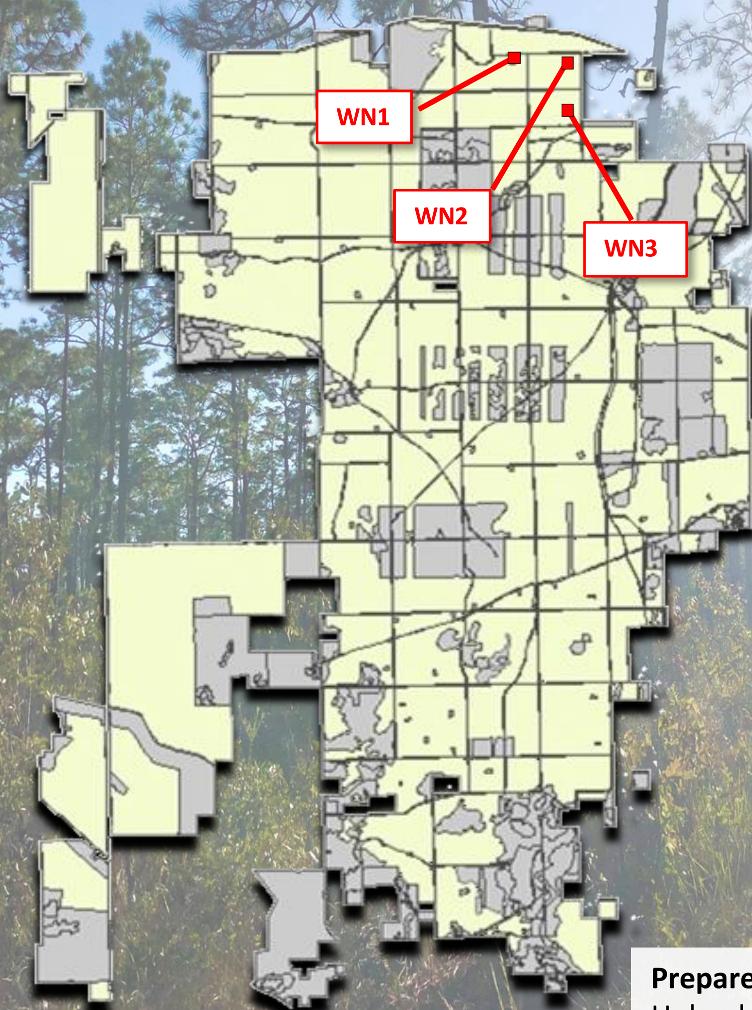
Plant-Pollinator Networks in Fire-Maintained Sandhills

Research Study (2019-2020)

Withlacoochee State Forest – Citrus Tract

Site-specific results



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Introduction

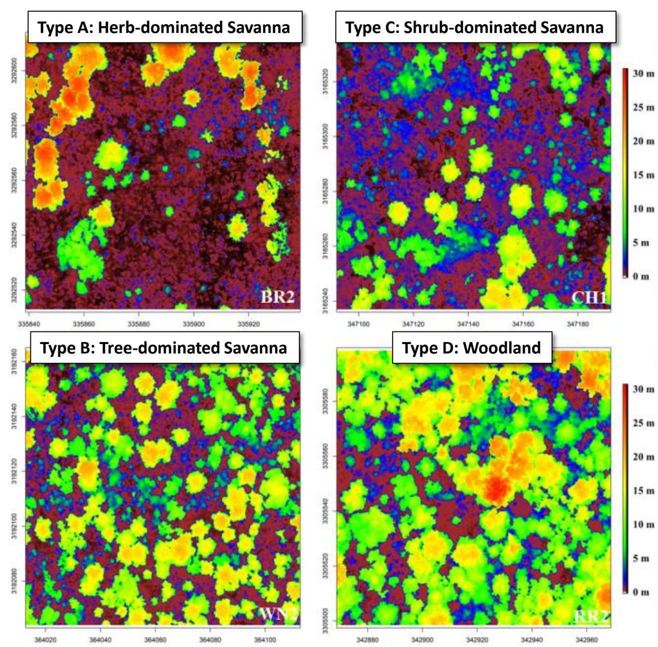
In Florida's fire-dependent longleaf pine savannas, as in terrestrial ecosystems worldwide, the mutualistic interaction networks formed by flowering plants and pollinators are of fundamental importance for the maintenance of biodiversity (Bascompte and Jordano 2007). Florida is part of the North American Coastal Plain floristic province, which is considered a global biodiversity hotspot due to unusually high vascular plant diversity and endemism (Noss et al. 2015). The pollinating insects of longleaf pine savannas likely play a central role in maintaining this high overall biodiversity, and they are also a diverse group in their own right, representing several prominent insect orders: Lepidoptera (butterflies and moths), Hymenoptera (bees and wasps), Coleoptera (beetles), and Diptera (flies) (Spiesman & Inouye 2013). Despite their ecological importance, the plant-pollinator networks of longleaf pine savannas have received little study (Spiesman & Inouye 2013). The purpose of this project is to begin filling critical baseline data gaps regarding plant-pollinator networks in Florida's fire-maintained uplands and their relationships to vegetation management.

Methods

24 1-hectare (2.5-acre) study plots were located at nine different fire-managed sandhill preserves in North-Central Florida: Withlacoochee - Citrus WEA, Bell Ridge WEA, River Rise Preserve State Park, Jennings State Forest, Black Creek Ravines Conservation Area, Ordway-Swisher Biological Preserve, two separate tracts of Withlacoochee State Forest, and Chassahowitzka WEA. The study sites were carefully selected according to several criteria, including: 1) Frequent and ongoing prescribed fire, in most cases upwards of 20 years; 2) No history of intensive agriculture or plantation forestry; 3) Old growth species in the understory indicative of low soil disturbance (i.e. wiregrass, various wildflowers); and 4) Approximately one year since the last prescribed fire.

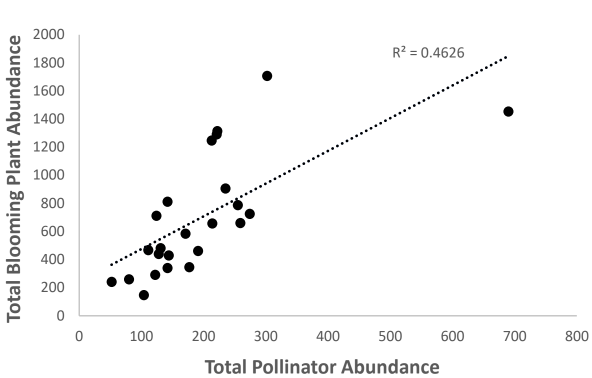
Within each preserve, two to three 1ha sampling plots were established at least 1km apart. Plant species composition was assessed in a grid of 25 5m x 5m quads. Species-specific flower abundance counts were conducted monthly from March 2019 – October 2019 along two transects (E-W and N-S) and in five 10m x 10m quads. Plant-pollinator interactions were sampled monthly using a 2hr timed transect sampling method. Every time the observer encountered an insect interacting with a flower, he or she captured the insect for identification and noted the plant species upon which it was encountered. Vegetation structure and surrounding landscape composition were assessed using LiDAR and aerial imagery via the GatorEye Unmanned Flying Laboratory.

