THREE MILE CREEK WATERSHED
Invasive Species Control Plan

Prepared for:

Mobile Bay National Estuary Program
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Three Mile Creek Invasive Species Control Plan- Final Report
Prepared for: Mobile Bay National Estuary Program
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Authorization for Release

The analyses, opinions, and conclusions in this document are based entirely on EnviroScience's unbiased, professional judgment. EnviroScience's compensation is not in any way contingent on any action or event resulting from this study.

The undersigned attest, to the best of their knowledge, that this document and the information contained herein is accurate and conforms to EnviroScience's internal Quality Assurance standards.

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EXECUTIVE SUMMARY

Three Mile Creek is a tributary of the Mobile River and drains approximately 30.1 sq. mi. through a mix of residential, commercial, industrial, and undeveloped sections of Mobile and Prichard, Alabama. The area includes habitat-rich wooded wetlands supporting a broad diversity of freshwater, estuarine, and marine species, along with highly urbanized areas.

Competition among species is a natural part of any ecosystem, but introduction of exotic species can disrupt intricate balances and relationships evolved over thousands of years among native species and their communities. These invasions often cause a loss of biological diversity within both the plant and animal communities (Vitousek 1990). To prevent this loss of biological diversity and improve water quality, Mobile Bay National Estuary Program requested development of an Invasive Species Control Plan for the Watershed.

The purpose of this Invasive Species Control Plan is to remove or control invasive plant and animal species within the Three Mile Creek Watershed, based upon available and survey data.

In order to provide a quantitative evaluation of invasive species within the Three Mile Creek Watershed, the Team used a plot-based sampling design to document invasive and native species and their locations within major waterway corridors. Spring and fall field surveys were completed to coincide with peak visibility of target species and to maximize positive identification through flowers or other diagnostic features.

The surveyed waterways included the entire run of the main channel of Three Mile Creek, extending from its headwaters downstream to approximately 1 km from the confluence with the Mobile River. A total of 368 sites were sample and equaled an area of 304,200 m^2 (75.2 acres), or approximately 9.3% of the riparian area of the Three Mile Creek Watershed (810 acres).

From the survey, a total of 43 invasive plant species and two invasive animal species were quantified within the Three Mile Creek Watershed during the two sampling events. The five invasive plant species most frequently observed in the plots on a presence/absence basis were Chinese tallow tree, alligatorweed, Chinese privet, cogongrass, and Japanese climbing fern. The most prevalent invasive animal observed was the island apple snail.

From this data, watershed-wide and species-specific control applications were developed to control invasive species within the Three Mile Creek Watershed. The plan is broken into eight key areas for implementation and should be followed as listed below.

1. Obtain access to large parcels within the Watershed for invasive control efforts
2. Strategy 1. Manage and protect existing intact native communities
3. Strategy 2. Target high or moderate density non-native invasive communities
4. Strategy 3. Continue and expand island apple snail removals
5. Use budgeting tool and species location maps to prioritize site selection
6. Reestablish native plant communities in riparian areas
7. Continue monitoring the Watershed to detect new invasive species while they are present in low numbers
8. Conduct community outreach regarding invasive species detection and control

1.0 INTRODUCTION

The mission of the Mobile Bay National Estuary Program (MBNEP) is to promote wise stewardship of the water quality characteristics and living resource base of the Mobile Bay estuarine system. The Mobile Bay Watershed drains two thirds of the state of Alabama and parts of Mississippi, Georgia, and Tennessee, and is the most biodiverse drainage basin in North America. The Mobile Bay estuary is the coastal transition zone of this Watershed. It contains waters and land of great economic importance due to a large and increasing amount of industry, development, recreation, and tourism in the region (MBNEP 2013-2018). Administered through and funded by the EPA under 1987 provisions of the Clean Water Act (CWA) of 1972, the initial task for the MBNEP was the development of a Comprehensive Conservation Management Plan (CCMP) as a blueprint for conserving the estuary. Since the program was founded, MBNEP has worked diligently to implement plans and respond to emerging environmental challenges in the Watershed.

Three Mile Creek (HUC 031602040504) is a tributary of the Mobile River and drains approximately 30.1 sq. mi. through a mix of residential sections of Mobile and Prichard, habitat-rich wooded wetlands supporting a broad diversity of both marine and freshwater species, and highly urbanized areas. In September 2014, MBNEP, Dewberry and subconsultants finalized the Three Mile Creek Watershed Management Plan (Dewberry 2014). As described in the Watershed Management Plan, Three Mile Creek suffers from the negative effects of stormwater runoff in the cites of Mobile and Prichard, Alabama. Major pollutants contributing to degradation include trash/litter; bacteria from sewage (i.e., pathogens); excessive amounts of nitrogen and phosphorus from fertilizers (i.e., nutrients); and small particles broken down through weathering and erosion (i.e., sediments).

The major challenges facing Three Mile Creek Watershed include:

- Abundance of invasive species – Infestation of island apple snails, Chinese tallow (popcorn) trees, and wild taro, among others.
- Abundance of aquatic vegetation – densely matted nuisance vegetation related to nutrient enrichment, particularly in the downstream segment of the creek, contributing to low dissolved oxygen (DO).
- Altered watershed hydrology - loss of floodplain connectivity; loss of connected wetland areas; reduced length of creek flow path; and loss of connectivity with historic streamway.
- Altered creek geomorphology – loss of riparian buffers; construction of engineered channels and bank stabilization; stream bank erosion and sedimentation.

The five goals of the Watershed Management Plan are to:

- Improve water quality;
- Provide access to resources;
- Protect and improve the health of fish and wildlife;
- Restore the heritage and cultural connection between the Watershed and the Community, and;
- Plan and prepare for climate resiliency.

The scope of this study regarding invasive species control is a peripheral component to many of the goals stated above.

1.1 PURPOSE AND OBJECTIVES

The purpose of this Invasive Species Control Plan is to remove or control invasive plant and animal species within the Three Mile Creek Watershed, based upon available and new data.

Per the TMC Watershed Management Plan, we developed a comprehensive, economically-feasible plan to control invasive species in the Watershed. Specifically, the 2018 Invasive Species Control Plan:

- Identifies the location and extent of the most impactful (targeted) invasive species;
- Identifies priority habitats at risk of being invaded and occupied by targeted invasive species;
- Prescribes methods and techniques designed to control invasive species most likely to respond to treatment;
- Develops a monitoring plan designed to assess the results of the management activities; and
- Offers estimated costs to remove or control target invasive species.

1.2 BACKGROUND OF INVASIVE SPECIES

Competition among species is a natural part of any ecosystem, but introduction of exotic species can disrupt intricate balances and relationships evolved over thousands of years among native species and their communities. These invasions often cause a loss of biological diversity within both the plant and animal communities (Vitousek 1990). There are many examples of disastrous exotic invasions that have resulted in losses of native species, changes in community structure and function, and even alterations of the physical structure of an ecosystem (Gaines 2018). The effects of invasions by exotic species depend in large part on which species and which natural communities are involved.

Some generalized characteristics of invasive exotic plant species include having a long lifespan, high dispersal rates, and being able to reproduce vegetatively (without seeds) and/or produce large numbers of seeds. These plants typically have a short generation time and are usually habitat generalists. Invasive animal species share many of the same characteristics: they often produce many offspring and are habitat generalists. A large contributor to the success of exotic species is an absence of predators, disease, or other factors that keep populations in check in the species' native regions.

Some characteristics of habitats that are prone to invasion include those that have a similar climate to the place of origin of the invading plant; habitats that have been disturbed by humans; early successional habitats (for example, clear cuts and abandoned agricultural fields or pastures); and habitats that have low natural diversity.

Exotic plant establishment is generally associated with disturbed habitats. The forms of disturbance can include ditching, stream channelization, or severe erosion that results in changes to the natural hydrology of the surrounding land. In addition, other human disturbances such as timber harvesting, agriculture, overgrazing by livestock, and development activities can also alter ecosystems in ways that may make them more vulnerable to invasive species.

Healthy, intact, and fully-functioning ecosystems are much more resistant to invasion by exotic species. For example, while it is not uncommon to find plant communities made up almost exclusively of exotics growing within or just outside of road rights-of-way, where excavation of ditches has highly disturbed the natural hydrology and native vegetation has been removed, it is rare to find non-native species becoming established beyond the zone of influence of the roadside ditch or disturbed area- as long as the adjacent habitat is relatively undisturbed. This is due to the natural competition between the various native plant species within healthy, intact communities, which fills any niche that may otherwise be invaded by exotics.

Three Mile Creek Watershed encompasses a highly urbanized region that possesses many of the risk factors for invasive species that are related to human development, and a list of potential species requiring control is outlined in Section 4.0.

2.0 METHODS

2.1 SAMPLING DESIGN

In order to provide a quantitative evaluation of invasive species within the Three Mile Creek Watershed, the Team used a plot-based sampling design to document invasive and native species and their locations within major waterway corridors. Spring and fall field surveys were completed to coincide with peak visibility of target species and to maximize positive identification through flowers or other diagnostic features.

The surveyed waterways included the entire run of the main channel of Three Mile Creek, extending from its headwaters downstream to approximately 1 km from the confluence with the Mobile River. The survey area included both the original and canal portions of the waterway between Conception Street Road and Dr. Martin Luther King Jr. Avenue. In addition, surveyed waterways included Twelve Mile Creek, One Mile Creek, Toulmins Spring Branch, and over 25 unnamed tributaries. The 368 total sites surveyed are shown in Figure 2.1.

Sample plots were spaced approximately 150m apart on each selected waterway. Sample plot spacing was determined in the field using a rangefinder. Certain areas were not sampled due to site constraints (obstructions, culverts, brush). In residential areas with poor stream access, sample plots were placed at road crossings. Sample plot spacing was altered in Langan Municipal Park Lake (Langan Lake) due to its width. Riparian sample plots were alternated every 150m between the north and south sides of the park, resulting in an interval of 300m between successive plots on each bank. Boat sampling was conducted through the center of the system.

Of the 368 total sites, 328 were 30m x 30m (900m^2) in area, while 40 were 15m x 15m (225m^2) in area due to visibility or sampling constraints. The area sampled totals 304,200 m^2 (75.2 acres), or approximately 9.3% of the riparian area of the Three Mile Creek Watershed (810 acres). The total riparian area of the Watershed was approximated via ArcGIS, using the National Hydrographic Dataset (NHD) for both the stream polylines and the watershed area. Using the buffer tool, a new polygon shapefile was derived, defined by a 15-meter buffer around all sides of the stream polylines. The area of the resulting stream buffer polygon totaled 810 acres, which was used as an approximation for the total area of riparian zones in the Three Mile Creek Watershed.

Path: P:\10_Projects\MMobile Bay National Estuary Program\GIS\MapX_ThreeMileCreekWatershed_DataOverview.mxd

Date: 11/7/2018

Figure 2.1 Sampling Site Map Overview.
Three Mile Creek Watershed.
Invasive Species Control Plan.

Sampling Site

Stream

0 3,000 6,000 12,000 Feet

0 875 1,750 3,500 Meters

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Basemap courtesy of Esri.

The Team mailed access notification letters to property owners with larger tracts of land or key areas before sampling (See Figure 2.2). The contacted property owners were informed of the plan to conduct field work on properties within the project area, and were notified of the preliminary field activity schedule, which was to consist of one week in spring 2018 and one week in fall 2018. Property access was in accord with the Alabama Code Section 35-2-32 rights of entry to private property (State of Alabama Acts 1971, No. 2249, p. 3608, §12.).

Figure 2.2. Targeted Large Parcels for 2018 Surveys.

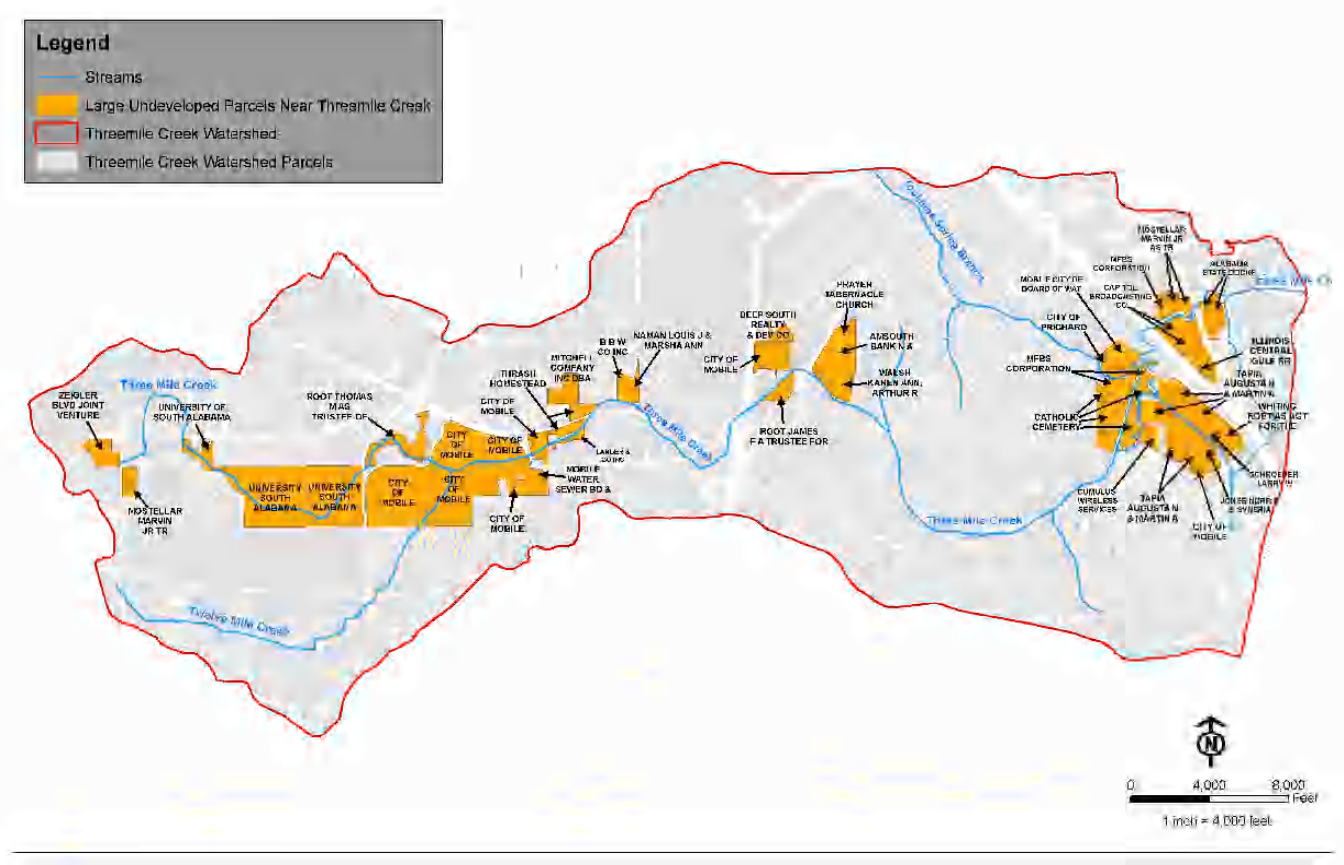

Figure from the Three Mile Creek Watershed Restoration Status of Activities Report 2018: MBNEP and City of Mobile

2.2 SAMPLE PLOT LAYOUT AND DATA COLLECTION

Standard sample plots measured 30m x 30m for a total square area of 900 m^2. For large stream segments (defined as > 20m wide), the center of the plot was placed on either the left or right descending bank. This placed the inward half of the plot within the stream, and the outward half of the plot in the riparian zone (Figure 2.2). For small stream segments (< 20m wide), the center of the plot was placed in the center of the stream channel, encompassing the entire width of the stream with riparian zone portions on either side (Figure 2.3). Spacing on sample plots ranged from 150 to 300 meters apart or where access to a stream or wetland was available. Depending on the width of the stream in the plot, the plot was either centered on the center of the channel or on the left or right bank, in the latter case alternating between plots.

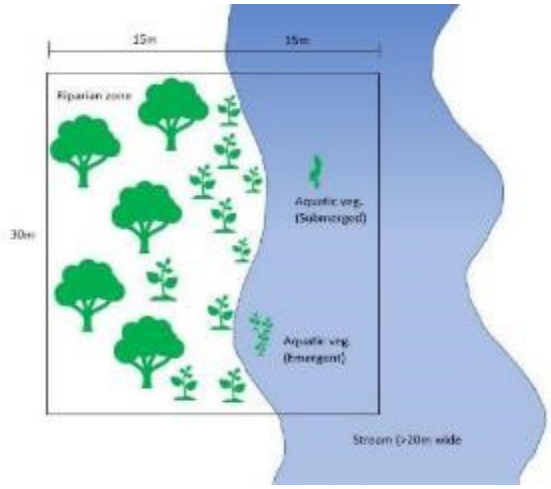

Figure 2.3 - Standard 30m x 30m sample plot for large (>20m wide) waterbodies.

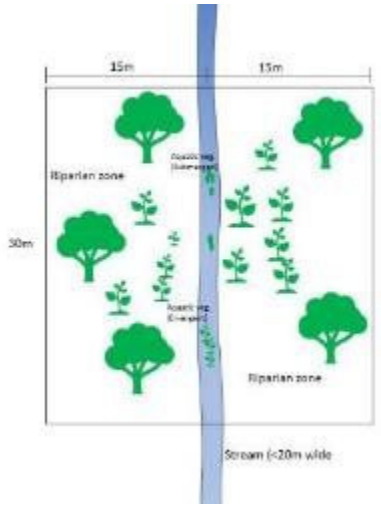

Figure 2.4 - Standard 30m x 30m sample plot for small (<20m wide) waterbodies.

The field biologists recorded invasive and native plant cover electronically on iPad tablet computers, using a fillable PDF to allow rapid population of all required fields (Appendix A). The field biologists recorded plant data in six cover classes (<1%, 1%-5%, 6%-25%, 26%-75%, 76%-94%, and >95%), and used three cover classes for invasive animals (low, medium, and high). Invasive plant species were also classified by the stratum in which they were typically observed (tree, shrub, vine, forb, grass, fern, aquatic). Any dominant native species were also documented at each plot location, with dominant being defined as having >20% cover. Dominant native species were noted, but cover classes were not estimated as with invasive species. Biologists also took photographs at each plot, including upstream and downstream photos, left and right banks, and substrate (when possible). The location of each plot was recorded using submeter-accurate Trimble GeoExplorer GPS devices.

2.3 SPRING FIELD SURVEY (266 PLOTS)

EnviroScience Incorporated (EnviroScience), Wetland Resources Environmental Consulting (WREC), and Volkert Incorporated (Volkert) completed the spring portion of the field survey between May 14 and May 18, 2018 and from May 24 thru June 1, 2018. The EnviroScience and WREC personnel were split into pairs, one wading the upstream wadeable portion of the Watershed and one working the downstream boatable portion. Volkert completed a survey on additional sites within the watersheds, specifically those located on properties owned by municipal and power companies. The upstream biologists primarily surveyed from the bank, while the downstream biologists primarily surveyed using 14-18-foot motorized boats and occasionally by canoe. A total of 266 plots were surveyed during the spring field survey.

2.4 FALL FIELD SURVEY (102 PLOTS)

The fall field survey was conducted from September 25 -27, 2018 to target plant species that are more readily identified in that season. The methods were identical to those of the spring survey, except for 40 plots with lack of access or visibility due to foliage. The survey plots in those locations measured 15m x 15m for a total square area of 225 m^2. A total of 102 plots were surveyed during the fall portion of the study, focusing on TMC mainstem, areas not sampled during the spring, and sites which were expected to have aquatic vegetation that may not have been visible in the spring surveys.

2.5 DATA ANALYSIS

Upon completion of field sampling, the PDF data sheets were uploaded and compiled into a database. The database enumerated the overall plots containing each specific type of invasive organism, grouped into six cover classes for plants (<1%, 1%-5%, 6%-25%, 26%-75%, 76%-94%, and >95%) and three cover classes for invasive animals (low, medium, and high). Invasive species were also classified by the stratum in which they were typically observed (tree, shrub, vine, forb, grass, fern, aquatic). To further classify the aquatic species, submerged aquatic vegetation (SAV) and emergent aquatic vegetation (emergent) were separated. Species with foliar herbicide application recommendations are considered emergent whereas aquatic species with biological or water-based herbicide application recommendations are considered SAV. Any dominant native species were also documented at each plot location, with dominant being defined as having >20% cover. Dominant native species were noted, but cover classes were not estimated as with invasive species. The full database of results is available in Appendix A.

Cover class data were used to estimate the percent cover of each invasive species within the entire watershed. If a plant was placed in a cover class in a plot, the midpoint of the cover class was used as the numerical value of its percent cover. These midpoint values were summed across all plots and divided by the total area of all plots to calculate a percent cover over the survey area. These values were then extrapolated to the riparian zone within the entire watershed.

2.6 INVASIVE POTENTIAL AND CONTROL METHODS LITERATURE REVIEW

Existing scientific, governmental, and trade publications were reviewed to determine the known control methods for the invasive species and summarized in species descriptions found in Section 5.

The Alabama Invasive Plant Council (ALIPC) invasiveness ranking system was used as an estimate of the relative severity of invasiveness by species. For management purposes, Category 1 species are those of highest importance followed by Category 2, then the various Watch Lists A-C below.

Criteria for Evaluating Plant Species for Invasiveness in Alabama (ALIPC 2012)

Category 1:

1) The plant species or sub-species or variety is non-native to Alabama.

2) The plant has the potential for rapid growth, high seed or propagule production and dispersal, and establishment in natural communities or in managed areas where it is not desired.

3) The plant is able or known to be able to out-compete other species in plant communities or cropping systems thereby impacting native plant biodiversity, ecosystem functions, or crop productivity.

4) The plant persists in free living infestations (without cultivation) within Alabama.

5) The plant is widespread and occurs in two or more invasive regions, which are 1. Plateaus and Piedmont 2. Mountains 3. Middle Coastal Plain 4. Black Belt 5. Lower Coastal Plain.

6) It occurs in dense stands of numerous individuals in frequent infestations.

Category 2:

7) The plant meets criteria 1-4.

8) The plant occurs within one or more cultural uses and one or two invasive regions.

9) It occurs as scattered individuals or widely scattered dense infestations.

Watch List A:

10) The plant meets criteria 1-3.

11) a. The plant has recently appeared as free-living populations within Alabama, or b. The plant is invasive in nearby states but its status in Alabama is unknown or unclear, and it has the potential, based on its biology and its colonization history in the Southeast and elsewhere, to become invasive in Alabama.

Watch List B:

12) The plant meets criteria 1-3.

13) The plant is grown in Alabama.

14) The plant has a documented history of invasiveness in other areas of the Southeast and/or is listed by the Global Invasive Species Program as a world-class invasive plant for habitats similar to those in the Southeast.

Watch List C: 15) The plant meets criteria 14 only.

3.0 RESULTS

3.1 INVASIVE PLANTS OVERVIEW

Field crews identified 43 invasive plant species within the Three Mile Creek Watershed during the two sampling events. The five invasive plant species most frequently observed in the plots on a presence/absence basis were Chinese tallow tree, alligatorweed, Chinese privet, cogongrass, and Japanese climbing fern (in descending order). Table 3.1 contains all observed invasive species with a measure of their distribution throughout the Watershed (# of occurrences) and their dominance in plots where they occurred (average percent cover). This table provides a basis for the invasive plant species control plan in Section 4 of this document.

Figure 3.1 shows the overall abundance of invasive species in Three Mile Creek Watershed. This figure was developed using the sum of each species' mean cover category (>1%, 1-5, 6-25…) to develop a total percent cover for each plot. The results indicate that the east and west ends of the mainstem of the system are the most affected by invasive species. Some of the north-south tributaries and overall central portion of the Watershed has less invasive species cover present. The least affected area is in the center of the Watershed in the region just to the west of Interstate 65 (I-65). These least impacted areas should be protected from further degradation.

Individual species profiles with location maps are contained in Section 5 of the report. For ease in finding individual species, the location of each species profile is identified in the "Species Profile" column of Table 3.1. Additionally, the table lists an invasiveness rating for each species from the Alabama Invasive Plant Council (ALIPC) criteria, described above. Species that were not on the ALIPC list were rated as Watch List C (WC). The risk ranking is an important consideration in analysis and planning moving forward from the standpoint that the most prevalent invasive species in the Watershed may be overtaken by a species that is only marginally present today. For example, the Chinese tallow tree is most common with respect to overall abundance in the Watershed, but with respect to average coverage in sample plots it only occupies a moderate percentage. Other species such as kudzu are present in fewer sample plots currently, but from knowledge of this species, it has the potential to occupy the aerial coverage by 100%. Even though these species occupy different strata, it is important to stay cognizant of the new arrivals and threats.

Figure 3.1
Total Invasive Species Coverage

Percent Cover, All Invasive Plants (Number of Plots)

- 0% (28)
- ≤10% (67)
- 11 - 25% (80)
- 26 - 50% (90)
- 51 - 75% (62)
- 76 - 100% (27)
- >100% (14)

0 0.5 1 2 Miles

0 1 2 4 km

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Date: 12/20/2018 Path: P:\10_Projects\MMobile Bay National Estuary Program\GIS\Invasive Coverage\TotalCoverage.mxd

Basemap courtesy of Esri.

Table 3.1 - Frequency of Invasive Plant Species in Surveyed Plots

Scientific Name	Common Name	# of Plots Present	% of Plots Present	Average % Cover	ALIPC Invasive Rating	Species Profile	Veg. Category
Triadica sebifera	Chinese tallow tree	214	58.15%	14.90%	1	5.38	Tree
Ligustrum sinense	Chinese privet	144	39.13%	16.35%	1	5.17	Shrub
Alternanthera philoxeroides	alligatorweed	142	38.58%	9.37%	1	5.2	Aquatic Emergent
Imperata cylindrica	cogongrass	87	23.64%	13.46%	1	5.15	Grass
Lygodium japonicum	Japanese climbing fern	85	23.10%	3.24%	1	5.21	Fern/Vine
Colocasia esculenta	wild taro	82	22.28%	8.37%	2	5.7	Aquatic Emergent
Panicum repens	torpedograss	66	17.93%	7.13%	2	5.28	Grass
Albizia julibrissin	mimosa (silktree)	63	17.12%	7.01%	1	5.1	Tree
Ludwigia peruviana	Peruvian primrose-willow	58	15.76%	7.14%	WC	5.20	Forb
Lonicera japonica	Japanese honeysuckle	50	13.59%	3.05%	1	5.18	Vine
Paspalum urvillei	Vasey's grass	47	12.77%	4.76%	2	5.29	Grass
Cinnamomum camphora	camphor tree	39	10.60%	9.60%	2	5.5	Tree
Verbena brasiliensis	Brazilian vervain	34	9.24%	4.10%	WC	5.40	Forb
Hyptis mutabilis	tropical bushmint	30	8.15%	2.33%	WA	5.14	Forb
Morus alba	white mulberry	26	7.07%	12.13%	WC	5.23	Tree
Clematis terniflora	sweet autumn virginsbower	23	6.25%	3.65%	2	5.6	Vine
Deparia petersenii	Petersen's spleenwort	16	4.35%	6.91%	WC	5.8	Fern
Pueraria montana	kudzu	14	3.80%	17.11%	1	5.30	Vine
Myriophyllum spicatum	Eurasian watermilfoil	11	2.99%	23.68%	1	5.26	Aquatic SAV
Sebania punicea	rattlebox	10	2.72%	5.25%	WC	5.35	Shrub
Egeria densa	Brazilian elodea	8	2.17%	18.31%	2	5.10	Aquatic SAV
Oxycarum cubense	Cuban bulrush	8	2.17%	9.25%	2	5.27	Aquatic Emergent
Wisteria sinensis	Chinese wisteria	8	2.17%	3.00%	1	5.41	Vine
Melia azedarach	Chinaberry	6	1.63%	7.17%	2	5.22	Tree
Lagerstroemia indica	crape myrtle	5	1.36%	4.00%	WC	5.16	Tree
Raphanus raphanistrum	wild radish	5	1.36%	2.00%	WC	5.31	Forb
Rhynchospora sp.	unidentified invasive beaksedge	5	1.36%	14.00%	WC	5.32	Aquatic Emergent
Myriophyllum aquaticum	parrotfeather	4	1.09%	17.38%	1	5.25	Aquatic Emergent

Scientific Name	Common Name	# of Plots Present	% of Plots Present	Average % Cover	ALIPC Invasive Rating	Species Profile	Veg. Category
Thelypteris dentata	downy maiden fern	4	1.09%	3.00%	WC	5.37	Fern
Bambusa vulgaris	common bamboo	3	0.82%	18.00%	WC	5.3	Grass
Canna indica	Indian shot	3	0.82%	3.00%	WC	5.4	Forb
Murdannia keisak	marsh dewflower	3	0.82%	14.67%	2	5.24	Forb
Salvinia minima	common salvinia	3	0.82%	0.50%	WC	5.34	Aquatic SAV
Dioscorea bulbifera	air potato	2	0.54%	1.75%	WA	5.9	Vine
Eichhornia crassipes	water hyacinth	2	0.54%	0.50%	1	5.11	Aquatic SAV
Sorghum halepense	Johnson grass	2	0.54%	1.75%	2	5.36	Grass
Elaeagnus spp.	thorny olive / autumn olive / Russian olive	1	0.27%	3.00%	2	5.42	Shrub
Firmiana simplex	Chinese parasoltree	1	0.27%	3.00%	2	5.12	Tree
Hygrophila polysperma	East Indian hygrophila	1	0.27%	0.50%	WC	5.13	Aquatic SAV
Ludwigia peploides	creeping waterprimrose	1	0.27%	3.00%	WC	5.19	Aquatic Emergent
Rosa spp.	rose	1	0.27%	3.00%	1(mutiflora),2 (other)	5.33	Shrub
Trachelospermum jasminoides	star jasmine	1	0.27%	15.50%	WC	5.42	Vine
Ulmus parvifolia	Chinese elm	1	0.27%	15.50%	WB	5.39	Tree

The overall invasive plant coverage was calculated for each plot. The overall invasive coverage is represented graphically in Figure 3.1 and Figure 3.2, with plots grouped into the following cover classes: 0%, 0 – 10%, 11 – 25%, 26 – 50%, 51 – 75%, 76 – 100%, and >100%. It was possible to have >100% coverage because plots may have consisted of species occupying multiple vegetative strata – canopy, understory, ground, or aquatic, and species' individual coverage statistics only referenced the habitat that it can naturally occupy.

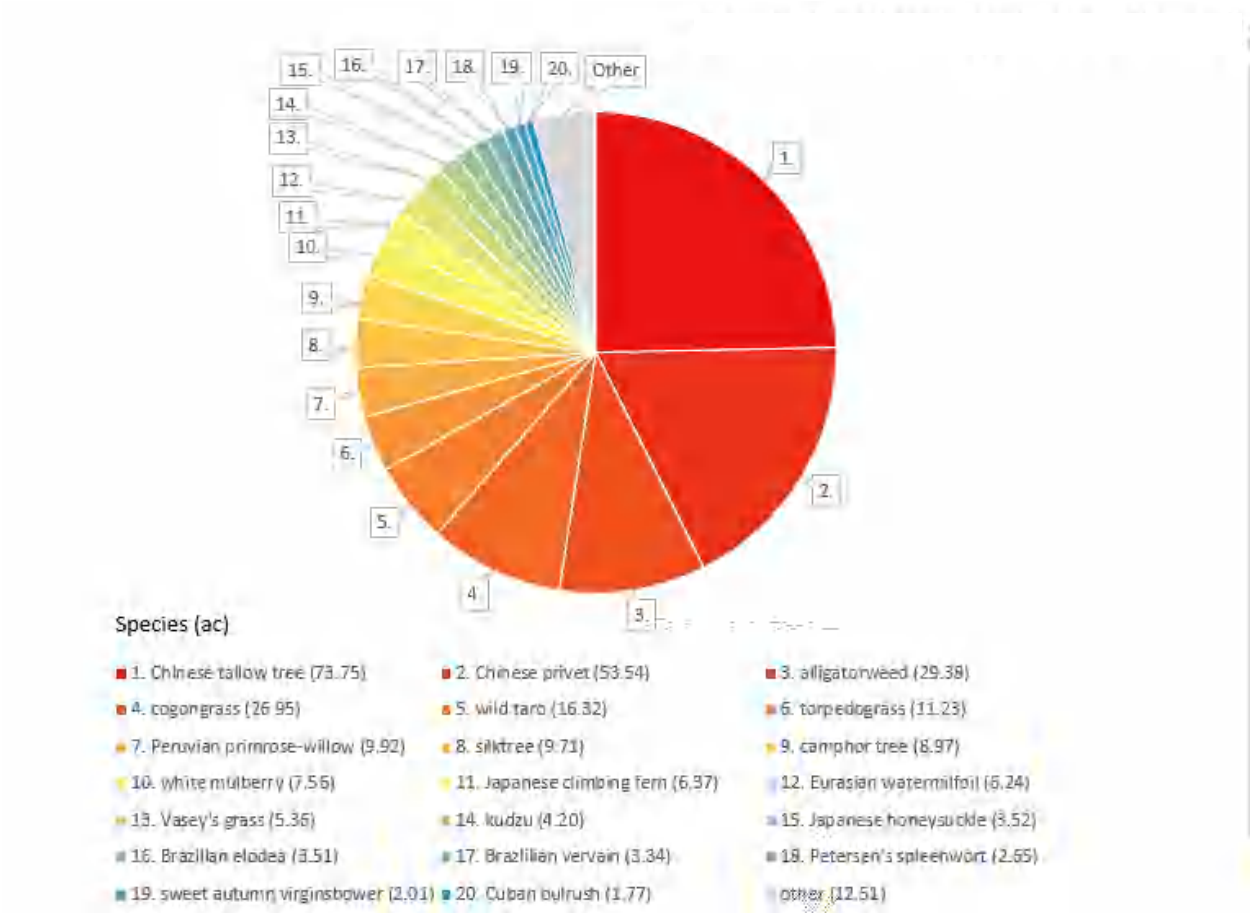
The five species that were estimated to have the highest percent coverage in the survey area were as follows, in descending order: Chinese tallow tree, alligatorweed, Chinese privet, cogongrass, and wild taro. The full table of each species' total estimated percent coverage of the area surveyed is below, along with an estimate of the total riparian coverage of the Three Mile Creek Watershed based on the ArcGIS calculation described in Section 2.1 (Table 3.2). Estimates assumed the mean percent within each stratum.

Table 3.2 - Estimated Invasive Plant Coverage of Survey Area and Riparian Area Within Watershed

Scientific Name	Common Name	Survey Area Coverage (m^2)	Percent of Survey Area Covered	Estimated Total Riparian Coverage (acres)
Triadica sebifera	Chinese tallow tree	27700	9.11%	73.75
Ligustrum sinense	Chinese privet	20111	6.61%	53.54
Alternanthera philoxeroides	alligatorweed	11034	3.63%	29.38
Imperata cylindrica	cogongrass	10124	3.33%	26.95
Colocasia esculenta	wild taro	6130	2.02%	16.32
Panicum repens	torpedograss	4218	1.39%	11.23
Ludwigia peruviana	Peruvian primrose-willow	3726	1.22%	9.92
Albizia julibrissin	silktree (mimosa)	3646	1.20%	9.71
Cinnamomum camphora	camphor tree	3371	1.11%	8.97
Morus alba	white mulberry	2840	0.93%	7.56
Lygodium japonicum	Japanese climbing fern	2394	0.79%	6.37
Myriophyllum spicatum	Eurasian watermilfoil	2345	0.77%	6.24
Paspalum urvillei	Vasey's grass	2012	0.66%	5.36
Pueraria montana	kudzu	1578	0.52%	4.20
Lonicera japonica	Japanese honeysuckle	1322	0.43%	3.52
Egeria densa	Brazilian elodea	1319	0.43%	3.51
Verbena brasiliensis	Brazilian vervain	1256	0.41%	3.34
Deparia petersenii	Petersen's spleenwort	995	0.33%	2.65
Clematis terniflora	sweet autumn virginsbower	756	0.25%	2.01
Oxycarum cubense	Cuban bulrush	666	0.22%	1.77
Hyptis mutabilis	tropical bushmint	630	0.21%	1.68
Rhynchospora sp.	unidentified invasive beaksedge	630	0.21%	1.68
Myriophyllum aquaticum	parrotfeather	626	0.21%	1.67
Bambusa vulgaris	common bamboo	486	0.16%	1.29
Sesbania punicea	rattlebox	473	0.16%	1.26
Murdannia keisak	marsh dewflower	396	0.13%	1.05
Melia azedarach	Chinaberry	367	0.12%	0.98
Lagerstroemia indica	crape myrtle	180	0.06%	0.48
Wisteria sinensis	Chinese wisteria	179	0.06%	0.48
Trachelospermum jasminoides	star jasmine	140	0.05%	0.37
Ulmus parvifolia	Chinese elm	140	0.05%	0.37
Thelypteris dentata	downy maiden fern	108	0.04%	0.29
Raphanus raphanistrum	wild radish	90	0.03%	0.24
Canna indica	Indian shot	81	0.03%	0.22

Scientific Name	Common Name	Survey Area Coverage (m^2)	Percent of Survey Area Covered	Estimated Total Riparian Coverage (acres)
Dioscorea bulbifera	air potato	32	0.01%	0.08
Sorghum halepense	Johnson grass	32	0.01%	0.08
Eleagnus spp.	thorny olive/autumn olive/Russian olive	27	0.01%	0.07
Firmiana simplex	Chinese parasoltree	27	0.01%	0.07
Ludwigia peploides	creeping waterprimrose	27	0.01%	0.07
Rosa spp.	rose	27	0.01%	0.07
Salvinia minima	common salvinia	14	<0.01%	0.04
Eichhornia crassipes	water hyacinth	9	<0.01%	0.02
Hygrophila polysperma	East Indian hygrophila	5	<0.01%	0.01

Figure 3.2 Invasive Plant Species (Total Acreage Covered)



The next series of data analyzes the sample plots by strata, which includes aquatic, fern, forb, grass, shrub and tree to allow comparison between the native and invasive diversity in the Watershed. This has implications for recovery potential and treatment options for management.

Table 3.3 Aquatic Herbaceous Invasive Species

Scientific Name	Common Name	# of Plots Present	% of Plots Present	Average % Cover	ALIPC Invasive Rating	Veg. Category
Alternanthera philoxeroides	alligatorweed	142	38.58%	9.37%	1	Aquatic Emergent
Colocasia esculenta	wild taro	82	22.28%	8.37%	2	Aquatic Emergent
Oxycarum cubense	Cuban bulrush	8	2.17%	9.25%	2	Aquatic Emergent
Rhynchospora sp.	unidentified invasive beaksedge	5	1.36%	14.00%	WC	Aquatic Emergent
Myriophyllum aquaticum	parrotfeather	4	1.09%	17.38%	1	Aquatic Emergent
Ludwigia peploides	creeping waterprimrose	1	0.27%	3.00%	WC	Aquatic Emergent
Myriophyllum spicatum	Eurasian watermilfoil	11	2.99%	23.68%	1	Aquatic SAV
Egeria densa	Brazilian elodea	8	2.17%	18.31%	2	Aquatic SAV
Salvinia minima	common salvinia	3	0.82%	50.00%	WC	Aquatic SAV
Eichhornia crassipes	water hyacinth	2	0.54%	0.50%	1	Aquatic SAV
Hygrophila polysperma	East Indian hygrophila	1	0.27%	0.50%	WC	Aquatic SAV

Table 3.3 identifies 11 species within the aquatic stratum that are impacting native communities. Data suggests that the most abundant of these is alligatorweed, but it is also important to evaluate the ALIPC Rating and Average % Cover. For example, if common salvinia were 50% dominant in several sample plots that suggests that this species can potentially significantly impact native species diversity; however, the ALIPC Watch List C (WC) status identifies it as an invasive species of concern in other areas of the southeast, but not yet in Alabama. Conversely, 23.68% cover of Eurasian watermilfoil is considered a moderate average, but it is listed by ALIPC as a Category 1 invasive plant; therefore, it may warrant more immediate attention to prevent further spread.

Table 3.4. Herbaceous Terrestrial Invasive Species

Scientific Name	Common Name	# of Plots Present	% of Plots Present	Average % Cover	ALIPC Invasive Rating	Veg. Category
Deparia petersenii	Petersen's spleenwort	16	4.35%	6.91%	WC	Fern
Thelypteris dentata	downy maiden fern	4	1.09%	3.00%	WC	Fern
Ludwigia peruviana	Peruvian primrose-willow	58	15.76%	15.76%	WC	Forb
Verbena brasiliensis	Brazilian vervain	34	9.24%	4.10%	WC	Forb
Hyptis mutabilis	tropical bushmint	30	8.15%	2.33%	WA	Forb
Raphanus raphanistrum	wild radish	5	1.36%	2.00%	WC	Forb
Canna indica	Indian shot	3	0.82%	3.00%	WC	Forb
Murdannia keisak	marsh dewflower	3	0.82%	14.67%	2	Forb
Imperata cylindrica	cogongrass	87	23.64%	13.86%	1	Grass
Panicum repens	torpedograss	66	17.93%	7.13%	2	Grass
Paspalum urvillei	Vasey's grass	47	12.77%	4.76%	2	Grass
Bambusa vulgaris	common bamboo	3	0.82%	18.00%	WC	Grass
Sorghum halepense	Johnson grass	2	0.54%	1.75%	2	Grass

Table 3.4. identifies two fern species, six forb and five grass species occupying the lower strata. It is apparent that with respect to the ranking system the cogongrass is the greatest threat to the lower strata due to its abundance in the Watershed, average percent cover and Category 1 rating. Forb species on the other hand are either in low percent cover or included on an ALIPC Watch List category.

Table 3.5. Shrub, Tree and Vine Invasive Species

Scientific Name	Common Name	# of Plots Present	% of Plots Present	Average % Cover	ALIPC Invasive Rating	Veg. Category
Ligustrum sinense	Chinese privet	144	39.13%	16.34%	1	Shrub
Sesbania punicea	rattlebox	10	2.72%	5.25%	WC	Shrub
Elaeagnus spp.	thorny olive / autumn olive / Russian olive	1	0.27%	3.00%	2	Shrub
Rosa spp.	rose	1	0.27%	3.00%	1(multiflora),2 (other)	Shrub
Triadica sebifera	Chinese tallow tree	214	58.15%	14.90%	1	Tree
Albizia julibrissin	mimosa (silktree)	63	17.12%	7.01%	1	Tree
Cinnamomum camphora	camphor tree	39	10.60%	9.60%	2	Tree
Morus alba	white mulberry	26	7.07%	12.13%	WC	Tree
Melia azedarach	Chinaberry	6	1.63%	7.17%	2	Tree
Lagerstroemia indica.	crape myrtle	5	1.36%	4.00%	WC	Tree
Firmiana simplex	Chinese parasoltree	1	0.27%	3.00%	2	Tree
Ulmus parvifolia	Chinese elm	1	0.27%	15.50%	WB	Tree
Lygodium japonicum	Japanese climbing fern	85	23.10%	3.24%	1	Vine/Fern
Lonicera japonica	Japanese honeysuckle	50	13.59%	3.05%	1	Vine
Clematis terniflora	sweet autumn virginsbower	23	6.25%	3.65%	2	Vine
Pueraria montana	kudzu	14	3.80%	17.11%	1	Vine
Wisteria sinensis	Chinese wisteria	8	2.17%	3.00%	1	Vine
Dioscorea bulbifera	air potato	2	0.54%	1.75%	WA	Vine
Trachelospermum jasminoides	star jasmine	1	0.27%	15.50%	WC	Vine

Table 3.5. identifies four shrubs, eight trees, and seven vines occupying the subcanopy and canopy layers. Chinese privet is the most serious threat to the shrub layer due to its widespread occurrence, moderate percent cover, and Category 1 ALIPC ranking. Targeted efforts could potentially reduce the occurrence and spread of *Eleagnus* spp. and non-native roses since these species currently have a very low percent cover in the Watershed but have an ALIPC ranking of Category 2 and 1, respectively.

Of the eight invasive exotic trees occurring in the Watershed, Chinese tallow tree is probably the most serious with it being a dominant in many areas and having a Category 1 ALIPC ranking. Silktree and camphor tree are also trees of serious concern with Category 1 and 2 rankings, respectively.

Japanese climbing fern and Japanese honeysuckle are moderately abundant in the Watershed accompanied by a Category 1 ALIPC ranking; however, their average percent cover is relatively low at ~3.0%. Kudzu, with an ALIPC ranking of Category 1, is currently low in abundance in the Watershed. Specifically targeting known occurrences could significantly reduce its threat.

