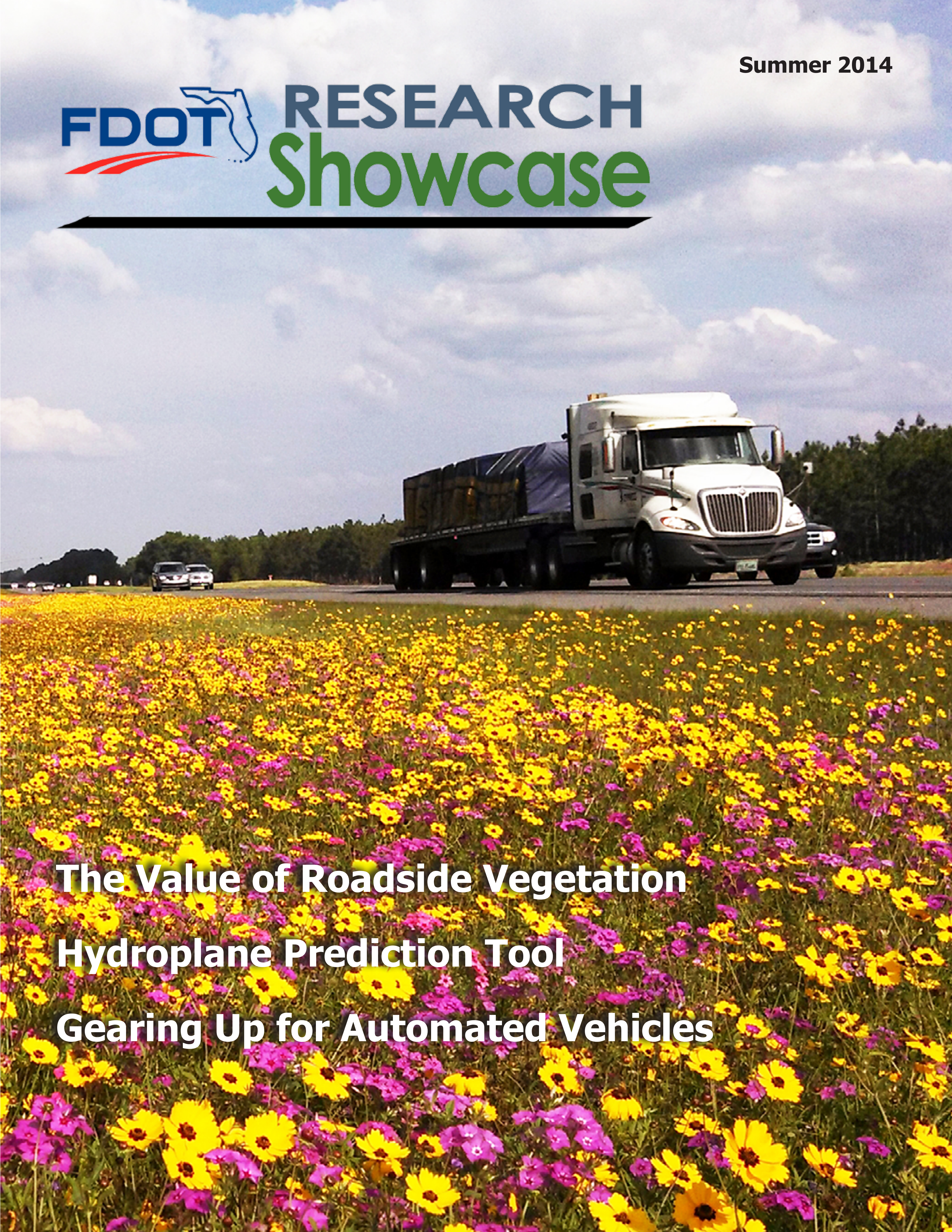
Summer 2014

FDOT RESEARCH Showcase



The Value of Roadside Vegetation

Hydroplane Prediction Tool

Gearing Up for Automated Vehicles

FDOT RESEARCH Showcase

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The Florida Department of Transportation (FDOT) Research Showcase is published to provide information regarding the benefits of FDOT-funded research.

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Coreopsis and phlox in bloom along I-75 near Ocala

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In This Issue

The Florida Legislature allocates nearly $30 million each year for highway landscape projects. Landscaping beautifies roadsides and helps to make Florida an attractive place to live, do business, and visit. However, landscaping accomplishes much more than just improving roadside aesthetics.

This issue of Research Showcase highlights the value of roadside vegetation, from stabilizing soil, which protects infrastructure and provides safe clear zones for errant vehicles, to providing habitat for wildlife and crop pollinators. Recent FDOT-funded research demonstrates the economic value of roadside vegetation management and the extent to which FDOT's investment in highway landscape projects impacts Florida's economy.

This issue also features three new technologies developed through research. First, a new hydroplane speed prediction software tool evaluates the potential for hydroplaning and predicts when hydroplaning could occur based on speed. This technology has been applied in the design of the I-4 Ultimate project. The Florida Sea Level Scenario Sketch Planning Tool helps planners identify areas of potential inundation and affected infrastructure. A non-destructive testing method, called phased array ultrasonic testing, gives engineers a more efficient and effective method to detect flaws in steel welds. Also in this issue is information about research on automated vehicles occurring at three Florida University Transportation Centers.

Contents

Understanding the Value of Roadside Vegetation

FDOT maintains approximately 186,000 acres of right-of-way. Approximately half of this acreage is comprised of turf grass and other landscape plants, which represent a significant financial investment. Landscaping roadside rights-of-way with appropriate trees, shrubs, flowers, and ground cover plants beautifies highways and enhances driver experience. Managed rights-of-way also produce many other important safety, environmental, and economic functions.

