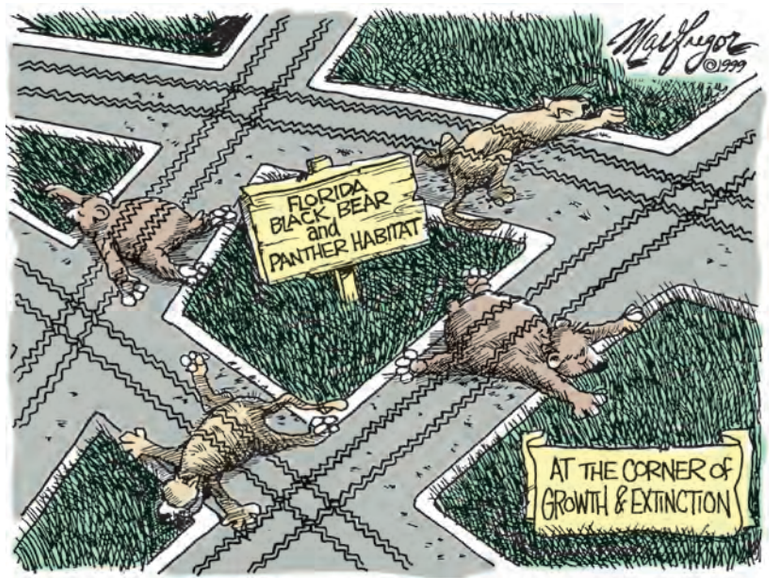
Chapter 8

Planning for Transportation Facilities and Wildlife

Photo Courtesy of David Moynahan

This chapter presents information and guidelines to assist in accommodating wildlife and habitat permeability and sustainability along Florida's roadways. The decision of how, when, and where to incorporate structures for wildlife linkages and maintaining habitat permeability must be based on scientific evidence. They benefit by being done with the cooperation and coordination from resource agencies, conservation experts, the Florida Department of Transportation (FDOT), local transportation authorities, and other interested entities.



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GUIDELINES FOR ACCOMMODATING WILDLIFE

Roads as obstacles to animal movement can be a major determinant of functional connectivity across landscapes. With this realization, roadway projects at many scales (national, state, regional or local) are beginning to incorporate designs for the maintenance of wildlife movement and habitat permeability. Roads, highways and their related facilities (e.g., stormwater management areas, or entrance and exit features) are prominent parts of the modern landscape and subdivide and fragment Florida habitats. Further, each road's environmental footprint can extend far beyond the edge of pavement–the "road-effect zone" is estimated to be 15 to 20 times as large as the actual paved right of way. In these regards, roads impact wildlife habitats and rural areas beyond just direct impacts.

While few people dispute the need to avoid or minimize roadway-wildlife interactions, it has not always been easy obtaining consensus on how to achieve this goal. Decisions regarding wildlife accommodations in planning transportation infrastructure must be based on careful consideration of relevant ecological, safety, engineering, financial, and regulatory concerns associated with an area and project. Each stakeholder in the process has a viewpoint that must be understood, although not necessarily agreed to, by all other stakeholders. It is important that questions of sustaining or restoring wildlife habitat connections are raised early in the transportation facility planning process.

As Florida's resident and visitor populations continue to expand, an increasing network of roadways is being planned and constructed to accommodate this growth. The majority of these roadway improvements include adding additional lanes on existing roadway to increase vehicle capacity; however, new roads are being planned and constructed in areas where locally-approved development is projected or occurring. As development and transportation projects occur in Florida, it is important to implement measures that will both serve public safety and sustain Florida's wildlife. To maintain Florida's rich diversity of wildlife, attention must be directed to local, regional, and state road building projects to reduce wildlife damaging impacts, including roadkill, displacement, and habitat fragmentation. Solutions to address these wildlife sustainability and traffic safety concerns may range from reducing speed limits and adding cautionary signage,

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The need for establishing a wildlife linkage along an existing or proposed roadway may seem straightforward, but can be clouded by conflicting viewpoints and goals among interested parties and project stakeholders. The need for a wildlife linkage should always be based on relevant scientific data and facts.

Photo Courtesy of Dan Pennington, 1000 Friends of Florida

State Road 29 in Collier County impacts the Fakahatchee Strand. In addition to signage and warning lights, several wildlife underpasses have been constructed and directional fencing provided.

Photo Courtesy of Florida Department of Transportation

Exclusionary fencing keeps animals from wandering onto roads.

to designing and building more habitat and wildlife linkage features for new facilities, to working to retrofit older facilities to incorporate wildlife friendly designs. The term "wildlife linkage" is used to describe the crossing structure, including associated components such as directional fencing or barrier walls, and the immediately adjacent habitat corridor on both sides of the roadway.

IDENTIFYING THE NEED AND GOALS FOR WILDLIFE LINKAGES

The need for establishing a wildlife linkage along an existing or proposed roadway may seem straightforward, but can be clouded by conflicting viewpoints and goals among interested parties and project stakeholders. The need for a wildlife linkage should always be based on relevant scientific data and facts. If construction of a crossing is warranted following an analysis of the data, the goal of the linkage is then defined. The goal establishes the benchmark by which the success of the linkage can be measured. But first, let's look at how the need for a wildlife linkage should be determined.

What Data are Available to Support the Need? – It is necessary to document the need for the wildlife linkage with scientifically valid data or evidence. The purpose of documenting the need is to ensure the linkage is designed and located in a manner that will maximize its success in meeting the established goal of the structure. Installing a structure because, "it seemed like a good idea," is a poor excuse and a waste of economic resources if target species don't occur in the area, or fail to use the crossing because of its location. The types of information that should be reviewed in assessing the need for a crossing may include:

- Identified chronic road-kill sites and carcass data.
- FDOT or local wildlife-vehicle crash data and law enforcement reports.
- Known wildlife migration/movement routes.
- Predictive modeling results and identified hot spots of focal species.

- Presence of listed, rare, endemic or species population of interest.
- Identified strategic habitat conservation areas.
- Riparian corridors.
- Designated greenways or presence of core conservation areas adjacent or nearby the project.
- Presence of separated required ecological resources for a species or set of species (e.g., a forest patch and ephemeral wetland breeding area for amphibians that are separated by a highway).
- Public ownership (or in public land acquisition programs or some permanent form of conservation or rural working lands designation) as opposed to private lands susceptible to development.
- Existing and future land-use on both sides of the roadway.
- Potential to be included in proposed road improvement project.

The data should be used to answer the following key questions in determining the need for a wildlife linkage:

- What are the ecological conditions that lead to the potential need for a wildlife linkage?
- What species would be affected by the presence or absence of a linkage?
- How would existing and future populations of these species be affected by the presence or absence of a linkage?
- How would the presence or absence of a linkage affect the safe passage of motorists on the highway?
- Instead of a linkage, would other wildlife accommodations be better suited to the situation (e.g., exclusionary fencing to prevent wildlife from crossing the road)?

The answers to each of these questions should be clearly documented in a technical memorandum or summary report with appendices containing the reviewed data and analysis process. This document then serves as the basis of decision for determining whether or not to proceed with planning, design, and construction of a wildlife crossing or other structure (e.g., exclusionary fencing, barrier wall, etc.).

What is the Goal of the Wildlife Linkage? – Once the need for a wildlife linkage has been determined, the central question that must be answered is: What are the goals of the structure(s)? It is not possible to consider the size, shape, and location of structures without first defining the purpose they are expected serve and what the desired outcomes are following construction. The goals should be well-defined and measurable where possible.

