SURVEY OF KEY MONARCH HABITAT AREAS ALONG ROADWAYS IN CENTRAL AND NORTH FLORIDA

BDV31-977-49

Final Report

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Metric Conversion Table

SI* (MODERN METRIC) Conversion Factors

APPROXIMATE CONVERSIONS TO SI UNITS

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	squareinches	645.2	square millimeters	mm^2
ft^2	squarefeet	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
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
ºF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	ºC

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft

m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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16. Abstract

Roadsides in North and Central Florida harbor a large number of milkweed populations important to the monarch butterfly. A total of 303 roadway locations had one or more plants of the target species *Asclepias humistrata* (pinewoods milkweed) or *Asclepias tuberosa* (butterflyweed). Plant densities ranged from 1 to 161 individuals per site, 40 high density sites were identified. The majority of these populations occurred on the back, steeply sloped section of the road verge with exposed sand/soil present and adjacent to dry habitats such as scrub, pineland, and sandhill. A comprehensive georeferenced Excel spreadsheet of all population locations and related population data was developed and submitted to Florida Department of Transportation. Communication/dissemination and vegetation management recommendations are presented to help maximize the availability and productivity of roadside milkweed populations for monarch and pollinator conservation.

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Executive Summary

The monarch is arguably one of the most iconic and popular butterflies in North America. Its annual multigenerational migration is considered one of the most spectacular natural phenomena on the planet. Unfortunately, estimates from the overwintering colonies in Mexico have documented a steady population decline over the past few decades and prompted a petition to list the butterfly as threatened under the Endangered Species Act. In response, various organizations and agencies have identified and are in the process of implementing proactive strategies designed to stabilize and ultimately reverse this population collapse. Much attention has focused on the loss of breeding habitat, with recent studies indicating that an estimated 1.8 billion milkweed stems would be needed to return monarchs to a more viable population size. The Presidential Memorandum — Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators and the resulting Pollinator Research Action Plan specifically identify roadsides and other rights-of-way as priority areas where habitat could be expanded.

Our one-year study aimed to enhance best roadside management of milkweeds along roadways in Central and North Florida. Primary objectives included the identification of key milkweed populations and plant densities along select state and county roads and the development of a georeferenced database with identification of high density hotspots. The resulting data were used in collaboration with FDOT (Florida Department of Transportation) to help develop management and communication recommendations to help identify high density milkweed populations where reduced vegetative maintenance will occur and to maximize the availability and productivity of these milkweed species to support early season monarch breeding.

Our results showed that roadsides in North and Central Florida harbor a large number of milkweed populations important to the monarch butterfly. A total of 303 roadway locations had one or more plants of the target species *Asclepias humistrata* or *Asclepias tuberosa*. Resulting plant densities ranged from 1 to 161 individuals per site, and a total of 40 high density sites were identified. High density sites are defined as an individual roadside location with 25 or more plants present. The majority of these populations occurred on the back, steeply sloped section of the road verge with exposed sand/soil present and adjacent to dry habitats such as scrub, pineland, and sandhill. Additional detailed information regarding all population locations and related habitat, plant, and monarch use was collected and included in a comprehensive georeferenced Excel spreadsheet submitted to FDOT.

Following extensive communications with FDOT maintenance personnel and mowing contractors, several vegetative management recommendations were identified. Avoid mowing during the spring wildflower season from February through May of most years. As this practice is already implemented in most areas with roadside wildflower populations, which includes most of the identified high density milkweed sites, no significant change of mowing practice is warranted. In areas without significant wildflower populations or for the time period of February through July, avoid mowing the back slope to enable adequate growth, flowering, and seed set of the target milkweed species as well as potential use by monarch butterflies and other insect pollinators. The back slope of roadways adjacent to scrub or pineland habitats (deep sand sites) harbors the greatest number of milkweed plants of the targeted species, *Asclepias humistrata* and *Asclepias tuberosa*. After July, the target milkweed species have set seed and have or are in the process of senescing. Thus, regular mowing, including that of the back slope, can proceed without any significant impact to the high density milkweed populations.

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1. Introduction

Florida is a particularly strategic state to the migratory lifecycle of the *Danaus plexippus* (monarch butterfly). Each spring, as adult monarchs leave their overwintering grounds and move northward in search of milkweeds on which to lay their eggs, the available host resources they encounter are critical to help jump start the annual repopulation of the eastern U.S. and southern Canada. Beyond simply supporting monarch breeding, the quality and quantity of such accessible host resources facilitate population recovery from depressed numbers in any previous year. In many ways, the success of such early season monarchs is a proxy for the overall health and size of the eastern population.

Of the 22 milkweed species that occur in Florida, *Asclepias humistrata* (pinewoods milkweed) is arguably one of the most important as it begins to emerge in February and early March just as adult monarchs begin returning to the central and northern portions of the state each spring. It additionally remains vegetative through early summer thereby supporting more than one monarch generation annually. While found in a variety of sandy, well-drained habitats from pinelands to pastures, it can be frequently encountered along roadsides – landscapes not typically impacted by prescribed fire, cattle, or development but highly beneficial for monarch breeding. In addition, all blooming native milkweeds (*Asclepias* spp.) are highly attractive to a wide variety of important insect pollinators (especially bees, butterflies, etc.).