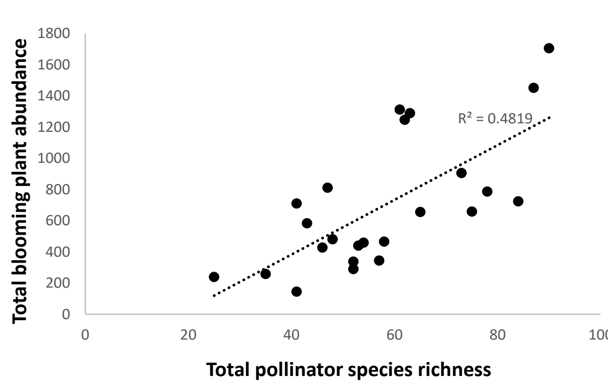
One of the primary objectives of this study was to identify relationships between fire, vegetation structure, and plant-pollinator networks. To that end, we used LiDAR-derived Leaf Area Index (LAI) values to assess the density of four canopy strata beginning at 0.5m, which is the lowest height at which LAI can be reliably calculated from LiDAR: understory (0.5m – 1m), lowstory (1m – 3m), midstory (3m – 6m), and overstory (6m+). We used these data in conjunction with ground-collected percent herbaceous cover estimates to approximate the overall structure of each plot.



Overall Study Results: Vegetation Structure
Using multivariate statistical techniques to analyze the relative proportions of ground layer, shrub layer, and tree layer LAI, we identified four significantly different types of fire-maintained sandhill structures: Type A (herb-dominated savannas), Type B (tree-dominated savannas), Type C (shrub-dominated savannas), and Type D (woodlands). The images at left are visualizations of the LiDAR data, showing representative 1-ha plots belonging to each category.

Overall Study Results: Flower and Pollinator Abundance
Across the whole study, we found that flowering plant abundance was strongly correlated with total annual pollinator abundance and total pollinator species richness, and varied greatly across plots and seasons, with total flower abundance ranging from 145 to 1,707 blooming plants per plot.

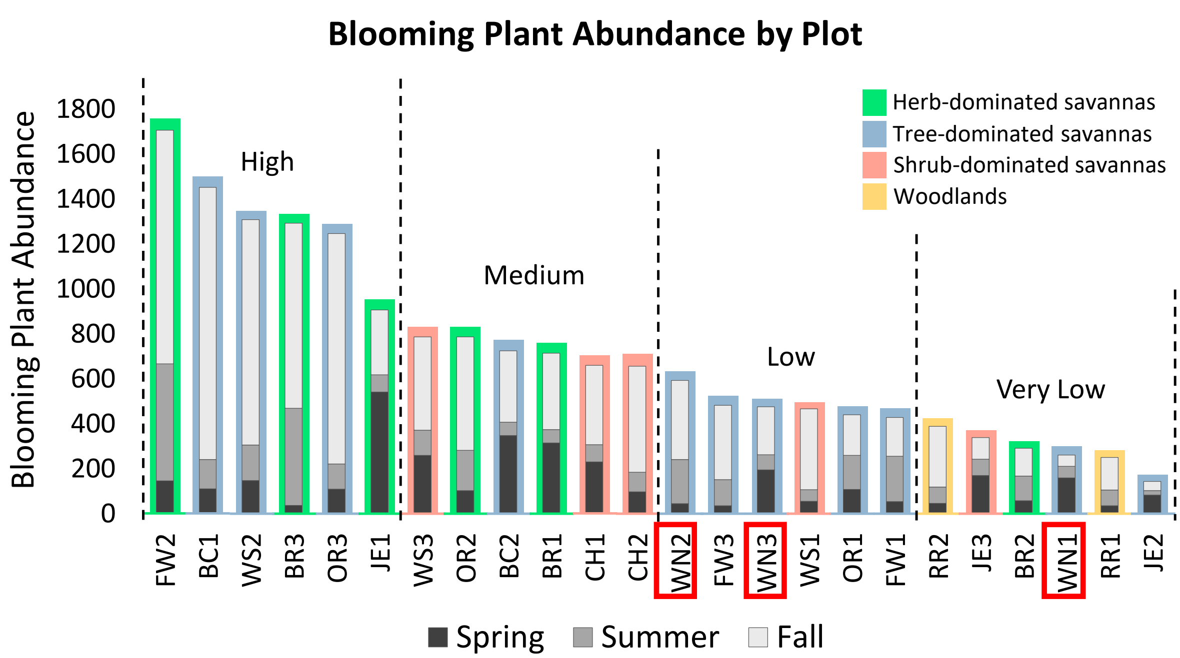




We found that the spring bloom season in longleaf pine sandhills is dominated by shrubs (particularly saw palmetto and blueberries), while the fall bloom season is dominated by herbaceous plants (especially members of the Asteraceae or sunflower family). Most of the herb-dominated plots in the study fell at the moderate to high end of the flower abundance range. Tree-dominated savanna plots had highly variable flower abundance, ranging from the lowest flower abundance to the second-highest, while shrub-dominated and woodland plots were somewhat less variable, ranging from very low to moderate flower abundance. Our habitat models showed that the abundance of individual flower-producing plants was only one predictor of actual flower production; tree-layer LAI had a significant negative influence on flower production, suggesting that even where appropriate understory plants are present, their flower production may be suppressed by higher levels of tree canopy LAI. *For a more detailed accounting of data analysis, conclusions, and management recommendations, check our FWRI/Upland Habitat website for publications and reports, which will be uploaded to* https://myfwc.com/research/habitat/upland/.

Withlacoochee/Citrus Results: Stand Structure and Flower Abundance

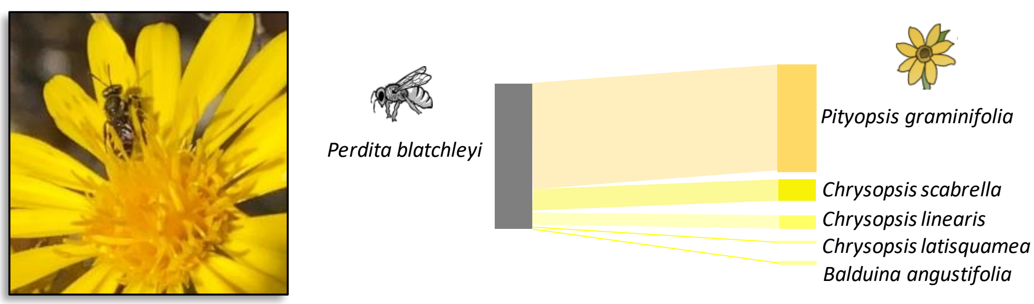
All three of the plots on the Citrus tract of Withlacoochee State Forest are tree-dominated savannas. Plots WN2 and WN3 were in the low flower abundance quantile, and plot WN1 was in the very low flower abundance quantile. The relatively low flower abundance in these three plots is likely due at least in part to relatively high midstory and lowstory oak cover. Many shrub species produce pollinator-attracting flowers, but oaks have wind-pollinated flowers and do not provide pollinator foraging habitat. Growing-season fire would likely reduce oak cover and promote wildflowers on the Citrus Tract.