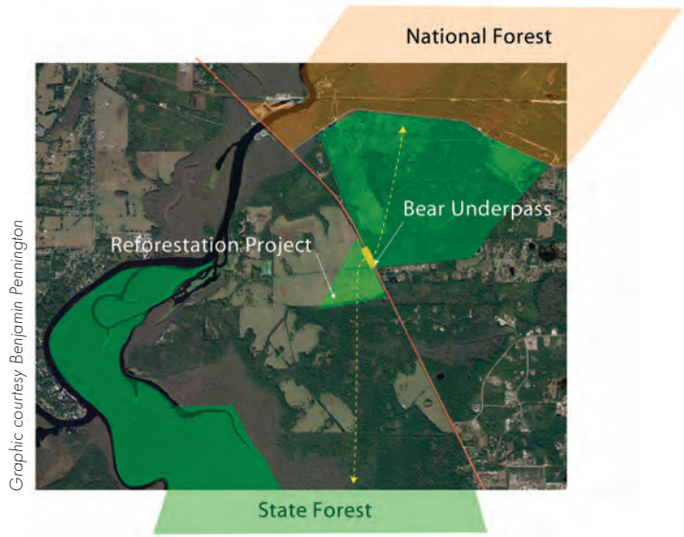
Goals of almost all wildlife linkages designed and constructed across transportation facilities originate from at least two important points of view; a human road use viewpoint and wildlife use and sustainability viewpoint. Each viewpoint needs to be considered. The human road use goals are often to reduce roadkill and thereby reduce the risk of wildlife-vehicle crashes with their resulting injuries, death and financial loss. The human viewpoint also includes a desire to conserve wildlife for our enjoyment and pleasure. From a wildlife use and sustainability perspective the goals are often to prevent individual road kill incidents, maintain or restore habitat permeability, decrease habitat and population fragmentation, and reduce direct habitat loss.

DESIGN CONSIDERATIONS FOR WILDLIFE LINKAGES

Much of the information used to justify the need for a wildlife linkage can also be used to assess the optimum design and location of the structure. As with the need for the crossing, scientifically valid data should be used to support the crossing's design

and location. Some important initial factors to consider include:

- Use by target species.
- Use by secondary or non-target species.
- Wildlife landscape and habitat linkage features.
- Specific location and design environmental factors of wildlife linkages.
- Long-term linkage sustainability (property ownership, conservation easements, etc.).
- Engineering and safety considerations.
- Costs.
- Monitoring and evaluation.
- Maintenance.



Graphic courtesy Benjamin Pennington

Hypothetical example showing a possible connection between two large conservation properties. As the highway is improved, a wildlife retrofit would strive to place an underpass, reforest a portion of pasture and install appropriate directional fencing to funnel wildlife to the underpass. Ownership out-right, or easements, of land on both sides of the highway facilitate the connection.

CASE STUDY
Wildlife Crossings in Florida

Although not the first state to install wildlife crossings, Florida is recognized as a national leader in the use of crossings to minimize roadway-wildlife interactions. FDOT initiatives to address roadway-wildlife interactions began in the early 1990s with the upgrading of SR 84 (Alligator Alley) to interstate standards. Following a Section 7 consultation under the Endangered Species Act, the FDOT constructed 23 wildlife crossings and 13 bridge extensions over dry land to allow the Florida panther and Florida black bear to safely cross the new four-lane roadway. No Florida panthers or black bears have been killed on Alligator Alley in the project area since completion of the project. This project was notable for both its use of multiple crossings and for targeting multiple species.

NOTABLE WILDLIFE CROSSINGS IN FLORIDA

Six-laning of I-4 in Volusia County – Based on the results of an Environmental Assessment in 2000, the FDOT designed two large wildlife underpasses and a wildlife overpass along a six-mile corridor of public lands in the area of Tiger Bay State Forest in Volusia County. Major issues addressed by this project included Florida black bear roadkills, habitat connectivity, impacts to public land, and direct and secondary habitat loss.

US 441 Crossing at Paynes Prairie State Preserve – The Payne's Prairie State Preserve is a unique wet prairie managed by the Florida Department of Environmental Protection. Thousands of reptiles and amphibians were being killed annually where US Highway 441 crosses the preserve. In 1999, a 3-foot high wildlife barrier wall and culvert underpass system was constructed to keep reptiles and amphibians off the highway and allow them to move under the road.

Photo Courtesy of Dan Pennington, 1000 Friends of Florida

Shown during very dry conditions, the Paynes Prairie box culvert wildlife crossing has an over-hanging upper lip to discourage crossing over the road.

Photo Courtesy of Dan Pennington, 1000 Friends of Florida

Wildlife crossing on State Road 29 is interesting in that on one side of the road is a canal. To allow access across the canal, and under the wildlife crossing, the designers constructed a small bridge. The bridge has white sand rather than concrete on the walkable area to encourage animals to cross and leave footprint evidence of usage. A sensor initiated camera is located under the underpass. And as evidenced by the April 2008 photo, the underpass functions as intended for panthers.

Photo Courtesy of Steve Homan

Concrete culverts designed as wildlife crossings for black bears on SR 46 between the Wekiva River State Park and Seminole State Forest in central Florida have high fencing to either side to funnel wildlife toward the underpass opening.

Photo Courtesy of FFWCC (panther surveillance photo)

SR 46 Bear Underpass in Lake County – Florida black bears were routinely being struck and killed by vehicles on SR 46 near County Road 433 as they crossed to habitat within central Florida's Wekiva River Basin. In 1994, FDOT constructed a dirt-floor box culvert 47 feet long by 24 feet wide by 8 feet high and planted pine trees in the open pasture on one side of the road to guide bears to the culvert. A second crossing was later added. Additionally, the FWC purchased a 40-acre private in-holding within Rock Springs Run State Park (RSRSP) to ensure preservation of the bears' travel corridor near the culvert. There are now two underpasses and bear movements have been recorded through both. Also, the second structure provides connectivity under the road for recently acquired additions to Seminole State Forest on the north side of the road. These crossings link Wekiva State Park and RSRSP to Seminole State Forest. This is part of the effort to maintain viable regional connections, between the Wekiva Basin and the Ocala National Forest to the north, for black bears as well as many other species of wildlife.

SR 29 Panther Crossings in Collier County – SR 29 in south-central Florida runs through prime Florida panther habitat. At least 23 panthers were killed on the highway between 1975 and 2005. Six wildlife crossings have been constructed along the highway in an effort to reduce roadway panther mortality. The two new crossings are 50 feet long and 8 feet high. Together, these six crossings allow panthers and other animals to move between Fakahatchee Strand State Forest and the Florida Panther National Wildlife Refuge on the west side of SR 29 and Big Cypress National Preserve on the east side of SR 29.

US 1 Key Deer Crossings on Big Pine Key – In 2002, the FDOT modified a 2.6 kilometer segment of US 1 to include fencing, experimental deer guards, and underpasses designed to prevent entry of Key deer onto the roadway. Post-construction monitoring showed a 95 percent reduction in Key deer-vehicle collisions by the second post-construction year.

The potential interactions among species should also be considered for placement and design of the crossing structure. Use of the passage system by predators may inhibit use by prey species. Careful study of the likely users of the structure and appropriate design features can minimize these interactions.

Use by Target Species – The target species is often the controlling factor in determining the type and size of the crossing structure. While no single design will accommodate all species at every crossing location, nearly three decades worth of crossing monitoring studies in the U.S. and Europe have revealed the following generalizations:

- Larger is generally better; however certain amphibians, reptiles, and small mammals may benefit from smaller diameter crossings.
- Most species prefer cover at both ends of the crossing. Other species require cover within the crossing.
- Natural lighting via a skylight in long crossings is preferred by most species but may repel certain reptiles or amphibians.
- To the maximum extent possible, crossing bottoms should mimic the substrate of the surrounding landscape.
- Crossings require fencing, barrier walls, or berms directing wildlife to the crossing entrance.
- The existence of conservation lands on both sides of the crossing is crucial to the long-term success of the crossing.

