

Implementation of Floating Aquatic Vegetative Tilling Technology in the Caloosahatchee River Watershed

Deliverable #19: Final Report

Site 1

Prepared for:

**Florida Department of Agriculture and Consumer Service
(FDACS)**

Contract #022563

Prepared by:

**Water & Soil Solutions, LLC
Loxahatchee, FL**

September 9, 2016

Revised September 14, 2016

Table of Contents

List of Figures	ii
List of Tables	v
Executive summary.....	1
Introduction	4
FAVT System Unit Processes	6
Optimization & Monitoring Results	7
Water Chemistry in the FAVT system.....	7
Characterization of inflow and outflow water chemistry	9
TP and pH monitoring at cell inflows and outflows	17
Floating and Submerged Aquatic Vegetation Surveys.....	24

List of Figures

Figure 1. Project location within the watershed (Source – Caloosahatchee River Watershed Protection Plan January 2009).	5
Figure 2. Water quality sampling locations in the FAVT facility for sampling performed July 2015 through June 2016.....	9
Figure 3. TP concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.	13
Figure 4. SRP concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.	13
Figure 5. DOP concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.	14
Figure 6. PP concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.	14
Figure 7. TN concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.	15
Figure 8. Nitrate+nitrite (NO _x) concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.....	15
Figure 9. Ammonia-N concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016..	16
Figure 10. Alkalinity in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.	16
Figure 11. pH in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.....	17
Figure 12. Surface water TP concentration and pH at the inflow and outflow of Cell 1 of the Caloosahatchee FAVT system. Monitoring was conducted on a weekly basis from July 2015 through June 2016.....	20
Figure 13. Surface water TP concentration and pH at the inflow and outflow of Cell 2 of the Caloosahatchee FAVT system. Monitoring was conducted on a weekly basis from July 2015 through June 2016.....	21
Figure 14. Surface water TP concentration and pH at the inflow and outflow of Cell 3 of the Caloosahatchee FAVT system. Monitoring was conducted on a weekly basis from July 2015 through June 2016.....	22
Figure 15. Mean surface water TP concentration (± 1 standard deviation) at the system inflow (=Cell 1 inflow), Cell 1 outflow (=Cell 2 inflow), Cell 2 outflow (=Cell 3 inflow), and system outflow (=Cell 3 outflow) of the Caloosahatchee FAVT system. Values were calculated from data collected during 34 weekly monitoring events from July 2015 through June 2016.	23
Figure 16. Mean surface water pH (± 1 standard deviation) at the system inflow (=Cell 1 inflow), Cell 1 outflow (=Cell 2 inflow), Cell 2 outflow (=Cell 3 inflow), and system outflow (=Cell 3	

outflow) of the Caloosahatchee FAVT system. Values were calculated from data collected during 34 weekly monitoring events from July 2015 through June 2016.	23
Figure 17. Very dense mat of <i>Eichhornia crassipes</i> (water hyacinth) and <i>Pistia stratiotes</i> (water lettuce) in Cell 1.....	27
Figure 18. Time-series for FAV species within Cells 1 and 2 depicting the percent of stations that was moderately dense or greater for each species.	28
Figure 19. Time-series for FAV species within Cells 1 and 2 depicting the percent of stations that each species present.	29
Figure 20. Mixed species mat with <i>Eichhornia crassipes</i> (water hyacinth) and <i>Pistia stratiotes</i> (water lettuce) in Cell 1.....	30
Figure 21. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during July 2015.....	31
Figure 22. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during August 2015.....	31
Figure 23. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during September 2015.	32
Figure 24. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during October 2015.	32
Figure 25. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during early November 2015.	33
Figure 26. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during late November 2015.....	33
Figure 27. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during December 2015.....	34
Figure 28. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during January 2016.....	34
Figure 29. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during February 2016.....	35
Figure 30. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during March 2016.....	35
Figure 31. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during April 2016.....	36
Figure 32. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during May 2016.	36
Figure 33. Relative cover of the FAV species <i>Eichhornia crassipes</i> and <i>Pistia stratiotes</i> in Cells 1 and 2 of the Caloosahatchee wetland during June 2016.	37
Figure 34. <i>Hydrilla verticillata</i> , an invasive SAV species, at the Cell 2 culvert.....	39
Figure 35. Time-series for SAV species within Cell 3 depicting the percent of stations that stations that was moderately dense or greater for each species.	40
Figure 36. Time-series for SAV species within Cell 3 depicting the percent of stations that each species is present.....	41

Figure 37. Mixed SAV assemblage containing <i>Utricularia</i> sp. (bladderwort) and other species in Cell 3.....	42
Figure 38. <i>Najas guadalupensis</i> (southern naiad) growing near the outflow of Cell 3.....	42
Figure 39. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the July 2015 vegetation survey.....	43
Figure 40. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the August 2015 vegetation survey.....	44
Figure 41. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the September 2015 vegetation survey.	45
Figure 42. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the October 2015 vegetation survey.	46
Figure 43. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the early November 2015 vegetation survey.	47
Figure 44. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the late November 2015 vegetation survey.	48
Figure 45. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the December 2015 vegetation survey.....	49
Figure 46. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the January 2016 vegetation survey.....	50
Figure 47. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the February 2016 vegetation survey.....	51
Figure 48. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the March 2016 vegetation survey.....	52
Figure 49. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the April 2016 vegetation survey.....	53
Figure 50. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the May 2016 vegetation survey.....	54
Figure 51. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the June 2016 vegetation survey.....	55

List of Tables

Table 1. Analytical methods used for laboratory analysis of surface water sampled for the Caloosahatchee FAVT project. Method detection limits (MDL) are shown for each chemical parameter analyzed.	8
---	---

Executive summary

Water & Soil Solutions, LLC (WSSLLC) has deployed an approximately 523-acre Floating Aquatic Vegetative Tilling (FAVT) wetland treatment facility in the Hendry-Hilliard Water Control District (HHWCD) in the East Caloosahatchee River Sub-Watershed southwest of Lake Okeechobee. The purpose of the project is to cost-effectively remove phosphorus (P) and nitrogen (N) from regional canals, including surface waters of the HHWCD and the Caloosahatchee River (C-43 Canal), using the patented FAVT technology in a man-made flow-through treatment marsh.

FAVT systems utilize a novel approach to enhance N and P removal from surface waters. The technology uses the direct assimilation of nutrients from the water column through the use of floating plant roots (as compared to plants rooted in the soil) and, rather than periodically harvesting the plants (which is costly and inefficient due to the high water content of the vegetation), all of the biomass is rapidly incorporated directly into the soil via tilling during the dry season. FAVT systems therefore operate similarly to a conventional treatment wetland by storing P in the soil, but they accomplish P removal more efficiently and at a significantly faster rate. At this site, FAV species common to the adjacent canals, namely *Eichhornia crassipes* (water hyacinth) and *Pistia stratiotes* (water lettuce), are utilized in the front two cells, while *Najas guadalupensis*, *Utricularia* spp., and other species of submerged aquatic vegetation (SAV) dominate the back end (Cell 3) as a final, “polishing”, component of the FAVT system.

The system became fully operational in September 2014, receiving regional source water and discharging through the outflow culverts beginning 9/15/14. Subsequent monitoring of system inflow and outflow water chemistry was conducted on a weekly basis. Monitoring results through June 2016 show that system outflow total phosphorus (TP) concentrations were consistently lower than inflow TP concentrations, despite highly variable inflow TP concentrations ranging from 33 µg/L to 147 µg/L. Outflow TP concentrations ranged from 12 to 41 µg/L. There was a generally declining trend in outflow TP concentration over the period July 2015 – June 2016. Overall mean TP concentrations in the inflow and outflow streams were 73 and 23 µg/L. Mean inflow TP

was nearly the same as the mean inflow TP during the previous sampling period (September 2014 – June 2015), yet mean outflow concentration has decreased by 30%. This may reflect system maturation and a declining release of legacy soil TP to the water column. Soluble reactive P (SRP) concentrations were considerably reduced in the outflow stream, from an average of 30 µg/L at the inflow to 3 µg/L at the outflow. On average, SRP accounted for 41 percent of TP in the inflow stream and 11 percent of TP in the outflow stream. The reduction in SRP concentration is assumed to be largely due to plant uptake. Inflow SRP concentration was consistently higher during the current (2015 – 2016) monitoring period, compared to the previous period, yet mean outflow SRP concentration was nearly identical during both periods, and close to the lower limit of detection. Dissolved organic P (DOP) and particulate P (PP) concentrations were also effectively reduced by the FAVT system.

TP monitoring at the inflow and outflow of each of Cells 1, 2 and 3 indicated that most of the P removal has occurred across Cells 1 and 2, a finding that was also observed in the previous year. Nearly all Cell 1 outflow samples were lower in TP concentration than inflows. This is in sharp contrast to the previous sampling period, where only in the later portion of the period was there a clear difference in inflow and outflow TP. Cell 1 outflow TP concentration was relatively stable, with an average value of 28 µg/L during the 2015 – 2016 period. Total P was further reduced in Cell 2, from an inflow mean concentration of 28 µg/L, to 18 µg/L at the outflow. Average TP concentration increased slightly across Cell 3, from 18 µg/L at the inflow to 23 µg/L at the outflow. As observed in previous reports, lack of reduction in TP across Cell 3 could be due to a number of factors, including slow release of phosphorus that has accumulated during previous land management practices.

As was the case for the previous monitoring period, Total N (TN) concentrations were not effectively reduced during the current period. The overall mean outflow TN concentration was slightly higher than mean inflow TN (1.50 versus 1.42 mg/L, respectively) and these values are nearly identical to those observed during the previous period. Nearly all of the TN load to the system was in organic form, representing a substantial pool of N that is not readily bioavailable. Both ammonia-N and NO_x-N were reduced in the FAVT, from 0.073

mg/L to 0.047 mg/L for ammonia-N, and 0.047 mg/L to 0.017 mg/L for NO_x-N. The sum of these two (dissolved inorganic N) represented approximately 8% of total N, thus considerable organic N (about 92% of TN) probably passes through the system and is unavailable for plant uptake.

In order to evaluate vegetation growth and health, visual assessments of speciation and areal coverage (i.e., relative abundance) of FAV (Cells 1 and 2) and SAV (Cell 3) were performed on a routine basis at stations located on a pre-determined grid pattern across Cells 1 (21 stations), 2 (33 stations) and 3 (53 stations). These surveys were conducted monthly from July 2015 through June 2016. Results of the surveys indicated that dense growth of water hyacinth has continued to increase in coverage, from 86% to 100% in Cell 1. Dense hyacinth coverage has declined in Cell 2, with dense growth of hyacinth observed at 67% of sampling stations in July 2015, declining to 49% of stations by July 2016. Both density and presence of hyacinth have declined in Cell 2 compared to the previous period. Spatiotemporal analysis showed persistent regions of open water appearing along the western and southern regions of Cell 2, and in the outflow region. As observed in the previous annual report, total P at the inflow to Cell 2 declined steadily over the November 2014 to June 2015 period. This decline may have impacted productivity of hyacinth in Cell 2. *Pistia* is currently a relatively minor though stable component of the FAV community in both cells. At both the beginning and end of the sampling period, no dense stands of *Pistia* were observed at any sampling station in Cell 1. Conversely, from 3% to 15% of sampling stations reported dense *Pistia* in Cell 2 over the course of the sampling period.