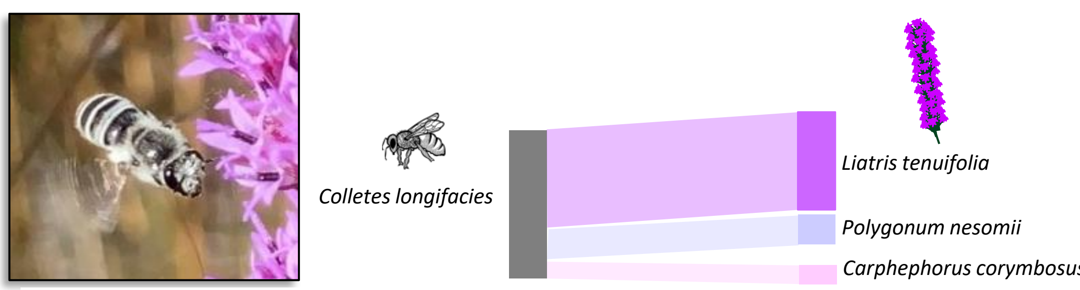
Withlacoochee - Citrus Results: Pollinator Overview

Overall pollinator species richness on the Citrus tract was low to very low, though overall pollinator abundance was moderate in plots WN2 and WN3. Hymenoptera (Bee & Wasp) and Diptera (Fly) species richness were low to very low in all three plots. Lepidoptera (Butterfly & Moth) and Coleoptera (Beetle), though moderately abundant in plots WN2 and WN3, had low species richness in WN2 and WN3. Order-specific pollinator results are presented in greater detail on the following pages, followed by plant-pollinator network diagrams for each plot.

We found two bee Species of Greatest Conservation Need (SGCN) on the Citrus Tract of Withlacoochee State Forest: *Perdita blatchleyi* and *Colletes longifacies.* We recorded enough observations of *P. blatchleyi* and *C. longifacies* in the overall study to draw conclusions about their flower preferences and make preliminary management recommendations. *P. blatchleyi* is a specialist on the closely-related plant genera *Pityopsis* and *Chrysopsis*, while *C. longifacies* appears to be less of a specialist, as we observed it interacting with the unrelated genera *Liatris* and *Polygonum*. Given the prevalence of interactions for the two SGCN bee species on *P. graminifolia* and *L. tenuifolia*, promoting flowering in these two plant species may be a good conservation target for improving *C. longifacies and P. blatchleyi* habitat. P. graminifolia's flower production and reproductive success are fire-induced and strongly influenced by season of burn, with spring and summer fires stimulating more flowers than winter fires (Brewer and Platt 1994). Both P. graminifolia and L. tenuifolia are sensitive to vegetation structure and become locally extirpated when shrub and tree cover become excessive. Management regimes that emphasize growing season fire and decrease woody dominance can be expected to favor these two SGCN bees.

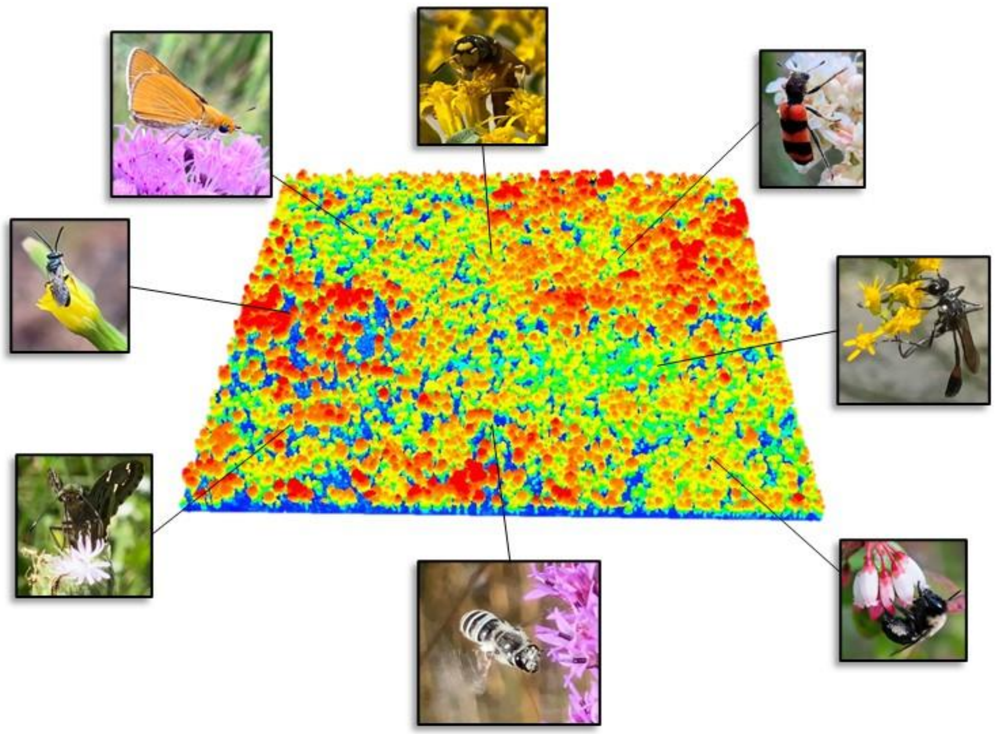


Flower interactions of *Perdita blatchleyi*, based on 103 observations recorded during the project.



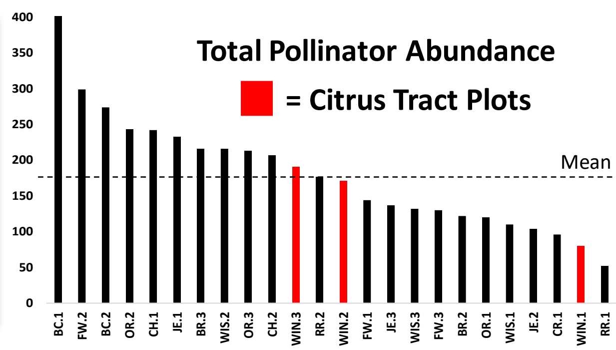
Flower interactions of *Colletes longifacies*, based on 24 observations recorded during the project.

