-2004 were examined to determine if these new occurrences of principal roadkill areas in Eglin and Osceola occurred in the last 10 years or if the two methodologies were contributing to these differences. During this time frame (1996-2004), the current methodology identified the principal roadkill areas in Eglin and Osceola again, whereas the Gilbert method did not select these areas nor areas previously identified through Gilbert's method in Chassahowitzka and Big Cypress (figure 6).

## Discussion

These findings illustrate the effect of different methodologies and different time frame scenarios on determining the locations of principal roadkill areas. Principal roadkill areas within the Big Cypress population clearly demonstrate the change in locations that can occur using the different methodologies and time frame scenarios (figure 7). Similar to Malo (2003), it is evident that the two methods consistently derive different results with respect to scale. Gilbert's method (8 bear/7mile) gives principal roadkill areas on a broader scale. The current methodology (3 bear/1mile) provides increased specificity on actual locations of "hotspots" within the broader framework. The time frame selected for analysis impacts the locations of the principal roadkill areas regardless of the spatial scale. For example, analyzing 28 years of data, using both methodologies, results in many roads being identified as problem roadkill areas. This may be an unrealistic scenario and logistically unfeasible for managers to address. On the other hand, using too few years of data can provide an inaccurate representation of what is really occurring. This raises the question of how many years of data should be used to accurately represent where principal roadkill areas occur.

A limitation to these analyses is that over time habitat and land use will change, thereby influencing the locations of principal roadkill areas. However, implementing conservation measures, such as wildlife crossings, signs, fencing, etc., is important in order to identify, address, and meet the immediate need of reducing the impact of the current "hotspot" on the target species. In addition, the average life span of the species of interest should be considered when selecting a specific time frame for analysis (Craighead et al. 2001). This will help to support the validity and relevance of identified principal roadkill areas. While other parameters, such as wildlife population dynamics, will influence the locations of concentrated roadkill, these parameters will also assist managers to interpret whether the impact of identified roadkill is of concern. In addition, factors such collision fatalities, insurance claims, and social perception may supersede the identification of principal roadkill areas from either methodology and may determine if action is necessary. Managers need to recognize that shifts may occur from a single factor or from a compilation of these factors. Therefore, both these methodologies will identify the specific locations for management actions to occur as well as identify larger areas of concern where comprehensive conservation planning needs to be implemented.

As previous research has identified, roadway features, habitat characteristics, population characteristics, etc., are critical to include in the assessment of where to implement conservation measures in response to areas with a high number of roadkill (Craighead 2001, Barnum 2003). However, when there are limited resources or opportunities to obtain these data, the methods described in this paper provide tools to identify principal roadkill areas using data that are readily and most commonly available (roadkill numbers and location). In addition, these methods provide the option to select the level of specificity required for the management objectives for a species or project.

Therefore, for different managers, a project's goals and objectives will influence the manager's choice of method to identify principal roadkill areas. For example, a transportation manager might consider the 3 bear/1mile method which will provide specific locations of road segments and principal roadkill areas that need to be addressed. However, a land manager might also select the 8 bear/7mile method, as this method will identify larger areas of concern to be targeted in developing land conservation measures, such as conservation easements, etc.

Depending on the method of choice, managers will need to select and prioritize which method to use based on each method's associated goals and results. For example, when choosing the Gilbert method, which selects broader areas of concern, techniques such as driver awareness/education measures through road design planning, which may include reduced speed zones and signs, can be used to reduce the number of roadkill. Selecting the current method may lead to implementing transportation planning, design, and redesign methods to reduce the number of roadkill and maintain or improve habitat connectivity (Servheen et al. 2003). These may include roadway design, enhancement, and construction; wildlife crossings (under and over passes); road closures, redirection of traffic, wildlife detection systems, signs, speed zones, line of sight improvements on roads, fencing, etc. The Gilbert and current methodologies, as illustrated in this paper, are useful in establishing both short- and long-term conservation measures to effectively address the negative consequences of roadkill on both wildlife and people.