The most common SAV species in Cell 3 were *Utricularia*, *Najas*, and *Hydrilla verticillata*. The most striking finding of the submerged aquatic vegetation (SAV) surveys for the July 2015 – June 2016 period is the increasing extent and density of *Hydrilla*. For example, during February 2015, *Hydrilla* was found at only 5% of the monitoring stations, and at no station was it found to be even moderately dense. By June 2016, *Hydrilla* was found to be at least moderately dense at 50% of the stations and was present at 80% of the stations. This has been accompanied by large declines in *Utricularia*. During the previous period, *Utricularia* density was relatively stable, with 40-70% of stations having dense stands of

Utricularia. By November 2015, this had declined to 2% of stations reporting dense *Utricularia*. Thus, *Hydrilla* seems to have mostly replaced *Utricularia* in Cell 3. Continued monitoring of both SAV and FAV will be performed in FY 2016, in order to enhance system operations and management practices, and to facilitate our understanding of spatial and temporal patterns in TP removal performance.

Introduction

Water & Soil Solutions, LLC (WSSLLC) has completed the first full year of operation of an approximately 523-acre Floating Aquatic Vegetative Tilling (FAVT) wetland treatment facility in the Hendry-Hilliard Water Control District (HHWCD) in the East Caloosahatchee River Sub-Watershed southwest of Lake Okeechobee. The watershed is located in the Northern Everglades west of Lake Okeechobee. The project site is part of a large parcel of private land (Sections 18 & 19/ Township 44 South/ Range 32 East) on the southern side of the Caloosahatchee River (Figure 1). The purpose of the project is to cost effectively remove phosphorus (P) and nitrogen (N) from regional canals, including surface waters of the HHWCD and the Caloosahatchee River (C-43 Canal), using the patented FAVT technology in a man-made flow-through treatment marsh. This document encompasses the Final Report for the project period July 1, 2015 through June 30, 2016.

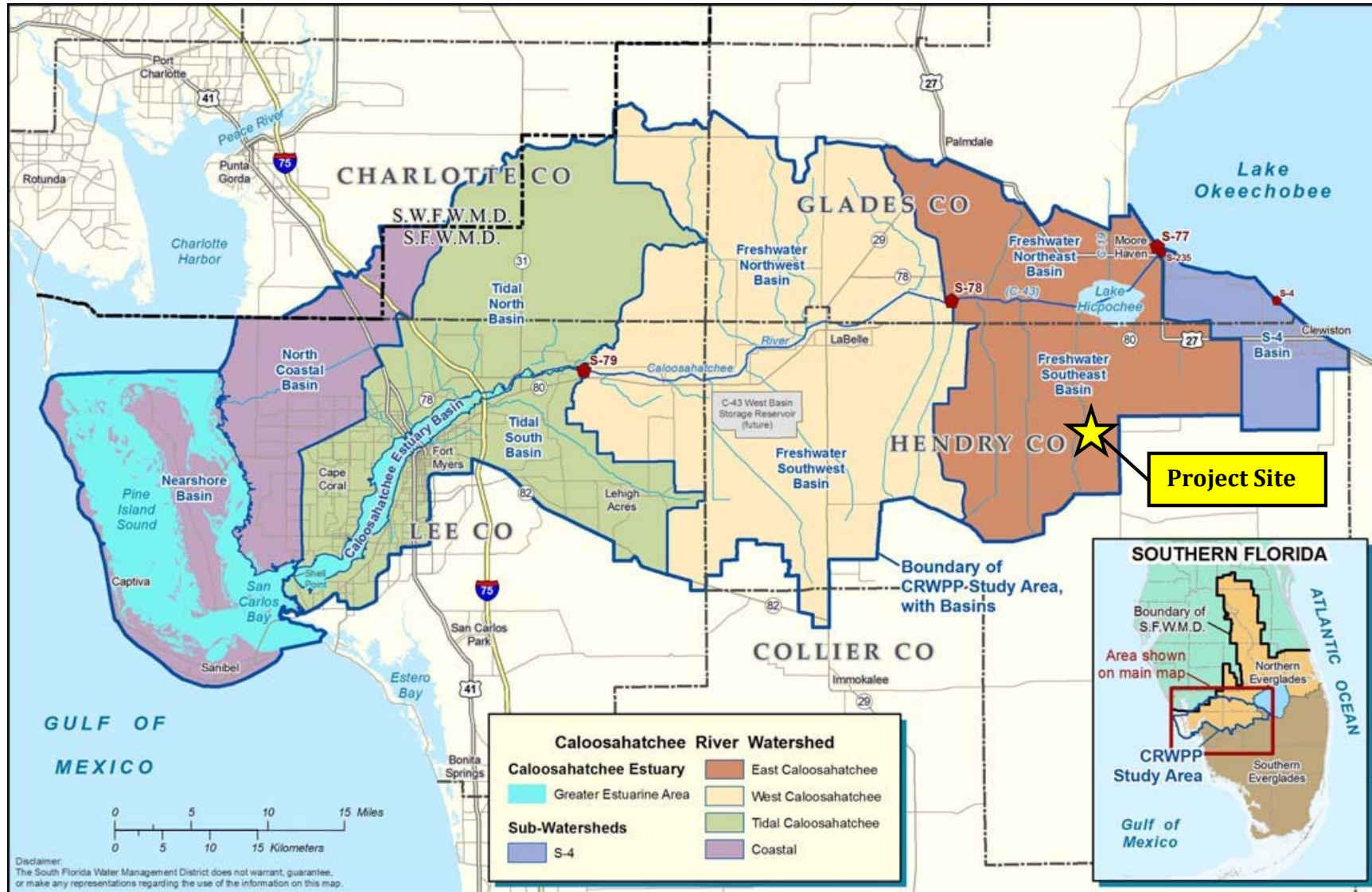


Figure 1. Project location within the watershed (Source - Caloosahatchee River Watershed Protection Plan January 2009).

FAVT System Unit Processes

FAVT systems utilize a novel approach to enhance N and P removal from surface waters. Many species of FAV, such as water hyacinth, are known to rapidly assimilate N and P, but their high nutrient uptake rate can only be sustained if the plants are maintained at an optimal density. The ideal coverage is usually achieved by periodic harvesting; however, since FAV are predominantly water, mechanical removal of the biomass is costly and inefficient. FAVT overcomes these constraints by using the following operational approach: (1) the FAV wetland is operated for an initial growing season, during which time the FAV assimilate nutrients and grow to a high density; (2) the wetland is drained during the dry season, thereby stranding the FAV on the soil; (3) after a natural drying process, the plant material is tilled into the soil together with its associated nutrients; (4) the wetland is reflooded; and (5) FAV that are stored in deeper zones are used to repopulate the wetland for the subsequent growth period. During this post-tilling process, water is held in the wetland without discharge for several weeks to provide time for the vegetation and water column nutrient levels to equilibrate. It is anticipated that tilling will be performed on a yearly basis (approximately) at the Project site. This FAVT system also contains an added component consisting of a variety of submerged aquatic vegetation (SAV) such as *Najas guadalupensis*, *Utricularia* spp., and other SAV species at the back end of the system (Cell 3). This provides a final, “polishing” step for treated water in the FAVT system.

FAVT systems therefore operate similarly to a conventional treatment wetland by storing P in the soil, but they accomplish P removal more efficiently and at a significantly faster rate. The technology uses the direct assimilation of nutrients from the water column through the use of floating plant roots (as compared to plants rooted in the soil), and all of the biomass is rapidly incorporated directly into the soil through tilling. The process thereby results in a reduction of up to 80% of land needed for treatment as compared to traditional wetland treatment systems. It is expected that the FAVT systems will provide P reductions in the range of 3 to 15 g P/m²-yr, depending on the growth rate of the FAV, which will be linked to factors such as the P loading rate, speciation of P in the inflow waters, and availability of inorganic N and other macro- and micro-nutrients in the inflow waters. Similarly, N removal can be extremely high in FAV systems (up to 250 g N/m²-yr) when the supply of

inorganic N is high in the inflow waters. An effort to estimate total P and N mass removal by the East Caloosahatchee River Project has not yet been made due to uncertainties of key underlying variables, such as water availability and nutrient levels.

At this site, FAV species common to the adjacent canals are being utilized, for example, *Eichhornia crassipes* (water hyacinth). Maximum growth (and P uptake) rates of this species occur in the summer, which coincides with the periods of highest runoff flows available for treatment.

As noted above, soils are the ultimate storage reservoir for P within all treatment wetlands. In conventional, emergent plant based wetlands such as the front-end cells of the Everglades Stormwater Treatment Areas (STAs), most of the soil P is associated with organic matter with lesser amounts associated with minerals such as calcium, aluminum and iron. An important aspect of the FAVT tilling approach is that it accelerates the rate of transferring not only P, but also organic matter and inorganic P-sorbing compounds into permanent storage. The treatment process of this FAVT consists of two initial cells that have been stocked with hyacinth and water lettuce (*Pistia stratiotes*) (Figure 2). A third and larger cell contains a variety of submerged aquatic vegetation. Water is pumped from the Orange Gate canal into Cell 1, and then flows south through Cell 1 and Cell 2. It is gravity-discharged through three culverts to Cell 3, flows northward, and is then discharged through four culverts to the McKinney canal on the north end of the system.

Optimization & Monitoring Results

The goal of this optimization and monitoring effort is to collect, analyze and report water quality, water flow, vegetation and soil data to facilitate optimization of the East Caloosahatchee FAVT system in an environmentally sound manner and in accordance with established protocols.

Water Chemistry in the FAVT system

The system became fully operational in September 2014, receiving regional source water and discharging through the outflow culverts, beginning 9/15/14. Subsequent monitoring

of system inflow and outflow water chemistry was conducted on a weekly basis. Results of ongoing water quality monitoring are presented for the period 7/1/2015 – 6/30/2016.

Water samples collected during each event were analyzed for the parameters listed in Table 1, using standard methods of analysis. Dissolved organic P (DOP) and particulate P (PP) were calculated from TP, SRP and TSP (DOP=TSP-SRP and PP=TP-TSP); total N (TN) was calculated as the sum of TKN and NO_x-N. pH was measured on site during each sampling event.

Additional weekly monitoring, for TP and pH only, was conducted at the outflows of Cells 1 and 2 (equivalent to the inflows of Cells 2 and 3, respectively), starting in November 2014. The objective of this supplemental monitoring is to evaluate water chemistry changes within each of the three system cells. For this purpose, the system inflow and outflow data represent the Cell 1 inflow and Cell 3 outflow, respectively.

Table 1. Analytical methods used for laboratory analysis of surface water sampled for the Caloosahatchee FAVT project. Method detection limits (MDL) are shown for each chemical parameter analyzed.

