Wildlife Crossing Handbook

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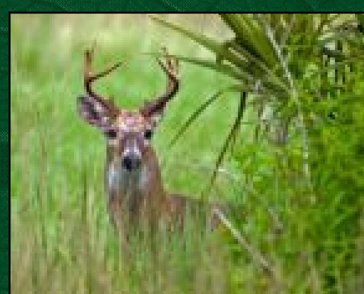

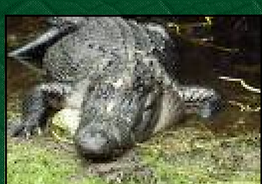

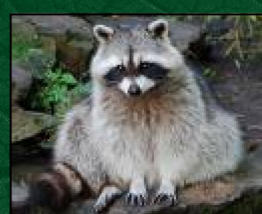

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BREEDLOVE, DENNIS & ASSOCIATES, INC.

WILDLIFE CROSSING HANDBOOK

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BREEDLOVE, DENNIS & ASSOCIATES, INC.

WILDLIFE CROSSINGS HANDBOOK

1.0 Purpose

Highways are known to have ecological effects on various species of wildlife and their habitats. These effects include loss and fragmentation of wildlife habitat, increased mortality of species attempting to cross highway corridors, and creation of barriers to wildlife movements and dispersal (Jackson 1999, Forman et al. 2003, Smith 2003). These ecological effects may occur not only at the highway/habitat interface, but may extend thousands of feet beyond (Forman 1995). Such effects may be more pronounced in small isolated animal populations. The presence of wildlife on roads can also pose safety hazards for motorists.

Wildlife crossings are often proposed as the solution to these problems during the planning phases of projects involving construction of new highways or improvements to existing roads. Wildlife crossings may or may not be needed based on site-specific circumstances. The need for wildlife crossings typically is a function of the types and configuration of habitats being crossed, site-specific landscape characteristics, the species of wildlife and their patterns of movement in the vicinity of the highway, and the design and transportation capacity of the highway. The type of wildlife crossing that is appropriate for a given situation is a function of the species to be accommodated, land ownership patterns, highway capacity (i.e., number of lanes), and highway design standards pertaining to safety, slope, topography, distance between intersections, line of sight, curves, etc.

The purpose for this handbook is to: (1) briefly describe ecological effects of roads on wildlife; (2) categorize species of wildlife according to requirements for crossings of a given size or type; (3) provide specifications for crossings of various types; and (4) provide a review of information useful for determining locations of wildlife crossings. This handbook is intended to provide a general overview and understanding of wildlife crossings as an aid to reviewing projects involving construction of new highways and improvements to existing roads.

2.0 Ecological Effects of Highways on Wildlife

Roads and road networks comprise essential components of human economic systems. They cross the landscape, providing transportation connections everywhere people need to travel. An entire ecological discipline has developed around the study of the effects of roads on plants, animals, natural communities, and entire landscapes. The following brief overview of the major ecological effects of highways on wildlife and their habitats is intended to provide a framework within which to better understand the need for wildlife crossings.

2.1 Habitat Loss and Fragmentation

"Habitat loss" has been defined as the loss of suitable habitat for a given species such that an area becomes unsuitable or less suitable for a species to occur within a specific area (Lindenmayer and Fischer 2006). Habitat loss is considered by many to be the root cause of declining biodiversity around the world (Hilty et al. 2006). Highways may result in direct loss of habitat for many species of wildlife because formerly natural habitat types are converted to unvegetated paved or unpaved surfaces bearing vehicular traffic, and the areas no longer function as habitats suitable for wildlife (Forman et al. 2003). "Habitat fragmentation" occurs when formerly large patches of wildlife habitat become smaller and increasingly isolated from one another, often in response to conversion of natural landscapes to human uses (Wilcove et al. 1986). Habitat fragmentation produces a variety of ecological consequences, including degradation of habitat quality in remaining patches of habitat, increased edge effects along fragment boundaries, demographic and genetic problems associated with smaller wildlife populations, and reduced connectivity among populations (Jackson 1999, Lindenmayer and Fischer 2006). Highways are viewed by many as a significant cause of habitat fragmentation in many areas of the world because they dissect the natural landscape into smaller units of remaining habitat (Noss and Cooperrider 1994, Jackson 1999, Forman et al. 2003).

2.2 Wildlife Mortality

Mortality of wildlife due to collisions with motor vehicles has the potential to negatively affect small populations of wildlife (Forman et al. 2003), and mortalities of common species also can be high in some areas (Barichivich and Dodd 2002). Highway mortality has been documented as a significant source of mortality for several imperiled species in Florida, including the Florida panther (*Puma concolor coryi*), Florida black bear (*Ursus americanus floridanus*), key deer (*Odocoileus virginianus clavium*), American crocodile (*Crocodylus acutus*), and Florida scrub-jay (*Aphelocoma coerulescens*). The endangered Florida panther population increased from 62 individuals in 2000 to an estimated 117 individuals in 2007 (McBride et al. 2008), and roadkill mortality during this period ranged from 5-18 individuals per year (Shindle et al. 2001, Land et al. 2002, Shindle et al. 2003, Land et al. 2004, Lotz et al. 2005, Florida Fish and Wildlife Conservation Commission [FWC] 2006, FWC 2007, FWC 2008). Highway mortality accounted for 19% of all known Florida panther mortalities between 1981 and 2005, and highway mortality was the third leading cause of mortality after intraspecific aggression (42%) and unknown causes (24%) (Land et al. 2005). Florida black bear highway mortalities have been increasing since 1976, prompting managers to identify and prioritize black bear hot spots for highway mortality (Gilbert et al. 2001, Simek et al. 2005b). More than 100 highway mortalities of bears were documented in Florida annually between 1999 and 2003 (Simek et al. 2005a), but the impact of highway mortality on black bear populations has not been studied. Collisions with motor vehicles have been the primary source of key deer mortality since the 1960s, having accounted for >50% of annual losses (Lopez et al. 2003). The construction of two underpasses and fencing along US 1 on Big Pine Key, Florida, has successfully prevented an increase in highway mortality despite an increasing deer population (Parker et al. 2007). Automobile collisions have been reported to account for 46% of human-related mortality of the endangered American crocodile (Gaby 1987). Roadside territories of Florida scrub-jays were considered to be habitat sinks because highway mortalities of breeders and fledglings were so high that roadside habitats could not sustain jays without immigration from other areas (Mumme et al. 2000).