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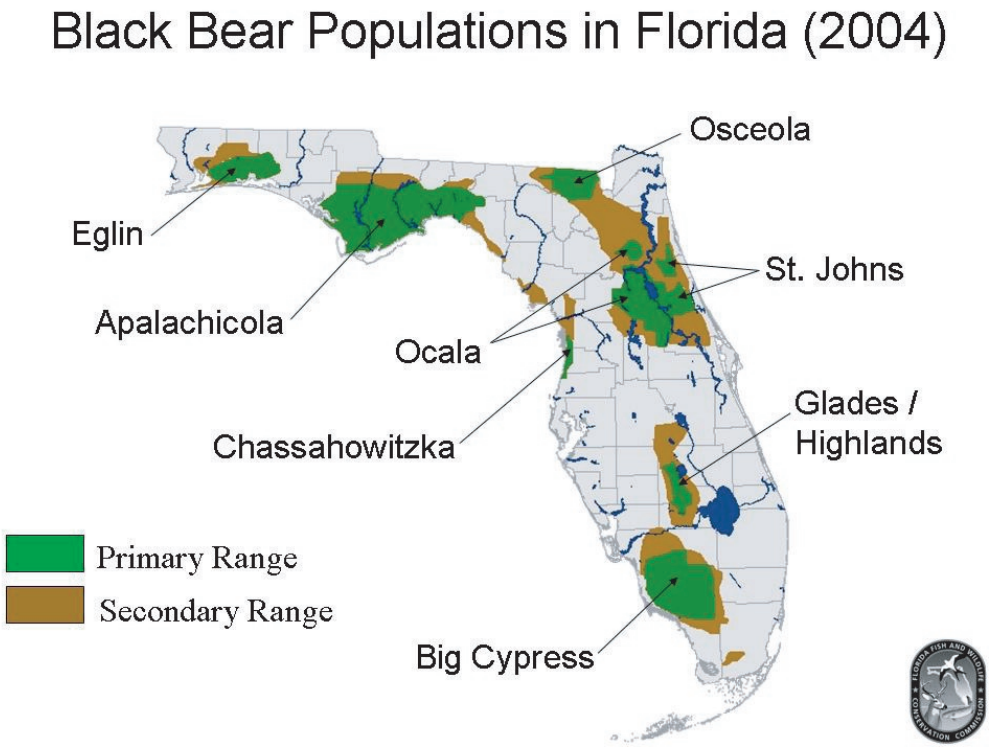



Figure 1. Black bear populations in Florida.