Parameter	Method	MDL
Total Phosphorus (TP)	SM4500-P F	3 µg/L
Soluble reactive P (SRP)	SM4500-P F/DBE SOP OPO4	2 µg/L
Total Soluble Phosphorus (TSP)	SM4500-P F	3 µg/L
Alkalinity	EPA 310.1	3 mg CaCO ₃ /L
Nitrate + nitrite (NO _x -N)	EPA/353.2/SM4500 NO ₃ -F	0.016 mg/L
Total ammonia (NH ₃ +NH ₄)	EPA 350.11	0.020 mg/L
Total Kjeldahl Nitrogen (TKN)	EPA 351.2	0.033 mg/L

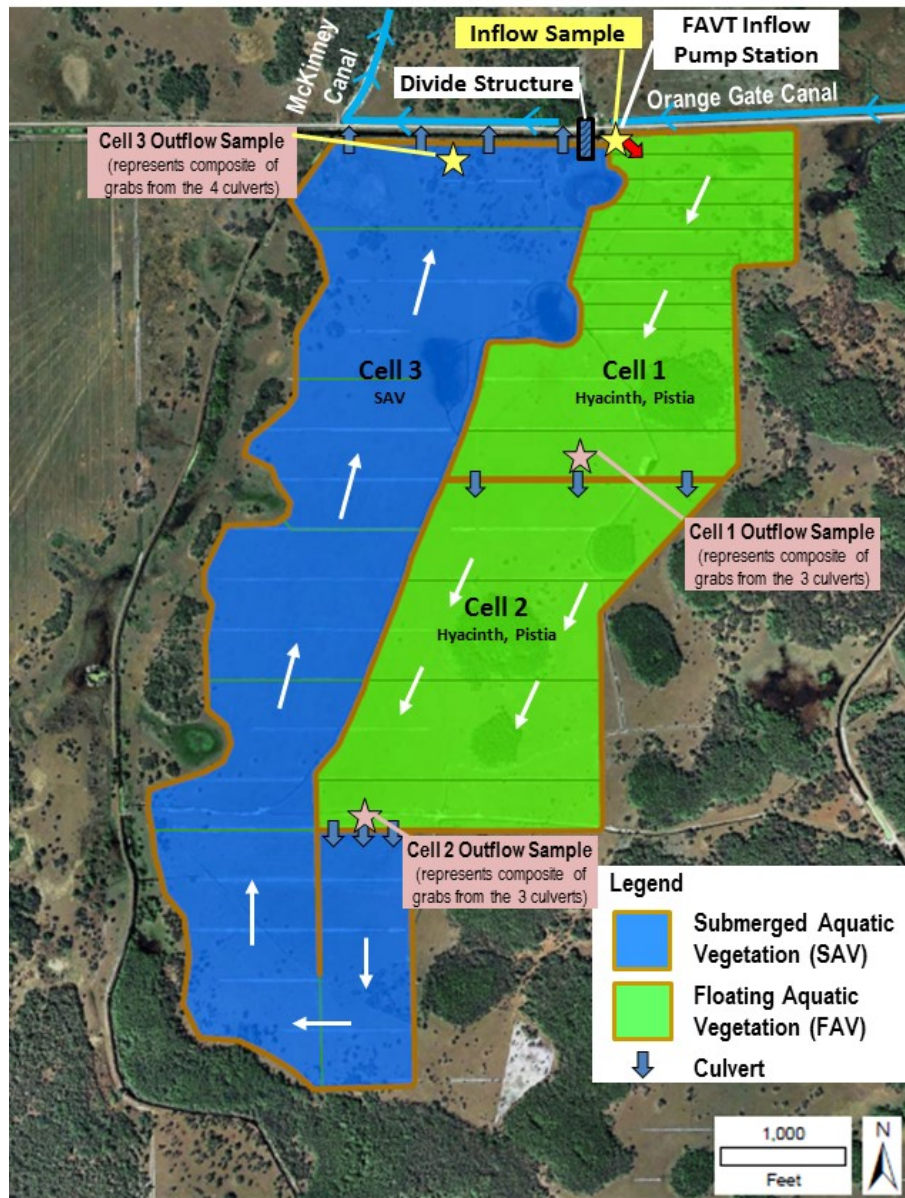


Figure 2. Water quality sampling locations in the FAVT facility for sampling performed July 2015 through June 2016.

Characterization of inflow and outflow water chemistry

During the July 2015 – June 2016 monitoring period, system outflow TP concentrations were consistently lower than inflow TP concentrations (Figure 3). Inflow TP concentrations ranged from 33 µg/L to 147 µg/L. Outflow TP concentrations ranged from 12 to 41 µg/L, showing a generally declining trend over the sampling period. Overall mean TP concentrations in the inflow and outflow streams were 73 and 23 µg/L, respectively.

Total P inflow concentrations were generally higher for this sampling period, compared to the 2014-2015 period, even though mean inflow concentrations were nearly identical for the two periods. Lower TP inflow concentrations during most of the 2014-2015 period were offset by several very high inflow values. Despite higher inflow TP concentration during July 2015 – June 2016, outflow TP was on average 10 µg/L lower than the September 2014 – June 2015 sampling period. This may reflect system maturation and a declining release of legacy soil TP to the water column.

Soluble reactive P concentration was considerably reduced in the outflow stream, relative to inflow concentration (Figure 4). Inflow SRP concentrations averaged 30 µg/L, but ranged widely, from 6 to 85 µg/L, during the monitoring period. In contrast, outflow SRP concentrations were always below 10 µg/L, ranging from non-detectable (<2 µg/L) to 6 µg/L, and averaging 3 µg/L. On average, SRP accounted for 41 percent of TP in the inflow stream, and 11 percent of TP in the outflow stream. The reduction in SRP concentration is assumed to be due largely to plant uptake. As with TP, inflow SRP concentration was consistently higher during the 2015 – 2016 monitoring period, compared to the 2014 - 2015 period. This may reflect recent changes in the watershed, or perhaps differences in seasonal factors between the periods. As with TP, despite higher average inflow SRP concentration in the current period, outflow SRP was maintained at low levels, often below the limit of detection. Temporal changes in inflow SRP concentrations were significantly correlated with changes in inflow TP ($r^2 = 0.87$). Thus, factors in the watershed that govern bioavailable P are responsible for regulating the overall supply of P to the FAVT, and likely the Caloosahatchee River as well.

Concentration of DOP, which is not readily available for plant uptake, was consistently lower in the outflow stream than in the inflow stream during the monitoring period (Figure 5). The overall mean inflow DOP concentration was 17 µg/L, compared with an outflow mean concentration of 7 µg/L. Inflow DOP concentrations were considerably more variable, ranging from 5 to 38 µg/L, relative to outflow DOP concentrations, which ranged from 2 to 18 µg/L. On average, the proportion of DOP as a fraction of total P increased slightly between the system inflow and outflow, from 24 to 31 percent of TP, reflecting the

lower bioavailability of DOP versus SRP. Unlike TP and SRP, inflow DOP declined on average for the July 2015 – June 2016 period, compared to the previous year. Also, removal of DOP was substantially better across the FAVT cells, with approximately 50% of inflow DOP removed.

Removal of PP was consistently more effective during this monitoring period, compared to 2014 – 2015. (Figure 6), with inflow and outflow PP concentrations averaging 26 and 13 $\mu\text{g/L}$, respectively. Inflow PP concentrations ranged from 6 to 55 $\mu\text{g/L}$, while outflow PP concentrations ranged from 5 to 29 $\mu\text{g/L}$. Though overall mean inflow concentrations for the two sampling years were the same (26 $\mu\text{g/L}$), inflow PP for the July 2015 – June 2016 period was consistently greater than the previous year. The same mean concentration for both periods reflects the effect of several very high PP values for September 2014 – June 2015 sampling period on the overall mean. There appears to be a seasonal effect on outflow PP, with higher values associated with the wetter months (August – October) compared with dry season concentrations. The stability in outflow PP concentration relative to inflow PP is indicative of effective settling of particulates over a wide range of inflow P concentrations.

As was the case for the previous (September 2014 through June 2015) monitoring period, TN concentrations in the inflow and outflow streams were similar (Figure 7), reflecting little or no net removal of N during this period. Inflow TN concentrations ranged from 1.03 to 2.33 mg/L, while outflow TN concentrations were more variable, ranging from 0.98 to 1.92 mg/L. The overall mean TN concentration in the outflow stream was slightly higher than the mean inflow TN concentration (1.50 vs. 1.42 mg/L, respectively). Both the average concentrations and the seasonal pattern in TN were strikingly similar for both sampling years. Higher concentrations in TN were observed in warmer summer and fall months, with a net decrease from December through May. Only a small fraction of the TN load to the system was in inorganic form, either as $\text{NO}_x\text{-N}$ or ammonia-N (Figure 8 and Figure 9). Inflow and outflow ammonia-N averaged 0.073 mg/L and 0.047 mg/L, respectively. Inflow and outflow $\text{NO}_x\text{-N}$ averaged 0.047 mg/L and 0.017 mg/L, respectively, possibly reflecting some plant uptake for both forms of inorganic N. Inorganic N ($\text{NH}_x + \text{NO}_x\text{-N}$) represented

8% of TN at the inflow and 5% of TN at the outflow. The large fraction of organic N in the system inflow represents a substantial pool of N that is not readily bioavailable. Although it is possible that release of legacy soil organic N contributes the lack of net TN removal, it is likely that the similarity between inflow and outflow TN concentrations after more than a year of operation simply reflects a high level of resistance to degradation (recalcitrance) of organic N in the inflow stream. Within the much smaller inorganic N pool in the system inflow, there is evidence of depletion of $\text{NO}_x\text{-N}$ either through plant uptake or denitrification, and ammonia-N via plant uptake or nitrification.

Alkalinity levels in the inflow water averaged 150 mg (as CaCO_3)/L and ranged from 92 to 214 mg/L, which is essentially the same as the previous year (Figure 10). Unlike the September 2014 – June 2015 period, there was a difference in alkalinity between inflow and outflow. Outflow alkalinity was lower, averaging 118 mg/L and ranging from 86 to 148 mg/L. This probably reflects the establishment of a robust submerged aquatic vegetation (SAV) community in Cell 3 and photosynthetic removal of HCO_3^- from the water column. Outflow pH was consistently higher than inflow pH (Figure 11), likely due in part to the consumption of dissolved CO_2 by SAV in Cell 3 of the treatment system. For the monitoring period, inflow pH ranged from 6.7 to 7.7, averaging 7.3. Outflow pH ranged from 7.0 to 8.1 and averaged 7.6.