The importance of the monarch butterfly and its habitat was recognized in the Presidential Memorandum — Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators (White House, 2014). The resulting Pollinator Research Action Plan (White House, 2015) identified three primary goals, including (1) increase the eastern population of the monarch butterfly to 225 million butterflies occupying an area of approximately 6 hectares (15 acres) in the overwintering grounds in Mexico, through domestic/international actions and public-private partnerships, by 2020; and (2) expand pollinator habitat along rights-of-way. The plan further identified rights-of-ways including roadsides as land that can provide substantial, continuous habitat for monarchs and other pollinators. Based on these recovery goals, a recent study estimated that over 1.8 billion milkweed stems would be needed to return monarchs to an average population size of 6 hectares (Thogmartin et al. 2017).

The overall goal of the project was to enhance best roadside management of pinewoods milkweed along roadways in Central and North Florida. The specific objectives included (1) identification of key milkweed populations and plant densities for *Asclepias humistrata* (primary focus), *A. tuberosa* (butterflyweed) (secondary focus), *A. amplexicaulis* (clasping milkweed), and *A. tomentosa* (velvetleaf milkweed) along select state and county roads within a survey area, including re-evaluation of previously surveyed areas. *A. amplexicaulis* and *A. tomentosa* represent additional important monarch hosts and are occasionally found along Florida roadways; (2) inclusion of data in a georeferenced database with identification of high density hotspots; and (3) survey of hotspot areas for use by monarchs as available. The resulting *A. humistrata* population hotspots could additionally be managed to help generate local ecotype seed production for other key habitat restoration or augmentation projects in the future. Following identification of hotspot areas, we worked to develop new FDOT vegetative management practice recommendations to maximize the availability and productivity of these milkweed species to support early season monarch breeding.

2. Scope of Work

2.1. Target Milkweed Species

Florida is home to the highest diversity of milkweeds in the U.S., with 22 recorded species. While all are theoretically viable hosts for *monarchs*, *Asclepias humistrata* (Figure 1) is arguably one of the most important as it begins to emerge in early spring just as adult monarchs begin colonizing central and northern portions of the state each year. As its name implies, *Asclepias humistrata* is a deep sand species and grows mostly in sandhills and scrubs. It can also be commonly encountered in other dry, sandy sites including pastures, old fields, utility corridors and along roadsides. In many areas of the state, such disturbed habitats now harbor some of the largest remaining populations. *Asclepias tuberosa* (Figure 1) often co-occurs with pinewoods milkweed in many of the same habitats and is equally abundant along roadways. It is used by both the *Danaus plexippus* and *Danaus gilippus* (queen butterfly) as a larval host. Beyond serving as larval hosts, the showy flowers of milkweeds also offer abundant, high-quality nectar to a wide range of other animal pollinators including hummingbirds, butterflies and bees.

For the purposes of this project, *Asclepias humistrata* and *Asclepias tuberosa* represent the two focal target species. Populations of *Asclepias amplexicaulis* and *Asclepias tomentosa* were recorded and georeferenced when encountered.

Figure 1. Target milkweed species: *Asclepias tuberosa* (butterflyweed) (left) and *Asclepias humistrata* (pinewoods milkweed) (right).

2.2. Research Sites

We defined the project target geographic area as North and Central Florida roadways. Specifically, this included a search boundary from approximately Osceola County north to the

Florida-Georgia line and west to Jackson County (Figure 2). As the two target milkweed species are associated with sandhill, scrub, and dry pineland, ArcGIS was used to identify adjacent habitat designations. These in turn were used to help refine the specificity of search parameters and identify roadsides or roadway verge sections that might have a higher probability of containing the target milkweed species. Based on time, travel, and weather constraints, not all counties were surveyed equally.

Figure 2. Map of Florida showing the specific target geographic area outlined in red where roadway milkweed surveys were conducted.

2.3. Milkweed Survey Methods

All surveys were conducted between 28 March and 29 June 2016. This time period corresponds to the initial date when emerging plants were visible and when most plants set seed

or began to senesce. Florida roadways were initially surveyed visually from a moving vehicle. At least two surveyors were present in a vehicle at all times in order to effectively scan both sides of each roadway. Once appropriate habitat or roadside conditions were identified (i.e., dry, arid soil; associated plants such as *Quercus laevis* (turkey oak); steep back slope of road verge with exposed sandy soil), travel speed was reduced to approximately 50 kph (31 mph) or less. If any target milkweed species were spotted, the field crew would stop the vehicle and survey the location in greater detail on foot (Figure 3). Using a digital measuring wheel, the distance from the paved edge of the road/shoulder to the beginning of the plants (in meters) was recorded along with the distance parallel to the road between the edge clusters of any plants (Figure 4). This provided the approximate total area (in meters) of any milkweed populations. Next, a detailed data sheet was completed for each site. The following items were recorded:

