Economic Impact of Ecosystem Services Provided by Ecologically Sustainable Roadside Right of Way Vegetation Management Practices

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DISCLAIMER

The opinions, findings, and conclusions expressed in this publication are those of the author and not necessarily those of the State of Florida Department of Transportation.

METRIC CONVERSION TABLE

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
Mass				
ton	ton	0.9072	Metric tonne	MT

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16. Abstract

The economic value of runoff prevention, carbon sequestration, pollination and other insect services, air quality, invasive species resistance, and aesthetics was estimated for Florida’s State Highway System roadside right-of-way (ROW) ecosystem using the benefits transfer method. Regardless of whether these benefits are classified as ecosystem services or functions, the sum total value of these benefits was conservatively estimated at nearly a half billion dollars. Utilizing sustainable vegetation management practices more than doubles the total value. And incorporating Wildflower Areas (WAs; remnant native plant communities as well as wildflower plantings) nearly triples the value of these benefits. While roadside ROW vegetation historically has been treated as a financial liability to fulfill main FDOT functions, information in this report provides evidence that roadside ROW vegetation is an asset. The cost of vegetation management, at least $33.5 million in 2011-12, is more than offset by the value of only carbon sequestration, a service that potentially could generate income for FDOT via the sale of carbon credits. And implementing sustainable management practices will reduce vegetation management costs nearly 30 percent. Understanding the economic benefits of the roadside ROW ecosystem and sustainable management practices will allow the department to measure outcomes and establish performance targets. Findings in this report serve as an incentive for FDOT to gradually implement innovative, broad scale, ecologically sustainable roadside ROW vegetation management practices and expand the number and acreage of WAs.

17. Key Word	18. Distribution Statement
Wildflower Area, roadside ecosystem, runoff , carbon sequestration, pollination, air quality, invasive species resistance, aesthetics	No restrictions

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EXECUTIVE SUMMARY

The Florida Department of Transportation manages an estimated 186,121 acres of right-of-way (ROW) on the State Highway System (SHS); about half of that acreage is believed to be vegetated. Like other states, much of that vegetation is turfgrass, which traditionally is used to stabilize soil and provide a safe clear recovery zone for vehicles which leave the highway. Roadside vegetation managers are responsible for maintaining the turf in a relatively healthy condition in order to fulfill turf's soil stabilization and safety functions, and secondarily, aesthetic appeal. Meeting these objectives is costly. In 2011-12, the cost of vegetation management was at least $33.5 million, with over 25 percent of that being mowing costs. It's not unexpected then, that roadside vegetation is historically viewed as a liability.

While roadside ROW vegetation historically has been treated as a financial liability to fulfill main FDOT functions, information in this report provides evidence roadside ROW vegetation is an asset.

The economic value of runoff prevention, carbon sequestration, pollination and other insect services, air quality, invasive species resistance, and aesthetics was estimated for Florida's SHS roadside ROW ecosystem using the benefits transfer method. Regardless of whether these benefits are classified as ecosystem services or functions, the sum total value of these benefits was conservatively estimated at about a half billion dollars. Utilizing sustainable vegetation management practices more than doubles the total value. And incorporating Wildflower Areas (WAs; remnant native plant communities as well as wildflower plantings) nearly triples the value of these benefits.

Furthermore, the cost of vegetation management, at least $33.5 million, is more than offset by the value of carbon sequestration alone, a service that potentially could generate income for FDOT via the sale of carbon credits. And implementing sustainable management practices will reduce vegetation management costs nearly 30 percent.

Results of this report will help the department to understand the economic benefits of the roadside ROW ecosystem and utilizing sustainable management practices thereby allowing the department to measure outcomes and establish performance targets. The department may also use this information in their decision making about roadside landscape design, construction, and maintenance. Findings in this report serve as an incentive for FDOT to gradually implement innovative, broad scale, and ecologically sustainable roadside ROW vegetation management practices and expand the number and acreage of WAs.

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CHAPTER 1: INTRODUCTION

Overview

The Florida Department of Transportation is believed to have 186,121 acres of right-of-way (ROW) on roads in the State Highway System (Caster, 2006); about half that acreage is estimated to be vegetated (J. Caster, personal communication, June 6, 2013). Much of the vegetated ROW is turfgrass. The national average ROW vegetation for roads in the National Highway System is 64 percent turfgrass, with the remainder about equally divided among shrubs, trees, and tree/grass mix (Federal Highway Administration, 2010a). In Florida, and other states as well, infrequent remnants of native communities[1] occur beyond the clear recovery zone[2].

Like other states, turfgrass traditionally is used to stabilize soil and provide a safe clear recovery zone for vehicles that leave the highway (Ferrell, Unruh, & Cruse, 2009).Why turfgrass? The answer seemingly has its roots in Jesse Bennett's book, *Roadsides: The Front Yard of the Nation* (Bennett, 1936).

> "…the maintenance of the average country roadside as a lawn would be highly impractical. A good stand of grass, however, is desirable, even though it is cut by means of scythes only two or three times each season…Grass areas maintained as lawns are commonplace, they surround every home and they appear inappropriate in few locations. From the standpoint of appearance, people in general are more interested in grass than in any other class of plants; they are accustomed to seeing grass where it should be grown and they are even frequently concerned with weeds in their lawns when they do not have flower beds or shrubs. The necessity and popularity of grass cannot be questioned and its use along the roadsides invites little criticism, while serving a most economical purpose."

Roadside vegetation managers are responsible for maintaining the turf in a relatively healthy condition in order to fulfill turf's soil stabilization and safety functions, and secondarily, aesthetic appeal. Meeting these objectives is costly. Mowing alone costs the state over $13 million per year. Add in the cost for fertilization, litter control, tree trimming, and control of weeds and invasive species, and it's no wonder that roadside vegetation is historically viewed as a liability.

However, roadside vegetation should be viewed as an asset since vegetation provides ecosystem services, benefits that can be worth millions of dollars annually and more than offset management costs. And the value of ecosystem services can be substantially increased by implementing sustainable roadside vegetation practices statewide. To implement sustainable roadside vegetation practices, the Florida Department of Transportation (FDOT) needs to be

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[1] Secondary succession does not occur in these native communities because all ROW vegetation typically is mowed back during the fence-to fence/tree line to tree line fall cleanup mowing.