2.3 Barriers to Movement

Landscape connectivity is important because some species require access to multiple habitat types to obtain their daily or lifetime needs, and connected landscapes allow for animals to move into and repopulate areas that have experienced local population declines (Forman et al. 2003). Highways may function as barriers that sever connectivity and impede or preclude the movements of some species of wildlife (Forman et al. 2003, Smith 2003). Beier (1995) observed that pumas dispersing during nighttime in California readily approached highways, but they usually stopped 150-300 feet short of a freeway and would wait until the following evening to cross the freeway or would turn back in the direction from which they came. Divided highways with four or more lanes are more likely to be barriers to movements of large carnivores, but secondary and unpaved roads often have little or no impact on the movements of larger animals (Belden and Hagedorn 1993, Forman et al. 2003, Dickson et al. 2005). Smaller animals may be more affected by roadway width than number of lanes or volume of traffic. A primary concern is whether or not highways are barriers to movement to the extent that populations become isolated, leading to genetic effects such as loss of genetic founders and inbreeding depression (Forman et al. 2003). Although there is no evidence that highways form a complete barrier to the movements of any wildlife species in Florida, strategically located wildlife crossings may effectively maintain landscape connectivity for some species.

3.0 Categories of Wildlife

Species of wildlife generally fall into one of three categories for purposes of evaluating proposed projects for the potential need for wildlife crossings. The categories are based primarily on body size, home range size, and movement and dispersal patterns of terrestrial species. The size and type of wildlife crossing that may be needed at a given site will be a function of which category of focal species are to be served by the crossing. The three categories of wildlife are: (1) large mammals, (2) mid-sized mammals, and (3) amphibians, reptiles and small mammals.

3.1 Large Mammals

Large mammals whose movements may need to be accommodated as new highways are planned or existing roads are upgraded in Florida include the Florida panther, Florida black bear, and white-tailed deer (*Odocoileus virginianus*). The Florida panther and Florida black bear are of particular concern because of their listed status, small populations, and need for large connected landscapes.

3.2 Mid-sized Mammals

Mid-sized mammals in Florida include bobcat (*Lynx rufus*), river otter (*Lontra canadensis*), gray fox *(Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*), coyote (*Canis latrans*), opossum (*Didelphis marsupialis*), raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*).

3.3 Amphibians, Reptiles, and Small Mammals

Examples of Florida amphibians, reptiles, and small mammals using wildlife crossings include southern leopard frog (*Rana utricularia*), green tree frog (*Hyla cinerea*), cottonmouth (*Agkistrodon piscivorus*), snapping turtle (*Chelydra serpentina*), striped mud turtle (*Kinosternon baurii*), Florida cooter (*Pseudemys floridana*), American alligator (*Alligator mississippiensis*), American crocodile, eastern cottontail (*Sylvilagus floridana*), round-tailed muskrat (*Neofiber alleni*), cotton rat (*Sigmodon hispidus*), rice rat (*Oryzomys palustris*), and cotton mouse (*Peromyscus gossypinus*).

4.0 Types of Wildlife Crossings

Researchers from Florida and various locations around the world have investigated wildlife use of wildlife crossings of various types, sizes, and configurations. Types of crossings typically considered successful at maintaining connectivity across highway corridors fall into six general types: (1) wide maintained highway shoulders, (2) bridges, (3) large or small rectangular box culverts, (4) multi-plate arches, (5) small circular culverts that function as wildlife pipes or amphibian tunnels, and (6) ecopassages which combine various sizes of crossings with barrier walls (Forman et al. 2003, Ruediger and DiGiorgio 2007). Modifications may be made to these basic types to accommodate site-specific features and the needs of the focal species that occur at a given crossing location. Fabricated or constructed types of wildlife crossings are expensive to install, especially if being retrofitted into an existing major roadway. Therefore, it is important to first determine whether a wildlife crossing is needed and then to determine the appropriate type of crossing to install. Provision and maintenance of wide road shoulders to maximize visibility of both wildlife and motorists can be a very effective type of crossing where many species of wildlife may be expected to cross a transportation corridor at non-specific locations. Large wildlife crossings may be designed as an overpass or underpass, depending on local topography and the presence of existing roads, or structures that are installed in wet areas may need to incorporate some form of dry passage that allows wildlife to move through the crossing during periods of high water. Chain link fencing or some type of low-profile barrier wall may be needed to prevent animals from entering the highway corridor and to direct animals to the crossing.

4.1 Wide Maintained Shoulders

Wide shoulders that are maintained along transportation corridors to maximize visibility and maneuverability of wildlife and motorists can be a very effective type of wildlife crossing where highways bisect natural areas of continuous and similar habitat type. These areas typically are of common elevation and cover type, and wildlife of various species and sizes move through the areas and cross the transportation corridor at non-specific locations. These factors make it difficult, if not impractical, to select an appropriate type of structural solution for a crossing, to identify suitable locations for crossings, and to install a structure. Wide-shoulder wildlife crossings need not be limited to specific areas. They can be maintained along highways that traverse expansive natural areas, conservation areas, and preserves and can successfully minimize the occurrence of wildlife mortality on those roads. The visibility provided with wide shoulders also improves safety for motorists by improving the motorist's opportunity to react and avoid collisions with large mammals. Signs should be installed to identify corridor segments where this type of wildlife crossing is maintained and to inform motorists that wildlife may be encountered. It may also be necessary to install lighting and enforce reduced speed limits through high-risk areas.