3.2 INVASIVE ANIMALS OVERVIEW

The primary animal species of concern in the Three Mile Creek Watershed is the island apple snail (*Pomacea maculata*). Island apple snails are easily identified by their distinct bright pink egg masses and have been observed with particular frequency and abundance in Langan Municipal Park (Langan Park). Figure 3.3 illustrated the 2018 observations of the apple snail. The other two invasive animal species targeted in this survey were the Asian clam (*Corbicula fluminea*) and tilapia (*Oreochromis* spp.). Tilapia were not definitively observed during this survey, although approximately four individuals of an unidentified fish species of a size corresponding to an adult tilapia were observed at the downstream end of Langan Park. The table below presents the number of occurrences and the visual estimations of abundance in the plot.

Table 3.6 Frequency and Abundance of Invasive Animal Species

Scientific Name	Common Name	Species Profile	# Plots where Absent	# Plots where Present	# Plots Low Abund.	# Plots Medium Abund.	# Plots High Abund.
Pomacea maculata	island apple snail	5.45	332	36	26	6	4
Corbicula fluminea	Asian clam	5.43	348	20	14	3	3
Oreochromis spp.	tilapia	5.44	368	0	0	0	0

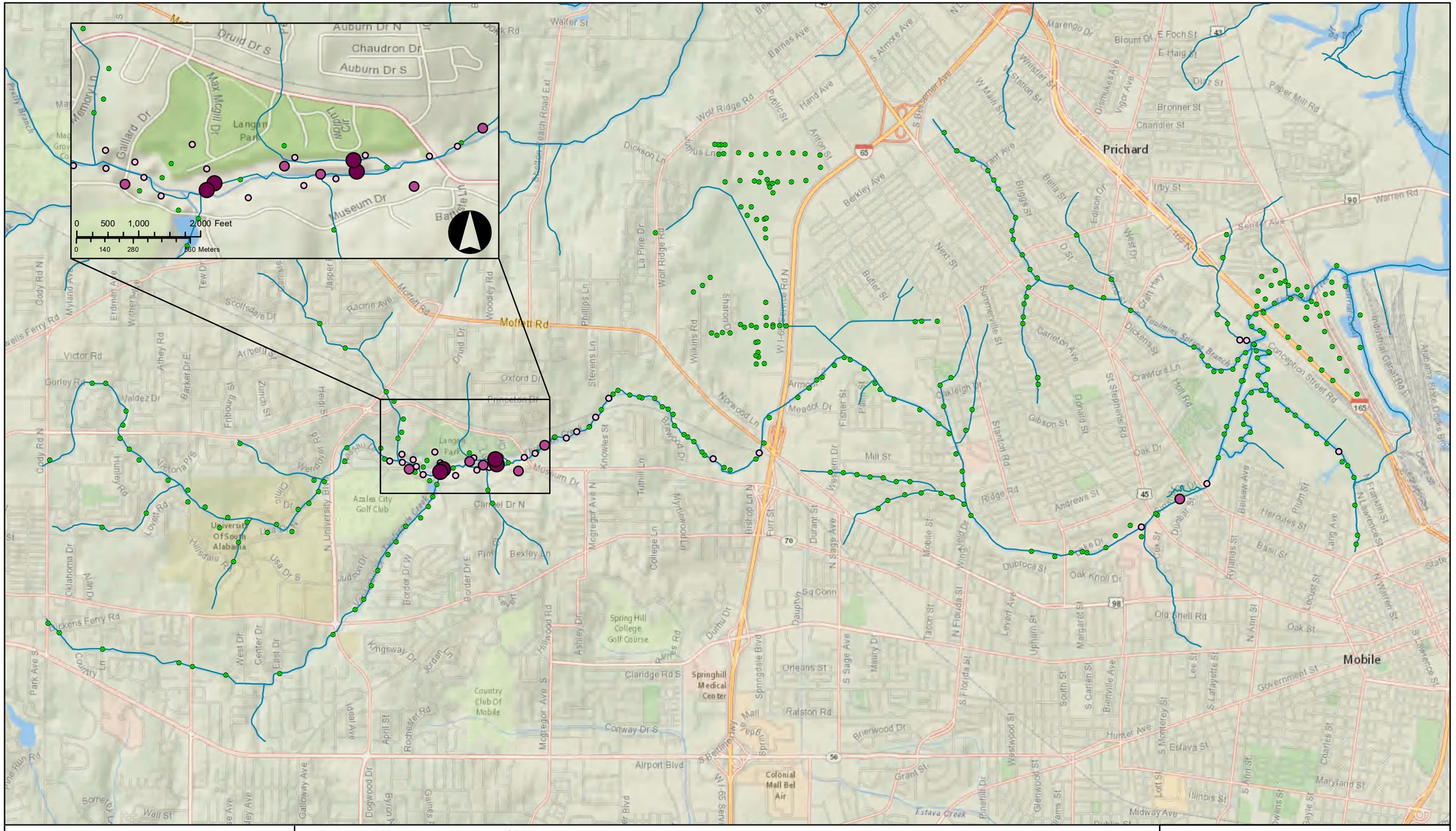


Figure 3.3
Pomacea maculata (island apple snail) occurrences

Estimated Abundance (Number of Plots)

- Zero (332)
- Low (26)
- Medium (6)
- High (4)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Date: 4/9/2019

Basemap courtesy of Esri.

3.3 NATIVE SPECIES OBSERVED

A total of 165 native species were observed during the two sampling events. See Appendix B. The field data forms provided a space to list any native species that were estimated to cover >20% of the plot. While these were not further detailed into estimated coverage classes like the invasive species were, the intent was to highlight areas that retained native growth and to identify some of the common native species in the riparian areas of Three Mile Creek Watershed. Table 3.7 represents the list of observed native species by Stratum. An overview map showing abundance of native species is contained in Figure 3.2. The native species greater than 20 percent recorded were as follows:

Table 3.7 - Native Species Observed in 2018 by Stratum

Scientific Name	Common Name	Total Plots Observed >20%	Veg. Category
Bacopa monnieri	waterhyssop	1	Aquatic
Cabomba caroliniana	fanwort	5	Aquatic
Ceratophyllum demersum.	coontail	2	Aquatic
Chara spp.	native macroalgae	4	Aquatic
Hydrocotyle spp.	pennywort	1	Aquatic
Hygrophila spp.	swampweed	1	Aquatic
Lemna minor	duckweed	2	Aquatic
Myriophyllum heterophyllum	variable watermilfoil	10	Aquatic
Najas spp.	southern naiad	1	Aquatic
Ruppia sp.	widgeon grass	1	Aquatic
Sagittaria latifolia	duck potato	10	Aquatic
Typha latifolia	broadleaf cattail	21	Aquatic
Utricularia spp.	bladderwort	1	Aquatic

Scientific Name	Common Name	Total Plots Observed >20%	Veg. Category
Osmunda regalis	royal fern	2	Fern
Osmundastrum cinnamomeum	cinnamon fern	7	Fern
Pteridum aquilinuim	bracken fern	1	Fern
Thelypteris kunthii	Kunth's maiden fern	4	Fern
Thelypteris palustris	marsh fern	1	Fern
Woodwardia areolata	netted chainfern	1	Fern
Woodwardia virginica	Virginia chainfern	8	Fern

Scientific Name	Common Name	Total Plots Observed >20%	Veg. Category
Drosera spp.	sundew	1	Forb
Eupatorium capillifolium	dog fennel	3	Forb
Helianthus spp.	sunflower	1	Forb
Impatiens capensis	common jewelweed	1	Forb
Juncus spp.	rushes	1	Forb
Persicaria spp.	knotweed	1	Forb
Ptilimnium capillaceum	mock bishopweed	1	Forb
Saururus cernuus	lizard's tail	3	Forb
Schoenoplectus acutus	hardstem bulrush	1	Forb
Sparganium americanum	American bur-reed	1	Forb
Solidago spp.	goldenrod	19	Forb
Tradescantia virginiana	spiderwort	1	Forb

Scientific Name	Common Name	Total Plots Observed >20%	Veg. Category
Andropogon spp.	bluestem grass	3	Grass
Dichanthelium scoparium	velvet panicum	1	Grass
Phragmites australis	common reed	4	Grass
Zizania aquatica	Indian rice	3	Grass
Zizaniopsis mileacia	giant cutgrass/water millet	3	Grass

Scientific Name	Common Name	Total Plots Observed >20%	Veg. Category
Baccharis halimifolia	groundsel tree	3	Shrub
Cyrilla racemiflora	swamp titi	14	Shrub
Ilex glabra	gallberry	8	Shrub
Rubus spp.	blackberry	7	Shrub
Sabal minor	dwarf palmetto	1	Shrub
Sambucus canadensis	American black elderberry	5	Shrub

Scientific Name	Common Name	Total Plots Observed >20%	Veg. Category
Acer rubrum	red maple	27	Tree
Carya illinoinensis	pecan	1	Tree
Carya spp.	hickory	7	Tree
Celtis laevigata	sugarberry	2	Tree
Ilex vomitoria	yaupon	15	Tree
Juniperus virginiana	red cedar	1	Tree
Liquidambar styraciflua	sweetgum	8	Tree
Liriodendron tulipifera	tulip poplar	7	Tree
Magnolia grandiflora	southern magnolia	3	Tree
Magnolia virginiana	sweetbay magnolia	7	Tree
Morella cerifera	wax myrtle	12	Tree
Nyssa biflora	swamp tupelo	5	Tree
Nyssa sylvatica	black gum	28	Tree
Persea palustris	swamp red bay	13	Tree
Pinus elliottii	slash pine	18	Tree
Pinus taeda	loblolly pine	5	Tree
Platanus occidentalis	sycamore	9	Tree
Prunus caroliniana	Carolina laurel cherry	8	Tree
Quercus hemisphaerica	Darlington oak	1	Tree
Quercus laurifolia	laurel oak	4	Tree
Quercus nigra	water oak	82	Tree
Quercus virginiana	live oak	6	Tree
Salix nigra	black willow	25	Tree
Taxodium ascendens	pond cypress	1	Tree
Taxodium distichum	bald cypress	2	Tree

Scientific Name	Common Name	Total Plots Observed >20%	Veg. Category
Ampelopsis arborea	peppervine	2	Vine
Brunnichia ovata	American buckwheat vine	6	Vine
Parthenocissus quinquefolia	Virginia creeper	1	Vine
Smilax spp.	smilax	1	Vine
Vitis rotundifolia	muscadine grape	15	Vine
Vitis vulpina	frost grape	1	Vine

A map showing native species distribution and coverage is presented in Figure 3.4. The map illustrates the presence of predominately native plant communities in the north central portion of the Watershed west of Interstate 65. There are sporadic clusters of predominately native communities along the main stem as well as intermixed with the some of the higher density invasive communities as can be seen when comparing Figures 3.1 and 3.4.

In the headwaters of Three Mile Creek upstream of Langan Park, the native plant communities appear to be the most impacted. Several large parcels that are owned by the University of South Alabama and the City of Mobile will potentially mean that access to these areas will be less complicated. As ownership becomes more segmented in large areas of the Watershed, it becomes more complex and problematic to gain access.

In the central part of the Watershed, a small tributary to the south of Mill Street has a high density of invasive species. Unfortunately, this area does not exhibit robust populations of natives and therefore a different strategy may have to be employed to ensure native recovery post treatment. Another area of concern is the most downstream reach of Three Mile Creek in the vicinity of Interstate 165 and Conception Street Road. However, here the survey documented scattered populations of predominantly native species which is positive from a treatment and restoration standpoint.

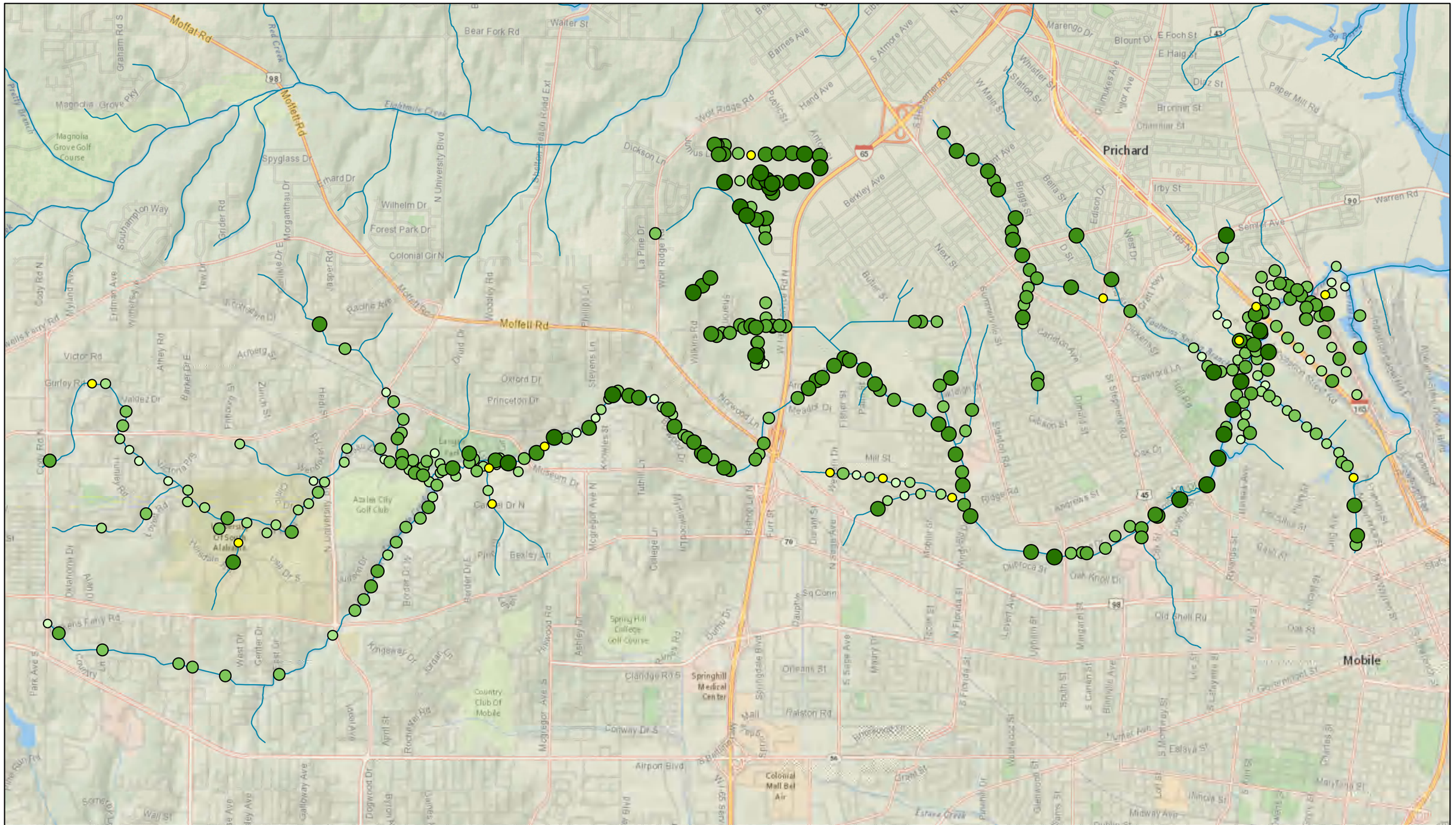

Figure 3.4
Total Native Species Coverage

Total Native Plant Coverage (Number of Plots)

- ~0% (14)
- ≤25% (27)
- 26 - 50% (62)
- 51 - 75% (90)
- 76 - 90% (80)
- 91 - 99% (67)
- 100% (28)

0 0.5 1 2 Miles
0 1 2 4 km

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Basemap courtesy of Esri.

4.0 PLAN

The field survey results show that a diverse group of invasive non-native species inhabit all the surveyed strata within the Three Mile Creek Watershed. Of these species, the greatest observed occurrences were alligatorweed (aquatic/wetland), Petersen's spleenwort (fern), Brazilian vervain (forb), cogongrass (grass), Chinese privet (shrub), Chinese tallow tree (tree), and Japanese climbing fern (vine) in each of the strata (Table 3.1). A total of 43 invasive species across these strata were identified in the Watershed. These species were ranked by threat level using a standard classification system from The Alabama Invasive Plant Council (ALIPC), which ranks plants on invasiveness level with Category 1 being the highest concern.

Fortunately, intact native areas with relatively low density of invasive species are present in the Watershed (Figure 3.2). It is important to protect these intact areas from disturbances that create opportunities for invasive species to become established. Intact native communities can serve as reference areas for restoration planning and may provide native seed sources for downstream areas. Conversely, areas that are predominantly non-native species (Figure 3.1) may require more drastic control measures and restoration efforts. Any invasive plant control program should consider the inclusion of native species plantings and/or seeding into areas where invasives have been removed. Natural recruitment of natives will likely occur to some extent, but it is more likely that the soil seedbank is primarily composed of the exotic species that have been removed. It will be important to first deplete the exotic species seedbank by allowing the seeds to germinate over at least one growing season. Seedlings should be pulled or treated with herbicide. Once the initial "flush" of germination has subsided and hand-pulling and spot treatment becomes practical, planting and/or seeding of appropriate native species should be done if deemed necessary. Establishment of a native plant community will aid in combating the reestablishment of invasive exotic species in the long term. In some areas it may be appropriate to establish short-term cover crops such as oats or brown-top millet if bare soils are in a location prone to erosion.

Invasive aquatic animals were also well documented throughout the Watershed. Animals are particularly problematic because of their greater mobility and potential for colonization upstream. The island apple snail is the animal species with the highest concentration and presumably highest risk in Three Mile Creek Watershed.

A diverse assemblage of invasive species creates substantial complexity when attempting to develop a management plan. The life history of different species (reproduction, defenses, resistance to treatment, etc.) often require species-specific strategies as detailed in Section 5.0. Of course, the importance of correct plant identification by the field crews tasked with controlling invasive species cannot be overstated.

Considering these factors, it is prudent to develop multiple flexible strategies for general application to the Watershed. The strategies presented in this plan are meant to be adaptable to a variety of situations and across strata. The adaptability comes from variable type of treatment and density of the target specie(s). This plan uses a density estimate of "High" "Moderate" and "Low" for each strategy, which is defined in more detail below. Based on the survey data, we recommend two broad, adaptable approaches for the Three Mile Watershed.

Strategy 1: Manage and protect existing intact native plant communities with a variety of treatment methodologies.

Strategy 2: Target high or moderate density non-native invasive plant communities where there are currently little or low-density native communities as a means to expand upon adjacent native communities or eliminate a threat to an existing community.

Strategy 3: Target island apple snail with chemical, physical and biological treatment methodologies in and around Langan Lake.

4.1 PLAN IMPLEMENTATION

Invasive species programs over a large geographic area require commitment and dedication to ensure long-term success. Funding for the program should be carefully managed to create initial successes and build momentum for future projects. This section provides additional detail regarding implementation aspects of the plan.

1. Obtain access to large parcels within the Watershed for invasive control efforts
2. Strategy 1: Manage and protect existing intact native plant communities
3. Strategy 2: Target high or moderate density non-native invasive plant communities
4. Strategy 3: Apple snail control
5. Budgeting and Prioritization
6. Reestablish native plant communities in riparian areas
7. Continue monitoring the Watershed for new invasive species while they are present in low numbers
8. Community outreach regarding invasive species detection and control

It is critical that invasive species control and monitoring is conducted repeatedly over many years and is a long-term commitment.

4.1.1 (1) Obtain Access to Large Parcels

Securing access rights to the riparian corridors and large parcels for invasive species control is a key element of the invasive species management program. Figure 2.2 shows the identified large parcels within the riparian areas. During the survey process right of entry agreements were set up with the Alabama State Port Authority and Alabama Power Company. MBNEP can build on this initial coordination effort as well as seek entry agreement with other large landowners.

4.1.2 (2) Strategy 1: Selectively Control Invasives Within Existing Native Communities

Strategy 1 will generally consist of spot treatment of invasive species among desirable natives. Application of this Strategy might target a single species, such as downy maiden fern, or treat all invasives occurring within a given area. Treatment method and type of herbicide to be used will be different for aquatic plants verses terrestrial species. Depending on the target strata and species, multiple visits to the same area may be necessary.

Replanting may or may not be necessary following removal of invasive species. The native plant community may fill in the gaps through growth of existing plants and natural recruitment. When plant communities are in the early stages of invasion, a relatively small amount of effort can be highly effective in preventing broadscale invasion. Areas such as these provide excellent opportunities to train staff and volunteers to develop a search image for target species.

In terms of cost estimating and applying the density estimates to target treatment areas, we used the following density assumptions.

High Density- This density classification is represented by a thick, intermixed community of both native and invasive exotic species. Monocultural or invasives-dominated areas are relatively small isolated pockets less than 0.93 m^2 (10 sq. ft.) in size. Invasives are mixed with natives at a ratio of up to 1:1, or 50% aerial coverage, creating the need to be selective in treatment to prevent harm to native species.

Moderate Density - This density classification is represented by moderate mixing of native and invasive exotic species or scattered defined pockets of invasives greater than 0.93 m^2 (10 sq. ft.). Any vegetation existing between these pockets is not an intermixing of native and invasive species. If mixing is present, the density of invasives is approximately 20-30% aerial coverage.

Low Density- This density classification is represented by low mixing of native and invasive exotic species with approximately 5-15% aerial coverage or scattered, defined greater sized pockets of invasives that occupy no more than 1-2 pockets per acre.

Application Method

Foliar Spot Treatment is an application approach that can be effective for both herbaceous and woody species. This application method typically involves the use of backpack sprayers or ATVs with a mounted tank and spray system. For aquatic systems, shallow draft boats with a spray system may be most appropriate. Green and growing leaves are the target of foliar herbicide treatment. Foliar spraying of low-growing species is most effective below 1.22 m (4 ft.) in height. Spraying above 1.22 m (4 ft.) may be ineffective since it is difficult to achieve adequate foliar coverage and it puts the applicator at risk of chemical exposure. Proper timing of foliar herbicide application is important to assure that the treatment is effective (see Section 5.0). Access into areas where invasive species occur, such as shallow-water marshes at the lower end of the Watershed, and the ability to transport an adequate water supply for chemical mixing into such areas will present challenges.

Cut Stump Treatment targets woody species that are too tall for foliar application and/or that have a basal diameter too great for basal bark application. Manual cutting is accomplished using a chainsaw, handsaw, loppers, or machete, followed by immediate herbicide application to the freshly cut stump. This method involves handwork only since it will be important to protect any existing native vegetation.

Basal Bark Treatment targets woody species but avoids cutting down the plant. Herbicide, typically mixed in an oil such as vegetable oil, is sprayed or painted on the lower trunk or stem. The herbicide is absorbed through the bark and kills the plant. This control method saves time and energy as well as keeps woody material standing, meaning that it is not on the ground and in the way of other invasives control or native planting work. Standing dead trees also provide nesting and foraging habitat for certain birds and other wildlife.

4.1.3 (3) Strategy 2: Control High and Moderate Density Invasives

Strategy 2 is designed to target the high and moderate density monocultures that are so often associated with the most prolific and dominant invasive species. This approach may be cost effective under certain site conditions since few native species that should be avoided are present. This strategy typically involves heavy equipment and powered-pump broadcast sprayers capable of treating large areas relatively quickly. After the initial treatment, these areas will likely require follow-up treatments as the soil seedbank germinates. On-going monitoring will reveal whether replanting of natives is appropriate. Several to many years of follow-up using Strategy 1 to prevent

invasive species from becoming reestablished will likely be necessary. In terms of cost estimating and applying the density estimates to target treatment areas, we used the following density assumptions.

High Density- This density classification is represented by a 75-100% dominant monoculture of one or two invasive species. A UTV, ARGO amphibious vehicle, or tractor is used for foliar application to broad swaths of vegetation from an engine-powered pump. This approach should not be used where native species are intermixed with invasives. Foliar application requires a minimum two-person crew. For costing purposes, a three-person crew is assumed for cut stump and basal bark applications.

Moderate Density - This density classification is represented by a moderate mix of native and invasives species or scattered, defined pockets of invasives greater than 0.93 m^2 (10 sq. ft.) in size, but not both. If mixing occurs, the density of natives is approximately 20-30% aerial coverage.

Low Density- Low density applications would fall under Strategy 1.

Application Method

Herbaceous Broadcast Treatment is an application approach that can be effective for both herbaceous and woody species. With this method, broadcast boom sprayers, mist blowers, or similar devices are used to distribute herbicide over broad areas. Typically, a powered-pump system is mounted on a UTV, ARGO amphibious vehicle, or tractor. Proper timing of foliar herbicide application is important to assure that the treatment is effective (see Section 5.0). Access into areas where invasive species occur, such as shallow-water marshes at the lower end of the Watershed, and the ability to transport an adequate water supply for chemical mixing into such areas will present challenges. A minimum two-person crew is needed for safety and efficiency.

Cut Stump Treatment involves targeting of woody species using mechanized equipment such as a skid steer-mounted brush-hog, tractor, or similar equipment to cover large areas. A minimum three-person crew is needed for safety and efficiency. At least one person must be a skilled equipment operator. When this method is used, it is not practical to apply herbicide to stumps, which must be done immediately to be effective. In this situation, stumps should be allowed to sprout back to a height of 0.3 – 0.6 m (1-2 ft.), then a foliar application of herbicide should be done in the proper season.

Basal Bark Treatment targets woody species but avoids cutting down the plant. Herbicide, typically mixed in an oil such as vegetable oil, is sprayed or painted on the lower trunk or stem. The herbicide is absorbed through the bark and kills the plant. This control method saves time and energy as well as keeps woody material standing, meaning that it is not on the ground and in the way of other invasives control or native planting work. Standing dead trees also provide nesting and foraging habitat for certain birds and other wildlife.

4.1.4 (4) Strategy 3: Apple Snail Removal

The island apple snail (*Pomacea maculata*) was first observed in Langan Park in 2003. In spite of concerted control efforts beginning in 2008, this species is now well-established in Langan Park and has been observed in the Three Mile Creek Watershed east to Telegraph Road.

The island apple snail was first observed in the TMC Watershed in Langan Park, and this area is still the nexus of the infestation. When dealing with an animal that is primarily aquatic, targeting the upstream extent of its range is essential to avoid constant reintroduction downstream. In this case, the upstream extent is a heavily-vegetated pond west of Gaillard Drive called Spring Hill Lake (1 acre). This small water body is directly connected under Gaillard Drive to the western portion of Langan Lake (16 acres). Both of the waterbodies have highly irregular shorelines and usually exhibit little flow. Flow only becomes obvious at the 100-foot spillway separating the eastern part of Langan Lake (33 acres).

Strategy 3 includes applying chelated copper at a rate of 400 ppb for 48 hours after egg laying commences in mid-April. With this strategy, excellent snail control or even eradication could be accomplished if such chelated copper applications were repeatedly employed in concert with intensive manual collection of eggs and adults. Collection of adults is greatly facilitated during copper treatments when the snails float to the surface or climb up aquatic vegetation. Complete success would be achieved when eggs are totally absent from the shoreline of the lakes.

The highly irregular shoreline of the western portion of the lakes at Langan Park. Google Maps

The characteristics of the spillway separating eastern and western Langan Lake make it an ideal site for a chelated copper injection system. Unfortunately, Spring Hill Lake and western Langan Lake are not conducive due to insufficient flow and extreme shoreline irregularity. This upstream area would continue to be a source of reinfestation so other control methods must be employed there first. In those sites, all egg clusters and adults could be removed at two-week intervals and iron phosphate pellets could be applied to areas harboring the most egg clusters where shoreline and flow are irregular. Two methods can be employed. The first is the use of a boat and applying

chelated cooper in bays and backwaters at a prescribed concentration and volume for the bay. Additionally, control to prevent a rebound of the snail population, blue catfish (*Ictalurus furcatus*) could be stocked in those upstream areas at a high rate (>100/acre). However, coordination is needed with Alabama Department of Conservation and Natural Resources on viability of stocking blue catfish.

There has been some discussion of a project to remove the organic sediment and recontour the lakes at Langan Park. Any such activity should be concluded prior to the initiation of system-wide chemical or biological snail control. If recontouring were to greatly simplify the shoreline structure of Spring Lake and eastern Langan Lake, a chelated copper injection system could be employed to treat the entire system if flow were conducive.

Chelated Copper Injection System

A stationary pesticide injection system for flowing water. JVD

The effective use of an aquatic pesticide requires the adequate concentration and contact time, so controlling a target organism in flowing water is a challenge. Single applications are rapidly diluted, while multiple applications create concentration pulses and high labor costs. To counter those problems, the use of a stationary pesticide injection systems in flowing water began in the 1960s for aquatic plant control in irrigation canals and have since been employed on many other targets and sights.

After accurately determining the flow rate, the pesticide is injected at the desired concentration for the time needed to control the target organism. Based on bench tests with the Island Apple Snail, success using this innovative approach in the TMC Watershed could be achieved by applying chelated copper at a rate of 400 ppb for 48 hours. Of the chelated copper products tested, “Captain” was the most effective (Snail Buster 2009). To achieve successful control, the stationary injection system must be located upstream of the entire range of the snails.

A stationary injection system can be simple, inexpensive, portable, and reusable. A 250-gal intermediate bulk container (IBC), called a "tote," can be used as the storage container. The pesticide leaves the tote via a 12V battery-operated pump, passes through a small gate valve through an in-line flow meter, and on to a manifold leading to multiple hoses. The rate of injection is based entirely on water flow. For instance, if the flow rate was 10 cubic feet per second, it would be necessary to inject chelated copper at 0.18 gallons per minute to achieve 400 ppb by volume. To accomplish that over a 48-hour period would require 518.4 gallons of chelated copper.

4.1.5 (5) Budgeting and Prioritization

Budgeting is obviously a critical success criterion that should be initiated as soon as possible or simultaneously with parcel access. We have provided a cost estimating matrix in the Sections below that help create a foundation for that budget. The two largest cost items for an invasive species control program are chemicals and labor. Herbicide costs are variable, depending on which chemicals are to be used and the quantities necessary for the project. Buying herbicide in bulk and mixing as needed is always recommended if possible.

Prioritization is a process of ranking areas, regions, or parcels within the Watershed and is a driver of the overall strategy, essentially, applying Strategies 1, 2 and 3 to different regions in the Watershed. Our team recommends making the application of Strategy 1 to the most threatened remaining native plant communities a high priority. "Threatened" can be construed in terms of an intrusion into an otherwise ideal/reference native community or a diverse intrusion into the edges of a native community. Increasing the resistance of these areas establishes a solid foundation with which to expand and also gives the Watershed early successes for building momentum. Strategy 2 could then be applied to dominant invasive areas adjacent to these native communities to expand outward. This prioritization approach could start at one location or, based on the data collected, multiple areas could be attempted in the west, central, and eastern areas of the Watershed.

Sequence is an important consideration when prioritizing target areas for invasive species control efforts. When possible, invasive species control should be completed from upstream to downstream within the Watershed in order to prevent recolonization of treated areas from upstream invasive sources. Conversely, areas that are immediately downstream of large untreated stands of invasive species may receive a lower priority than those that are downstream of healthy native populations.

We recommend the following priority areas illustrated on Figure 4.1 and listed below for all three strategies. These areas are highlighted as priority due to the upstream orientation, invasive coverage, and species specifics treatment areas.

- The area upstream and northeast of the University of South Alabama is one of the most upstream portions of the Watershed and included a high invasive species percent coverage. The species with higher percent coverage areas are Chinese tallow tree, Chinese privet and cogongrass. Additionally, this was the only area where downy maiden fern was observed. Strategy 2 is recommended in areas with large infestations.
- The University of South Alabama property is an area where obtaining access should require minimal effort and there is a mix of low- and high-density areas of invasive plants. Strategy 1 is recommended.
- Langan Park is a priority for multiple reasons that include the island apple snail prevalence, aquatic invasive plants (ex. Eurasian watermilfoil) throughout the lakes and a control for

the rest of TMC downstream of the park. All three strategies can be employed with in this area.

- The fourth area highlighted is the northernmost section of the Watershed and includes a large parcel of property just west of Interstate 65. This area includes wetland and streams with a mix of native and invasive communities. Invasive species within this area include mimosa, kudzu and cogongrass, and Strategy 1 is recommended.
- The area just east of Interstate 65 and north of Moffett Road is residential, but is an area of high invasive coverage of wild taro, camphor tree, bamboo, and kudzu. With the higher invasive plant density, this unnamed tributary appears to be a source of invasive plants to TMC, and with little native coverage, Strategy 2 is recommended.
- One Mile Creek is a priority with a large portion of this smaller watershed being owned by one landowner. Prevalent invasive species within this area include alligatorweed, Chinese tallow tree, white mulberry, and Chinese privet. With some native communities present, Strategy 1 is recommended.

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Invasive Control Plan Areas

Strategy 1 Strategy 2 Strategy 3

Figure 4.1
Three Mile Creek Watershed
Priority Strategy Areas

Percent Cover, All Invasive Plants (Number of Plots)

- 0% (28)
- ≤10% (67)
- 11 - 25% (80)
- 26 - 50% (90)
- 51 - 75% (62)
- 76 - 100% (27)
- >100% (14)

0 0.5 1 2 Miles
0 1 2 4 km

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Basemap courtesy of Esri

4.1.6 (6) Reestablish Native Communities

Following invasive species control, including any necessary soil seedbank depletion, it will be necessary to assess native species recruitment potential to determine whether planting and/or seeding is needed. The following factors should be considered:

- Size of treatment area
- Species controlled
- Native species abundance and composition within and near the treatment area
- Non-native species abundance outside treatment area
- Life history of the treated plant(s)

In some cases, it will be determined necessary or desirable to plant native species to ensure the establishment of an ecologically appropriate plant community.

A basic principle used for plant species selection is to assess a nearby undisturbed natural community that is on similar soils, at essentially the same elevation, and with matching hydrologic conditions. Plants found in the undisturbed natural area can be used to create a plant list for the area being restored.

Another important rule of thumb is to refrain from introducing native plant species into areas where they are not known to occur naturally.

It is also critical to place the right plants in the right habitats. For example, a live oak, which typically grows in well-drained uplands, should not be planted in a wet bottomland. Conversely, bald cypress, which is common in some wetlands, should not be planted in upland areas. While bald cypress can grow just fine in uplands and is often used as a landscape tree, if the goal is to restore and maintain appropriate natural communities, then bald cypress belongs only in the wetlands.

Planting should be done in fall and winter and when soil is moist.

Appendix B is a list of native species observed in the Watershed, some of which are generally available from nurseries that grow native plants.

4.1.7 (7) Establish an Invasive Species Monitoring Program

It will be important to establish an on-going monitoring program in order to maintain the progress that is made toward invasive species control and restoration of native ecosystems. Ideally, this task would be assigned or contracted to one or more qualified professionals with the ability to identify invasive species known to occur in the Watershed and new ones that may appear. Monitoring should include assessment of the native plant community and recommendations of any actions or management measures deemed appropriate. Regular monitoring (at least annually) will aid MBNEP in scheduling and prioritizing additional invasives control and management efforts.

The survey plan completed by the project team to develop this invasive species plan can serve as good standardized monitoring tool and baseline for invasive species controls. A standardized form used for the survey is attached in Appendix C and the electronic database is attached in Appendix A. The survey form was developed to be a fillable electronic pdf form but can be used in paper form as well.

4.1.8 (8) Community Outreach Regarding Invasive Species Detection and Control

The Mobile Bay National Estuary Program should continue to implement and expand its existing outreach program, which includes invasive species information and control events. Teaming with local governments, native plant societies, community groups, and others will allow MBNEP to continue to spread awareness of this issue within the Three Mile Creek Watershed. Training citizen scientists could allow MBNEP to continue monitoring the Watershed on a regular basis at a lower cost.

4.2 COST ESTIMATES

Invasive treatment areas are often a complex collage of different species and densities occupying different strata at a single site. Recognizing this site complexity, the Team developed a static summary cost table as well as an adaptable Excel-based tool for cost estimating given the inherent variability that is common to so many sites.

Table 4.1 provides an estimate of variable costing for the two Strategies (1 & 2) described above with respect to density and treatment type. Graphically, these costs are also represented in Figure 4.2 and 4.3. Additional detail is provided outlining the assumptions with regard to crew size, work day, equipment, etc. below for each strategy. Density assumptions and treatment types were explained in Section 4.1.1.

Table 4.1 Cost Estimates for Invasive Species Control by Strategy

	Strategy 1							
Density	Herbaceous Spot Treatment		Herbaceous Aquatic Spot Treatment		Cut/Stump		Basal Bark	
	Avg Rate Acres / Day	Cost / Acre	Avg Rate Acres / Day	Cost / Acre	Avg Rate Acres / Day	Cost / Acre	Avg Rate Acres / Day	Cost / Acre
High	1.5	$ 1,536.83	1.5	$ 1,757.50	1	$ 2,325.25	1.5	$ 1,536.83
Moderate	4	$ 576.31	2.5	$ 1,054.50	2	$ 1,162.63	2.5	$ 922.10
Low	6	$ 384.21	5	$ 527.25	3.5	$ 664.36	4	$ 576.31
	Strategy 2							
Density	Herbaceous Broadcast Treatment		Herbaceous Aquatic Treatment		Cut/Stump		Basal Bark	
	Avg Rate Acres / Day	Cost / Acre	Avg Rate Acres / Day	Cost / Acre	Avg Rate Acres / Day	Cost / Acre	Avg Rate Acres / Day	Cost / Acre
High	6	$ 344.54	4	$ 621.56	2.5	$ 1,078.90	1	$ 2,547.25
Moderate	3	$ 689.08	2	$ 1,243.13	4	$ 674.31	2	$ 1,273.63
Low	N/A	N/A			N/A	N/A	N/A	N/A

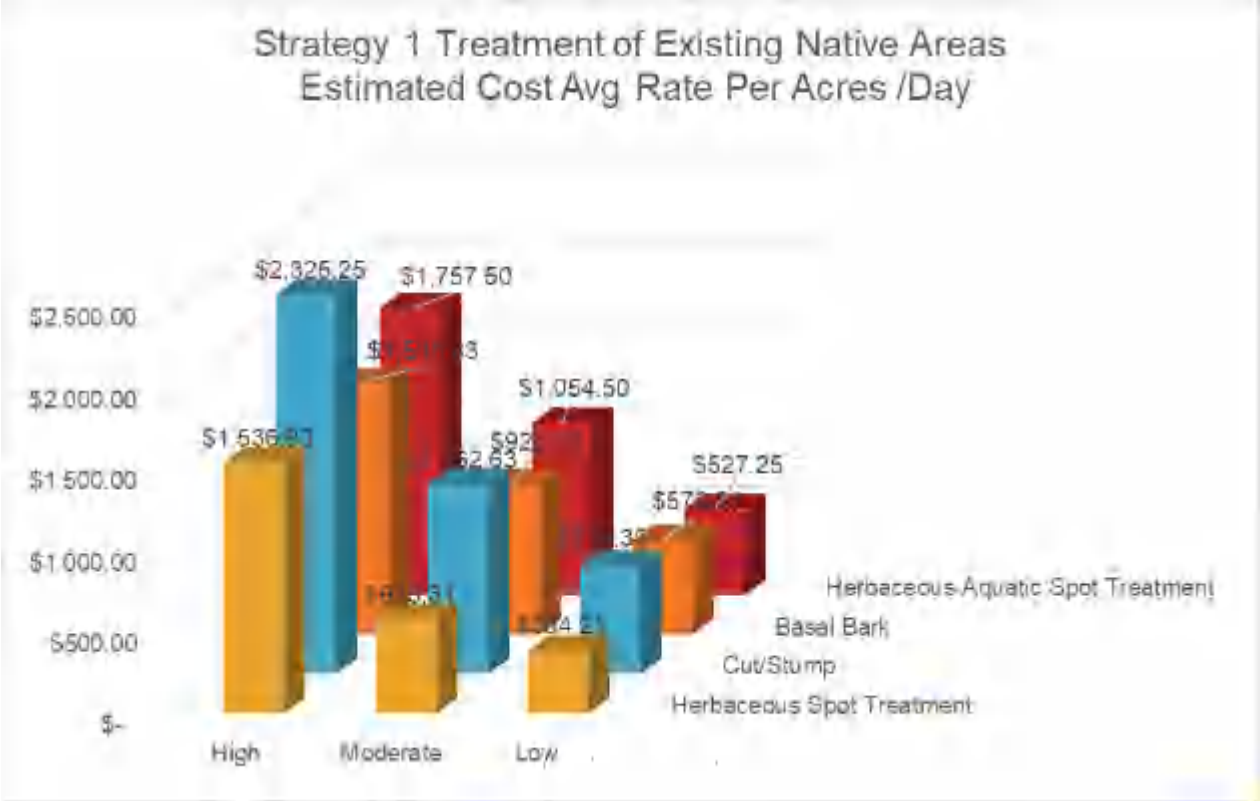
Strategy 1 has the following assumptions. Estimate assumes one crew leader and 2 technical laborers on the crew for a 10-hour work day. Crew production is assumed at 8 hours for each person with one hour each day for mobilization and one hour for demobilization to the site, loading, unloading gear, etc. Each daily estimate includes a GPS rental for tracking progress and navigating to target areas.

Herbaceous Spot Treatment assumes use of a backpack and or UTV mounted tank sprayers if site accessibility permits.

Cut Stump Treatment assumes the use of hand equipment such as saw, loppers, chainsaws, etc. to target individual plants in a systematic manner.

Basal Bark Treatment assumes a three-person crew with backpack or containerized units.

Figure 4.2 Strategy 1: Treatment of Existing Native Areas Estimated Cost Per Acre/Day



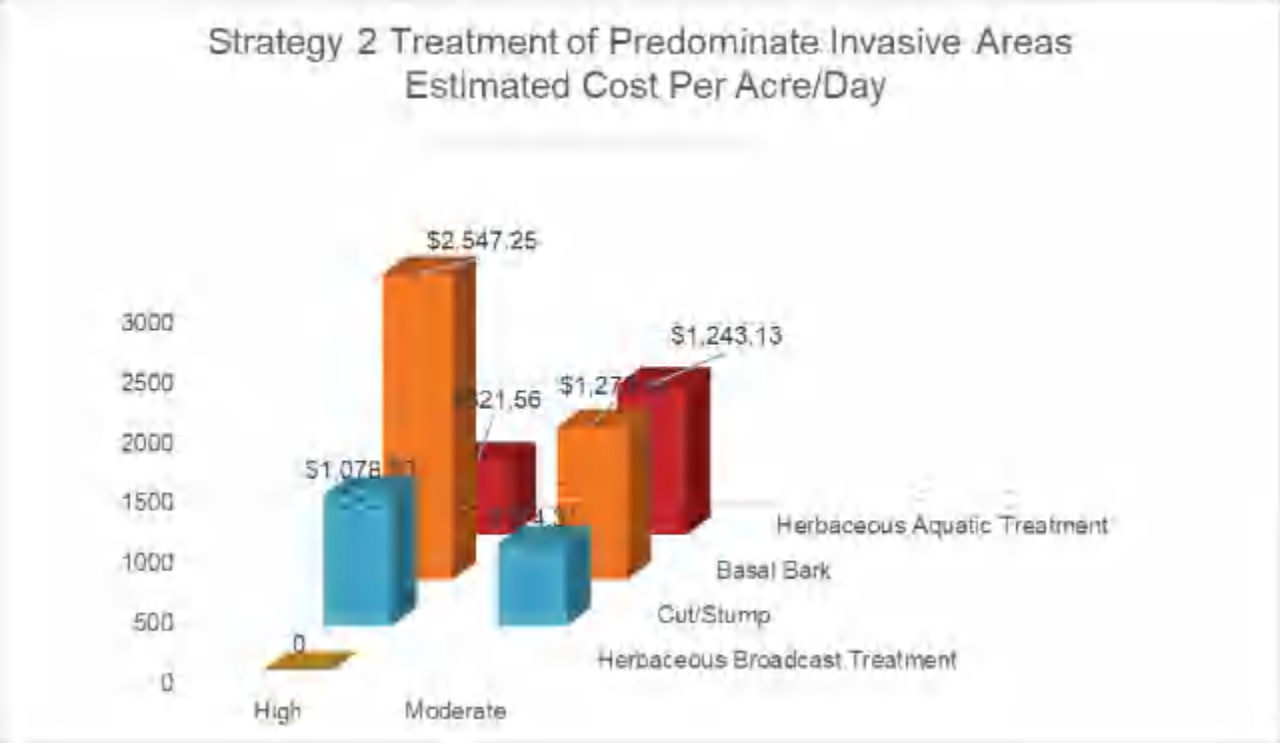
Strategy 2 has the following assumptions. Estimate assumes one crew leader and 1 or 2 technical laborers on the crew for a 10-hour work day. Crew production is assumed at 8 hours for each person with one hour each day for mobilization and one hour for demobilization to the site, loading, unloading gear, etc. Each daily estimate includes a GPS rental for tracking progress and navigating to target areas.