Data on the target species should also be used to support the location of the crossing. A properly designed crossing may not be used by the target species if it is not placed in an appropriate location. Telemetry recordings, least-cost pathways (travel/migration corridors), home range requirements, and life-cycle requirements of target species should all be used in assessing crossing location. For example, habitat use in the Everglades is dictated by the wet and dry seasons, with a more general use of the area during dry seasons. This was a consideration in measures to protect the Florida panther and other wildlife along Alligator Alley (I-75), where crossings were placed in the highway to allow wildlife movement to the drier northern areas during exceptionally wet years when habitat values were diminished in the area south of the interstate.

Use by Secondary Species – Although the target species should be one of the determining factors in selecting the size, shape, and location of a crossing, ideally, the crossing should also provide habitat connectivity to other species that occur in the area. A large box culvert with an open dirt bottom may be appropriate for the Florida black bear, but certain species of small rodents and amphibians may be reluctant to enter the structure because of the lack of cover and moisture. Providing hollow logs, stumps, stones (often called debris walls) and a shallow channel within the culvert and vegetative plantings near the entrances may greatly increase the use of the crossing by secondary species (this would not be appropriate in an area where no stream channel exists). Structures in dry areas should be constructed so that they do not contain the lowest elevation to the surroundings. Most importantly, characteristics in a structure should most closely mimic the adjacent habitat.

Remember that the "target species" may be amphibians and reptiles or small mammals, so primary design concerns may center on them instead of needs for bears and panthers. Crossing structure systems should be designed as multi-species conveyances and for ecosystem level benefits, not for a single species.

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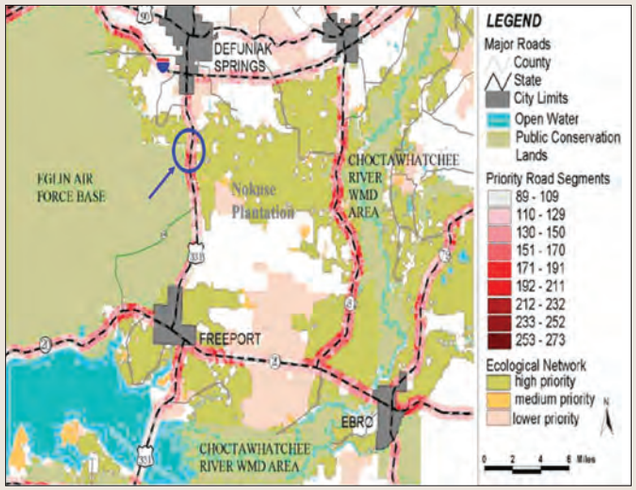
Wildlife Landscape and Habitat Linkage Features – The landscape and habitat features surrounding the roadway may have a profound effect on the success of the wildlife linkage. Landscape features include such variables as topography, hydrology, and vegetative habitats. Specific design criteria for wildlife linkages will always need to be made on a case-by-case basis since they must take into account site-specific landscape and habitat features variables (e.g., topography, hydrology, adjacent habitats and species of interest habitat characteristics, etc.). Nevertheless, initiating planning studies to determine the need

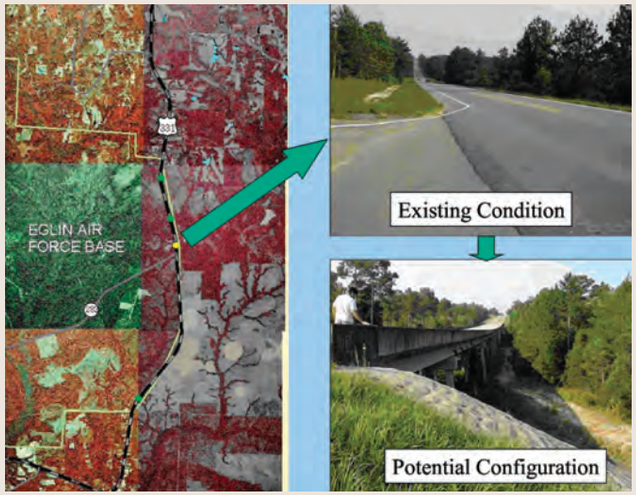
CASE STUDY

Planning for a Eglin-Nokuse Wildlife Linkage

US 331 is a major highway that bisects the combined Eglin-Nokuse conservation area. The average annual daily traffic level is about 11,000 vehicles. Rapid growth and development in the coastal areas of Walton County have recently highlighted the need to widen the road to four lanes for hurricane evacuation purposes. The researchers used a comprehensive approach that employed several methods to determine the current and potential impacts of US 331 on wildlife resources in the Nokuse-Eglin habitat corridor. These methods included roadkill and track surveys, mark-recapture and existing culvert wildlife use studies, and GIS analysis of habitat types and configuration. The study used each method to evaluate road impacts on different taxa and used this multi-species approach to determine effects of the road on presence and movement behavior for suites of wildlife (e.g., primarily carnivores, selected herptiles, and small mammals).

Source: Smith, Daniel J. Ph.D., Reed F. Noss, Ph.D., and Thomas S. Hoctor, Ph.D., 2005. US 331Wildlife Impact Study, Final Report.





Graphic courtesy of Daniel J. Smith, Ph.D

Highway 331 is just east of Eglin Air Force Base in North Florida. The circled area has the topography to allow altering the existing "at grade" wildlife linkage to a bridged linkage.

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In some instances likely or known interactions between particular wildlife species and planned or expanding transportation infrastructure are reasonably well known. This may be the case when wildlife populations of a particular umbrella species such as bear, panther, or gopher tortoises are already documented in an area and rely heavily on identified landscape features.

for wildlife linkages should proceed along at least two lines of rationale: (1) areas of known or likely wildlife transportation infrastructure interactions; and (2) ecological "hotspot" areas.

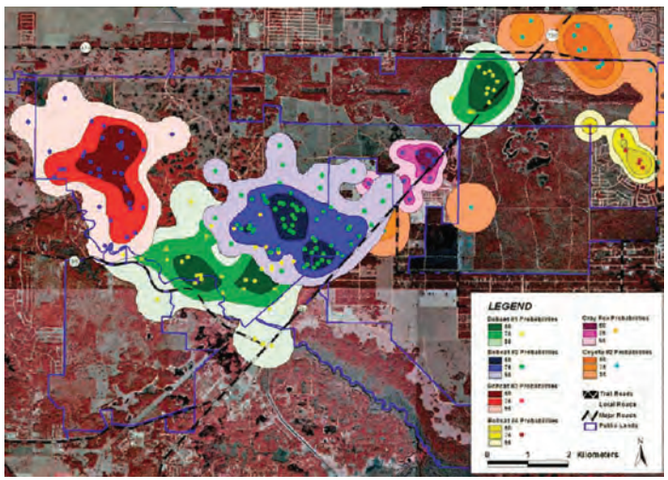
Areas of known or likely wildlife transportation infrastructure interactions – In some instances likely or known interactions between particular wildlife species and planned or expanding transportation infrastructure are reasonably well known. This may be the case when wildlife populations of a particular umbrella species such as bear, panther, or gopher tortoises are already documented in an area and rely heavily on identified landscape features. For example, existing data, public investment, and other factors made it clear that linkages for the Florida black bear needed to be a part the planned connection of the Orlando Beltway through the Wekiva Basin or, similarly, the planned expansion of SR 40 through the Ocala National Forest. The Florida panther and its identified habitat areas in south Florida may at times also be instances of known or likely wildlife transportation infrastructure interactions.