4.2 Bridges

Bridges that are intended to function as wildlife crossings generally are large structures typically built to span wide rivers, streams, and wetlands; span upland landscapes where wildlife movements commonly occur; or they may be constructed to cross over existing highways. Bridges designed to allow animals to pass beneath them are referred to as *underpasses* whereas bridges that are designed specifically to accommodate wildlife movements over a transportation corridor, such as an existing highway, are referred to as *overpasses*. The actual dimensions for construction of a bridge at a given site are usually determined by site-specific conditions.

4.2.1 Underpasses

Perhaps the best example of the use of bridges as wildlife underpasses in Florida is along Interstate 75 (I-75) in Collier County (Figure 1). It became clear during project planning that highway mortality of Florida panthers on the existing two-lane highway was a threat to the survival of the endangered population, and that steps should be taken to accommodate panther movements within the landscape that would be crossed by the proposed interstate (Logan and Evink 1985). A series of 38 bridges was planned and constructed at selected sites within the landscape to safely accommodate continued movements of Florida panthers under this transportation corridor. These bridges were 120 feet wide, 8 feet high, and 120 feet long, and a dirt substrate was maintained as the bottom of the crossings at grade elevation. The locations for these bridges were determined based on criteria that were developed from site-specific knowledge of habitats used by panthers in the region. They have been successfully used by Florida panthers and other species of wildlife including Florida black bears, white-tailed deer, bobcats, and raccoons (Foster and Humphrey 1995, Land and Lotz 1996, Evink 2002). These bridges were very expensive to install, and subsequent research has demonstrated that bridges of smaller dimensions will accommodate movements of panthers and other large species of wildlife (Land and Lotz 1996).

4.2.2 Overpasses

The Cross Florida Greenway Land Bridge over I-75 in Marion County is one of the best examples of an overpass in Florida. The Land Bridge was designed primarily as a recreational facility to allow hikers, cyclists, and equestrians to safely cross over six lanes of traffic where I-75 bisects the publicly owned Cross Florida Greenway. Potential use of the overpass by wildlife also was touted as a benefit of the Land Bridge, but was not a primary consideration in the planning for this structure. The Land Bridge is 52.5 feet wide and 200 feet long with an additional 400 feet of ramps on either end. Irrigated, 4.5-foot deep planters were installed along both sides of the overpass, and saw palmetto (*Serenoa repens*), Chickasaw plum (*Prunus angusifolia*), rusty lyonia (*Lyonia ferruginea*), and yellow hawthorn (*Crataegus flava*) were planted for landscaping. A similar land bridge dedicated to equestrian, hiking, and wildlife use spans six lanes of Interstate 95 (I-95) in Flagler County, Florida, and connects Pellicer Creek Corridor and Florida Agricultural Museum lands on either side of the highway. Overpasses specifically designed for wildlife have been installed over the Trans-Canada Highway in Banff National Park to accommodate the movements of grizzly bears (*Ursus arctos horribilis*), wolves (*Canis lupus*), and large ungulates, but these structures are very expensive and not warranted for all species (Ruediger 2007).

4.3 Large Rectangular Concrete Box Culverts

Large prefabricated concrete box culverts have been installed under several two-lane roads in Florida, including State Road (SR) 29 in Collier County and SR 46 in Seminole County (Figure 2). These structures function as underpasses, and the design has proven successful in accommodating the movements of large mammals, including Florida panthers, Florida black bears, bobcats, and white-tailed deer (Land and Lotz 1996, Roof and Wooding 1996, Evink 2002). These large concrete culverts are 8 feet high, 24 feet wide, and 47 feet long (i.e., from roadside to roadside), and they have a dirt substrate at grade elevation. Large box culverts also have been successfully used by other species of wildlife, including alligators, wild turkey (*Meleagris gallopavo*), rabbits (*Sylvilagus* spp.), raccoons, nine-banded armadillos (*Dasypus novemcinctus*), and gray foxes (Land and Lotz 1996, Walker and Baber 2003).

4.4 Multi-Plate Arches

Multi-plate arches are constructed using curved steel plates or occasionally cement arches, which are usually hauled to a site and assembled (Ruediger and DiGiorgio 2007). These structures have been used in the western United States for large carnivores such as black bear, mountain lion, and grizzly bears, as well as deer and elk (*Cervus canadensis*). Multi-plate arches with a height of 10 feet and a width of 20+ feet have been recommended as suitable for black bears and mountain lions in the western U.S. (Ruediger and DiGiorgio 2007). Multi-plate arches have the advantage of being less expensive to install than large concrete box culverts. A multi-plate wildlife crossing designed with a height of 7 feet and a width of 24 feet and incorporating features of both large concrete box culverts and multi-plate arches will soon be constructed to reduce road mortalities of Florida panthers along a segment of County Road (CR) 846 in Collier County, Florida.

4.5 Small Wildlife Culverts

Wildlife culverts are designed to accommodate movements of small to medium-sized mammals typically in locations where water may also flow beneath a road (Forman et al. 2003). Wildlife culverts intended for these species should have a diameter of 48 inches (Forman et al. 2003, Ruediger and DiGiorgio 2007). Wildlife culverts should incorporate a 1.3-foot wide raised ledge on each side of the central water channel to facilitate animal movements during periods of high water; however, the ledges may be submerged for short periods of time during high flow events (Forman et al. 2003). Culverts in north Florida with heights of ≤5 feet received greater use by mid-sized mammals (e.g., raccoons, armadillos, opossums), small mammals, and herpetofauna than culverts with higher ceilings (Smith 2003). Ruediger and DiGiorgio (2007) recommend that culverts should have a diameter ≥48 inches to accommodate bobcats and coyotes in the southern Rocky Mountain region, and culvert diameters of >36 inches should be sufficient to allow use by small carnivores such as mink (*Mustela vison*), river otters, striped skunks, red fox, gray fox, and opossum.