[2] The part of the roadside ROW immediately adjacent to the edge of pavement that is "… the relatively flat unobstructed area that is to be provided for safe use by errant vehicles." The width of this zone varies by road type, location, and speed limit (Florida Department of Transportation, 2013d).

equipped with the information needed to make and justify decisions about sustainable ROW vegetation management practices. Understanding the economic impacts will allow the department to measure outcomes and establish performance targets. In addition, knowing the economic value of ecosystem services dovetails with FHWA's Ecosystem Services Market initiatives (Federal Highway Administration, 2010b).

Current Status of Florida Roadside Right-of-Ways

State and National Highway System

There are 12,079 miles of roads owned by the State of Florida (State Highway System [SHS]) and maintained by FDOT of which 8,144 miles also are part of the National Highway System (NHS) (Table1-1) (Florida Department of Transportation, 2013a). Over 40 percent of SHS miles are in Districts 2 and 3 – the panhandle and extreme northern peninsular Florida, and nearly a third of NHS roads are in these two Districts (Table 1-2) where many of these miles are rural. The most urbanized Districts – 4 and 6 in southeastern Florida from Indian River County to the Keys – have about 17 percent and 19 percent of SHS and NHS miles, respectively. The increase in SHS and NHS mileage has been nil since 2011 (Table 1-2).

What has increased since 2011-12 is the SHS mileage under Asset Maintenance. Mileage under Asset Maintenance has jumped from 4,263 in 2011-12 (D. Strickland, personal communication, September 24, 2013) to 5,359 (Florida Department of Transportation, 2013c), an increase of over 25 percent, with the majority of the increases in Districts 1 to 3.

Right-of-Way Vegetation

The vegetated portion of NHS road ROWs is comprised mainly of turfgrass as noted previously. Since 67 percent of roads in the SHS are NHS system roads, and turfgrass is the main type of vegetation used on all roadside ROWs, it could be presumed that vegetation on the roadside ROW of the other 3,935 miles of the SHS is at least 64 percent turfgrass, with the remaining 36 percent comprised of trees, shrubs, and a mix of woody vegetation and turfgrass.

One vegetation type which was not accounted for in the FHWA report (Federal Highway Administration, 2010a) was wildflower areas – either planted or naturally occurring. This type of vegetation in Florida accounts for less than 1 percent of the total vegetated ROW acreage on the SHS (Table 1-3).

Management activities and their cost. Vegetation management activities performed on the SHS are listed below; specific activities within a main activity are noted in parentheses (Florida Department of Transportation, 2012b):

- Mowing (large, intermediate, and small machine; slope)
  Note: See Table 1-4 for number of annual mowing cycles by District
- Tree Trimming
  Note: The current MRP handbook (Florida Department of Transportation, 2013b) *specifies that "No encroachment of trees, tree limbs or vegetation in or over travel way or clear zone,*

lower than 14-1/2 feet or lower than 10 feet over sidewalks. No vegetation shall violate the horizontal clearance as defined by this standard."

- Wildflowers
  Note: Establishment and management only; does not include seed cost.
- Sodding
- Seeding, Fertilizing, and Mulching
  Note: Different than turf fertilization;"…associated with reworking non-paved shoulders and slope repair, standard 436 and ditch repair, standard 461" (Florida Department of Transportation, 2012b)
- Emergency Seeding, Fertilizing, Mulching, and Sodding (*note: none reported in FY 2011-12*)
- Fertilizing turf
- Control of Invasive/Exotic Species
- Weed Control (manual, chemical [nonselective], chemical [selective])

Maintaining roadside ROW vegetation is a significant cost for FDOT (Table 1-5)[3]. A very conservative estimate of the per acre cost averaged over Districts is about $414, which is based on only seven mowing cycles per year (Table 1-4)[4]. Mowing costs were conservatively estimated to show the minimal cost savings that would be realized by reducing mowing frequency 50 percent, and eliminating the routine application of fertilizers and chemical herbicide. The other maintenance activities would continue to be implemented; these activities are tree trimming, wildflowers, wildflower seed purchase, control of exotic/invasives, sodding, 'seeding, fertilizing, and mulching'.

The greatest expenditure was for mowing, which in FY 2011-12 cost the state nearly $13 million, and well over that sum if including the cost of mowing for roads under Asset Maintenance contracts. In 2011 and 2012, the number of mowing cycles per year ranged from six on ROWs on Rural Limited Access roads in District 7 to 24 cycles on ROWs in Urban Limited Access roads in District 6. The number of mowing cycles clearly increases from the panhandle to south Florida for arterial roads as well as when all types of roads are averaged by District (Table 1-4). While there is no clear trend for limited access roads, the number of mowing cycles is greatest in south Florida – District 6 and the Turnpike (Table 1-4). Interestingly, tree trimming is a major expenditure (data not shown) and accounts for a substantial portion of the "Other" vegetation maintenance activities listed in Table 1-5.

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[3] Based on FY 2011-12 cost data provided by FDOT. However, FDOT noted that these are not exact costs and other factors could affect production costs not included in the cost reporting system. In addition, while the cost reporting system has built-in methods to flag inaccuracies, the data only is as accurate as the information provided and entered into the system.

[4] Minimal mowing cost – the most frequent lowest number of mowing cycles as well as the number of cycles averaged across Districts 2, 3 and 7, Districts where there are the least number of mowing cycles.

Table 1-1. Public road mileage summary (Florida Department of Transportation, 2013a).

System	Miles	% of Public Miles	% Paved
Public Roads	121,829	100%	
County	70,034	57.5%	77.8%
City	37,519	30.8%	96.8%
State	12,079	9.9%	100%
Federal[1]	2,232	1.8%	
State Highway System[2]	12,079	9.9%	100%
National Highway System[3]	8,144	6.7%	100%

[1] Federal Roads – Roads that are owned by agencies of the U.S. Government. Includes many (but not all) roads in National Parks, National Forests, and Indian reservations, as well as roads owned by the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and the National Aeronautical and Space Administration.

[2] State Highway System – Roads owned and maintained by the State of Florida; includes interstate highways, turnpike, U.S. routes, and state roads.

[3] National Highway System – Public roads that have been designated by Congress or the Federal Highway Administration as nationally important. The NHS data include only the State Highway System portion of the NHS.