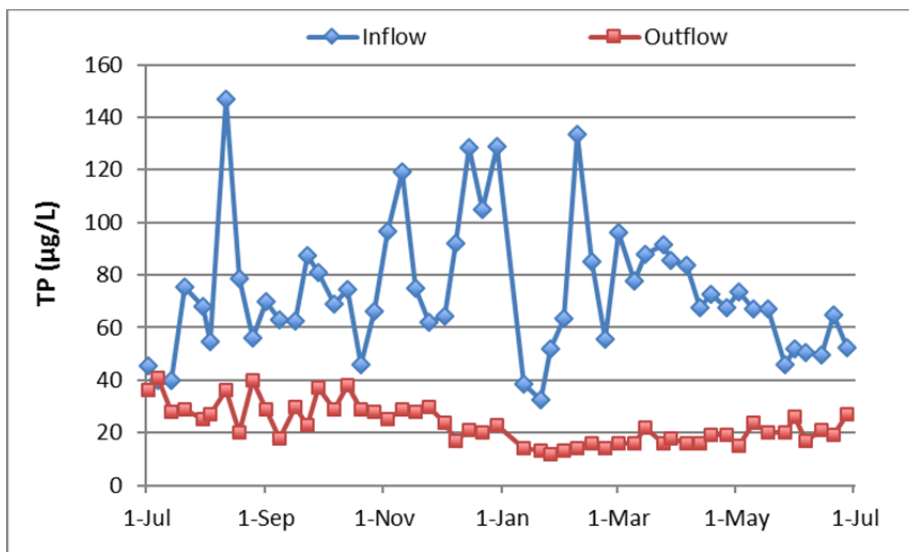


Figure 3. TP concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

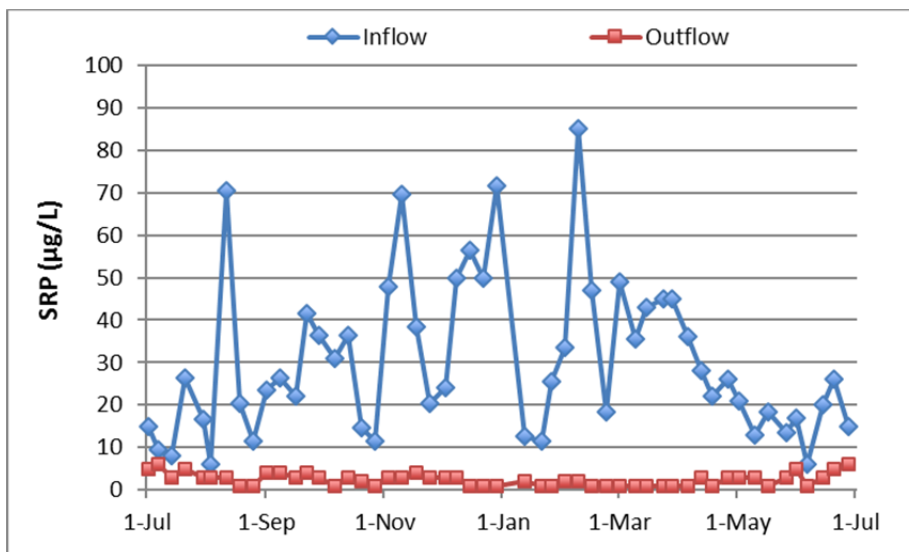


Figure 4. SRP concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

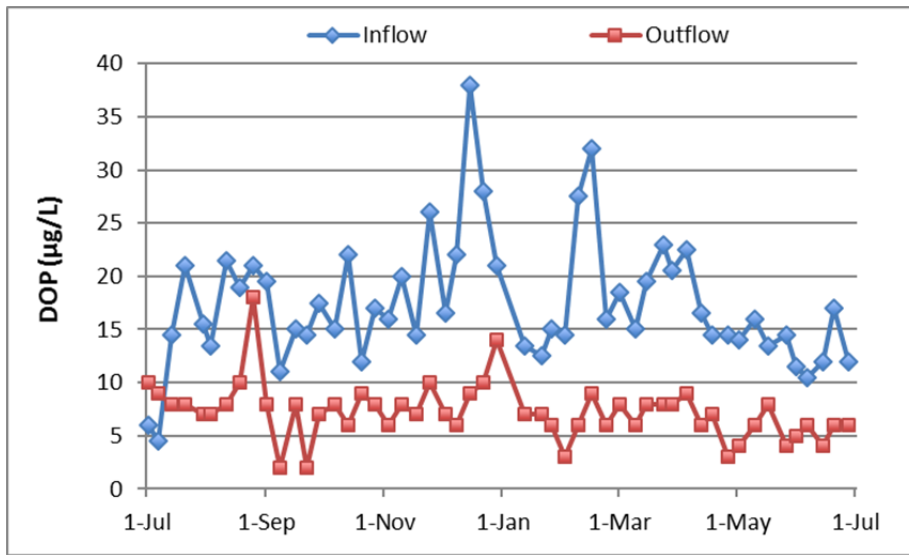


Figure 5. DOP concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

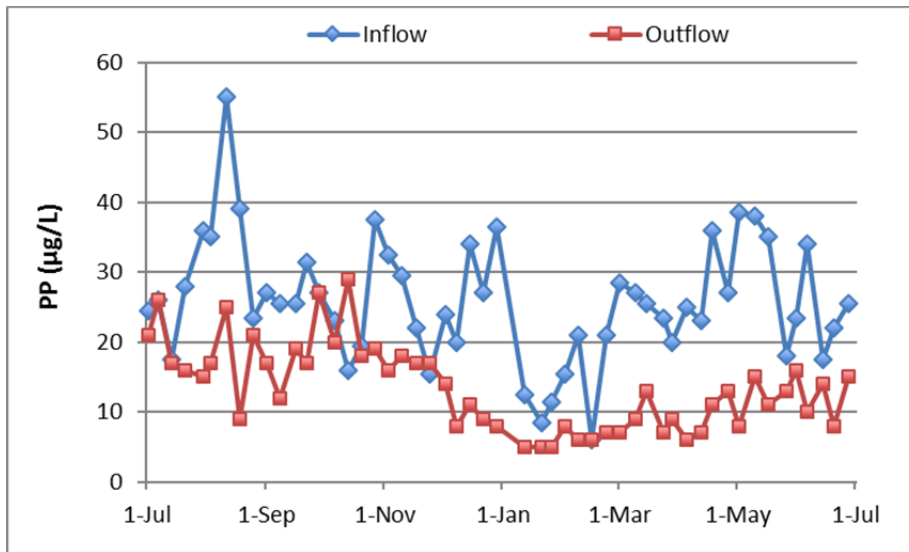


Figure 6. PP concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

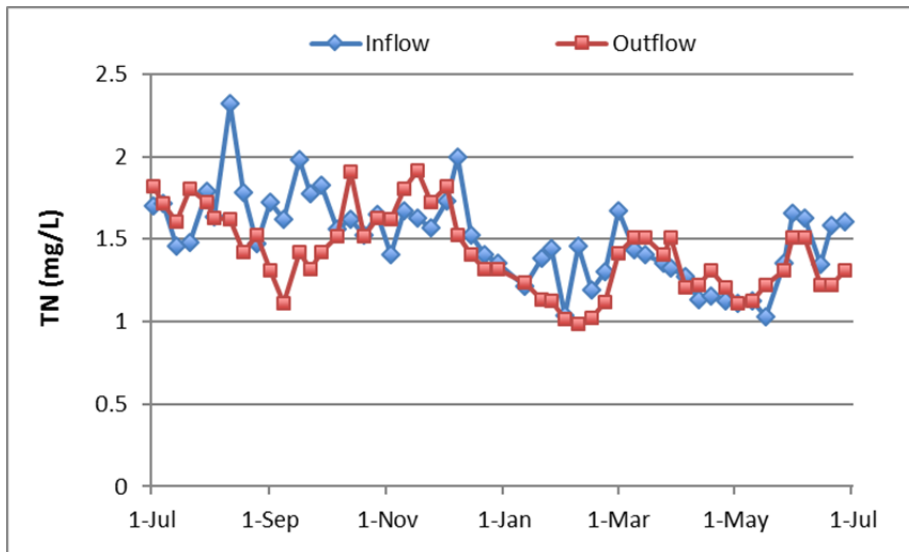


Figure 7. TN concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

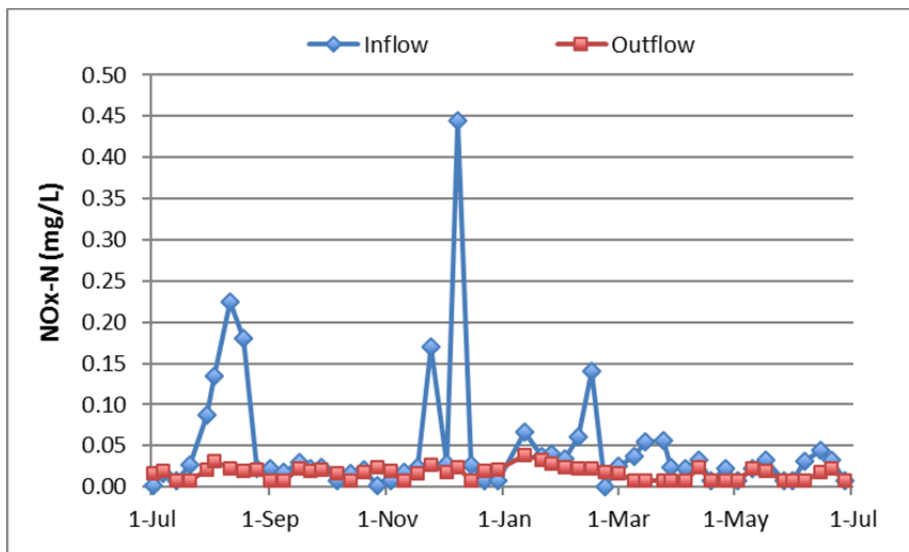


Figure 8. Nitrate+nitrite (NOx) concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

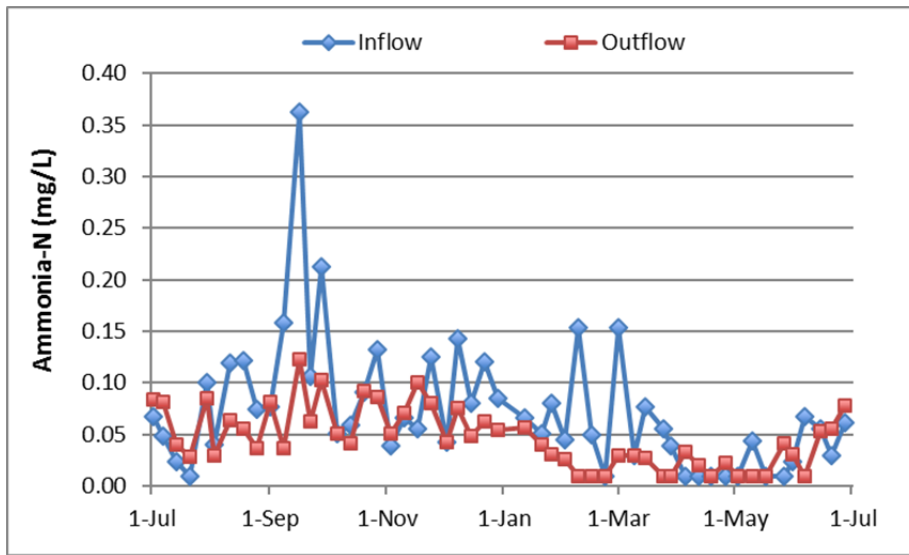


Figure 9. Ammonia-N concentrations in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

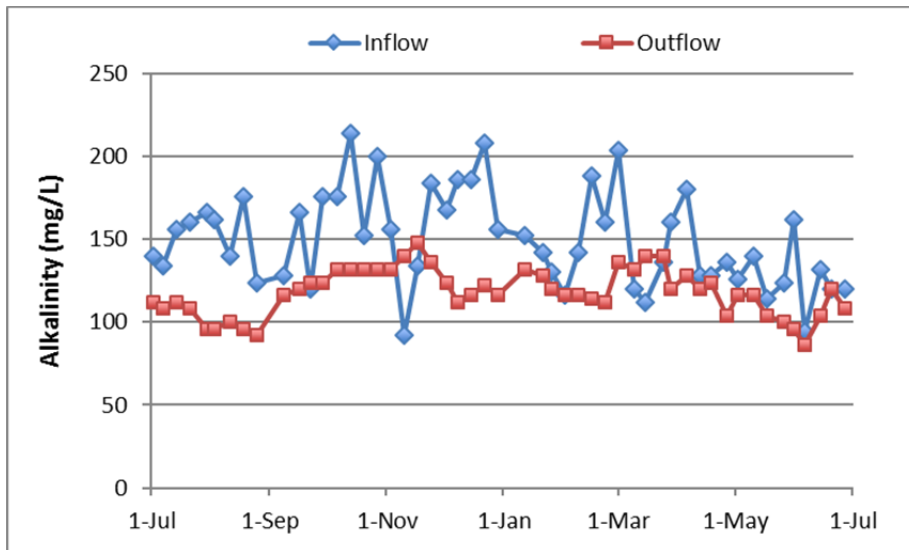


Figure 10. Alkalinity in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

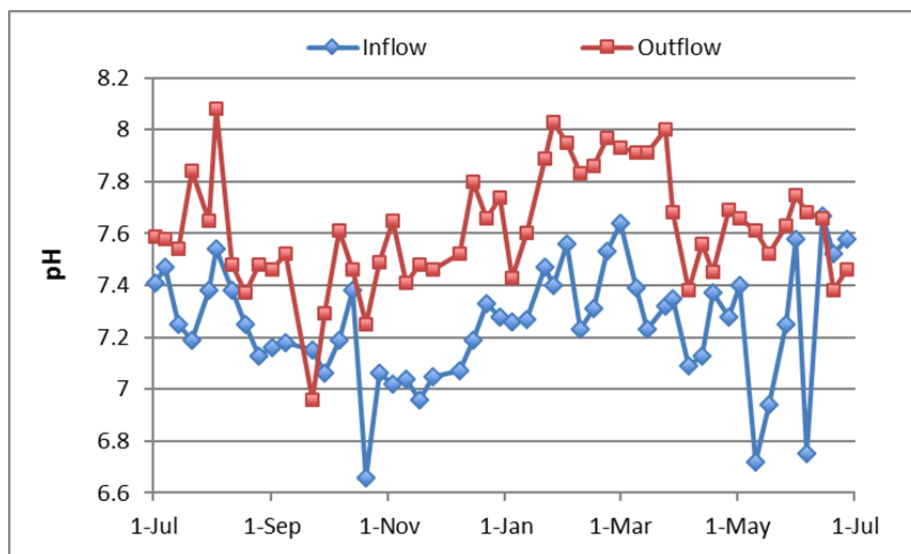


Figure 11. pH in the Caloosahatchee FAVT system inflow and outflow streams. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

TP and pH monitoring at cell inflows and outflows

With the exception of one sample, all Cell 1 outflow samples were lower in TP concentration than Cell 1 inflows (Figure 12). This is in sharp contrast to the November 2014 – June 2015 sampling period, where only in the later portion of the period was there a clear difference in inflow and outflow TP for Cell 1. Average TP concentration declined across Cell 1, from 73 µg/L to 28 µg/L, or a 62% reduction. Cell 1 outflow concentration was relatively stable over the period, with the majority of values falling between 20 and 40 µg/L.