4.5.1 Wildlife Pipes

Wildlife pipes are small tunnels placed in dry locations without flowing water. They are designed to accommodate movements of small to medium-sized mammals in dry habitats. Wildlife pipes are typically 12 to 16 inches in diameter, but pipes up to 3 feet in diameter have been used for otters in the United Kingdom (Forman et al. 2003).

4.5.2 Amphibian Tunnels

Amphibian tunnels are widely used in Europe where annual amphibian migrations to and from breeding sites may be blocked by roads (Forman et al. 2003). Amphibian tunnels typically have a diameter of 1.0-3.3 feet for lengths that are less than 66 feet, but tunnels with a diameter of 5 feet may be employed for lengths greater than 164 feet.

4.6 Ecopassages

Ecopassages are designed to reduce highway mortalities suffered by multiple species, including reptiles, amphibians, and small mammals. They typically consist of a barrier wall combined with one or more small culverts, box culverts, or bridges of varying sizes. The barrier wall functions to prevent terrestrial species of amphibians and reptiles from reaching a road surface, to direct animals to wildlife crossing entrances, and to allow animals to pass beneath the road from one side to the other. The best known example of an ecopassage in Florida is along U.S. 441 through Paynes Prairie south of Gainesville (Figure 3). The Paynes Prairie Ecopassage consists of a concrete barrier wall that is 3.5 feet high and extends for 1.8 miles along either side of U.S. 441. A key feature of the wall is a 6-inch lip along the top that prevents reptiles and amphibians from scaling and crossing the wall. The wall also incorporates two 8-foot–by-8-foot partially submerged concrete box culverts, two 6–foot-by-6-foot usually dry box culverts, and four round culverts with a diameter of 3 feet to allow animals to pass beneath the road. This design has successfully reduced highway mortality for many species on the segment of U.S. 441 that passes through Paynes Prairie (Barichivich and Dodd 2002).

4.7 Fencing and Barriers

Most wildlife crossings, particularly those for large and mid-sized carnivores, include fencing along both sides of a road to direct animals to the crossing and to prevent animals from accessing the road (Figure 4). Fencing dimensions are usually determined based on site-specific circumstances. Fencing for panther underpasses along I-75 and for bear or panther underpasses along SR 29 and SR 46 consisted of 10-foot high chain link fence with an outrigger along the top consisting of three-strand barbed wire to deter animals from climbing over the fence (Land and Lotz 1996). The length of fencing needed along either side of the road is a function of the habitat types and configurations along either side of the road. For example, narrow forested wetland corridors through open pasturelands may need to be fenced for a relatively short distance beyond the edge of forest. However, wildlife crossings located in areas with wide habitat features such as broad swamps may require longer fencing. Barrier walls are most suitable along roads that pass through low herbaceous wetlands systems and where highway mortality of reptiles and amphibians is high.

5.0 Selection of Sites for Wildlife Crossings

Site selection for wildlife crossings must be strategically determined to successfully reduce highway mortality and reduce safety hazards for motorists. Several types of data, information, and criteria are available for determining when and where wildlife crossings should be constructed.

5.1 Aerial Photography

Digital aerial photography is widely available in either GIS format or though internet-based imagery such as Google Earth. A review of aerial photography will reveal vegetation patterns and types, locations of housing and other human developments, and the presence of water bodies. Wildlife crossings typically incorporate natural vegetative features, particularly where roads cross vegetated corridors, and they avoid developed lands and water bodies.

5.2 Land Ownership Maps

The Florida Department of Transportation and other governmental agencies involved in road construction will not approve funds for construction of wildlife crossings in areas where the lands on both sides of the road have not been secured by some form of legal protection, such as fee simple public ownership or a dedicated conservation easement. Therefore, maps of land ownership should be reviewed to select locations where lands on both sides of a proposed crossing can be protected by some form of public ownership. This information may also reveal sites where there are opportunities to work with willing private landowners to dedicate land to conservation use in areas where a wildlife crossing is needed.

5.3 Vegetation Maps

Many species of wildlife typically occur in specific vegetation types. Therefore, knowledge of the vegetation types in candidate areas for wildlife crossings is needed. This information is readily available in GIS format from the several sources. Land use (i.e., human uses of the land) and land cover (i.e., natural and disturbed vegetation types) data are available for download in vector format from Florida's five Water Management Districts. Minimum mapping units (MMU) are 5 acres for uplands and 0.5 acre for wetlands in all areas except south Florida where the MMU for wetlands is 2.0 acres. Map dates range from 1995 in north Florida to 2004-2006 in peninsular Florida. The Florida Fish and Wildlife Conservation Commission (FWC) also distributes land use/land cover data for Florida in raster format. The FWC data contain 43 cover classes statewide and are derived from 2003 Landsat satellite imagery with a 30m resolution (Kautz et al. 2007). This type of information is useful in selecting sites where natural vegetative corridors intersect a roadway.

5.4 Wildlife Range Maps, Habitat Models, and Least Cost Path Models

Wildlife range maps, habitat models, and least-cost-path models can be very useful for determining locations where wildlife crossings may be appropriate for certain species, particularly wide-ranging species such as the Florida panther and Florida black bear. The range of the Florida panther in south Florida is generally well known and mapped, including an optimal dispersal pathway out of south Florida (Kautz et al. 2006), and habitat models have identified areas of south central Florida that are candidate areas for reintroduction of panthers (Thatcher et al. 2006). This information has been used by the U.S. Fish and Wildlife Service (USFWS) to define the Panther Focus Area (Figure 5), a map that provides consultation guidance to federal agencies with regulatory authority over proposed projects. Least-cost-path models have been used to determine the paths most likely used by panthers moving about south Florida (Swanson et al. 2008), from public lands in south Florida to large patches of potential habitat on public lands in central Florida (Kautz et al. 2006), and between potential reintroduction sites in central Florida (Thatcher et al. 2006). Logan and Kautz (2006) have reviewed this information in the context of documented panther highway mortalities to recommend candidate locations for wildlife crossings for panthers in Collier County, Florida.