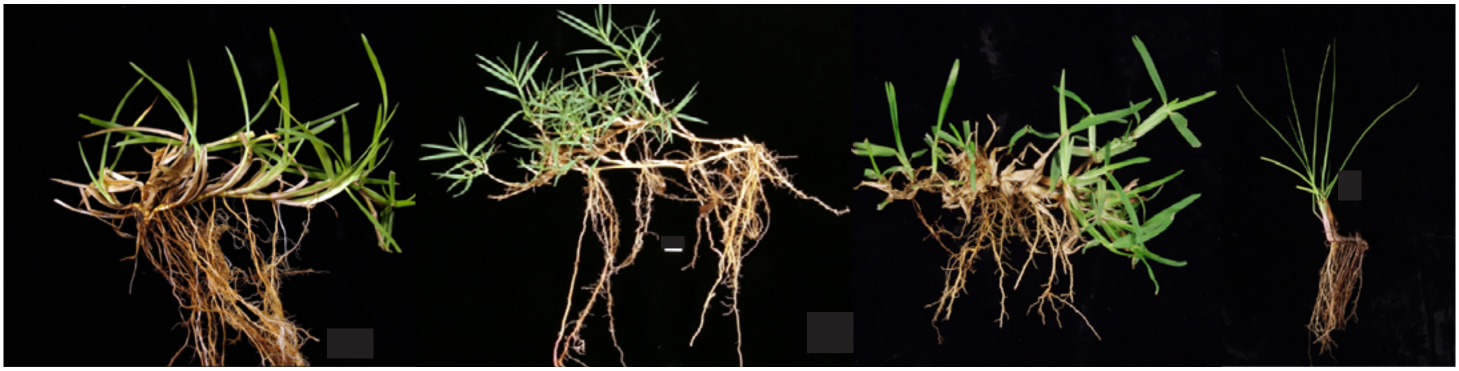
Landscaping can improve safety by protecting roadsides and infrastructure from erosion, reducing hazards at the pavement edge, and providing a clear and safe recovery zone for errant vehicles. Roadside vegetation can significantly enhance the environment by improving water quality, managing storm water, protecting soil, increasing biodiversity, and creating habitat for wildlife. Well-planned, self-sustaining landscapes consisting of locally adapted plants reduce annual maintenance costs and improve worker and public safety because they require less frequent mowing or herbicide treatments.

Effective roadside vegetation management requires expertise and resources to plan, design, construct, and maintain the roadside environment. It also requires vegetation managers to make informed choices among management practices and to integrate different management techniques to achieve the greatest benefits. In the past several decades, FDOT has funded research on various aspects of roadside design and maintenance to develop best management practices that enhance safety, reduce costs, beautify roadsides, and protect its investment in roadside landscaping.

One early product of FDOT-funded research was the development of the 1995 publication, *Florida Highway Landscape and Safety Guide*. The guide provides standardized information to help transportation agencies throughout Florida make decisions about design and aesthetics when landscaping roadsides. The guide recommends the use of native plants and wildflowers, particularly those which are drought tolerant and disease and pest resistant. The guide also recommends creating simple, low-maintenance landscapes by using plants that are compatible with the natural environment, considering factors such as salt tolerance, sun or shade tolerance, and wind exposure.

While the guide discourages the use of noxious and invasive exotic plants in roadside designs, such plants still encroach on the natural landscape and pose a threat to landscaped areas, particularly turf grass. In 2009, FDOT contracted with researchers at the University of Florida's Institute of Food and Agricultural Sciences (IFAS) to develop *A Guide for Roadside Vegetation Management*, a best practices manual to serve as a resource and training guide covering major aspects of turf management on rights-of-way, including the management of invasive species. The manual establishes procedures for the successful manage-

The *Florida Highway Landscape and Safety Guide* recommends creating simple, low-maintenance landscapes by using native plants and wildflowers, particularly those that are drought tolerant and disease and pest resistant. Above left: wildflowers in Duval County. Above right: red phlox along I-75 in Hamilton County.



Centipede, Bermuda, St. Augustine, and Bahia grasses are the four grasses most commonly used on Florida rights-of-way. Healthy turf helps to protect roadsides and infrastructure from erosion, reducing hazards at the pavement edge and providing a clear and safe recovery zone for errant vehicles.

ment of turf, including mowing height and frequency, fertility, weed control, and the safe and effective use of herbicides. The manual defines terms, describes soil characteristics, and identifies different types of turf grasses and desirable plants. The manual also covers maintenance and the safe operation of mowing equipment, and offers checklists for a variety of equipment. FDOT implemented the manual statewide in 2013.

As part of this project, IFAS researchers created a database that enables maintenance technicians to map and track, with handheld GPS devices, the location of invasive species common to rights-of-way. After identification, technicians record the location and size of the invasive species colony. The database allows technicians to monitor the plant colonies for months or years after treatment and to document the effectiveness of the weed management program.

IFAS researchers also developed a training program and conducted training to instruct district maintenance personnel on weed identification, best practices for effective weed control, and the use of GPS technology. The database and GPS technology enable FDOT to comply more effectively with its Environmental Policy 000-625-001-l, which calls for FDOT to cooperate in the state's program to control the spread of invasive exotic plants. Florida's Turnpike Enterprise and parts of FDOT Districts 1 and 4 have implemented the database tracking system. FDOT's Maintenance Office anticipates implementation of the GPS weed location mapping program statewide in the near future.