Total P removal was not as dramatic in the two downstream cells, although it is likely that the overall recalcitrance of P increased downstream from Cell 1. Total P declined across Cell 2, from an inflow mean concentration of 28 µg/L, to 18 µg/L at the outflow (Figure 13). Since May 2015, Cell 2 outflow TP concentration has been relatively stable, with most values falling between 10-20 µg/L.

As observed during the latter part of the November 2014 – June 2015 sampling period, average TP concentration increased slightly across Cell 3, from 18 µg/L at the inflow to 23 µg/L at the outflow (system outflow) (Figure 14). Higher average outflow TP was mostly

due to higher outflow values over the period July 2015 through December 2015, where TP averaged 28 µg/L. For the remainder of the sampling period, Cell 3 outflow averaged 18 µg/L versus 17 µg/L for Cell 3 inflow. As pointed out in the previous report, a lack of reduction in TP across Cell 3 could be due to a number of factors, including slow release of phosphorus that has accumulated during previous farm management practices. In addition, it is likely that much of the remaining TP in the water column consists of refractory forms of P that are not readily available to the plant community and this fraction simply “passes through” the FAVT system. It is clear from Figure 5 and Figure 6 that, even though substantial DOP is removed by the FAVT system, a persistent 5 – 10 µg/L DOP remains at the system outflow, as does approximately 10 µg/L PP. These two fractions, in addition to any soil P release, could account for the approximately 20 µg/L TP that remains at the system outflow.

System inflow pH averaged 7.26 units, with a standard deviation of 0.23 (Figure 12). Cell 1 management activities for both sampling periods did appear to have resulted in a slight decline (0.07 units for July 2015 – June 2016) in pH across the cell. Also, wet season months (July – November) were on average lower in pH for both inflow and outflow. For example, inflow pH averaged 7.18 for the wet season vs. 7.30 for the dry season. As was true for the November 2014 – June 2015 period, pH increased across Cell 2, increasing significantly from an average of 7.19 to 7.52 (Figure 13). A further slight increase in pH was observed between the inflow and outflow of SAV-dominated Cell 3, though this effect was not as consistent or as pronounced as during the November 2014 – June 2015 sampling period (Figure 14).

Figure 15 summarizes the overall decreasing trend in TP concentration along the system flow path during the July 2015 - June 2016 period. The mean system inflow TP concentration of 73 µg/L during that period decreased to a mean value of 28 µg/L at the Cell 1 outflow and further decreased to 18 µg/L at the Cell 2 outflow. The simultaneous decrease over time in Cell 2 outflow TP concentration and lack of change in Cell 3 outflow TP concentration (Figure 14) is reflected in Figure 15 as a slight increase in the overall mean outflow TP concentration (23 µg/L) as compared to mean Cell 2 outflow TP. This is a

very similar result to that observed for the November 2014 – June 2015 sampling period. Standard deviations of mean TP concentrations at the cell inflow and outflow points reflect a substantial decrease in temporal variability in TP concentrations along the system flow path, and are indicative of substantial attenuation within the system of highly fluctuating inflow TP concentrations observed during the monitoring period. The FAVT system is thus quite effective in moderating abrupt changes in inflow parameters, particularly with respect to forms of phosphorus, $\text{NO}_x\text{-N}$, ammonia-N, and alkalinity.

Changes in pH across sequential treatment cells are summarized in Figure 16. Mean pH values for the July 2015 – June 2016 period indicate the small decrease in pH observed between the system inflow and Cell 1 outflow, and subsequent increases in pH across Cells 2 and 3. The mean pH of 7.34 at the system inflow decreased slightly to a mean pH of 7.19 at the Cell 1 outflow, while the mean pH values for the Cell 2 and Cell 3 outflows were 7.52 and 7.62, respectively. These results are very similar to results observed for the November 2014 – June 2015 period.

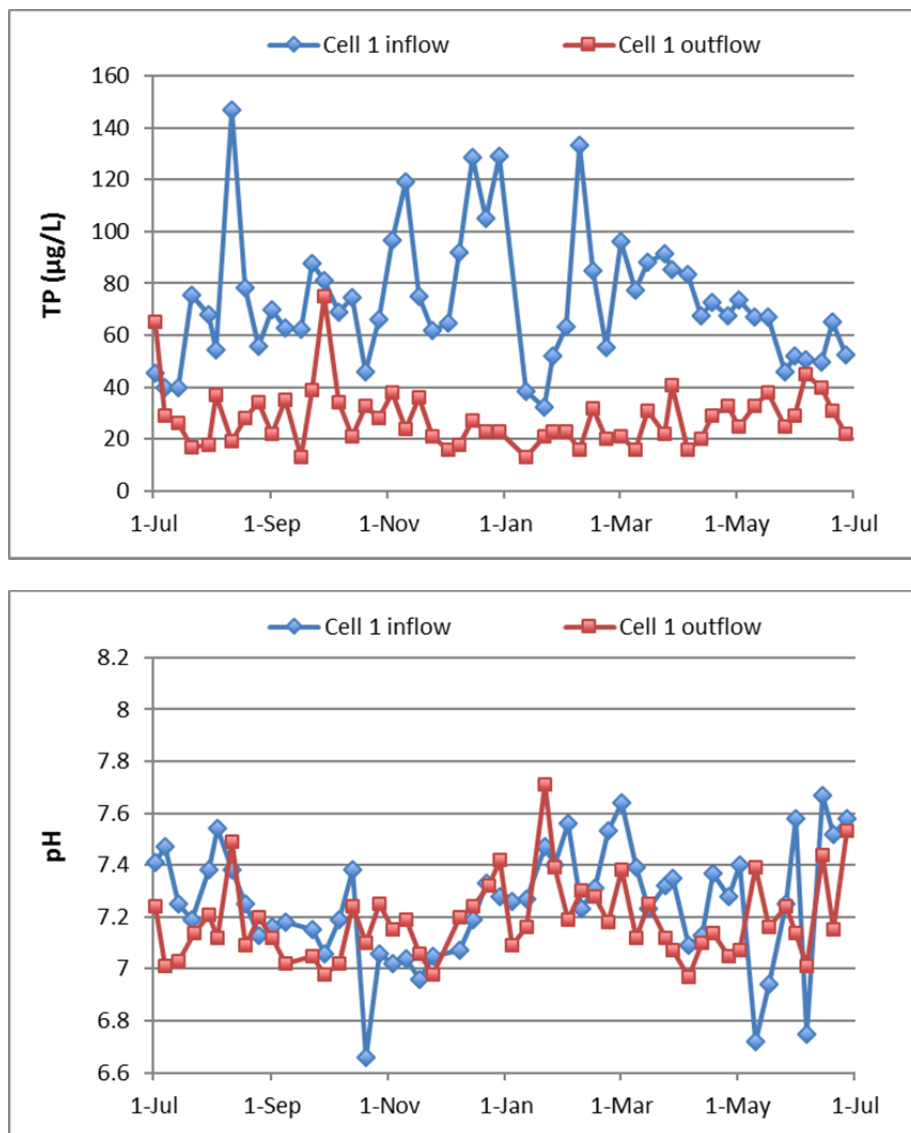


Figure 12. Surface water TP concentration and pH at the inflow and outflow of Cell 1 of the Caloosahatchee FAVT system. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

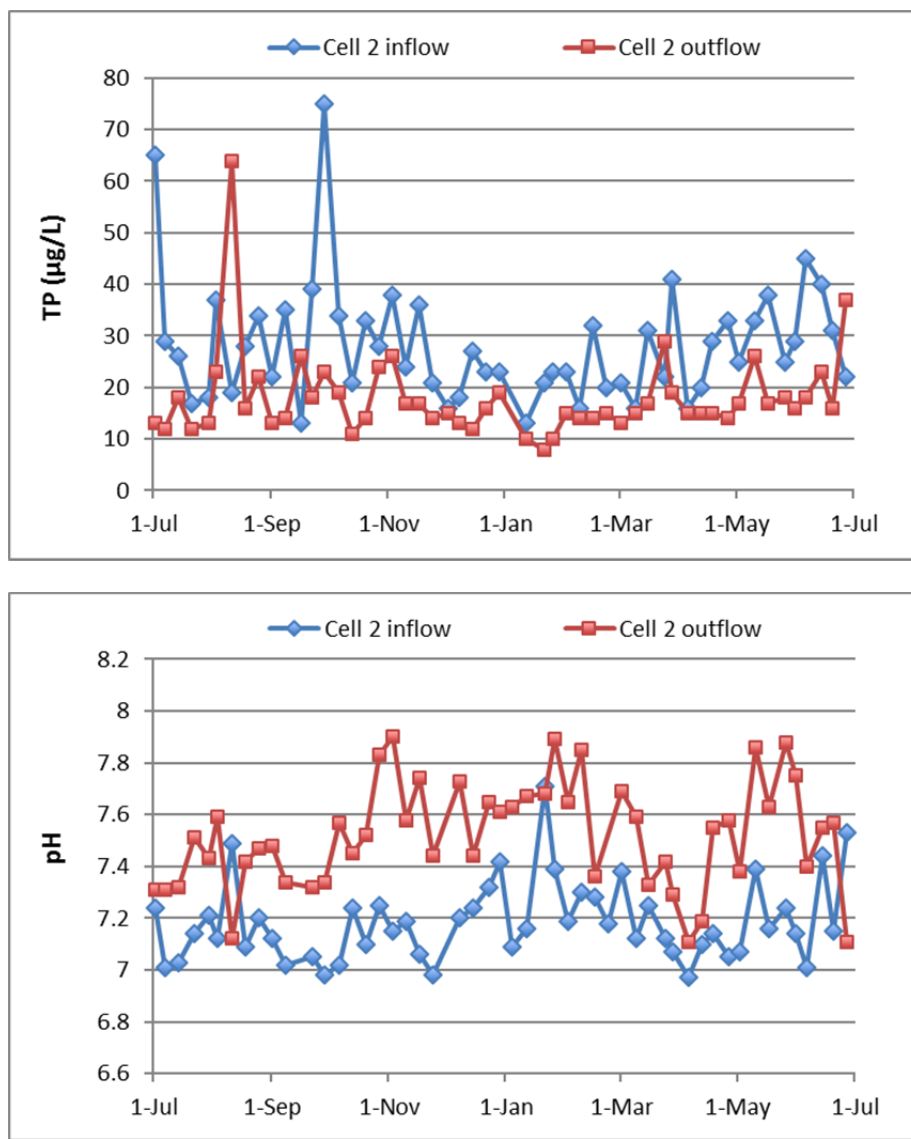


Figure 13. Surface water TP concentration and pH at the inflow and outflow of Cell 2 of the Caloosahatchee FAVT system. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