Other examples may be less clear but may occur where known habitat for rare, threatened or endangered species is being affected. For example, upland scrub area in central Florida is home to the Florida scrub jay, gopher tortoise, bluetail mole skink, sand skink, Florida pine snake, scrub lizard, and short-tailed snake.

Identification of ecological hotspots – Where specific data are lacking about likely wildlife-transportation infrastructure interactions, a two-tiered ecological hotspots analysis can be used. First, if actual species data are unavailable for the site of interest, a habitat model results can be consulted. Second, if the models denote that the area may include important wildlife resources, then site surveys should be initiated to assess the potential impacts and what species are likely affected. Such surveys should not be simple one-time or minimal site visits. With the tremendous seasonal and inter-annual variability of rainfall in Florida, ideally these surveys should span a minimum of 2-3 years.

As an example, a multi-year survey of wildlife-vehicle interactions was performed on SR 200 and County Road 39 at Ross Prairie in Marion County, Florida. During the second year of the survey, significant rainfall occurred and Florida gopher frogs were observed killed on the roadway in large numbers. If monitoring had occurred only during the first year a conclusion that few gopher frogs occur in the area might have been made. Years with relatively little rainfall also affect animal movements; for example, river otters and alligators have been known to be killed on roadways in much higher numbers in dry versus wet years.

Essentially, when a project is considered, it should trigger an evaluation of whether data exists to make an informed decision. If it does not exist and ecological models show that a crossing may be needed, than efforts should be initiated to collect needed data to determine exactly what type of crossing, if any, is needed. This is necessary so that determinations that crossing are or are not needed are based on fact. A lack of information should not be the basis for a final decision to not address wildlife needs.



Graphic courtesy of Daniel Smith, Ph.D.

Ross Prairie and SR 200 Wildlife Impact Study showing the combined home range for all carnivores with various ranges overlapping S R 200 from "Ecological Impacts of SR 200 on the Ross Prairie Ecosystem", 2005.

A) Bobcat resting along the Withlacoochee River.;
B, C & D) Identify existing highway and wildlife cross-over points (left). Highway retrofit or widening projects can include strategic wildlife movement improvements such as the improvements to US 192 just east of the Harmony development where forested wetland stands on both sides of the highway were better linked with larger culverts, one with a internal shelf to allow passage during times of high water.

Photo Courtesy of Matt Fleming

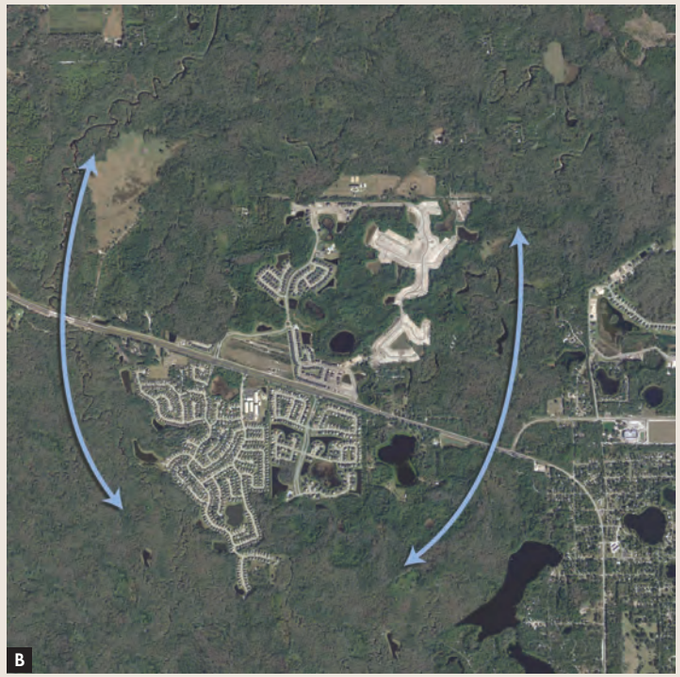
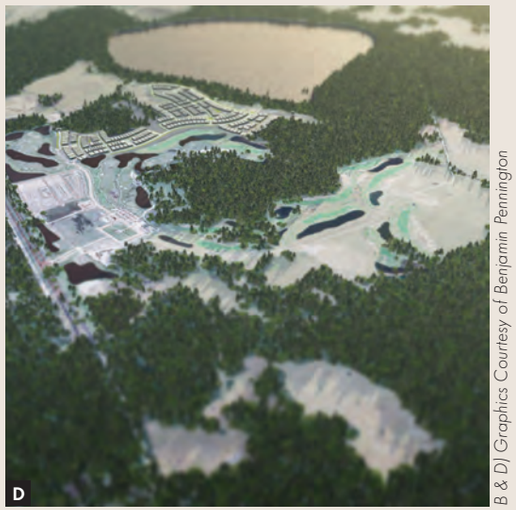


Photo Courtesy of Don Pennington



B & D) Graphics Courtesy of Benjamin Pennington

INTERSECTING PATHS: LINEAR HABITATS AND ROADWAYS

When a transportation corridor is being planned, special attention should be given to linear habitats and geophysical features such as rivers, streams, wetlands, known karst features and upland ridges. These features should be identified and mapped against the proposed corridor. In addition, existing habitat should be modeled against the corridor's path and likely wildlife interaction hotspots identified.

For example, animals often follow along water courses (rivers, streams, sloughs) as a necessity for their daily and life-cycle needs–a natural wildlife movement corridor (a wildlife highway, so to speak). Thus, where a road or highway crosses one of these features, it should be treated as one transportation facility crossing another.

Water courses are in fact duel purpose corridors serving both upland and aquatic species–upland for many mammals such as otter, bobcats, raccoons, skunks, ferrets, bears and panthers, and aquatic for fish, amphibians, reptiles and some mammals. The reality of upland passage of wildlife is made clear by road-kill studies that show higher animal mortalities where roads meet rivers, streams, and wetlands.

Roadways passing over or through these natural wildlife corridors should be designed to provide adequate wildlife passage, habitat linkage enhancements, and general habitat clearance and disturbance limitations so that wildlife will continue to traverse unimpeded. Above are a series of photos that help to demonstrate good road-to-wildlife corridor linkages.

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Placement and spacing of wildlife linkages directly affects travel distance to a passage and can influence use by the target species. Spacing may be especially important for small animals. Mammals are often capable of learning to use underpass and culvert cross-road linkages and may impart this knowledge to their young. However, the learned use of linkage structures is unlikely with reptiles and amphibians. Successful passage of these animals relies on regularity, distance, and designed habitat cues such as vegetation, upland edges, moisture, temperature and lighting.

SPECIFIC DESIGN ENVIRONMENTAL FACTORS OF WILDLIFE LINKAGES

Much of the information used to justify the need for wildlife linkages can also be used to determine the optimum design and location of particular structures. As with the need for the crossing, scientifically valid and applicable evidence (when available) should be used to support the linkage's design, location, and unique environmental attributes. In order to design effective wildlife linkage structures, attention needs to be directed to features that affect their utilization by the intended wildlife. The following factors may need to be considered.

Placement and Spacing – Placement and spacing of structures can be very important for some species, even relatively mobile species. In particular, culverts and bridges serve as connections between landscapes divided by highways and play a critical role in decreasing the barrier effect of roadways for wildlife. Bridges and culverts can be designed from the start for use as a passageway, or when redesigned and retrofitted can function as useable passageways for one or several species.