FDOT evaluates roadside vegetation according to FDOT's *Maintenance Rating Program Handbook* (MRP). First developed in the 1980s, the MRP includes guidance for evaluating vegetation height and health, overhanging limbs, litter, and encroachment onto roadways and sidewalks. IFAS researchers recently inventoried vegetation species present on rights-of-way at field sites in each district and Florida's Turnpike Enterprise, noting turf quality and erosion. Based on their findings, researchers recommended de-listing four species (maidencane, castor bean, tropical soda apple, and dogfennel) from the MRP's list of 14 plants to be limited or prevented on roadsides. These plants are declining in population because they do not tolerate repeated mowing. Researchers also identified several new species (giant smut grass, tea weeds, white head bloom, and large flower pusley) that could be added to the MRP list or that are of concern. FDOT incorporated the recommendations from this research into the 2013 edition of the MRP.

While it is important to maintain roadside vegetation and protect rights-of-way from deterioration,

Right: Cogongrass is widely acknowledged as one of the Southeast's most damaging invasive species.

Mowing the I-10 test site in Madison County. Researchers observed no adverse impacts concerning erosion, safety, aesthetics, or turf quality at the test site. They also found that the modified mowing schedule conserved energy and saved over $1,000 per mile per year.

roadside maintenance results in a financial liability. In 2009, FDOT contracted with OecoHort, LLC, consulting services to study the impacts of reduced mowing frequency of interstate highway roadsides on energy consumption, maintenance costs, and turf quality. The researchers selected a one-mile segment of I-10 in Madison County as a test site. At the site, 10-foot safety strips adjacent to the inside and outside lanes of pavement were mowed regularly, and the remainder of the clear zones was mowed only once in the fall. The researchers also selected a site in Polk County; however, a modified mowing schedule for this site was abandoned five months into the project due to excessive weed growth.

After the fall 2009 mowing of the I-10 test site, the researchers observed no adverse impacts concerning erosion, safety, aesthetics, or turf quality. The pilot study was extended another year, and in 2011, they again found that the modified schedule did not cause erosion. Non-turf grass that became more prevalent and out-competed some traditional clear zone turf grass appeared to provide the same soil stabilization functions as traditional turf grass. Researchers also found that the modified mowing schedule enhanced the overall roadside aesthetics due to the increase in blooming native wildflowers.

Despite three MRP criteria not being met due to the modified mowing schedule—some tall vegetation was flattened by mowers and remained uncut, trees outside the clear zones were not trimmed adequately, and litter was not removed sufficiently—the researchers found that the modified mowing schedule conserved energy and saved over $1,000 per mile per year. While a modified mowing schedule may not be practical everywhere in Florida, these findings are useful as FDOT considers methods to conserve resources and reduce expenditures.

FDOT estimates that the cost of maintaining roadside vegetation in 2011-2012 was $33.5 million, a third of which was for mowing in rural areas. In a 2013 proj-

Florida's Top 15 Invasive Species

1. Cogongrass
2. Tropical Soda Apple
3. Brazilian Pepper
4. Australian Pine
5. Melaleuca
6. Hydrilla
7. Water Hyacinth
8. Climbing Fern
9. Air Potato
10. Kudzu
11. Torpedo Grass
12. Water Lettuce
13. Alligator Weed
14. Castor Bean
15. Chinese Tallow

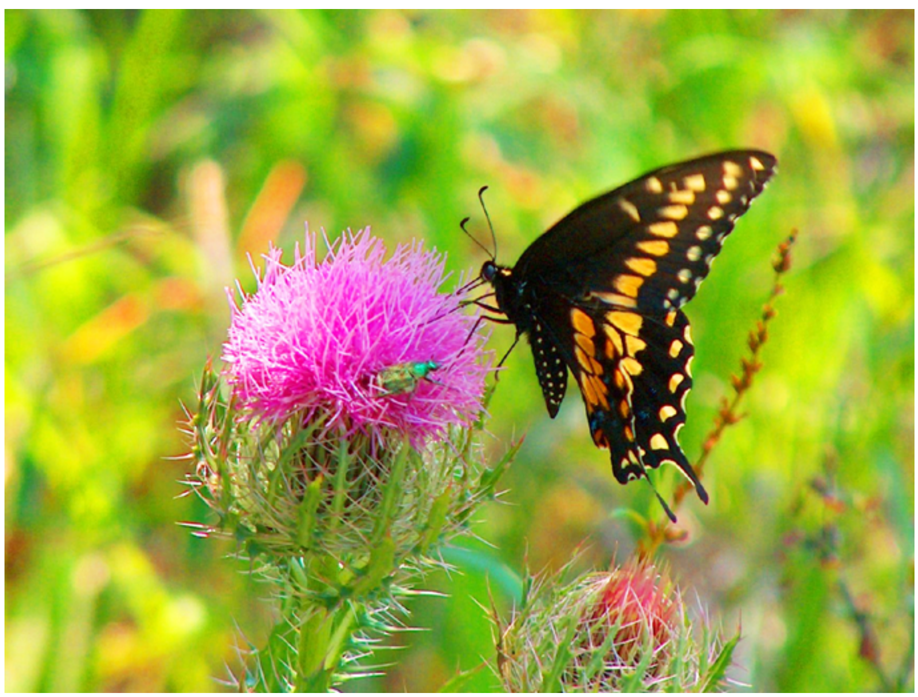
ect, IFAS researchers studied the economic impact of ecosystem services provided by ecologically sustainable roadside right-of-way vegetation management practices. Ecosystem services include carbon sequestration, runoff prevention, and support of crop pollinators and other beneficial insects, as well as contributions to air quality, invasive species resistance, and roadside aesthetics. The researchers determined that roadside vegetation performs nearly half a billion dollars worth of ecosystem services and functions. They found that using sustainable vegetation management practices, such as reduced mowing, would more than double the total value, and the value would triple to $1.5 billion if wildflower areas were incorporated into roadside landscapes.