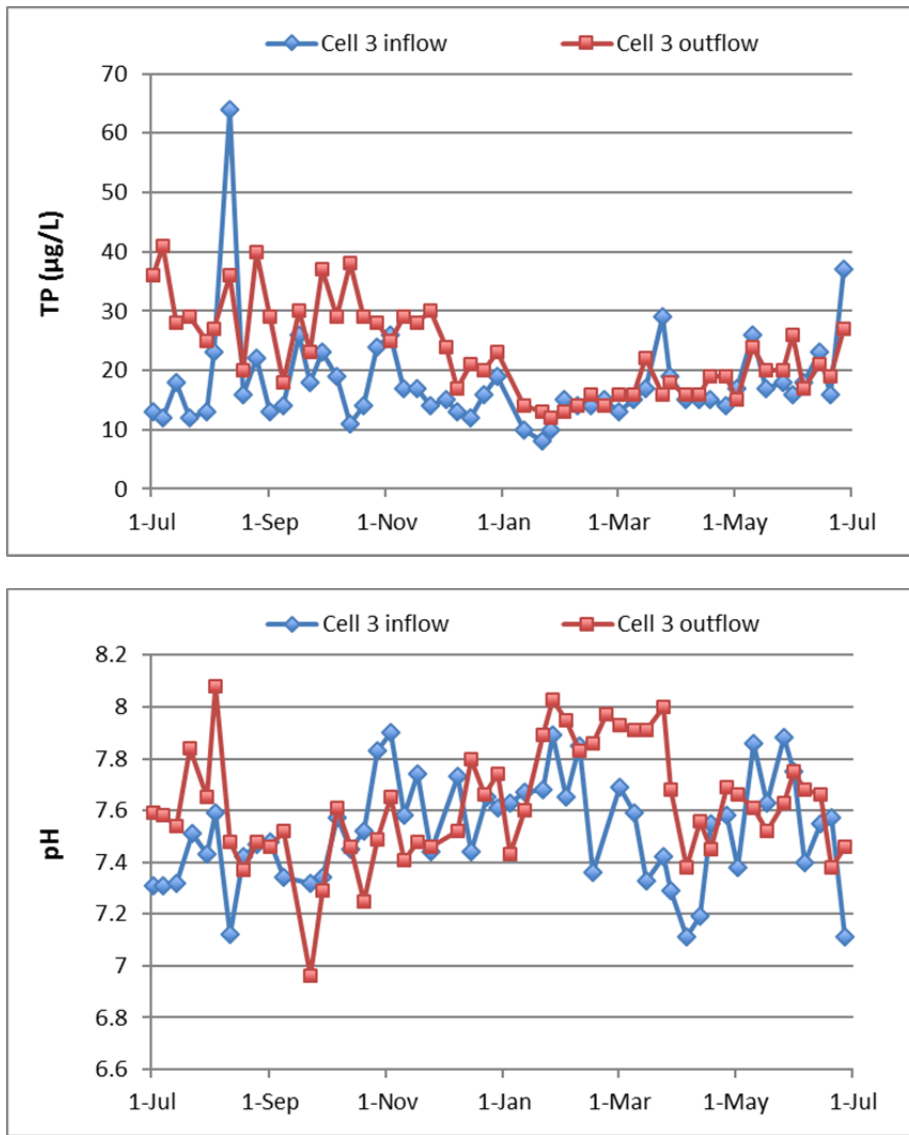


Figure 14. Surface water TP concentration and pH at the inflow and outflow of Cell 3 of the Caloosahatchee FAVT system. Monitoring was conducted on a weekly basis from July 2015 through June 2016.

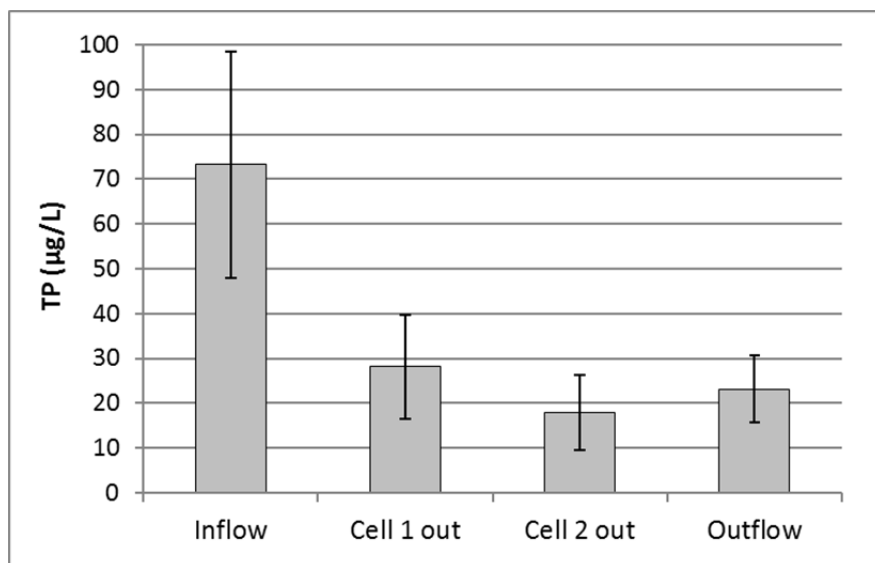


Figure 15. Mean surface water TP concentration (± 1 standard deviation) at the system inflow (=Cell 1 inflow), Cell 1 outflow (=Cell 2 inflow), Cell 2 outflow (=Cell 3 inflow), and system outflow (=Cell 3 outflow) of the Caloosahatchee FAVT system. Values were calculated from data collected during 34 weekly monitoring events from July 2015 through June 2016.

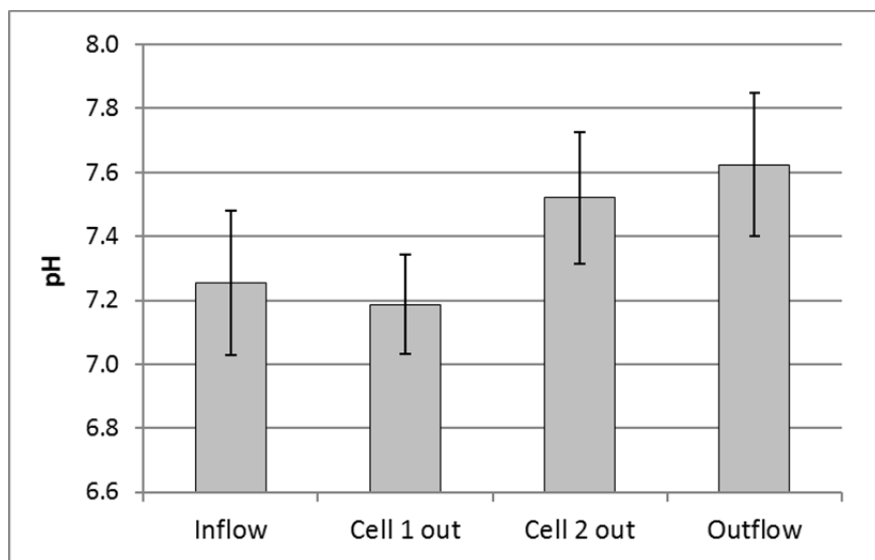


Figure 16. Mean surface water pH (± 1 standard deviation) at the system inflow (=Cell 1 inflow), Cell 1 outflow (=Cell 2 inflow), Cell 2 outflow (=Cell 3 inflow), and system outflow (=Cell 3 outflow) of the Caloosahatchee FAVT system. Values were calculated from data collected during 34 weekly monitoring events from July 2015 through June 2016.

Floating and Submerged Aquatic Vegetation Surveys

Visual assessment of speciation and areal coverage (i.e., relative abundance) of FAV (Cells 1 and 2) and SAV (Cell 3) was performed on a routine basis at stations located on a pre-determined grid pattern across Cells 1 (21 stations), 2 (33 stations) and 3 (53 stations). These surveys were conducted monthly from July 2015 through June 2016. Survey dates were 7/30/2015, 8/25/15, 9/23/2015, 10/20/2015, 11/5/2015, 11/24/2015, 12/15/15, 1/12/16, 2/16/2016, 3/15/2016, 4/12/2016, 5/11/2016, and 6/14/2016.

During turbid water conditions or when SAV was not visible in the water column, the SAV assessment in Cell 3 was performed using a systematic collection method, whereby a garden rake was dragged three times along the bottom (~1 m distance) to collect the vegetation. Note that this rake method was not used if dense SAV was present. The coverage of each species was scored based on the five-point scale below. For SAV, each of these coverage categories included vegetation observed within the water column as well as any vegetation collected with the rake.

Vegetation coverage (relative abundance) categories were reported as follows:

- None
- Sparse: 0–10 percent
- Moderately Dense: 10–40 percent
- Dense: 40–80 percent
- Very dense: > 80 percent

Results of the FAV surveys reflect a further increase in moderately-dense to very-dense (hereafter referred to as “dense”) coverage of water hyacinth (Figure 17) in Cell 1 between September 2015 and July 2016 (Figure 18). Dense coverage increased from 86% of the sampling stations to 100% by April 2016 and remained at that density for the remainder of the sampling period. Unlike the same period in 2014, the extent of “dense” hyacinth coverage in Cell 2 steadily declined from 67 percent to 33 percent. With the exception of the July and August 2015 periods, water hyacinth coverage was always greater in Cell 1 compared to Cell 2, presumably due to the higher concentrations of plant-available nutrients in Cell 1. Unlike the 2014 – 2015 vegetation survey, hyacinth was not found at every station in Cell 1, although it was always present at >90% of stations (Figure 19). For

Cell 2, hyacinth was found at approximately 80% of stations. Its presence declined over the interval July 2015 – June 2016, to presence at only 70% of stations by the end of the period. This is in contrast to the 2014 – 2015 sampling period, where hyacinth was found at nearly 100% of sampling stations in Cell 2. Thus, both density, and presence of hyacinth has declined in Cell 2 compared to the previous period. As mentioned in the previous year’s annual report, total P at the inflow to Cell 2 declined steadily over the November 2014 to June 2015 period. This decline may have impacted productivity of hyacinth in Cell 2.

Coverage of *Pistia stratiotes* (water lettuce; Figure 20) was consistently lower than hyacinth coverage, in both cells 1 and 2. In Cell 1, “dense” coverage of *Pistia* was found at less than 20 percent of stations during this monitoring period (Figure 18). There did not appear to be a seasonal effect on *Pistia* density. *Pistia* density in Cell 1 declined compared to the September 2014 – June 2015 period, with 6 of the 13 sampling events reporting less than even moderately dense coverage. *Pistia* density in Cell 2 was generally slightly greater than Cell 1, ranging from 3 to 15 percent of stations with at least moderate coverage of *Pistia*. Presence of *Pistia* in Cell 1, at all densities, has undergone a steady decline over the entire period of record, from 81 percent of stations reporting *Pistia* in October 2014, to 24 percent of stations reporting *Pistia* in June 2016 (Figure 19).

In summary, hyacinth is much more prevalent and also denser than *Pistia* in Cell’s 1 and 2. Hyacinth growth in Cell 1 has been vigorous, with only 48% of stations reporting dense hyacinth in October 2014, increasing to 100% of stations reporting dense coverage by April 2016. *Pistia* coverage in both cells has been considerably lower in density and occurrence across the sampling grid. For Cell 2, density and frequency of occurrence of hyacinth has declined over the period July 2015 – June 2016. Frequency of occurrence of *Pistia* was overall slightly greater for Cell 2 than Cell 1, and it was present at less than 40% of sampling stations for both cells.