1. Name of each surveyor
2. Date of survey
3. Distance from the paved edge of the road/shoulder to the beginning of the plants (in meters)
4. Distance parallel to the road between the edge clusters of any plants (in meters)
5. *Asclepias* species found
6. Total number of plants at site
7. Leaf Color: Purple – P, Green – G, Mix – M
8. Are mature seed pods present?
9. Are seeds present? (i.e., is pod open and silk visible?)
10. Is the plant in bloom?
11. Are monarch eggs or immatures present?
12. Nearest intersection or approximate location on road
13. GPS waypoint(s): if there was a very large distance between the two farthest plants, a waypoint for each plant or several points spread across the area covered were taken and recorded
14. Any notes specific to the site or relating to the data collection

Following data collection, the survey date, surveyors' initials, and the roadway (state road number or other designation) were written on a small whiteboard. The whiteboard was then placed in the site, and two photographs were taken: one with a close-up photo(s) of plant(s) with ruler for scale and one with a shot showing the plants' location in relation to the road. Each photo included the whiteboard (see Figure 4).

At the end of each field day, all site photographs were downloaded, and all data was entered on a comprehensive master georeferenced Excel spreadsheet (Figure 5). All files were backed up on Florida Museum of Natural History servers. Following completion of the surveys, all data was comprehensively reviewed. Sites with 25 or more plants were considered to be high density populations.

Figure 3. Road verge showing a population of *Asclepias humistrata* (pinewoods milkweed), with most plants being located on the back upward slope where exposed sand exists.

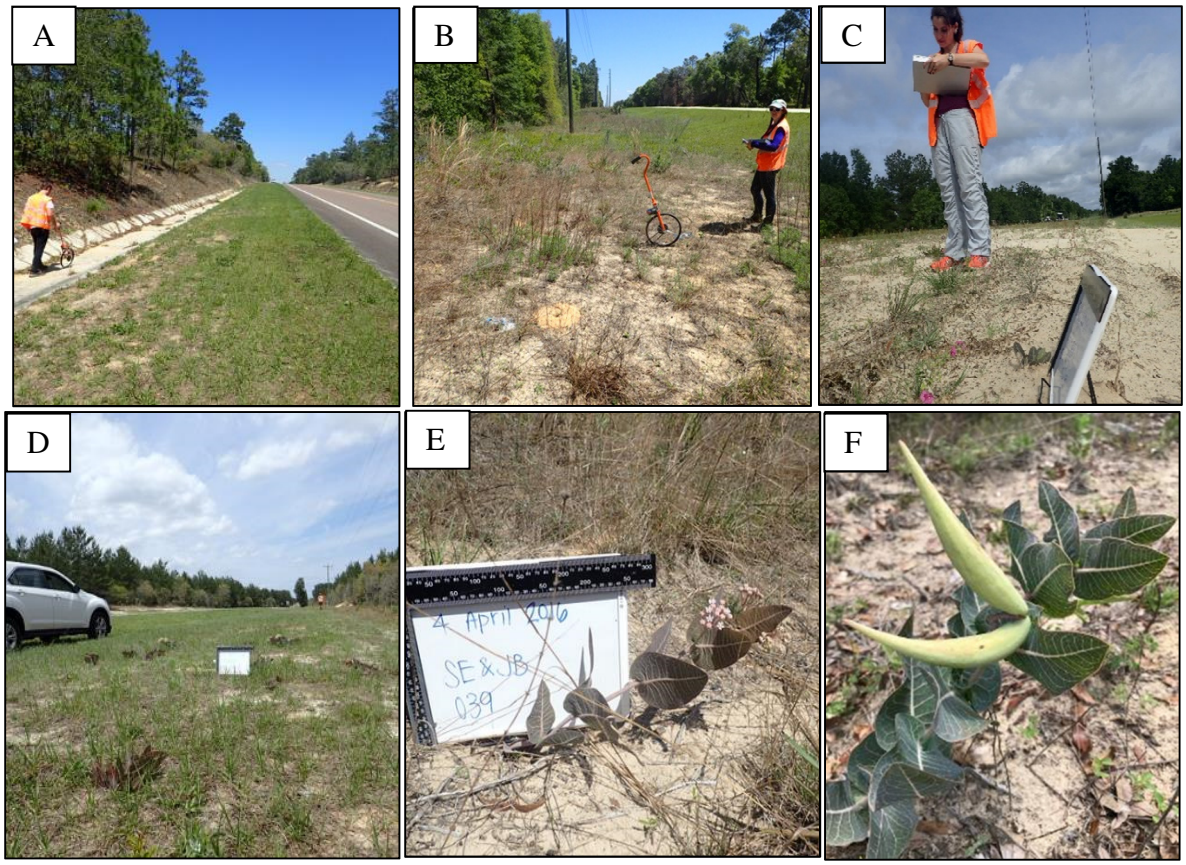


Figure 4. Roadside survey methodology: A. Measuring distance parallel to the road between the edge clusters of any plants (in meters) with a digital measuring wheel; B. Measuring the distance from the paved edge of the road/shoulder to the beginning of the plants (in meters); C. Surveyor completing data sheet; D. Milkweed plants along road verge showing whiteboard; E. Close-up of whiteboard next to pinewoods milkweed plant; pinewoods milkweed plant with nearly mature seed pods.