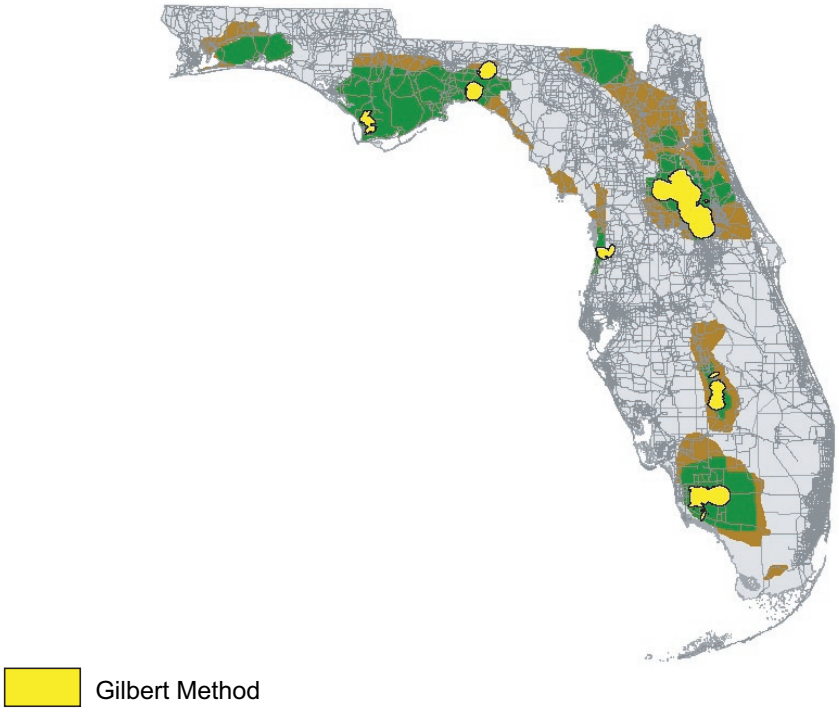



Figure 2. Principal roadkill areas using Gilbert methodology with data from 1976-1995.

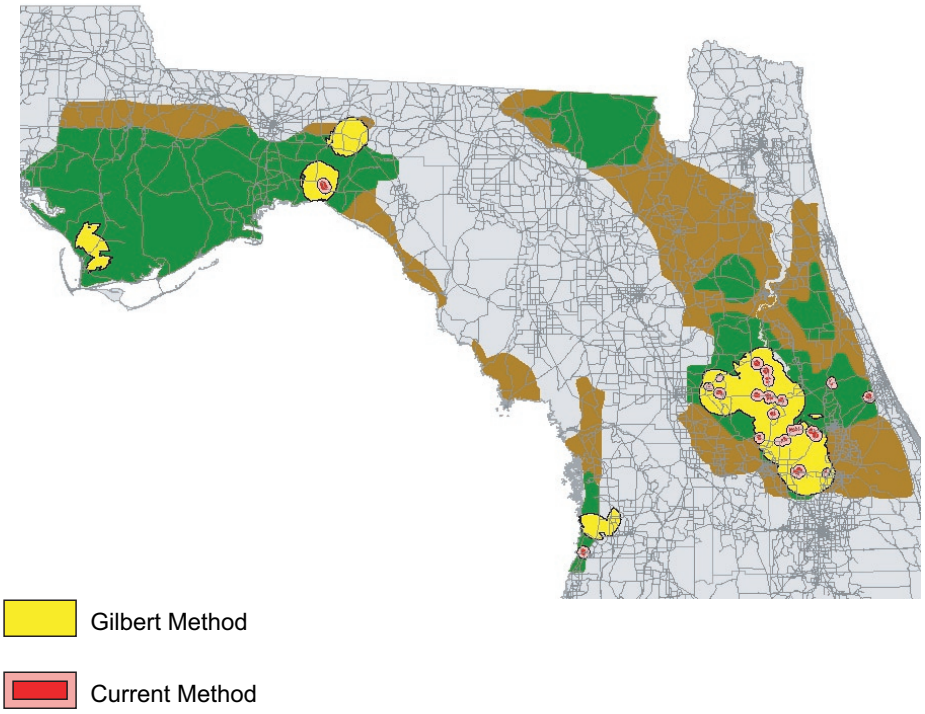



Figure 3. Overlap of principal roadkill areas using the Gilbert methodology (1976-1995) and the current methodology (2001-2003).