Table 1-2. State Highway System (SHS) and National Highway System (NHS) mileage by Maintenance District (Florida Department of Transportation, 2013a)[1]

	SHS[2]		NHS[3]	
District	Miles	% SHS Miles	Miles	% NHS Miles
1	1,867.3	15.5%	1,380.8	17.0%
2	2,555.3	21.2%	1,407.4	17.3%
3	2,387.3	19.8%	1,207.1	14.8%
4	1,373.0	11.4%	1,017.7	12.5%
5	2,119.3	17.5%	1,735.2	21.3%
6	700.0	5.8%	539.0	6.6%
7	1,076.8	8.9%	856.4	10.5%
Total	12,079	100%	8,143.7	100%

[1] Based on 2013 data (Florida Department of Transportation, 2013c) ; mileage on the Turnpike System not shown since the mileage data for the SHS and NHS within a District already incorporates Turnpike System mileage.

[2] Data published in 2013 (Florida Department of Transportation, 2013a). The 2013 data varied less than 0.02% from 2011 data published in September 2012 (Florida Department of Transportation, 2012a); 12,076 total miles in that report.

[3] These data are not directly comparable to the data published in September 2012 because of the methods used to classify mileage; however, if 2011 mileage data were classified the same as in the 2013 report it is expected that mileage would be 0.02% or less based on the SHS data for those years.

Table 1-3. Roadside wildflower acreage since 2011: new sites established by seed and natural stands preserved through reduced mowing practices.

District		Seeded sites (acreage) Planted	Seeded sites (acreage) Still exist	Natural wildflower sites preserved (acreage)
1		0.06	0.06	0
2		------ Both types exist but acreage not recorded -----		
3		0.6[1]	Info not available	0
4[2]		0	---	0
5		106	26	224
6		-------- See footnote 3 -------		0
7		2.2	Info not available	0
8[4]	Z2	6	5.5	0
	Z3	-------------------------- No response -----------------------		

[1] Five sites, all in Santa Rosa County.

[2] Wildflowers only sparsely re-germinate in the subtopics (if at all), therefore, does not provide adequate erosion control. Planting container-grown wildflowers yearly essentially becomes an annual which this District has made the decision not to fund. (Elisabeth Hassett, e-mail response to inquiry about wildflower plantings, September 23, 2013.)

[3] All planted wildflower acreage (6 A; 5.5 still exist) in this region is on the Turnpike (District 8).

[4] Zone 2 – MM 200 and south; Zone 3 – MM 200 and north. “For the entire Turnpike system we have ~100 acres of planted wildflowers, spread over 54 sites. Most of these are in the Orlando – Tampa area. There are also about 300 acres of natural stands we have identified that the mowers are supposed to avoid at certain times of the year.” (Andrew Seibel, e-mail response to inquiry about wildflower plantings September 18, 2013).

Table 1-4. Number of mowing cycles per year by District and road type; 2011-2012.

		Rural		Urban		
	District[1]	Arterial	Limited Access	Arterial	Limited Access	District Ave.[2]
Panhandle	3	7	7	7	7	7
	2	7	7	9	N/A[3]	8
	5	8	9	10	10	9
	7	8	6	10	6.5[4]	8
	1	10	8	10	8	9
	4[5]	10	10	10	10	10
South Florida	6[6]	16	21	20	24	20
	8[7]	N/A	12	N/A	12	12
	Road type ave.[2]	9	10	11	11	---

[1] Districts arranged from panhandle to south Florida.

[2] Rounded off to nearest whole number.

[3] No Urban Limited Access roads (Lizbeth Yates, e-mail response about mowing cycles, April 10, 2013).

[4] District 7 – Average for 2011 and 2012.

[5] District 4 – Occasionally cycles for Urban Arterial may increase to 12 (Kim Gutierrez, e-mail response about mowing cycles, April 10, 2013).

[6] District 6 – Averages shown for Rural: Rural Limited Access – 18 to 24 per year; Rural Arterial – 12 to 20 per year (Khaled Al-Said, e-mail response about mowing cycles, May 29, 2013).

[7] District 8 – Turnpike System; contracts only cover Milepost 0 to Milepost 200 on the system, central and south Florida. While the Turnpike System is not divided by roadway types, all are Limited Access (Charmaine Colley, e-mail response about mowing cycles, July 22, 2013).

Table 1-5. Projected right-of-way (ROW) vegetation management cost savings by implementing sustainable ROW management practices. Values are based on data provided by FDOT for July 1, 2011 to June 30, 2012[1], and 93,060 acres of vegetated ROW on the State Highway System.

	ROW Vegetation Mgt. Cost[2]	
	Per Acre	Total
Current Total (2011-2012)	$414.10	$33,495,434
Mowing (7 cycles)[3,4]	$145.83	$8,685,343[5]
Chemical weed control	$54.85	$5,104,341
Fertilization[4,6]	$4.63[5]	$275,753
Other[7]	$208.79	$19,429,997
Sustainable Practices - Total	$281.71	$23,772,966
Mowing (50% reduction)[8]	$72.92	$4,342,969
Chemical weed control (eliminate)	0	0
Fertilization (eliminate)	0	0
Other[7]	$208.79	$19,429,997

[1] See footnote 3 on page 3.

[2] Maintenance activities defined in FDOT's *Maintenance Cost Handbook* (Florida Department of Transportation, 2012b) , and performed by FDOT, contractor, and inmate crews. Since data was not available for work performed under Asset Maintenance Contracts, the actual cost for maintenance activities was considerably greater.

[3] To conservatively estimate the lowest mowing costs, this expenditure was based on seven mowing cycles, the most frequent lowest number of mowing cycles (Table 1-4) as well as the number of cycles averaged across Districts 2, 3 and 7, Districts where there are the least number of mowing cycles.

[4] Based on 59,558 acres, which is the estimated acreage of turfgrass based on the national average that turfgrass comprises 64% of roadside ROW vegetation (Federal Highway Administration, 2010a).

[5] Value calculated as $145.83 x 59,558 acres; however, since there are more mowing cycles in central and south Florida, the actual mowing expenditure in 2011-12 was $12,850,252.

[6] This is a best estimate based on the limited amount and type of data provided; tons was the units for the data provided by FDOT.

[7] "Other" are the remaining roadside vegetation management activities defined in FDOT's Maintenance Cost Handbook: tree trimming, wildflowers, wildflower seed purchase, control of exotic/invasives, sodding, 'seeding, fertilizing, and mulching' ["To include seeding, fertilizing, and mulching associated with reworking non-paved shoulders and slope repair, standard 436 and ditch repair, standard 461"). For this Research Project, all activities classified under "Other" were considered essential.