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Approaches, Context Sensitivity, and Substrates – The physical and vegetative characteristics of the approaches to a wildlife linkage may affect their use by some species. Forest animals such as black bears may prefer well vegetated approaches, while other species appear to prefer approaches that provide good visibility to avoid predators. The presence of cover on the approaches, in the form of vegetation, rocks, and logs, may enhance use by a variety of small, and mid-sized mammals. For example, rows of stumps in an underpass appear to facilitate use by small mammals (often called debris walls). In addition, the selection and location of vegetation along a road and leading to the planned wildlife linkage should be consistent with the surrounding habitat.

Practical efforts may include maximizing the natural attributes of the area. These include maintaining the native forested landscape, minimizing mowed landscapes, and not planting exotic species for groundcover. Further, substrates should be of similar texture and form with the adjacent area. Constructed passage substrate should not be of concrete, asphalt or rip rap when the natural approach substrate is forest soil, riverine sand, or other natural soil or surface feature. Consideration should be given to using or mimicking the surrounding natural substrate. For example, mimicking stream bed conditions within culverts or bridges that maintain semblance of habitat continuity through the linkage may facilitate use by salamanders, frogs, small mammals and aquatic invertebrates.

Other variables that investigators have found correlated with crossing success include distance from the structure to the nearest habitat, the type of vegetation present near the entrances of the crossing structure, and the height of vegetation adjacent to the structure.

Directional Fencing – Wildlife is often opportunistic in its daily travels and will either wholly avoid roads or will cross over at any point. Directional fencing should be considered to funnel wild-life through passages and away from road surface. Although some species may utilize underpass or overpass systems without fences, some form of fencing does appear to be necessary for most species. Fences guide animals to passage

Photos Courtesy of Dan Pennington, 1000 Friends of Florida

Along the SunCoast Parkway in Pasco and Hernando Counties, bridges were designed with well vegetated underpasses and high fencing to discourage wildlife from venturing up onto the highway.

systems and prevent wildlife from circumventing the system. Fencing is also a means to improve safety and reduce general automobile and wildlife collisions. If the placement and spacing of crossings is sufficient and fencing is provided to funnel wildlife toward properly vegetated approaches, then the number of animal and automobile collisions can be reduced.

Berming – Berming can be used to reduce effects of traffic noise and lights in the area of the planned wildlife crossing. Berming can also be used to guide some species (bats and birds for example) to cross above highways at sufficient height to avoid collisions (see Case Study on page X).

Size – It is difficult to determine critical size thresholds for passage structures because these size thresholds undoubtedly vary from species to species. For some species, openness (the size of underpasses relative to the width of the roadway) may be more important that absolute size. Tunnel layouts that allowed animals to see the opposite end of a wildlife passage may be preferred by some species. In general, bigger is better and if water passes through the connection, the design and construction of a passable upland edge should occur. This allows wildlife use even during rainy high water season months.

Length, Width, and Height – The effects of length, width, and height of a structure, especially culverts, may combine to form a "tunnel effect" that deters many animals from passing through the structure. As length increases, the width and/or height must be increased to reduce tunnel effect. A measure of tunnel effect is the openness index value which is computed as width (W) x height (H) ÷ length (L). This index needs to be used with care because it can be skewed, thus distorting true performance measures. Basically the same index value for two completely different sized structures can be obtained by adjusting each value. For instance, a tall-narrow (2 x 4) structure can have the same index value as a short-wide (4 x 2) structure given equal lengths. However, each would not result in equal use by the same wildlife.

Lighting – Some species are hesitant to enter underpasses that lack sufficient ambient light. Maintenance of natural lighting through the crossing may help some species avoid long, dark passages. Helpful design improvements for increasing light within an underpass include overhead grates, increasing the openness value (height to width and length), and providing open medians for light penetration beneath divided highways.

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Consideration should be given to use of the linkage by predators that may inhibit use by prey species. Entrances and exits to regularly used wildlife linkages may prove to be a good place for predator species to wait for their meal. Careful study of the likely users of the connector and appropriate design mitigative features can minimize these interactions.

Moisture and Hydrologic Variability – Moisture is important for some species. For instance, shrews are often more active on rainy nights and may prefer wet substrates for traveling. Underpasses at stream crossings with sufficient upland edge will probably suffice for species that utilize riverine or riparian habitat, provided there is enough water to maintain moist travel conditions without creating flooded or overflow conditions. In some instances, providing open-top (grated or slotted) underpasses may provide sufficient moisture for crossings that lack flowing water, and also provide for some ambient lighting. Proper drainage is important, because some wildlife species are less likely to use structures when they contain standing water. An elevated terrestrial passage such as upland edge or shelf should be provided at semi-aquatic sites during periods of high water levels, thus providing dry, moist and wet environments. Culvert or bridge wildlife passages that are poorly planned and flooded most of the time waste money and fail to support intended wildlife connectivity functions.

Temperature – Small tight linkages may create temperature disparities (inside versus outside the structure) that deters use by some wildlife. Larger underpasses or open-top grate systems that allow for more air flow may effectively address this concern by keeping adjoining ambient and linkage temperatures similar.

Noise – Traffic and adjoining community noise can be a problem for some mammals, especially those sensitive to human disturbance. Certain underpass designs, such as those with expansion joints or uncovered medians, can be very noisy. Open-top designs would be inappropriate for species that are sensitive to traffic noise. Just as planning for noise reduction for adjacent human communities, a variety of design and best management practice features can mitigate noise impacts. These may include planting hedges, tree and shrub edges, providing strategically placed berms or walls, or providing raised or depressed crossing areas.

Interactions Among Species – Consideration should be given to use of the linkage by predators that may inhibit use by prey species. Entrances and exits to regularly used wildlife linkages may prove to be a good place for predator species to wait for their meal. Careful study of the likely users of the connector and appropriate design mitigative features can minimize these interactions.

Human Presence/Disturbance – Human disturbance or presence in or near designated wildlife crossings may reduce their usage by some wildlife. In an evaluation of underpasses in Banff National Park, human influence–either as proximity of town or human activity within an underpass–was consistently ranked high as a significant negative factor affecting passage use by ungulates and carnivores.

Long-term Linkage Sustainability – Once constructed wildlife crossings are a permanent fixture within the landscape and cannot be easily moved because of a change in local land use or property ownership. For this reason, natural habitats in the vicinity of a crossing should be conserved to prevent future loss of habitat and a functional loss of the wildlife linkage. Land on both sides of the wildlife linkage can be protected by conservation easement or public ownership. For example, a community or the road building entity can buy the adjacent land that would connect protected areas in proximity of the crossing. Linkages can be made between areas in conjunction with a proposed road project, or be established ahead of a project. Whatever the initial land ownership situation, if the need for a linkage has been sufficiently demonstrated by the needs study, the planning and development of wildlife linkage facilities should be considered in planning transportation infrastructure and not cast aside simply because there may be a current gap in public ownership.

The width and size of adjacent habitat areas are entirely relative and species-specific. Movement or dispersal corridors do not have to serve all "life requirements" of a species. Their purpose is to act as a linkage or conduit from one block of core habitat to another and they likely will be serving multiple species. Thus, a crossing for amphibians may only need to have adjacent wetlands and upland buffers under protection,




whereas a crossing for the Florida black bear or Florida panther should have significant area of protected land available on both sides of the crossing.

Sometimes it may be possible to include public acquisition and preservation of land adjacent to the crossing as part of the roadway project. For example, concurrent with construction of the SR 46 bear underpass in Lake County, the Florida Fish and Wildlife Conservation Commission purchased a 40-acre private in-holding within Rock Springs Run State Park to ensure preservation of the bears' travel corridor near the crossing.