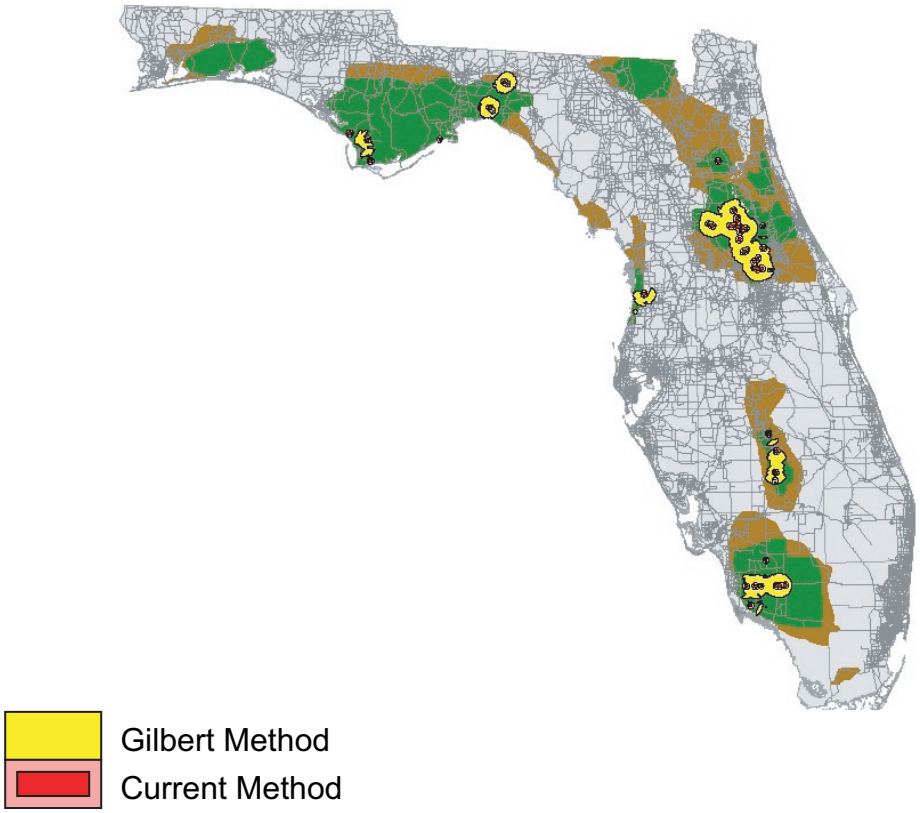



Figure 4a. Overlap of principal roadkill areas using the Gilbert and current methodologies with roadkill data from 1976-1995.

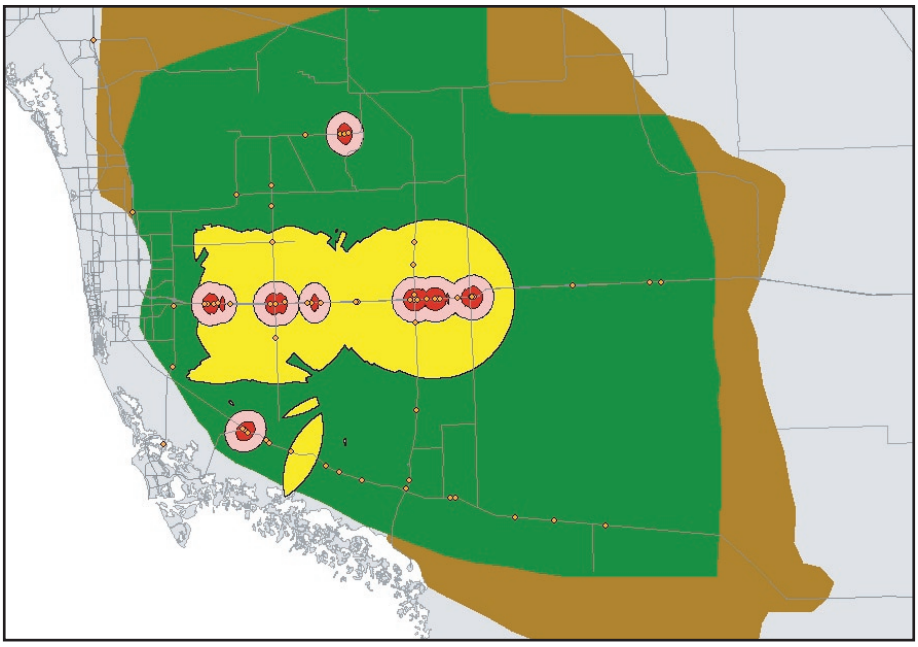


Figure 4b. Zoom view of Big Cypress population principal roadkill areas demonstrating the difference between the Gilbert and current methodologies.