3. Findings

3.1. Survey Results

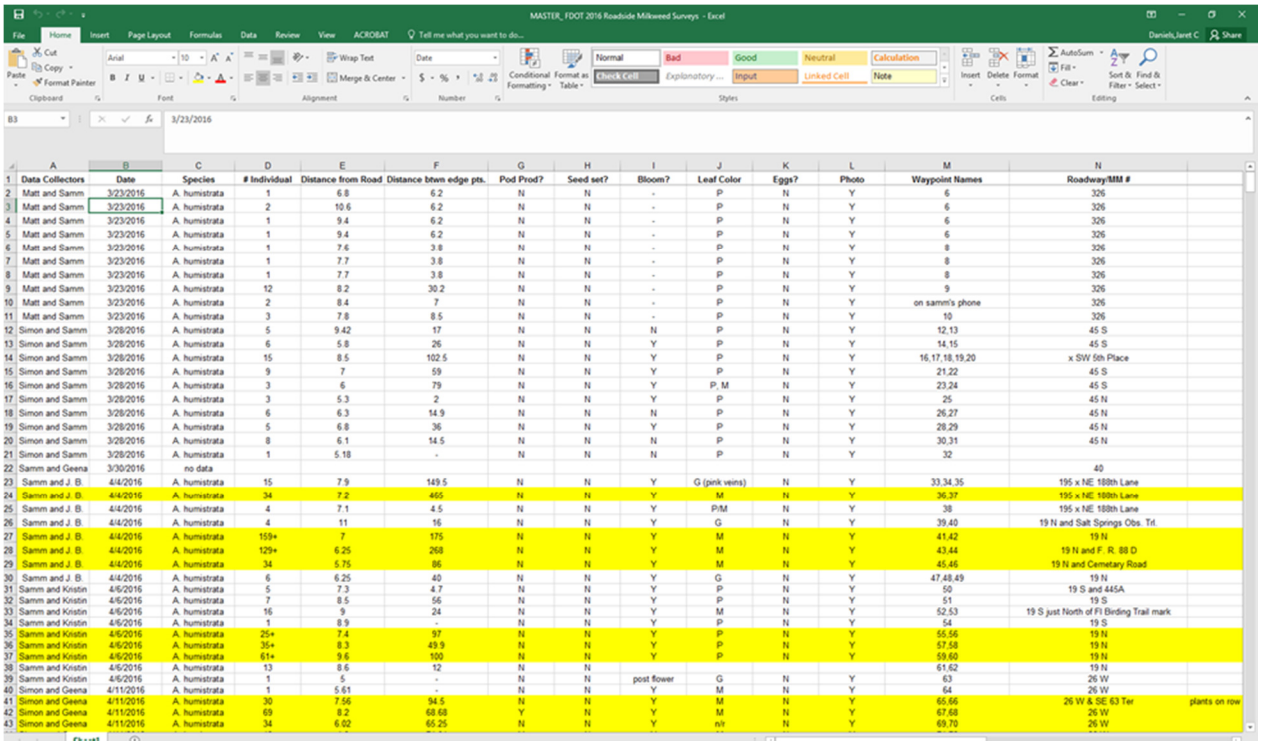
From 1 March to 10 July 2016, over 400 FDOT-maintained roadway locations across North and Central Florida were comprehensively surveyed for milkweeds. Of these, a total of 303 roadway locations were found to have one or more plants of the two target milkweed species, *Asclepias humistrata* and *A. tuberosa*. These were the dominant species found. Plant densities ranged from 1 to 161 individuals per site and a total of 40 high density sites were identified. Without exception, the vast majority of all plants recorded were located on the back slope of the road verge closest to the adjacent natural habitat. This portion of the roadside verge tended to be steeply sloped with exposed sand/soil present. The average distance from the paved edge of the road/shoulder to the beginning of the plants in high density location was 7.1 meters (23.3 ft.). The overall linear distance occupied by the high density stands was extensive. The average distance parallel to the road between the edge clusters of any plants was 91.6 meters (300.5 ft.). The highest number of plants per meter at any of the sites characterized as high density was 1.3 plants/meter (1 plant/2.5 ft.). No surveyed sites had *Asclepias amplexicaulis* or *Asclepias tomentosa.* The only other milkweed species recorded was *Asclepias lanceolata* (fewflower milkweed) at a single location.