Withlacoochee – Citrus Tract Results
Pollinator Abundance and Species Richness



Overall Pollinator Abundance and Species Richness

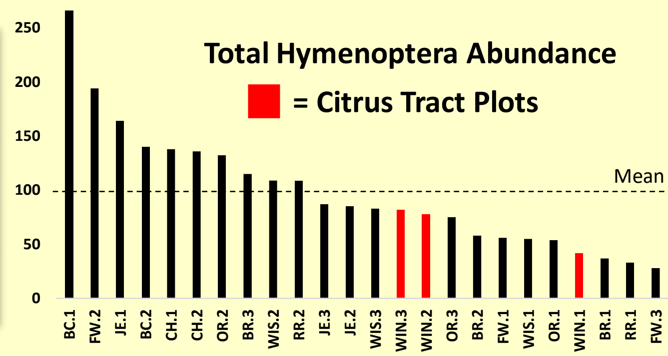
	Abundance (# of individuals)		Species Richness	
	Total	Rank	Total	Rank
Plot **WN1**	**80**	**Low**	**35**	**Low**
Plot **WN2**	**171**	**Med-Low**	**43**	**Med-Low**
Plot **WN3**	**191**	**Med-High**	**54**	**Med-Low**
Study Average	181.6		57.6	
Study Range	52 - 402		25 - 90	



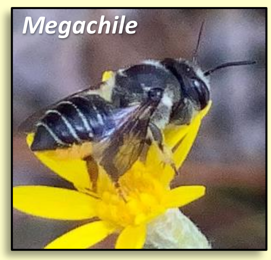
The above table shows the total pollinator abundance (number of individual insects caught) and total pollinator species richness for the three study plots at the Withlacoochee Citrus Tract, along with their rank relative to the entire 24-plot study. Plots within one Standard Deviation (SD) above the mean were ranked "**Medium-High**," and plots within one SD below the mean were ranked "**Medium-Low**." Plots >1 SD above the mean were ranked "**High**," and >1 SD below the mean were ranked "**Low**." Pollinator abundance and species richness were low to moderate across all three plots on the Citrus tract, with the highest values in plot WN3. Plot WN1 had high oak cover, very little herbaceous ground cover, and low flower abundance, which is likely the cause of that plot's low pollinator abundance and richness. In the following sections, the same method is used to assess pollinator abundance and species richness within insect groups (Bees/Wasps, Butterflies/Moths, Beetles, and Flies) for each plot.

Hymenoptera (Bees & Wasps)

	Abundance # of individuals		Species Richness	
	Total	Rank	Total	Rank
Plot **WN1**	42	Med-Low	19	Low
Plot **WN2**	78	Med-Low	25	Med-Low
Plot **WN3**	82	Med-Low	33	Med-Low
Study Average	98.2		33.6	
Study Range	28 - 266		12 - 61	

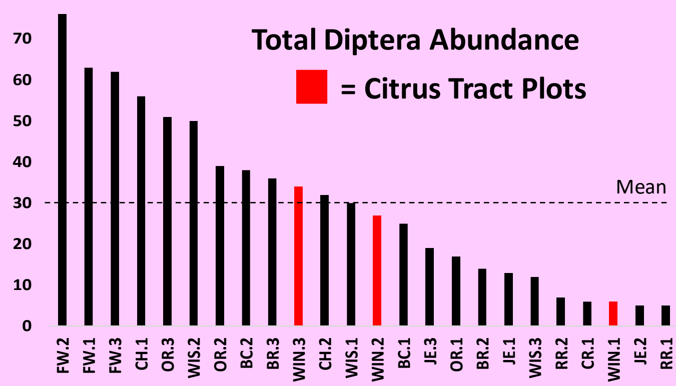


Bee & Wasp abundance and species richness were below the study average in all three of the Citrus Tract plots, with Plot WN3 having the highest richness and abundance of the three. Some of the most common Hymenoptera species on the Citrus tract were *Augochlorella gratiosa* (a sweat bee), *Myzinum maculatum* (a flower wasp), *Lasioglossum apopkense* (a Sweat Bee), *Augochloropsis metallica* (Northeastern sweat bee), and *Megachile mendica* (Beggar Leafcutter Bee). *Photo credits for non-FWRI photos on last page.



Diptera (Flies)

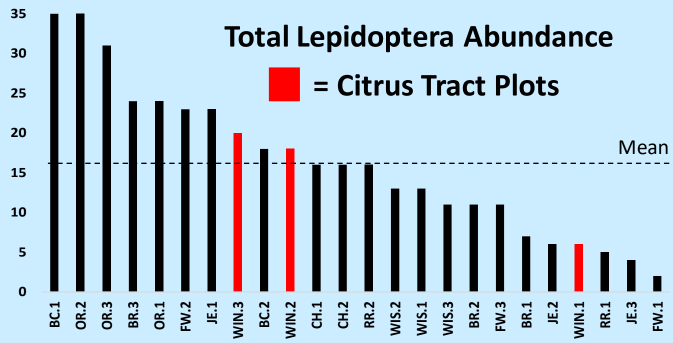
	Abundance # of individuals		Species Richness	
	Total	Rank	Total	Rank
Plot **WN1**	6	Low	3	Low
Plot **WN2**	27	Med-Low	5	Med-Low
Plot **WN3**	34	Med-High	6	Med-Low
Study Average	30.1		7.6	
Study Range	5 - 79		2 - 18	



Fly abundance and richness were low in plot WN1 and medium-low in plot WN2. Fly species richness was medium-low in plot WN3, but abundance was medium-high. The most common Dipterans on the Citrus tract were *Exoprosopa fasciata* (Banded Bee Fly), *Anthrax analis* (A Bee Fly, exotic), *Poeciliognathus sulphureus* (Sulphurous Bee Fly), *Physoconops sp.* (A Thick-Headed Fly), and *Pseudodoros clavatus* (Blue-Black Syrphid Fly). *Photo credits for non-FWRI photos on last page.

Lepidoptera (Butterflies & Moths)

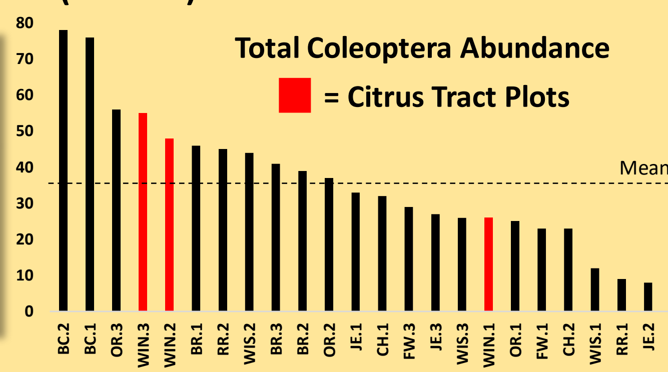
	Abundance # of individuals		Species Richness	
	Total	Rank	Total	Rank
Plot **WN1**	6	Low	6	Med-Low
Plot **WN2**	18	Med-High	6	Med-Low
Plot **WN3**	20	Med-High	9	Med-High
Study Average	16.2		8.1	
Study Range	2 - 35		2 - 14	



Lepidopteran abundance was above average in plots WN2 and WN3, and WN3 also had above-average Lepidopteran species richness. Plot WN1 had very low Lepidopteran abundance and low species richness. The most frequently observed Lepidopteran species on the Citrus tract were *Urbanus proteus* (Long-Tailed Skipper), *Panoquina ocola* (Ocola skipper), *Agaulis vanillae* (Gulf fritillary), *Junonia coenia* (Common Buckeye), and *Strymon melinus* (Gray Hairstreak). *Photo credits for non-FWRI photos on last page.