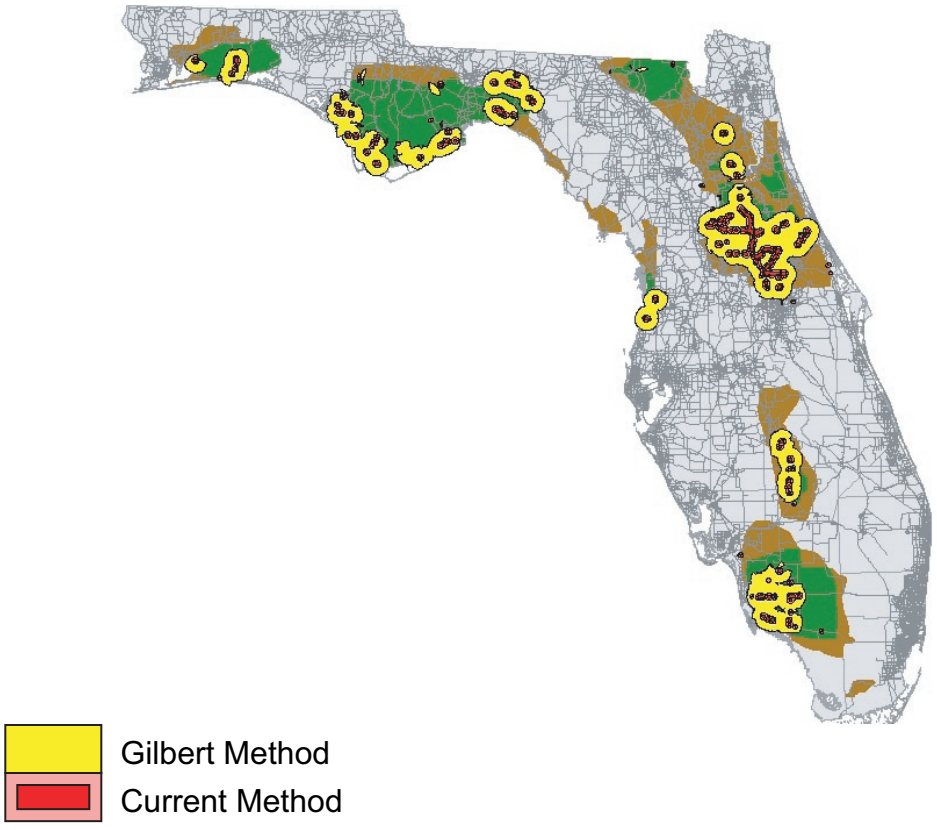



Figure 5a. Overlap of principal roadkill areas using the Gilbert and current methodologies with roadkill data from 1976-2004.