The plants encountered represented a continuum of new recruits to older, well-established plants. A large portion of the populations surveyed were productive plants with blooms, pods, and seed set confirmed. A small portion of the individual plants surveyed hosted immature monarch larvae or had eggs present. We also noted a wide variation in leaf color from green to purple. It is unclear how the leaf color and morphology impact monarch choice and utilization. It is possible that darker leaves are preferred earlier in the season as they may provide a thermoregulatory benefit (helped monarch larvae reach higher body temperature) and help promote more rapid larval development.

3.2. Products

3.2.1. Georeferenced Excel Spreadsheet

A comprehensive georeferenced Excel spreadsheet was completed (Figure 5). A final edited version was submitted to FDOT as a deliverable.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Data Collectors	Date	Species	# Individual	Distance from Road	Distance btwn edge pts.	Pod Prod?	Seed set?	Bloom?	Leaf Color	Eggs?	Photo	Waypoint Names	Roadway/MM #
2	Matt and Samm	3/23/2016	A. humistrata	1	6.8	6.2	N	N	-	P	N	Y	6	326
3	Matt and Samm	3/23/2016	A. humistrata	2	10.6	6.2	N	N	-	P	N	Y	6	326
4	Matt and Samm	3/23/2016	A. humistrata	1	9.4	6.2	N	N	-	P	N	Y	6	326
5	Matt and Samm	3/23/2016	A. humistrata	1	9.4	6.2	N	N	-	P	N	Y	6	326
6	Matt and Samm	3/23/2016	A. humistrata	1	7.6	3.8	N	N	-	P	N	Y	8	326
7	Matt and Samm	3/23/2016	A. humistrata	1	7.7	3.8	N	N	-	P	N	Y	8	326
8	Matt and Samm	3/23/2016	A. humistrata	1	7.7	3.8	N	N	-	P	N	Y	8	326
9	Matt and Samm	3/23/2016	A. humistrata	12	8.2	30.2	N	N	-	P	N	Y	9	326
10	Matt and Samm	3/23/2016	A. humistrata	2	8.4	7	N	N	-	P	N	Y	on samm's phone	326
11	Matt and Samm	3/23/2016	A. humistrata	3	7.8	8.5	N	N	-	P	N	Y	10	326
12	Simon and Samm	3/28/2016	A. humistrata	5	9.42	17	N	N	N	P	N	Y	12,13	45 S
13	Simon and Samm	3/28/2016	A. humistrata	6	5.8	26	N	N	Y	P	N	Y	14,15	45 S
14	Simon and Samm	3/28/2016	A. humistrata	15	8.5	102.5	N	N	Y	P	N	Y	16,17,18,19,20	x SW 5th Place
15	Simon and Samm	3/28/2016	A. humistrata	9	7	59	N	N	Y	P	N	Y	21,22	45 S
16	Simon and Samm	3/28/2016	A. humistrata	3	6	79	N	N	Y	P, M	N	Y	23,24	45 S
17	Simon and Samm	3/28/2016	A. humistrata	3	5.3	2	N	N	Y	P	N	Y	25	45 N
18	Simon and Samm	3/28/2016	A. humistrata	6	6.3	14.9	N	N	N	P	N	Y	26,27	45 N
19	Simon and Samm	3/28/2016	A. humistrata	5	6.8	36	N	N	Y	P	N	Y	28,29	45 N
20	Simon and Samm	3/28/2016	A. humistrata	8	6.1	14.5	N	N	N	P	N	Y	30,31	45 N
21	Simon and Samm	3/28/2016	A. humistrata	1	5.18	-	N	N	N	P	N	Y	32	
22	Samm and Geena	3/30/2016	no data											40
23	Samm and J. B.	4/4/2016	A. humistrata	15	7.9	149.5	N	N	Y	G (pink veins)	N	Y	33,34,35	195 x NE 188th Lane
24	Samm and J. B.	4/4/2016	A. humistrata	34	7.2	465	N	N	Y	M	N	Y	36,37	195 x NE 188th Lane
25	Samm and J. B.	4/4/2016	A. humistrata	4	7.1	4.5	N	N	Y	P/M	N	Y	38	195 x NE 188th Lane
26	Samm and J. B.	4/4/2016	A. humistrata	4	11	16	N	N	Y	G	N	Y	39,40	19 N and Salt Springs Obs. Trl.
27	Samm and J. B.	4/4/2016	A. humistrata	159+	7	175	N	N	Y	M	N	Y	41,42	19 N
28	Samm and J. B.	4/4/2016	A. humistrata	129+	6.25	268	N	N	Y	M	N	Y	43,44	19 N and F. R. 88 D
29	Samm and J. B.	4/4/2016	A. humistrata	34	5.75	86	N	N	Y	M	N	Y	45,46	19 N and Cemetary Road
30	Samm and J. B.	4/4/2016	A. humistrata	6	6.25	40	N	N	Y	G	N	Y	47,48,49	19 N
31	Samm and Kristin	4/6/2016	A. humistrata	5	7.3	4.7	N	N	Y	P	N	Y	50	19 S and 445A
32	Samm and Kristin	4/6/2016	A. humistrata	7	8.5	56	N	N	Y	P	N	Y	51	19 S
33	Samm and Kristin	4/6/2016	A. humistrata	16	9	24	N	N	Y	M	N	Y	52,53	19 S just North of Fl Birding Trail mark
34	Samm and Kristin	4/6/2016	A. humistrata	1	8.9	-	N	N	Y	P	N	Y	54	19 S
35	Samm and Kristin	4/6/2016	A. humistrata	25+	7.4	97	N	N	Y	P	N	Y	55,56	19 N
36	Samm and Kristin	4/6/2016	A. humistrata	35+	8.3	49.9	N	N	Y	P	N	Y	57,58	19 N
37	Samm and Kristin	4/6/2016	A. humistrata	61+	9.6	100	N	N	Y	P	N	Y	59,60	19 N
38	Samm and Kristin	4/6/2016	A. humistrata	13	8.6	12	N	N					61,62	19 N
39	Samm and Kristin	4/6/2016	A. humistrata	1	5	-	N	N	post flower	G	N	Y	63	26 W
40	Simon and Geena	4/11/2016	A. humistrata	1	5.61	-	N	N	Y	M	N	Y	64	26 W
41	Simon and Geena	4/11/2016	A. humistrata	30	7.56	94.5	N	N	Y	M	N	Y	65,66	26 W & SE 63 Ter
42	Simon and Geena	4/11/2016	A. humistrata	69	8.2	68.68	Y	N	Y	M	N	Y	67,68	26 W
43	Simon and Geena	4/11/2016	A. humistrata	34	6.02	65.25	N	N	Y	n/r	N	Y	69,70	26 W