Herbaceous Broadcast Treatment assumes the use of a UTV, ARGO amphibious vehicle or tractor and powered pump system. The method assumes a two-person crew for safety, loading and unloading, and prepping chemical and water for efficient turn-around time.

Cut Stump Treatment assumes the use of mechanized equipment such as a skid steer-mounted brush-hog, tractor, or similar apparatus for removal of large swaths of woody invasive. This method assumes a three-person crew for safety, loading and unloading.

Basal Bark Treatment assumes a three-person crew.

Figure 4.3 Strategy 2: Treatment of Predominate Invasive Areas Estimated Cost Per Acre/Day



In addition to the static cost estimating Table 4.1, a usable Excel-based cost-estimating tool is provided, such that individual parcels or collection of parcels could be evaluated.

The Excel cost-estimator tool is designed to generate cost estimates for single parcels or a combination parcels, as long as specific “known” or “estimated” data is input into the spreadsheet. The required input data includes *target acreage, treatment type, density* and *Strategy approach 1 or 2*. Knowing these pieces of information, costs can be generated for

complex areas that contain different species occupying different strata, such as aquatic and riparian herbaceous, and at varying densities.

Mobilization costs are built into the cost/acre/day estimates for each category. However, when a value less than the minimum acres/day is input then a minimum mobilization cost is applied. This necessary minimum is to guard against small estimates for example of 0.1 acre X 1,500/day would estimate $150.00. It is unrealistic to assume that a crew could mobilize to a site, find the 0.1 acre and treat it for the cost of $150.00. Instead, this $150.00, which is the cost in time and materials to treat this 0.1 acre, is added to the baseline mobilization cost creating a new total of base mobilization cost (e.g. $700) + 0.1 acre $150.00 treatment, resulting in a total of $850.00. This creates an economy of scale such that mobilizing for small singular treatments will be more cost prohibitive rather than larger scale projects.

The Excel-based tool is on an accompanying “thumb drive” (Appendix A). Data input should only be done in the green-shaded cells to avoid affecting cell formulas. To demonstrate the Cost Estimating Tool we selected a conceptual target area on the One Mile Creek Subwatershed. This tract of land has a few large parcels in which access is likely attainable, making it a feasible location for initial treatments.

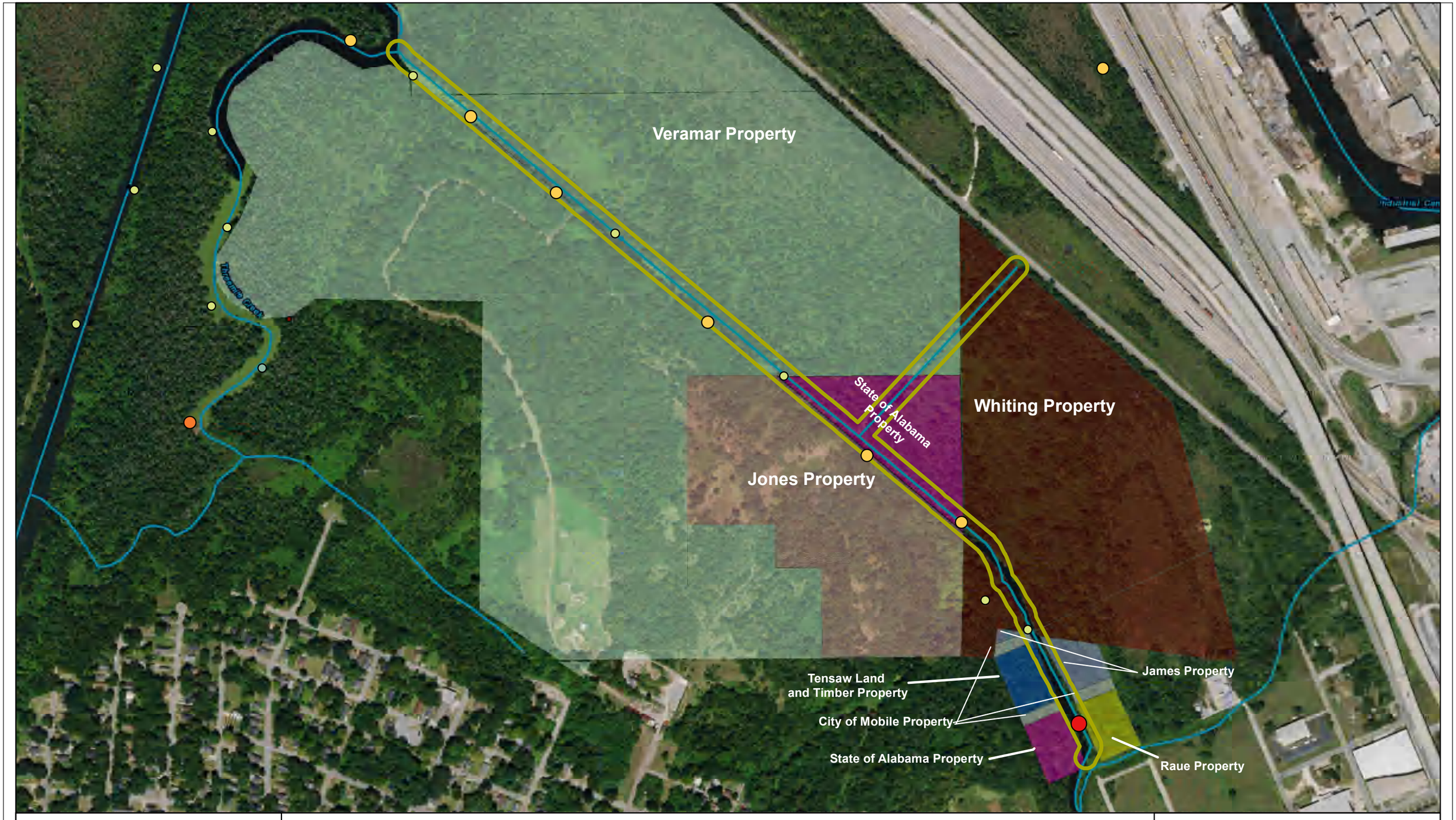


Figure 4.4
One Mile Creek
Example Cost Region

Percent Cover, All Invasive Plants

0% | 10 - 25% | 51 - 75% | >100% (Max 149%)
<10% | 25 - 50% | 76 - 100% | One Mile Creek Strategy 2 Region

0 405 810 1,620 Feet
0 125 250 500 Meters

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Basemap courtesy of Esri

Table 4.2 Example Cost Calculator of One Mile Creek Subwatershed

	Strategy 1											
Density	**Aquatic Treatment**		**Mobilization**	**Aquatic (ac)**	**Cost Estimate**	**Herbaceous/Riparian (ac)**	**Cost Estimate**	**Sub-canopy (ac)**	**Cost Estimate**	**Canopy (ac)**	**Cost Estimate**	**Totals**
	Avg Rate Acres / Day	**Cost / Acre**										
High	1.5	$ 1,757.50	$ 800.00	0.00	$ -							$ -
Moderate	2.5	$ 1,054.50	$ 800.00	0.00	$ -							$ -
Low	5	$ 527.25	$ 800.00	0.00	$ -							$ -
											Subtotal	$ -
	Herbaceous Spot Treatment / Foliar											
	Avg Rate Acres / Day	**Cost / Acre**										
High	1.5	$ 1,536.83	$ 700.00	0.00	$ -	0	$ -	0	$ -	0.00	$ -	$ -
Moderate	4	$ 576.31	$ 700.00	**1.35**	$ 893.80	0	$ -	0	$ -	0.00	$ -	$ 1,693.80
Low	6	$ 384.21	$ 700.00	**0.04**	$ 702.32	0	$ -	0	$ -	0.00	$ -	$ 1,502.32
											Subtotal	$ 3,196.12
	Cut/Stump											
	Avg Rate Acres / Day	**Cost / Acre**										
High	1	$ 2,325.25	$ 700.00	**1.45**	$ 4,071.61	0	$ -	0	$ -	0.00	$ -	$ 4,071.61
Moderate	2	$ 1,162.63	$ 700.00	0.00	$ -	0	$ -	**2.87**	$ 2,369.03	**3.51**	$ 2,740.71	$ 5,809.74
Low	3.5	$ 664.36	$ 700.00	0.00	$ -	0	$ -	**0.04**	$ 706.87	0.00	$ -	$ 1,406.87
											Subtotal	$ 11,288.22
	Basal Bark											
	Avg Rate Acres / Day	**Cost / Acre**										
High	1.5	$ 1,536.83	$ 700.00	0.00	$ -	0	$ -	0	$ -	0.00	$ -	$ -
Moderate	2.5	$ 922.10	$ 700.00	0.00	$ -	0	$ -	0	$ -	0.00	$ -	$ -
Low	4	$ 576.31	$ 700.00	0.00	$ -	0	$ -	0	$ -	0.00	$ -	$ -
											Subtotal	$ -
											Total All Treatments	**$ 14,484.34**

Table 4.2. above indicates that multiple treatment types at various densities exist on the site. This estimate was based on the sample plot date obtained during the study. Total cost estimate suggests that $14,484.34 would be a feasible budget estimate for one round of treatment to all the invasive components at the site.

Strategy 3: Island Apple Snail Costs

Costing for the island apple snail includes a couple different cost options and include:

1. Physical Removal. The periodic collection of eggs and adult snails would cost nothing if Mobile Baykeeper is willing to continue to organize the volunteer "Apple Snail Roundups."
2. Iron Phosphate. "Ferroxx AQ" costs $178 per 50 lb. bag, and it is safe for volunteers to handle(Neudorff).
3. Blue catfish. Fingerlings at 5-7" cost $1.25 each, so at a stocking rate of 100 fish /acre, the total cost would be $6250 for the lakes at Langan Park (50 acres).
4. Chelated Copper Injection System. The portable and reusable application system will cost $750-1000 to construct. "Captain" costs $30/gallon. The amount required depends on the flow, but at 10 cfs, 520 gallons chelated copper would cost $15,600 per treatment. Estimated labor would be 125 man-hours per treatment.

The recommended Strategy 3 costing would be approximately $25,000 to $30,000 per year and looking at multiple year treatments for at least three years. This yearly cost will include Chelated Copper Injection with manual application on the western side of the lakes or catfish stocking.

Individual estimated costs for *Corbicula* and tilapia are described in their Individual prescription.

4.3 SCHEDULE

The following schedule can be used as a guide in planning invasive species control efforts. Full details can be found in the species descriptions in Section 5. This table functions as a treatment planning tool to coordinate efforts and timing with respect to certain species but also treatment types by chemical or approach (i.e. cut stump).

Table 4.3 Summary of Preferred Treatments and Schedule for Invasive Species

Scientific Name	Common Name	Preferred Treatment*	Secondary treatment*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Albizia julibrissin	silktree (mimosa)	Garlon 4	Garlon 3A	CS	CS			CS	CS	CS	CS	CS	CS	CS	CS
		Garlon 4	Pathfinder II	BT	BT			BT	BT	BT	BT	BT	BT	BT	BT
		Glyphosate	Transline + Garlon 3A							F	F	F			
Alternanthera philoxeroides	alligatorweed	Biological				B									
			Imazapyr				AH	AH	AH						
Bambusa vulgaris	common bamboo	Glyphosate	Arsenal AC									F	F		
		Glyphosate	Arsenal AC									CS	CS		
Canna indica	Indian shot	Clearcast + Methylated seed oil		F	F	F	F	F	F	F	F	F	F		
Cinnamomum camphora	camphor tree	Garlon 3A	Garlon 4						CS	CS	CS				
		Garlon 4							BT	BT	BT				
		Garlon 3A							SI	SI	SI				
		Glyphosate	Garlon 3A						F	F	F				
Clematis terniflora	sweet autumn virginsbower	Garlon 4	Glyphosate							F	F	F	F		
		Garlon 4	Pathfinder II	BT	BT			BT	BT	BT	BT	BT	BT	BT	BT
Colocasia esculenta	wild taro	Clearcast + Methylated seed oil		AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH
Deparia petersenii	Petersen's spleenwort	Glyphosate			F	F	F								
Dioscorea bulbifera	air potato			MR	MR										MR
		Garlon 3A	Glyphosate					F	F	F	F	F	F		
Egeria densa	Brazilian elodea	Sonar	Reward	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH
				B	B	B	B	B	B	B	B	B	B	B	B
				D	D	D	D	D	D	D	D	D	D	D	D
Eichornia crassipes	water hyacinth	Weedar 64					AH	AH	AH	AH	AH	AH			
Firmiana simplex	Chinese parasoltree	Glyphosate	Arsenal AC	F	F	F	F	F	F	F	F	F	F	F	F
		Glyphosate	Garlon 3A	CS	CS					CS	CS	CS	CS	CS	CS
		Glyphosate	Garlon 3A	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
		Garlon 4		BT	BT	BT	BT	BT	BT	BT	BT	BT	BT	BT	BT

Scientific Name	Common Name	Preferred Treatment*	Secondary treatment*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
				MR	MR					MR	MR	MR	MR	MR	MR
Hygrophila polysperma	East Indian hygrophila			MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR
		Clipper			AH	AH	AH						AH	AH	AH
Hyptis mutabilis	tropical bushmint	Glyphosate				F	F								
Imperata cylindrica	Cogongrass	Arsenal AC	Glyphosate						F	F	F	F			
Lagerstroemia indica	crape myrtle	Glyphosate	Transline + Garlon 3A						F	F	F	F	F		
		Garlon 4	Pathfinder II					BT	BT	BT	BT	BT	BT		
		Garlon 3A		CS	CS			CS	CS	CS	CS	CS	CS	CS	CS
Ligustrum sinense	Chinese privet	Glyphosate		F	F	F	F	F				F	F	F	F
		Garlon 4	Pathfinder II	B	B	B	B	B	B	B	B	B	B	B	B
		Garlon 3A	Glyphosate	CS	CS			CS	CS	CS	CS	CS	CS	CS	CS
Lonicera japonica	Japanese honeysuckle	Glyphosate	Garlon 3A							F	F	F	F		
		Glyphosate	Garlon 3A	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
Ludwigia peploides	creeping waterprimrose	Weedar 64	Renovate	HT	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH
Ludwigia peruviana	Peruvian primrose-willow	Glyphosate					F	F	F	F	F	F			
		Glyphosate	Garlon 3A	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
Lygodium japonicum	Japanese climbing fern		Mechanical	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR
		Glyphosate								F	F	F			
Melia azedarach	Chinaberry	Garlon 3A	Garlon 4	CS	CS			CS	CS	CS	CS	CS	CS	CS	CS
		Garlon 3A		SI	SI			SI	SI	SI	SI	SI	SI	SI	SI
		Garlon 4		BT	BT			BT	BT	BT	BT	BT	BT	BT	BT
		Garlon 3A	Garlon 4							F	F	F	F		
Morus alba	white mulberry	Garlon 3A	Garlon 4	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
		Garlon 3A		SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
		Garlon 4		BT	BT	BT	BT	BT	BT	BT	BT	BT	BT	BT	BT
		Garlon 3A	Garlon 4							F	F	F	F		
Murdannia keisak	marsh dewflower		Mechanical	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR
		Renovate 3	Rodeo			AH	AH	AH	AH						
Myriophyllum aquaticum	parrotfeather	Weedar 64	Imazapyr	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH
Myriophyllum spicatum	Eurasian watermilfoil	Navigate	Renovate OTF	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH
Oxycarum cubense	Cuban bulrush		Mechanical	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR

Scientific Name	Common Name	Preferred Treatment*	Secondary treatment*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
		Glyphosate + Clipper	Diquat					F	F	F	F	F	F		
Panicum repens	torpedograss	Glyphosate	Glyphosate + Imazapyr						F	F	F	F			
Paspalum urvillei	Vasey's grass	Glyphosate							F	F	F	F			
Pueraria montana	kudzu	Milestone VM	Garlon 4							F	F	F			
		Milestone VM		CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
		Garlon 4	Pathfinder II	BT	BT	BT	BT								
Raphanus raphanistrum	wild radish		Mechanical	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR
		Glyphosate						F	F	F	F	F	F		
Rhynchospora sp.	unidentified invasive beaksedge		Mechanical	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR
		Glyphosate	Imazapyr					F	F	F	F	F	F		
Rosa spp.	rose	Glyphosate						F	F	F	F	F	F		
		Garlon 4	Pathfinder II	BT	BT			BT	BT	BT	BT	BT	BT		
Salvinia minima	common salvinia	Biological		B	B	B	B	B	B	B	B	B	B	B	B
			Clipper			AH	AH	AH	AH	AH	AH	AH	AH		
Sesbania punicea	rattlebox		Mechanical	MR	MR			MR	MR	MR	MR	MR	MR	MR	MR
		Biological		B	B			B	B	B	B	B	B	B	B
Sorghum halepense	Johnson grass	Outrider	Glyphosate						F	F	F	F	F		
Thelypteris dentata	downy maiden fern	Glyphosate				F	F	F							
Triadica sebifera	Chinese tallow tree	Arsenal AC	Clearcast	SI	SI			SI	SI	SI	SI	SI	SI	SI	SI
		Garlon 3A	Garlon 4	CS	CS			CS	CS	CS	CS	CS	CS	CS	CS
		Clearcast	Garlon 4							F	F	F	F		
Ulmus parvifolia	Chinese elm		Mechanical	MR	MR	MR	MR	MR	MR	MR					
		Garlon 4	Glyphosate					F	F	F	F	F	F		
		Garlon 4	Pathfinder II					BT	BT	BT	BT	BT			
Verbena brasiliensis	Brazilian vervain		Mechanical	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR
		Triclopyr					F	F	F	F	F	F	F		
Wisteria sinensis	Chinese wisteria	Garlon 4	Glyphosate							F	F	F	F		
		Garlon 4	Pathfinder II	BT	BT			BT	BT	BT	BT	BT	BT	BT	BT

AH = Aquatic Herbicide, BT = Basal Treatment, B = Biological, CT = Chemical Treatment, CS = Cut Stump, D = Dewater, F = Foliar, MR = Manual Removal, SI = Stem Injection

* This is a summary of treatments and the individual prescriptions should be reviewed for full recommendations.

5.0 SPECIES DESCRIPTIONS

This section describes invasive species documented within the Three Mile Creek Watershed during the 2018 survey. Plant species are arranged alphabetically by scientific name, followed by the three animal species. Each species description provides information and photographs to aid in the identification of these species, and general prevention and control recommendations. They also list specific control procedures. Much of the information in the species profiles is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests* (Miller 2013) as well as other sources, as noted.

Important Note: Pesticide application should only be conducted by trained personnel under the supervision of a certified applicator. The entire product label should be read and followed, particularly instructions regarding application in and around aquatic systems and personal protection requirements and equipment.

5.1 *ALBIZIA JULIBRISSIN*, SILKTREE (MIMOSA)

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
58	15.76	6.28%	1	7.01

This species is a relatively small tree, 3 to 6 m (10 to 50 ft.) tall, in the pea family. Also known as mimosa, it reproduces by abundant seeds as well as root sprouts. It has traditionally been, and is currently, planted as an ornamental for its fast growth and abundant showy, fragrant pink and white flowers in spring and summer. The fruits are flat peapods that hang from the tree through winter. Deciduous leaves are compound, with small leaflets that produce a somewhat feathery look. Seedpods float to spread along waterways and ditches. They also seem to be spread by wildlife and possibly by mowing along roadways. Seeds remain viable for many years.

Silktree (*Albizia julibrissin*)

General Recommendations:

- Young plants should be removed before they begin producing seeds.
- Small seedlings and young saplings can be pulled by hand and with a weed wrench in moist soil conditions and if infestation is not too dense to make hand removal impractical. If the entire root is not removed, re-sprouting is likely.

Specific Control Procedures:

Trees. The following control procedures can be used in Alabama effectively any time of year *except March and April*. Cut trees and large saplings down within a couple inches of the ground using a chainsaw or hand saw, then immediately apply one of the following herbicides to stump tops and sides:

- Garlon 4 as a 20% solution in vegetable oil.
- Garlon 3A as a 20% solution in water or as specified on the herbicide label.

Saplings. Apply a basal spray to young bark using one of the following. Solution should be applied between the ground surface and approximately 12 in. above ground all the way around the stem.

- Garlon 4 as a 20% solution in vegetable oil.
- Undiluted Pathfinder II (a pre-mixed, oil-based triclopyr product).

Resprouts and Seedlings. From *June to August*, thoroughly wet all leaves with the following:

- Glyphosate at 3% solution in water + non-ionic surfactant + blue indicator dye; or
  From *July to September*, thoroughly wet all leaves with the following:
- Transline at 0.25% + Garlon 3A at 4% in water + non-ionic surfactant + blue indicator dye.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.1
Albizia julibrissin (silktree)

Percent Cover (Number of Plots)

- 0% (310)
- 1 - 5% (32)
- 26 - 50% (2)
- <1% (12)
- 6 - 25% (17)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.2 *ALTERNANTHERA PHILOXEROIDES*, ALLIGATORWEED

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
142	38.58%	9.37%	1	29.38

A sprawling mat of alligatorweed at Langan Park on April 24, 2018. JVD

Alligatorweed (*Alternanthera philoxeroides*) is an invasive South American perennial herb that prefers aquatic sites but can also grow on damp soil in riparian and agricultural areas. Its elliptical leaves have smooth margins and are on opposite sides of smooth hollow stems. Roots appear at the nodes, and white flower clusters grow on 5 cm (2") stalks. Though alligatorweed forms viable seeds in its native range, this emersed semi-aquatic plant relies entirely on vegetative reproduction elsewhere. Hollow stems up to 15 m (50 ft.) in length provide excellent buoyancy in water. Free-floating fragments with two or more nodes can easily move downstream and root along the shoreline. Subsequently, this sprawling invasive species can form dense floating mats in slow-moving freshwater systems that can impede navigation, reduce light penetration, and displace native species.[1]

Transported to the U.S. in the ballasts of ships in the early 1900s, alligatorweed became a severe problem by 1963, covering an estimated 97,000 acres in the South. In response, alligatorweed was the first aquatic plant targeted for biological control using co-evolved insects from its native range. Biological control research of alligatorweed began in 1960 with surveys in South America for natural enemies. These field studies by U.S.D.A. entomologists resulted in the screening and introduction of three species of South American insects into the United States. By 1981, the combined predation by the alligatorweed flea beetle, thrips, and stem borer had reduced the alligatorweed infestation to only 1000 acres.[2]

Specific Control procedures:

The striped, black and yellow adult flea beetle severely damages the leaves of alligatorweed. JVD

Biological Control

Alligatorweed Flea Beetle (*Agasicles hygrophila*)

Native to southern Brazil and northern Argentina, the alligatorweed flea beetle (*Agasicles hygrophila*) was chosen to be the first insect studied for biological control of aquatic plants. Released in the U.S. in 1964, this species is now widespread and naturalized throughout the South where this insect's numbers peak in the spring and fall. Adults and larvae consume the emergent leaves and stems of alligatorweed and can decimate the densest mats within three months.[3]

Alligatorweed Thrips (*Amynothrips andersoni*)

A second natural enemy of alligatorweed, the alligatorweed thrips (*Amynothrips andersoni*), was released into the U.S. in 1967. The black and shiny adults are only 2 millimeters long. This tiny insect attacks the new growth of rooted alligatorweed causing leaf distortion and reduced plant vigor.[4]

Alligatorweed Stem Borer (*Arcola malloi*)

In 1971, the alligatorweed stem borer (*Arcola malloi*) was the third and final South American insect introduced into the U.S. to control Alligatorweed. The larvae of this small, brown moth devour the stems from the inside, killing the leaves. A heavy infestation can quickly eliminate a floating mat, and when this moth and the alligatorweed flea beetle work together the alligatorweed rarely recovers.[5]

Chemical Control

An airboat is standard equipment for aquatic herbicide applications. SFWMD

Biological control of alligatorweed can be quite economical and effective but often requires patience. The population densities of the insect control agents vary in relation to the harshness of the previous winter. While alligatorweed thrips are hardier, many alligatorweed flea beetles and stem borers succumb to cold winters. Because insect numbers may rebound slowly, alligatorweed can form dense mats the following spring. If the need for rapid control arises in selected areas, however, chemical control is an available option.

Alligatorweed is susceptible to several systemic herbicides labeled for water: glyphosate, triclopyr, and imazapyr. Glyphosate ("Rodeo," "Refuge," *et al*.)[6] works well on rooted alligatorweed but leaches quickly from floating plants and is often ineffective. Foliar applications of both triclopyr ("Renovate," "Navitrol," *et al*.)[7] and imazapyr ("Habitat," "Arsenal," *et al*.)[8] work well in controlling floating alligatorweed. Imazapyr controls alligatorweed better than triclopyr when applied in April, but the herbicides were equally effective when applied in July. These herbicides can be mixed and multiple treatments can be employed to control mature populations. All three herbicides require the addition of an aquatic surfactant such as a non-ionic wetting agent ("Kinetic," "Cide-Kick," *et al*.).[9]

There are a number of considerations to evaluate prior to the chemical control of alligatorweed. The proper application of aquatic herbicides requires experienced personnel and specialized equipment, most often airboats with tanks and pumps. Herbicide "drift" and non-target damage to desirable native vegetation is always a possibility. Though the herbicides above have no recreational use restrictions, other restrictions may apply such as the distance from any irrigation intakes. Most importantly, the widespread use of herbicides on alligatorweed in TMC Watershed is counter-productive to the long-term success of biological control there. Formerly a great problem in Florida, herbicides are no longer used to control alligatorweed due to the immense success of biocontrol insects.

Physical/Mechanical Control

Mechanical harvester cutting and storing aquatic vegetation prior to dumping. NYIC

Its seeds are not viable outside of its native range, so alligatorweed reproduces and spreads via floating fragments. Although rapid control of alligatorweed mats can be achieved by various aquatic mowers, shredders, and harvesters, the subsequent creation of numerous fragments may actually increase the problem. Even the laborious task of manual removal results in some fragmentation. Aside from spreading the plant, the labor and mobilization costs of various physical/mechanical control methods are much greater than those of biological and chemical control. Non-target plants and animals are inadvertently removed, and deposition sites are required. All in all, physical/mechanical methods of aquatic plant control do not make sense in TMC Watershed, with one exception.

In the areas east of Dr. Martin Luther King Jr. Avenue, including One Mile Creek, reproduction by fragmentation is not an issue. Any floating alligatorweed fragments will be exposed to lethal salinities a short distance downstream. This area lacks launching access for a mechanical harvester but not for a small boat with a special engine. Boats powered by surface drive motors ("Go-Devil," "Mud-Skipper," *et al*.) are the 4X4s of aquatic sites.[10] They can quickly and easily cut through floating mats of vegetation to create boat trails for recreational paddlers and standard outboard boaters. Periodic trips by a surface drive boat to the lower tributaries of TMC could eliminate obstructive surface mats at little expense.

Surface drive boat easily shreds a dense mat of water hyacinths. BOSS

Summary with Specific Recommendations:

Robust stand of alligatorweed in Langan Park on April 24, 2018. JVD

Because of the great success of introduced biocontrol insects, alligatorweed is no longer considered to be a serious pest in the South. Nevertheless, monocultures of this exotic species were thriving in spring 2018 in Langan Lake, and mats of alligatorweed associated with native pennywort (*Hydrocotyle ranunculoides*) were also found downstream in One Mile Creek. To counteract a serious spring expansion of alligatorweed, this plant with its associated biocontrol insects could be maintained in a local greenhouse during the winter. Alternatively, arrangements could be made with South Florida biologists to ship these insects after Mobile's last frost. In either case, introducing supplemental insects to Langan Lake and One Mile Creek in the early spring would assist in their rapid reestablishment after a cold winter and thwart the development of alligatorweed mats.

If herbicide use is deemed necessary, imazapyr (0.14-0.57 lbs. active ingredient/acre) is the most effective chemical agent for controlling alligatorweed, especially in the spring. Triclopyr (5.8 lbs. active ingredient/acre) works as well as imazapyr in the summer, but glyphosate (5.7 lbs. active ingredient/acre) is not dependable on floating mats though it is commonly used.[11,12]

For floating mats that obstruct navigation near Mobile Bay, employing a surface drive boat to periodically create channels would be simple and inexpensive. Mobilizing a large mechanical harvester would not. In our opinion, the best approach to controlling alligatorweed in TMC Watershed is to rely on biocontrol insects to do most of the work and supplement with herbicides and surface drive boats in stubborn areas as needed in the summer.

Thick mat of alligatorweed and pennywort in One Mile Creek on April 25, 2018. JVD

Cost Estimates

1. Supplement biological control insects in the spring:

A. Request assistance from a South Florida biologist to collect and ship insects in late March/early April ($100 for shipping).

Contact:
Jackie Smith, Regional Biologist
FWC Invasive Plant Management
South Florida Field Office
18150 SW Martin Hwy., Indiantown, FL 34956
772-597-5462

B. Fund, all or in part, the construction of a greenhouse on the University of South Alabama campus in exchange for the annual fall collection, winter maintenance, and spring reintroduction of biocontrol insects into Langan Park and One Mile Creek (Starting at $2000).

Contact:
Dr. Tim Sherman, Chair
Biology Department
5871 USA Dr. N. Room 124
University of South Alabama
Mobile, AL 36688
251-460-6331

2. Professional application of imazapyr and/or triclopyr.

The cost of the herbicides to control alligatorweed should be well below $250/acre. However, for an experienced professional with an airboat to mobilize and correctly apply the herbicides, the cost will be much greater, perhaps as much as an additional $1000-1500/acre.

3. Utilizing a surface drive boat to reduce mats and create navigation trails in lower TMC.

Given the proximity to Mobile Bay, it is likely that there are numerous owners of surface drive boats in the area. One of them might volunteer to periodically inspect the lower TMC area while seeking and eliminating obstructive mats. Alternately, someone with such equipment could be placed under contract to do so ($150/trip or $600/year).

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Figure 5.2
Alternanthera philoxeroides (alligatorweed)

Percent Coverage (Number of Plots)

- 0% (226)
- <1% (31)
- 1 - 5% (60)
- 6 - 25% (40)
- 26 - 50% (8)
- 51 - 75% (2)
- 76 - 95% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.3 *BAMBUSA VULGARIS*, COMMON BAMBOO

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
3	0.82%	18%	WC	1.29

Common bamboo and other nonnative bamboos are perennial infestation-forming canes 5 to 12 m (16 to 40 ft.) in height. They have jointed cane stems and bushy tops of lanceolate leaves in fan clusters on jutting branches, often golden green. Plants arise from large branched rhizomes, and infestations rapidly expand after disturbance. Seeds rarely, if ever, produced - potentially once every 50 to 100 years. Still sold and planted as ornamentals. Bamboos are very difficult to eradicate. They resemble switchcane, the only native bamboolike canes in the South, distinguished by a lower height—usually only 2 to 2.5 m (6 to 8 ft.) and persistent sheaths on the stem and absence of long, opposite horizontal branches. Common bamboo also resembles the invasive giant reed.

Common bamboo (*Bambusa vulgaris*)

Management Strategies:

- Do not plant. Remove prior plantings.
- Bulldoze and root rake to excavate root crowns and rhizomes, pile, and burn. Caution: Do not bulldoze bamboo infestations where blackbird species frequently roost because the infectious fungus, histoplasmosis can be present in the soil and cause deadly lung infections.
- Repeated cutting to groundline will not yield control but can assist herbicide applications to resprouts.

- Burning treatments are suspected of having minimal top-kill effect due to scant litter.

Recommended control procedures:

- Cut large stems and apply foliar sprays to resprout tips when plants are 1 to 1.2 m (3 to 4 ft.) tall or use restricted spray nozzles and increased spray pressures to treat leaves as high as possible. When damage of nontarget plants is a concern, repeatedly apply a glyphosate herbicide as a 10-percent solution (1 quart per 3-gallon mix) in water with a surfactant. When there are no concerns of nontarget plant damage, thoroughly wet all leaves and sprouts with Arsenal AC* as a 1-percent solution (4 ounces per 3-gallon mix) in water with a surfactant. For greatest effectiveness, use a combination of the two herbicides. Treat in September or October with multiple applications to regrowth when adequate foliage is present.
- Cut just above ground level between stem sections and immediately apply into the stem cup a double-strength batch of the same herbicide or herbicide mixture in September or October.
- For treatment of extensive infestations in forest situations, apply Velpar L* to the soil surface as spots in a grid pattern at spacings specified on the herbicide label at 2 gallons of herbicide per acre.

* Nontarget plants may be killed or injured by root uptake.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.3
Bambusa vulgaris (common bamboo)

Percent Cover (Number of Plots)

- 0% (365)
- 6 - 25% (1)
- <1% (1)
- 26 - 50% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.4 *CANNA INDICA*, *CANNA* X *GENERALIS*, INDIAN SHOT

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
3	0.82%	3.0%	WC	0.22

Indian shot is an herbaceous perennial that is commonly used in landscaping. It spreads by rhizomes and seeds and can get up to 2.1 m (7 ft.) tall. It has large, dark green leaves that are oblong and up to 50 cm (20 in.) long and 20 cm (8 in.) wide. Flowers are typically bright red to orange-red. Seeds are hard, shiny, and black, about twice the size of a BB.

This plant is known to have the potential to escape and become established outside of cultivation. According to Floradata.com, *Canna indica* and related hybrids have "…*become naturalized in many parts of the world with suitable climate. Indian shot can be found growing along road shoulders and ditches in the West Indies, southeastern U.S., Hawaii and southern Europe.*"

Indian shot (*Canna indica, Canna x generalis*)

This plant was observed during May 2018 data collection in Three Mile Creek Watershed in at least two locations where it has obviously not been planted. It is possible that this plant is in the early stages of becoming naturalized in the general area; therefore, it would be prudent to remove it from areas where it occurs outside of cultivation.

A related species, golden canna, *Canna flaccida*, also called Bandanna of the Everglades, is native to southwest Alabama. It is considered a wetland species, but it will grow in sunny landscape areas outside of wetlands. Golden canna has yellow flowers rather than the red to orange-red of the non-native species and hybrids.

(Some of the above information was taken from https://floridata.com/Plants/Cannaceae/Canna+indica/1163 .)

General Recommendations:

- This plant should not be grown in landscapes. Use the native *Canna flaccida* instead or other non-invasive plants.
- Young plants should be removed before they begin producing seeds.
- If seeds are present, they should be bagged and sent to the landfill.

Specific Control Procedures:

Manual Control. When individual plants or small infestations are found, plants should be dug up, taking care to remove the entire root system, bagged, and sent to the landfill.

Foliar Treatment. When leaves are green:

- Wet the leaves and stems with 2% Clearcast + 1% Methylated Seed Oil (MSO) + blue dye mixed in water.

Figure 5.4
Canna indica (Indian shot)

Percent Cover (Number of Plots)

- 0% (365)
- 1 - 5% (3)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.5 *CINNAMOMUM CAMPHORA*, CAMPHOR TREE

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
39	10.60%	9.60%	2	8.97

This tree is an evergreen up to 18 to 30 m (16-100 ft.). in height, with trunks up to 0.6 m (2 ft.) in diameter and a round, spreading crown formed by large branches radiating from mid-tree. Leaves are glossy, lanceolate, alternate at the twig tips, and have a camphor odor when crushed, cut, or bruised. Twigs are slender, green-to-reddish brown. Abundant clusters of spherical, black drupes are present in fall to winter, and are spread by animals, water, and gravity. This tree also colonizes by root sprouts and may be found in dense thickets.

Camphor tree (*Cinnamomum camphora)*

General Recommendations:

- Young plants should be removed before they begin producing seeds.
- Small seedlings and young saplings can be pulled by hand and with a weed wrench in moist soil conditions and if infestation is not too dense to make hand removal impractical. If the entire root is not removed, re-sprouting is likely.

Specific Control Procedures:

Large Trees. These control procedures are most effective *June through September*. Do one of the following:

- Make stem injections using undiluted Garlon 3A in cut-spacings specified on the herbicide label.
- Cut the tree down with a chainsaw or hand saw, then *immediately* apply Garlon 3A as a 30% solution mixed in water to the stump tops.
- Cut the tree down with a chainsaw or hand saw, then *immediately* apply Garlon 4 as a 25% solution mixed in vegetable oil to the stump tops.

Saplings. During *June to September*, for saplings up to 10 cm (4 in.) in diameter:

- Apply a basal spray using Garlon 4 as a 30% solution mixed in vegetable oil. Solution should be applied from ground level to approximately 30 cm (12 in.) above ground all the way around the stem.

Seedlings and Small Saplings. Thoroughly wet all leaves with one of the following:

- Glyphosate as a 2% solution in water + non-ionic surfactant + blue indicator dye
- Garlon 3A as a 2% solution in water + non-ionic surfactant + blue indicator dye
- Garlon 4 as a 2% solution in water + non-ionic surfactant + blue indicator dye

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.5
Cinnamomum camphora (camphor tree)

Percent Cover (Number of Plots)

- 0% (329)
- <1% (7)
- 1 - 5% (19)
- 6 - 25% (8)
- 26 - 50% (5)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.6 *CLEMATIS TERNIFLORA*, SWEET AUTUMN VIRGINSBOWER

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
23	6.25%	3.65%	2	2.01

This climbing, deciduous to semi-evergreen, perennial vine has opposite, compound leaves with three leaflets each. Leaf margins are entire (without teeth or lobes). Flowers occur in late summer through fall and are white with four petals. Showy fruits with long, silvery-gray, feather-like hairs are produced in profusion. This species is spread by wind-dispersed seed. It is commonly found invading forest edges, rights-of-way and urban areas along streams and roads. It grows vigorously over other vegetation, forming dense blankets that block sunlight to the plants underneath. It prefers full sun but can tolerate partial shade. Sweet autumn virginsbower was introduced into the United States as an ornamental vine and is still widely sold in the nursery trade.

There are native species of *Clematis* that can be confused with the non-native species. The flowers of *Clematis terniflora* are perfect (both male and female reproductive parts are present), with 5-10 carpels (female reproductive organ consisting of ovary, stigma, and style); anthers 1.5-3 mm long; leaf margins entire (rarely cleft); leaflets (3-) 5 (-7) (*Flora of Alabama*, Alan S. Weakley).

General Recommendations:

- Treat young plants with herbicide to prevent seed formation.
- Pull, cut, and treat when seeds are not present.
- Hand-pull new seedlings when soil is moist, ensuring removal of all roots.

Sweet autumn virginsbower (*Clematis terniflora)*

Photo by Fred Nation

Specific Control Procedures:

Foliar Treatment. In *July to October* for successive years when regrowth appears, thoroughly wet all leaves (until runoff) with one of the following:

- Garlon 4 as a 4% solution in water + a non-ionic surfactant + blue indicator dye.
- Glyphosate as a 4% solution + a non-ionic surfactant + blue indicator dye.

Basal Treatment. Treat the length of surface vines within reach anytime *except March and April* with one of the following:

- Garlon 4 as a 20-% solution in vegetable oil.
- Pathfinder II, a pre-mixed, oil-based triclopyr product. Avoid the bark of desirable trees.

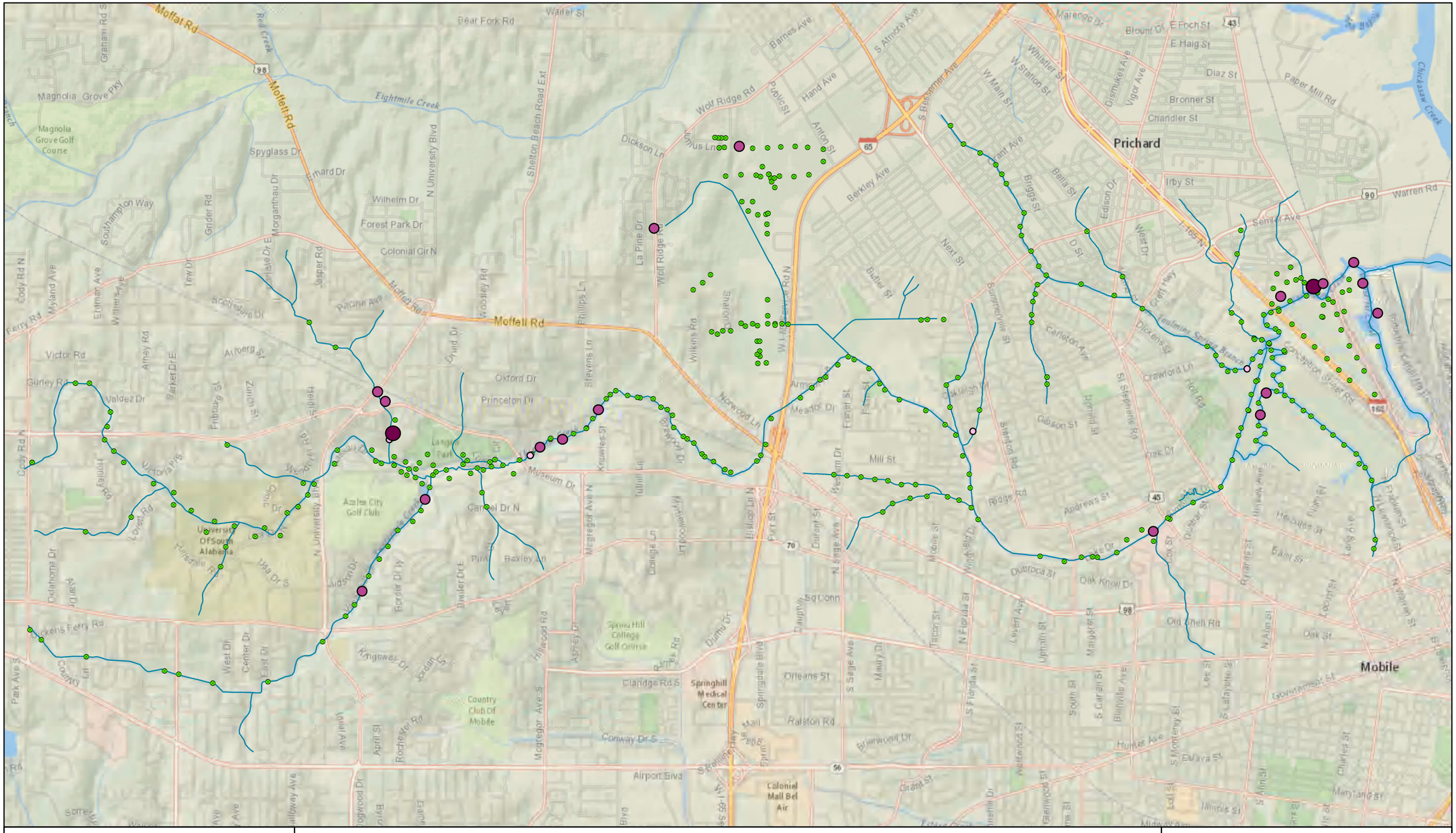

Figure 5.6
Clematis terniflora (sweet autumn virginsbower)

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Basemap courtesy of Esri.

5.7 *COLOCASIA ESCULENTA*, WILD TARO

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
82	22.28%	8.37%	2	14.81

Wild taro (*Colocasia esculenta*) is likely a native of Malaysia but is now pandemic in warmer, wetter climes. Because of its nutritious corms, this emergent species is one of the most important root crops in the world. The U.S. Department of Agriculture promoted its cultivation in Florida in the 1920s, but now wild taro is present in over half of Florida's public waterbodies and considered an invasive species throughout the southeastern United States and Pennsylvania. Wild Taro's large arrow-shaped leaves produce enough shade to create monocultures by crowding native plants from shorelines and wooded wetlands. Once established, this perennial forb spreads vegetatively through rhizomes, stolons, offshoot corms and vegetative fragments.[1]

Typical, dense monoculture of wild taro along a shoreline

Wild taro can be confused with several native aquatic and wetland species, including arrow arum (*Peltandra virginica*), duck potato (*Sagittaria latifolia*), and lizard's-tail (*Saururus cernuus*). Taro can be distinguished from these native species by a couple of key features. First, the stem of wild taro attaches to the leaf away from the leaf margin while native species stem attachment is at the margin. Second, there is a dark purple spot on top of taro leaves where the stem attaches. The native species do not have a purple spot.

Specific Control Procedures:

Physical/Mechanical

Young plants may be excavated and removed by hand. Care must be taken to remove the entire root system. Plant material should be bagged and disposed in a landfill. Older, more well-established plants may also be excavated. Hand removal is quite labor-intensive and repeat efforts will often be required. Because of the toxic oxalic acid in its sap, protective gear is necessary when dealing with cut portions of this plant. There have been many instances of severe skin and eye inflammation of those wearing short pants attempting to control wild taro with a string trimmer. Caution is advised.