[8] 50% reduction accounts for reduced frequency and/or extent of mowing (that is, the width of the mowed swath).

Ecosystem Services

Introduction

Environmental issues came to national prominence after the first Earth Day in 1970, and along with that recognition a concomitant increase in ecology-based research, including issues related to roadside ecology and roadside ecosystems.

The term 'ecosystem services' was first coined by Paul and Anne Ehrlich (Ehrlich & Ehrlich, 1981) but the concept arguably could be traced back to the 1930s. Frank Waugh, a landscape architect who recognized the importance of roadside ecology, pointed out that native roadside vegetation is inherently valuable because it provides motorists with a sense of place (Waugh, 1931; Waugh, 1937), which is now classified as a cultural ecosystem service.

The definition of ecosystem service varies but nearly all of them incorporate the human benefits derived from ecosystems or ecosystem functions. Ecosystem functions are the "…processes or attributes that contribute to the self-maintenance of an ecosystem; in other words, what the ecosystem does" (King & Mazzotta, 2000). Preventing stormwater runoff is an example of a roadside ROW ecosystem function.

Ecosystem functions, however, may directly affect more than one ecosystem service, and functions may even overlap. For example, roadside vegetation functions to absorb rain water thereby preventing runoff, and the runoff prevention function provides services such as preventing or reducing erosion and pollution of lakes and streams by chemicals or soil nutrients.

Regardless whether the ecological benefits provided by roadsides are classified as functions or services, the value of these benefits can be monetized, that is, their dollar value can be estimated.

Classification of Ecosystem Services

Ecosystem services (ES) are classified into four types – regulating, cultural, provisioning, and supporting (Millennium Ecosystem Assessment, 2005), with regulating and cultural ES being the two most pertinent to roadside ROWs.

- **Regulating services** are those "… received from the regulation of ecosystem processes; includes services that improve human well-being by regulating the environment in which people live…[and while]…these services are generally not marketed…many have clear value to society" (U.S. Environmental Protection Agency, 2009). With respect to roadside ROWS, the most pertinent services are carbon sequestration, pollination, air quality, and resistance to invasive plant species. Roadside ROWs may provide other regulating services such as flood protection and water purification[5], and climate control[6].

[5] No valuation study data was available to allow value assessment of flood protection and water purification on roadside ROWs.

[6] Climate control is a regulating service that mostly impacts urban environments, with the main effect being provided by trees (McPherson, Simpson, Peper, & Xiao, 1999) ; no valuation study data was available to allow accurate assessment of climate control on roadsides.

- **Cultural services** – "…services that contribute to the cultural, spiritual, and aesthetic dimensions of people's well-being" as well as "…to establishing a sense of place" (Comin, 2010).

Provisioning services are those from products obtained from ecosystems, and "…include food, fuel, fiber, biochemicals, genetic resources, and fresh water. Many of these, but not all, are traded in markets" (Comin, 2010). **Supporting services** are those "…that maintain basic ecosystem processes and functions such as soil formation, primary productivity, biogeochemistry, and provisioning of habitat. These services affect human well-being indirectly by maintaining processes necessary for provisioning, regulating, and cultural services" (U.S. Environmental Protection Agency, 2009).

Valuation of Ecosystem Services

Estimating the dollar value of ES began in the 1960s but only started to become widely used by scientists in the 1990s so decision makers would be equipped with information about the economic impacts of ecological issues (Farley, 2012). .

Several methods are used to estimate the pecuniary value of ES. An excellent, non-technical explanation of each method and application is presented on the web site "Ecosystem Valuation" (King & Mazzotta, 2000).

Market Price Method
Estimates economic values for ecosystem products or services bought and sold in commercial markets.

Productivity Method
Estimates economic values for ecosystem products or services contributing to the production of commercially marketed goods

Hedonic Pricing Method
Estimates economic values for ecosystem or environmental services which directly influence market prices of some other good. Most commonly applied to variations in housing prices which reflect the value of local environmental attributes.

Travel Cost Method
Estimates economic values associated with ecosystems or sites used for recreation. Assumes that the value of a site is reflected in how much people are willing to pay to travel to visit the site.

Damage Cost Avoided, Replacement Cost, and Substitute Cost Methods
Estimate economic values based on costs of avoided damages resulting from lost ecosystem services, costs of replacing ecosystem services, or costs of providing substitute services.

Contingent Valuation Method
Estimates economic values for virtually any ecosystem or environmental service. The most widely used method for estimating non-use, or "passive use" values. Asks people to directly state their willingness to pay for specific environmental services, based on a hypothetical scenario.

Contingent Choice Method
Estimates economic values for virtually any ecosystem or environmental service. Based on asking people to make tradeoffs among sets of ecosystem or environmental services or characteristics. Does not directly ask for willingness to pay—this is inferred from tradeoffs that include cost as an attribute.

Benefit Transfer Method[7]
Estimates economic values by transferring existing benefit estimates from studies already completed for another location or issue.

All but the Benefits Transfer Method require substantial amounts of data including mapping (acreages, vegetation types, etc. – often obtained via satellite imagery and GIS), market and energy values, and/or surveys (public perceptions, willingness to pay, and other opinions) (Costanza, et al., 1997; Holzman, 2012).

Regardless of the method, it is important to be aware that all ES values are estimates and the value of an ES in a specific ecological community is relative, that is, it can vary by the opinions of the target audience as well as the opinions of scientific experts and economists (U.S. Environmental Protection Agency, 2009).

The value of ES has been estimated for numerous marine and terrestrial ecological communities. Costanza et al. (1997) estimated the total global value of ES for 16 ecological communities, with values ranging from $128 billion for cropland to $12.6 trillion for all coastal ecological communities. The value of ES for forests was $4.7 trillion and for grass/rangelands $906 billion. In 2012, de Groot et al. (2012) estimated global values of ten ecological communities based on 320 publications and 300 case studies. To standardize the monetary values, results were presented as international $/ha/year[8]. While their results are not directly comparable to those of Costanza et al. (1997), de Groot et al. (2012) did show that ES provided by marine communities were two orders of magnitude more valuable than ES provided by tropical forests, temperate forests, woodlands , or grasslands.

The total value of ES provided by roadside ROW ecosystems has not been published, nor does any of the software used to calculate the values of ES for ecological communities include roadside ROW ecosystems. However, the value of some ES provided by vegetation on roadside ROWS has been estimated. Also included in the following review is a benefit provided by roadside ROW vegetation but usually classified as an ecosystem function – runoff prevention. Reasons for including it will be discussed.