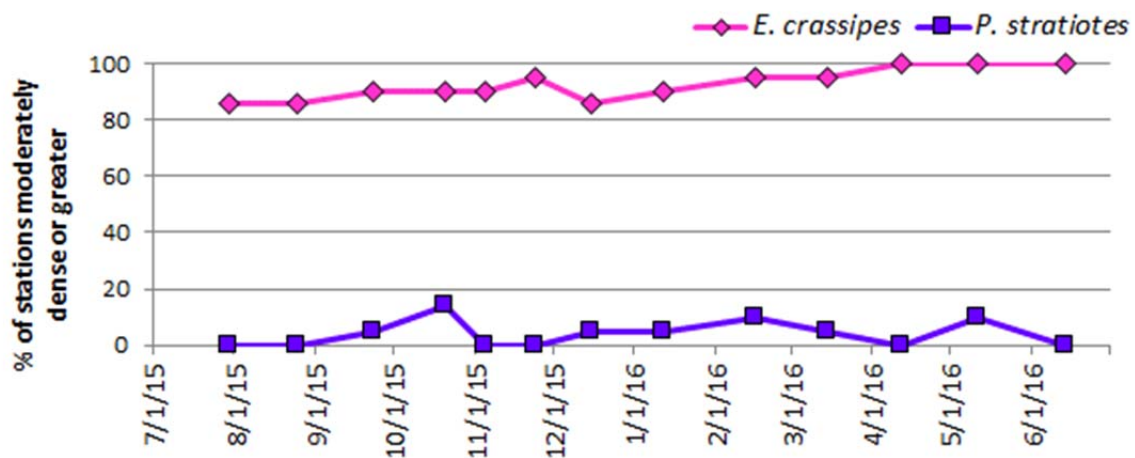
The spatial distributions of hyacinth and *Pistia* are shown for monthly intervals, from July 2015 through June 2016, in Figure 21 through Figure 33. Cell 1 maintained a dense to very dense coverage of hyacinth throughout the sampling period. Lower densities were associated with inflow and outflow regions. There were only occasional isolated pockets of

open water. Density of hyacinth declined January through March, but recovered by April and by June were as robust as the beginning of the period, with approximately 90% of the area of the cell having very dense hyacinth coverage. Cell 2 showed constant declines in hyacinth coverage through the period. Persistent regions of open water appeared along the western and southern regions of the cell, and in the outflow region. Greater hyacinth densities within Cell 2 seemed to be associated with cypress domes, perhaps due to the effect of the cypress domes on wind movement of plants. By June 2016, there were large areas of open water on the western and southern region of Cell 2, and most of the cell was characterized as having a sparse (or less) coverage of hyacinth. *Pistia* was generally absent at most stations in both Cell 1 and Cell 2. When it occurred in Cell 1, it was found most frequently in the southern end of the cell, and was usually found at a sparse or less density. The April 2016 sampling found a complete lack of *Pistia* for Cell 1. Cell 2 usually had a greater coverage area and a greater density of *Pistia*. *Pistia* seemed to favor the region between the two cypress domes in Cell 2, perhaps also due to the effect of the cypress domes on wind distribution of the plants. Unlike hyacinth in Cell 2, *Pistia* coverage and density in Cell 2 did not seem to show a temporal trend. In fact, there seemed to be a greater density and distribution of *Pistia* during the final June 2016 sampling than the initial July 2015 sampling. This might be due to *Pistia* colonizing regions of Cell 2 that had seen declines in hyacinth coverage.



Figure 17. Very dense mat of *Eichhornia crassipes* (water hyacinth) and *Pistia stratiotes* (water lettuce) in Cell 1

Cell 1:



Cell 2:

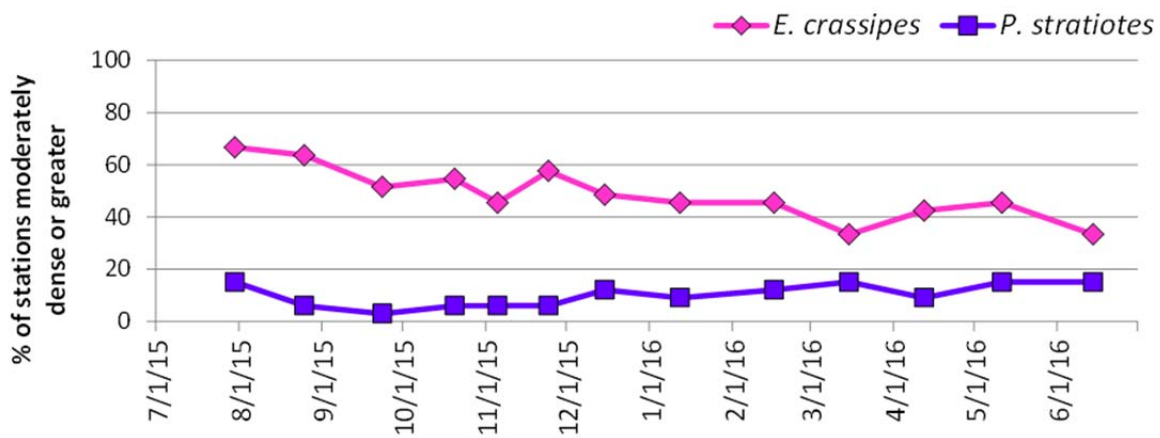
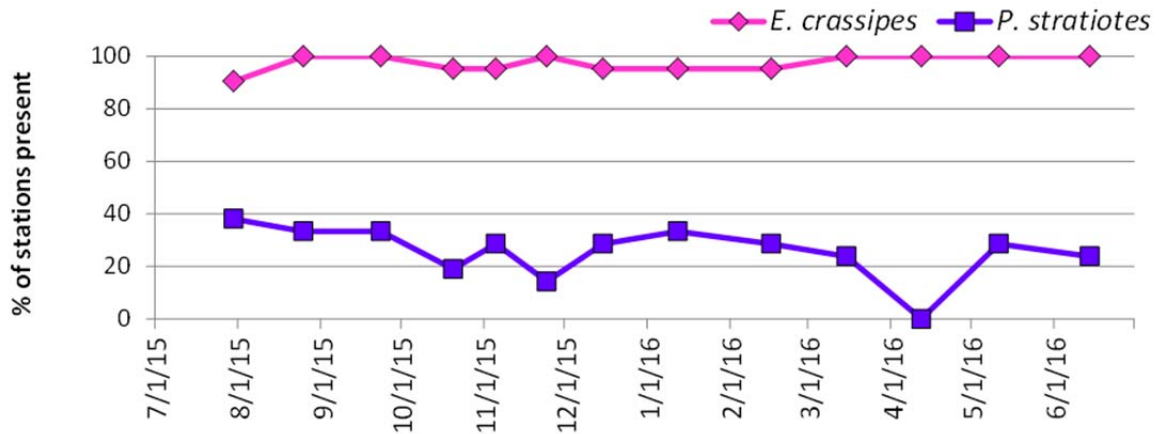


Figure 18. Time-series for FAV species within Cells 1 and 2 depicting the percent of stations that was moderately dense or greater for each species.

Cell 1:



Cell 2:

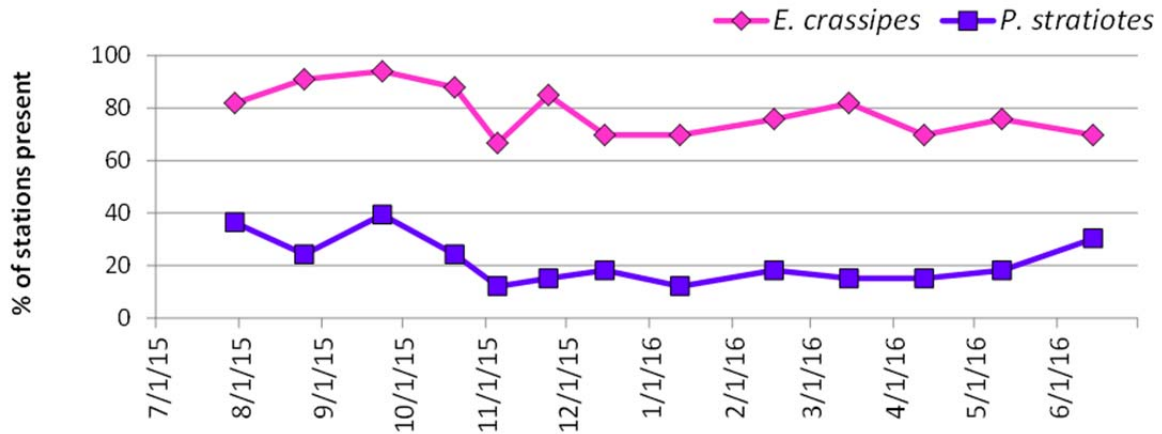


Figure 19. Time-series for FAV species within Cells 1 and 2 depicting the percent of stations that each species present.



Figure 20. Mixed species mat with *Eichhornia crassipes* (water hyacinth) and *Pistia stratiotes* (water lettuce) in Cell 1.

Hilliard FAVT FAV Survey Locations: July 2015

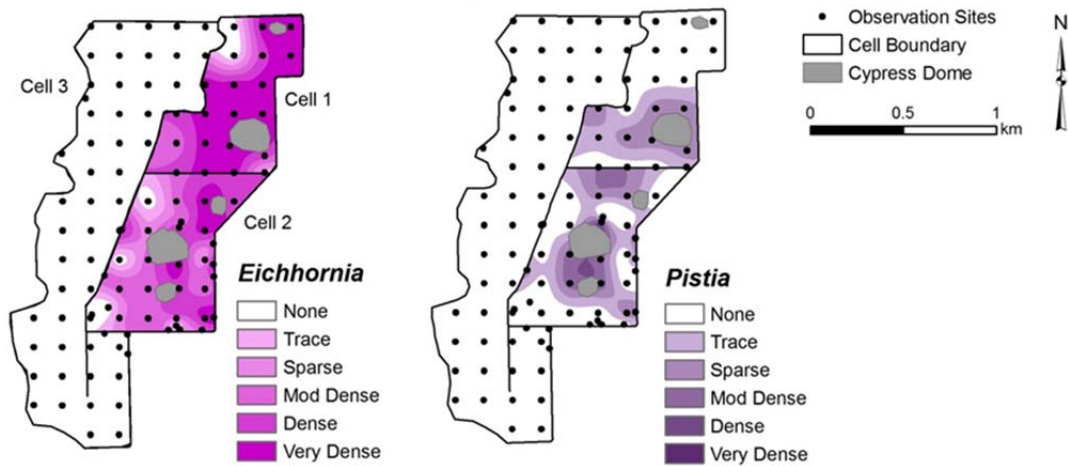


Figure 21. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during July 2015.

Hilliard FAVT FAV Survey Locations: August 2015

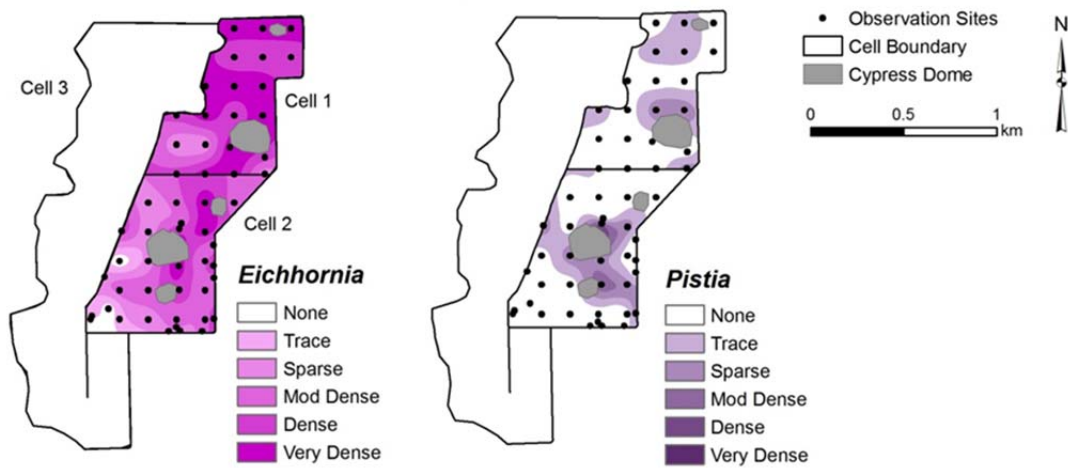


Figure 22. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during August 2015.