While roadside vegetation historically has been considered a financial liability to fulfill main FDOT functions, the researchers demonstrated that the value of roadside vegetation management is more than offset by the value of carbon sequestration alone. Researchers also found that FDOT can reduce annual maintenance costs by 30 percent by implementing sustainable management practices, such as reduced mowing. The project's findings help FDOT to better identify the value and economic benefits of vegetation, including wildflowers and native plant communities, along Florida's highways, and to demonstrate that roadside vegetation is an important and productive asset.

Most recently, IFAS researchers investigated the impacts of Florida's highway beautification program on the local economy. They found that activities related to highway beautification generate direct economic impacts in the form of increased revenues such as employment, income, and local and state government tax revenues. Spending for highway beautification also stimulates additional indirect and induced economic activity through economic multiplier effects. For example, indirect effects occur when contractors purchase landscaping materials and equipment from local businesses. Induced effects occur when households of proprietors and employees of affected businesses purchase goods and services for personal consumption. The combined direct, indirect, and induced impacts of landscaping activities represent total economic impacts that occur over the period of the highway landscaping project, typically 18-24 months.

The researchers estimated total economic impacts of FDOT's highway beautification expenditures using regional economic models constructed with Impact Analysis Planning (IMPLAN) software. For the 2008-2013 study period, they found that expenditures in FDOT's seven districts and Florida's Turnpike Enterprise generated impacts of 2,112 full- and part-time job years (i.e., one job for one year), $245.2 million in revenue, $147.6 million in value-added contribution (i.e., value increase minus cost) to the gross domestic product, $110 million in labor income, $32.6 million in other property income, and $5 million in indirect business tax. They found that annual average economic impacts of highway beautification expenditures totaled $46 million in output impacts and $28 million in value-added impacts. The impact per dollar of highway beautification investment was $1.53 in output, $.92 in value added, $.62 in labor income, and $.03 in state and local taxes, while the employment impact was 13.2 jobs per million dollars of investment. The findings from this research demonstrate the extent to which FDOT's investment in highway beautification projects impacts Florida's economy.

While the most obvious effect of landscaped rights-of-way is highway beautification, the findings of these research projects demonstrate the importance of roadside management to enhance safety, protect FDOT's infrastructure investments, conserve resources, and benefit local economies. ⬣



IFAS researchers found that roadside vegetation performs nearly half a billion dollars worth of ecosystem services, including carbon sequestration, runoff prevention, and support of crop pollinators and other insects. Roadside vegetation also contributes to air quality, invasive species resistance, and roadside aesthetics.

I-4 Ultimate Project Designed with Hydroplane Prediction Tool

The reconstruction of Interstate 4—the biggest roadway project in FDOT history—applies a design technology developed through FDOT-funded research. In 2012, researchers at the University of South Florida (USF) developed a hydroplane speed prediction (HP) software tool for evaluating the potential for a vehicle to hydroplane on wet roads. The tool, along with data developed by Florida Gulf Coast University (FGCU) researchers in a companion project that evaluated driver reaction to hydroplaning using a driving simulator, was developed into an FDOT design guidance procedure. The tool helps roadway engineers understand the risk of hydroplaning and reduce costs associated with road widening.

In the past, FDOT has designed multi-lane roadways sloped in one direction for a maximum of three lanes. Limiting slope in one direction to three lanes was intended to mitigate the potential for hydroplaning by limiting water film thickness (WFT) formed from rain flowing across the road. FDOT's *Plans Preparation Manual* (PPM) has specified that widening beyond three lanes would require additional lanes to be sloped in the opposite downward angle, resulting in great cost in time and expense. Using the HP tool, roadway engineers can now predict the driving speed and WFT at which hydroplaning could occur, and demonstrate that roads wider than three lanes can be sloped in one direction without compromising safe driving conditions during periods of rain.

FDOT roadway engineers have applied the HP tool to the design of the reconstructed I-4. Construction is scheduled to begin in 2015 and end in 2021. The 21-mile section, referred to as the I-4 Ultimate project, extends from west of Kirkman Road in Orange County to east of State Road 434 in Seminole County. The project adds four tolled express lanes to I-4—two in each direction—while maintaining the existing free general use lanes—four in each direction. The four-lane-wide general use lanes will slope towards the outside right-of-way while the inside toll lanes will slope towards the inside median.

The potential for hydroplaning is governed by several factors, many of which are out of the driver's control, but one crucial factor within driver control is vehicle speed. How drivers adjust their speed in wet conditions is an important behavioral topic in roadway design. FGCU researchers studied patterns of driver behavior during rainfall events. They gathered data of drivers in actual highway settings from FDOT databases and in simulated settings using a driving simulator. For highway settings, data on traffic volume and free-flow speed for six highway segments was drawn from Florida's statewide 511 website and FDOT's State Traffic Engineering Warehouse for Advanced Regional Data (STEWARD).

Driving simulator participants drove in a virtual world ranging from suburban to highway routes, with and without rain. FGCU researchers recorded driving speed and analyzed data to correlate driver responses to simulator conditions. They found that in field and simulator studies, drivers tend to reduce speed during rainfall events. Field data showed that drivers reduced speed by 2 to 8 miles per hour with greater decreases during night and weekday peak hours. The simulator studies agreed closely with field studies. Simulation drivers did not slow for light rainfall but slowed significantly at higher rain intensity, decreasing on average by 6 to 12 mph.

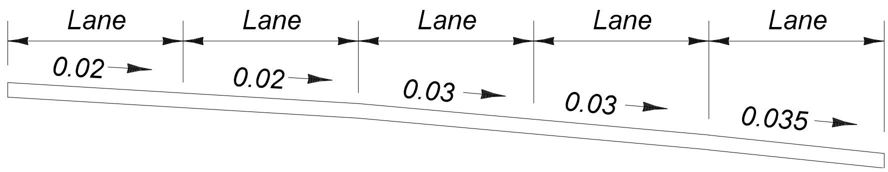
Rendering of lane configuration of the reconstructed I-4 Ultimate project. The project adds four tolled express lanes—two in each direction—to the center of the highway, while maintaining the existing free general use lanes—four in each direction. Research demonstrates that roads wider than three lanes can be sloped in one direction without compromising safe travel conditions during periods of rain.