Biological

Several island apple snails eagerly consuming a Wild Taro leaf. JVD

Island Apple Snail (*Pomacea maculata*)

Ironically, one of the invasive targets in TMC Watershed, the island apple snail, is the greatest threat to taro cultivation in Hawaii. Typical losses due to snails are 20% of the crop, but heavily infested fields can be completely wiped out, destroying 10-12 months of time and effort. It is, therefore, likely that wild taro would be a greater problem in Langan Park were it not for the

presence of the invasive snails. However, depending on one invasive species to control another is not an effective strategy to protect native biodiversity.[2]

Taro Leaf Blight Fungus (*Phytophthora colocasiae*)

Taro leaf blight primarily attacks taro leaves, but the petioles and corms are also susceptible to damage by this virulent fungal disease. Fungal infection can result in a 30-40% crop loss in heavily affected taro fields. Leaf yield losses of 95% were reported for susceptible varieties in Hawaii. Taro leaf blight fungus may also be present in the continental United States having been tentatively reported in North Carolina. Eventually, vulnerable cultivars of wild taro in Alabama will likely be negatively affected by this fungal disease, perhaps to an extreme degree. However, use of this pathogen in TMC Watershed as biological control of wild taro is neither practical nor ethical at this time.[3,4]

Chemical

Spray crew applying herbicides to wild taro. IFAS

Many plant managers using herbicides have been repeatedly frustrated because of the rapid regrowth of wild taro. This is consistent with other emersed plants having a large percentage of their biomass and energy stores below ground. Contact herbicides, like diquat, have been particularly ineffective. Even systemic herbicides, like 2,4-D and glyphosate, have not performed well on wild taro. Fortunately, new systemic herbicides have become available to plant managers, such as triclopyr, imazapyr, and imazamox. The latest prescription for excellent control relies on "Clearcast" (12.1% Imazamox).[5]

Summary with Specific Recommendations:

Other than dealing with small infestations, physical and mechanical removal of wild taro is simply not cost-effective, and the danger of skin and eye injury from exposure to the sap must also be considered. Biological control via the island apple snail has likely reduced the extent of this plant in Langan Park, but this exotic snail is also a target for eradication. The only viable control method for moderate to widespread amounts of the species is the use of herbicides. Specifically, wild taro is vulnerable to a foliar application of a 2% solution of "Clearcast" (imazamox) and 1% methylated seed oil (MSO) with a blue indicator dye mixed in water. Thoroughly wet the leaves and stems when the plants are actively growing. Follow-up applications will likely be necessary.

Cost Estimates

Given that "Clearcast" costs $300/gallon, "Pro Solutions MSO" costs $80/2.5 gallons, and "Alligare Blue Dye Spray Indicator" costs $24/quart, the standard 50-gallon tank mix described above would cost $322. A treatment of wild taro at the recommended 30 gallons per acre would therefore cost about $200 per acre. The cost of a professional application would depend upon the

mobilization distance and the total treatment area. Combining treatments of multiple plant species would greatly reduce application costs.

References and Additional Information:

1. Invasive Species Compendium. (n.d.) *Colocasia esculenta (taro).* Retrieved from https://www.cabi.org/isc/datasheet/17221

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5. SePro Corporation. (n.d.). *Clearcast Herbicide*. Retrieved from https://sepro.com/Documents/Clearcast_Label.pdf

6. *Control recommendations are based on personal communication with Dr. Stephen Enloe, University of Florida, Agronomy Department/Center for Aquatic and Invasive Plants and Matt Phillips, Florida Fish and Wildlife Conservation Commission.*

Figure 5.7
Colocasia esculenta (wild taro)

Percent cover (Number of Plots)

- 0% (286)
- <1% (14)
- 1 - 5% (41)
- 6 - 25% (22)
- 26 - 50% (4)
- 51 - 75% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.8 *DEPARIA PETERSENII*, PETERSEN'S SPLEENWORT

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
16	4.35%	6.91%	WC	2.65

This non-native fern has proven to be quite invasive in southwest Alabama and beyond. It is deciduous, rhizomatous, and up to 18 in. tall. The lower part of the rachis, or main stem, of the fronds tends to be purplish-black. The rachis and leaves are covered in short, white, erect hairs. The lower approximate half of the rachis has scattered dark brown scales present. When fertile fronds are mature, rows of straight to slightly curved, narrow sori are present on the back of the leaves.

Petersen's spleenwort (*Deperia petersenii*)

(Photo from: Keener, B. R., A.R. Diamond, L. J. Davenport, P. G. Davison, S. L. Ginzbarg, C. J. Hansen, C. S. Major, D. D. Spaulding, J. K. Triplett, and M. Woods. 2018. *Alabama Plant Atlas*. [S.M. Landry and K.N. Campbell (original application development), Florida Center for Community Design and Research. University of South Florida]. University of West Alabama, Livingston, Alabama.)

Although it can occur in a variety of habitats, this species tends to occur in wetlands along stream corridors and is easily overlooked, especially when growing with other fern species. It is important to learn to distinguish this (as well as a very similar-appearing invasive fern, *Thelypteris dentata*) from desirable native ferns. An excellent publication is *Ferns of Alabama* by John W. Short and Daniel D. Spaulding.

General Recommendations:

- It will be important to train personnel to not only recognize this species when mature, but to recognize the sporelings, or baby plants, which tend to occur on bare ground, especially at the base of roots and can be partially hidden and difficult to spot.

- Ideally, treatment should be done in the spring after leaves have fully formed, but prior to spore production.

Specific Control Procedures:

Foliar Treatment Wet all leaves with the following:

- Glyphosate as a 3% solution in water + a non-ionic surfactant + blue indicator dye.

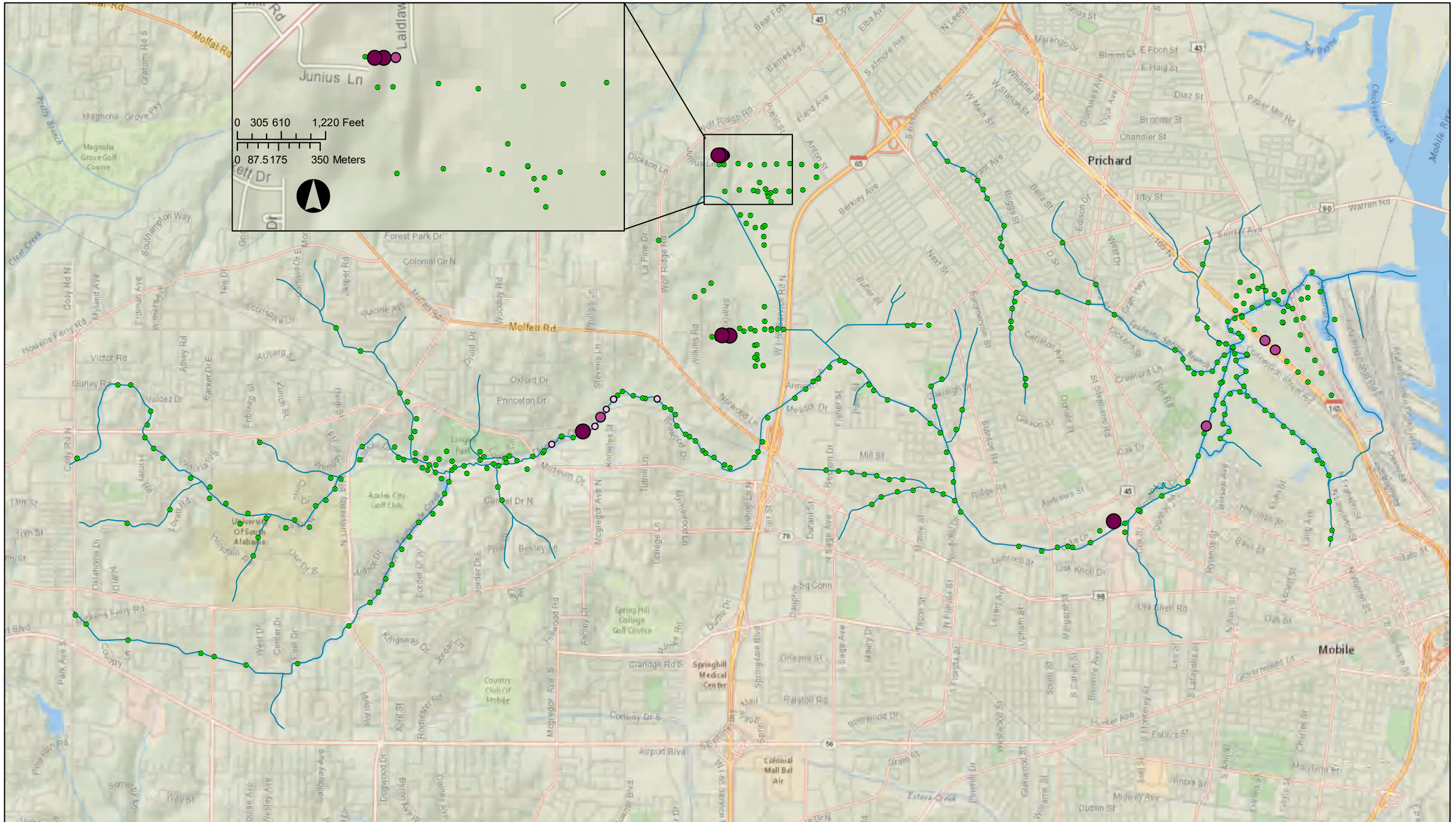

Figure 5.8
Deparia petersenii (Petersen's spleenwort)

Percent Cover (Number of Plots)

- 0% (352)
- 1 - 5% (5)
- <1% (5)
- 6 - 25% (6)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.9 *DIOSCOREA BULBIFERA*, AIR POTATO

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
2	0.54%	1.75%	WA	0.08

Air potato's distinctive aerial tubers (or "bulbils") and large, heart-shaped leaves. (Fred Nation)

Growing up to 20 cm (8 in.) per day and reaching 18 m (60 ft.) in length, air potato (*Dioscorea bulbifera*) vines can quickly smother a mature forest and drastically reduce the biodiversity of natural areas. These invasive vines emerge in late spring and typically die back at the first frost. Native to Asia and tropical Africa, this twining herb is used in agriculture and traditional medicine. Because of its nourishing aerial tubers, called "bulbils," it may have been introduced into the American colonies from Africa via the slave trade.

No seeds are produced outside of its native range, so the bulbils are its only means of reproduction in the southeast U.S. Flowing water can disperse the buoyant bulbils, but uniformed people are the primary culprits in its distribution. Air potato, and possibly two other non-native climbing yam species, water yam, *D. alata*, and Chinese yam, *D. polystachya,* occur in Mobile County. In parts of Florida, air potato forms extensive infestations in parks, forestland, and other landscapes. It is expanding in southwest Alabama and was recently observed along a tributary to Langan Lake. There is also a native yam in Alabama. Our native wild yam, *D. villosa*, is a similar-looking species that can be easily mistaken for a non-native yam. However, wild yam has smaller leaves than air potato and does not produce bulbils.

Air potato vines completely blanket the competing vegetation in Florida. (Ken Langeland)

Specific Control Procedures:

Bright red air potato leaf beetles stand out on a damaged leaf of air potato. (G. Tocia)

Biological Control

In 2012, a biological control insect, called the air potato leaf beetle (*Lilioceris cheni*), was introduced into Florida from China. Importantly, this beetle is host-specific, attacking only air potato. The adults of the Chinese biotype of this beetle are 1 cm (3/8 in.) long, bright red, and are therefore easily spotted. These insects are highly fecund and live as long as six months. In that time, one female can produce 4000 eggs. Not only does this insect cause severe damage to the leaves and bulbils, but also clusters of hungry larvae stunt the air potato's growing tips thwarting vine extension. Since its introduction, this beetle has spread on its own and become naturalized in many areas of Florida, Georgia, Louisiana, and Alabama. In fact, nearly every occurrence of air potato recently observed in Mobile and Baldwin counties has been infested with this introduced beetle. Although it is unlikely to lead to complete eradication, hopefully the air potato leaf beetle will check the invasiveness of this exotic vine.

Extensive leaf damage caused by air potato leaf beetles. (Gena Todia)

Physical/Mechanical Control

The most important physical method of controlling air potato is the collection of bulbils. Detailed removal of these potato-like structures is crucial because each one can produce a new vine. This task is easier in the winter when obstructive vegetation recedes. Placing them in a freezer for a day will render them harmless. As an alternative, bagging them and sending them to a landfill will ensure containment. Physically removing underground tubers of mature air potato vines is arduous and usually impractical given their large size. Herbicide control is a better option.

Chemical Control

Repeated foliar application of Roundup (glyphosate) late in the growing season has been the standard herbicide control method for air potato. However, the use of triclopyr has become widely accepted due to its greater efficacy. Use Garlon 3A as a 2% solution in water with a non-ionic surfactant and a blue indicator dye. Vines can be pulled to the ground and sprayed in areas when collateral damage to surrounding native foliage is a concern. Also, the climbing vines can be cut just above the soil surface and immediately treated with a 50% solution of Garlon 3A in water.

Specific Recommendations

It appears that the air potato leaf beetle is gaining the upper hand on its invasive target. One option would be to simply wait and see. However, given that air potato infestation in TMC Watershed is currently very low and bulbils can float downstream, the prudent approach would be to treat the area with triclopyr during the growing season and manually collect all bulbils the following winter. Repeat if necessary.

Cost Estimates

The total cost of the control of an isolated site of air potato will depend entirely on its size. A foliar application 2.5 ounces Garlon 3A (or Renovate) per gallon of water in the spring is the best approach. For eradication, repeated treatments of any regrowth will be necessary. Given that one gallon of the salt formulation of triclopyr costs $100 and is enough for 50 gallons of spray mixture, the cost of materials will be minimal and exceeded by the cost of labor. Because of the small size of the control area, both the herbicide application and bulbil collection might be easily accomplished via volunteer efforts.

References and Additional Information:

1. Keener, B. R., A.R. Diamond, L. J. Davenport, P. G. Davison, S. L. Ginzbarg, C. J. Hansen, C. S. Major, D. D. Spaulding, J. K. Triplett, and M. Woods. 2018. Alabama Plant Atlas. [S.M. Landry and K.N. Campbell (original application development), Florida Center for Community Design and Research. University of South Florida]. University of West Alabama, Livingston, Alabama.Air Potato Leaf Beetle

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Figure 5.9
Dioscorea bulbifera (air potato)

Percent Cover (Number of Plots)

- 0% (366)
- 1 - 5% (1)
- <1% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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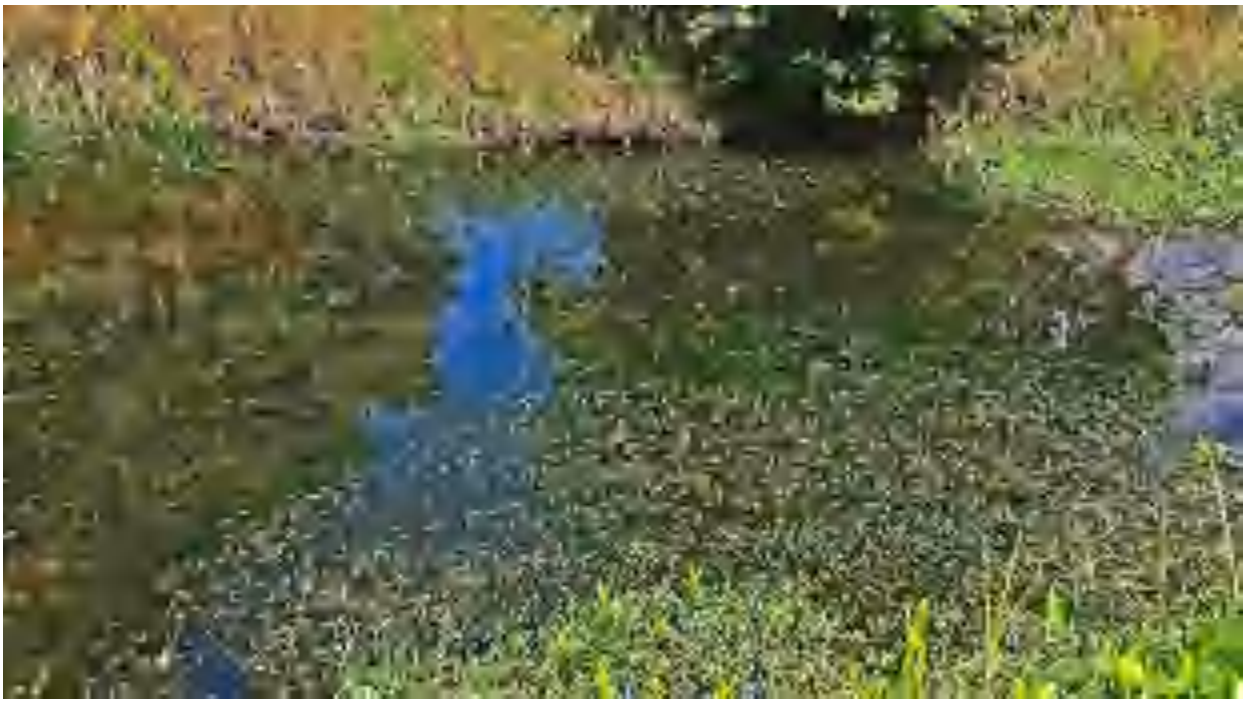
Basemap courtesy of Esri.

5.10 *EGERIA DENSA*, BRAZILIAN ELODEA (BRAZILIAN WATERWEED)

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
8	2.17%	18.31%	2	3.51



A small infestation of Brazilian elodea thrives near the southern shore of Langan Lake on April 24, 2018. (JVD)

Brazilian elodea (*Egeria densa*) is a soft bright-green submersed plant from Argentina, Brazil and Uruguay. First observed on Long Island in 1893, this popular aquarium plant has been dispersed on boat trailers throughout the United States. The male flowers with three white petals extend on stalks above the water surface. Because female plants are not present outside of its native range, this dioecious perennial plant reproduces only by fragmentation in the United States. Fragments with only two nodes produce abundant adventitious roots as they float downstream. Because of the short intermodal distance, the plant has a leafy appearance. Dense strap-like leaves, 2.5 cm (1 in.) long and 6 mm (1/4 in.) wide, attach in whorls along cylindrical stems that are either simple or branching. Brazilian elodea can tolerate a wide range of water temperatures and low light conditions in freshwater systems to form thick mats that can block water intake structures and impair recreational uses of a water body.[1,2,3]

Specific Control Procedure:

Physical/Mechanical Control

As with other aquatic plants that reproduce by fragmentation, physical or mechanical disturbance can cause the unintended consequence of further range expansion. Containment and removal of all plant parts is the key to success in any physical removal effort, which is not easy except in the case of small infestations. However, because it has no seeds or turions (wintering buds) that can

survive complete drying, Brazilian elodea is vulnerable to extended dewatering of the substrate via “drawdown.”

Biological Control

The grass carp (*Ctenopharyngodon idella*) has been used successfully to control Brazilian elodea in contained sites. However, grass carp are highly mobile riverine fish that will readily disperse from target areas unless they are somehow physically constrained. Other biological control agents offering some promise are an isolate of the fungus *Fusarium graminearum* and a leafminer fly *Hydrellia* spp.[4,5]

Chemical Control

Brazilian elodea is susceptible to a number of aquatic herbicides, including diquat, copper, endothall, fluridone, and penoxsulam. The systemic products require longer contact times, so fast-acting contact herbicides are preferable in flowing water.

An underwater image of Brazilian elodea’s soft bright-green leaves. (Lamiot)

Summary with Specific Recommendations:

Brazilian elodea infests a small site along the southern shore of Langan Lake indicative of an individual emptying an aquarium to avoid killing his pet fish. This is all too common, so public education on curbing the spread of invasive species is the first line of defense. This site needs to be immediately addressed because much of TMC Watershed is prime habitat for dense infestations of Brazilian elodea. Scouting the area for new infestations is also crucial. The current area of infestation is small enough to attempt hand removal, but the risk of spreading fragments is great. A drawdown lasting several months could eliminate the infestation. Grass carp can

control this plant, but it is unlikely they would remain in the area long enough to complete the task. Other biological control methods are experimental.

The only viable option is the use of herbicides. Even a small flow of water at the site could impair the efficacy of systemic herbicides, like fluridone and penoxsulam. If the water is completely still, though, split treatments with "Sonar" (41.7% fluridone) or "Galleon" (21.7% penoxsulam) would be effective. In that case, the easiest way to treat the site is to simply pour "Sonar RTU" (3.79% fluridone) from the shoreline. If there is any water flow, the standard method for controlling Brazilian elodea with contact herbicides is to treat with "Reward" (37.3% diquat) at a rate of ½ gallon per acre-foot every two weeks until the Brazilian elodea is eradicated. Add 7.5 lbs. of "Aquathol Super K" (63% endothall) per acre-foot to the "Reward" treatments if the plant somehow persists.[6,7,8]

Cost Estimates:

One quart of "Sonar RTU" costs $90 and that should be all that is required. During the growing season, pour in 16 oz. from the proximate shoreline on Day 1, 8 oz. on Day 21, and the last 8 oz. on Day 42. This simple technique will work if there is no flow. As for the contact herbicides, "Reward" costs $95 per gallon and "Aquathol Super K" costs $25 per pound. The total cost of the materials will depend on the size and depth of the treatment site, but a professional applicator will likely be unnecessary.

The staminate flower of Brazilian elodea extends above the water surface. (P. B. Pelser)

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Figure 5.10
Egeria densa (Brazilian elodea)

Percent Cover (Number of Plots)

- 0% (360)
- <1% (3)
- 1 - 5% (2)
- 6 - 25% (1)
- 26 - 50% (1)
- 76 - 95% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.11 *EICHHORNIA CRASSIPES*, WATER HYACINTH

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
2	0.54%	0.50%	1	0.02

A water hyacinth monoculture completely obstructs a Florida river. (J Hinkle)

One of the most problematic and invasive aquatic plants, the water hyacinth (*Eichhornia crassipes*) relies on bulbous petioles to provide buoyancy for dense monotypic mats created by interconnecting stolons. Because of its abundant and beautiful flowers, this floating plant from the Amazon Basin was widely distributed for use in water gardens and quickly escaped cultivation. In 1884, water hyacinths were disbursed at the Southern States Cotton Exposition in New Orleans, Louisiana. Now, this pest plant is established throughout the southeastern U.S. from Virginia to Texas, as well as in California and Hawaii. Water hyacinths infest all of Alabama's drainage basins except for the Middle Tennessee-Hiwassee Basin.[1,2]

Water hyacinths reproduce vegetatively and by copious seed production. The stolons are easily broken, allowing "pups" to float downstream and establish new populations. Numerous seeds can either germinate immediately or remain dormant for years in bottom sediments. In nutrient-rich waters, the growth rate of this plant can be exceptionally high resulting in biomass densities of up to 200 tons per acre. Unless subjected to two to four weeks of freezing temperatures, water hyacinths can act as perennial plants. Leaves damaged by moderate freezes will quickly regrow from submerged portions. Water Hyacinths do not tolerate brackish water well. Consequently, the distribution of these plants in the Mobile Bay area is determined more by salinity than temperature extremes.[3,4]

Water hyacinth mats reduce phytoplankton abundance and dissolved oxygen levels while generating an enormous amount of organic sedimentation. Consequently, native plants, fish, and invertebrate populations suffer. These floating mats also obstruct recreation, navigation, and water intake pipes.

Flowers buoyed by bulbous petioles rise above a mat of water hyacinths. (USDA)

Specific Control Procedures:

Physical/Mechanical Control

Because of the extreme weight of dense water hyacinths, physical and mechanical removal is most often impractical. Removing the odd floating plant by hand can be beneficial, but water hyacinths can grow faster than most physical or mechanical removal efforts.

Biological Control

After decades of research, there is an array of biological control agents that impact water hyacinths by reducing plant vigor. The most successful introductions were two South American weevils, *Neochetina eichhorniae* and *Neochetina bruchi* whose larvae tunnel into the petioles and crowns of the plant. The larvae of the water hyacinth moths (*Niphograpta albiguttalis*) tunnel into the petioles of the younger, bulbous form of water hyacinth. Both the nymphs and adults of the water hyacinth planthopper (*Megamalus scutellaris*) damage the leaves to feed on the sap. Finally, large numbers of the native water hyacinth mite (*Orthogalumna terebrantis*) can damage the leaves rendering them brown and unproductive. Unfortunately, the rapid growth of water hyacinths in nutrient-rich waterbodies can negate any negative effects of these biological control agents.[5]

Chemical Control

The standard technique for herbicidal control of water hyacinths is the repeated application of 2,4-D amine with a surfactant and a drift control agent when the plants are actively growing.[6]

The striking beauty of water hyacinth flowers attracted public attention and assured dispersal. (J Alder)

Summary with Specific Recommendations:

Physical removal of water hyacinths is an inefficient and laborious task. As for biological control, the insects are already present in the area and are providing some service in reducing the growth rate of this invasive plant. The mainstay of water hyacinth control in TMC Watershed must be monthly treatments beginning in late April and ending in late September of Weedar 64 (46.8% 2,4-D amine) with the goal of total eradication. The 50 gallon tank mix should include ½ gallon of Weedar 64, 1 pint of Kinetic surfactant, and 6 ounces of Poly Control 2 drift control adjuvant.

Cost Estimates:

Weedar 64 costs $24 per gallon, Kinetic costs $100 per gallon, and Poly Control 2 costs $40 per gallon. Therefore, a 50-gallon tank mixture would cost $26. That is enough tank mix to control one acre of water hyacinths in summer conditions. The cost of a professional application would depend on the total size of the project and the distance of mobilization.

References and Additional Information:

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2. USFWS. (2018). *Water Hyacinth (Eichhornia crassipes): Ecological Risk Screening Summary.* Retrieved from https://www.fws.gov/fisheries/ans/erss/highrisk/ERSS-Eichhornia-crassipes-FINAL.pdf

3. University of Florida. (2001). *Center for Aquatic Weeds Directory: Eichhornia crassipes*. Retrieved from https://plants.ifas.ufl.edu/plant-directory/eichhornia-crassipes/

4. FFWC. (n.d.). *Weed Alert: Water-hyacinth (eichhornia crassipes*). Retrieved from http://plants.ifas.ufl.edu/wp-content/uploads/files/caip/weedalerts/invasiveplants_waterhyacinth.pdf

5. University of Florida. (n.d.) *Biological Control*. Retrieved from https://plants.ifas.ufl.edu/manage/control-methods/biological-control/

6. University of Florida. (n.d.). 2,4-D Considerations. Retrieved from http://plants.ifas.ufl.edu/manage/developing-management-plans/chemical-control-considerations/24-d-considerations/

Figure 5.11
Eichhornia crassipes (water hyacinth)

Percent Cover (Number of Plots)

- 0% (366)
- <1% (2)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.12 *FIRMIANA SIMPLEX,* CHINESE PARASOLTREE

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
1	0.27%	3.00%	2	0.07

Chinese parasoltree is an increasingly planted ornamental deciduous upright tree that grows up to 16 m (50 ft.) in height. It has smooth, striped trunks to 60 cm (2 ft.) in diameter with stout alternate branches. Leaves can be over 30 cm (1 ft.) across, dark green above and fuzzy white beneath, and mostly three-to-five lobed with petioles almost as long as the leaf. Terminal large showy clusters of tan and yellow flowers appear in midsummer to quickly yield unusual pods that split into four leaflike sections (little boats) joined at the apex with several pea-sized fruit attached along the upper margins. Round oily seeds can germinate immediately after fully formed in winter in semitropical parts of Florida and the Gulf Coastal Plain or in the spring further north. Leaves turn yellow in fall, and multibranched showy fruit stalks remain over winter into early summer. An extremely rapid growing species with variegated cultivars advertised and sold for “instant shade.” Abundant seeds per tree are highly viable and spread by wind and water to form surrounding infestations. Seedlings will persist in shade, growing rapidly tall to reach sunlight, while saplings and trees require partial to full sunlight. Many surface roots can lift sidewalks in urban plantings and sprout after tree kill. Capable of spread throughout the region.

Chinese parasoltree (*Firmiana simplex)*

Management Strategies:

- Treat when new plants are young to prevent seed formation.
- Cut and bulldoze when fruit are not present in spring and early summer.
- Manually pull new seedlings and tree wrench saplings when soil is moist, ensuring removal of all roots.
- Burning treatments are useful for seedling and sapling topkill when leaflitter is present and fires can be hot.

Specific control procedures:

Large Trees

Make stem injections using a glyphosate herbicide or Garlon 3A in dilutions and cut-spacings specified on the herbicide label. For stems too tall for foliar sprays, cut large stems and immediately treat the stump tops with a glyphosate herbicide or Garlon 3A as a 30-percent solution (7 pints per 3-gallon mix) or Garlon 4 as a 25-percent solution (3 quarts per 3-gallon mix), and add a penetrant for more effective control. ORTHO Brush-B-Gon and Enforcer Brush Killer are effective undiluted for treating cut-stumps and available in retail garden stores (safe to surrounding plants).

Saplings

Apply a basal spray for trees up to 10 cm (4 in.) in diameter, using Garlon 4 as a 30-percent solution (7 pints per 3-gallon mix) in vegetable oil.

Seedlings and Small Saplings

Thoroughly wet all leaves with one of the following herbicides in water with a surfactant: a glyphosate herbicide as a 4-percent solution (1 pint per 3-gallon mix) whenever green foliage is present and when safety to surrounding plants is desired; or Arsenal AC* as a 0.5-percent solution (2 ounces per 3-gallon mix), or Arsenal PowerLine* as a 1-percent solution (4 ounces per 3-gallon mix).

* Nontarget plants may be killed or injured by root uptake.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.12
Firmiana simplex (Chinese parasoltree)

Percent Cover (Number of Plots)

- 0% (367)
- 1 - 5% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.13 GLOCHIDION PUBERUM, NEEDLEBUSH

This plant was first observed in Alabama in July 2000 by Miriam L. Fearn near Halls Mill Creek in Mobile. An article written by Dr. Fearn and Lowell E. Urbatsch about this species and its occurrence in Mobile was subsequently published in the journal SIDA in 2001. This plant is also known to occur in the Three Mile Creek watershed, but not observed during the 2018 survey.

The SIDA article states, "The largest tree was approximately 4.5 m tall with a diameter of nearly 7.5 cm at its base while the smallest was a seedling less than 5 dm tall. Simple, alternate, distichous leaves characterized these plants. Numerous, axillary clusters of small, yellowish flowers and young fruit were evident on the larger individuals. On subsequent visits to the site mature fruits were observed."

It further describes the species as follows: "*Glochidion puberum* are large shrubs or trees. According to label data, one individual on the University of Florida campus was multi-trunked, 10 meters tall. Based on the material for Alabama the bark is brown with closely spaced fine longitudinal furrows; milky sap or exudate absent; twigs tan densely pubescent; hairs uniseriate, spreading or tangled. Leaves simple, alternate, distichous, deciduous, 5-7 cm long, 2-3 cm wide, abaxially pubescent; blades narrowly elliptic, somewhat coriaceous; apex acute; bases rounded, asymmetric margin entire; venation pinnate, secondary veins ca. 9 pairs, evenly spaced; prominent, arcuate, yellowish; petiole ca. 4 mm long, rusty-brown, densely pubescent, stipules laterally placed, free of one another, scale-like acute 1-2 mm long. Inflorescences axillary, 10-20 flower per cluster; pedicels ca. 2 mm long. Flowers at least some unisexual with staminate and pistillate flowers on the same plant, actinomorphic; ca. 5 mm in diameter; perianth consisting of 6 sepals, distinct, persistent in fruit; petals absent; stamens ca. 8; filaments joined, free of the perianth; ovary superior, carpels 4-5, bilocular; styles bi-lobed. Fruit capsular, pale green to yellow, ca. 14 mm in diameter. Seeds reddish-orange, ca. 4 mm long." (*Miriam L. Fearn and Lowell E. Urbatsch,* Glochidion puberum *(Euphorbiaceae) Naturalized in Southern Alabama, SIDA, Contributions to Botany, Vol. 19, No. 3 (23 August, 2001), pp. 711-714)*

Needlebush

Photo by Howard Horne

Needlebush

(Line drawing found at: http://efloras.org/object_page.aspx?object_id=128566&flora_id=1)

General Recommendations:

- Young plants should be removed before they begin producing seeds.
- If infestations are not too dense, small seedlings and saplings can be pulled by hand and with a weed wrench in moist soil conditions. The root system must be completely removed or resprouting is likely to occur.

Specific Control Procedures:

Large Trees. Do one of the following:

- Cut down the trees with a chainsaw or hand saw, then ***immediately*** apply Garlon 4 as a 25% solution mixed in vegetable oil to the stump tops.

Saplings and Shrubs. For stems up to 4 in. in diameter:

- Apply a basal spray for plants up to 4 in. in diameter using Garlon 4 as a 30% solution in vegetable oil. Solution should be applied from ground level to approximately 12 in. above ground completely around the stem.

Seedlings and Small Saplings. Thoroughly wet all leaves with one of the following:

- Glyphosate as a 4% solution in water + non-ionic surfactant + blue indicator dye.

Figure 5.13
Glochidion puberum (Needlebush)

0% (368)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.14 *HYGROPHILA POLYSPERMA*, EAST INDIAN HYGROPHILA

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
1	0.27%	0.50%	WC	0.01

An island apple snail feeding on East Indian hygrophila in Langan Lake on April 28, 2018. (J Van Dyke)

In 1945, East Indian hygrophila (*Hygrophila polysperma*) was introduced to the United States from China and sold as an aquarium plant. Now, this perennial aquatic herb is established in Alabama, Florida, Kentucky, Mississippi, South Carolina, and Texas inhabiting lakes, streams, marshes, and rice-fields. This plant with opposite, elliptical leaves continues to expand its range due to its shade tolerance and extremely rapid growth rate. Its growth is determined by soil nutrients, water temperature, and day length. Hygrophila's somewhat square stems, which grow to 1.8 m (6 ft.) or more, are extremely brittle. Floating fragments produced by disturbance are quite viable and are this plant's major mode of reproduction and dispersal. It also produces seeds in narrow fruits of

nearly hidden bluish flowers. Partially emersed but primarily submersed, this highly invasive rooted plant can form dense mats that overwhelm native species and clog waterways. Because of its rapid growth, high reproductive capacity, and general resistance to herbicide control, the USDA's "weed risk assessment for *H. polysperma* is "High Risk"."[1,2,3]

Floating mats of hygrophila obstructing a waterway. (A. Murray, University of Florida)

Specific Control Procedures:

Physical/Mechanical Control

Because physical disturbance of hygrophila creates numerous fragments, raking, mowing and harvesting this species can greatly aid in its dispersal. This is especially true of mechanical harvesting. Physical removal is only recommended for small areas with careful control of fragments. The use of a peripheral seine net in those instances can greatly reduce the number of escaping fragments. Preventing escape is crucial because the viability of these fragments approaches 100% and each can start a new infestation.[2]

Biological Control

There are currently no effective biological control agents for hygrophila. A rust fungus (*Puccinia* spp.) infects hygrophila in India and is being investigated further as a biocontrol agent. So far, no insects feeding on this plant overseas appear to be host specific. In the U.S., native insects and nematodes have been observed attacking hygrophila but not to the point of controlling this fast-growing plant. Extremely high stocking rates of grass carp (*Ctenopharyngodon idella*) have been used with marginal success to control hygrophila in canals in Florida, but the general consensus is that this herbivorous fish is not a good control option.[4,5]

Chemical Control

Herbicide control of hygrophila has been a frustrating exercise for decades. This plant prefers flowing water which reduces herbicide contact time, but even in static water, hygrophila is only marginally controlled with standard herbicides, such as copper, diquat, endothall, fluridone and 2,4-D, alone or in combination. Fortunately, a relatively new herbicide, called "Clipper" (51%

flumioxazin), has proven to be quite effective in controlling this invasive plant. Flumioxazin is a contact herbicide that is rapidly absorbed by hygrophila and is lethal when applied at half the maximum label rate.[6,7]

Summary with Specific Recommendations:

Completely encircle small infestations of hygrophila in shallow water with a 25' X 4' polyethylene minnow seine net. Uproot and remove all of the plant material with heavy-duty bow rakes. Place all of the vegetation into plastic garbage bags while within the net enclosure. Dispose of these bags in a landfill. Success will depend on removing all plant fragments within the deployed seine net.

For larger infestations in slow moving or quiescent waters, use "Clipper" at a rate of 200 ppb. This herbicide works best on actively growing plants in the cooler waters of the spring and fall seasons. Flumioxazin is a fast-acting herbicide that needs just 4-6 hours of contact time to kill hygrophila, but it also rapidly degrades. The half-life of flumioxazin is determined by the acidity of the water. For instance, the half-life of this product is 39 hours in water with a pH of 6, but only 1.7 hours at a pH of >8.5. Therefore, buffer the tank mix at a pH of 7 and do not treat in basic water. As an extra precaution, use flumioxazin in the morning when the diurnal pH is relatively low.

Cost Estimates:

The cost of the 25' minnow seine net required for the physical removal of small infestations of hygrophila should not exceed $50, and heavy-duty bow rakes and garbage bags are likely already available. The labor costs are difficult to determine, but the work, though wet, is not arduous. This task seems appropriate for well-supervised volunteers who understand the importance of removing every last fragment.

In contrast, "Clipper" (flumioxazin), a water dispersible granule, seems rather expensive at well over $100 per pound. However, 1.1 lb. of this product will treat 1 acre-foot of water at the concentration (200 ppb) necessary to control hygrophila. The cost of chemically controlling this invasive plant will depend on its total area and the fees charged by the professional applicators. Costs can be contained if the applicators can combine treatments of multiple target plants while mobilized to the Mobile area.

References and Additional Information:

1. CABI. (n.d.) Invasive Species Compendium: *Hygrophila polysperma (Indian swampweed).* Retrieved from https://www.cabi.org/isc/datasheet/28135

2. Thayer, D.D., I.A. Pfingsten, C.C. Jacono, and J. Li. (2018) *Hygrophila polysperma (Roxb.) T. Anderson: U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, FL,* https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=225

3. USDA. (2015). *Weed Risk Assessment for Hygrophila polysperma (Roxb.) T. Anderson (Acanthaceae) – Miramar weed*. Animal and Plant Health Inspection Service. Version 1. http://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Hygrophila-polysperma.pdf

4. Florida Aquatic Pant Management Society. (Spring 2012). *Aquatics* http://www.fapms.org/aquatics/issues/2012spring.pdf

5. Neisch, Michael (2014). A Study on Biological Threats to Texas Freshwater Resources. Master's thesis, Texas A & M University. https://oaktrust.library.tamu.edu/handle/1969.1/152488

6. University of Florida. (n.d.) *Plant Management in Florida Waters- An Integrated Approach: Hygrophila*. Retrieved from https://plants.ifas.ufl.edu/manage/why-manage-plants/floridas-most-invasive-plants/hygrophila/

7. University of Florida. (n.d.) *Plant Management in Florida Waters- An Integrated Approach: Flumioxazin Considerations*. Retrieved from http://plants.ifas.ufl.edu/manage/developing-management-plans/chemical-control-considerations/flumioxazin-considerations/

Figure 5.14
Hygrophila polysperma (East Indian Hygrophila)

Percent Cover (Number of Plots)

- 0 (367)
- <1% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.15 *HYPTIS MUTABILIS*, TROPICAL BUSHMINT

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
30	8.15%	2.33%	WA	29.38

This herbaceous perennial plant is in the mint family and has opposite leaves, square stems, and small, lavender, bilabiate (two-lipped) flowers that form in the leaf axils. The leaves and other plant parts have a strong, somewhat unpleasant fragrance when crushed. Each plant produces hundreds, if not thousands, of tiny seeds. The entire plant is covered in tiny prickly hairs. This plant is typically found in disturbed sunny areas, such as roadsides, old fields, and forest edges and openings. It seems to be spreading prolifically and shows signs of becoming a serious invader of southeastern natural plant communities.

Tropical bushmint (*Hyptis mutablis*)

(Photo from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (**http://florida.plantatlas.usf.edu/**). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

Tropical bushmint (*Hyptis mutablis)*

(Photo from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (**http://florida.plantatlas.usf.edu/**). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

General Recommendations:

- It will be important to train personnel to recognize this species and distinguish it from similar-looking native mints, such as *Stachys floridana* (Florida betony), and others.
- Ideally, treatment should be done in the spring after leaves have fully formed, but prior to seed production.
- Seed production can be prevented with mowing or weed-eating.

Specific Control Procedures:

Foliar Treatment Wet all leaves with the following:

- Glyphosate as a 3% solution in water + a non-ionic surfactant + blue indicator dye.

Figure 5.15
Hyptis mutabilis (tropical bushmint)

Percent Cover (Number of Plots)

- 0 (338)
- 1 - 5% (16)
- <1% (13)
- 6 - 25% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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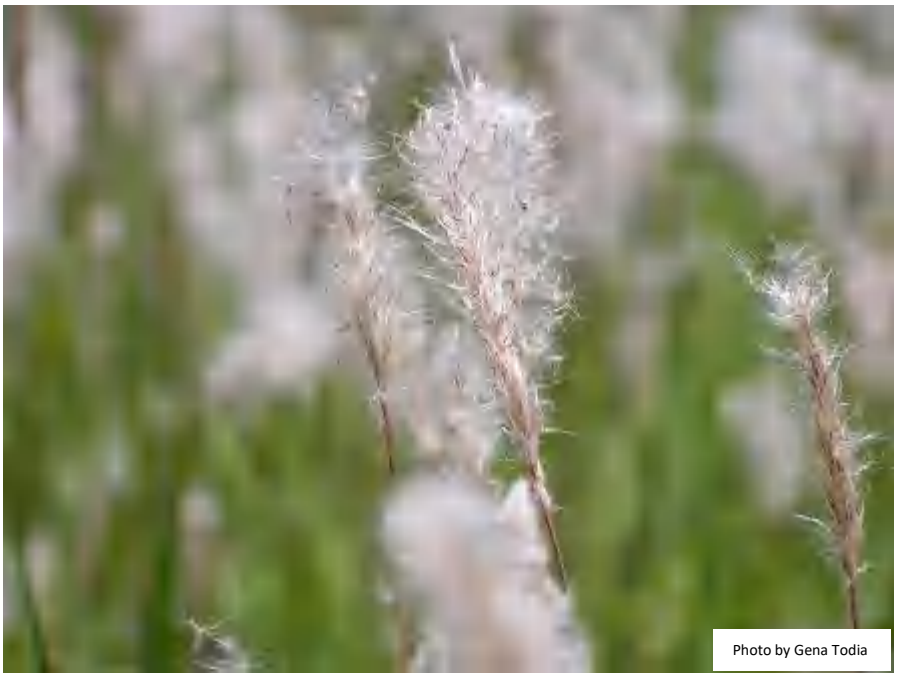
Basemap courtesy of Esri.

5.16 *IMPERATA CYLINDRICA*, COGONGRASS

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
87	23.64%	13.86%	1	26.95

This grass is a very aggressive, colony-forming, dense erect perennial that grows 0.3 m to 2 m (1 to 6 ft.) tall. It has tufts of long leaves hiding short stems, yellow-green blades, each with an off-center mid-vein and finely serrated margins. Flowers and seeds are fluffy and silver-plumed. They appear in spring and sporadically year-round, typically associated with some sort of disturbance, such as mowing or burning. Seed are dispersed by wind and on contaminated clothing, equipment, and in products such as pine straw mulch and fill material from borrow pits where it occurs. Dense stands of dead grass persist through winter and are a severe fire hazard. Cogongrass burns hot even when green. Infestations form dense rhizome mats, making eradication difficult. Older infestations are more difficult to control than new patches.



Cogongrass (*Imperata cylindrica*) seed head

Cogongrass (*Imperata cylindrica*) in flower

General Recommendations:

- Diligently monitor for new occurrences and treat new patches as soon as feasible while grass is green and actively growing.
- Do not use or transport fill dirt, rock, hay, or pine straw from infested lands.
- Seed production can be stopped by mowing, burning, or herbicide treatments in early stages of flowering or shortly before flowering.
- Clean seed and rhizomes from equipment and personnel working in infestations before leaving the infested site.