[7] The Benefits Transfer Method will be utilized in this report to estimate the dollar value of ES provided by vegetation on FDOT ROWs because of the substantial amount of data that would be required to calculate the value of ES provided by vegetation on Florida's State Highway System ROWs.

[8] "The international dollar, or the Geary–Khamis dollar, is a hypothetical unit of currency that is used to standardize monetary values across countries by correcting to the same purchasing power that the U.S. dollar had in the United States at a given point in time. Figures expressed in international dollars cannot be converted to another country's currency using current market exchange rates; instead they must be converted using the country's PPP (purchasing power parity) exchange rate. 1 Int. $ ¼ 1 USD." (de Groot, et al., 2012).

Value of Ecosystems Services Provided by Roadside ROW Ecosystems

NOTE: The following review includes only those ES for which there was published data about their value on roadside ROW ecosystems, and/or there was sufficient pertinent data to enable an economist to reasonably estimate the value of these ES on roadside ROW ecosystems in Florida.

Regulating services. These are the most significant ES provided by roadside ROW ecosystems – pollination and other services provided by insects, carbon sequestration, improved air quality, and resistance to infestation by invasive species.

Pollination and other insect services. The roadside ROW ecosystem serves as an important refuge for many insects, including native pollinators [Noordijk, Raemakers, Schaffers, & Sykora (2009) and references within]. One reason that roadsides provide good habitat for native bees and pollinators is because roadsides "…are not subject to further development" (Hopwood, 2006), although it should be noted that road shoulders may be re-worked periodically resulting in substantial disturbance of the clear recovery zone. The areas from the backslope and beyond are the least likely to be disturbed and serve as the best potential refuge for pollinator and insect habitat, especially when native plant communities have been restored or preserved in those areas.

The value of pollination and other services provided by insects (e.g., pest control) has not been estimated for roadside ROW ecosystems. However, "Florida crops pollinated by honey bees have a $3.3 billion economic impact and produce $192 million in tax revenues" (Florida Department of Agriculture and Consumer Services, 2011). Nationally, pollination services by native bees for citrus, strawberries, and vegetable and field crops (excluding sugar beets since they are not grown in Florida) was estimated at nearly $2 billion annually, with the estimated value of natural pest control attributable to insects at nearly $5 billion (Losey & Vaughan, 2006). Also, in estimating the ES provided by bees, Losey and Vaughan (2006) only included native bees; managed honeybees were excluded as were feral honeybees. Feral honeybees, that is, the "wild" ones, were excluded as Losey and Vaughan (2006) posited that feral honeybees "…most likely have been only a negligible component of crop pollination since their drastic decline in the mid-1990s…".

Carbon sequestration. Vegetation and soil (including bacteria and fungi) sequester carbon dioxide (CO_2) from the air, that is, they remove CO_2 from the air and convert it to a solid form. The length of time CO_2 is sequestered varies. Long-lived woody vegetation sequesters CO_2 much longer than short-lived annuals. For example, National Highway System (NHS) ROW grasslands were estimated to remove 0.4 to 10 metric tons (MT) of carbon per acre annually and forested areas about 2.2 MT of carbon annually (Federal Highway Administration, 2010a).

Nationwide, the FHWA estimated that the unpaved right-of-way on the National Highway System annually can sequester 425 to 680 metric million tons (MMT) of carbon (Federal Highway Administration, 2010a). A conservative value of $20 per MT results in a potential value of $8.5 to $14 billion; Florida's portion was estimated at $157 to $363 million[9] (Federal Highway Administration, 2010b).

Air quality. Roadside trees and turf can improve air quality by removing air pollutants such as particulate matter, ozone, nitrogen and sulfur dioxide, and carbon monoxide (Macdonald, Sanders, & Supawanich, 2008). While the value of this ES has not been estimated for roadside ROW ecosystems, the value of this service been studied in urban environments, but only for trees. For example, in Modesto, Calif. trees provided about $1.4 million in air quality improvement (Macdonald, Sanders, & Supawanich, 2008). About 47 lb/yr of pollutants at a value of $117 was removed by 879 street trees in Iowa (Thompson, Nowak, Crane, & Hunkins, 2004), while in Chicago the 806 MT of pollutants removed per year by its urban forest was valued at $6.4 million (Nowak, Crane, Stevens, & Fisher, 2010).

Resistance to infestation by invasive species. Reducing disturbance of roadside ROW ecosystems, utilizing sustainable management practices, and preserving and established native plant communities will help facilitate resistance to invasion by exotic species. It is well known that disturbance makes sites susceptible to invasion [e.g., see Hobbs (1989)], and that well-established plant communities are resistant to invasion [e.g., see Rejmanek, Richardson, & Pysek (2013)].

According to The Nature Conservancy, over $100 million is spent annually managing invasive exotic species in Florida. Roadside ROWs are corridors for the spread of invasive species via wind-blown seed, mowing equipment, and even shoes and clothing of maintenance personnel. In 2011-12, about $269,700 was expended by FDOT on invasive species control. However, that cost could be nearly 45 percent more when considering the expenditures for SHS roads under Asset Maintenance contracts. Utilizing practices that minimize infestation by invasive species in Florida would provide a service valued at nearly $390,000 based on current maintenance practices.

Cultural services. The main cultural service provided by the roadside ROW ecosystem is aesthetics, which in turn can contribute to providing a sense of place. No pertinent literature was available about the value that vegetation provided for sense of place on roadside ROWs.

Aesthetics. Roadside ROW vegetation is established and managed to provide motorists with an aesthetically pleasing landscape that does not comprise safety or normal highway operation. While trees, shrubs, turf, and remnants of native plant communities all contribute to aesthetics, and for the most part seem taken for granted, wildflowers often are what motorists are 'wowed' by. Texas has a well-deserved national reputation for its showy displays of roadside wildflowers. Florida is slowly gaining a reputation for its wildflowers. And North Carolina receives rave reviews for its flower plantings. The bottom line is that swaths of seasonal color are valued by motorists.

[9] Estimate was based on FHWA's estimate of 91,856 acres of unpaved ROW on the National Highway System (NHS) in Florida. FDOT estimates that there are about 93,060 acres of unpaved ROW on the State Highway System [Caster (2006); (J. Caster, personal communication, June 6, 2013)].which includes the NHS.