The primary and secondary ranges of black bear populations in Florida have been mapped in GIS format by Simek et al. (2005), and these maps have been updated to 2008 (FWC, unpublished data) (Figure 6). Hoctor (2006) produced a statewide model of black bear habitat suitability, and least-cost-path models have been used to identify the best landscape connections for black bears between Chassahowitzka National Wildlife Refuge and public lands in the interior of the peninsula (Larkin et al. 2004). Principal areas where highway mortalities of Florida black bears routinely occur also have been identified (Gilbert et al. 2001, Simek et al. 2005).

A review of this information would be very helpful in selecting locations where construction of wildlife crossings may be appropriate for the Florida panther and Florida black bear.

5.5 Wildlife Database Review

The Florida Natural Areas Inventory maintains a statewide database of documented occurrences of rare and imperiled plants, animals, and natural communities. FWC maintains a statewide database of documented observations of nongame species of wildlife. FWC also maintains a database of models of habitats potentially suitable for many species of rare and imperiled wildlife. A review of this information would be very useful in determining specific locations for wildlife crossings intended to accommodate selected species.

5.6 Roadkill and Track Count Surveys

Field work may be necessary to determine the best locations for wildlife crossings based on studies of the occurrences and locations of highway mortality and wildlife use of roadside edges. Studies can be designed to inventory the species and numbers of individuals killed in collisions with motor vehicles along specific segments of highways being evaluated for installation of wildlife crossings. Tracks counts of species using roadside edges can be performed by herbiciding the edges of existing roads, disking to mineral soil, and counting the number of tracks of each species. Locations where the greatest number of tracks occurs may be the best places for a wildlife crossing. These data will also be necessary to determine appropriate wildlife crossing designs for installation. These types of surveys have been used to assess highway mortality hot spots for Florida black bears along SR 40 in the Ocala National Forest (McCown et al. 2004), adjacent to the wildlife crossing fence along SR 46 in Seminole County (Walker and Baber 2003), for multiple species of wildlife in eastern Collier County (Smith et al. 2006), and along SR 200 through Ross Prairie State Forest in Marion County (Smith and Voigt 2005).

5.7 Florida Department of Transportation Wildlife Crossing Guidelines

The Florida Department of Transportation (FDOT) has developed guidelines for determining the appropriateness of including wildlife crossings or exclusionary devices (e.g., fencing, walls, temporary barriers) on proposed highway projects. General wildlife-related criteria to be used in determining whether a crossing may be necessary include a scientific determination of need by FWC and/or the USFWS; demonstrated use of the area by the species of concern; documented evidence of highway mortality; crossing of a documented landscape level habitat linkage for the target species; occurrence in an area where motorist safety is an issue; and presence of public lands or lands under conservation easement on both sides of the road at the site of the proposed crossing. The FDOT recommends that the specific design (i.e., type, size, and location) of a wildlife crossing should be determined through coordination with FWC and/or USFWS. Criteria that should be utilized to determine crossing design include but are not limited to the following:

- The crossing cannot compromise any state or federal safety criteria.
- The crossing cannot restrict access to adjacent property owners.
- The crossing cannot negatively impact adjacent properties (e.g., provide access for people and/or wildlife to private properties where none presently exist).
- The crossing cannot have the potential to negatively impact existing drainage patterns or flood off-site properties.
- The crossing utilizes the most cost-feasible design for the species of concern.
- Significant additional habitat (e.g., upland and/or wetland) impacts cannot result from the construction of the crossing.
- The addition of the crossing cannot result in significant modifications to the proposed project (e.g., excessive increases in roadway grade).

6.0 Project Scale

The size and scope of a project will influence how the aforementioned data, information, and criteria are used for selecting sites and types of structures for wildlife crossings. Highway projects undertaken by federal, state, and local governments require planning for wildlife crossings from both regional and local perspectives to ensure that habitat connectivity and wildlife movements remain unimpeded to the extent practicable. Roads constructed as part of new development projects, however, may utilize more localized information gathered from environmental reviews and surveys performed on and adjacent to the development property in combination with data and information gleaned from the sources described above. Areas within developments where crossings should be considered include roads that traverse conservation areas and roads that cross on-site habitats that are linked to habitats off-site. The number, designs, and sizes of the structures appropriate for a given site are dependent on the species of wildlife that will potentially use the structure and natural features specific to the site. The structure installed in a given location may be designed and sized to facilitate continued wildlife movement, or it may be designed and sized to prohibit wildlife use if there are certain areas where specific species of wildlife may not be desired (e.g., bears near residential or commercial areas) or where wildlife may be subjected to undesirable disturbances and situations.

7.0 Summary

Highways may have significant ecological effects on wildlife and their habitats, and wildlife crossings are often proposed to ameliorate these effects during planning for construction of new highways or for improvements or retrofits to existing roads. Species of wildlife likely to benefit from wildlife crossings include large mammals; mid-sized mammals; and amphibians, reptiles, and small mammals. The locations, types, and sizes of crossing structures should be determined by assessing the needs of the species of concern and site-specific features of the landscape or project site. Highway design standards related to public safety, access to private lands, rate of change of roadway grade, and secondary impacts on drainage or flooding of off-site properties also influence the feasibility of constructing wildlife crossings.

Literature Cited

Barichivich, W. J. and C. K. Dodd, Jr. 2002. The effectiveness of wildlife barriers and underpasses on US highway 441 across Paynes Prairie State Preserve, Alachua County, Florida. Phase II post-construction final report. Florida Department of Transportation contract no. BB-854. U.S. Geological Survey, Florida Caribbean Science Center, Gainesville, FL.

Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. Journal of Wildlife Management 59(2):228-237.

Belden, R. C. and B. W. Hagedorn. 1993. Feasibility of translocating panthers into northern Florida. Journal of Wildlife Management 57(2):388-397.

Dickson, B. G., J. S. Jenness, and P. Beier. 2005. Influence of vegetation, topography, and roads on cougar movement in southern California. Journal of Wildlife Management 69(1):264-276.