USF researchers obtained pavement permeability and macro-texture properties to estimate the WFT formed during sheet flow on open-graded and dense-graded pavements. They also formed analytical equations for predicting the critical WFT under different road geometric conditions, such as straight runs, super-elevations, and transition sections.

USF researchers also analyzed crash statistics, geometric data, pavement condition data, and other relevant information available in numerous FDOT databases. They verified the models through tests on a test course equipped to produce a regulated adjustable water film, and developed a numerical model to predict WFT needed to produce critical friction conditions for smooth tires sliding on wet and rough pavement surfaces.

The quantitative results from the FGCU project and other data developed by USF researchers resulted in the development of the hydroplane prediction (HP) software. The software tool will enable roadway engineers to design safe multi-lane roadways while saving millions of dollars in design and construction costs. FDOT has issued a design bulletin that provides guidance for using HP in quantifying the hydroplaning risk analysis. The software is free and available on the FDOT website at www.dot.state.fl.us/rddesign/Bulletin/Default.shtm. ⬣

Potential Hydroplane Speed: Example Design Speed of 65 mph



Cross Slope	0.02	0.02	0.02	0.03	0.03	0.035	Predicted Driver Speed
Rainfall Intensity i (in/hr)	Shoulder	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5	
0.10	--					100 (n/a)	65
0.25	--					100 (n/a)	65
0.50	--					100 (n/a)	59
1.00	--					76	57
2.00	--					56	53
3.00	--					50	45
4.00	--					53	45

HP predicts the speed at which hydroplaning could occur given the rainfall intensity. In the scenario above, HP provides hydroplane speeds for the outermost lane, in this case, Lane 5, cross-sloped at 0.035 or 3.5%. Therefore, for .10, .25 and .50 inches of rain per hour, HP predicts that hydroplaning could occur at 100 mph; at 1 inch per hour, hydroplaning could occur at 76 mph; at 2 inches per hour, hydroplaning could occur at 56 mph; at 3 inches per hour, hyrdoplaning could occur at 50 mph, and at 4 inches per hour, hydroplaning could occur at 53 mph. Based on research, the speeds at which drivers are predicted to travel depending on rainfall intensity are shown in the far right column.

Gearing Up for Automated Vehicles

Automated vehicle (AV) technology is an umbrella term that includes autonomous vehicle and connected vehicle technologies. Autonomous vehicle technology includes the use of sensors and advanced software that interpret a vehicle's surroundings to make intelligent decisions on routing and maneuvering. The technology directly impacts the vehicle's safety-critical functions, such as steering, accelerating, and braking.

Connected vehicle (CV) technology differs in that CV relies on information broadcast to the vehicle by infrastructure or other vehicles about real-time operations of the transportation network. Broadcast information enables the driver to make informed decisions about routing and maneuvering. CV does not impact safety-critical functions of the vehicle, as the driver remains in control of the vehicle at all times.

UFTI researchers are using an automated vehicle, shown above, in their research.

The National Highway Traffic Safety Administration (NHTSA) defines five levels of automated vehicles ranging from "0", where the driver is in "complete and sole control of the primary vehicle controls," to "4", where the vehicle "performs all safety-critical driving functions and monitors roadway conditions for an entire trip." AV promises to offer extraordinary improvements to both the safety and efficiency of existing roadways and mobility systems.

The USDOT has approved two automated vehicle test beds in Florida—the Selmon Expressway in Hillsborough County and a route in proximity to the Orlando-Orange County Convention Center. These and other test locations nationwide provide researchers with the capability to test the safety, mobility, environmental, and efficiency advantages, and services, standards, and components of automated vehicles.

In November 2013, FDOT co-hosted Florida's first automated vehicle summit in Tampa to explore the current state of AV technology in Florida and the key regulatory issues FDOT needs to address prior to deployment of AV technology. Subsequent to the summit, in May 2014, FDOT formed three AV stakeholder working groups to identify challenges and opportunities of AV technology in the areas of policy, modal applications, and technology. Working group findings will be presented at the second Florida AV summit in Orlando in December 2014.

Also in 2014, FDOT contracted with the University of South Florida's Center for Urban Transportation Research (CUTR), Florida State University's Center on Accessibility and Safety for an Aging Population (ASAP), and the University of Florida's Transportation Institute (UFTI) to conduct research on various aspects of AV technology and support the work of the AV stakeholder working groups. These research teams will present their work at the upcoming summit.

CUTR researchers are working with the Jacksonville Transportation Authority and the North Florida Transportation Planning Organization to identify currently available AV technologies that could be installed on transit vehicles. Such technologies include software and hardware such as radar, lidar, magnetic guidance, mechanical guidance, optical guidance, and global positioning systems; transit-related AV applications including lane guidance, shoulder operations, precision docking, collision avoidance, and adaptive cruise control; and other technologies relating to vehicle operator assistance, automated dispatch, passenger-to-vehicle communications, or adaptation of current technologies from light-duty vehicles to heavier transit buses or paratransit vehicles. Researchers also will review industry publications, technical reports, and inventories of relevant technologies. Their final product will be a classification of transit-related technologies pursuant to NHTSA vehicle automation categories.