The dollar value of aesthetics typically is based on responses to willingness-to-pay surveys, a type of contingent valuation method (King & Mazzotta, 2000). Reports are very limited about the value provided by the aesthetics of vegetation on the roadside ROW ecosystem. The most pertinent study is one from Arizona in which residents were surveyed about their willingness-to-pay for "…increased levels of wildflowers on public lands, and increasing amount and diversity of vegetation along urban highways…" (Mast, 2002). Mast concluded that

> "…under the most conservative assumptions, the public is willing to spend between $1.6 million and $3.5 million per year to increase wildflower and highway landscaping [with] …one result from these programs [being] to create $20 to $90 million in aesthetic value in the form of wildflower and highway amenities…"

In a Georgia study, the aesthetic value of forested land on a roadside buffer ranged from $371/acre/yr in south Georgia to $1,695/acre/yr in north Georgia (Moore, Williams, Rodriguez, & Hepinstall-Cymmerman, 2011).

Runoff prevention. Preventing or limiting stormwater runoff is considered an ecosystem function of the roadside ROW ecosystem, while the corresponding ES would include erosion control, limiting pollution of streams and lake, and limiting flooding. Based on the literature, the data most pertinent to estimating the economic benefit of roadside vegetation for reducing pollution, erosion, flooding, etc., were lumped under the economic impact of reduced runoff.

Most literature focused on trees [e.g., Werner, Raser, Chandler, & O'Gorman (1996); Macdonald, Sanders, & Supanwich (2008); McPherson, Simpson, Peper, & Xiao (1999)]. For example, in Santa Monica, Calif., the reduction in stormwater runoff provided by trees was valued at about $616,000 annually (McPherson, Simpson, Peper, & Xiao, 1999), while water filtration and reduced runoff provided by turfgrass was valued at about $739,000 (A-G Sod Farms, 2008).

The most pertinent study was a recent one in Beijing, China; it specifically addressed roadside green space and runoff (Zhang, Xie, Zhang, & Zhang, 2012). Of 152,450 acres of green space, 30,033 acres (nearly 20 percent) is roadside green space. The authors estimated that the annual value of runoff reduction due to roadside green space at about $1.98 million dollars[10], or nearly $66 per acre.

[10] Value based on avoiding water purification costs and the replacement cost for water storage in a reservoir.

CHAPTER 2: METHODS

The economic benefits provided by the roadside right-of-way (ROW) ecosystem were assessed based on studies which placed a dollar value on specific features that had value, but were not quantifiable in accounting terms. Values were calculated only for those ecosystem services (ES) for which there was published data about their value on roadside ROW ecosystems, and/or there was sufficient pertinent data to enable an economist to reasonably estimate the value of these ES on roadside ROW ecosystems in Florida.

Values were calculated by the benefits transfer method, a process often used by economists to estimate values of benefits based on values derived from previous valuation studies (U.S. Environmental Protection Agency, 2009). Estimating values by any other method mentioned on pages 10 and 11 would have required substantial amounts of data including mapping (acreages, vegetation types, etc. – often obtained via satellite imagery and GIS), market and energy values, and/or surveys (public perceptions, willingness to pay, and other opinions) (Costanza, et al., 1997; Holzman, 2012); obtaining and accurately interpreting such data was beyond our resources and/or expertise.

Estimating the value of ES is highly subjective, which is further compounded by limitations of the benefits transfer method[11] [e.g., see, King and Mazzotta (2000)]. Therefore, to minimize the likelihood of overestimating ES values, calculations were done very conservatively based on the literature listed in Table 2-1. While it was difficult to calculate values for ambiguous concepts such as aesthetics and invasive species resistance, the concepts have value to the study respondents as reflected in the literature.

Ecosystem service values were calculated based on an estimated 93,060 vegetated ROW acres on the State Highway System (SHS) [Caster (2006); (J. Caster, personal communication, June 6, 2013)]. What follows is an example that illustrates the methodology used to calculate the value of an ecosystem service. The first explanation is in laymen's terms and the second in an economist's vernacular.

<u>The Simple Explanation</u> – FDOT right-of-way maintenance cost records were examined and compiled to accurately reflect current costs of both traditional treatment and native wildflower treatment. This evaluation included: mowing, seeding, mulching and other recurring activities. To assign values to the esoteric categories, professional journals were reviewed for assessments of the categories' worth in current dollar terms. Mindful of the concept that value in these categories is abstract and is based on the perception of what the author has gauged the worth at the time of publication, the amounts for each category were summed and then reduced to a fractional percentage. While this method of calculating values may underestimate the true worth of some categories by some individuals, it is a means of establishing a defendable set of economic values which may receive much scrutiny as a public asset and expenditure.

<u>The Economist Explanation</u> – FDOT right-of-way maintenance cost records were examined and compiled to accurately reflect current expenditures of both traditional treatment and native

[11] All methods of estimating ecosystem services values are subjective and have their limitations (King & Mazzotta, 2000) .

wildflower treatment using general accepted accounting methods. This evaluation included: mowing, seeding, mulching and other recurring activities that have been tracked by the FDOT Districts and compiled into aggregate sums. All values accurately reflect the data presented by FDOT. To assign values to the esoteric categories, peer reviewed journals which addressed the particular category or subject were employed for assessments of the categories' worth in current dollar terms. The concept of value is an abstract and nebulous idea that is dynamic and simply demonstrated visually in a demand curve. In what has been defined by some economists as typical, the higher the charge will result in fewer buyers. Mindful of this concept that value, real or nominal, is not static, the amounts for each category were summed and then reduced to a fractional percentage. While this way of calculating values may underestimate the true worth of some categories as assessed by individual with different perspectives, it is a means of establishing a defendable set of economic values that may receive much scrutiny, criticism and review as a public asset and expenditure.

Listed in Table 2-1 are the ES and references used to estimate the value of each ES on the roadside ecosystem of Florida's SHS. As noted previously, values only were estimated for those ES for which there was sufficient data in the literature to allow an economist to calculate a reasonable estimate of that service. Results are based FDOT data in Tables 1-1 to 1-5.

Invasive Species Resistance.