Endries, M., G. Mohr, G. Kratimenos, S. Langley, B. Stys, K. Root, and R. Kautz. 2007. Wildlife habitat conservation needs in Florida: updated recommendations for strategic habitat conservation areas. Draft technical report. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Evink, G. 2002. Interaction between roadways and wildlife ecology. National Cooperative Highway Research Program synthesis 305, Transportation Research Board, Washington, DC.

Florida Fish and Wildlife Conservation Commission. 2006. Annual report on the research and management of Florida panthers: 2006-2007. Technical report. Fish and Wildlife Research Institute & Division of Habitat and Species Conservation, Naples, FL.

Florida Fish and Wildlife Conservation Commission. 2007. Annual report on the research and management of Florida panthers: 2005-2006. Technical report. Fish and Wildlife Research Institute & Division of Habitat and Species Conservation, Naples, FL.

Florida Fish and Wildlife Conservation Commission. 2008. Annual report on the research and management of Florida panthers: 2007-2008. Technical report. Fish and Wildlife Research Institute & Division of Habitat and Species Conservation, Naples, FL.

Forman, R. T. T., D. Sperling, J. A. Bissonette, A. P. Clevenger, C. D. Cutshall, V. H. Dale, L. Fahrig, R. France, C. R. Goldman, K. Heanue, J. A. Jones, F. J. Swanson, T. Turrentine, and T. C. Winter. 2003. Road ecology: science and solutions. Island Press, Washington, DC.

Foster, M. and S. Humphrey. 1995. Use of highway underpasses by Florida panthers and other wildlife. Wildlife Society Bulletin 23(1):95-100.

Gaby, R. 1987. Utilization of human-altered habitats by American crocodiles in southern Florida. *In* Odum, R. R., K. A. Riddleberger, and J. C. Ozier, editors. Proceedings of the third southeastern nongame and endangered wildlife. University of Georgia, Athens, GA.

Gilbert, T., R. Kautz, T. Eason, R. Kawula, and C. Morea. 2001. Prioritization of statewide roadkill problem areas in Florida. Pages 574-579 *in* Proceedings of the 2001 International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC.

Hilty, J. A., W. Z. Lidicker, Jr., and A. M. Merenlender. 2006. Corridor ecology: the science and practice of linking landscapes for biodiversity conservation.

Hoctor, T. 2006. Developing updated statewide potential habitat and habitat significance maps for the Florida black bear. Unpublished technical report. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Jackson, S. D. 1999. Overview of transportation related wildlife problems. Unnumbered pages *in* Evink, G. L., P. Garrett, and D. Zeigler, editors. Proceedings of the third international conference on wildlife ecology and transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC.

Kautz, R., R. Kawula, T. Hoctor, J. Comiskey, D. Jansen, D. Jennings, J. Kasbohm, F. Mazzotti, R. McBride, L. Richardson, and K. Root. 2006. How much is enough? Landscape-scale conservation for the Florida panther. Biological Conservation 130:118-133.

Kautz, R., B. Stys, and R. Kawula. 2007. Florida vegetation 2003 and land use change between 1985-89 and 2003. Florida Scientist 70(1):12-23.

Land, D. and M. Lotz. 1996. Wildlife crossing designs and use by Florida panthers and other wildlife in southwest Florida. *In* Evink, G., P. Garrett, D. Zeigler, and J. Berry (editors). Trends in addressing transportation related wildlife mortality. Florida Department of Transportation, Tallahassee, FL.

Land, D., M. Cunningham, R. McBride, D. Shindle, and M. Lotz. 2002. Annual report: Florida panther genetic restoration and management 2001-2002. Technical report. Florida Fish and Wildlife Conservation Commission, Naples, FL.

Land, D., D. Shindle, M. Cunningham, M. Lotz, and B. Ferree. 2004. Annual report: Florida panther genetic restoration and management 2003-2004. Technical report. Florida Fish and Wildlife Conservation Commission, Naples, FL.

Larkin, J. L., D. S. Maehr, T. S. Hoctor, M. A. Orlando, and K. Whitney. 2004. Landscape linkages and conservation planning for the black bear in west-central Florida. Animal Conservation 7:1-12.

Lindenmayer, D. B. and J. Fischer. 2003. Habitat fragmentation and landscape change: an ecological and conservation synthesis. Island Press, Washington, DC.

Logan, T. and G. Evink. 1985. Safer travel for the Florida panther. Florida Naturalist 6(3/4):6-7.

Logan, T. H. and R. S. Kautz. 2006. Proposed functional habitat preservation concept to assist recovery of the Florida panther. Technical report. Breedlove, Dennis & Associates, Inc., Tallahassee, FL.

Lopez, R., M. E. P. Vierra, N. J. Silvy, P. A. Frank, S. W. Whisenant, and D. A. Jones. 2003. Survival, mortality, and life expectancy of Florida key deer. Journal of Wildlife Management 67:34-45.

Lotz, M., D. Land, M. Cunningham, and B. Ferree. 2005. Florida panther annual report 2004-2005. Technical report. Florida Fish and Wildlife Conservation Commission, Naples, FL.

McBride, R. T., R. T. McBride, R. M. McBride, and C. E. McBride. 2008. Counting pumas by categorizing physical evidence. Southeastern Naturalist 7(3):381-400.

McCown, W., P. Kubilis, T. Eason, and B. Scheick. 2004. Black bear movements and habitat use relative to roads in Ocala National Forest. Final report, contract no. BD-016. Florida Fish and Wildlife Conservation Commission, Gainesville, FL.

Mumme, R. L., S. J. Schoech, G. E. Woolfenden, and J. W. Fitzpatrick. 2000. Life and death in the fast lane: demographic consequences of road mortality in the Florida scrub-jay. Conservation Biology 14(2):501-512.

Noss, R. F. and A. Y. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Island Press, Washington, DC.