Engineering and Safety Considerations – In addition to the environmental considerations discussed above, engineering and safety aspects must also be considered when determining the configuration and location of a wildlife crossing. Design engineers should consider the following criteria when evaluating potential crossing locations:

- The crossing must accommodate state or Federal safety criteria.
- The crossing must accommodate or support access to adjacent property owners.
- The crossing should not negatively impact existing drainage patterns or flood off-site properties.
- For existing roadways, significant modifications that would decrease public safety cannot occur as a result of the addition of the crossing (e.g., an excessive increase in roadway grade may decrease sight distance).

In keeping with these criteria, modifications may be made in the design of the crossing in order to minimize impacts to habitats, project design modifications, and costs while still meeting the overall objective of the crossing.

Cost – Finally, it must be realized that financial resources are limited and a cost analysis of each wildlife linkage option should be undertaken. While the design and construction of crossing structures is not inexpensive, consideration should also be given to the economic benefit of the presence of the crossing, such as decreased physical damage and human injury costs. Likewise, it is not always the case that the most expensive crossing alternative is the best alternative. For example, there is no need to design a crossing suitable for bears and panthers when the target species are amphibians.

Monitoring and Evaluation – Although many wildlife linkages have been constructed across the U.S., the vast majority of these have no monitoring program to evaluate the effectiveness of the structure in preserving wildlife, maintaining habitat connectivity, and reducing vehicle crashes. Fortunately, there is a tendency for a greater percentage of new linkages to be monitored for efficacy.

Sometimes it may be possible to include public acquisition and preservation of land adjacent to the crossing as part of the roadway project.

Photos Courtesy of (from left to right): Jeffrey Pennington, Matthew Paulson and the Florida Wildlife Federation; Mark Lotz, FWC; David Moynahan

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Since many animals use floodplains and water bodies to move from one wildlife corridor to the next, it's logical and easy to design bridge ends to extend farther beyond the floodplain or water body than is required.

MODELING TOOLS FOR WILDLIFE CROSSINGS

The National Cooperative Highway Research Program has sponsored research to evaluate the use and effectiveness of wildlife crossings and to include analytical tools to help assess under what conditions wildlife crossings may be needed and where they should be located. The research describes guidelines for the selection, configuration, and location of crossing types, as well as suggestions for the monitoring and evaluation of crossing effectiveness, and their maintenance. The guidelines are available as a final report and a web-based electronic decision tool. The decision tool can be found at **www.wildlifeandroads.org**. The basic outline of the decision tool has been developed with the following seven steps listed in hierarchical order.

1. Consideration – Do we need to consider mitigation measures?
2. Selection – What type of structures for what species and processes?
3. Placement – Where along the highway and on the landscape do we place these measures?
4. Configuration – What are the dimensions, materials, bottom surface, light and noise considerations, and human activities?
5. Monitoring/Evaluation – How do we assess the effectiveness of our efforts?
6. Maintenance – What actions are necessary to maintain structure efficacy?
7. Final Plan – Full suite of mitigation efforts and necessary actions, and how to enact them.

The National Cooperative Highway Research Program's web site is at **www.trb.org/default.asp**

LONGER BRIDGE SPANS PROVIDE MORE SPACE FOR WILDLIFE PASSAGE

Since many animals use floodplains and water bodies to move from one wildlife corridor to the next, it's logical and easy to design bridge ends to extend farther beyond the floodplain or water body than is required. Longer bridge spans also cost far less than a separate wildlife crossing under an existing roadway. Over the last few decades the Florida Department of Transportation has designed and built extended bridges on I-75 (Alligator Alley) in Collier County and in other locations throughout the state. The efforts are paying off. Florida panthers and other wildlife are using the bridges to safely cross roads and to move back and forth between wildlife corridors.

Source: Keeping It Simple: Easy Ways to Help Wildlife Along Roads, U.S. Department of Transportation and FDOT.

Photo Courtesy of Florida Department of Transportation

Photo showing bridges constructed to allow for good vegetative coverage and wildlife connections.

CASE STUDY

Design, Installation, and Monitoring of Safe Crossing Points for Bats in Wales

Photo Courtesy of David Maynahan

In order to reduce the likelihood of horseshoe bats being killed on a new road, it was necessary to discourage the bats from for-aging along the road edge, while simultaneously providing safe and attractive crossing points at locations where the bats were already known to cross the route. This involved: (1) maintaining attractive vegetative linear features perpendicular to the route to lure the bats away from the road; (2) placing a relatively wide verge of poor quality habitat directly adjacent to the road to discourage the bats from for-aging; (3) including safe crossing points at culverts underneath the road on the alignment of existing flight lines (the effort found that there is value in maintaining existing flight line routes - particularly for horseshoe bats in question); and (4) controlling street lighting at crossing points to ensure that the areas remained in relative darkness. The exact location of the tunnels, the planting leading to them, and the engineering design of the tunnel approaches were developed by an integrated team of ecologists and engineers. The success of the mitigation measures has been monitored, and the tunnels are proving to be extremely effective in allowing bats to cross the road safely.

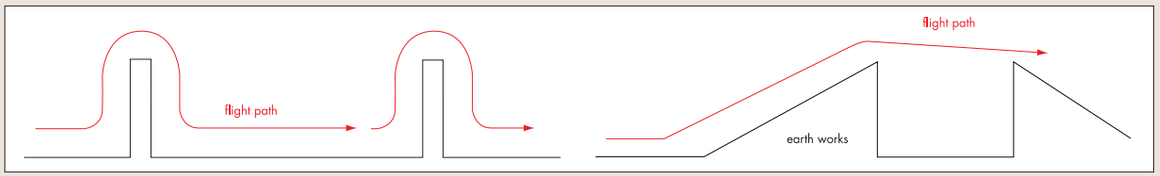
The culverts were positioned on the lines of severed hedgerows so that they followed the bats' desired flight lines as far as possible. Small embayments were made in the embankment earthworks, creating a "funnel" shape to maximize the chance of bats encountering the tunnel. Planting was provided around the vertical sides of the funnels, extending towards the severed hedgerows, to increase the funnel effect. The intention of the planting was to guide bats from the severed hedgerow to the culvert mouth and, thus, planting was not extended up over the top of the culvert as this might encourage bats to fly over the road.

Further, because bats encountering a fence fly up and over it, and immediately twist to return to their original flight path height, gently-sloping earthworks were employed and appear to greatly reduce this pattern by extending the bats' higher flight path. The effectiveness of this mitigation has depended upon:

- Identifying in a timely manner the potential impacts allowing mitigation measures to be put in place during construction and avoiding costly retro-fit.
- Locating safe crossing points for bats in the positions most likely to be effective based on a comprehensive baseline survey.
- Modifying the earthworks and planting close to crossing structures so that bats are led towards them.
- Monitoring effectiveness post-construction so that any necessary modifications can be made.

This example from Wales illustrates the common problem that jurisdictions face whether in Florida, the United Kingdom or elsewhere, and that care should be taken in relation to the interpretation of each particular situation when applying solutions or corrective measures. Each situation is unique as there are differences in species behavior and general context.

Source: Design, Installation, and Monitoring of Safe Crossing Points for Bats on a New Highway Scheme in Wales, by Dr. Stephanie Wray, Paola Reason and David Wells, Warren Cresswell and Hannah Walker, Cresswell Associates, 2005. All graphics used with permission of Transport Wales and the Welsh Assembly Government.