Coleoptera (Beetles)

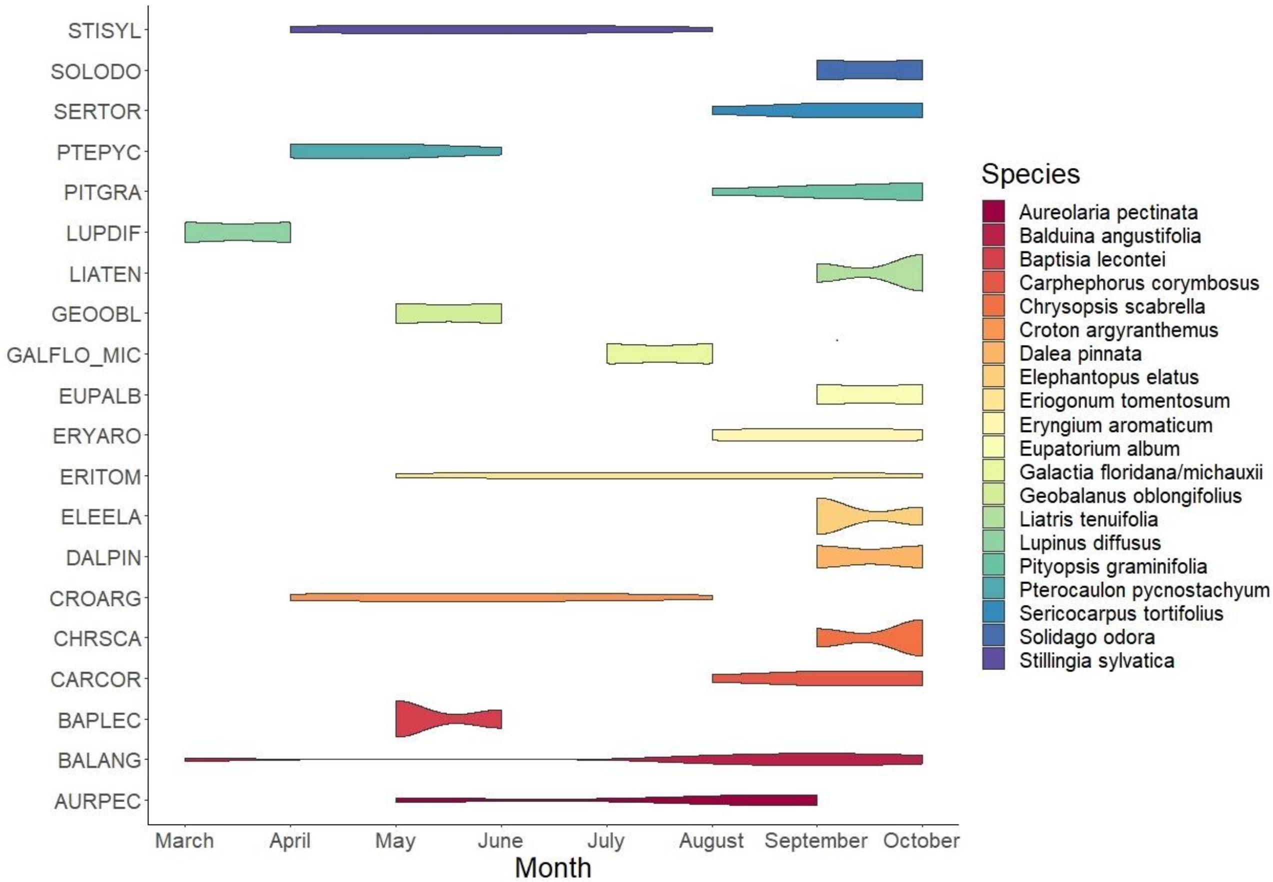
	Abundance # of Individuals		Species Richness	
	Total	Quantile	Total	Quantile
Plot **WN1**	26	Med-Low	7	Med-Low
Plot **WN2**	48	Med-High	7	Med-Low
Plot **WN3**	55	High	6	Med-Low
Study Average	35.2		8.0	
Study Range	6 - 78		4 - 14	



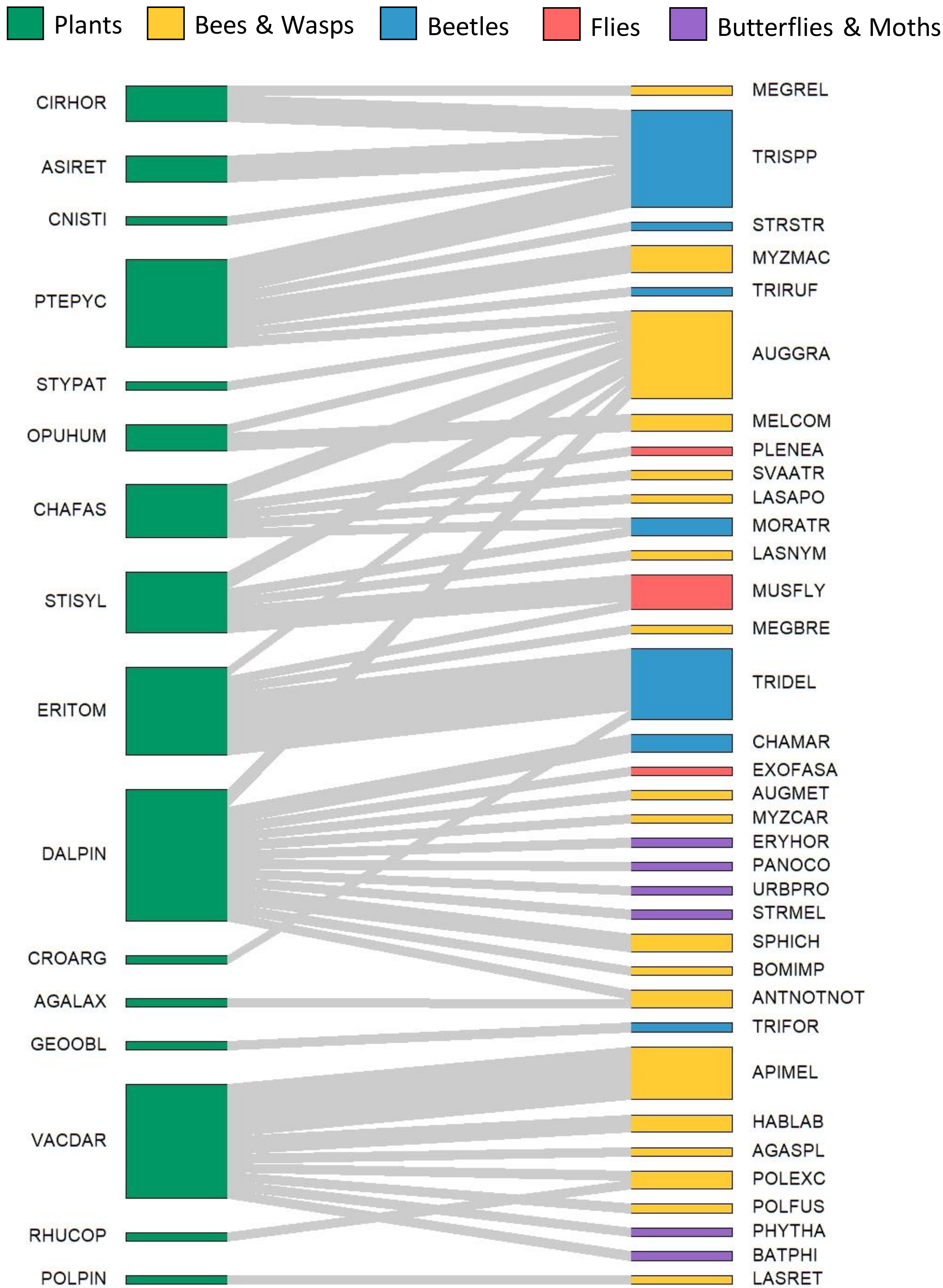
Beetle abundance was high in plot WN3 and medium-high in plot WN3, though species richness was medium-low in all plots. The most abundant native beetle pollinators on the Citrus Tract were *Epicauta sp.* (Blister Beetles), *Trichiotinus sp.* (Flower Scarabs), *Trigonopeltastes delta* (Delta Flower Beetle), *Mordella atrata* (Tumbling Flower Beetle), and *Chauliognathus marginatus* (Margined Leatherwing).