Parker, I. D., A. W. Braden, R. R. Lopez, N. J. Silvy, D. S. Davis, and C. B. Owen. 2007. Effects of a highway improvement project on Florida key deer. Page 615 *in* Irwin, C. L., D. Nelson, and K. P. McDermott, editors. Proceedings of the 2007 International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC.

Roof, J. and J. Wooding. 1996. Evaluation of SR 46 wildlife crossing in Lake County, Florida. *In* Evink, G., P. Garrett, D. Zeigler, and J. Berry (editors). Trends in addressing transportation related wildlife mortality. Florida Department of Transportation, Tallahassee, FL.

Ruediger, B. and M. DiGiorgio. 2003. Safe passage: a user's guide to developing effective highway crossings for carnivores and other wildlife. Technical report. www.CarnivoreSafePassage.org.

Shindle, D., D. Land, M. Cunningham, and M. Lotz. 2001. Annual report: Florida panther genetic restoration and management 2000-2001. Technical report. Florida Fish and Wildlife Conservation Commission, Naples, FL.

Shindle, D., M. Cunningham, D. Land, R. McBride, M. Lotz, and B. Ferree. 2003. Annual report: Florida panther genetic restoration and management 2002-2003. Technical report. Florida Fish and Wildlife Conservation Commission, Naples, FL.

Simek, S. L., S. A. Jonker, B. K. Scheick, M. J. Endries, and T. H. Eason. 2005a. Statewide assessment of road impacts on bears in six study areas in Florida from May 2001 – September 2003. Final report for contract BC-972, Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Simek, S. L., S. A. Jonker, and M. J. Endries. 2005b. Evaluation of principal roadkill areas for Florida black bear. Pages 279-286 *in* Erwin, C. L., P. Garrett, and K. P. McDermott, editors. Proceedings of the 2005 International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC.

Smith, D. J. 2003. Ecological effects of roads: theory, analysis, management, and planning considerations. Ph.D. dissertation. University of Florida, Gainesville, FL.

Smith, D. J. 2003. Monitoring wildlife use and determining standards for culvert design. Final report, contract BC354-34, Florida Department of Transportation, Tallahassee, FL.

Smith, D. J., R. F. Noss, and M. B. Main. 2006. East Collier County wildlife movement study: SR 29, CR 846, and CR 858 crossing project. Unpublished report. University of Central Florida, Orlando, FL.

Smith, D. J. and M. Voigt. 2005. SR 200 wildlife impact study. Final report for contract no. BD354-74 submitted to Florida Department of Transportation, Tallahassee, FL.

Swanson, K., D. Land, R. Kautz, and R. Kawula. 2008. Use of least-cost pathways to identify key road segments for Florida panther conservation. Florida Wildlife Research Institute technical report TR-13, Florida Fish and Wildlife Conservation Commission, St. Petersburg, FL.

Thatcher, C. A., F. T. Van Manen, and J. D. Clark. 2006. An assessment of habitat north of the Caloosahatchee River for Florida panthers. Final report, submitted to U.S. Fish and Wildlife Service, Ecological Services Office, Vero Beach, FL.

Walker, G. and J. A. Baber. 2003. Wildlife use and interactions with structures constructed to minimize vehicle collisions and animal mortality along State Road 46, Lake County, Florida. Final report, contract no. BD-162. Florida Department of Environmental Protection, Division of Recreation and Parks, Apopka, FL.

Wilcove, D. S., C. H. McLellan, and A. P. Dobson. 1986. Habitat fragmentation in the temperate zone. Pages 237-256 *in* Soule, M. E., editor. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Inc., Sunderland, MA.

Figure 1. Panther underpass along I-75 (Alligator Alley) in Collier County, Florida.

Figure 2. Prefabricated concrete box culvert along SR 46 in Seminole County, Florida.

Figure 3. Barrier wall and wildlife culvert comprising Paynes Prairie Ecopassage along US 441 in Alachua County, Florida.

Figure 4. An example of fencing used at a wildlife underpass along Suncoast Parkway in Pasco County, Florida.