Flight paths of lesser horseshoe bats over obstructions

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Fortunately, there is a tendency for a greater percentage of new linkages to be monitored for efficacy. Monitoring and evaluation of wildlife linkages is important in determining whether the best use of resources is being made, and providing critical information useful for future projects. Although it costs money to design and implement a monitoring program, the results may more than pay for these costs on later projects.

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All monitoring plans should be clearly written, and state the original goal of the linkage as a benchmark measure of success. If possible, the plan should include both pre-construction and post-construction monitoring. It is recommended that monitoring should occur for at least five years following construction, and that pre-construction monitoring should be at a minimum one year and optimally two to three years in advance of the project design. In many cases, it takes wildlife at least two years to adapt to the presence of the crossing, especially if it is used for seasonal migration. Finally, results of the monitoring should be made available in a timely manner so that corrective actions can be undertaken, if necessary.

Maintenance – In several instances across the U.S., the failure of a wildlife linkage to produce the desired results has been attributed to lack of proper maintenance of the structure. Examples range from collapse or obstructions within the crossing to human habitation of the crossing. One of the most critical areas is maintenance of fences or barrier walls. Damage to fences and gaps caused by erosion allows animals to cross the barrier and enter the roadway. For example, at the Payne's Prairie crossings in Alachua County, infrequent mowing of adjacent vegetation allows animals to climb over the wall and enter the roadway.

Roadway maintenance crews should be made aware of the presence of linkage structures and instructed how best to maintain them. Periodic inspections of the structures should be made by qualified biologists and engineers. Ideally, these inspections should be incorporated into the monitoring plan developed for the linkage.

LINKAGES FOR ETDM PROJECTS

Wildlife linkage options are increasingly being considered and developed for FDOT projects, but it is very important to incorporate wildlife mitigation needs early in the programming, planning, and design process. The magnitude of current environmental, safety, capacity, and financial aspects of roadway projects makes early planning a must. Florida has addressed this challenge by developing the Efficient Transportation Decision Making (ETDM) process.

The ETDM process defines the procedures for planning, conducting environmental reviews, and developing and permitting state transportation projects. During the ETDM process, present and future FDOT projects are reviewed by the state and federal natural resource and regulatory agencies. It is during this process that the Florida Fish and Wildlife Conservation Commission, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other commenting regulatory agencies work with the FDOT to identify and consider potential roadway/wildlife interactions and the need for a wildlife linkage for a particular project.

The ETDM Process and Wildlife Linkages – The transportation planning process begins when Metropolitan Planning Organizations (MPOs) and FDOT identify mobility needs. Project needs are matched to available funding for projects and ultimately a cost-feasible plan is adopted by the MPOs. This is referred to as the Long Range Transportation Plan. Similarly, FDOT develops a cost-feasible plan for the Florida Intrastate Highway System and for the Bridge Program. Priority projects are selected annually from these cost-feasible plans and are presented to the Legislature as the tentative Work Program. The Legislature then approves the Work Program which is a five-year program. New projects may await funding for up to five years before significant work proceeds. The Project Development and Environment (PD&E) process begins after funding for a project is approved, and then design survey work is conducted and the design phase begins.

In the ETDM process, member agencies are provided two opportunities to review projects prior to the start of significant engineering work. These opportunities are referred to as the "Planning Screen" and the "Programming Screen." The Planning Screen occurs in conjunction with development of cost-feasible plans by MPOs or the FDOT. Project information is reviewed by regulatory and resource agencies which then respond to project planners on the effect that a project may have on resources protected by that agency. The time to highlight the potential need for a wildlife linkage is when the project is reviewed in the Planning Screen.

The Programming Screen occurs before projects are considered for the FDOT Work Program. The intent during the Programming Screen is that member agencies provide specific information to identify technical issues that must be addressed by engineers and planners during the Project Development phase. The Programming Screen is where the resource agencies re-state the potential need for a wildlife linkage, and provide preliminary information on potentially affected species and their habitat in the vicinity of the project. This information is used later in the project development phase to develop the goal of the crossing. Finally, the specific location, type, and size of the structure are determined during the design phase.

Once a project proceeds to the construction phase, it is very costly and possibly prohibitive to address major design features such as wildlife linkages and their associated infrastructure, if they have not been previously identified. The ETDM process was designed to prevent such delays and extra costs from being incurred, while at the same time improving environmental aspects of roadway projects through early coordination with permitting and review agencies. Those with concerns for wildlife linkages for a specific project should work through the ETDM process to ensure their concerns are identified early, and coordinated with the appropriate wildlife resource member agencies (i.e., U.S. Fish and Wildlife Service, National Marine Fisheries Service, and Florida Fish and Wildlife Conservation Commission).

A key component of ETDM is the Environmental Screening Tool (EST), an internet-accessible interactive database and mapping application. The EST integrates resource and project data from multiple sources into one standard format, and provides quick and standardized analyses of the effects of the proposed project on natural and human resources. The EST also supports communication between agencies, planners, engineers, and the public. The databases supporting the EST are constantly being updated as new data become available; however, it is likely that additional site-specific studies and surveys will be required to support the need for a linkage.

The public is able to view planning/project information, agency reviews, summary reports, maps, and all official member agency comments. Additionally, the public is able to provide comments on projects via email and during MPO and FDOT meetings and workshops. Each FDOT District Community Liaison Coordinator is responsible for summarizing public input into the EST, and this information is visible to the public. More information on how to become involved in the ETDM process can be found at **http://etdmpub.fla-etat.org/est/.**

The accompanying FDOT decision tree outlines the steps taken when addressing roadway/wildlife interactions for projects within the ETDM process. Note that this process addresses each of the critical steps discussed above to ensure that a linkage is sited and designed appropriately to meet the stated goal of the linkage. In instances where crossing structures are not feasible, or it is not possible to place adjacent lands in conservation due to zoning or land use changes, the decision tree considers the use of exclusionary fencing, barricades, or other conservation measures to reduce impacts to wildlife. Nevertheless, community/road planners should consider the alternative of purchase or placing under easement adjacent private land that would connect existing conservation lands served by the proposed crossing. Barriers should not be the only alternative where private land is involved; it should be examined in the context of local and regional greenway plans, the Florida Greenways Plan, and how it may serve larger conservation goals.

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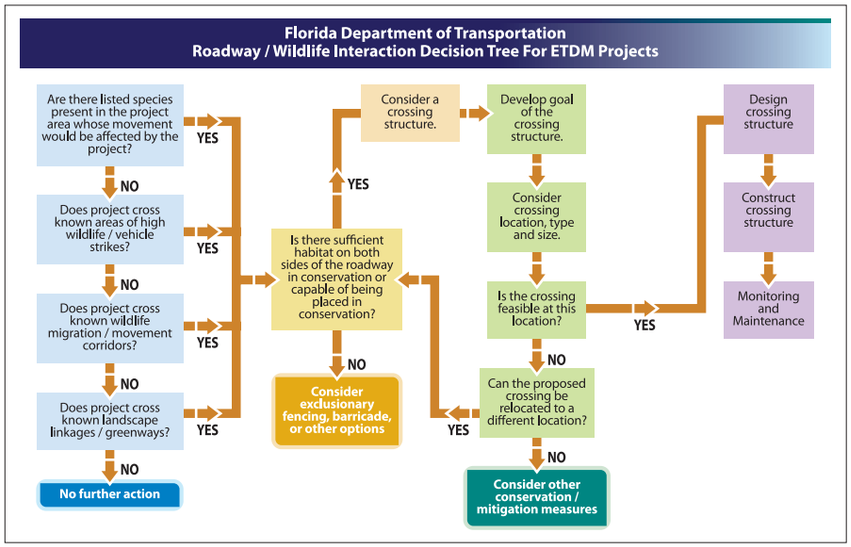
LINKAGES FOR NON-ETDM PROJECTS

In some instances, it may be necessary to address roadway/wildlife interactions along a segment of roadway that is not part of a project within the ETDM process. Natural resource agencies, local governments, or the public may have identified a potential need for a structure to reduce roadkill or improve public safety. In these cases, interested parties can approach FDOT for support in funding studies to assess the need for linkages and/or to design and construct crossing structures. However, crossings cannot be supported or funded by FDOT without first demonstrating the need for the crossing.