Specific Control Procedures:

Foliar Treatment. When grass is *actively growing* and at least 0.5 m (1 to 2 ft.) high, or for older growth, treat from *June to September*, thoroughly wet all leaves with one of the following:

- Arsenal AC* as a 1% solution in water + a non-ionic surfactant + blue indicator dye. Repeat applications in subsequent years may be required for patch eradication.
- Glyphosate at 2-5% + Arsenal AC at 1% in water + a non-ionic surfactant + blue indicator dye. This treatment will accelerate burn-down of actively growing shoots but may not improve rhizome kill.
- Glyphosate as a 2-5% solution in water + a non-ionic surfactant + blue indicator dye. Two applications per growing season (just before flowering in spring and again in late summer to regrowth) are typically necessary. For eradication, apply in successive years when regrowth is present until no live rhizomes are observed.

**Arsenal AC and other products containing imazapyr are soil-active, meaning that it can be taken up by the roots of non-target plants and cause damage or death.*

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.16
Imperata cylindrica (cogongrass)

Percent Cover (Number of Plots)

- 0%
- <1% (8)
- 1 - 5% (40)
- 6 - 25% (28)
- 26 - 50% (5)
- 51 - 75% (4)
- 76 - 95% (2)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

0 500 1,000 2,000 Feet
0 320 640 1,280 Meters

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Basemap courtesy of Esri.

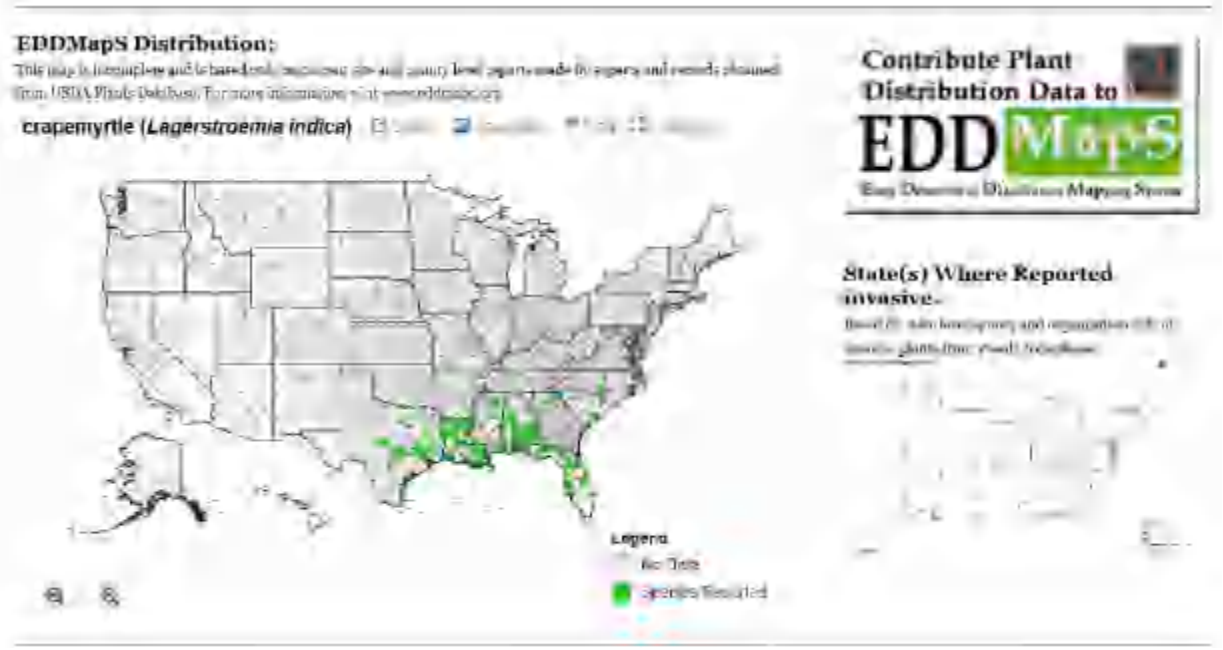
5.17 *LAGERSTROEMIA INDICA*, CRAPE MYRTLE

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
3	0.82%	0.50%	WC	0.04

Crape myrtle is a familiar ornamental tree much loved and frequently used in landscaping in the South. Unfortunately, it is increasingly seen in disturbed habitats where it has obviously not been planted and may prove to be invasive at some point.

Alvin Diamond writes the following about this species: *Crape Myrtle is an introduced large deciduous shrub or small tree in the Loosestrife family (Lythraceae). It is native to Asia from China and Korea south to India. Crape Myrtle is widely cultivated in the South and often persists or escapes. It can be found around old home sites, on roadsides, along fence rows, and in disturbed woods.* (Keener, B. R., A.R. Diamond, L. J. Davenport, P. G. Davison, S. L. Ginzbarg, C. J. Hansen, C. S. Major, D. D. Spaulding, J. K. Triplett, and M. Woods. 2018. ***Alabama Plant Atlas***. [S.M. Landry and K.N. Campbell (original application development), **Florida Center for Community Design and Research**. **University of South Florida**]. **University of West Alabama**, Livingston, Alabama.)

This general description of crape myrtle was found at the following online PDF document produced by the USDA: https://plants.usda.gov/plantguide/pdf/pg_lain.pdf : *Crape Myrtle is a medium to large shrub or a small multi-stemmed tree that can grow up to 40 feet. Flowering begins as early as May in some cultivars and continues into the fall. Each 6- to 18-inch cluster of flowers (or panicle) develops on the tips of new growth and is composed of hundreds of 1-to 2-inch flowers. Color ranges include shades of purple, lavender, white, pink and red, including "true" red, a relatively recent development. Some cultivars have bicolor flowers (two colors on each petal), some cultivars have flower colors that fade with age or certain environmental conditions, and other cultivars have panicles composed of a mix of flower colors. Strips of bark peel off in early summer to reveal mottled new bark ranging in color from pale cream to dark cinnamon to rich brown to bright orange. The bark color gradually fades over winter until it peels again the next summer*.



Crape myrtle distribution outside of cultivation, as reported to EDDMapS.

(Swearingen, J., C. Bargeron. 2016 Invasive Plant Atlas of the United States. University of Georgia Center for Invasive Species and Ecosystem Health. http://www.invasiveplantatlas.org/)

Crape myrtle (*Lagerstroemia indica)*

Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (**http://florida.plantatlas.usf.edu/**). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.

General Recommendations:

- Young plants should be removed before they begin producing seeds.
- Small seedlings and young saplings can be pulled by hand and with a weed wrench in moist soil conditions and if infestation is not too dense to make hand removal impractical. If the entire root is not removed, re-sprouting is likely.
- Use native and non-invasive species for landscaping.

Specific Control Procedures:

Trees. These control procedures can be used effectively any time of year *except March and April*. Cut trees and large saplings down within a couple inches of the ground using a chainsaw or hand saw, then **immediately** apply to stump tops and sides:

- Garlon 3A as a 20% solution in water or as specified on the herbicide label.

Saplings. Apply a basal spray to young bark using one of the following:

- Garlon 4 as a 20% solution in vegetable oil. Solution should be applied between the ground surface and approximately 12 in. above ground all the way around the stem.
- Undiluted Pathfinder II (a pre-mixed, oil-based triclopyr product), spraying all the way around the stem between the ground surface and approximately 12 above ground.

Resprouts and Seedlings. From *June to August*, thoroughly wet all leaves with the following:

- Glyphosate at 3% solution in water + non-ionic surfactant + blue indicator dye; or
  From *July to September*, thoroughly wet all leaves with the following:
- Transline as a 0.25% solution + Garlon 3A as a 4% solution in water + non-ionic surfactant + blue indicator dye.

Figure 5.17
Lagertroemia indica (crape myrtle)

Percent Cover (Number of Plots)

- 0 (363)
- 1-5% (1)
- <1% (3)
- 6-25% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.18 *LIGUSTRUM SINENSE*, CHINESE PRIVET AND OTHER *LIGUSTRUM* SPECIES

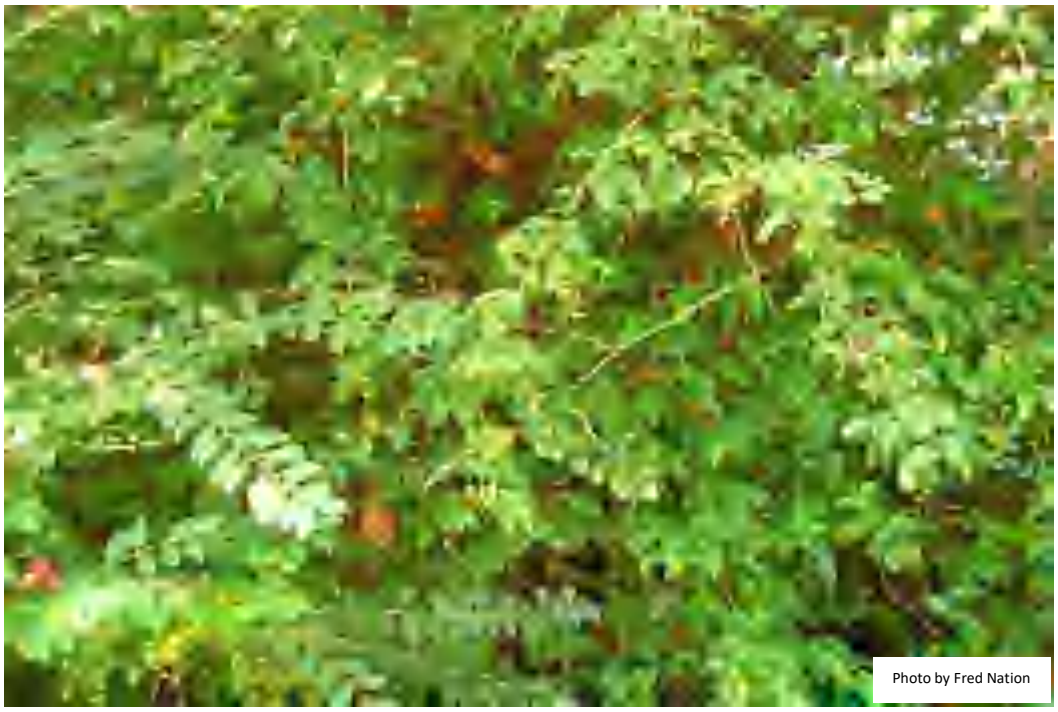
# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
144	39.13%	16.34%	1	53.54

Chinese privet and several other ornamental species of *Ligustrum* are shrubs to small trees that have been, and continue to be, used extensively in landscaping. All have opposite leaves and are in the olive family. Chinese privet has thin, semi-evergreen, somewhat small leaves. Other species have thicker, evergreen, larger leaves. Chinese privet is thicket-forming, shades out native shrub and herbaceous species, and prevents native tree and shrub recruitment. Chinese privet is one of the most widely spread invasive plants in the South, while other *Ligustrum* species are less common. All have showy clusters of small white flowers in spring that yield abundant clusters of small, ovoid, dark purple berries during fall and winter. Chinese privet colonizes by root sprouts and seeds and is spread widely by birds and other animals. Seeds are thought to be viable for only one year. Many shallow surface roots may sprout when the parent plant is top-killed.

Japanese privet

Chinese privet fruit being eaten and dispersed by an American robin.

Chinese privet (*Ligustrum sinense)* in flower



Chinese privet (*Ligustrum sinense)* with unripe fruit

General Recommendations:

- Young plants should be removed before they begin producing seeds.

- Small seedlings and young saplings can be pulled by hand and with a weed wrench in moist soil conditions and if infestation is not too dense to make hand removal impractical. If the entire root is not removed, re-sprouting is likely.

Specific Control Procedures:

Foliar Application. If within reach, *Ligustrum* spp. can be effectively controlled by applying herbicide to the leaves. Note that *summer* foliar applications of glyphosate may not be as effective as other times and require a higher percent solution. Otherwise, thoroughly wet all leaves with the following:

- Glyphosate as a 3% solution in water + a non-ionic surfactant + blue indicator dye.

Basal Treatment. For stems too tall for foliar sprays and when safety to surrounding vegetation is desired, apply a basal spray between the ground and approximately 0.3 m (12 in.) above ground all the way around the stem using:

- Garlon 4 as a 20% solution in vegetable oil.
- Undiluted Pathfinder II, a pre-mixed, oil-based triclopyr product.

Cut Surface Treatment. For best results, cut surface treatment should be done any time of year *except March and April*. For large stems and when safety to surrounding vegetation is desired, cut with a chainsaw or hand saw and ***immediately*** treat stump tops and sides with one of the following:

- Garlon 3A as a 20% solution in water + a non-ionic surfactant + blue indicator dye.
- Glyphosate as a 20% solution in water + a non-ionic surfactant + blue indicator dye.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.18
Ligustrum sinense (Chinese privet)

Percent Cover (Number of Plots)

- 0% (224)
- <1% (9)
- 1 - 5% (46)
- 6 - 25% (62)
- 26 - 50% (18)
- 51 - 75% (9)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.19 *LONICERA JAPONICA*, JAPANESE HONEYSUCKLE

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
50	13.59%	3.05%	1	3.52

This woody vine is semi-evergreen to evergreen, high climbing and trailing to 25m (80 ft.), branching and often forming arbors in forest canopies and/or groundcover under canopies. It has ovate to oblong opposite leaves that are green above and whitish underneath. Both surfaces are smooth to rough-hairy. Vines root at the nodes when covered by leaves or duff, which makes control difficult. Japanese honeysuckle occurs as dense infestations along forest edges and rights-of-way, as well as under dense tree canopies and as arbors high in canopies. It is shade tolerant and has large woody rootstocks. It spreads mainly by vines rooting at the nodes and less by animal-dispersed seeds. It infrequently seeds within forest stands and has very low germination rates. Seed survival in the soil is less than two years. This species is still planted in wildlife openings and invades surrounding lands where it is planted. (The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Japanese honeysuckle (*Lonicera japonica)*

General Recommendations:

- If hand-pulled, bag and dispose of plants and fruit at the landfill or burn.
- Treat when plants are young to prevent seed formation.
- Pull, cut, and treat with herbicide when fruit are not present.
- Hand pull when soil is moist to ensure removal of all stolons and roots.

Specific Control Procedures:

Foliar Treatment. For best results, *July to October, or during warm days in winter*, treat leaves with one of the following:

- Glyphosate as a 2% solution in water + a non-ionic surfactant + blue indicator dye.
- Garlon 3A as a 3- 5% solution in water + a non-ionic surfactant + blue indicator dye.
- Garlon 4 as a 3- 5% solution in water + a non-ionic surfactant + blue indicator dye.

Cut Stem Treatment. Cut large vines just above the soil surface and ***immediately*** treat the freshly cut stem with one of the following:

- Glyphosate as a 20% solution in water + a non-ionic surfactant + blue indicator dye.
- Garlon 3A as a 20% solution in water + a non-ionic surfactant + blue indicator dye.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

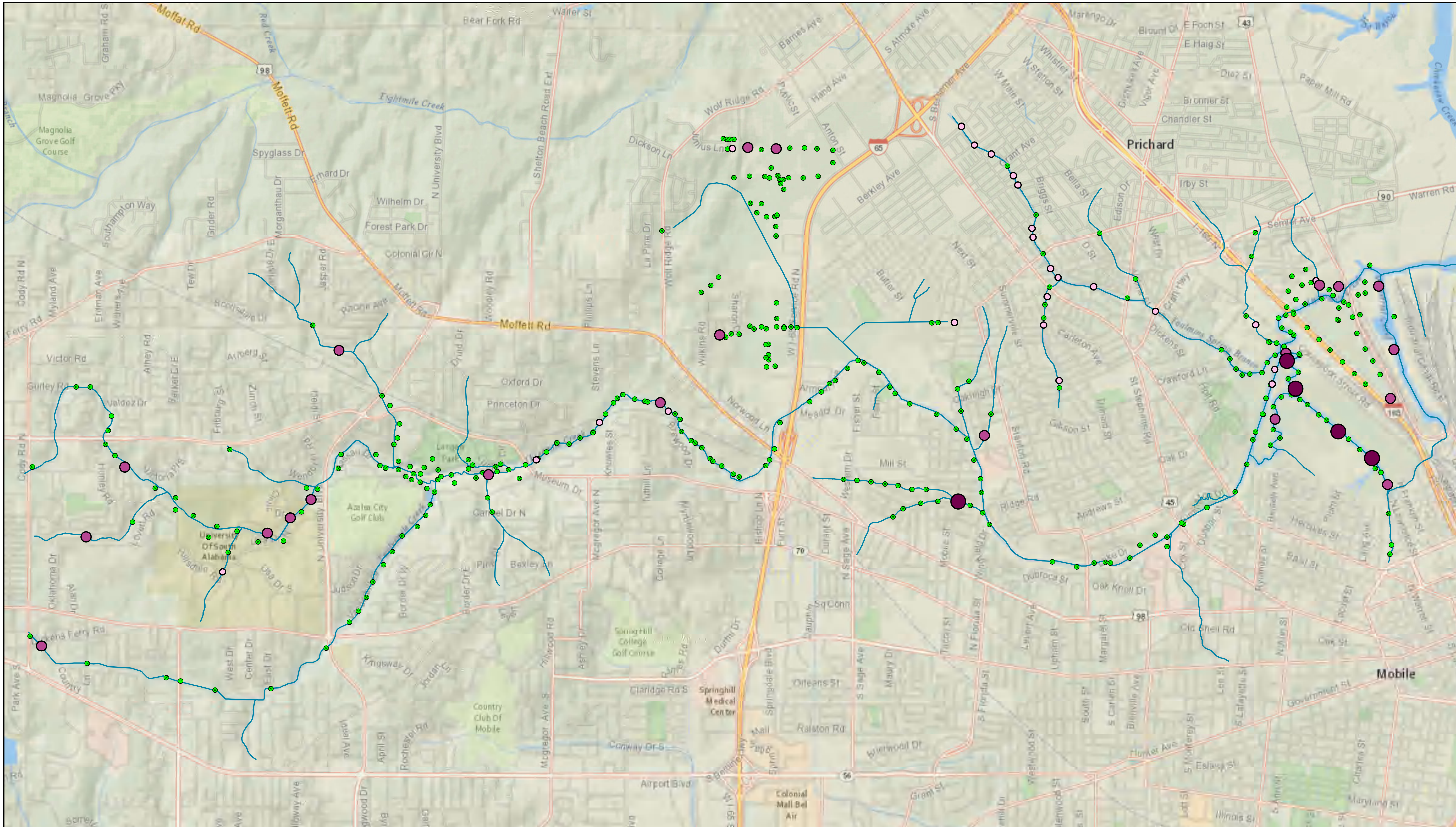

Figure 5.19
Lonicera japonica (Japanese honeysuckle)

Percent Cover (Number of Plots)

- 0% (318)
- 1 - 5% (21)
- <1% (24)
- 6 - 25% (5)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Date: 2/25/2019

Basemap courtesy of Esri.

5.20 *LUDWIGIA PEPLOIDES*, CREEPING WATERPRIMROSE / PRIMROSE-WILLOW

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
1	0.27%	3.00%	WC	0.07

Creeping waterprimrose sprawls across the surface of the water. (USDA)

There is a great deal of taxonomic confusion regarding creeping waterprimrose and also uncertainty about its place of origin. Some experts believe *Ludwigia peploides* to be a native of Alabama, but subspecies, hybridization, and plasticity contribute to identification complexity. What is not in doubt is that this perennial herbaceous plant is one of the most aggressive wetland species on Earth. It is considered to be native to Australia, New Zealand, and North and South America, but creeping waterprimrose often behaves like an exotic invader even within its home ranges.[1,2]

The alternate leaves of waterprimrose which can be lanceolate or ovate vary from 1 cm to 10 cm (½ in. to 4 in.) long. Its solitary flowers have five or six bright yellow petals. Reproduction is by fragmentation and via the production of numerous seeds. Roots grow extensively along sprawling horizontal stems that either float on the water surface or attach to moist soils. Highly adaptable creeping waterprimrose imperils native biodiversity and ecosystem function. This fast-growing

plant forms dense mats that displace native species, reduce dissolved oxygen levels, increase sedimentation, impede water flow, and block recreational and navigational access.[3,4,5]

Creeping waterprimrose's yellow flower and ovate leaves are supported by its floating stems. (Tenaglia)

Specific Control Procedures:

Physical/Mechanical Control

Because creeping waterprimrose is still relatively sparse in TMC Watershed, physical removal may still be a viable option after detailed scouting. Because each fragment that is lost downstream can produce a new infestation, careful containment and disposal of all plant material is the key to successful physical removal.

Biological Control

A survey of herbivorous insects associated with creeping waterprimrose was conducted in the southern U.S. At least nine species were identified, primarily weevils and leaf beetles. In Alabama, the waterprimrose flea beetle (*Lysathia* spp.) was reported to feed on waterprimrose to the point of reducing plant biomass. Grass carp (*Ctenopharygodon idella*) will not effectively control waterprimrose. Grazing animals have produced marginal results.[6]

Chemical Control

A comparative study of six herbicides, including 2,4-D, triclopyr, imazapyr, glyphosate, penoxsulam, and imazamox, indicated that 2,4-D and triclopyr provided superior control of creeping waterprimrose. Twelve weeks after treatments, 2,4-D at a rate of 2 lbs. a.i./acre (active ingredient per acre) produced an 88% reduction of plant biomass and triclopyr at a rate of 3.0 lbs. a.i./acre produced a 93% reduction.[7]

Summary with Specific Recommendations:

For small infestations, careful physical removal has merit as long as all plant material is removed. Biological control via native waterprimrose flea beetles offers some promise. However, the only reliable method to control larger areas of this plant are foliar applications of either ½ gallon of Weedar 64 (46.8% 2,4-D amine) or 1 gallon of Renovate 3 (44.4% triclopyr) in 50-100 gallons of spray mixture per acre plus 8 ounces to 32 ounces of Kinetic, a non-ionic surfactant.

Cost Estimates:

Weedar 64 costs $25 per gallon, Renovate 3 costs $70 per gallon, and Kinetic, a non-ionic surfactant, costs $30 gallon. Therefore, the cost of materials per acre with Weedar 64 is $20/acre and with Renovate 3 is $75/acre, including the surfactant. The cost of professional application will vary depending on the total size of the project and the distance of mobilization.

References and Additional Information:

1. USDA (n.d.) *Plant Profile: Ludwigia peploides.* Retrieved from https://plants.usda.gov/core/profile?symbol=LUPE5

2. Invasive Plant Atlas. (n.d.) *Creeping waterprimrose Ludwigia peploides (Kunth) Raven*. Retrieved from https://www.invasiveplantatlas.org/subject.html?sub=5962

3. Center for Invasive Species. (n.d.) *Creeping waterprimrose Ludwigia peploides (Kunth) Raven.* Retrieved from https://www.invasive.org/browse/subinfo.cfm?sub=5962

4. CABI Invasive Species Compendium (n.d.) *Ludwigia peploides (water primrose)*. Retrieved from https://www.cabi.org/isc/datasheet/31673

5. Grewell, B.J., Netherland, M.D.& Skaer Thomason, M.J. (2016). *Establishing Research and Management Priorities for Invasive Water Primroses (Ludwigia* spp.*)*. USACE, Aquatic Plant Control Research Program: ERDC/EL TR-16-2.http://www.dtic.mil/dtic/tr/fulltext/u2/1002917.pdf

6. Harms, N.E. & Grodowitz, M.J. (2012). *Herbivorous Insects Associated with Ludwigia peploides (Onagraceae) in the Southern United States.* The Southwestern Naturalist 57(1):123-127. http://www.bioone.org/doi/abs/10.1894/0038-4909-57.1.123

7. Sartain, B.T. et. al. (2015). *Evaluation of six herbicides for the control of water primrose (Ludwigia peploides (Kunth) P.H. Raven* spp. *Glabrescens)*. Journal of Aquatic Plant Management 53(1):134-137.http://www.apms.org/wp/wp-content/uploads/japm-53-01-134.pdf

Figure 5.20
Ludwigia peploides (creeping waterprimrose)

Percent Cover (Number of Plots)

- 0 (367)
- 1 - 5% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.21 *LUDWIGIA PERUVIANA*, PERUVIAN PRIMROSE-WILLOW

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
58	15.76%	15.76%	WC	9.92

Alvin Diamond, Alabama Plant Atlas, describes this species as follows: *Peruvian primrose-willow is an introduced semi-woody perennial in the evening-primrose family (Onagraceae). It is native to South America, but is now a pantropical weed. In Alabama, it occurs in the southern third of the state. Peruvian primrose-willow grows in wet ditches, along streams and river, and around ponds and lakes. It is a large plant, reaching 12 feet in height. The stem is woody below and herbaceous above. It is usually killed back to ground level in our area. The woody portions of the stem have brown bark that peels in long, thin strips. The herbaceous portions of the stem are green in color and shaggy pubescent. The stem is branched from near the base, and often has spongy roots growing into the water from the lower portions of the stem if it is submerged. The leaves are alternate, short petiolate, lanceolate to elliptic in outline, and entire. Both surfaces of the leaves are pubescent with long hairs. Flowers are produced singly from the axils of the leaves. There are 4 triangular sepals and 4 yellow petals. The petals are lighter in color near their base and easily detached. The ovary is inferior. The fruit is a capsule. Peruvian primrose-willow is a fast-growing species that can clog waterways and hamper access to the shoreline of ponds and lakes. It is listed as an invasive plant in Florida.*

(Keener, B. R., A.R. Diamond, L. J. Davenport, P. G. Davison, S. L. Ginzbarg, C. J. Hansen, C. S. Major, D. D. Spaulding, J. K. Triplett, and M. Woods. 2018. ***Alabama Plant Atlas***. [S.M. Landry and K.N. Campbell (original application development), **Florida Center for Community Design and Research**. **University of South Florida**]. **University of West Alabama**, Livingston, Alabama.)

Peruvian primrose-willow (*Ludwigia peruviana)*

Photo from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (**http://florida.plantatlas.usf.edu/**). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

Peruvian primrose-willow (*Ludwigia peruviana)*

(Photo from: Keener, B. R., A.R. Diamond, L. J. Davenport, P. G. Davison, S. L. Ginzbarg, C. J. Hansen, C. S. Major, D. D. Spaulding, J. K. Triplett, and M. Woods. 2018. ***Alabama Plant Atlas***. [S.M. Landry and K.N. Campbell (original application development), **Florida Center for Community Design and Research**. **University of South Florida**]. **University of West Alabama**, Livingston, Alabama.)

General Recommendations:

- If hand-pulled, bag and dispose of plants and fruit in a landfill.
- Treat when plants are young to prevent seed formation.
- Pull, cut, and treat with herbicide when fruit are not present.
- Hand pull when soil is moist to ensure removal of all roots.

Specific Control Procedures:

Foliar Treatment. When plants are green and growing, but preferably prior to seed formation, treat leaves with the following:

- Glyphosate as a 2% solution in water + a non-ionic surfactant + blue indicator dye.

Cut Stem Treatment. Cut stems just above the soil surface and ***immediately*** treat the freshly cut stem with one of the following:

- Glyphosate as a 20% solution in water + a non-ionic surfactant + blue indicator dye.
- Garlon 3A as a 20% solution in water + a non-ionic surfactant + blue indicator dye.

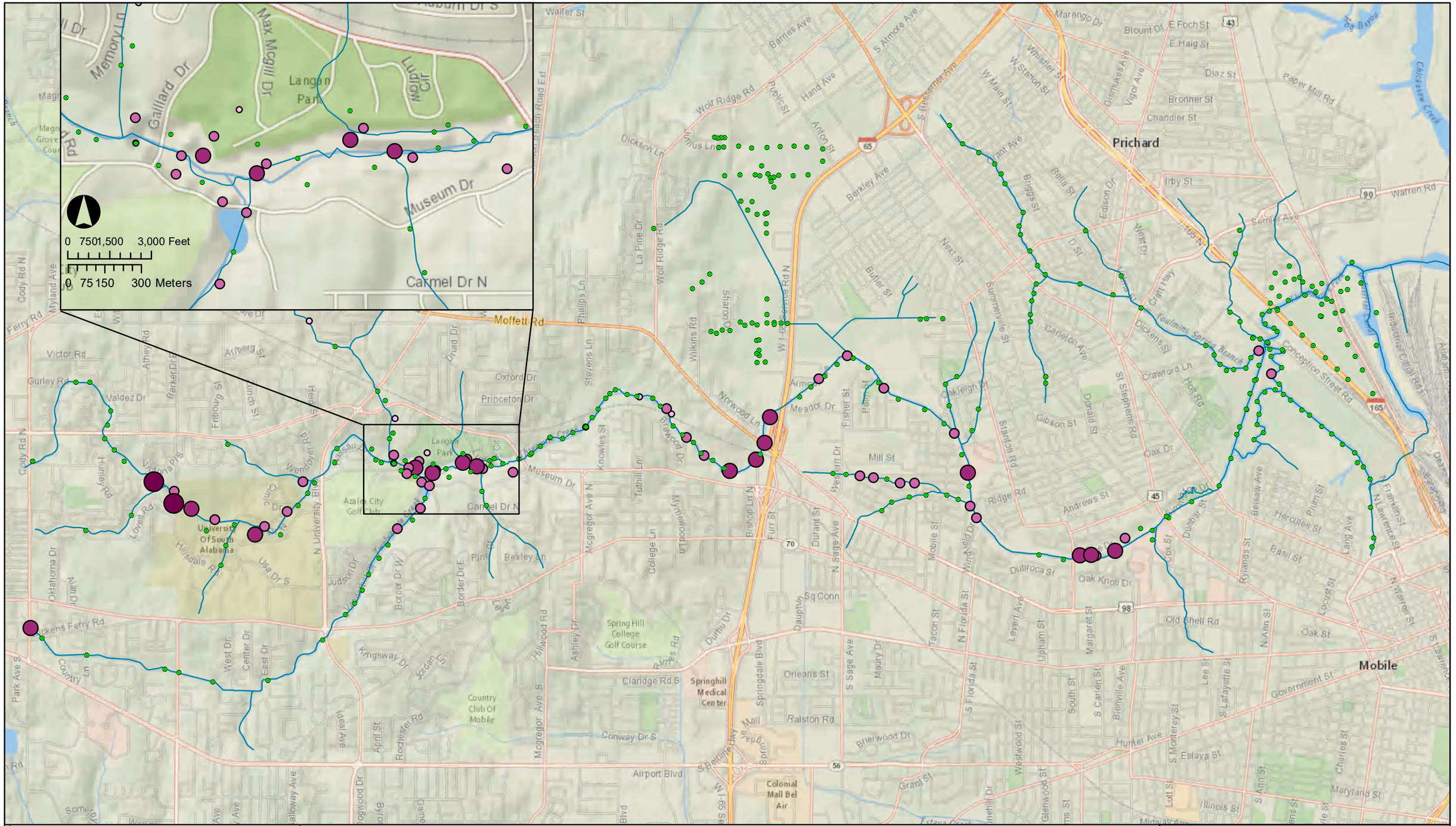

Figure 5.21
Ludwigia peruviana (Peruvian primrose-willow)

Percent Cover (Number of Plots)

- 0 (310)
- <1% (7)
- 1 - 5% (34)
- 6 - 25% (15)
- 26 - 50% (2)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Date: 2/25/2019

Basemap courtesy of Esri.

5.22 *LYGODIUM JAPONICUM,* JAPANESE CLIMBING FERN

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
85	23.10%	3.24%	1	6.37

This vine is a true perennial fern that climbs and twines and can grow up to 27 m (90 ft.) long. It often forms mats that cover shrubs and trees. Leaves are lacy and finely divided along thin, wiry stems that range from green to orange to black in color. In sheltered areas, fronds may remain green through winter; otherwise, fronds typically die back and turn tan to brown in winter. New growth appears in mid to late spring from underground slender, dark brown to black, wiry rhizomes, which must be killed to eradicate the plant. This fern spreads by rhizomes and by wind-dispersed spores. (The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Sterile Frond Fertile Frond

Japanese climbing fern (*Lygodium japonicum)*

General Recommendations:

- If pine straw is to be used for mulch, check to be sure it is not contaminated with climbing fern.
- Use of pine bark mulch instead of pine straw is an option that minimizes the risk of introducing climbing fern into landscape beds.
- Plant material with fertile fronds should be bagged and sent to the landfill.
- Herbicide treatments and hand removal should be timed to occur when plants are young to prevent spore formation.

Specific Control Procedures:

Hand Removal. When only an occasional plant is present, these can be dug up with a shovel, taking care to remove the entire root system, bagged, and sent to a landfill. If fertile fronds are present, these should be removed and bagged as well.

Foliar Treatment. In *July to September* before spore release, thoroughly wet all leaves to as high as safe with the following:

- Glyphosate as a 2% solution in water + a non-ionic surfactant + blue indicator dye.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.22
Lygodium japonicum (Japanese climbing fern)

Percent Cover (Number of Plots)

- 0 (283)
- <1% (36)
- 1 - 5% (42)
- 6 - 25% (6)
- 26 - 50% (1)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.23 *MELIA AZEDARACH*, CHINABERRY

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
6	1.63%	7.17%	WC	0.98

Chinaberry historically was planted as a fast-growing ornamental shade tree on homesites. It has escaped cultivation and become widely established. It is a deciduous tree up to 50 ft. tall with compound leaves and toothed leaflets. Flowers grow in showy, tiny, lavender, open clusters in spring. Fruits are pulpy, round, yellowish, and persist on the tree through the winter. Fruits are eaten and spread by birds.

Chinaberry (*Melia azedarach*)

Chinaberry (*Melia azedarach*)

General Recommendations:

- Young plants should be removed before they begin producing seeds.
- Small seedlings and young saplings can be pulled by hand and with a weed wrench in moist soil conditions and if infestation is not too dense to make hand removal impractical. If the entire root is not removed, re-sprouting is likely.
- Remove ornamental plantings from landscapes and control root and stump sprouts and seedlings.
- Bag and dispose of seeds in a landfill.

Specific Control Procedures:

Large Trees. Any time *except March and April*, do one of the following:

- Make stem injections using undiluted Garlon 3A in cut-spacings specified on the herbicide label.
- Cut the tree down with a chainsaw or hand saw, then ***immediately*** apply Garlon 3A as a 30% solution mixed in water to the stump tops.
- Cut the tree down with a chainsaw or hand saw, then ***immediately*** apply Garlon 4 as a 25% solution mixed in vegetable oil to the stump tops.

Saplings. Any time *except March and April*, do one of the following for saplings up to 4 in. in diameter:

- Apply a basal spray using Garlon 4 as a 30% solution in vegetable oil. Solution should be applied from ground level to approximately 30 cm (12 in.) above ground all the way around the stem.

Seedlings and Small Saplings. *July to October*, thoroughly wet all leaves with one of the following:

- Garlon 3A as a 2% solution in water + non-ionic surfactant + blue indicator dye
- Garlon 4 as a 2% solution in water + non-ionic surfactant + blue indicator dye

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

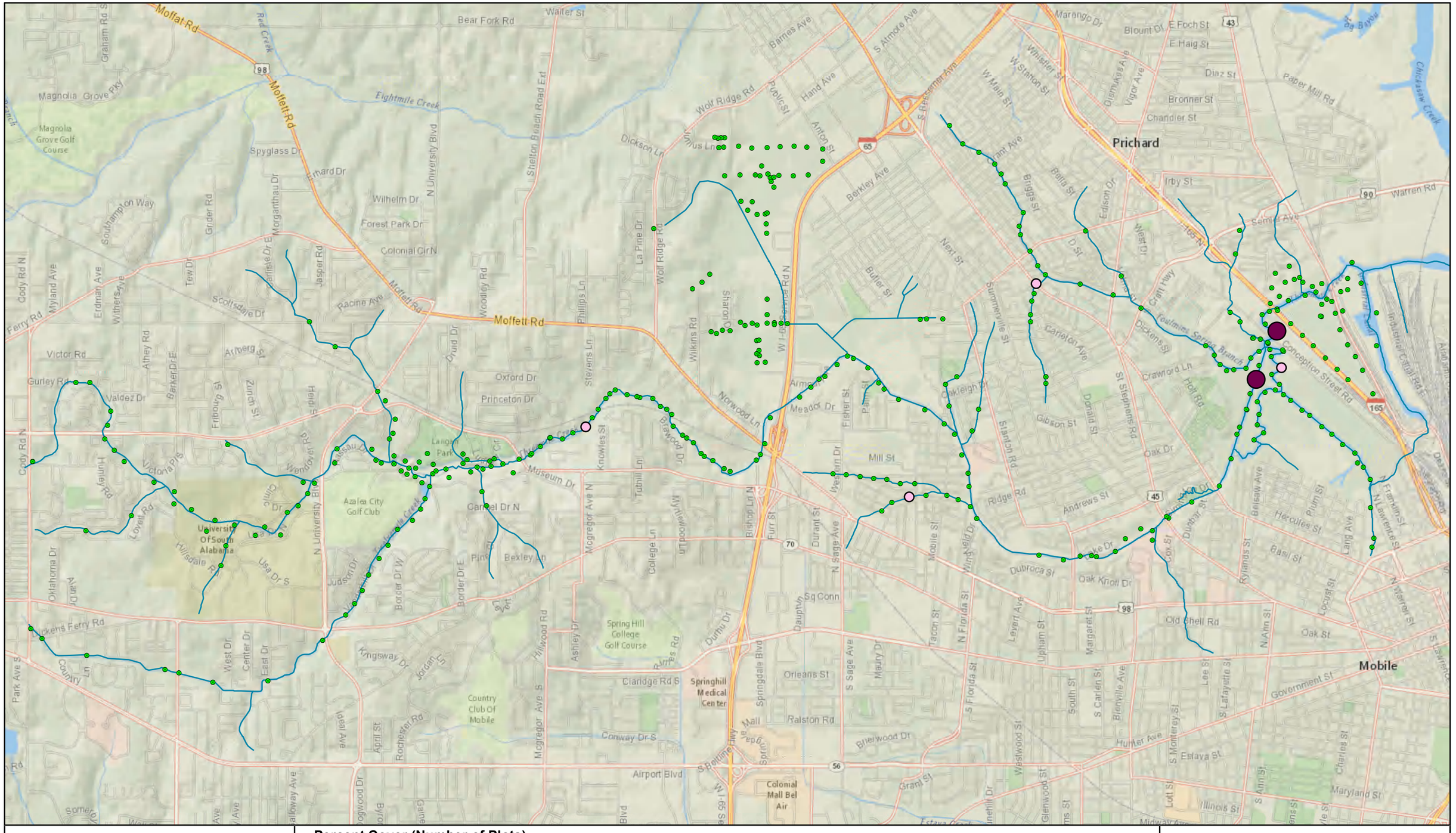

Figure 5.23
Melia azedarach (Chinaberry)

Percent Cover (Number of Plots)

- 0 (362)
- 1 - 5% (4)
- 6 - 25% (2)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.24 *MORUS ALBA,* WHITE MULBERRY

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
26	7.07%	12.13%	WC	7.56

Alvin Diamond, Alabama Plant Atlas, gives the following description: *White mulberry is an introduced deciduous tree that is native to eastern Asia, but has been widely planted as food for silkworms, for food, and as a shade tree. It can be found throughout Alabama. It grows as a shrub or tree up to 50 feet tall. The bark on older trunks is brown and furrowed, with long narrow ridges. Young shoots have prominent reddish, elliptic lenticels. Leaves are alternate, petiolate, ovate in outline, with serrate margins. Leaves on vigorous stems are often deeply and irregularly lobed. The upper surface of the leaf is glabrous or sparsely pubescent and shiny. The lower surface of the leaf is glabrous or with hairs along the major veins or in tufts in the axils of major veins. Flowers are produced in greenish-yellow catkins. The fruit is a fleshy compound fruit composed of the fruits of several flowers. At maturity the fruit are white, purple, or black in color. Many species of wildlife, especially birds, consume the fruit and disperse the seeds. White Mulberry is quite variable and often confused with our native Red Mulberry (*Morus rubra*). Red mulberry tends to be more "tree-like" in growth form with leaves that are pubescent on both surfaces and rough to the touch on the upper surface. The upper surface of red mulberry leaves tends to be dull and not lustrous in appearance. Some individuals are intermediate in characteristics and are of possible hybrid origin (description provided by Alvin Diamond,* http://www.floraofalabama.org/Plant.aspx?id=2680).

White mulberry (*Morus alba*)

(Photos from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (**http://florida.plantatlas.usf.edu/**). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

General Recommendations:

- Young plants should be removed before they begin producing seeds.
- Small seedlings and young saplings can be pulled by hand and with a weed wrench in moist soil conditions and if infestation is not too dense to make hand removal impractical. If the entire root is not removed, re-sprouting is likely.
- Remove ornamental plantings from landscapes and control root and stump sprouts and seedlings.

Specific Control Procedures:

Large Trees. Do one of the following:

- Make stem injections using Garlon 3A as a 15% solution in water in cut-spacings specified on the herbicide label.
- Cut the tree down with a chainsaw or hand saw, then ***immediately*** apply Garlon 3A as a 30% solution mixed in water with a surfactant to the stump tops.
- Cut the tree down with a chainsaw or hand saw, then ***immediately*** apply Garlon 4 as a 25% solution mixed in vegetable oil to the stump tops.

Saplings. Do the following for saplings up to 10 cm (4 in.) in diameter:

- Apply a basal spray using Garlon 4 as a 20% solution mixed in vegetable oil. Solution should be applied from ground level to approximately 30 cm (12 in.) above ground all the way around the stem.

Seedlings and Small Saplings. *July to October*, thoroughly wet all leaves with one of the following:

- Garlon 3A as a 2% solution in water + non-ionic surfactant + blue indicator dye.
- Garlon 4 as a 2% solution in water + non-ionic surfactant + blue indicator dye.
- Glyphosate as a 3% solution in water + non-ionic surfactant + blue indicator dye.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.24
Morus alba (white mulberry)

Percent Cover (Number of Plots)

- 0 (342)
- <1% (3)
- 1 - 5% (7)
- 6 - 25% (14)
- 26 - 50% (2)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.25 *MURDANNIA KEISAK*, MARSH DEWFLOWER

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
3	0.82%	14.67%	2	1.05

Mats of marsh dewflower encroaching into a creek. (J. Fabian)

Imported via contaminated seed from its native eastern Asia, marsh dewflower (*Murdannia keisak*) was first reported in South Carolina's rice fields in 1935. Now, this annual emergent member of the spiderwort family has invaded the shores of lakes and slow-moving streams, freshwater tidal marshes, and roadside ditches in the southeastern and northwestern United States. It favors disturbed and nutrient-rich sites. In the late summer, small pink flowers appear with three petals each. The fruit produce very abundant seeds that are readily consumed and spread by waterfowl. Dewflower also reproduces vegetatively via stem fragments that produce adventitious roots at each node. This plant is also spread by man for inclusion in aquaria and ornamental water gardens. Alternate, lance-shaped leaves grow from nodes on succulent, prostrate stems forming dense mats that overwhelm and shade native plant species. For instance, Dewflower caused the extinction of Taiwan wild rice (*Oryza perennis formosana*) and threatens several rare native plants in Oklahoma. Its thick mats and fibrous roots can restrict recreation, navigation, and water flow.

The lanceolate leaves and distinctive fall flowers of the marsh dewflower. (B.E. Wafford)

Marsh dewflower is well-established in the lakes at Langan Park and Spring Hill Lake. The key to preventing further spread of this invasive species into TMC Watershed is thorough scouting each spring. Hand pulling of small areas of dewflower can provide successful control if conducted prior to seed production and without allowing fragments to escape. This aggressive plant is hard to control once established, and there are no biological control agents to weaken dewflower at this time. However, because it is a common weed in rice cultivation, herbicide control has been investigated. The repeated use of glyphosate and/or triclopyr is commonly practiced with good success if applied before seeds are set in late summer.

Specific Control Procedures:

Scouting the waterways each spring for new locations of dewflower is a crucial tool followed by immediate hand removal of new infestations and careful disposal of plant material. The only effective recourse for the control of large established mats is the repeated use of herbicides in the spring and early summer. Use one gallon of Renovate 3 (44.4% triclopyr) and/or one gallon

of Rodeo (53.8 % glyphosate) in 50-100 gallons of spray mixture per acre plus 8 ounces to 32 ounces of Kinetic, a non-ionic surfactant on mats of dewflower.

Cost Estimates:

Renovate costs $140 per gallon, Rodeo costs $30 per gallon, and Kinetic costs $40 a quart, so the cost of materials will vary from $70 to $210 depending on the spray mixture. The cost of a professional application will depend on the total size of the project and the distance of mobilization.