Figure 5. Screenshot showing data format in a georeferenced Excel spreadsheet. Yellow highlighted rows represent populations categorized as high density, with 25 or more plants present at an individual roadside location. Note: Due to the large number of columns, only a portion of the data fields are visible.

3.2.2. Prioritized List of Appropriate Strategies

Following the completion of all roadside surveys and the corresponding georeferenced Excel spreadsheet, extensive communications with FDOT maintenance personnel and mowing contractors were initiated to establish a variety of potential strategies to appropriately identify/mark high density roadway milkweed populations. Based on these discussions, four potential related strategies were identified:

1. *Making georeferenced data on milkweed populations available to District Field Offices along with potential mowing recommendations.* Using ArcGIS software, we created shapefiles containing semi-transparent polygons. These covered all high density populations of both *Asclepias humistrata* and *Asclepias tuberosa* with a buffer of 1 km (0.6 miles) around the population edges. From these data, we worked with FDOT to create a web map application (Figure 6). The color base map was selected to provide better contrast at higher map scales and allow users to see the whole dataset. As the user zooms in the base map changes to imagery to show the most recent ESRI aerials with the monarch butterfly habitats. This application can be viewed in any web browser on any web enabled device. To activate the location of the user, click the My Location widget and the application will zoom to the users location. The pilot web application can be accessed at:https://fdot.maps.arcgis.com/apps/webappviewer/index.html?id=dfac6cee4198487e9b8

da80b54b683a9 (note that the web map application is considered a beta version and is only available to FDOT employees). While originally envisioned to help provide real time location in the field, this application would serve as a viable first step for working with district field personnel and mowing contractors to initially identify potential high priority areas in which to implement time limited reduced mowing. Inherent in this step is the identification of appropriate or workable roadways. These may be roadways with extensive wildflower augmentation (and thus limited spring mowing already in place), limited sections of priority roadways particularly important for milkweed (reduced from larger areas identified with web-based app), and roadways with wider margins to better accommodate safety strip mowing without impacting milkweed populations.