Researchers at Florida State University's ASAP are studying the mobility needs and other behavioral issues related to the elderly population, attitudes

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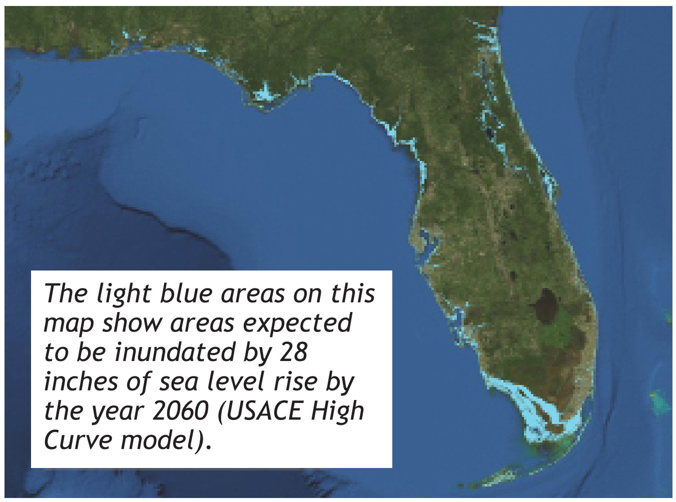
Sea Level Rise Planning Tool Maps Potential Inundation Areas

The longest record of sea levels in the Western Hemisphere began in 1846 in Key West, Florida. Since 1900, records show a steady and gradually accelerating sea level rise. Rising sea levels have major implications for Florida, with its extensive coastal exposure, hurricane history, and low-lying coastal areas. Recently, FDOT funded research to better understand the possible impacts of rising sea levels on the state's transportation system and to explore ways to support decision making and increase the resiliency of transportation infrastructure to these impacts.

In 2010-11, FDOT contracted with researchers at Florida Atlantic University (FAU) to review sea level change projections, studies, models, and methodologies used in Florida. They recommended that FDOT use the U.S. Army Corps of Engineers (USACE) sea level change guidance for forecasting scenarios of possible future rates of sea level change over various planning horizons. These scenarios can help FDOT identify and assess infrastructure vulnerabilities and make informed decisions about when impacts might occur.



The light blue areas on this map show areas expected to be inundated by 28 inches of sea level rise by the year 2060 (USACE High Curve model).

In a subsequent project, researchers at the University of Florida (UF) GeoPlan Center in 2012-13 developed the Florida Sea Level Scenario Sketch Planning Tool. FDOT and other transportation agencies can use the tool to evaluate transportation facilities which may be vulnerable to inundation, building on the methodology recommended by FAU researchers. This interactive Geographic Information System (GIS) tool facilitates the identification of transportation infrastructure potentially at risk from projected sea level changes. The tool builds upon the USACE sea level change projection methodology, as outlined in the latest published USACE Engineering Circular EC 1165-2-212.

The benefits of the methodology include the use of local data to generate relative sea level change projections for multiple scenarios, and the ability to revise the calculations based on the latest available guidance and trends. The tool consists of three elements that can be used either separately or in combination—a map viewer, the output modeled GIS data layers (inundation surfaces and affected infrastructure), and an ArcGIS calculator for creating custom inundation surfaces. The project's website, http://sls.geoplan.ufl.edu/, includes publicly accessible map viewers displaying areas of potential inundation and affected transportation infrastructure. Inundation and affected transportation infrastructure layers, including FDOT-derived data from the Roadway Characteristics Inventory (RCI), Strategic Intermodal System (SIS), and the Uniform Basemap Repository (UBR), are available for download in GIS format.

The map viewer displays areas of potential inundation and affected infrastructure at three rates of sea level rise for two digital datums and for the years 2040, 2060, 2080, and 2100. It offers a variety of base maps, including high resolution imagery, streets, and terrain, and features a time-slider widget, which allows for visualization of consecutive inundations over multiple decades. It also features a report generation function, which summarizes potentially affected infrastructure, miles or area inundated, and other key attributes.

The tool enables transportation planners and engineers to consider a broad range of possibilities and to monitor various scenarios over different periods. To increase its efficacy in decision support, GeoPlan researchers are testing and refining the tool and exploring methods to incorporate refined data products, such as higher resolution digital elevation model data and bridge elevation data, and additional storm surge and flooding data. Researchers are working with the Federal Highway Administration's climate resiliency adaptation pilot projects and providing data and tools to assist with Florida pilot efforts (www.fhwa.dot.gov/environment/climate_change/adaptation). The pilot projects will assess infrastructure vulnerability to the impacts of trends, such as sea level changes and extreme weather events, and determine adaptation options. The pilot projects offer a unique opportunity for regional partners to test the tool and provide feedback on enhancements needed for usability. ⬣

Meet the Project Manager: Joe Santos, Transportation Safety Engineer

Safety is a critical component of roadway planning and design. Joe Santos, Transportation Safety Engineer in FDOT's Safety Office, has been working to improve safety by reducing crashes on Florida's roadways since 2007. One of his primary responsibilities involves implementing the American Association of State Highway Transportation Officials' (AASHTO) Highway Safety Manual (HSM) and its corresponding SafetyAnalyst (SA) software.

The HSM provides transportation agencies with quantitative scientific methods to analyze safety based on crash data and estimate safety impacts, enabling transportation practitioners to determine how to reduce the number and severity of crashes. The HSM helps FDOT build safer roads, reduce roadway problems, and ensure that drivers have the information they need to make safe driving decisions.

SA is a set of software tools that highway agencies can use for safety management. Developed cooperatively by the Federal Highway Administration (FHWA) and 27 state agencies including FDOT, SA can automate procedures that agencies previously performed manually.