Key flowering plant species

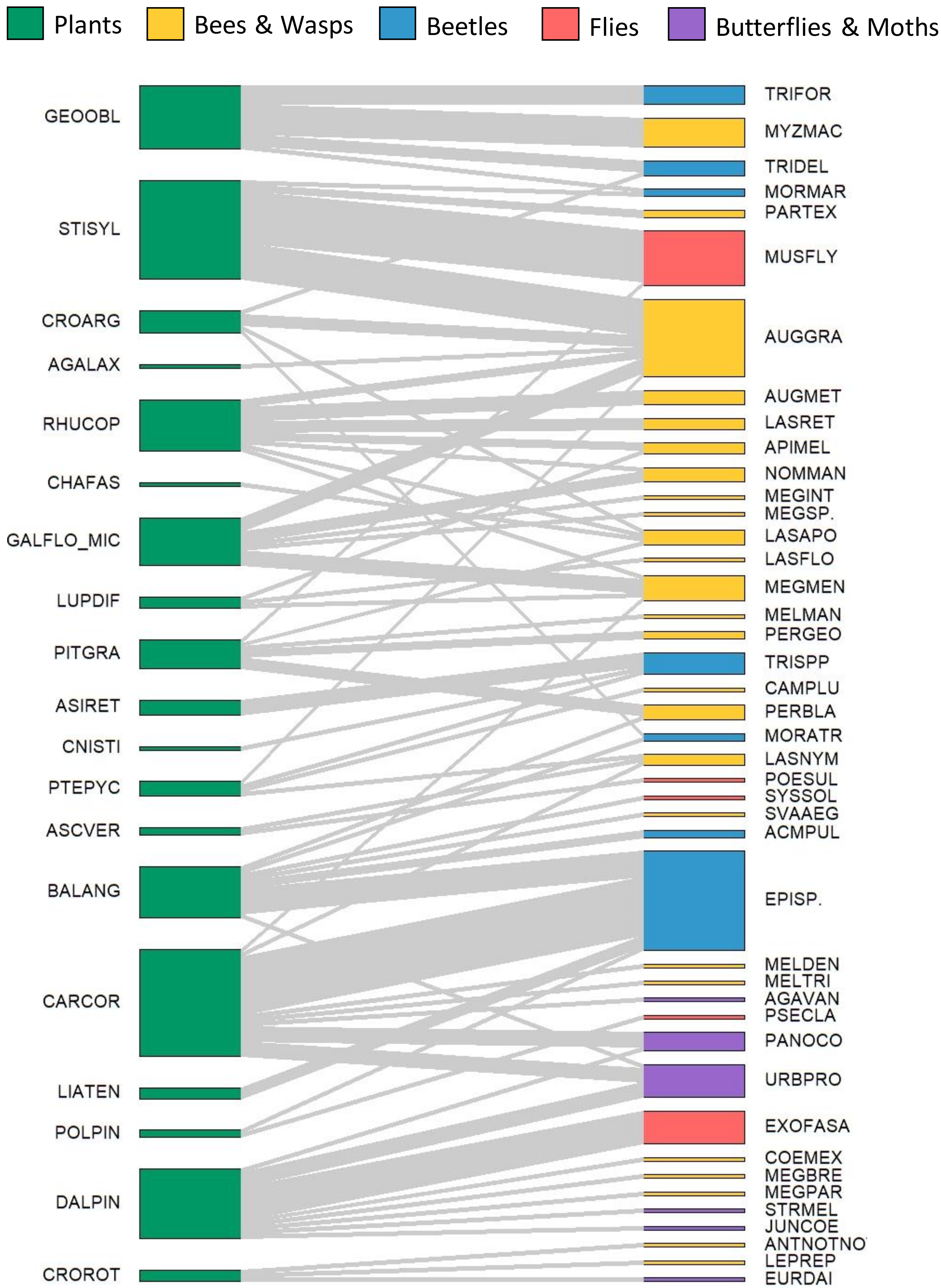
We identified 20 of the most important herbaceous flowering species that were present on multiple sites and had high pollinator interaction rates throughout the study. Many of these species, shown in the graphic below with their blooming time/duration, were present in the Withlacoochee – Citrus Tract sandhills.