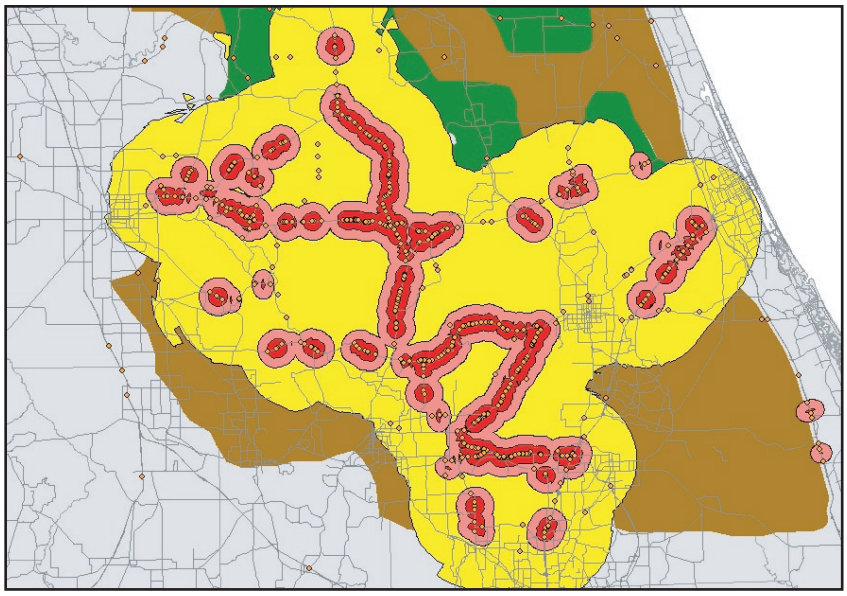


Figure 5b. Zoom view of Ocala population principal roadkill areas demonstrating the difference between the Gilbert and current methodologies.

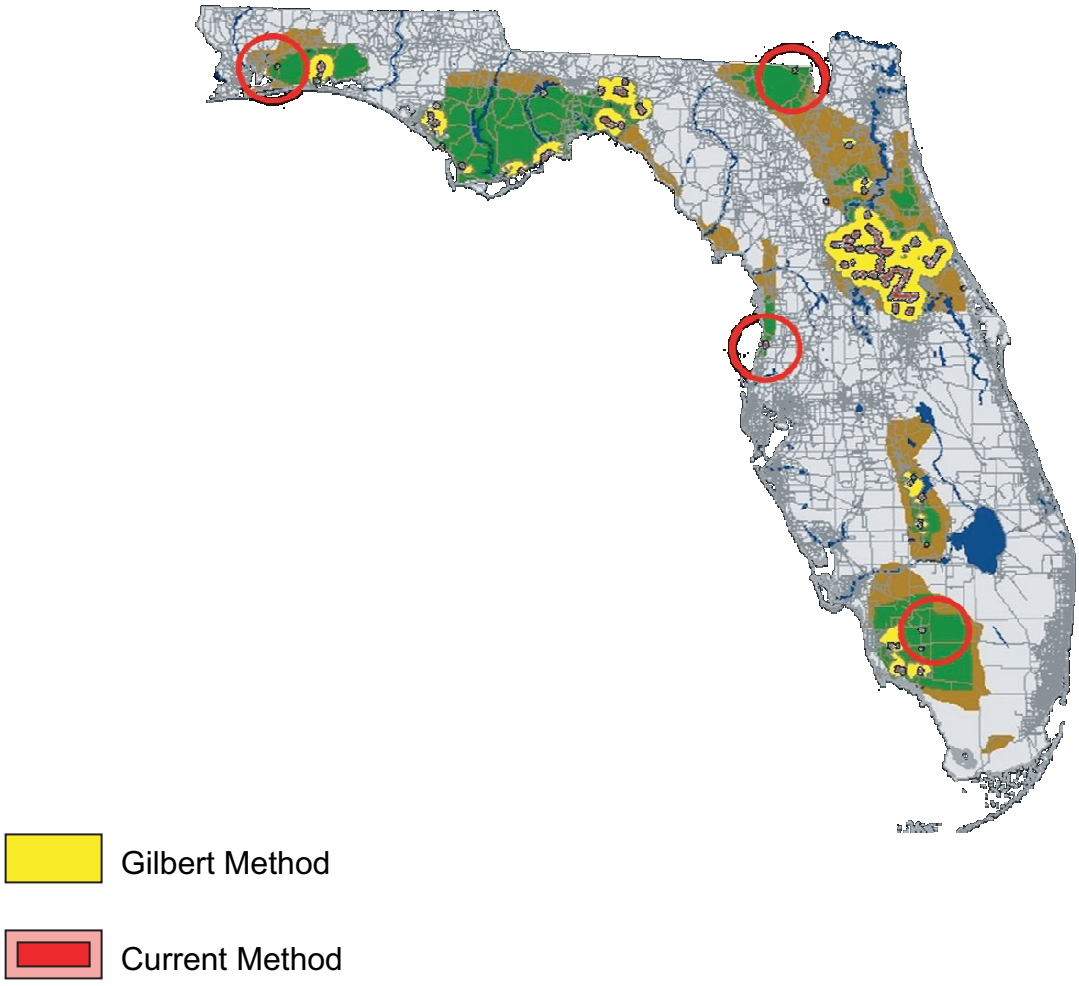
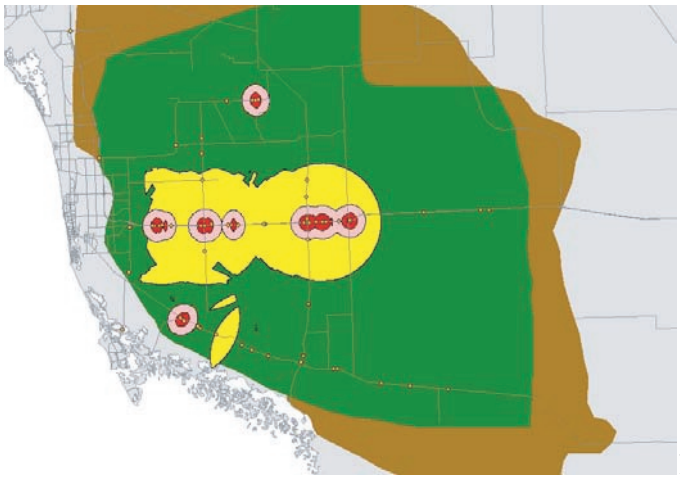
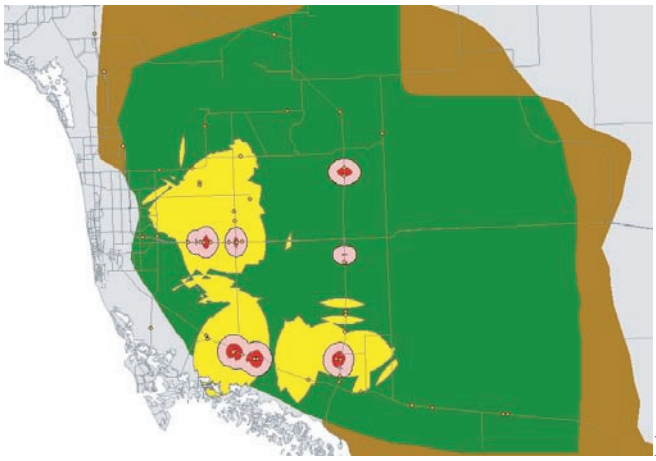