In 2008, Santos managed a project to develop an interface between FDOT's crash analysis reporting (CAR) system and SA. He and researchers at the University of South Florida developed a method to convert and transfer required information being stored in CAR to a format that can be used by SA. The research team also worked with other Florida databases, such as the Road Characteristics Inventory (RCI), until the completed interface—the Safety Analyst Data Converter (SADC)—was able to convert data from all needed databases into the SA data format. The project enabled SA to incorporate state-of-the art safety management approaches into computerized analytical tools to help decision makers identify safety improvement needs and develop a system-wide program of site-specific improvement projects.

In 2010, Santos and researchers at Florida International University (FIU) helped FDOT progress toward statewide deployment of SA. His research team developed safety performance functions for predefined roadway subtypes, obtained average annual daily traffic (AADT) data from local governments, developed a converter program to assist analysts with inputting data, and developed a geographic information system tool to visualize SA output. The data compiled and tools developed will help FDOT to systemically analyze roadway types and features and reduce crashes.

The release of the HSM and corresponding SA created an opportunity for FDOT to implement a statewide standardized crash reporting and analysis system. In 2010, Santos and researchers at FIU examined the current practice of crash analysis in Florida and ways to standardize the process. They identified critical roadway characteristics and developed recommendations for proceeding toward standardization, based on analysis of survey results from FDOT districts and local transportation agencies.

Most recently, Santos and FIU researchers investigated developing additional data to support the use of HSM and SA in Florida. They examined FDOT's comprehensive RCI database to identify variables needed but not included in the HSM or SA, identified and prioritized variables, and examined their impact on HSM calculations. For each facility type included in the HSM, they ranked the importance of variables based on their influence on crash predictions. Researchers also developed software to convert crash and roadway data into files that can be used by SA. These enhancements improve the processes for meeting the data requirements for implementing HSM and SA.

Other projects Santos has managed include studies to reduce pedestrian crashes in Florida and assist smaller local transportation agencies to collect and analyze crash data in rural areas.

"Safety issues can be diagnosed if the right tools and data are available," says Santos. "The projects I have managed help ensure that roadway engineers have the tools necessary to make Florida's roads safe." ⬣

Meet the Principal Investigator: Marty Wanielista, Senior Advisor, UCF SMA

For 50 years, Marty Wanielista has studied stormwater, both its impacts to the environment and ways to manage it. He came to the University of Central Florida's (UCF) College of Engineering and Computer Sciences in 1970 and was appointed Dean of Engineering in 1993. In 2002, FDOT provided seed money to establish UCF's Stormwater Management Academy, and Wanielista became its first director. The academy works with federal, state, and local agencies to find better methods to manage pollution caused by stormwater. The academy features the world's largest outdoor rainfall simulator, which can release up to the equivalent of 20 inches of rain an hour in varying drop sizes that replicate Florida rainfall conditions, enabling researchers to study how water falls on and runs off different surfaces.

Wanielista has been the principal or co-principal investigator on numerous FDOT research projects involving stormwater management, water quality, and erosion control. In 2005, he and his research team studied the Wekiva River to determine how roads in the area could be constructed without adversely affecting spring flow and water quality. Their findings were used in the planning and design of the 27-mile Wekiva Parkway, which has been heralded as a shining example of sound transportation planning through an environmentally sensitive area.

In 2007, Wanielista and his research team studied pollutant levels in 14 central Florida detention ponds used to collect stormwater runoff from transportation facilities to determine whether it could be used for irrigation. They determined that filtering pond water through soil in a horizontal well would reduce pollutant levels, resulting in stormwater that meets irrigation water quality standards. The research demonstrated that filtered stormwater can be a cost-effective alternative to using potable water resources or reclaimed or treated sewage water for irrigation and other uses.

Wanielista and his research team next tested biosorption activated media (BAM) to filter stormwater pumped from detention ponds. At the time of the study, only horizontal wells and sand filters were approved for water reuse. They found that in test swales equipped with beds of BAM, pollutants were removed more effectively than with sandy soils, and that filtered stormwater using BAM also results in higher water quality than reclaimed water at much lower cost. They developed a model called Stormwater Harvesting and Assessment for Reduction of Pollution (SHARP), which predicts interactions among groundwater, ponds, rainfall, and runoff. They have also authored a model called BMPTRAINS that evaluates the nutrient removal effectiveness of different stormwater facilities.

Most recently, Wanielista and his research team developed design and operating equations to compute the expected removal of pollutants from stormwater in underground retention facilities equipped with BAM. FDOT frequently constructs these facilities in urban environments where insufficient land is available to build retention or detention ponds. Wanielista and his research team placed a BAM called Bold and Gold™ in the underground facilities to remove pollutants and determined the volume of BAM needed to remove pollutants and meet water reuse quality standards.

Over the past eight years, UCF has patented six mixes of BAM made with a variety of recycled materials such as ground tire crumbs. "As its use catches on, roadway designers will start using BAM more and more in wet detention facilities to filter stormwater so it can be reused," says Wanielista. "Reusing filtered stormwater for irrigation can save cities, counties, and other users millions of dollars and reduce adverse environmental impacts."

Wanielista anticipates a bright future for the Stormwater Academy and envisions future research to find more applications for BAM, including its application to solve water quality problems in springs and estuaries. "The use of BAM holds tremendous potential to remove pollutants from stormwater and to help FDOT, municipalities, and others achieve water reuse quality standards." ⬣

Weld Inspection Method Saves Time and Money

Welds critical to a steel bridge's integrity are tested before they leave the workshop to ensure they meet rigorous standards governed by the American Association of State Highway Transportation Officials (AASHTO)/ American Welding Society's (AWS) Bridge Welding Code. To detect flaws without damaging the weld, the code requires nondestructive testing be performed. Two methods are commonly used: radiographic testing (RT) or conventional ultrasonic testing (UT). Both are valid test methods, but both have limitations.