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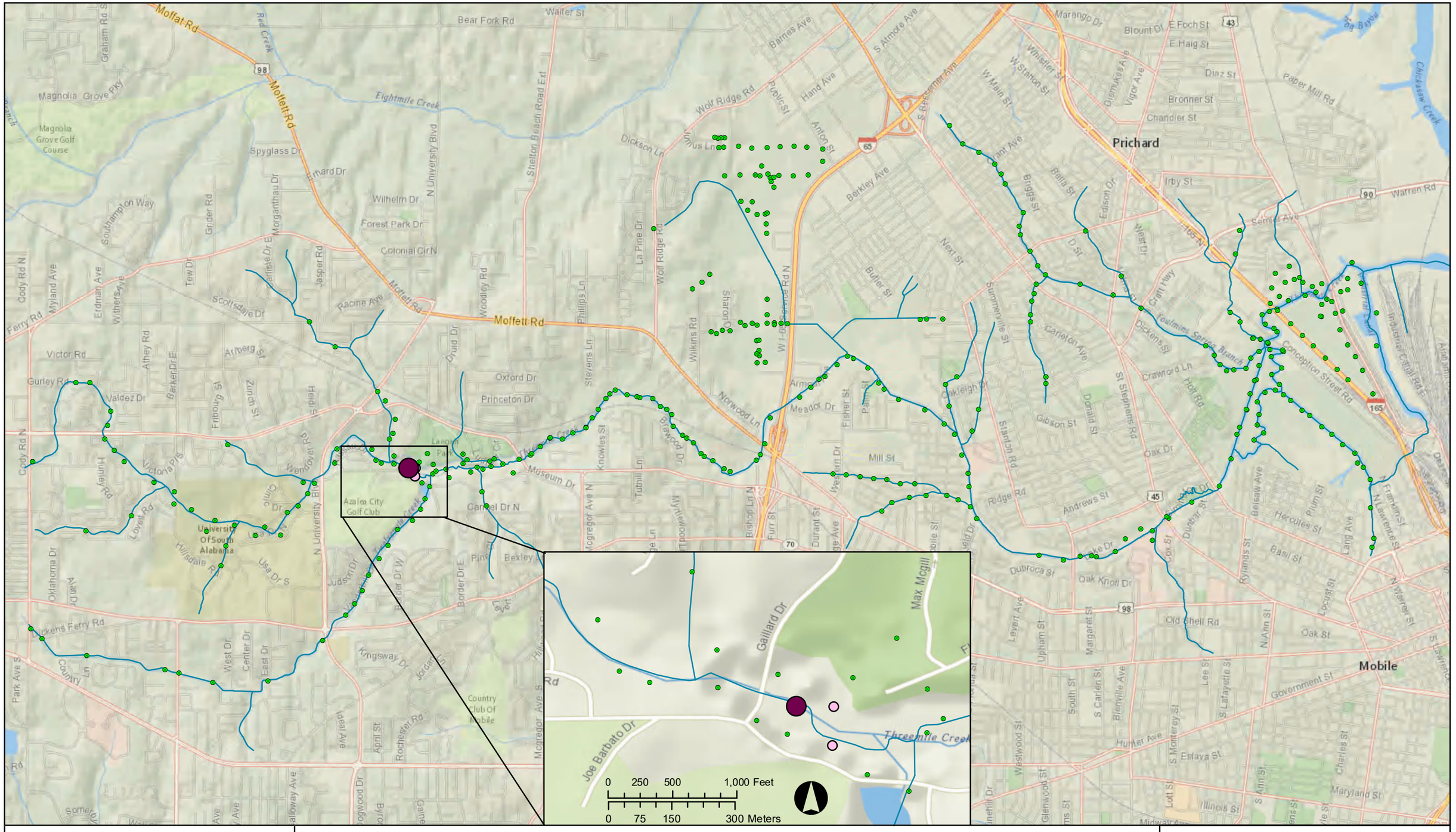

Figure 5.25
Murdannia keisak (marsh dewflower)

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Basemap courtesy of Esri.

5.26 *MYRIOPHYLLUM AQUATICUM*, PARROTFEATHER

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
4	1.09%	17.38%	1	1.67

The bright-green leaves of parrotfeather have a filiform feathery appearance. (USDA)

Parrotfeather (*Myriophyllum aquaticum*) is a perennial plant native to South America's Amazon River Basin. Because of its interesting foliage and ease of cultivation, this popular aquarium and aquatic garden plant has escaped cultivation and now thrives in nutrient-rich freshwater lakes and streams throughout the warm regions of the world. Four to five feathery leaves form dense whorls along cylindrical stems that can grow up to five feet long. These decumbent stems become erect and leafy at the ends which can extend up to one foot above the surface of the water. Outside of its native range, only female plants exist, displaying small pinkish-white flowers. Consequently, no seeds are produced in the U.S. so reproduction depends entirely on fragmentation.[1,2]

Relying primarily on human dispersal, parrotfeather rapidly invades new areas and forms dense canopies that block sunlight, impede gas exchange, provide habitat for mosquito reproduction, and displace native plants that are more valuable to fish and wildlife. By reducing water flow, these sprawling mats can impair irrigation and increase the duration and intensity of floods. Recreational and commercial boating activities are greatly impeded, as well. Taken together, there is little wonder that the U.S. Fish and Wildlife Service's ecological risk assessment is "high."[3,4]

The intertwining floating stems of parrotfeather create obstructive rafts of vegetation. (C Haden)

Specific control Procedures:

Physical/Mechanical Control

Hand removal of small infestations of parrotfeather can be successful if all of the plant material is carefully contained. Because fragmentation is this invader's only mode of reproduction, any plant segments that escape will simply exacerbate colonization.

Biological Control

The general robust health of parrotfeather, both here and in its native range, indicates a hardy resistance to biological control. The grass carp (*Ctenopharyngodon idella*) does not prefer to consume parrotfeather. Therefore, using this herbivorous fish on this target species has been unsuccessful. In Argentina, a flea beetle, *Lysathia flavipes*, and a weevil, *Listronotus marginicollis,* cause moderate damage to parrotfeather. In the U.S., larvae of the watermilfoil leaf cutter moth (*Parapoynx allionealis*) mine its leaves. Milfoil weevils (*Euhrychiopsis lecontei*) also cause damage. Two fungi, *Rhizoctonia solani* and *Pythium carolinianaum*, can reduce the growth rate of parrotfeather, but they are also pathogenic to ornamental plants and agricultural crops.

Chemical Control

While parrotfeather is susceptible to a number of herbicides, it is very hard to eradicate. Multiple treatments are necessary. The two herbicides that stand out in terms of efficacy are the old standby 2,4-D and the newer herbicide imazapyr. Both liquid and granular 2,4-D have produced excellent results. Six weeks after treatment, foliar application of 2,4-D resulted in ≥ 90% biomass reduction of Parrotfeather in one comparative study of seven herbicides. In another study, foliar application of imazapyr resulted in complete control after 10 weeks, and there was no regrowth. A non-ionic surfactant is required.[5,6,7,8]

Summary with Specific Recommendations:

Because of the low cost and greater selectivity, use ½ gallon of Weedar 64 (46.8% 2,4-D amine) and 8 ounces to 32 ounces of Kinetic, a non-ionic surfactant, in 50-100 gallons of spray mixture for foliar applications to Parrot Feather. It is likely that multiple applications will be required. If that fails, use Habitat (27.77% imazapyr) but take care to avoid non-target damage to desirable plants, including shoreline trees.

Cost Estimates:

Weedar 64 costs $25 per gallon and Kinetic, a non-ionic surfactant, costs $30 gallon. Therefore, the cost of materials per acre with Weedar 64 is $20/acre. The cost of a professional application will depend on the size of the project and distance of mobilization.

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Figure 5.26
Myriophyllum aquaticum (parrotfeather)

Percent Cover (Number of Plots)

- 0% (364)
- <1% (1)
- 6 - 25% (2)
- 26 - 50% (1)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.27 *MYRIOPHYLLUM SPICATUM*, EURASIAN WATERMILFOIL

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
11	2.99%	23.68%	1	6.24

A dense canopy of Eurasian watermilfoil dominates other submersed species. (J Topic)

There is some debate about its native range, Eurasia or Northern Africa, and about when it arrived in the U.S., late 1800s or 1942, but there is no disputing the fact that Eurasian watermilfoil (*Myriophyllum spicatum*) is the most widespread, invasive aquatic plant in North America. This perennial submersed invader produces smooth stems up to 6 m (20 ft.) in length anchored by fibrous roots in the bottom sediment. Whorls of four feather-like leaves are arranged along the slender stems. Flowers appear on erect emersed spikes. EWM reproduces sexually and asexually. Fragmentation appears to be the dominant mode of reproduction, but EWM's seed bank may be an important survival mechanism in harsh environments. EWM is cold hardy and tolerant of a variety of water quality conditions.[1,2]

EWM has persisted in Gulf of Mexico estuaries for decades. First documented in the Mobile Bay area in 1975, EWM consistently dominates and replaces submersed native species in the region by rapidly forming dense canopies and "shading out" the competition. Dissolved oxygen levels plummet at night under these canopies impairing fish and invertebrate habitat. Upon the decomposition of this plant's substantial biomass, dissolved oxygen is further diminished. In addition, EWM has less wildlife value than the native plants it displaces. Finally, dense stands of Eurasian Watermilfoil block navigation, obstruct recreational activity, and clog water intakes.[3]

Eurasian watermilfoil's deeply divided leaves are soft, feather-like, and about two inches long. (TVA)

Specific Control Procedures:

Physical/Mechanical Control

Eurasian watermilfoil spreads via plant fragments on boats, boat trailers, and by water currents. EWM even breaks apart naturally as a means of dispersal. Therefore, the use of physical removal or mechanical harvesting usually backfires. Harvesters have been used to quickly mow large infestations, but this expensive technique must be repeated several times a year. The use of water level fluctuation in the form of extreme drawdowns has had some temporary success in controlling EWM.[4]

Biological Control

Grass carp (*Ctenopharyngodon idella*) can control EWM but only at stocking rates high enough to eliminate most desirable plant species. The native milfoil weevil (*Euhrychiopsis lecontei*) has been employed since the 1990s to reduce the growth rate of EWM. A native strain of the fungal plant pathogen *Mycoleptodiscus terrestris* has been used to control EWM, alone and in combination with herbicide treatments. Native to Europe, the water veneer moth (*Acentria ephemerella*) has caused significant declines in EWM densities in the Great Lakes, allowing native plants to make a strong recovery.[5]

Chemical Control

The standard herbicide control method for Eurasian watermilfoil has been the use of Navigate (granular 2,4-D BEE) via a granular blower or cyclone spreaders mounted on airboats. This technique has resulted in effective and selective control of EWM. Recently, the use of a newer, auxin mimicking herbicide has gained attention. Renovate OFT (granular triclopyr) has been used successfully to control EWM with great selectivity but at more expense.[6,7]

Typically, whorls of four leaves each appear along the stem of EWM. (TVA)

Summary with Specific Recommendations:

Physical and mechanical control would likely backfire because of the creation of numerous viable fragments. The introduction of biological control insects into TMC Watershed to weaken EWM would be entirely experimental. The current range of these insects is at least 644 km (400 miles) north of Mobile. Therefore, the most practical technique for EWM control would be the application of 6-10 lbs. of Navigate per acre-foot of water. An alternative would be the use of 14-67 lbs. of Renovate OTF per acre-foot. Granular herbicides are recommended because some flow is expected and both herbicides require intermediate contact time. For best results, treat in the spring when the EWM starts to grow and make a second treatment upon signs of recovery.

Cost Estimates:

The cost of the herbicide materials varies greatly. Given Navigate costs ~$4.00 per pound, the cost per treatment would be $24-40 per acre-foot. Given Renovate OTF costs ~8.00 per pound, the cost per acre-foot would be $112-536. Consequently, the use of Navigate is recommended. The price of professional application of these products will depend on the area treated, mobilization distance, and concurrent tasks in TMC Watershed.

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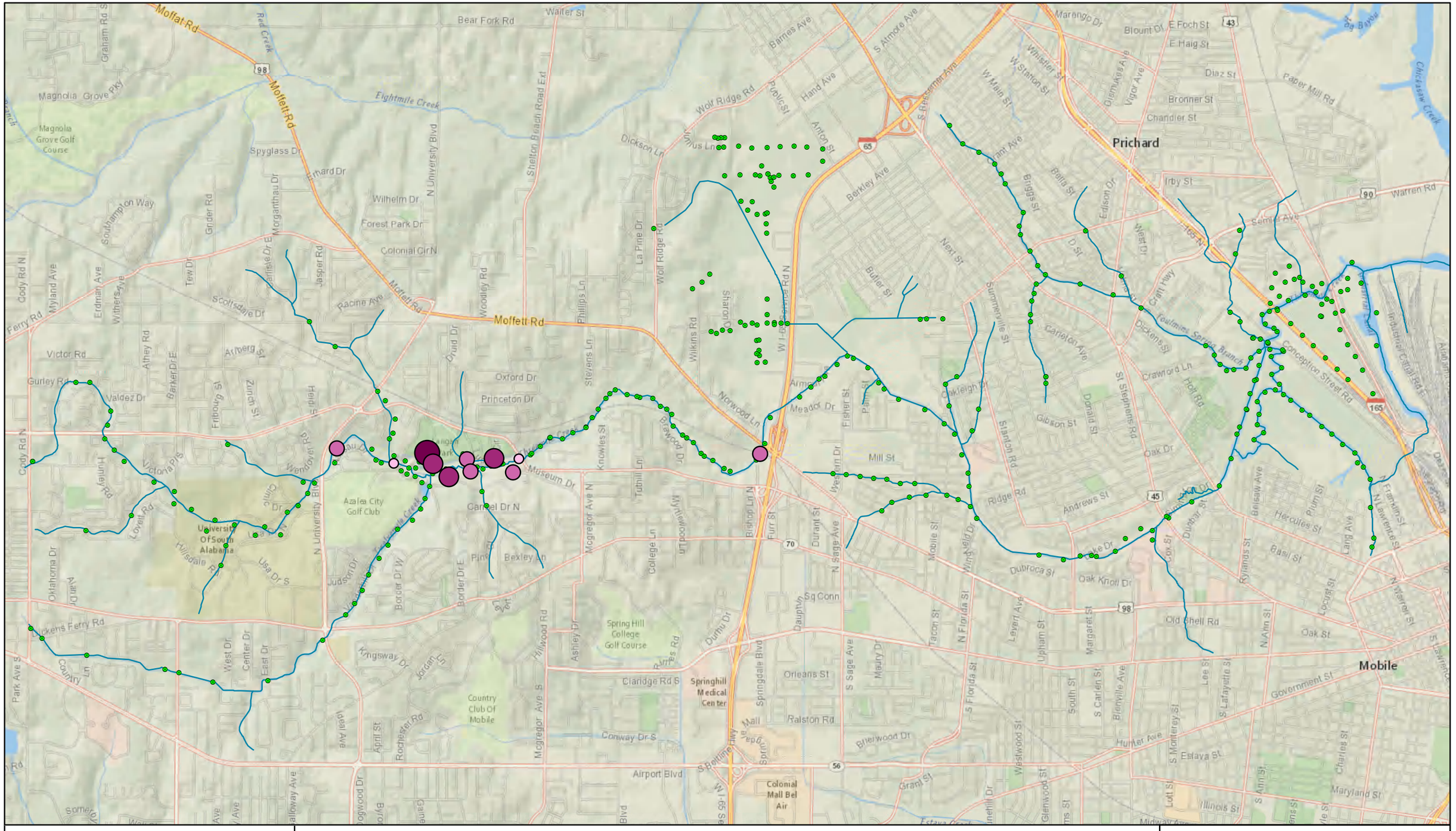

Figure 5.27
Myriophyllum spicatum (Eurasian watermilfoil)

Percent Cover (Number of Plots)

- 0% (357)
- 1 - 5% (2)
- 6 - 25% (5)
- 26 - 50% (3)
- 51 - 75% (1)

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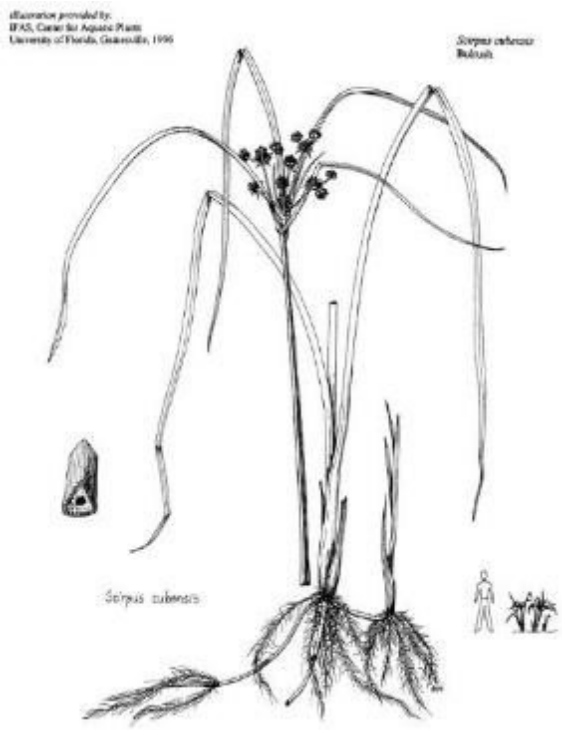
Basemap courtesy of Esri.

5.28 *OXYCARYUM CUBENSE*, CUBAN BULRUSH

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
8	2.17%	9.25%	2	1.77

Cuban bulrush, also called burhead sedge, spreads by thin reddish rhizomes and typically forms patches where it occurs. It is common in freshwater marshes of north and central Florida. A small infestation has also been found in Langan Lake. This species grows 0.45 to 0.9 m (1.5 to 3 ft.) tall. Stems are sharply triangular and smooth. Cuban bulrush is very leafy. Leaves grow from the base of the plant and are approximately 6 mm (0.25 in.) wide and 0.9 to 1.2 m (3 to 4 ft.) long, many being longer than the stem of the inflorescence, which is at the tip of the stem. A distinctive feature of the inflorescence is the long leaf-like bracts that spread around the base of the inflorescence. The best way to differentiate Cuban bulrush from other sedges in the genus *Cyperus* is that Cuban bulrush has 1 to 6 dense, burr-like clusters of flowers/fruits while other *Cyperus* species do not. (Source of the above information: http://plants.ifas.ufl.edu/plant-directory/oxycaryum-cubense/)



Cuban bulrush (*Oxycaryum cubense*)

(Line drawing from: https://plants.ifas.ufl.edu/manage/why-manage-plants/floridas-most-invasive-plants/cuban-club-rush/)

Cuban bulrush (*Oxycaryum cubense,* syn. *Cyperus blepharoleptos*)

(Photo from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (**http://florida.plantatlas.usf.edu/**). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

Cuban bulrush (*Oxycaryum cubense*) at Langan Lake

General Recommendations:

- Learn to distinguish this sedge from other native sedges in the area.
- Herbicide labeled for aquatic application must be used.

Specific Control Procedures:

Manual Removal.

- Since this sedge grows in floating mats or in a soft, mucky substrate and coverage is limited, it may be possible to simply pull it up, toss it onto the lake bank to dry, then bag the plant material and send it to the landfill.

Foliar Treatment. When *actively growing* and at least 0.15 to 0.3 m (0.5-1 ft.) high, thoroughly wet all leaves with the following:

- If rooted in the substrate or along lake banks, a glyphosate product labeled for aquatic use as a 2-5% solution in water + flumioxazin (Clipper) at a rate as prescribed on the label + a non-ionic surfactant + blue indicator dye. Repeat applications may be necessary.
- For floating mats, Diquat as a 0.5% solution in water + a non-ionic surfactant + blue indicator dye.

(Control recommendations are based on personal communication with Dr. Stephen Enloe, University of Florida, Agronomy Department/Center for Aquatic and Invasive Plants and Matt Phillips, Florida Fish and Wildlife Conservation Commission.)

Figure 5.28
Oxycarum cubense (Cuban bulrush)

Percent Cover (Number of Plots)

- 0% (360)
- 6 - 25% (4)
- 1 - 5% (4)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.29 *PANICUM REPENS*, TORPEDOGRASS

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
66	17.93%	7.13%	2	11.23

A monoculture of torpedograss dominates a Florida lake's shoreline. (A Murray)

Torpedograss, a perennial grass that can grow three feet tall, was brought to America in the late 1800s as a forage crop. The U. S. Department of Agriculture went so far as to distribute seeds of this hardy native of Africa and Eurasia to cattle ranchers. Now, it is well-established in the Lower Coastal Plain of the Southeastern United States from South Carolina to Texas and also infests parts of California and Hawaii. This aggressive invader prefers wet riparian areas but can also be found in lawns, pastures, sand dunes and in water up to 10 feet deep. Its range is limited by cold temperatures but not by fire or moderate salinities. Torpedograss reproduces vegetatively and derives its common name from the hard pointed tips of its creeping rhizomes that punch through surrounding soil to claim more territory. Fragments of this plant are quite viable and can float downstream or be inadvertently transported in fill. Seeds are produced in considerable numbers but are generally non-viable.[1,2]

Specific Control Procedures:

Biological Control

Aside from grazing animals, such as cattle, sheep and goats, there are no useful biological control agents for torpedograss at this time. High stocking rates of grass carp (*Ctenopharyngodon idella*) have reduced this plant's density in aquatic sites but only after the more preferred, native species have been eliminated. Pathogenic fungi have been evaluated but none have proven to be effective. Finally, no host-specific insects have been identified.[2]

Branched, open inflorescences are about 8–18 cm (3-7 in.) long. (V. Ramey)

Physical/Mechanical Control

While a healthy, diverse ecosystem deters infestation, torpedograss readily invades disturbed areas following land clearing, mowing and burning. Mowing is ineffective, and infrequent disking may actually enhance the abundance of torpedograss via rhizome fragmentation. A single disking, however, may be useful in increasing the efficacy of a subsequent herbicide application. Carefully cleaning machinery helps prevent the spread of viable fragments.[2]

Chemical Control

The use of Rodeo (53.8% glyphosate) has been the mainstay of torpedograss control. A tank mix of 2-3% glyphosate with 0.25% non-ionic surfactant plus an indicator dye is quite effective. Thoroughly wet all leaves when the grass is at least 30-45 cm (12-18 in.) tall and actively growing. Treat older stands from June to September. Torpedograss eradication requires multiple applications, especially when the plant is partially submerged. Non-target damage via herbicide drift may occur during a wind or temperature inversion (winds below 3.2 km/hr. (2 mph)) or when wind speeds exceed 16 km/hr. (10 mph). Lower pump pressures and larger droplet sizes help reduce drift and non-target damage. Avoid treating when rain is predicted because glyphosate requires at least six hours of contact time to kill torpedograss.[3]

Recently, Habitat (27.77% imazapyr) has been combined with glyphosate to improve the longevity of torpedograss control. Two-to-five years of control have been reported using this combination. Instead of using 7.5 pints /acre of glyphosate alone, this option involves applying six pints of glyphosate plus two pints of imazapyr per acre. Two pints per acre of a non-ionic surfactant are required in both cases. Because imazapyr is active in soils, it is important to avoid spraying near the bases of desirable trees. Both glyphosate and imazapyr are non-selective systemic herbicides, so caution is advised regarding non-target damage.[4,5]

Torpedograss invades a lake in Orlando, Florida. (Orange County EPD)

Summary with Specific Recommendations:

Torpedograss is a challenging species. Physical, mechanical, and biological control options have limited success. Long term success depends upon repeated herbicide applications to known sites and thorough scouting for new infestations to address. Use Rodeo (glyphosate) or Rodeo (glyphosate) plus Habitat (imazapyr) to control this highly invasive species. Apply glyphosate at 120 oz./ac alone (2-3%) or imazapyr at 16 oz. /ac (0.5%) + 96 oz. /ac (2.5%) glyphosate.

Cost Estimates:

Rodeo costs $30 per gallon and Habitat $125 per gallon. Therefore, the herbicide costs for Rodeo alone would be $28 per acre, while the combination of Rodeo plus Habitat would be $54 per acre. Generic products are available for both herbicides so prices can be reduced. At $16 per gallon, the cost of the non-ionic surfactant would be $2 per acre. Bullseye Spray Pattern Indicator, a non-staining blue liquid colorant, costs about $50 gallon, so its cost would be $5 per acre. Therefore, the cost of materials for treating torpedograss with Rodeo would be $35 per acre, while the combination of Rodeo and Habitat would cost $61 per acre.

The majority of expense for torpedograss control will go for the professional application of herbicides. The cost of mobilization of a truck and airboat to the Mobile area could add as much as $200 per acre depending on the total area treated. Combining the treatment of various target plants would result in significant cost reductions.

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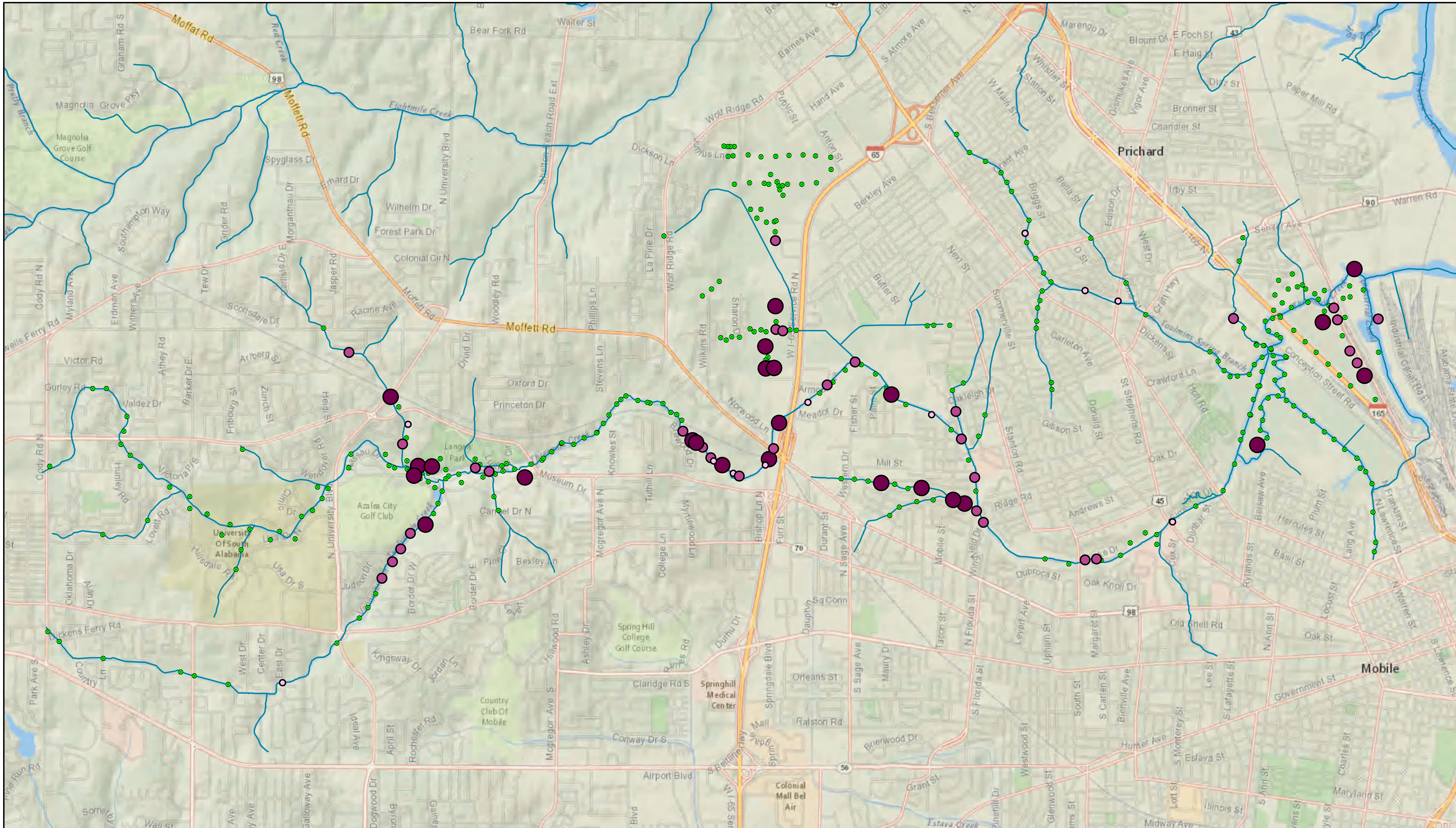

Figure 5.29
Panicum repens (torpedograss)

Percent Cover (Number of Plots)

- 0% (302)
- <1% (11)
- 1 - 5% (31)
- 6 - 25% (24)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\TorpedoGrass.mxd

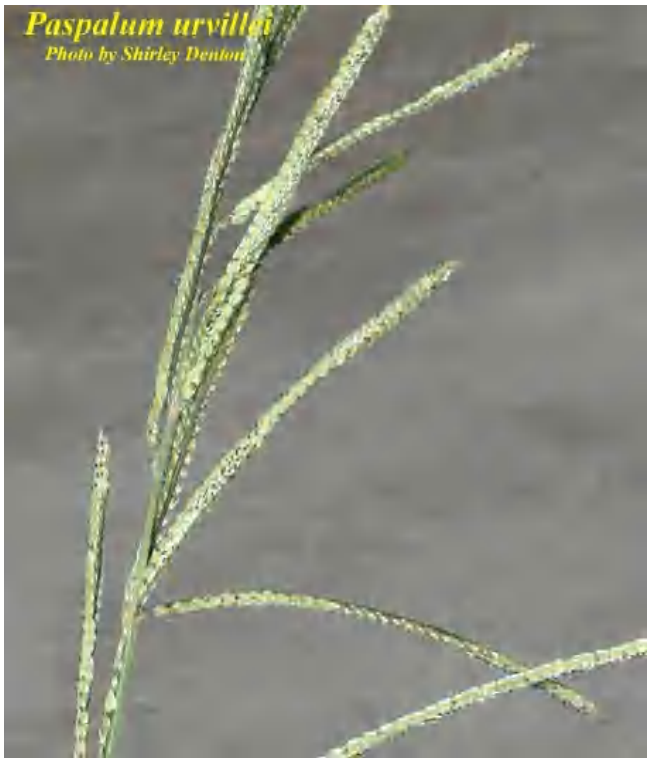
Date: 2/26/2019

Basemap courtesy of Esri.

5.30 *PASPALUM URVILLEI*, VASEY'S GRASS

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
47	12.77%	4.76%	2	5.36

This erect, coarse, tufted perennial grass grows up to 2.1 m (7 ft.) tall, sometimes branching. Lower leaf sheaths are sometimes hairy. Leaf blades are usually about 0.6 m (2 ft.) long by 2 cm (0.8 in.) wide and are hairy at the base. Panicles (flower/seed heads) are erect, with 20 or so spikes (racemes) per stem, densely arranged. Seeds are round and flat. This grass is native to South America. It is commonly found in disturbed habitats.



Vasey's grass (*Paspalum urvillei*)

General Recommendations:

- Learn to distinguish this grass from other native grasses that look similar.
- Seed production can be stopped by mowing, burning, or herbicide treatments in early stages of flowering or even shortly before flowering.
- If this grass is growing in or very near water, herbicide labeled for aquatic application should be used.

Specific Control Procedures:

Foliar Treatment. When grass is *actively growing* and at least 15-30 cm (0.5-1 ft.) high, or for older growth, treat from *June to September*, thoroughly wet all leaves with the following:

- Glyphosate as a 2-5% solution in water + a non-ionic surfactant + blue indicator dye. Two applications per growing season (just before flowering in spring and again in late summer to regrowth) may be necessary.

Figure 5.30
Paspalum urvillei (Vasey's grass)

Percent Cover (Number of Plots)

- 0% (321)
- 1 - 5% (29)
- 26 - 50% (1)
- <1% (11)
- 6 - 25% (6)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Date: 2/26/2019 Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\Vaseys.mxd

Basemap courtesy of Esri.

5.31 *PUERARIA MONTANA*, KUDZU

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
14	3.80%	17.11%	1	4.2

Kudzu is a well-known deciduous, twining, trailing, mat-forming, woody vine in the pea family. It grows 10 to 30 m (35 to 100 ft.) long and forms dense infestations along forest edges and roadsides, in old fields, and other sunny, disturbed habitats. Leaves have three leaflets with variable lobes. Slender tight clusters of white and violet pea-like flowers appear in midsummer. Dangling flat peapods form in fall. Pods fall unopened, and seed are variable in viability across the region. Kudzu spreads by vines rooting at the nodes and by wind-, animal-, and water-dispersed seeds. Large semi-woody tuberous roots reach depths of 1 to 5 m (3 to 16 ft.). The target of control on older plants is a knot- or ball-like root crown on top of the soil surface where vines and roots originate. (The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Kudzu (*Pueraria montana)*

Kudzu (*Pueraria montana)*

General Recommendations:

- Treat with herbicide when plants are young to prevent spread.
- Root crowns can be removed with mattocks, hoes, and saws; removal of the tuberous taproot is not required for control.

Specific Control Procedures:

Foliar Treatment. In *July to early September* for successive years, thoroughly wet all leaves, including those on climbing vines, as high as possible with one of the following:

- Milestone VM as a 0.5% solution in water + blue indicator dye.

Or, for partial control and no soil activity, repeatedly apply one of the following *during the growing season*:

- Garlon 4 as a 4% solution in water + a non-ionic surfactant + blue indicator dye.
- Glyphosate as a 4% solution in water + a non-ionic surfactant + blue indicator dye.

Cut Stem Treatment. Cut large vines and immediately apply to the cut surface the following:

- Milestone VM as a 10% solution in water.

Basal Treatment. In *January to April*, to control vines less than 5 cm (2 in.) in diameter, apply one of the following to stems between the ground and approximately 30 cm (12 in.) above ground:

- Garlon 4 as a 20% solution in vegetable oil.

- Pathfinder II, a pre-mixed, oil-based triclopyr product.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.31
Pueraria montana (kudzu)

Percent Cover (Number of Plots)

- 0% (354)
- <1% (2)
- 1 - 5% (5)
- 6 - 25% (3)
- 26 - 50% (3)
- 51 - 75% (1)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Date: 2/26/2019 Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\Kudzu.mxd

Basemap courtesy of Esri.

5.32 *RAPHANUS RAPHANISTRUM*, WILD RADISH

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
5	1.36%	2.00%	WC	4.2

Alvin Diamond, Alabama Plant Atlas, describes this species as follows: *Wild radish is an introduced annual or biennial member of the Mustard family (Brassicaceae). It occurs throughout Alabama. Wild radish grows in fallow fields, on roadsides, along rail road tracks, and in other disturbed habitats. It is native to the Mediterranean area or Asia. It now occurs worldwide, and is a serious pest in some countries. Wild radish is considered by some to be the ancestor of the Garden Radish (*Raphanus sativus *Linnaeus). Wild radish differs from the garden radish in that it usually has creamy yellow or white flowers as opposed to white, pink, or purple in the garden radish. The fruit of the wild radish is strongly constricted between the seed while on the Garden Radish the fruit are only slightly constricted. The roots of wild radish usually do not become fleshy as in the garden radish. The fruit of the radish is a silique. This is a fruit developing from two fused carpels that is dry at maturity and more than two times as long as wide. At maturity the outer walls separate leaving the seed exposed on a papery septum.* (Keener, B. R., A.R. Diamond, L. J. Davenport, P. G. Davison, S. L. Ginzbarg, C. J. Hansen, C. S. Major, D. D. Spaulding, J. K. Triplett, and M. Woods. 2018. ***Alabama Plant Atlas***. [S.M. Landry and K.N. Campbell (original application development), **Florida Center for Community Design and Research**. **University of South Florida**]. **University of West Alabama**, Livingston, Alabama.)

Wild radish (*Raphanus raphanistrum*)

(Photo from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (**http://florida.plantatlas.usf.edu/**). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

Wild radish (*Raphanus raphanistrum*)

(Photos from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (**http://florida.plantatlas.usf.edu/**). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

General Recommendations:

- Since this plant is an annual, control measures should be made prior to seed formation when feasible.
- Seed production can be stopped by mowing.

Specific Control Procedures:

Manual Control. Where occurrence is low, this species can be pulled by hand. If seeds are present, plant material should be bagged and sent to the landfill.

Foliar Treatment. For infestations with too many plants to pull by hand, thoroughly wet all leaves with the following:

- *Note that if plants have gone to seed there is no benefit to applying herbicide.*
- Glyphosate as a 2% solution in water + a non-ionic surfactant + blue indicator dye.

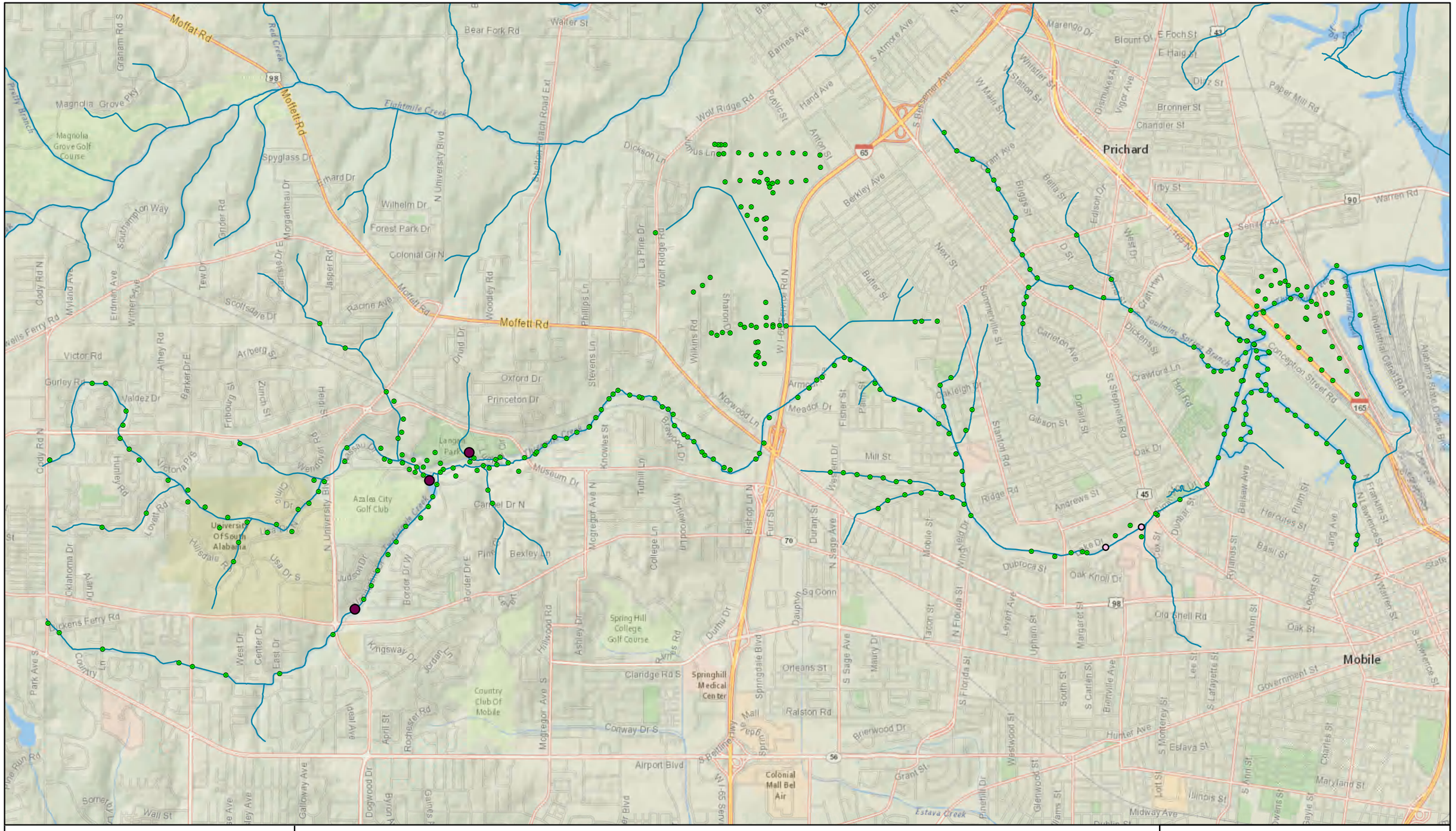

Figure 5.32
Raphanus raphanistrum (wild radish)

Percent Cover (Number of Plots)

- 0% (363)
- 1 - 5% (3)
- <1% (2)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.33 *RHYNCHOSPORA* SP., UNIDENTIFIED INVASIVE BEAKSEDGE

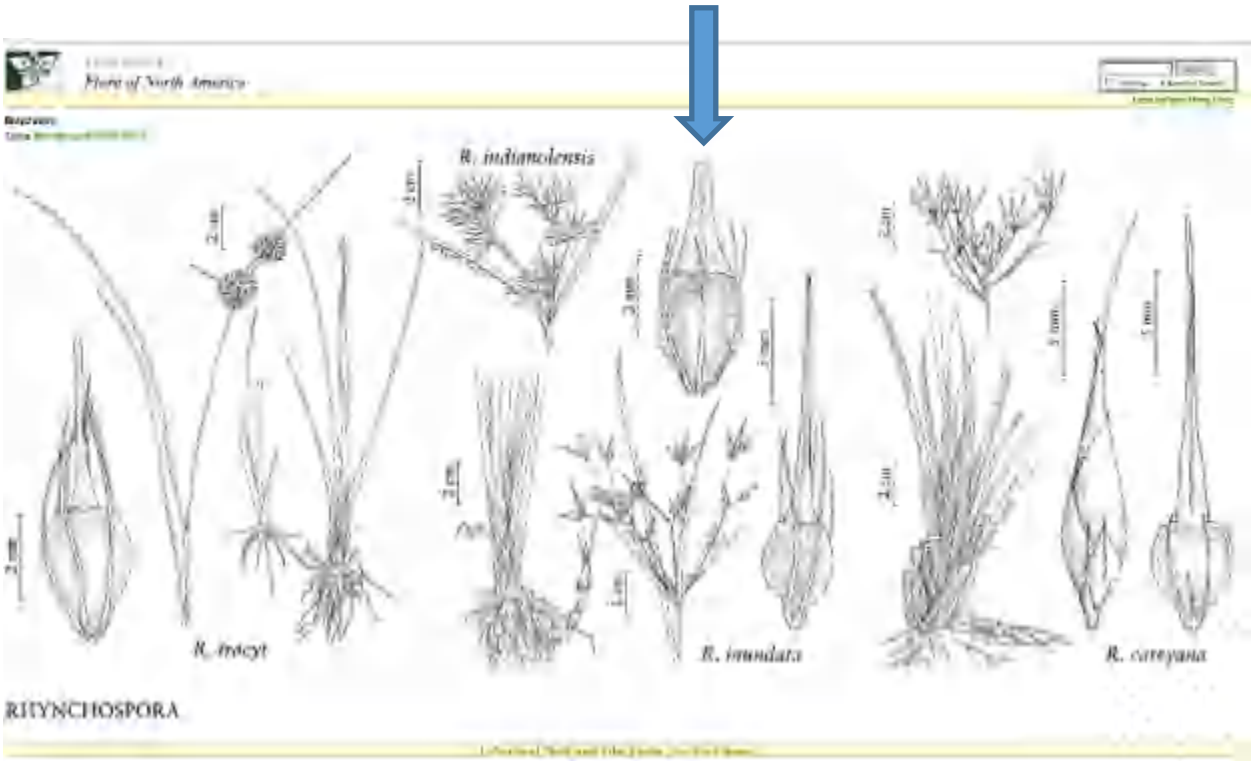
# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
5	1.36%	14.00%	WC	1.68

The following description of this species was provided by Robert F. C. Naczi, Ph.D., Arthur J. Cronquist Curator of North American Botany, New York Botanical Garden; and Howard Horne, botanist, Barry A. Vittor & Associates, Inc.:

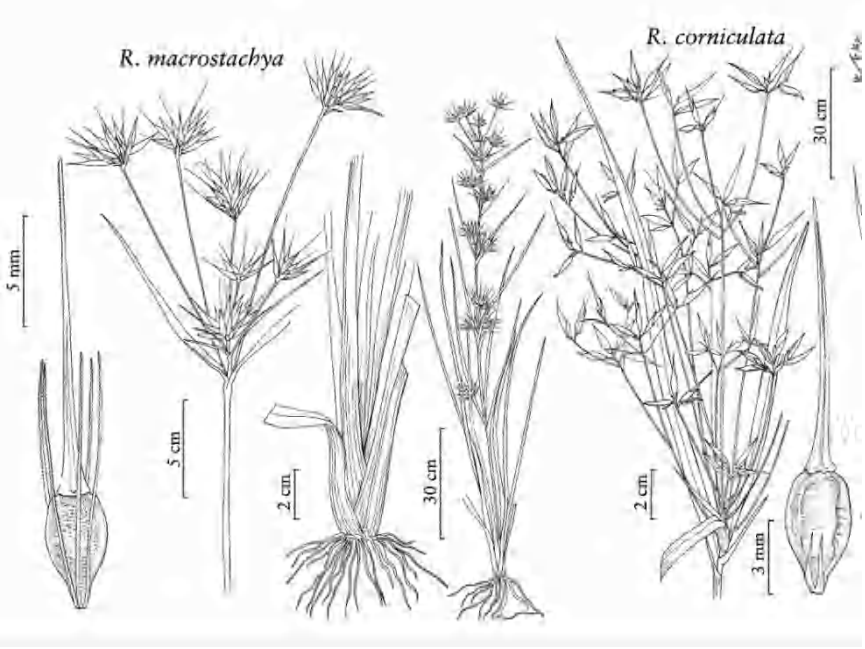
Plants *perennial; robust; densely cespitose, rhizomes very short, 0.2—3 cm long.* ***Culms****: 100–150(–200) cm in height; upwards of 1 cm in diameter at base; typically erect, sometimes lax or drooping when heavy with infructucenses; stems pith-filled; triangular in cross section, the angles sharply rounded; upper stem obscurely five-angled with one angle gradually becoming flattened and narrowly grooved; stem surfaces multi-ribbed (~15 narrowly spaced ribs per side); dotted with minute pale callosities; primary stem angles smooth near base, becoming scabridulous to scabrous upwards along the margins;* ***Leaves:*** *basal leaves up to 100 cm in length, 1.5 cm wide; V-shaped in cross section; leaf margins scabrous; abaxial surface smooth with a single midvein, the raised vein strongly antrosely scabrous (easily determined by running fingers down the midvein on the leaf underside).*

Perianth bristles *6, the longest per fruit 4.7−5.0 mm long, 0.75−0.76 times as long as fruit (including tubercle), antrorsely minutely denticulate for nearly their entire lengths.* ***Fruits*** *(including tubercle) 5.5−6.7 × 2.1−2.2 mm, 2.8−3.0 times as long as wide; bearing persistent perianth bristles; fruit body 3.4−3.7 × 2.1−2.2 mm, 1.5−1.7 times as long as wide, transversely and irregularly coarsely rugulose on both faces, ellipsoid in cross-section, medium or dark brown when mature; tubercle compressed-conic, 2.8−3.0 mm long, 2.2−2.4 mm wide at base and 100−110 % width of fruit, 1.2−1.4 mm wide at mid-length, 1.2−1.4 times as long as wide, 45−49% length of fruit, 1.3−1.5 mm thick at base, basal margin shallowly 0−2-incised, distally antrorsely scabridulous, each face longitudinally shallowly sulcate.*

In order to control this species, it must first be correctly identified, which requires mature fruits (achenes). Below are illustrations and photographs that will aid identification. The invasive beaksedge is part of a complicated group of several species whose classifications have not been fully resolved. Botanists Robert Naczi and Howard Horne are studying its identity and expect to be able to provide its scientific name in the near future. The achenes of this species are very distinctive. They are readily distinguished from other native beaksedge species, of which there are many, but only a few with a long tubercle (hardened style base). The tubercle is the triangular-shaped, sometimes long and narrow, structure that sits on top of the fruit body, which is more or less oval-shaped. Bristles attached at the base of the achene (perianth bristles) are of various lengths and numbers or absent and are often important in identifying beaksedge species.