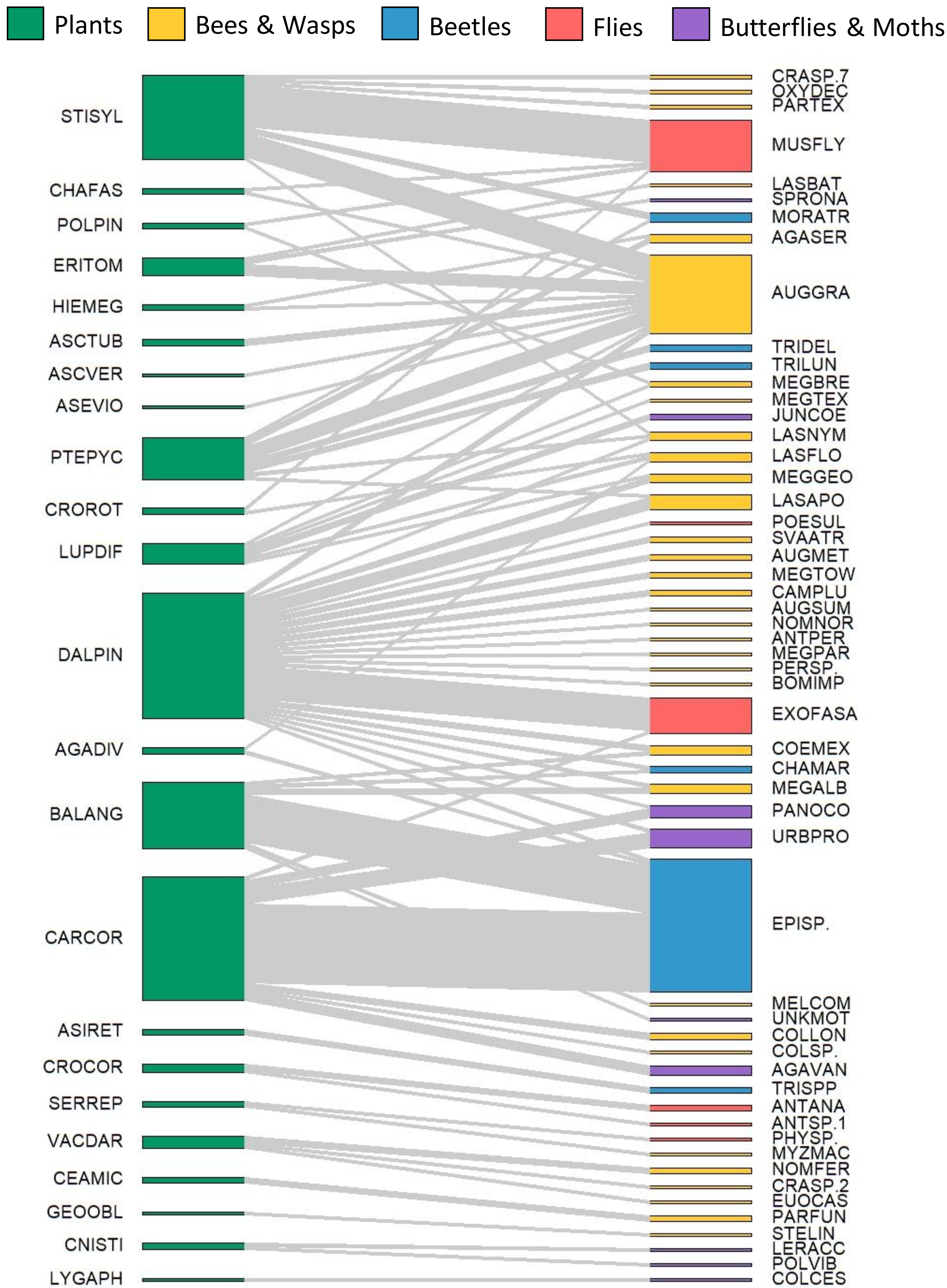
WN1 Plant-Pollinator Network *Plant and insect code key included at end of report



WN2 Plant-Pollinator Network *Plant and insect code key included at end of report



WN3 Plant-Pollinator Network *Plant and insect code key included at end of report



Most abundant native pollinator genera on the Citrus Tract

Insect Code Key for network diagrams, with plot occurrence data

		Number Caught			
Code	**Species**	**WIN-1**	**WIN-2**	**WIN-3**	**Insect type**
ACMPUL	Acmaeodera pulchella	0	2	0	Beetles
AGASER	Agapostemon sericeus	0	0	3	Bees & Wasps
AGASPL	Agapostemon splendens	1	0	0	Bees & Wasps
AGAVAN	Agaulis vanillae	0	1	3	Butterflies & Moths
ANTANA	Anthrax analis	0	0	2	Flies
ANTNOTNOT	Anthidiellum notatum notat	2	1	0	Bees & Wasps
ANTPER	Anthidiellum perplexum	0	0	1	Bees & Wasps
ANTSP.1	Anthracinae sp. 1	0	0	1	Flies
APIMEL	Apis mellifera	6	3	0	Bees & Wasps
AUGGRA	Augochlorella gratiosa	12	21	26	Bees & Wasps
AUGMET	Augochloropsis metallica	1	4	2	Bees & Wasps
AUGSUM	Augochloropsis sumptuosa	0	0	1	Bees & Wasps
BATPHI	Battus philenor	1	0	0	Butterflies & Moths
BOMIMP	Bombus impatiens	1	0	1	Bees & Wasps
CAMPLU	Campsomeris plumipes foss	0	1	2	Bees & Wasps
CHAMAR	Chauliognathus marginatus	2	0	2	Beetles
COEMEX	Coelioxys mexicanus	0	1	3	Bees & Wasps
COLCES	Colias cesonia	0	0	1	Butterflies & Moths
COLLON	Colletes longifacies	0	0	2	Bees & Wasps
COLSP.	Colletes sp.	0	0	1	Bees & Wasps
CRASP.2	Crabronidae sp. 2	0	0	1	Bees & Wasps
CRASP.7	Crabronidae sp. 7	0	0	1	Bees & Wasps
EPISP.	Epicauta sp.	0	27	44	Beetles
ERYHOR	Erynnis horatius	1	0	0	Butterflies & Moths
EUOCAS	Euodynerus castigatus	0	0	1	Bees & Wasps
EURDAI	Eurema daira	0	1	0	Butterflies & Moths
EXOFASA	Exoprosopa fasciata	1	9	12	Flies
HABLAB	Habropoda laboriosa	2	0	0	Bees & Wasps
JUNCOE	Junonia coenia	0	1	2	Butterflies & Moths
LASAPO	Lasioglossum apopkense	1	4	5	Bees & Wasps
LASBAT	Lasioglossum batya	0	0	1	Bees & Wasps
LASFLO	Lasioglossum floridanum	0	1	3	Bees & Wasps
LASNYM	Lasioglossum nymphale	1	3	3	Bees & Wasps
LASRET	Lasioglossum reticulatum	1	3	0	Bees & Wasps
LEPREP	Leptochilus republicanus	0	1	0	Bees & Wasps
LERACC	Lerema accius	0	0	1	Butterflies & Moths
MEGALB	Megachile albitarsis	0	0	3	Bees & Wasps
MEGBRE	Megachile brevis	1	1	2	Bees & Wasps
MEGGEO	Megachile georgica	0	0	3	Bees & Wasps
MEGINT	Megachile integra	0	1	0	Bees & Wasps
MEGMEN	Megachile mendica	0	7	0	Bees & Wasps
MEGPAR	Megachile parallela	0	1	1	Bees & Wasps