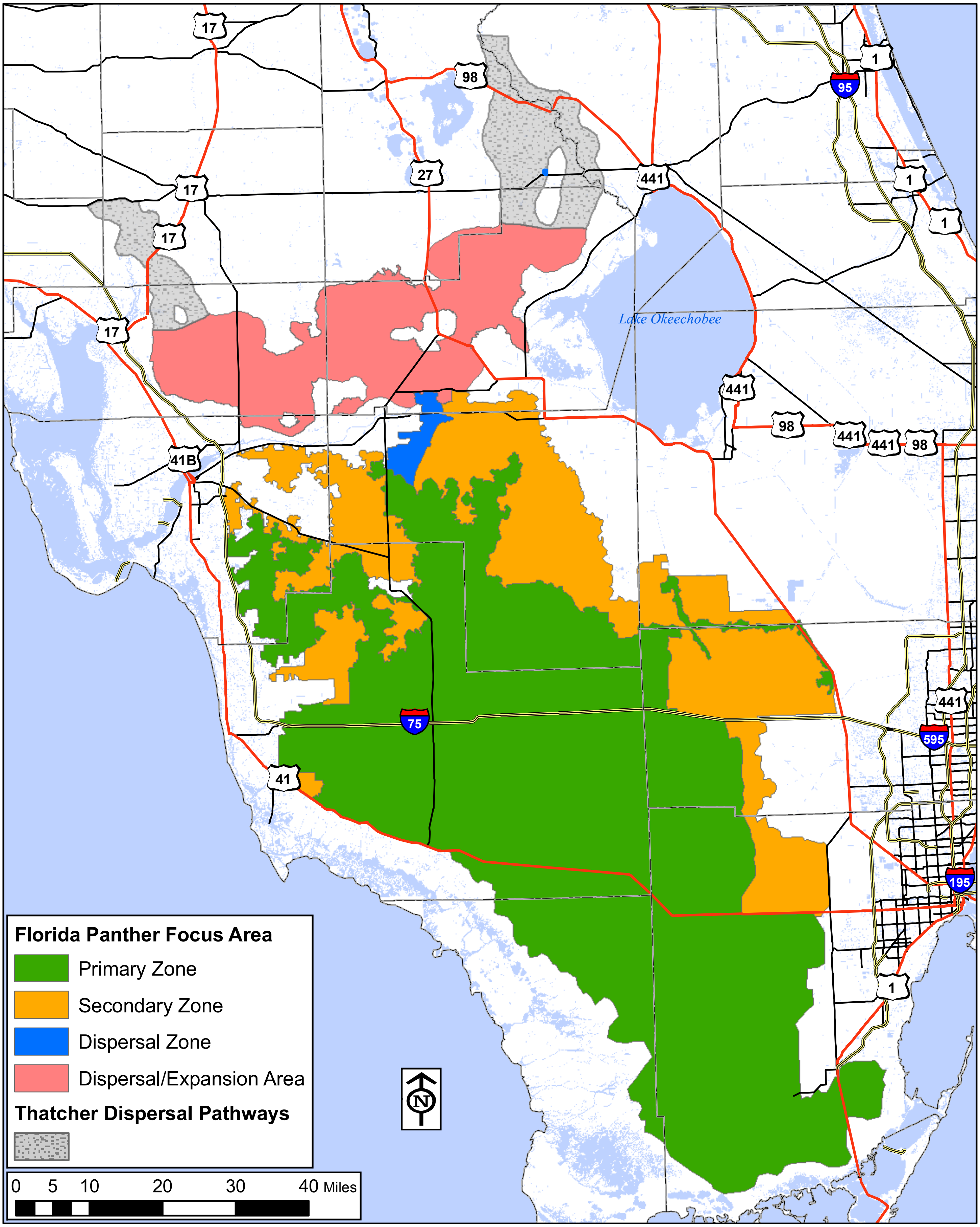

Figure 5. USFWS Florida Panther Focus Area and Thatcher Model Dispersal Pathways used to determine which projects may require consultation for impacts on Florida panthers and their habitats.

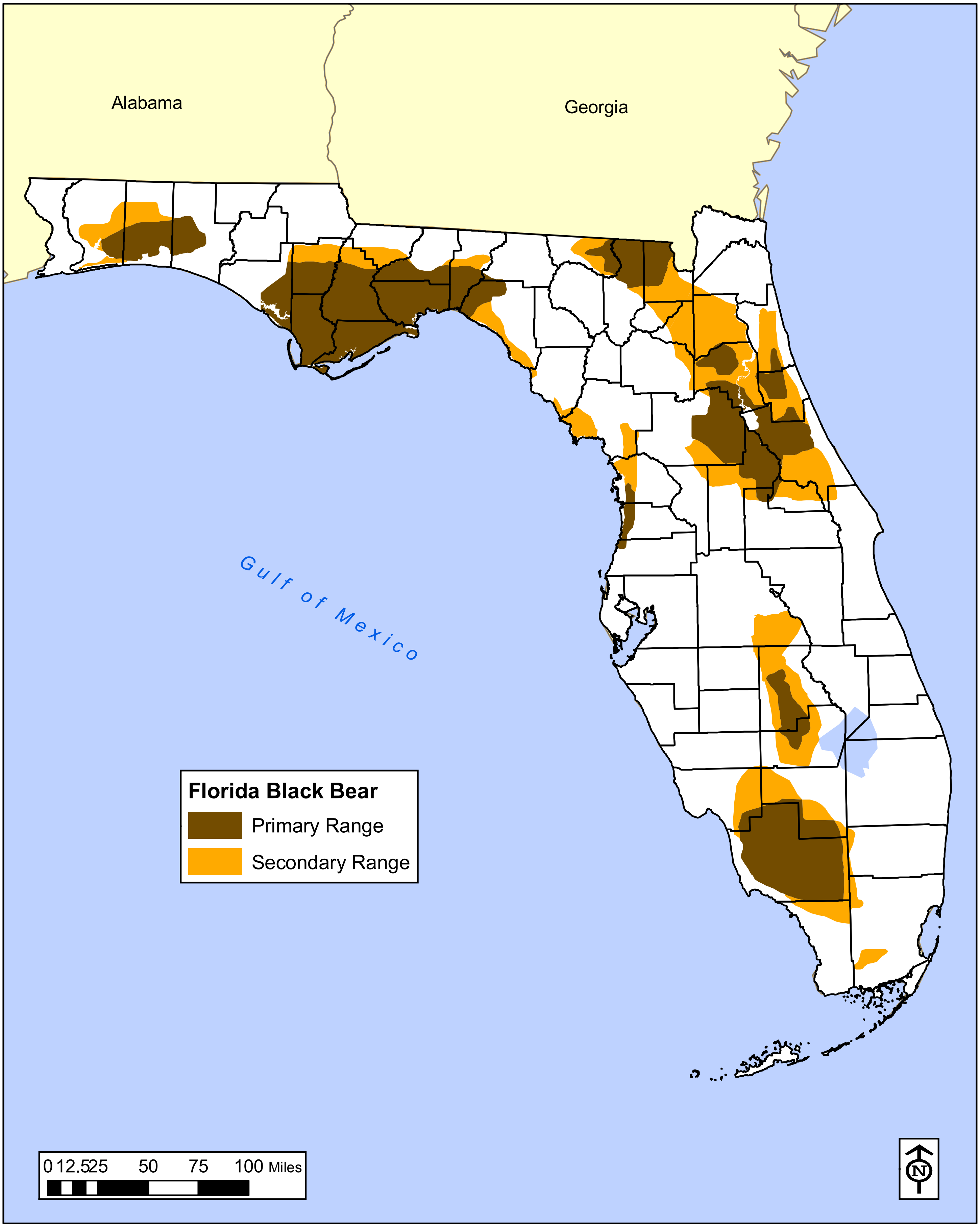

Figure 6. Primary and Secondary Ranges of the Florida Black Bear as mapped by the Florida Fish and Wildlife Conservation Commission in 2008.