West Indian beaksedge (*R. indianolensis*) and other *Rhynchospora* spp. with long tubercles. This unidentified invasive beaksedge looks very similar to West Indian beaksedge.
(Illustration found at: http://www.efloras.org/object_page.aspx?object_id=42389&flora_id=1)



Two other native *Rhynchospora* spp. that have long tubercles.
(Illustration (cropped) found at: http://www.efloras.org/object_page.aspx?object_id=42389&flora_id=1)

Botanical keys of this genus typically divide the *Rhynchospora* spp. with long tubercles from those with short tubercles at the beginning of the key. There are those with tubercles 4 mm or longer vs. those that do not exceed 2 mm. This species, which does not appear in the keys, has tubercles that are greater than 2 mm and less than 4 mm. It also has the distinctive bumps as seen in the close-up achene photos below.

Unidentified Beaksedge (*Rhynchospora* sp.*)*

Unidentified Beaksedge *(Rhynchospora* sp.*)* Achenes

General Recommendations:

- Location data for this species can be found on Figure 5.32 of this plan. This Figure illustrates the presence of this species within sample plots, therefore this unidentified *Rhynchospora* should be expected to be more widely distributed than reflected by the table.
- Since this species requires mature achenes for positive identification, it will be necessary to conduct more intensive surveys to locate, mark, and record where it occurs.
- There will be situations where this plant occurs with desirable, and possibly uncommon or rare, native species, such as *Lilaeopsis carolinensis*, Carolina grasswort, which is ranked in the state as **S1** - *Typically 5 or fewer occurrences, very few remaining individuals, acres, or miles of stream, or some factor of its biology making it especially vulnerable in the state*. Carolina grasswort is present at Langan Lake.

Specific Control Procedures:

Hand Removal

When small patches of this plant are present, or if special native plants are nearby, it can be dug up with a shovel, taking care to remove the entire root system, bagged, and sent to a landfill. If seeds are present, the entire inflorescence should be cut off and placed in a bag. Care should be taken to prevent knocking seeds off in the process.

Foliar Treatment

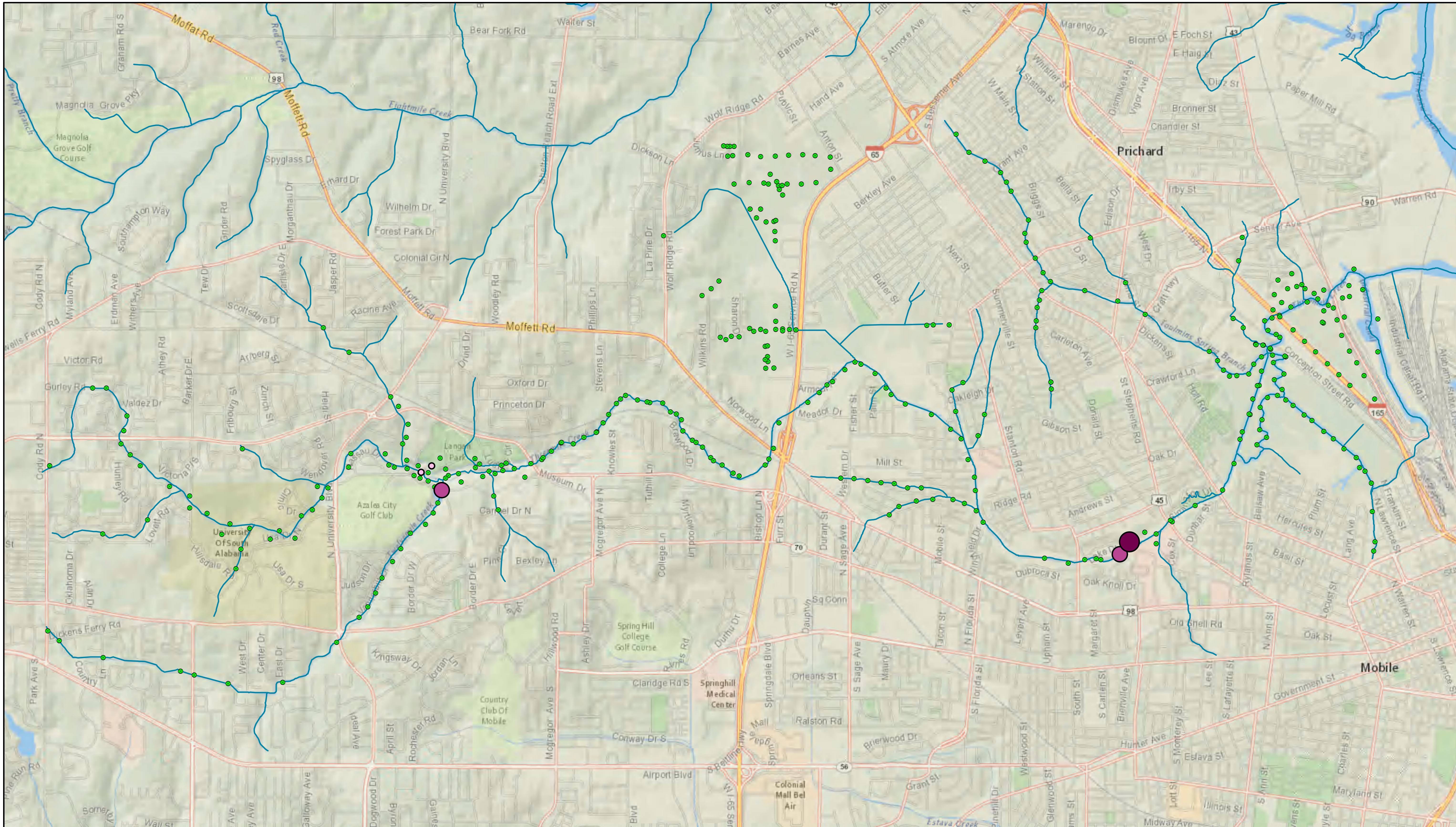
Once occurrences of this plant have been identified and marked, remove any mature inflorescences. If patches are solid and no special native species will be harmed, thoroughly wet all leaves with one of the following:

- *Glyphosate (labeled for aquatic use) as a 2% solution in water + a non-ionic surfactant + blue indicator dye.

(Liquid glyphosate formulations have been effective on sedges above the water line, but ineffective on plants in the water. (How to Control Sedges, found at: https://aquaplant.tamu.edu/management-options/sedges/))

- *Habitat (or other brand of imazapyr labeled for aquatic use) as a 0.5% solution in water + a non-ionic surfactant + blue indicator dye.

*(*The active ingredient, imazapyr, inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates. (How to Control Sedges, found at: https://aquaplant.tamu.edu/management-options/sedges/))*



Date: 2/26/2019

Figure 5.33
Rhynchospora spp.

Percent Cover (Number of Plots)

- 0% (363)
- <1% (2)
- 6 - 25% (2)
- 26 - 50% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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5.34 *ROSA* SPP., EXOTIC ROSES

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
1	0.27%	3.00%	1 (*multiflora*), 2 (other)	0.07

At least three non-native roses have escaped cultivation and become naturalized in the southeast. They include multiflora rose (*Rosa multiflora*), Cherokee rose (*R. laevigata*), and McCartney rose (*R. bracteata*). Two native rose species occur in Alabama, swamp rose (*R. palustris*) and Carolina rose (*R. carolina*), but neither are known to occur in Mobile County.

The exotic roses are all erect, arching, or trailing, clump-forming shrubs that often climb high into trees if not controlled. Leaves are pinnately compound with three to nine leaflets. Stems have straight to recurved thorns. Multiflora rose has clusters of flowers ranging from pink to white. Cherokee and McCartney rose both have single white flowers. (The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Cherokee rose (*Rosa laevigata*)

(Photo from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. Atlas of Florida Plants (http://florida.plantatlas.usf.edu/). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

McCartney rose (*Rosa bracteata*)

(Photo from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. Atlas of Florida Plants (http://florida.plantatlas.usf.edu/). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

Multiflora rose (*Rosa multiflora*)

(Photo from: Keener, B. R., A.R. Diamond, L. J. Davenport, P. G. Davison, S. L. Ginzbarg, C. J. Hansen, C. S. Major, D. D. Spaulding, J. K. Triplett, and M. Woods. 2018. ***Alabama Plant Atlas***. [S.M. Landry and K.N. Campbell (original application development), **Florida Center for Community Design and Research**. **University of South Florida**]. **University of West Alabama**, Livingston, Alabama.)

General Recommendations:

- Treat new plants to prevent seed formation.
- Manual removal is hindered by thorny branches and is limited to young plants.

Specific Control Procedures:

Foliar Treatment. In *May to October*, apply:

- Glyphosate as a 4% solution in water + non-ionic surfactant + blue indicator dye. Repeat applications may be necessary.

Basal Treatment. If stems are too tall for foliar application, apply the following basal spray (*January to February* or *May to October*)

- Garlon 4 as a 20% solution in vegetable oil.
- Pathfinder II, a pre-mixed, oil-based triclopyr product.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

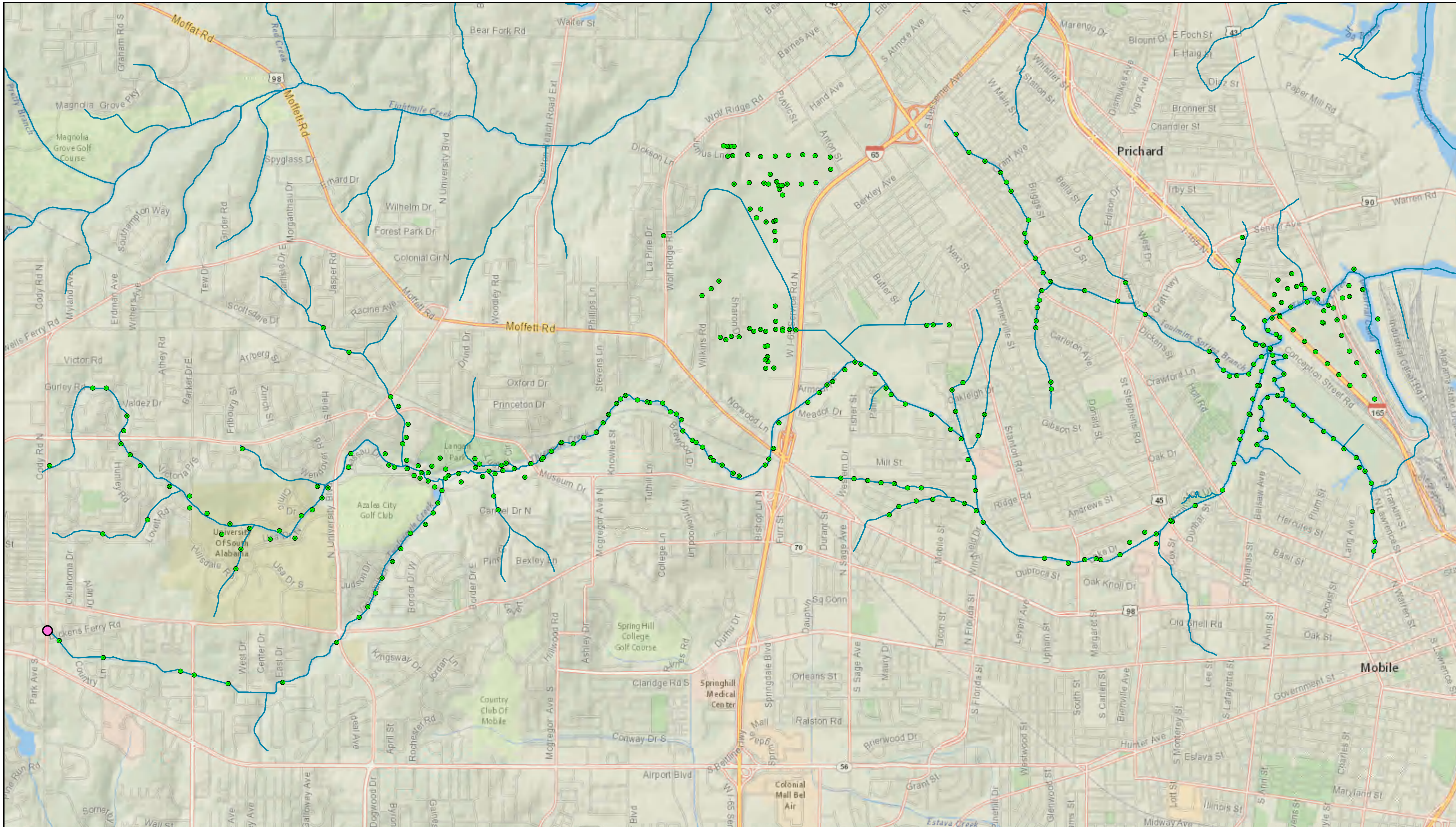

Figure 5.34
Rosa spp. (exotic roses)

Percent Cover (Number of Plots)

- 0% (367)
- 1 - 5% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\ExoticRoses.mxd

Date: 3/14/2019

Basemap courtesy of Esri.

5.35 *SALVINIA MINIMA*, COMMON SALVINIA

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
3	0.82%	50.00%	WC	0.04

A mat of common salvinia provides support for leopard frog in Otter Lake. Bob Thompson

Ten species of *Salvinia* comprise the only genus in the aquatic fern Family Salviniaceae. These small, free-floating plants are found in still waters rich in organic matter throughout the tropics and warm temperate regions of the world. Having neither flowers nor seeds, they reproduce vegetatively and via spores. Each plant consists of a whorl of three leaves born on a horizontal rhizome. Water-resistant "hairs" cover two of the green ovate leaves while a third submersed leaf provides buoyancy and may act as a root. Introduced in the 1920s, common salvinia (*Salvinia minima*) has become naturalized in the United States and is present, though rare, in TMC Watershed.[1]

Specific Control Procedure:

Physical/Mechanical

To reach problem proportions, all floating plants require high levels of nutrients in the water column. In the case of common salvinia, nitrate levels appear to be the dominant triggers for excessive growth.[2] Controlling nitrate pollution in the Watershed via stormwater ponds, adequate sewage treatment, and reduced fertilizer usage is the first step to avoid problems with common salvinia. Small populations can be easily seined or netted, but physically removing large mats would be impractical in terms of cost and effort. Plus, care is required to avoid spreading the plant on boats and trailers during disposal.

Biological

Salvinia weevil (*Cyrtobagous salviniae*) on common salvinia. IFAS

A native of Brazil, the salvinia weevil (*Cyrtobagous salviniae*) has been feeding on common salvinia in Florida since at least 1960.[3] These tiny weevils are highly fecund with a life cycle of only 46 days. The adult weevils feed on the leaves of the plant while the larvae tunnel inside the leaves and rhizomes, eventually causing the plants to turn brown and sink. This weevil has been successfully used worldwide to control dense infestations of Salvinia, especially the highly invasive giant salvinia (*Salvinia molesta*). After introduction into Australia in 1980, the salvinia weevil reduced giant salvinia by 95% in just over a year.

Chemical

Common salvinia can be controlled with numerous herbicides but results are often short in duration. The key to success is to treat with a fast-acting combination of herbicides that does not greatly reduce the population densities of the salvinia weevil. Clipper (flumioxazin) with a nonionic surfactant and buffering agent can rapidly control common salvinia without excessive harm to the weevil population.[4] Add glyphosate to the mix and long term control is possible.[5]

Summary with Specific Recommendations:

The goal of common salvinia control in TMC Watershed should be total eradication. That extreme position is not only due to the problems this species causes, such as low dissolved oxygen levels, but also because it is so easily confused with one of the world's worst invasive species, giant salvinia (*Salvinia molesta*).[6] The impact of an introduction of giant salvinia to TMC could be devastating, and it is present nearby in Pascagoula, Mississippi and Pensacola, Florida. Differentiating the two species requires magnification and observation of the shape of the leaf "hairs." common salvinia's pubescence pictured above has open tips while those of giant salvinia below come together. Often managers assume they are spotting common salvinia until it is too late to stop the onslaught of giant salvinia.

Magnified view of the dreaded giant salvinia (Salvinia molesta) with "egg beater" pubescence. Mic Julien

Typically, the best way to control common salvinia is to combine biological and chemical control techniques. The recommended approach to eliminating the small amount of this plant in TMC Watershed is repeated herbicide treatments using 6 oz. by weight of Clipper (51% flumioxazin), 71 fluid oz. of Aquamaster (5.4% glyphosate), and 0.5% v/v of Agridex (100% nonionic surfactant) per acre.[7] The resulting spray mixture is rather innocuous to the weevil and would cost about $80 per acre. The cost of professional application would depend on the size of the project and mobilization distance.

Common salvinia and duckweed (*Lemna minor*). Bob Thompson

References and Additional Information:

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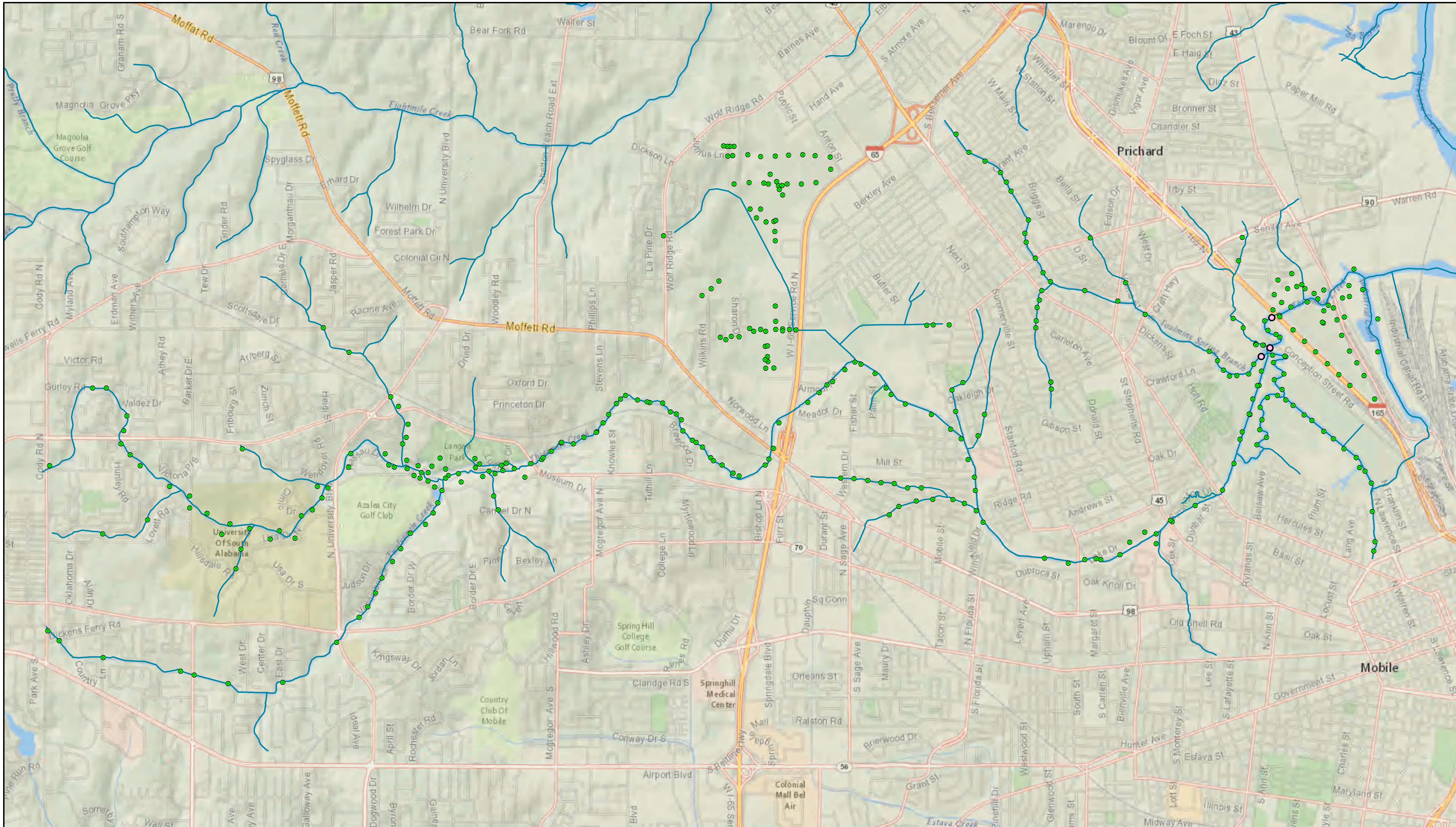

Figure 5.35
Salvinia minima (common salvinia)

Percent Cover (Number of Plots)

- 0% (365)
- <1% (3)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\CommonSalvinia.mxd

Date: 3/14/2019

Basemap courtesy of Esri.

5.36 *SESBANIA PUNICEA*, RATTLEBOX

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
10	2.72%	5.25%	WC	1.26

This member of the pea family is a deciduous shrub or small tree that grows up to 3.7 m (12 ft.) tall. It has compound leaves each with 10-40 small, dark-green leaflets in opposite pairs. Each leaflet is oblong and ends in a tiny pointed tip. The flowers, shaped like typical pea flowers, appear in clusters in spring and early summer and are reddish-orange in color. The seed pods are longitudinally 4-winged, oblong, and held on short stalks. The tip of the pod is sharply pointed. Rattlebox is native to South America.

Rattlebox seed pods and flowers

Rattlebox

General Recommendations:

- Young plants should be pulled by hand or with a weed wrench when soil is moist.
- Young plants should be removed before they begin producing seeds.

Specific Control Procedures:

Large Plants. These control procedures can be used effectively any time of year *except March and April*. Cut down stems to within a couple inches of the ground using a chainsaw or hand saw, then ***immediately*** apply one of the following herbicides to stump tops and sides:

- Garlon 4 as a 20% solution in vegetable oil.
- Garlon 3A as a 20% solution in water.
- Pathfinder II, a pre-mixed, oil-based triclopyr product.

(The above information is based on work by *Barry Rice, Global Invasive Species Team, The Nature Conservancy,* as found on the BugwoodWiki. It is also based on information adapted from the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.36
Sesbania punicea (rattlebox)

Percent Cover (Number of Plots)

- 0% (358)
- 1 - 5% (7)
- <1% (1)
- 6 - 25% (2)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\Rattlebox.mxd

Date: 3/14/2019

5.37 *SORGHUM HALEPENSE*, JOHNSON GRASS

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
2	0.54%	1.75%	2	0.08

Johnson grass (*Sorghum halepense*)

(Photo from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (http://florida.plantatlas.usf.edu/). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

Johnson grass is an erect, perennial, warm-season grass, with stout round stems, 0.9 – 2.4 m (3 – 8 ft.) tall, branching from the base. It has leaves that are long and wide with a prominent white midvein. Flowerheads form in summer on stalks typically taller than the leaves and are open, reddish, and cone-shaped. Tiny blackish seeds form in the fall. This grass is spread by rhizomes and seeds.

This species may potentially be confused with the native purpletop grass (*Tridens flavus*), the leaves of which have a thin whitish midvein and a reddish tinged base. The seeds of purpletop are maroon on distinctly drooping branches.

General Recommendations:

- Diligently monitor for new occurrences of Johnson grass and treat new patches as soon as feasible while grass is green and actively growing.
- Treat when plants are young to prevent seed formation.

- Seed production can be stopped by mowing, burning, or herbicide treatments in early stages of flowering or shortly before flowering.
- Clean seed and rhizomes from equipment and personnel working in infestations before leaving the infested site.

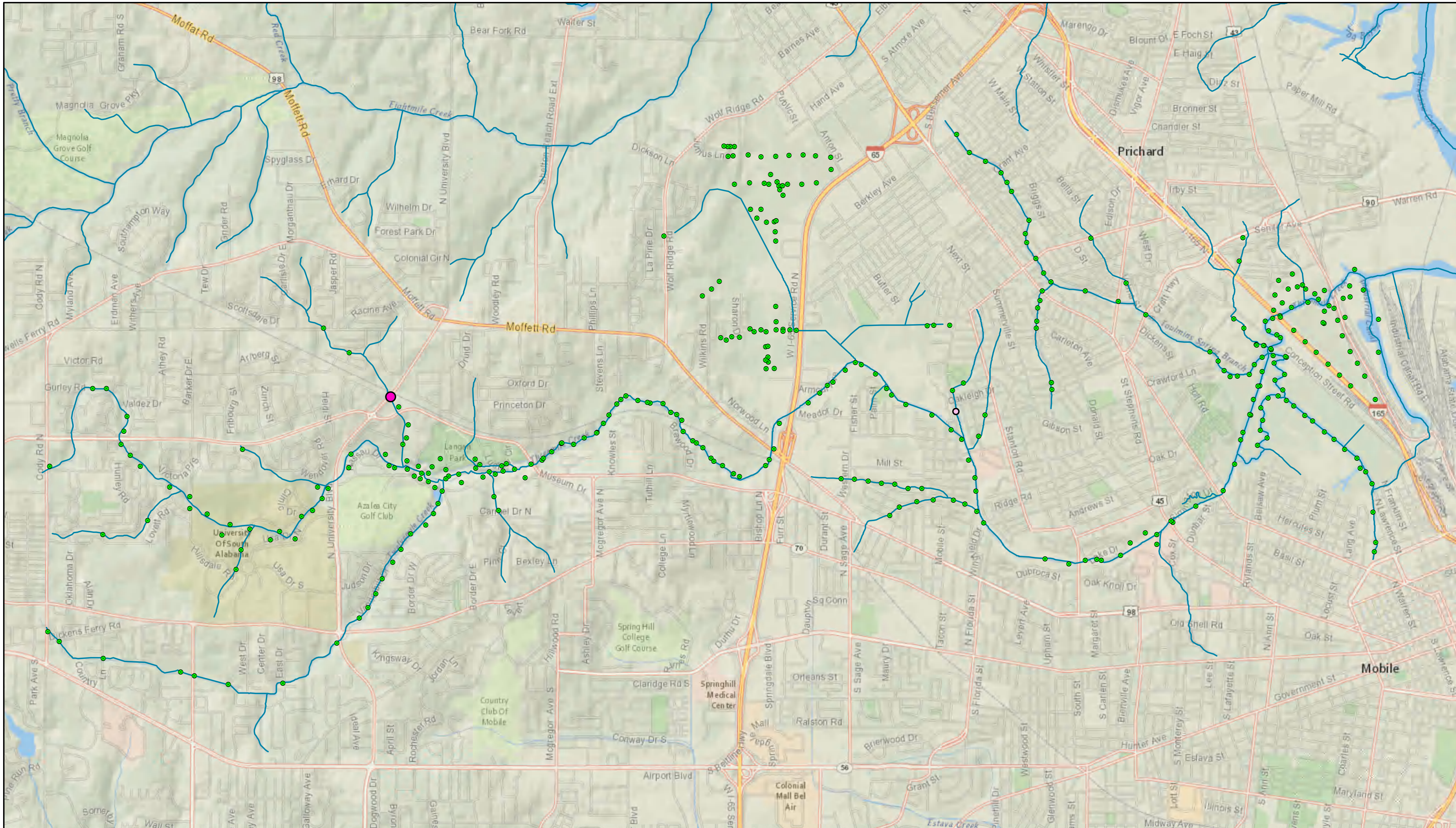
Specific Control Procedures:

Foliar Treatment. From *June to October*, thoroughly wet all leaves with the following:

- For mature grass control: Outrider* as a broadcast spray at 0.75 – 2 oz./acre (0.2 – 0.6 dry oz. /3-gal. mix) + non-ionic surfactant + blue indicator dye in water.
- For handheld and high-volume sprayers, apply 1 oz. of Outrider/100 gal. of water + 0.25% non-ionic surfactant + blue indicator dye.
- Glyphosate as a 2% solution in water + a non-ionic surfactant + blue indicator dye. Multiple applications to regrowth may be necessary.

**Outrider is soil active, meaning that it can be taken up by the roots of non-target plants and cause damage or death. Outrider is a selective herbicide that can be applied over the top of other grasses to control Johnsongrass.*

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)



Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\Johnsongrass.mxd

Date: 3/14/2019

Figure 5.37
Sorghum halepense (Johnson grass)

Percent Cover (Number of Plots)

- 0% (366)
- 1 - 5% (1)
- <1% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.38 *THELYPTERIS DENTATA*, DOWNY MAIDEN FERN

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
4	1.09%	3.00%	WC	0.29

This non-native fern has proven to be quite invasive in southwest Alabama and beyond. It is deciduous, rhizomatous, and up to 45 cm (18 in.) tall. The rachis, or main stem, of the fronds tends to be purplish-black. The rachis and leaves are covered in short white, erect hairs. The lower approximate half of the rachis has scattered dark brown scales present. When fertile fronds are mature, rows of round sori are present on the back of the leaves.

Downy maiden fern (*Thelypteris dentata)*

(Photo from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (**http://florida.plantatlas.usf.edu/**). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

Downy maiden fern (*Thelypteris dentata)*

(Photo from: Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2018. *Atlas of Florida Plants* (**http://florida.plantatlas.usf.edu/**). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.)

Although it can occur in a variety of habitats, this species tends to occur in wetlands along stream corridors and is easily overlooked, especially when growing with other fern species. It is important to learn to distinguish this (as well as a very similar-appearing invasive fern, *Deparia petersenii*) from desirable native ferns. An excellent publication is *Ferns of Alabama* by John W. Short and Daniel D. Spaulding.

General Recommendations:

- It will be important to train personnel to not only recognize this species when mature, but to recognize the sporelings, or baby plants, which tend to occur on bare, moist ground, especially at the base of roots and can be partially hidden and difficult to spot.
- Ideally, treatment should be done in the spring after leaves have fully formed, but prior to spore production.

Specific Control Procedures:

Foliar Treatment Wet all leaves with the following:

- Glyphosate as a 3% solution in water + a non-ionic surfactant + blue indicator dye.

Figure 5.38
Thelypteris dentata (downy maiden fern)

Percent Cover (Number of Plots)

- 0% (365)
- 1 - 5% (3)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Date: 3/14/2019 Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\DownyMaidenFern.mxd

Basemap courtesy of Esri.

5.39 *TRIADICA SEBIFERA,* CHINESE TALLOW TREE; POPCORN TREE

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
214	58.15%	14.90%	1	73.75

This deciduous, fast-growing tree can get as tall as 18 m (60 ft.) and, in some situations, form pure stands. Leaves are broadly ovate to diamond-shaped and turn bright yellow and scarlet in the fall. Abundant white waxy popcorn-like seeds appear in the fall. Seeds, high in fat and protein, are consumed and spread by birds and other wildlife. Saplings as young as 3 yr. can produce viable seed and remain reproductive for up to 100 yr. to produce 100,000 seeds per year. Infestations intensify by prolific surface root sprouts. Seed viability in the soil is 2 to 7 yr.

Chinese tallow tree or popcorn tree in flower

Chinese tallow tree or popcorn tree in fruit

General Recommendations:

- Tallow tree mulch and leaf litter should not be used for landscape beds or other purposes since it inhibits the germination of native seeds and likely contains viable tallow tree seeds.
- Young plants should be removed before they begin producing seeds.
- Small seedlings and young saplings can be pulled by hand and with a weed wrench in moist soil conditions and if infestation is not too dense to make hand removal impractical.

Specific Control Procedures:

Large Trees and Saplings. These control procedures can be used effectively any time of year *except March and April*.

Stem Injections:

- Make stem injections using dilutions and cut-spacings specified on the herbicide label with Arsenal AC*, Clearcast*, Habitat*, or Milestone herbicide in aquatic situations; or
- When safety to surrounding vegetation is desired, inject Garlon 3A.

Cut Stump Treatment:

Cut down trees and large saplings to within a couple inches of the ground using a chainsaw or hand saw, then ***immediately*** apply one of the following herbicides to stump tops and sides:

- Garlon 4 as a 20% solution in vegetable oil.
- Garlon 3A as a 20% solution in water.
- If NOT growing in standing water or ground with a high water table, Glyphosate mixed in water as a 20-50% solution + blue indicator dye.
- Pathfinder II (a pre-mixed, oil-based triclopyr product).

Dense Infestations of Seedlings and Small Saplings. These control procedures should be used *July through October*. Thoroughly wet all leaves with the following:

- Clearcast* as a 2% solution in water + a non-ionic surfactant + blue indicator dye.
- Garlon 4 as a 2% solution in water + a non-ionic surfactant + blue indicator dye.

**Nontarget plants may be injured or killed by root uptake.*

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Figure 5.39
Triadica sebifera (Chinese tallow tree)

Percent Cover (Number of Plots)

- 0% (154)
- <1% (7)
- 1 - 5% (73)
- 6 - 25% (100)
- 26 - 50% (29)
- 51 - 75% (5)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Date: 3/14/2019 Path: P:\10_Projects\MIMobile Bay National Estuary Program\GIS\Invasive Coverage\ChineseTallowTree.mxd

Basemap courtesy of Esri.

5.40 *ULMUS PARVIFOLIA*, CHINESE ELM

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
1	0.27%	15.50%	WB	.37

Chinese elm, also called lacebark elm, is a tree from 9-18 m (30-60 ft.) tall with a slender trunk and crown. The bark is exfoliating and flakey with colors ranging from gray, green, orange, reddish-brown, and tan. The small, elliptical, leaves are from 2-5 cm (0.8-2 in.) long, to 1.25-2.5 cm (0.5-1 in.) wide. The leaf margins are mostly single-toothed with a few double-toothed. The leaf base is unequal, as is typical in the genus *Ulmus*. The small, tight green inflorescence arises from the leaf axil. It blooms from August through September. Fruits are samaras, lime green when immature, and then maturing to a deep russet about October. The seed is notched at the tip and nearly fills the samara when mature. Chinese elm is widely planted in landscapes and can be found in a variety of different habitat types such as meadow, forest edges, and even marsh. It prefers full to partial sun and well drained soils. (https://www.invasiveplantatlas.org/subject.html?sub=6567).

Chinese elm (*Ulmus parvifolia*)

Chinese elm (*Ulmus parvifolia*)

General Recommendations:

- Young plants should be pulled by hand or with a weed wrench when soil is moist.
- Young plants should be removed before they begin producing seeds.
- This species should not be used in landscaping.

Specific Control Procedures:

Foliar Treatment. If hand-removal is not practical:

- Garlon 3A as a 3% solution in water + a non-ionic surfactant + blue indicator dye.
- Glyphosate as a 4% solution + a non-ionic surfactant + blue indicator dye.

Large Trees. These control procedures can be used most effectively *July through September*. This species sprouts vigorously from stumps, so cutting is not recommended. Apply one of the following solutions between the ground surface and approximately 30 cm (12 in.) above ground all the way around the stem:

- Garlon 4 as a 25% solution in vegetable oil.
- Pathfinder II, a pre-mixed, oil-based triclopyr product.

(Source: https://wiki.bugwood.org/Ulmus_parvifolia/NJ).

Figure 5.40
Ulmus parvifolia (Chinese elm)

Percent Cover (Number of Plots)

0% (367)

6 - 25% (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\ChineseElm.mxd

Date: 3/14/2019

5.41 *VERBENA BRASILIENSIS*, BRAZILIAN VERVAIN

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
34	9.24%	4.10%	WC	3.34

Brazilian vervain is an annual or short-lived perennial herb with erect, hispid, quadrangular stems of 1-2.5 meters in height. Upper branches are 4-9 cm long, opposite, and ascending. Opposite, elliptic leaves are simple and serrate, 4-10 cm long by 0.8-2.5 cm wide. Leaves are generally hispid, with veins on undersides bearing large bristles. Bracted flowers are borne on terminal, loosely arranged spikes which are 0.5-4.5 cm long by 4-5 cm wide and are arranged in triads.

Brazilian vervain

Management Strategies:

- Should not be planted or sold as an ornamental.

Recommended control procedures:

- Removal of plants by hand has been found to work in eradicating the plant.
- The herbicide Triclopyr 480. has been used in Gauteng, South Africa for eradication. 2,4-D (2,4-D L.V. 4 ESTER & 2,4-D L.V. 6 ESTER) is reported to provide good control of the plant. Refer to the product label for mixing and application rates.

Figure 5.41
Verbena brasiliensis (Brazilian vervain)

Percent Cover (Number of Plots)

0 | 1 - 5%

<1% | 6 - 25%

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\BrazilianVervain.mxd

Date: 3/14/2019

5.42 *WISTERIA SINENSIS*, CHINESE WISTERIA

# of 2018 Plots	% Occurrence in Plots	Average % Cover in 2018	ALIPC Rating	Acres in 2018
7	1.90%	3.00%	1	0.1

This woody vine is deciduous, high-climbing, twining, or trailing with long, pinnately compound leaves and showy dangling clusters of lavender flowers that appear in spring. Chinese and Japanese Wisteria are difficult to distinguish from each other due to hybridization. Both spread by twining and covering shrubs and trees as well as by runners that root at nodes when vines are covered by duff or leaf litter. Seeds are dispersed by water along riparian areas. The large size of the seeds is a deterrent to animal dispersal. Exotic wisteria, including many cultivars, are still sold and planted. (The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Chinese wisteria (*Wisteria sinensis)*

Exotic wisteria can be distinguished from American wisteria (*W. frutescens*) by the timing of flowering in relation to leaf-out. American wisteria blooms June to August *after leaves* have developed. American wisteria flower clusters are much smaller and more compact than those of the exotic wisterias. Weakley's *Flora of Alabama* distinguishes *W. frutescens* from the exotic species as follows:

***Wisteria frutescens,* American wisteria -** Legume and ovary glabrous; pedicels 5-10 (-15) mm long; standard reflexed near the middle; seeds reniform; leaflet margins plain; leaflet apices acute to slightly acuminate.

Exotic *Wisteria* - Legume and ovary velvety pubescent; pedicels 15-20 mm long; standard reflexed at the base; seeds lenticular; leaflet margins undulate; leaflet apices mainly strongly acuminate.

American wisteria

General Recommendations:

- Treat young plants with herbicide to prevent seed formation.
- Pull, cut, and treat when pods are not present.
- Hand-pull new seedlings when soil is moist, ensuring removal of all roots.

Specific Control Procedures:

Foliar Treatment. In *July to October* for successive years when regrowth appears, thoroughly wet all leaves (until runoff) with one of the following:

- Garlon 4 as a 4% solution in water + a non-ionic surfactant + blue indicator dye.
- Glyphosate as a 4% solution + a non-ionic surfactant + blue indicator dye.

Basal Treatment. Treat the length of surface vines within reach anytime *except March and April* with one of the following:

- Garlon 4 as a 20-% solution in vegetable oil (avoid the bark of desirable trees).
- Undiluted Pathfinder II, a pre-mixed, oil-based triclopyr product. Avoid the bark of desirable trees.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

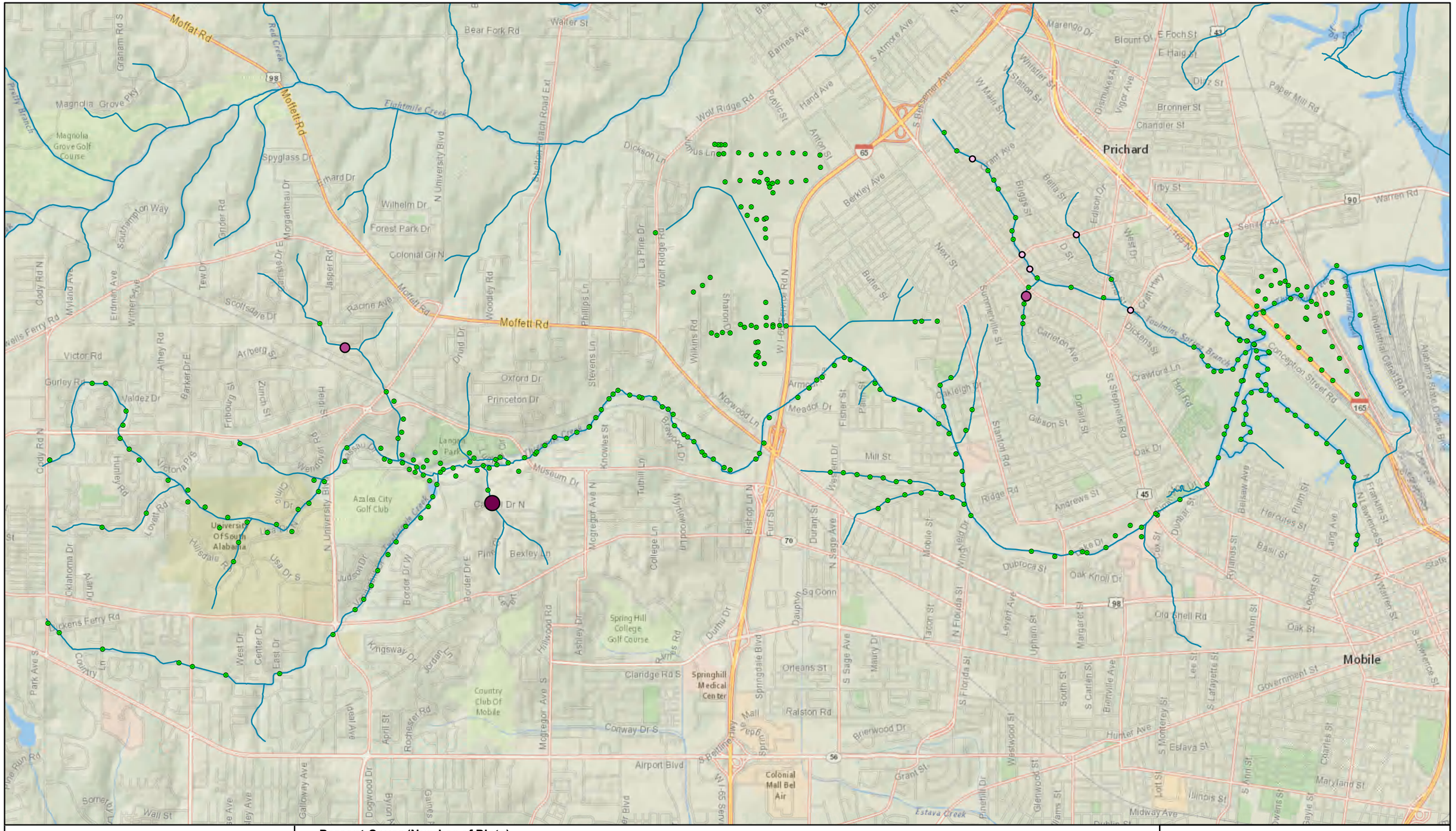

Figure 5.42
Wisteria sinensis (Chinese wisteria)

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Basemap courtesy of Esri.