In RT, the weld is irradiated from one side and a detector is placed on the opposite side. The patterns of light and dark that form the image represent the amount of radiation reaching each area. Because radiation presents serious safety issues, RT must be performed by specialized operators, which imposes significant costs. RT also requires exclusion of workers from the test area due to safety concerns.

UT uses a single-element probe to emit an ultrasonic beam. Compared to RT, UT is more portable, easily penetrates to greater depths, is nonhazardous, and determines depth of flaws better.

University of South Florida (USF) researchers recently investigated a non-destructive technique called phased array ultrasonic testing (PAUT), which uses a multi-element probe. PAUT can sweep through a wide area at a fairly fast speed without physical manipulation, and with increased accuracy, efficiency, and reach of testing.

PAUT offers several benefits over RT. It features no radiation source, increases productivity for inspectors, increases productivity for the job site, has a better detection capability, saves money on inspection costs, and offers increased reliability. It also offers several benefits over UT. It is allowable as a replacement for RT, allows a permanent record, produces more versatile waveforms and focus, has better detection and sizing capabilities, and offers enhanced imaging through multiple displays.

The Main Street Bridge in Jacksonville, Florida, over the St. Johns River, is a steel girder bridge.

Researchers inspected 35 RT, UT, and PAUT test welds, yielding 92 PAUT tests, 54 UT tests, and 108 RA tests. Rejection rates of PAUT (8.7%) were similar to RT (9.3%) and UT (7.4%). Additional testing was performed on three custom-designed test plates with built-in edge flaws. PAUT, RT, and UT all agreed concerning plate defects. Researchers concluded that PAUT would make a suitable substitute for RT and UT in bridge weld inspection, provided an appropriate procedure is followed.

FDOT's State Materials Office has implemented a procedure for the use of PAUT technology and received approval from internal review committees, industry, the Federal Highway Administration (FHWA) and AWS. FDOT is the first state in the U.S. to allow the use of PAUT to inspect steel welds, potentially saving FDOT thousands of dollars or more per project. ⬣

Automated Vehicles, continued from page 10

of this population toward the use of autonomous vehicles, and related transportation challenges. The research will provide FDOT with information and guidance on how autonomous and connected vehicle technologies could enhance mobility operations for certain segments of the population, particularly the aging and transportation disadvantaged segments. Automated vehicles potentially could reduce costs and expand services to the aging population. Researchers will identify both near- and long-term challenges and opportunities associated with the implementation of automated vehicles for Florida's residents.

The researchers anticipate presenting their findings at the summit concerning literature reviews on travel behavior and mobility needs, and travel safety and technology adoption of elderly populations. They will also present a summary of preliminary work on attitudes of elderly residents toward AV and related technologies.

UFTI researchers are studying policy impacts of AV technology on industries and trades, such as taxis, transit, trucking, roadway engineering, traffic engineering, construction, insurance, transportation planning, and the judicial system. Research findings will help FDOT understand the current policy framework that either enables or prohibits adoption of AV technologies by public and private entities. Researchers will develop guidance on how FDOT can draft and implement policies associated with AV technology. Researchers also will include recommendations on how FDOT can address the potential challenges and opportunities AV technology presents, and identify how the benefits of AV technology may impact FDOT's transportation planning and policy development strategies. ⬣

For More Information

Roadside Vegetation

B8411, Florida Landscape and Safety Guide
Gary Henry, Project Manager
Gerald Lott, Principal Investigator

BDK75-977-11, Techniques and Training for Management of Invasive Species and Vegetation of Florida Rights-of-Way
Tim Allen, Project Manager
Jason Ferrell, Principal Investigator

BDK75-977-54, Undesirable Roadside Vegetation
Tim Allen, Project Manager
Brent Sellers, Principal Investigator

PR4516611, Energy Conservation Study
Jeff Caster, Project Manager
Jeff Norcini, Principal Investigator

BDK75-977-74, Economic Impact of Ecosystem Services Provided by Ecologically Sustainable Roadside Right-of-Way Vegetation Management Practices
Jeff Caster, Project Manager
George Harrison, Principal Investigator

BDV31-977-03, Investigation of Economic Impacts of Florida's Highway Beautification Program
Jeff Caster, Project Manager
Hayk Khachatryan, Principal Investigator

Hydroplane Prediction Tool

BDQ22-977-01, Evaluation of Driver Behavior to Hydroplaning in the State of Florida Using Driving Simulation
Jennifer Green, Project Manager
Claude Villiers, Principal Investigator

BDK84-977-14, Hydroplaning on Multi-Lane Facilities
Jennifer Green, Project Manager
M. Gunaratne, Principal Investigator

Automated Vehicle Technology

BDV32-977-06, Policy Implications of Automated Vehicle Technology
Ed Hutchinson, Project Manager
Siva Srinivasan, Principal Investigator

BDV26-977-07, Evaluation of Automated Vehicle Technology for Transit
Ed Hutchinson, Project Manager
Brian Pessaro, Principal Investigator

Sea Level Rise Planning Tool

BDK75-977-63, Development of a GIS Tool for the Preliminary Assessment of the Effects of Predicted Sea Level and Tidal Change on Transportation Infrastructure
Maria Cahill, Project Manager
Alexis Thomas, Principal Investigator

BDK79-977-01, Development of a Methodology for the Assessment of Sea Level Rise Impacts on Florida's Transportation Modes and Infrastructure
Maria Cahill, Project Manager
Leonard Berry, Principal Investigator

Phased Array Ultrasonic Testing

BDK84-977-26, Comparative Testing of Radiographic Testing, Ultrasonic Testing, and Phased Array Advanced Ultrasonic Testing Non-Destructive Testing Techniques in Accordance with the AWS D1.5 Bridge Welding Code
Steven Duke, Project Manager
Stuart Wilkinson, Principal Investigator