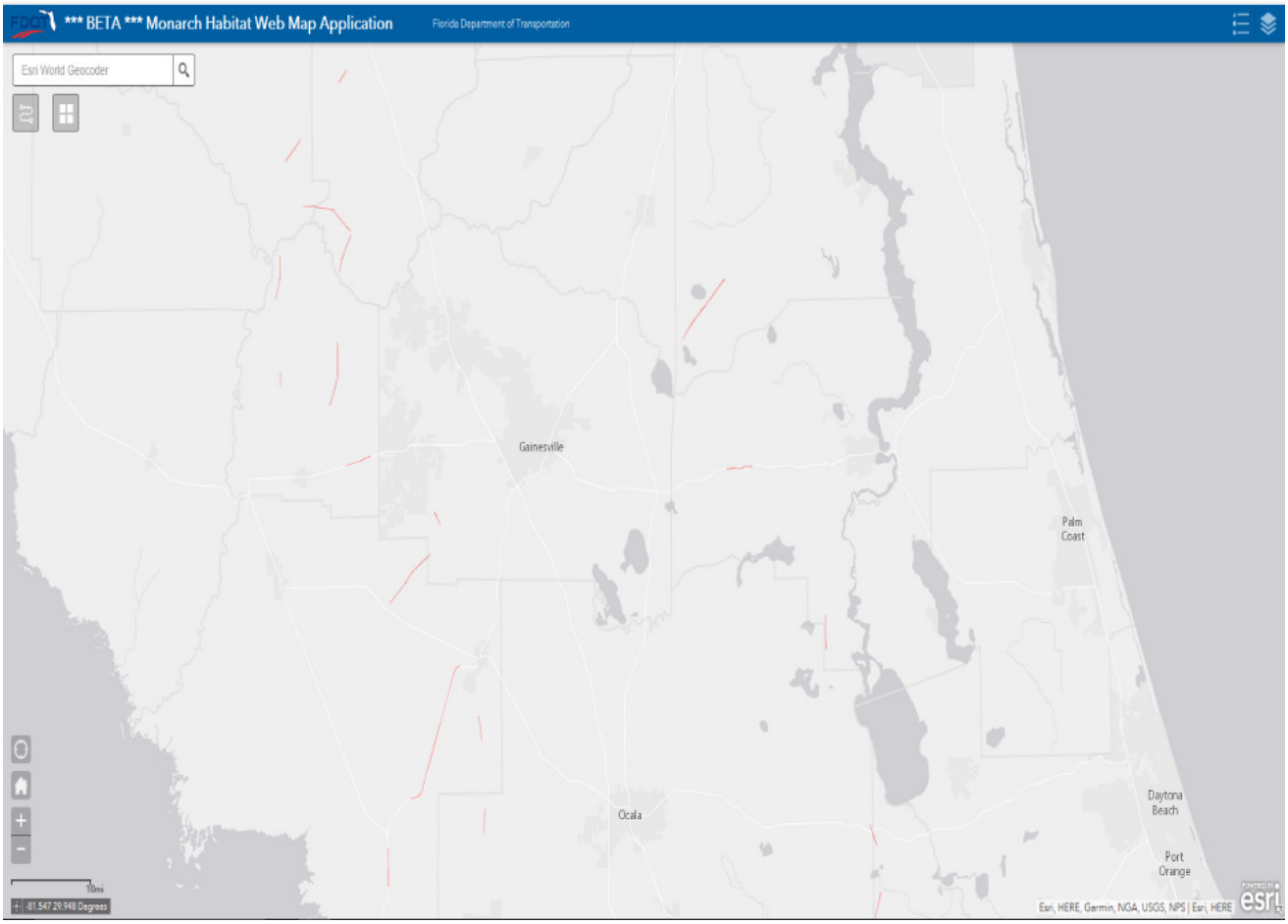


Figure 6. Screenshot of beta version of a Web map application used to delineate high density populations of *Asclepias humistrata* and A. *tuberosa* along FDOT-maintained roadways in North and Central Florida. Red lines indicate target road sections where high density milkweed populations were identified.

2. *Regular in-person meetings with District field personnel and mowing contractors to identify key workable locations where time limited reduced mowing could be implemented.* In-person meetings are critical to help provide buy-in and work through any potential issues.

3. *Determination of appropriate field signage identifying key milkweed areas.* The resulting signage would serve two important purposes: A. Identify specific sites for FDOT field maintenance personnel and contractors, and B. Alert the public of the reason reduced mowing is being implemented. The exact language/text used for signage would be identified and mutually agreed upon by UF (Daniels lab) and appropriate FDOT District Office personnel.

4. *Determination by FDOT administration if reduced mowing to help protect and maintain milkweed populations is a priority.* While this program served as a pilot to identify the number and location of select milkweed species important to the monarch that occur along FDOT managed roadsides, larger scale implementation of a no mow or time-limited reduced mowing strategy would only be voluntary. If this strategy is a priority, FDOT administration would need to direct/recommend that District Offices work to implement the program in North and Central Florida as available.

3.2.3. Modification of Priority Strategies

Following completion of the Web map application, we again met with FDOT District 2 maintenance personnel and contractors to evaluate the potential applicability of this tool for guiding roadside mowing. Following extensive conversations and feedback, it was determined that such a mobile application could not be used on tractors for the following reasons: A. Driver safety, B. Lack of appropriate technology/devices being available to contractors, and C. Cost of acquiring appropriate technology/devices and subsequent personnel training by contractor.

Based on the detailed feedback, it was determined that unless FDOT would provide all technology and appropriate training, the resulting web application could not be used in mowers. It was, however, viewed as a useful tool for District Office personnel to identify priority areas for planning purposes only.

FDOT District 2 maintenance personnel and contractors recommended that it would be significantly easier and cost effective to identify all priority areas with signage similar to existing wildflower areas. The resulting signage would serve two important purposes: 1. Identify specific sites for FDOT field maintenance personnel and contractors, and 2. Alert the public of the reason reduced mowing is being implemented. The exact language/text used would need to be identified and mutually agreed upon by the University of Florida (UF) and FDOT. All agreed that areas to receive reduced mowing of any kind would also be written into the work plan and identified at the time of annual contract renewal. Moreover, critical for this step would be the identification of appropriate or workable roadways. These may be roadways with extensive wildflower augmentation (and thus limited spring mowing is already in place), limited sections of priority roadways particularly important for milkweed (reduced from larger areas identified with web application) to streamline the process, and roadways with a wider margin to better accommodate safety strip mowing without impacting existing milkweed populations.