5.43 ORNAMENTAL PLANTS (OTHER)

There are two additional plants that were observed once throughout the survey and they include thorny olive / autumn olive /Russian olive (*Elaeagnus* spp.), and star jasmine (*Trachelospermum jasminoides*).

Silverthorn or thorny olive (*Elaeagnus pungens*) is an evergreen, densely bushy shrub 3 to 25 ft. (1 to 8 m) in height with long limber projecting shoots that can eventually grow upward spread into tree crowns. Leaves are simple and silver scaly and alternate along shoots with sharp stubby branches, some thorned. Tiny flower clusters appear in fall that yield oblong, red olivelike fruit covered in brown scales in spring. This shrub is spread by animal-dispersed seeds and occurs as scattered individuals, both in the open and under forest shade. Shrubs rapidly increase in size by prolific stem sprouts.

Autumn olive (*Elaeagnus umbellata*) is a tardily deciduous bushy leafy shrub, 3 to 20 ft. (1 to 6 m) in height, with scattered thorny branches. It has alternate leaves that are green above and silvery scaly beneath, with many red berries in fall having silvery scales. Species spreads by bird- and mammal-dispersed seeds.

Russian olive (*Elaeagnus angustifolia*) is a small thorny deciduous tree to 35 ft. (10 m) tall that has microscopic silvery scales covering leaves, twigs, and fruits. Leaves are long and narrow with entire margins. Bark is fissured and reddish brown. Olivelike fruit are yellow (seldom red), appear in late summer to fall, and are spread by birds and mammals. Found as rare plants in city forests and emanating to nearby disturbed areas. Rare at present in the South while
a widespread invasive tree elsewhere in the United States. Most often confused with the widely invasive autumn olive (*E. umbellata*) that has silvery scaled leaves and twigs, red fruit that are only slightly scaly, and smooth bark.

General Recommendations:

- Do not plant. Remove prior plantings, and control sprouts and seedlings. Bag and dispose of fruit in a dumpster.
- Treat when new plants are young to prevent seed formation.
- Cut, mulch, or bulldoze when fruit are not present.
- Manual pulling and herbicide treatments are hindered by thorny branches.
- Manually pull new seedlings and tree wrench saplings when soil is moist, ensuring removal of all roots. Wear eye protection during treatment.

Specific Control Procedures:

- Thoroughly wet all leaves with Garlon 3A or Garlon 4 as a 2% solution.
- When nontarget damage is not a concern, use Arsenal AC* or Vanquish* as a 1% solution in water with a surfactant.
- For stems too tall for foliar sprays, apply a basal spray of Garlon 4 as a 20% solution in vegetable oil (January to February or May to October).
- Where safety to surrounding vegetation is not a concern, Stalker* as a 6 – 9% solution in vegetable oil (January to February or May to October).
- Cut large stems and immediately treat the stump tops with one of the following herbicides in water with a surfactant:

    - Arsenal AC* as a 5% solution
    - When safety to surrounding vegetation is desired, a glyphosate herbicide as a 20% solution.
- ORTHO Brush-B-Gon and Enforcer Brush Killer are effective undiluted for treating cut-stumps and available in retail garden stores (safe to surrounding plants).

* Nontarget plants may be killed or injured by root uptake.

(The above information is taken from, and/or based on, the USDA Forest Service publication, *A Management Guide for Invasive Plants in Southern Forests*; by James H. Miller, Steven T. Manning, and Stephen F. Enloe; April 2013.)

Star jasmine is a monoecious, twining, evergreen, woody perennial. In areas where it is winter hardy (e.g., southern California, southwestern and southeastern U.S.) it may be grown as a vine, a sprawling shrub or as a ground cover. Axillary and terminal clusters of salverform, sweetly fragrant, starry, creamy white flowers appear in late spring with sporadic additional bloom in summer. Flowers are attractive to bees. Shiny, oval, opposite, dark green leaves (to 3.5" long) on wiry dark brown stems. Stems exude a milky sap when broken. (Description from the Missouri Botanical Garden: http://www.missouribotanicalgarden.org/PlantFinder/)

General Recommendations:

- Do not plant. Extremely difficult to eradicate when well-established.
- Remove prior plantings, and control sprouts and seedlings.
- Bag and dispose of plants and fruit in a dumpster or burn.
- Treat when new plants are young to prevent seed formation.
- Pull, cut, and treat when fruit are not present.
- Repeated cutting and mowing to groundline commonly recommended for control of young infestations.

Specific Control Procedures:

Thoroughly wet all leaves (until runoff) with one of the following herbicides in water with a surfactant (July to October for successive years):

- Garlon 3A or Garlon 4 as a 3 – 5% solution
- Glyphosate herbicide as a 4% solution

Cut large vines and apply these herbicides to cut surfaces or apply basal sprays of:

- Garlon 4 as a 20% solution in vegetable oil, avoiding the bark of desirable trees
- Undiluted Pathfinder II, avoiding the bark of desirable trees

Figure 5.43
Eleaegnus spp., Trachelospermum spp.
(Ornamental plants)

Percent Cover (Number of Plots) [Species]

- 0% (366)
- 1 - 5% (1) [silverberry]
- 6 - 25% (1) [star jasmine]

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Date: 4/8/2019

Basemap courtesy of Esri.

5.44 *CORBICULA FLUMINEA*, ASIAN CLAM

of 2018 Plots
20

A handful of Asian clams, one of the most invasive species in freshwater ecosystems.[1] (B Holden, NPS)

Native to southeastern China, Korea, and southeastern Russia, the Asian clam (*Corbicula fluminea*) is a small bivalve with a light-brown shell possessing distinct concentric grooves. This highly invasive clam was reportedly brought to America by Chinese immigrants as a food item. Asian clams were first documented in the Columbia River of Washington State in 1938. It is currently present throughout the continental United States and Hawaii. The most notable economic impact of the Asian clam is the fouling of industrial water intakes which causes damage in the millions of dollars per year.[1]

The Asian clams reproduce prolifically with population densities reaching thousands per square yard. With an average lifespan of 2 to 4 years, larvae produced in the spring become adults by the next fall. Juveniles move easily in water currents, on aquatic birds, and inadvertently by boaters. This filter-feeder prefers flowing water with high dissolved oxygen levels and sandy substrates in which to partially burrow.[2] However, it can survive in wide range of habitats and outcompete native species for limited resources. According to the U.S. Fish and Wildlife Service, “The ease of spread, large numbers of offspring produced sexually or asexually, wide habitat

tolerances, ability to outcompete native species, and potential to cause negative economic impacts make this a very high risk species."[3]

An Asian clam filter-feeding via ciliary tracks on its muscular foot. (C. Mornoff)

Specific Control Procedures:

Physical

Across the globe, the Asian clam has been the target of numerous innovative eradication efforts. None have been successful in long term control.[4] Suction dredging and gas-impermeable benthic barriers have been the primary physical control techniques. Both methods have proven to be expensive, destructive, and ineffective.[5] Heat and cold have been employed, but introducing temperature extremes in large areas is impractical. Experiments with dry ice pellets have provided some short term control.[4]

Chemical

Chemical control has thus far proven to be equally disappointing. Sodium hypochlorite, bromine, and other disinfectants are commonly used in industrial situations but their use is not appropriate in natural system due to harmful by-products.[4] Though larvae are vulnerable to copper treatments, adults are not.[6] Laboratory test with other molluscicides have also proven to be ineffective.[7,8] Chemical control is further confounded by the clam's ability to sense toxic threats and simply close its shell.[9]

Biological

A single Asian clam can repopulate an entire aquatic ecosystem, so eradication in TMC Watershed is not a realistic goal. Using biological control, however, may significantly reduce the population of this pest. Its predators include insects, crustaceans (especially crayfish), insects, fish (including catfish and tilapia), turtles, various wading birds, and mammals. Burrowing is this clam's primary mode of predator avoidance so a large bottom-feeding fish is its greatest biological threat.[10] The blue catfish (*Ictalurus furcatus*) is such an animal. Biologist have documented that blue catfish readily consume Asian clams in North Carolina, Oklahoma, California, and Texas.[11]

The stomach analysis of over 16,000 blue catfish from the Virginia tidal rivers revealed that Asian clams comprised 16% of their diet.[12]

Summary with Specific Recommendations:

A blue catfish locates its prey, an Asian clam. (Ak-Sar-Ben)

There is no viable physical control method for the Asian clam in TMC Watershed. However, the most effective chemical and biological control methods for the exotic clam dovetail nicely with those of another invasive target species, the island apple snail (*Pomacea maculata*). The use of chelated copper in Langan Lake to control island apple snails would negatively affect the Asian clam larvae downstream, and stocking 5,000 blue catfish there as suggested for snail control would ultimately reduce the Asian clam population throughout TMC Watershed.

Cost Estimate:

If the suggested protocol to address the island apple snails in Langan Lake is followed, there would be no additional cost to greatly reduce the abundance of Asian clams in TMC Watershed.

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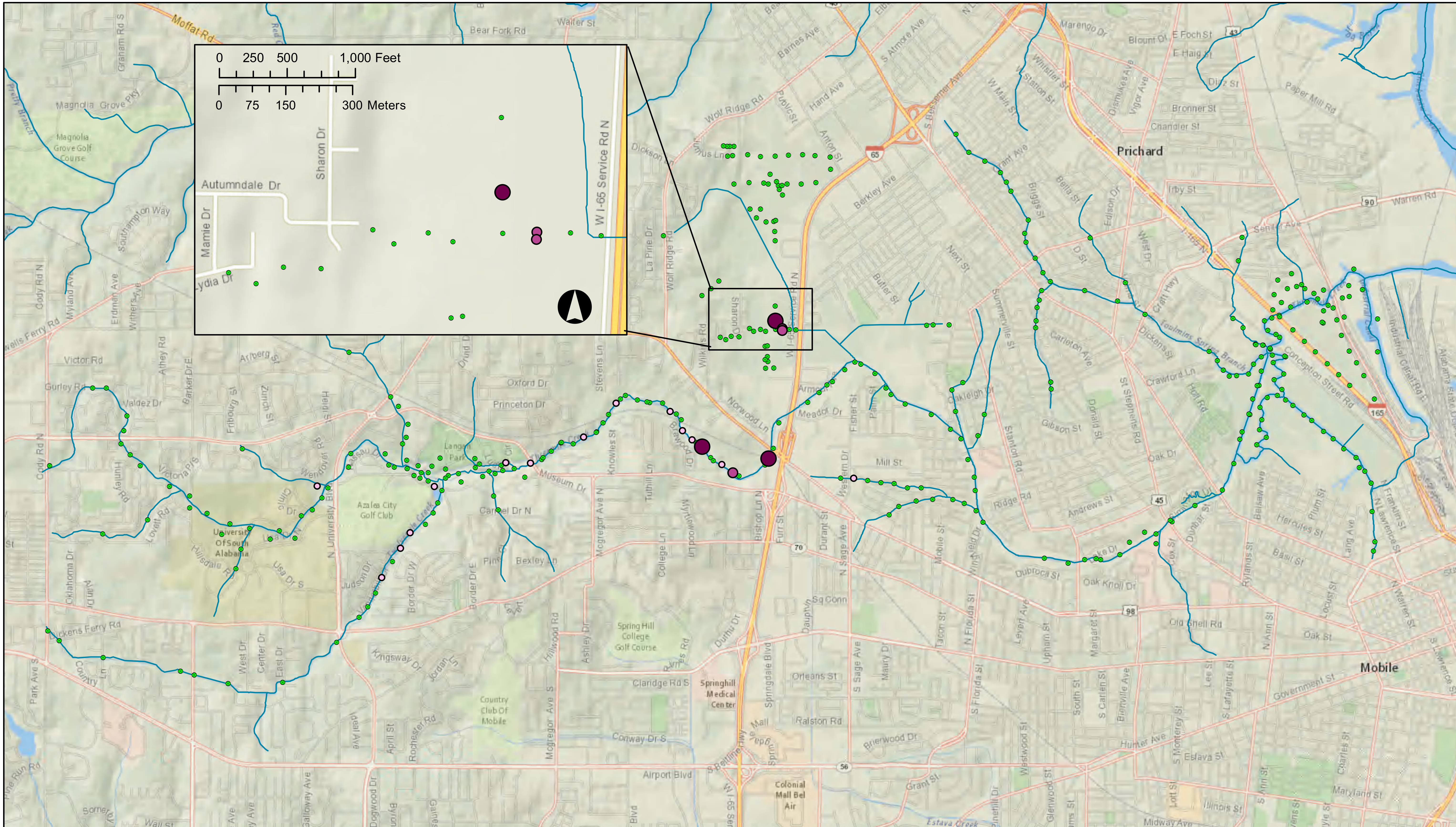

Figure 5.44
Corbicula fluminea (Asian clam)

Estimated Abundance (Number of Plots)

- Zero (348)
- Low (14)
- Medium (3)
- High (3)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\AsianClam.mxd

Date: 3/14/2019

Basemap courtesy of Esri.

5.45 *OREOCHROMIS* SPP., TILAPIA

of 2018 Plots
0

Nile tiilapia with their distinctive striped caudal fins have been documented in Langan Lake. (Auburn Univ.)

While there are about 150 species that are classified as tilapia, just two currently threaten the ecological health of TMC Watershed. Only recently taxonomically distinguished, the blue tilapia (*Oreochromis auratus*)[1] and the Nile tilapia (*O. niloticus*)[2] are members of the Family Cichlidae which has gained global notoriety both as a food source and as biological invaders. Natives to Africa and the Middle East, these hardy fish have been introduced into the United States for aquatic plant control, fish farming, and supplemental forage for game fish. Because of their mild, delicious taste and low price, tilapia have become the fourth most consumed seafood in America after shrimp, salmon, and tuna.[3]

The downside of the tilapia's hardiness and prolific reproduction is their ability to invade aquatic ecosystems. Feral populations of tilapia are present in every country in which they have been introduced. Brought to Florida in 1961, blue tilapia are now the most widespread exotic fish in the state and a major problem in natural areas including in the Everglades National Park. In 2007, Nile tilapia were documented in eastern Mobile Bay's Fish and Magnolia rivers. This species was also observed in Langan Lake that same year.[6] In their African native range, blue and Nile tilapias

are distinct species, but hybridization and introgression in aquaculture settings and subsequent escape during extreme flooding events have resulted in hybrid fish that are even more tenacious and invasive.[4,7]

Both blue and Nile tilapia are tolerant of a wide range of ambient conditions, including temperature, salinity, and dissolved oxygen. Their hybrids may be even more resistant to environmental stress. Couple that with high growth and reproductive capacities and it is easy to imagine how these exotic fish could thrive in Alabama's lakes, rivers, and estuaries. Some investigators have taken solace in the belief that cold winters eliminates the threat of widespread invasion because laboratory experiments indicate that both blue and Nile tilapia cannot survive water temperatures much below 50° F. However, given the warmer winters of late, it is likely that these fish can survive and reproduce in the Mobile Bay area.[4,5]

The environmental impacts of naturalized tilapia can be severe.[8] Though aquatic plants and filamentous algae are their food staples, tilapia also consume phytoplankton, zooplankton, detritus, invertebrates and other fish. Tilapia can create drastic changes in aquatic ecosystems via competition for food, overcrowding, predation on other fish, reduction in vegetation, and especially in competition for nesting habitat. When water temperature exceeds 68° F, males excavate nesting pits up to two feet deep in shallow water and aggressively protect them, thus excluding native sunfish (Family Centrarchidae).[9]

Blue tilapia (*Oreochromis aureus*) nesting in mid-January at Silver Glen Springs, Florida. (J. Alder)

Specific Control Procedures:

Biological Control

Though fish farmers often battle bacterial and viral diseases related to overcrowding, there are no host-specific diseases that can be used to infect and reduce a tilapia population. In terms of predators, redfish (*Sciaenops ocellatus*) and hybrid striped bass (*Morone saxatilis*) X white bass (*Morone chrysops*) have been effectively employed to reduce spawning success of blue tilapia X Nile tilapia hybrids in aquaculture ponds. The use of tarpon (*Megalops cyprinoides*) as a biological control for tilapia is also a possibility but such predator introductions would also have negative environmental impacts.[9]

Chemical Control

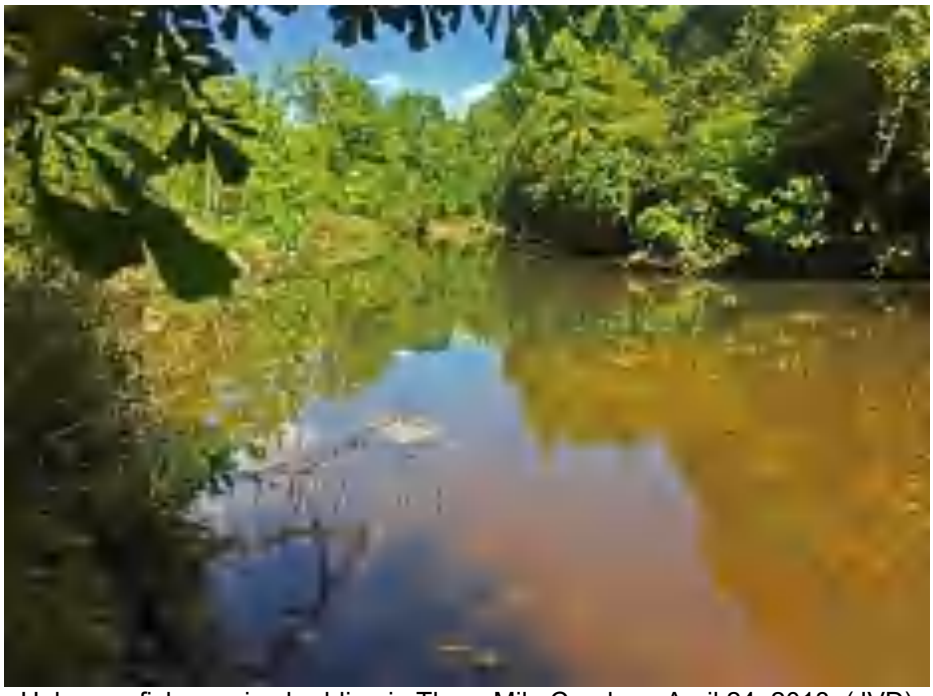
Chelated copper has been previously discussed as a means of controlling the island apple snail in Langan Lake. If that action were to be taken, no doubt there would detrimental effects on any tilapia present. However, tilapia are rather tolerant to copper, depending on ambient pH, alkalinity, and hardness. Using copper at concentrations high enough to significantly reduce the numbers of tilapia would also kill native fish and vegetation.[10] Another option is a non-selective fish toxicant,

such as Rotenone. This pesticide has been successfully used on tilapia beds in static water. However, the use of Rotenone in flowing water can result in severe non-target fish mortality downstream.[11]

Physical/Mechanical Control

Tilapia are harvested globally for food using nets, traps, and hook-and-line, but these methods never lead to eradication due to the fish's high fecundity. Electrofishing was employed to remove adult tilapia in Australia. However, as the adult population decreased, the numbers of juvenile fish increased.[12] At this time, the only practical physical control method in TMC Watershed is recreational fishing.[13]

Catching a four-pound Nile tilapia on light tackle puts a smile on her face. (Shefishes)



Unknown fish species bedding in Three Mile Creek on April 24, 2018. (JVD)

Summary with Specific Recommendations:

The extent of the tilapia problem in TMC Watershed has not been determined, so the first step is a careful evaluation of the local fish assemblage. An electrofishing study of the identity, abundance, and location of the various fish species inhabiting the area is necessary. In addition, a creel study of anglers at Langan Park is also needed. If it is determined that tilapia are established and numerous, recreational angling could be used to reduce the population of these invasive fish. Public service announcements and signage could alert the public to the tilapia problem and that “catch and release” is not the appropriate response for tilapia. Local sportswriters could educate the public on the best fishing sites and techniques. Fishing tournaments at Langan Park could stimulate interest controlling tilapia and provide an avenue for disseminating information on this invasive threat.

Cost Estimates:

Creel and electrofishing studies of exotic fish are within the mission of the Alabama Department of Conservation and Natural Resources, Wildlife and Freshwater Fisheries Division. Entirely funding or providing matching fund could encourage this highly qualified agency to prioritize research on the fisheries of TMC Watershed. The cost of such an effort would be based on its intensity and duration, but $5,000 to $10,000 should achieve the desired result of a scientific document describing the fish assemblage of TMC Watershed and the extent of naturalization of tilapia within that fishery.

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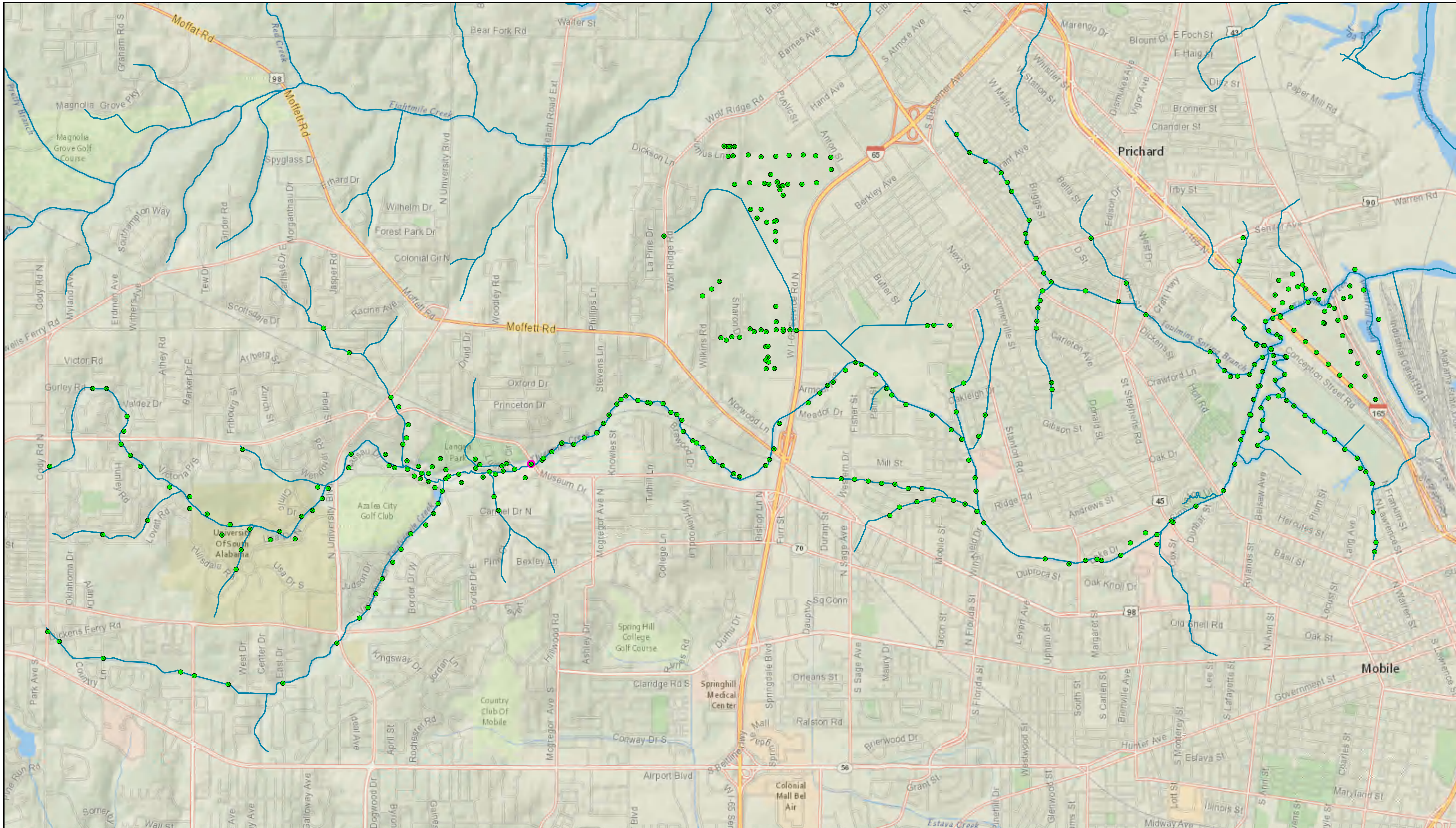

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Date: 3/14/2019

Figure 5.45
Oreochromis spp. (tilapia)

Estimated Abundance (Number of Plots)

- Zero (367)
- Unconfirmed sighting (1)

0 0.5 1 2 Miles

0 1 2 4 Kilometers

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Basemap courtesy of Esri.

5.46 *POMACEA MACULATA,* ISLAND APPLE SNAIL

of 2018 Plots
36

Though island apple snails prefer aquatic vegetation, their appetite has few limitations. (JVD)

Considered to be some of the world's most destructive biological invaders, South American apple snails (*Pomacea* spp.) were introduced by the aquarium trade into Florida in the 1950s and can presently be found throughout the South. The island apple snail has stripped the vegetation from lakes in Florida and Louisiana, disrupted rice and crawfish farming in Texas, and now threatens the Mobile-Tensaw Delta, arguably the biologically richest estuary in North America. Coinciding with the sale of the snails at a local pet store, the island apple snail (*Pomacea maculata*) was first observed in Langan Park in 2003. In spite of concerted control efforts beginning in 2008, this species is now well-established in Langan Park and has been observed in TMC Watershed east to Telegraph Road.

Often characterized as aquatic and herbivorous, the island apple snail is actually amphibious and omnivorous.[1] While possessing gills to obtain oxygen when submerged, this gastropod also possesses a modified mantle cavity which acts as a "lung" in terrestrial environments. Consequently, this snail is capable of traversing on moist soil at up to 7 meters/hour in search of food. The diet of this mobile, opportunistic snail consists of both plant and animal material. Using a saw-like radula, the island apple snail rasps plant leaves, stems, and roots, while also consuming detritus, animal eggs, and carrion.

Aside from being able to eat almost anything and to survive both on land and in water, the island apple snail can effectively seal itself from adverse conditions using its operculum. In so doing, it can survive extreme droughts for 8 months by estivating buried in mud. This snail is also highly fecund producing numerous egg clusters per season with up to 2,000 individual eggs each. It avoids predation with its relatively large size and by being primarily nocturnal. It can stay

submerged even in low oxygen conditions by using a snorkel and can dive quickly when sensing danger or float downstream employing its “lung” as ballast system. Given these numerous survival adaptations, no wonder those seeking to control this highly invasive species are usually frustrated.

Vulnerabilities:

The pink, “warning coloration” of the eggs is obvious to both predators and managers.

Fortunately, the island apple snail has several important vulnerabilities. First, its egg clusters are bright pink to warn predators of a chemical targeting their digestive systems. The obviousness of the eggs assists managers to not only find and destroy the clusters but also to locate the adults. Second, because of its excellent chemoreception, the snail can be attracted to certain baits in water. Third, the snail is unable to detect certain molluscicides in solution and will not evade exposure. Finally, this snail is vulnerable to predation by certain fish. Eradication is a tall order. However, by combining physical, biological, and chemical methods targeting these weaknesses, an effective control plan can be developed.

Island apple snails are easily attracted to certain baits. JVD

Primary Target Area:

The complex lake system at Langan Park from Spring Hill Lake to Spring Hill Avenue occupies 50 acres. (Google)

A 200’ spillway dam separates the eastern and western lakes at Langan Park. (J Van Dyke)

Specific Control Procedure:

Physical Control

Manual removal of island apple snails is labor-intensive and futile. (JVD)

The initial reaction of most resource managers to an infestation of exotic apple snails is to collect and destroy the obvious pink egg clusters while collecting any adults in the process. In time, the futility of using this labor-intensive process alone becomes obvious. For instance, five tons of adult snails and 3.2 million eggs were physically removed from a 15-acre pond west of

Tallahassee.[2] This two-year control program stabilized the aquatic plant community, but the costs of continuing were prohibitive.

Since 2012 at Langan Park, the Mobile Baykeeper, in cooperation with the Alabama Department of Conservation and Natural Resources, Wildlife and Freshwater Fisheries Division, and the U.S. Fish & Wildlife Service has sponsored "Apple Snail Roundups" where local volunteers scour the lakes for eggs and adults. No doubt these efforts have had a positive effect, but the infestation continues due to the fecundity and stealth of their invasive target.

Five tons were removed from Wellman Pond (15 acres). (J Van Dyke)

Chemical Control with Copper

Beginning October 2009, four tons of copper sulfate (25% elemental copper) were applied to the waters of Langan Park and Three Mile Creek, but copper concentrations declined rapidly and were undetectable 24 hours after application. Though relatively inexpensive, the copper sulfate treatments proved to be only partially effective. Snail mortality was estimated at only 50– 75%.[3]

In terms of efficacy, Captain proved superior to K-Tea, Komeen, and Nautique. (JVD)

Captain contains only 9.1% elemental copper, but it has an ethanolamine chelation complex that keeps the copper in solution much longer than copper sulfate.[4] When an application of copper sulfate creates a high concentration of copper in solution for a short period, the snail senses it and either closes its operculum or crawls out of the water. However, chelated copper at low concentrations (0.2-0.4ppm) is undetectable and deadly to the snails if present for 2-4 days.[5]

Effects are temperature dependent. At 80.6 F (27° C), Captain was lethal at 48 hours. (JVD)

Chemical Control with Iron Phosphate

An island apple snail eagerly consuming iron phosphate pellets. (JVD)

Copper can be rather non-selective to invertebrates, even fish, so a more environmentally friendly approach to control snails is the use of an iron phosphate (FePO4) bait made by Neudorff, called Ferroxx AQ.[6] The active ingredient targets the digestive system in snails and kills by inhibiting

oxygen metabolism and damaging internal tissues. In bench tests, Neudorff's 3% iron phosphate bait had dose-related, detrimental effects on adult island apple snails in terms of appetite and survival. Feeding ended at 2.0g and 4.0g/snail treatments, and six days after those treatments, only 25% of the snails survived.[7] Iron phosphate is only toxic to mollusks and crustaceans, so it poses a reduced threat to non-target organisms. Also, iron phosphate is nearly insoluble in water, so groundwater will not be effected. Because iron is one of the Earth's most common metals, it is impossible to pollute with iron.

Afterwards, the island apple snail has succumbed to the ingestion of iron phosphate. (JVD)

Biological Control

In January of 2010, 14,000 redear sunfish (*Lepomis microlophus*) were stocked into the lakes of Langan Park by the Alabama Department of Conservation and Natural Resources, Wildlife and Freshwater Fisheries Division, to control juvenile apple snails. The results are unknown but likely beneficial; however, the redear sunfish is too small to consume adult apple snails.[3] The blue catfish (*Ictalurus furcatus*), however, is the third largest freshwater fish in North America, so unlike redear sunfish, the average blue catfish is large enough to readily consume adult island apple snails. Importantly, apple snails have been found in the stomach contents of blue catfish in Texas where these fish are used as biological control agents for invasive snails.

Redear sunfish (*Lepomis microlophus*). (J Van Dyke)

The range of the blue catfish includes the Mississippi River Watershed and the Gulf Coast from Florida to Central America. In Alabama, this species is widespread and locally abundant in the Mobile Basin and the Tennessee River. Because of its size and excellent flavor, the blue catfish has become an important component of the recreational and commercial fishery of Mobile Bay and elsewhere. However, controversy followed introduction of the blue catfish into the tidal rivers of Chesapeake Bay due to concerns raised about potential impacts on menhaden, blue crabs and other native species.

Blue catfish (*Ictalurus furcatus*). (Auburn University)

A recent, extensive study that sampled over 16,000 stomachs found that 52% of the blue catfish's diet was aquatic vegetation, primarily invasive hydrilla (*Hydrilla verticillata*).[8] The Asian clam (*Corbicula fluminea*) was second at 16%, and blue crabs (*Callinectes sapidus*) was third at 7% of its diet. Declining species like American shad (*Alosa sapidissima*), river herring alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and American eel (*Anguilla rostrata*) were found in less than 1% of stomachs. Blue catfish now support an exceptional trophy fishery in the Chesapeake Bay, where fish over 50 lbs. are routinely caught by anglers.

Summary:

Across the globe, the island apple snail has proven to be difficult to control, much less eradicate. Thus far, the salinity of Mobile Bay has delayed the range expansion of this invasive species into the prized Mobile-Tensaw Delta. The center of the snail infestation in TMC Watershed is in Langan Park. Flowing water and the extreme shoreline complexity add to the challenge of snail control there. Nevertheless, new methods have become available to address this destructive invader. While efforts to manually collect the eggs and adult snails should continue, iron phosphate pellets should be applied simultaneously where eggs are abundant. With the approval of Alabama Department of Conservation and Natural Resources, Wildlife and Freshwater

Fisheries Division, a high rate of blue catfish should be stocked in western Langan Park to not only address the island apple snail, but also the Asian clam and invasive, aquatic plants throughout system. Excavation of the lakes at Langan Park would add complexity to the timing of stocking the blue catfish, but in the end, simplifying the shoreline on the western portion of Langan lake would facilitate the periodic use of a stationary, chelated copper injection system to treat the entire system for island apple snails, including Three Mile Creek.

Eggs of the island apple snail cover a cypress buttress on Lake Munson, Leon County, Florida. (J Van Dyke)

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Figure 5.46
Pomacea canaliculata (island apple snail)

Estimated Abundance (Number of Plots)

Zero (332)
Low (26)
Medium (6)
High (4)

0 0.5 1 2 Miles
0 1 2 4 Kilometers

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Date: 3/14/2019 Path: P:\10_Projects\M\Mobile Bay National Estuary Program\GIS\Invasive Coverage\IslandAppleSnail.mxd

Basemap courtesy of Esri.

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Appendix A

Electronic Database and Costing Calculator

Appendix A-Electronic Database.xlsx

Appendix A-Costing Calculator.xlsx

Appendix B

Native Species Observed

Scientific Name	Common Name
Acer negundo	Boxelder
Acer rubrum	Red Maple
Alnus serrulata	Hazel Alder
Ambrosia artimisiifolia	Ragweed
Ambrosia trifida	Giant Ragweed
Andropogon glomeratus	Common Bushy Bluestem
Andropogon spp.	Bluestem
Arundinaria gigantea	Giant Cane
Baccharis halimifolia	Groundsel Tree
Bacopa monnieri	Smooth Water Hyssop
Betula nigra	River Birch
Bidens alba	Romerillo
Bidens mitis	Small Fruit Beggarticks
Boehmeria cylindrica	False Nettle
Bolboschoenus robustus	Saltmarsh Bulrush
Brunnichia ovata	American Buckwheat Vine
Cabomba caroliniana	Carolina Fanwort
Campsis radicans	Trumpet Creeper
Carex baileyi	Bailey's Sedge
Carex crus-corvi	Ravenfoot Sedge
Carya aquatica	Water Hickory
Carya illinoinensis	Pecan
Catalpa bignonioides	Southern Catalpa
Celtis laevigata	Sugarberry
Centella erecta	Stiff Spadeleaf; Coinleaf
Cephalanthus occidentalis	Buttonbush
Ceratophyllum demersum	Coontail
Chrysopsis sp.	Golden-aster
Cicuta maculata	Spotted Water Hemlock
Cissus trifoliata	Grape Ivy; Sorrel Vine
Cocculus carolinus	Carolina Coralbeads
Conoclinium coelestinum	Blue Mistflower
Conyza canadensis	Common Horseweed
Coreopsis tinctoria	Golden Tickseed
Crinum americanum	American Swamp Lily; Seven Sisters
Cyperus spp.	Flatsedge
Cyrilla racemiflora	Titi
Dichanthelium scoparium	Velvet Witch Grass
Dichanthelium spp.	Witch Grass; Rosette Grass
Dichanthelium villosissimum var.	Long Hair Witch Grass
Dichondra carolinensis	Carolina Ponysfoot
Drosera sp.	Sundew
Eleocharis acicularis	Needle Spikerush
Eleocharis sp.	Spikerush
Eleocharis sp.	Slender Spikerush
Elephantopus carolinianus	Carolina Elephantsfoot
Elymus virginicus	Virginia Wildrye
Erigeron sp.	Fleabane
Eupatorium capillifolium	Dogfennel
Euthamia galetorum	Slender Goldentop
Fraxinus sp.	Ash
Gelsemium sempervirens	Yellow Jessamine
Helianthus angustifolius	Swamp Sunflower
Hydrangea barbara	Climbing Hydrangea
Hydrocotyle ranunculoides	Floating Marshpennywort
Hydrocotyle sp.	Pennywort
Hydrolea quadrivalvis	Waterpod
Hymenocallis sp.	Spiderlily
Hypericum sp.	St. Johnswort
Ilex glabra	Gallberry; Inkberry
Ilex vomitoria	Yaupon

Illicium floridanum	Florida Anise
Impatiens capensis	Jewelweed
Itea virginica	Virginia Sweetspire
Juncus effusus	Soft Rush
Juncus marginatus	Grassleaf Rush
Juniperus virginiana	Red Cedar
Kosteletzkya pentacarpos	Seashore-mallow
Lactuca sp.	Wild Lettuce
Lemna sp.	Duckweed
Lepidium virginicum	Virginia Pepperweed
Lilaeopsis carolinensis	Carolina Grasswort
Liquidambar styraciflua	Sweetgum
Liriodendron tulipifera	Tuliptree; Yellow Poplar
Ludwigia sp.	Primrose-Willow
Lycopus spp.	Waterhorehound
Lymnobium spongia	American Frog's-bit
Magnolia grandiflora	Southern Magnolia
Magnolia virginiana	Sweetbay
Mikania scandens	Climbing Hempvine
Morella cerifera	Wax Myrtle
Morus rubra	Red Mulberry
Myriophyllum heterophyllum	Southern Watermilfoil
Myriophyllum pinnatum	Cutleaf Watermilfoil
Najas guadalupensis	Southern Waternymph
Nekemias arborea	Peppervine
Nymphaea odorata	American White Waterlily
Nyssa biflora	Tupelo Gum
Nyssa sylvatica	Blackgum
Oenothera sp.	Evening Primrose
Onoclea sensibilis	Sensitive Fern
Orontium aquaticum	Goldenclub
Osmunda spectabilis	Royal Fern
Osmundastrum cinnamomeum	Cinnamon Fern
Packera glabella	Butterweed
Parthenocissus quinquefolia	Virginia Creeper
Peltandra virginica	Arrow Arum
Persea palustris	Swamp Red Bay
Persicaria (Polygonum) sp.	Smartweed
Phragmites australis	Common Reed
Phytolacca americana	American Pokeweed
Pinus elliottii	Slash Pine
Pinus taeda	Loblolly Pine
Platanus occidentalis	American Sycamore
Pluchea sp.	Camphorweed
Pontederia cordata	Pickerelweed
Prunus caroliniana	Carolina Laurel Cherry
Prunus serotina	Black Cherry
Pteridium aquilinum	Bracken Fern
Ptillimnium capillifolium	Threadleaf Mock Bishopweed
Quercus hemisphaerica	Darlington Oak
Quercus laurifolia	Laurel Oak; Diamondleaf Oak
Quercus nigra	Water Oak
Quercus virginiana	Live Oak
Rhexia mariana	Maryland Meadowbeauty
Rhynchospora corniculata	Short-bristled Horned Beaksedge
Robinia pseudoacacia	Black Locust
Rubus sp.	Blackberry
Rubus trivialis	Southern Dewberry
Rumex verticillatus	Swamp Dock
Sabal minor	Dwarf Palmetto
Sabal palmetto	Cabbage Palm
Sacciolepis striata	American cupscale

Sagittaria lancifolia	Bulltongue Arrowhead
Sagittaria latifolia	Broadleaf Arrowhead; Duck Potato
Salix nigra	Black Willow
Sambucus canadensis	American Black Elderberry
Saururus cernuus	Lizard's Tail
Schoenoplectus sp.	Bulrush
Scirpus cyperinus	Woolgrass
Sesbania sp.	Riverhemp
Smilax rotundifolia	Roundleaf Greenbrier
Smilax smallii	Jackson-briar
Smilax sp.	Greenbrier
Solanum carolinense	Carolina Horsenettle
Solidago altissima	Canada Goldenrod
Solidago sempervirens	Seaside Goldenrod
Solidago sp.	Goldenrod
Sparganium americanum	American Bur-Reed
Spiranthes sp.	Lady's Tresses Orchid
Stachys floridana	Florida Hedgenettle
Stenotaphrum secundatum	St. Augustine Grass
Taxodium ascendens	Pond Cypress
Taxodium distichum	Bald Cypress
Thelypteris kunthii	Kunth's Maiden Fern
Thelypteris palustris	Eastern Marsh Fern
Tradescantia subaspera	Zigzag Spiderwort
Tradescantia virginiana	Virginia Spiderwort
Tripsacum dactyloides	Eastern Gamagrass
Typha domingensis	Southern Cattail
Typha latifolia	Broadleaf Cattail
Utricularia sp.	Bladderwort
Verbesina sp.	Crownbeard
Vigna luteola	Wild Cowpea
Viola sp.	Violet
Vitis aestivalis	Summer Grape
Vitis cinerea var. *floridana*	Florida Grape
Vitis rotundifolia	Muscadine
Wisteria frutescens	American Wisteria
Woodwardia areolata	Netted Chainfern
Woodwardia virginica	Virginia Chainfern
Xyris sp.	Yelloweyed Grass
Zanthoxylum clava-herculis	Hercules' Club
Zizania aquatica	Annual Wildrice
Zizaniopsis mileacea	Giant Cutgrass

Appendix C

Example Field Data Form

Surveyor Name: Date:

Site: Lat: Long:

Plot Type: Riparian Stream Habitat Type: Waterfall

Plot Dimensions: by
(In meters 15m x 15m minimum)

Plot Location: Center of Channel Notes:

Invasive Plants Observed

Scientific Name	Common Name	Coverage	Notes
Albizia julibrissin	Mimosa	0%	
Alternanthera philoxeroides	Alligator weed	0%	
Canna sp.	Canna lilies	0%	
Cinnamomum camphora	Camphor tree	0%	
Clematis terniflora	Sweet autumn virgins	0%	
Colocasia esculenta	Wild taro	0%	
Deparia petersenii	Petersen's spleen wort	0%	
Eichornia crassipes	water hyacinth	0%	
Hygrophila polysperma	East Indian hygrophila	0%	
Hyptis mutabilis	Tropical bushmint	0%	
Imperata cylindrica	Cogon grass	0%	
Lagerstroemia indica	Crepe myrtle	0%	
Ligustrum sinense	Chinese privet	0%	
Lonicera japonica	Japanese honeysuckle	0%	
Ludwigia peploides	Floating primrose-willow	0%	
Ludwigia peruviana	Peruvian water-primrose	0%	
Lygodium japonicum	Japanese climbing fern	0%	
Melia azedarach	Chinaberry	0%	
Myriophyllum spicatum	Eurasian watermilfoil	0%	

Scientific Name	Common Name	Coverage	Notes
Myriophyllum aquatium	Parrot feather	0%	
Oxycaryum cubense	Cuban bulrush	0%	
Panicum repens	Torpedograss	0%	
Paspalum urvillei	Vasey grass	0%	
Pueraria lobata	Kudzu	0%	
Raphanus raphanistrum	Wild radish	0%	
Rhynchospora scutellata	West Indian Beaksedge	0%	
Rosa spp.	rose	0%	
Salvinia minima	Common salvinia	0%	
Sesbania punicea	Spanish gold	0%	
Thelypteris dentata	Downy maiden fern	0%	
Triadica sebifera	Chinese tallow	0%	
		0%	
		0%	
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		0%	
		0%	

Upstream Photos

Downstream Photos

LDB

RDB

Substrate

Invasive animals observed

Scientific Name	Common Name	Coverage	Notes
Corbicula fluminea	Asian clam	zero	
Pomacea maculata	Island apple snails	zero	
Oreochromis spp	Tilapia	zero	

Dominant native plants observed (>20% cover)

Scientific Name	Common Name	Notes