The cost to control invasive species in 2011-12 according to FDOT Maintenance records was about $269,708, with less than 3 percent of that expended on herbicide, although as pointed out previously, the total expenditure could be nearly 45 percent more when considering the expenditures for SHS roads under Asset Maintenance contracts. However, to estimate the value of this ES, the per acre value of invasive species resistance was conservatively calculated using cost accounting methods and based on the estimated labor and input cost to monitor, treat and assess invasive control using non-chemical methods. While many areas may never face this problem, they must still be actively monitored on a regular basis. Those which do develop infestations will experience high cost because of the exceptional amount of labor hours to control the problem; labor accounts for nearly 80 percent of the cost to control invasive species based on FDOT FY 2011-12 data. Hand labor may be necessary since spraying agricultural chemicals would be impractical and counterproductive. Also, sprays could result in native plant health and safety problems resulting from drift onto desirable plants, insects, and animals, water quality concerns, and a potential public relation issues given the close proximity to human populations.

Included in the ES valuation analysis was the added value of ES if sustainable ROW vegetation management practices were utilized; the data in Table 1-5 were used to calculate the added values. Also included in the analysis was the effect of Wildflower Areas (WAs) on roadside ROWs; WAs include remnants of native plant communities as well as areas planted with native wildflowers and grasses. The WAs are part of FDOT's Wildflower Management Program Procedure 650-030-001 (Florida Department of Transportation, 2014), which was implemented in January 2014. For the purpose of this report, it was presumed that 1) WAs will be mowed 2 times per year, and the safety strip between the WA and shoulder mowed 7 times per year, and 2) no herbicide or fertilizer is applied to the safety strip or the WA.

Table 2-1. References used to estimate the value of ecosystem services, via the benefits transfer method[1,2], on the roadside ecosystem of Florida's State Highway System.

Ecosystem Service	References used to Estimate Value of Ecosystem Service via the Benefits Transfer Method[1]
Aesthetics	Economic Development Research Group (2001); Liechty et al. (2010); Mast (2002); Moore et al. (2011); Sipes et al. (1997)
Air quality	Addnik (2007); Kusnierz and Dwyer (2010); Macdonald et al. (2008); Nowak et al. (2010); Nowak et al. (2013); Werner et al. (1996)
Carbon sequestration	Addnik (2007); CTC and Associates (2010); Kusnierz and Dwyer (2010); Moore et al. (2011); Nowak and Crane (2002); Sollenberger (2008); FHWA and Volpe National Transportation Systems Center (2009)
Invasive species resistance[2]	See text, page 16
Pollination and other insect services	FDACS (2011); Hopwood (2006); Losey and Vaughan (2006); Moore et al. (2011)
Runoff prevention[3]	A-G Sod Farms (2008); Kusnierz and Dwyer (2010); Low Impact Development Center et al. (2006); MacMullan and Reich (2007) ; Macdonald et al. (2008); Natural Resources Defense Council (2011); Werner et al. (1996); Zhang et al. (2012)

[1] King and Mazzotta (2000).

[2] There was no pertinent data in the literature about the value of the ecosystem services provided by invasive species resistance so these values were estimated using cost accounting methods based on FY 2011-12 data provided by FDOT.

[3] Preventing or limiting stormwater runoff is considered an ecosystem function of the roadside ROW ecosystem, while the corresponding ecosystem services would include erosion control, limiting pollution of streams and lake, and limiting flooding. Based on the literature, the data most pertinent to estimating the economic benefit of roadside vegetation reducing pollution, erosion, flooding, etc. were lumped under the economic impact of reduced runoff.

CHAPTER 3: RESULTS AND DISCUSSION

This report is the first to estimate the economic value of numerous benefits provided by roadside ROW ecosystems. For 2011-12, the value of ES provided by the State Highway System roadside ROW ecosystem in Florida is conservatively estimated at over $547 million (Table 3-1). Implementing sustainable vegetation management practices statewide would double to nearly triple that value depending on the practices implemented.

Runoff Reduction

Limiting stormwater runoff, which in turn limits erosion, flooding, and pollution of lakes and streams, is the most valuable benefit provided by the roadside ROW ecosystem. This benefit is valued at over $465 million, and triple that if sustainable management practices are combined with 1000 acres of Wildflower Areas (WAs).

The U.S. EPA has a Stormwater Calculator that estimates the amount of runoff reduction under different scenarios (U.S. Environmental Protection Agency, 2013). Three sites were examined to calculate the amount of runoff reduction if turf was converted to meadow (the closest vegetation type to wildflowers). The three Florida sites were I-10 in Madison County, the Turnpike in Winter Garden, and the Sawgrass Expressway in South Florida. Site size varied from 1 to 1.3 acres and each site included the interstate plus the roadside on both sides. The roadside portion and medians were all in turf – the baseline scenario. Preliminary results showed that including a considerable percentage of trees had a small but substantial effect on reducing runoff but only in central and south Florida. Those results are not unexpected given that other studies have shown that trees reduce runoff (Macdonald, Sanders, & Supawanich, 2008; McPherson, Simpson, Peper, & Xiao, 1999; Werner, Raser, Chandler, & O'Gorman, 1996). Converting most of the turf to meadow had a negligible effect on reducing runoff at all sites. A more extensive follow-up study is needed to accurately determine the vegetation effect on runoff noted in this preliminary work.

Carbon Sequestration

Sequestration of carbon on the roadside ROW ecosystem provides over $39 million in ES, and over double that if sustainable management practices are combined with1000 acres of WAs. The values estimated for Florida are substantially less than those in the FHWA report (Federal Highway Administration, 2010a). In that report, carbon sequestration on Florida's roadside ROWs was valued at $157 to $363 million. And that estimate was based on 91,856 of unpaved acres, less than the 93,060 acres of unpaved ROW in Florida) [Caster (2006); (J. Caster, personal communication, June 6, 2013)]. The main reason for the discrepancy likely was that we used very conservative methods for estimating the values of ES.

Given the substantial value of sequestered carbon, FDOT investigated the possibility of using the roadside as a source of income through the sale of carbon credits (Kalbli, 2009). It was suggested that "…FDOT should continue to actively monitor this opportunity and engage in discussions with likely partners to more fully evaluate the possibility of becoming a provider of carbon credits in an emerging market" (Kalbli, 2009). If carbon credits were sold, carbon sequestration could be considered a provisioning service, and its value estimated by the marketing price or productivity method (King & Mazzotta, 2000).