Following these conversations, UF and the District 2 Field Office in Chiefland agreed to pilot two areas of reduced mowing in May/June 2017. These included high density milkweed sites on SR-24 and SR-121. Two roadway types were chosen. SR 24 has narrow margins (width approximately that of one mower pass) and SR 121 has significantly wider margins. In collaboration with FDOT, we identified a high priority section of each roadway where reduced

mowing was implemented. This included one pass of a standard mower to ensure that the safety strip (approximately 12 feet) was clear and any adjacent portion of the road verge impacted by the width of the mower. We subsequently evaluated/compared mowed and non-mowed sections of each roadway to see if any damage was inflicted on milkweed populations and if plants with developing pods successfully set seed. All post-mowing evaluations were completed in late June and early July 2017.

Following evaluations, we found minimal impact to any target milkweed populations. As many milkweeds commonly occur on the back slope of the margin in deep sand areas with exposed soil, safety strip or any adjacent section of front slope did not result in any significant impacts. All of the identified milkweed plants in these high density areas were completely unaffected. They continued to bloom and many were able to successfully set seed. Even in areas where reduced mowing was not implemented, we noticed minimal impact to existing milkweeds due to their predominant location on the back slope of the road verge.

3.2.4. Summary

1. Roadsides in North and Central Florida harbor a large number of milkweed populations important to the monarch butterfly.

2. *Asclepias humistrata* (pinewoods milkweed) was more common and occurred in the highest densities.

3. 303 roadway locations had one or more plants. Plant densities ranged from 1 to 161 individuals per site and a total of 40 high density sites were identified.

4. The vast majority of plants were located on the back slope closest to the adjacent natural habitat. The average distance from the paved edge of the road/shoulder to the beginning of the plants in high density location was 7.1 meters (23.3 ft.). The overall linear distance occupied by the high density stands was extensive. The average distance parallel to the road between the edge clusters of any plants was 91.6 meters (300.5 ft.).

5. Pilot mowing trials with the FDOT District 2 Office in Chiefland indicated that reduced mowing defined as one pass of a standard mower (approximately 12 ft.) did not adversely impact existing roadside milkweed populations. Plants surveyed were unharmed and were able to successfully flower and set seed.

3.3. Management Implications

Based on results from this one-year study, we have the following management recommendations:

1. Avoid mowing during the spring wildflower season from February through May of most years. As this practice is already implemented in most areas with roadside wildflower populations, which includes most of the identified high density milkweed sites, no significant change of mowing practice is warranted.

2. In areas without significant wildflower populations or for the time period of February through July, avoid mowing the back slope to enable adequate growth, flowering and seed set of the target milkweed species as well as potential use by monarch butterflies and other insect pollinators. The back slope of roadways adjacent to scrub or pineland habitats (deep sand sites) harbors the greatest number of milkweed plants of the targeted species, *Asclepias humistrata* and *Asclepias tuberosa* (See Figures 2-4). After July, the target milkweed species have set seed and have or are in the process of senescing. Thus, regular mowing including that of the back slope can proceed without any significant impact to the high density milkweed populations.

3.4. Communication and Dissemination Recommendations

Based on discussions with District 2 personnel and contractors, we have the following dissemination recommendations:

1. FDOT Central Office determines if native milkweed management along roadways is desirable. FDOT District personnel and contractors felt it is imperative that direction comes from the Central Office.

2. If determined to be desirable, FDOT Central Office issues recommendation to all District Offices.

3. UF (Daniels lab) meets with District Offices and uses web application identifying high density milkweed populations to discuss potential priority areas. Based on discussions with District personnel/vegetation managers and contractors, a draft mowing plan will be developed. This would specifically outline the road, specific road sections, time period of implementation, and areas of road verge where mowing should or should not take place for the identified time period. Direct, in-person communication was strongly recommended by FDOT personnel and appears to work the best in our trials.

4. All of the agreed to areas to receive reduced mowing would then be written into an annual work plan to be shared with FDOT field personnel and contractors. The resulting plan would also be included as part of the Asset Maintenance contract renewal if possible. The ideal timeline of reduced mowing to enable growth, flowering and seed set of the identified milkweed species is February through July (although that may vary slightly based on specific location/region).

5. If deemed necessary by appropriate FDOT Field Office personnel, FDOT would fabricate and install signs at all site boundary areas in order to: a) identify specific sites for FDOT field maintenance personnel and contractors, and b) alert the public of the reason reduced mowing is being implemented. The exact language/text used for signage would be identified and mutually agreed upon by UF (Daniels lab) and appropriate FDOT District Office personnel.

6. UF (Daniels lab) needs to hold regular annual discussions with District Offices to ensure participation, and modify the work plan if needed.

4. References

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