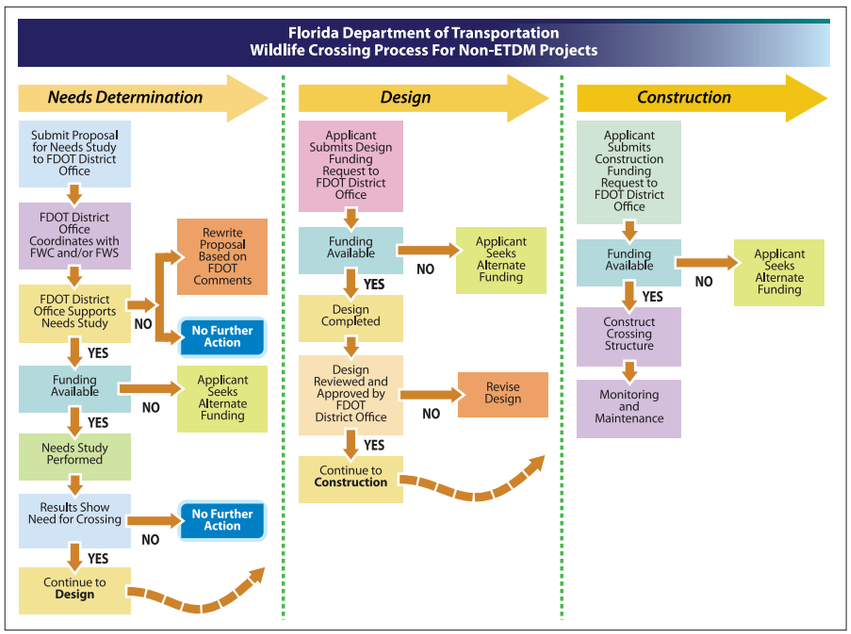
Interested parties may submit a written proposal for a "Needs" study to their local FDOT district office, as depicted in the accompanying flow chart. The proposal should clearly state how the need for a linkage will be determined, and what data will be gathered to support the need. As part of their review of the proposal, the FDOT will coordinate with the FWC and/or FWS. The FDOT district office may then support the proposal by assisting the applicant in obtaining funds for the study. If approved by FDOT, funds may be allocated for the study if and when available. Reasons for not supporting the proposal may include inconclusive or insufficient data, lack of public control of property adjacent to the roadway, and engineering and safety considerations.

If the results of the study demonstrate the need for a wildlife linkage, the applicant may then submit a request for assistance from the FDOT for funding the design of the structure, or the applicant may choose to seek alternative funding from other sources. The completed design is then submitted to the FDOT district office for review and approval to ensure it meets engineering, safety, and cost considerations. Once the design is approved by the FDOT district office, the applicant may submit a request for financial assistance from the FDOT to construct the crossing. If approved by FDOT, construction funds may be allocated, or if funds are not immediately available, the project may be placed on a list for future funding.



Flowchart for ETDM projects.

Photo Courtesy of Florida Department of Transportation



Flowchart for Non-ETDM projects.

Photo Courtesy of Florida Department of Transportation

ROAD AND HIGHWAY RELATED STORMWATER FACILITIES

Stormwater management facilities occupy sizable acreages and are a major part of many road or transportation projects. A certain dilemma exists in that stormwater management facilities are created to capture, sequester, and treat pollutants that, when concentrated, may not present desirable healthy habitat for wildlife. Nevertheless, by design or not, stormwater facilities are regularly used by wildlife. In fact, at times stormwater facilitates and the habitat they present act as wildlife attractors. This attractor role is noticeable during drought, when they may still hold water, or when due to their rather rigorous fencing, these facilities keep local feral predators at bay, offering areas of relative safe haven to wildlife. A challenge to community planners and engineers may be to design structures that will manage stormwater, improve water quality, and at times provide intentional wetland and wildlife habitat features.

Opportunities exist to incorporate wildlife-friendly design features for stormwater facilities that can maximize habitat value and assure capture and treatment of runoff from roadways or bridges. In addition, in suburban and urban areas, local and regional greenway development for bike and foot trails can be incorporated into the required road or highway stormwater facilities inclusive of wildlife habitat design features. In Tallahassee, the adopted Blueprint 2000 program took a multi-use approach with the extension of the major cross-town corridor of Blair Stone Road. This project integrated road, stormwater management and greenway facilities that served to provide some habitat aspects.

Photo Courtesy of Dan Pennington, 1000 Friends of Florida

Park Avenue in Tallahassee is an example of a major road and stormwater management improvement that made it more difficult for wildlife to cross at a traditional wildlife crossing point. Wildlife mortality is now often visible on the road here.

Photo Courtesy of Marsha Drew

Opportunities exist to incorporate wildlife-friendly design features for stormwater facilities that can maximize habitat value and assure capture and treatment of runoff from roadways or bridges. In addition, in suburban and urban areas, local and regional greenway development for bike and foot trails can be incorporated into the required road or highway stormwater facilities inclusive of wildlife habitat design features.

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Wherever feasible, site plans, PUDs, DRIs, etc. should specify wildlife-supportive buffer zones along existing site drainage features such as upland swales, ditches, intermittent and ephemeral streams, ponds, wetlands, sinkholes, lakes, rivers, etc. Establishing buffer zones along existing drainage features enhances wildlife potential, preserves the drainage system and promotes greater site stability, less erosion, higher aesthetic potential, increased habitat value, and more economical site development.

INTEGRATING TRANSPORTATION AND STORMWATER FACILITY PLANNING WITH WILDLIFE-FRIENDLY COMMUNITY PLANNING

- Educate and train development and site review and planning and zoning staff (as well as citizens) to look for possible greenway and habitat cross parcel connection options prior to development approvals and road or highway development.
- Wherever feasible, site plans, PUDs, DRIs, etc. should specify wildlife-supportive buffer zones along existing site drainage features such as upland swales, ditches, intermittent and ephemeral streams, ponds, wetlands, sinkholes, lakes, rivers, etc. Establishing buffer zones along existing drainage features enhances wildlife potential, preserves the drainage system and promotes greater site stability, less erosion, higher aesthetic potential, increased habitat value, and more economical site development.
- Draft and adopt guiding policy for development reviews to encourage wildlife and greenway interconnections that link throughout and across communities.
- Avoid or minimize the use of highly fenced-off stormwater "stalags" (square/rectangular, steep-sided stormwater retention sites with high, often barbed wire fences). They tend to block and barricade community connectivity as well as wildlife connectivity. This might mean working with FDOT or other city or county transportation planning and design people early on to ensure adequate land is acquired to build larger community multi-use stormwater facilities.
- Factor in existing habitat needs into hydrological flows and fluctuations calculations (seasonal or yearly variations).
- Use native species for vegetated areas, landscaping, and stream or wetland buffer areas wherever possible. Native species can provide year-round attractive scenery, important habitat, pollutant buffering, and structural stability for soils. Native trees and shrubs will not need as much care and maintenance as ornamentals or non-natives.

Fenced-off, stalag-like stowmwater facilities, such these in Tallahassee, create barriers.

Photos Courtesy of Dan Pennington, 1000 Friends of Florida