MEGREL	Megachile relativa	1	0	0	Bees & Wasps
MEGSP.	Megachile sp.	0	1	0	Bees & Wasps
MEGTEX	Megachile texana	0	0	1	Bees & Wasps
MEGTOW	Megachile townsendiana	0	0	2	Bees & Wasps
MELCOM	Melissodes communis	2	0	1	Bees & Wasps
MELDEN	Melissodes denticulatus	0	1	0	Bees & Wasps
MELMAN	Melissodes manipularis	0	1	0	Bees & Wasps
MELTRI	Melissodes trinodis	0	1	0	Bees & Wasps
MORATR	Mordella atrata	2	2	3	Beetles
MORMAR	Mordella marginata	0	2	0	Beetles
MUSFLY	muscoid fly	4	15	17	Flies
MYZCAR	Myzinum carolinianum	1	0	0	Bees & Wasps
MYZMAC	Myzinum maculatum	3	8	1	Bees & Wasps
NOMFER	Nomada fervida	0	0	2	Bees & Wasps
NOMMAN	Nomia maneei	0	4	0	Bees & Wasps
NOMNOR	Nomia nortoni	0	0	1	Bees & Wasps
OXYDEC	Oxybelus decorosus	0	0	1	Bees & Wasps
PANOCO	Panoquina ocola	1	5	4	Butterflies & Moths
PARFUN	Paracyphononyx funereus	0	0	2	Bees & Wasps
PARTEX	Paratiphia texana	0	2	1	Bees & Wasps
PERBLA	Perdita blatchleyi	0	4	0	Bees & Wasps
PERGEO	Perdita georgica	0	2	0	Bees & Wasps
PERSP.	Perdita sp.	0	0	1	Bees & Wasps
PHYSP.	Physoconops sp.	0	0	1	Flies
PHYTHA	Phyciodes tharos	1	0	0	Butterflies & Moths
PLENEA	Plecia nearctica	1	0	0	Flies
POESUL	Poeciliognathus sulphureus	0	1	1	Flies
POLEXC	Polistes exclamans	2	0	0	Bees & Wasps
POLFUS	Polistes fuscatus	1	0	0	Bees & Wasps
POLVIB	Polites vibex	0	0	1	Butterflies & Moths
PSECLA	Pseudodoros clavatus	0	1	0	Flies
SPHICH	Sphex ichneumoneus	2	0	0	Bees & Wasps
SPRONA	Spragueia onagrus	0	0	1	Butterflies & Moths
STELIN	Stenodynerus lineatifrons	0	0	1	Bees & Wasps
STRMEL	Strymon melinus	1	1	0	Butterflies & Moths
STRSTR	Stranglia strigosa	1	0	0	Beetles
SVAAEG	Svastra aegis	0	1	0	Bees & Wasps
SVAATR	Svastra atripes	1	0	2	Bees & Wasps
SYSSOL	Systoechus solitus	0	1	0	Flies
TRIDEL	Trigonopeltastes delta	8	4	2	Beetles
TRIFOR	Trigonopeltastes foridana	1	5	0	Beetles
TRILUN	Trichiotinus lunulatus	0	0	2	Beetles
TRIRUF	Trichiotinus rufobrunneus	1	0	0	Beetles
TRISPP	Trichiotinus spp.	11	6	2	Beetles
URBPRO	Urbanus proteus	1	9	6	Butterflies & Moths

Plant Code Key for network diagrams, with plot occurrence data

		Relative Frequency (% of quads in which present)			
Code	**Species**	WN1	WN2	WN3	**Plant Type**
AESVIS	Aeschynomene viscidula	0	1	0	Forb
AGEJUC	Ageratina jucunda	6	14	8	Forb
ASCTUB	Asclepias tuberosa	0	0	2	Forb
ASCVER	Asclepias verticillata	3	3	5	Forb
ASEVIO	Asemia violacea	1	1	1	Forb
ASIINC	Asimina incana	1	6	0	Shrub
ASIRET	Asimina reticulata	1	2	9	Shrub
BALANG	Balduina angustifolia	0	9	21	Forb
BAPLEC	Baptisia lecontei	1	1	0	Forb
CARCOR	Carphephorus corymbosus	4	55	49	Forb
CEAMIC	Ceanothus microphyllus	0	1	1	Forb
CENVIR	Centrosema virginianum	42	11	0	Forb
CHAFAS	Chamaecrista fasciculata	0	9	6	Forb
CHANIC	Chamaecrista nictitans	0	12	17	Forb
CNISTI	Cnidoscolus stimulosus	7	13	6	Forb
CONCAN	Conyza canadensis	0	2	2	Forb
CROARG	Croton argyranthemus	10	17	30	Forb
CROCAR	Crocantheumum carolinianum	14	6	5	Forb
CROCOR	Crocantheumum corymbosum	3	4	7	Forb
CRODIV	Croptilon divaricatum	2	0	0	Forb
CROMIC	Croton michauxii	6	14	4	Forb
CROROT	Crotalaria rotundifolia	5	15	15	Forb
DALPIN	Dalea pinnata	29	31	56	Forb
DIOSVI	Diospyros virginiana	43	16	26	Shrub
ERITOM	Eriogonum tomentosum	23	30	46	Forb
EUPALB	Eupatorium album	4	2	0	Forb
EUPCOM	Eupatorium compositifolium	2	1	0	Forb
GALFLO_MIC	Galactia floridana/michauxii	7	38	8	Forb
GEOOBL	Geobalanus oblongifolius	24	24	33	Forb
HIEMEG	Hieracium megacephalon	12	1	6	Forb
HYPSUF	Hypericum suffruticosum	6	0	1	Shrub
LACGRA	Lactuca graminifolia	3	0	1	Forb
LESHIR	Lespedeza hirta	6	4	33	Forb
LIATEN	Liatris tenuifolia	26	25	50	Forb
LUPDIF	Lupinus diffusus	1	1	1	Forb
LYGAPH	Lygodesmia aphylla	1	0	0	Forb
OPUHUM	Opuntia humifusa	0	3	1	Forb
PALINT	Palafoxia integrifolia	8	3	15	Forb
PARPAT	Paronychia patula	0	12	0	Forb
PIRCIS	Piriqueta cistoides	1	2	4	Forb
PITGRA	Pityopsis graminifolia	12	82	68	Forb

POLNES	Polygonum nesomii	0	2	1	Forb
POLPIN	Polygonum pinicola	9	16	36	Forb
PTEPYC	Pterocaulon pycnostachyum	17	3	24	Forb
RHUCOP	Rhus copallinum	20	20	21	Shrub
RHYREN	Rhynchosia reniformis	19	2	31	Forb
RUBCUN	Rubus cuneifolius	6	0	0	Shrub
RUECAR	Ruellia caroliniensis	22	8	25	Forb
RUECIL	Ruellia ciliosa	1	1	1	Forb
SCUINT	Scutellaria integrifolia	3	3	0	Forb
SERREP	Serenoa repens	1	3	1	Shrub
SERTOR	Sericocarpus tortifolius	0	3	0	Forb
SMIAUR	Smilax auriculata	27	12	29	Shrub
SOLODO	Solidago odora	15	0	0	Forb
STISYL	Stillingia sylvatica	28	30	35	Forb
STYBIF	Stylosanthes biflora	3	1	3	Forb
STYPAT	Stylisma patens	13	19	26	Forb
TEPCHR_SPI	Tephrosia chrysophylla/spicata	42	63	53	Forb
TEPFLO	Tephrosia florida	4	0	5	Forb
TRIDIC	Trichostema dichotomum	4	18	2	Forb
VACDAR	Vaccinium darrowii	3	0	4	Shrub
VACMYR	Vaccinium myrsinites	13	20	0	Shrub

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Additional Resources

For more information on the natural history and identification of the insects we found on the Citrus Tract of Withlacoochee State Forest, these are good places to start:

BugGuide.net: https://bugguide.net/node/view/15740

Discover Life: https://www.discoverlife.org/

For more information on the natural history and identification of the pollinator plants Citrus Tract of Withlacoochee State Forest, start with these resources:

Flora of North America: http://floranorthamerica.org/Main_Page

Atlas of Florida Vascular Plants: https://florida.plantatlas.usf.edu/

For a more detailed accounting of data analysis, conclusions, and management recommendations, check our FWRI/Upland Habitat website for publications and reports, which will be uploaded as they are finalized: https://myfwc.com/research/habitat/upland/.

Feel free to contact FWRI's Upland Habitat Research & Monitoring team with plant and pollinator questions any time, if we don't have the answer we can find out or point you in the right direction:

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