Figure 6. Overlap of principal roadkill areas using the Gilbert and current methodologies with roadkill data from 1996-2004, with major differences highlighted by red circles.



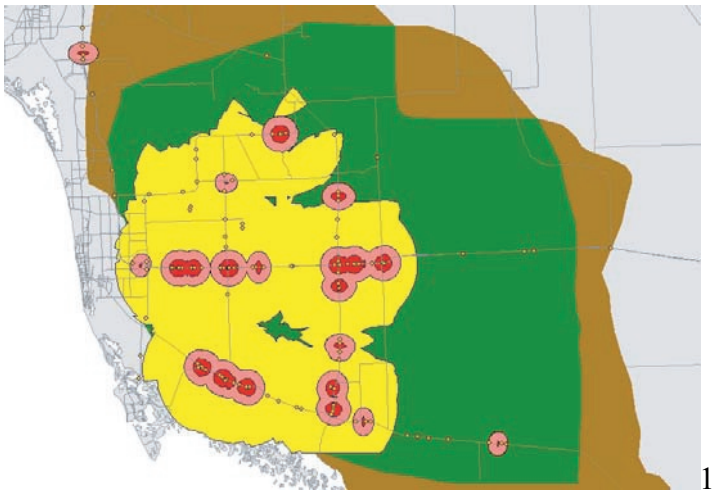
1976-1995



Gilbert Method

Current Method

1996-2004



1976-2004

Figure 7. Effect of different methodologies and different time frame scenarios on determining the locations of principal roadkill areas using Big Cypress as an example.