Table 3-1. Economic benefits in 2011-12 of using sustainable right-of-way (ROW) vegetation management practices on Florida's State Highway System. Values were estimated using the benefits transfer method[1] (King & Mazzotta, 2000), and based on 93,060 vegetated acres of state-maintained ROW) [Caster (2006); (J. Caster, personal communication, June 6, 2013)].

		Additional Value if Including Sustainable ROW Vegetation Mgt. Practices	
Ecosystem Service	Value	Plus Wildflower Area[2]	Minus Wildflower Area[3]
Aesthetics	$2,233,452	$3,200,498	$967,073
Pollination and other insect services	$34,246,264	$49,074,896	$14,828,632
Carbon sequestration	$39,457,650	$56,542,810	$17,085,160
Invasive species resistance[1]	$388,380	$1,011,082	$622,696
Runoff reduction[4]	$465,300,000	$939,636,000	$702,468,000
Air quality	$5,955,872	$11,113,657	$8,534,765
Total	$547,581,618	$1,060,578,943	$744,506,326

[1] There was no pertinent data in the literature about the value of the ecosystem services provided by invasive species resistance so these values were estimated using cost accounting methods based on FY 2011-12 data provided by FDOT. Also, these values assume that the future of invasive plants will mirror the past and no new species are introduced. In reality, the likelihood of new problem species being introduced is high, rendering these values low. Without knowing the invasive species or its problematic qualities, it is speculation to assign values.

[2] Based on 1000 acres of Wildflower Areas, which is about 1% of the total vegetated State Highway System ROW.

[3] Same sustainable management regime as shown in Table 1-5.

[4] Preventing or limiting stormwater runoff is considered an ecosystem function of the roadside ROW ecosystem, while the corresponding ecosystem services would include erosion control, limiting pollution of streams and lake, and limiting flooding. Based on the literature, the data most pertinent to estimating the economic benefit of roadside vegetation reducing pollution, erosion, flooding, etc. were lumped under the economic impact of reduced runoff. See also page 14.

Pollination and Other Insect Services

The roadside ROW ecosystem provides pollination and other insect services (e.g., biological pest control) valued at over $34 million, and over double that if sustainable management practices are combined with1000 acres of WAs. This considerable increase is well-justified as many have shown the benefits of native vegetation for pollinators and other insects [e.g., see Hopwood (2006); Ries et al. (2001)].

And since this service includes pollination by native bees the value of this service may rise even more if honeybee colony collapse disorder continues to be an issue.

Air Quality

Removal of air pollutants such as particulate matter, ozone, nitrogen and sulfur dioxide, and carbon monoxide by roadside ROW vegetation is valued at over $5.9 million, and almost triple that if sustainable management practices are combined with 1000 acres of WAs. As the amount of traffic increases, as evidenced by the widening of roads statewide, there will be in increasing need for vegetation that can effectively remove pollutants from the air (Macdonald, Sanders, & Supawanich, 2008; Nowak, Crane, Stevens, & Fisher, 2010; Thompson, Nowak, Crane, & Hunkins, 2004), especially in the vicinity of population centers. While trees are known to be effective at removing air pollutants, there is little to no information about the ability of other types of vegetation to remove air pollutants.

Aesthetics

Aesthetics is valued at over $2.2 million and more than double that if sustainable management practices are combined with1000 acres of WAs. As of the 2011-12 fiscal year, a little over 250 acres could be classified as WAs (Table 1-3).

Improved aesthetics could significantly impact Florida's economy. In Minnesota, Liechty, Schneider, & Tuck (2010) concluded that the economic impact of travelers on the Paul Bunyan Scenic Byway in 2010 was at least $12.7 million dollars, which included "..199 jobs and $4.3 million in labor income". One of the most famous scenic byways, the Blue Ridge Parkway in North Carolina and Virginia, has a very substantial economic impact. In 1987, visitors spent about $1.3 billion in counties along the Parkway, which generated about $98 million in tax revenues and supported over 26.500 jobs (Federal Highway Administration, 1990). A thorough review of scenic byway economic impacts is presented by Petraglia and Weisbrod (2001), although the information is a bit dated (pre-2001).

Invasive Species Resistance

The value of this service is almost $390,000, and over triple that if sustainable management practices are combined with 1000 acres of WAs. The low estimated value of this ES, which contributes less than 0.1 percent of the total value of ES provided by the roadside ROW ecosystem, fails to convey the economic (and ecological) importance of controlling invasive exotic species. Perhaps the "Damage Cost Avoided, Replacement Cost, and Substitute Cost Method" (see page 10) would more accurately depict the value of invasive species resistance. However, utilizing that method would require a considerable amount of pertinent economics data.

CHAPTER 4: CONCLUSIONS

This is the first report that has estimated the value of numerous benefits provided by the roadside right-of-way (ROW) ecosystem.

In Florida, runoff prevention, carbon sequestration, pollination and other insect services, air quality, invasive species resistance, and aesthetics, regardless of whether they are classified as ecosystem services or functions, all provide value that can be monetized. The sum total value of these benefits was conservatively estimated at about a half billion dollars. Utilizing sustainable vegetation management practices more than doubles the total value. And incorporating Wildflower Management (WAs; remnant native plant communities as well as wildflower plantings) nearly triples the total value of these benefits.

Moreover, sustainable management practices and WAs will not comprise safety or normal highway operation. For example, in a pilot study implemented in 2009 on a 1-mile segment of I-10 in Madison County (Norcini, 2012), typical annual mowing costs were lowered by over $1,000 when the frequency and width of mowing were reduced. The modified mowing regime did not result in any erosion or safety concerns, nor were there complaints from the public. Additionally, safety probably has improved because of the reduced presence of mowing equipment and operators.

While roadside ROW vegetation historically has been treated as a financial liability to fulfill main FDOT functions, information in this report provides evidence that roadside ROW vegetation is an asset. The cost of vegetation management, at least $33.5 million in 2011-12, is more than offset just by the value of carbon sequestration, a benefit that potentially could generate income for FDOT via the sale of carbon credits. And implementing sustainable management practices will reduce vegetation management costs nearly 30 percent.

This report sheds light on the economic benefits of the roadside ROW ecosystem. The department may consider this information useful in their decision making involving roadside and landscape design, construction, and maintenance. Understanding the economic impacts will allow the department to measure outcomes and establish performance targets. Moreover, it is hoped that the information in this report serves as an incentive for FDOT to gradually implement innovative, broad scale, and ecologically sustainable roadside ROW vegetation management practices and expand the number and acreage of WAs.

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