Hilliard FAVT FAV Survey Locations: September 2015

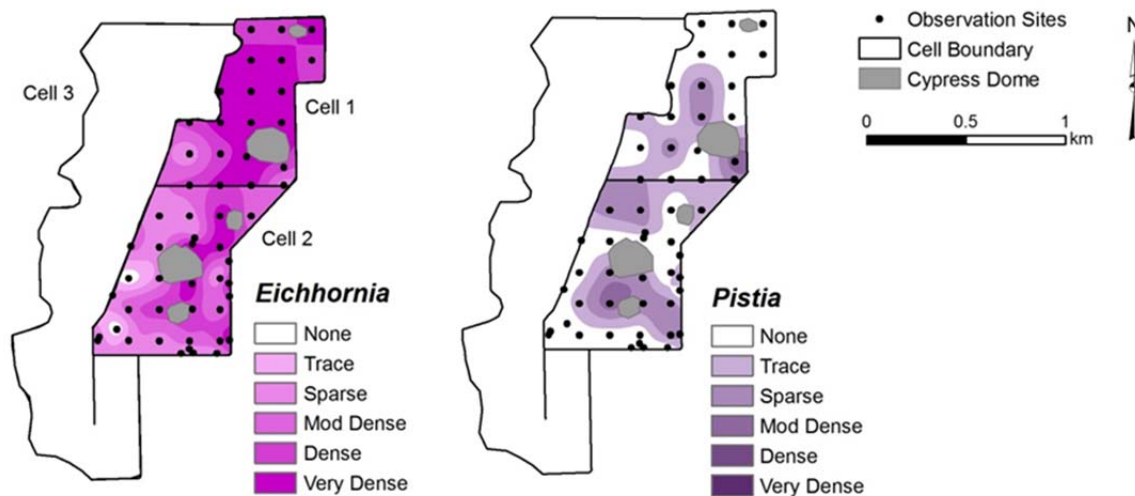


Figure 23. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during September 2015.

Hilliard FAVT FAV Survey Locations: October 2015

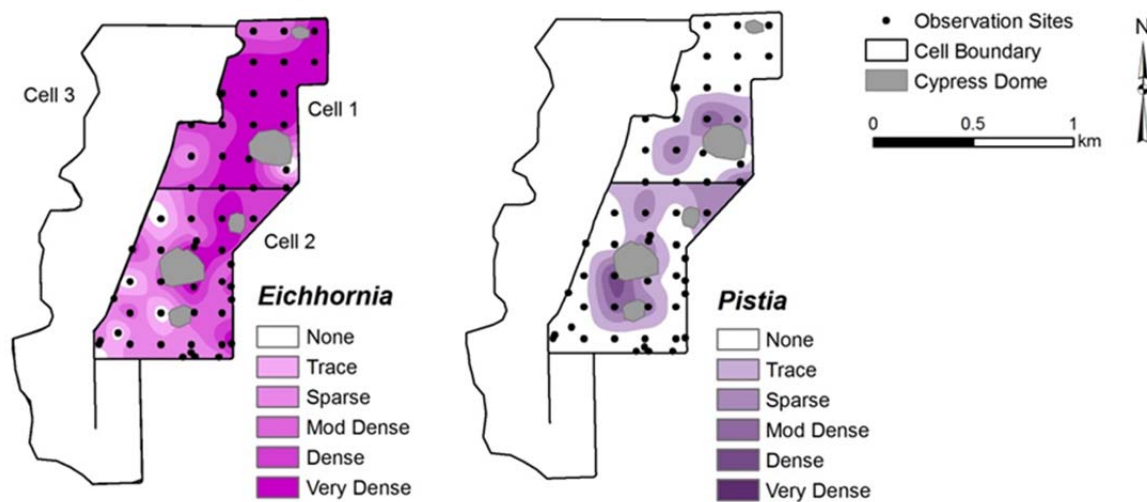


Figure 24. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during October 2015.

Hilliard FAVT FAV Survey Locations: November 5, 2015

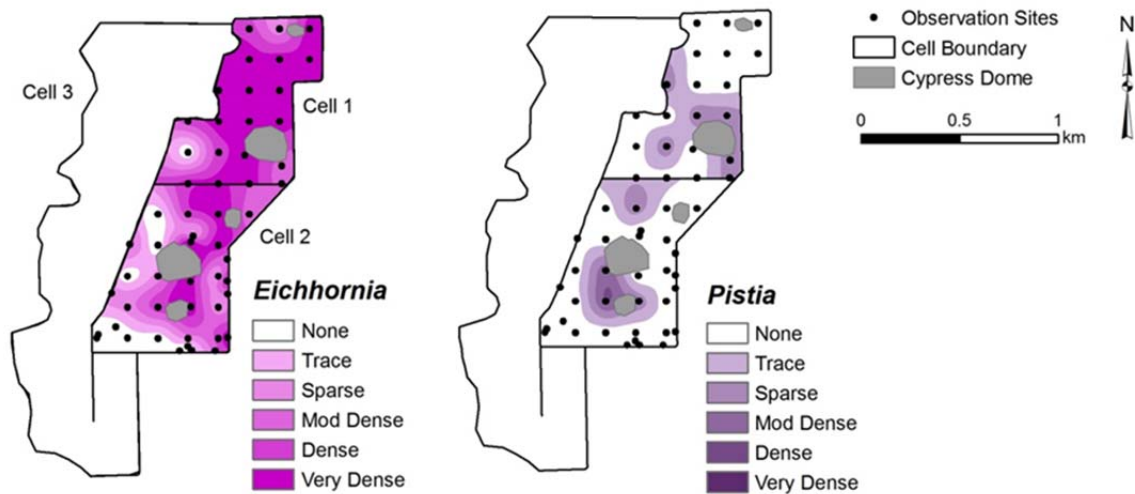


Figure 25. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during early November 2015.

Hilliard FAVT FAV Survey Locations: November 24, 2015

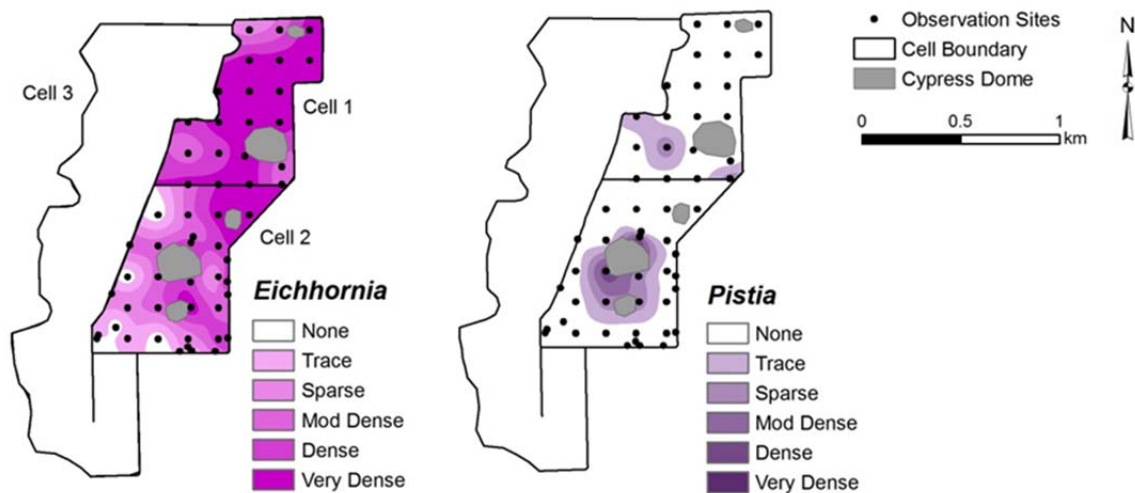


Figure 26. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during late November 2015.

Hilliard FAVT FAV Survey Locations: December 2015

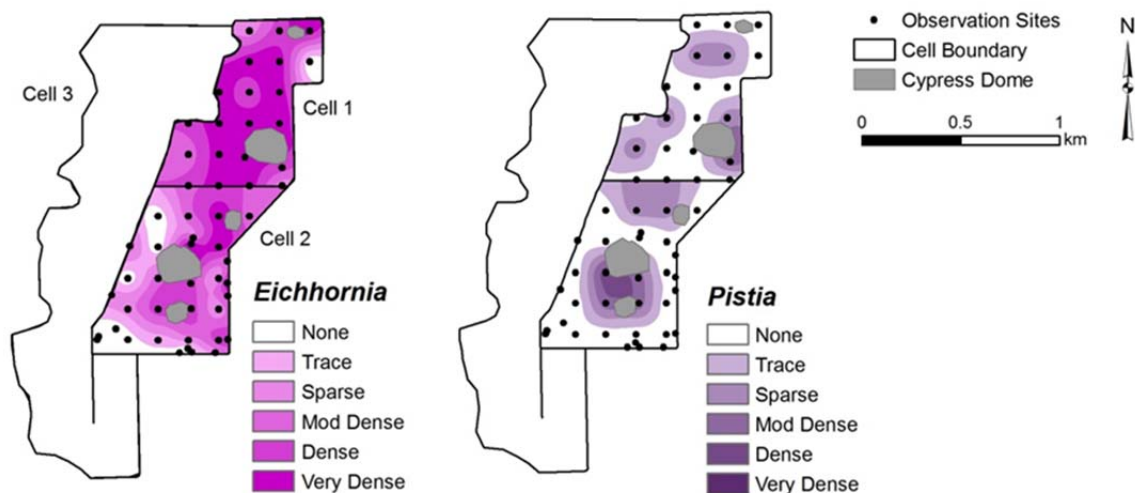


Figure 27. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during December 2015.

Hilliard FAVT FAV Survey Locations: January 2016

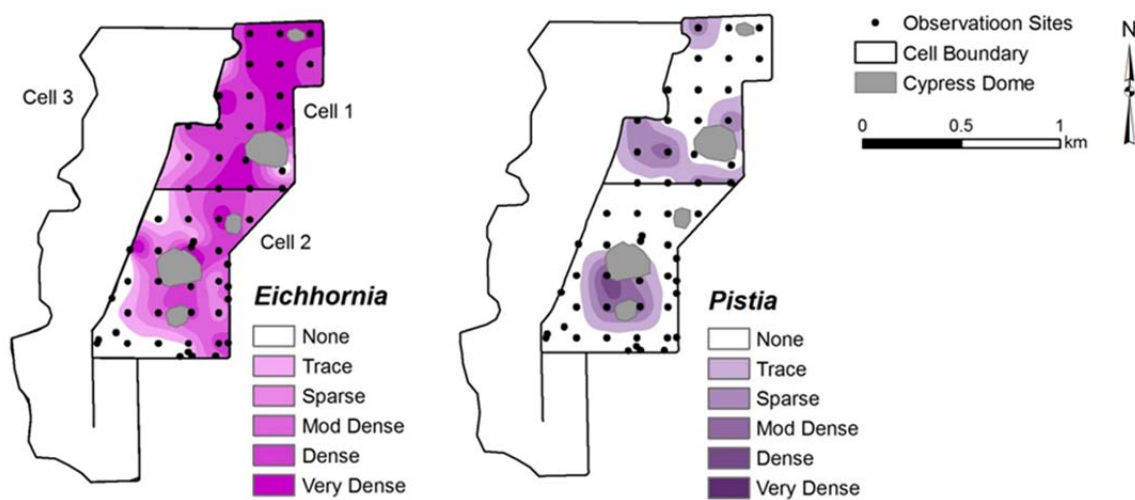


Figure 28. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during January 2016.

Hilliard FAVT FAV Survey Locations: February 2016

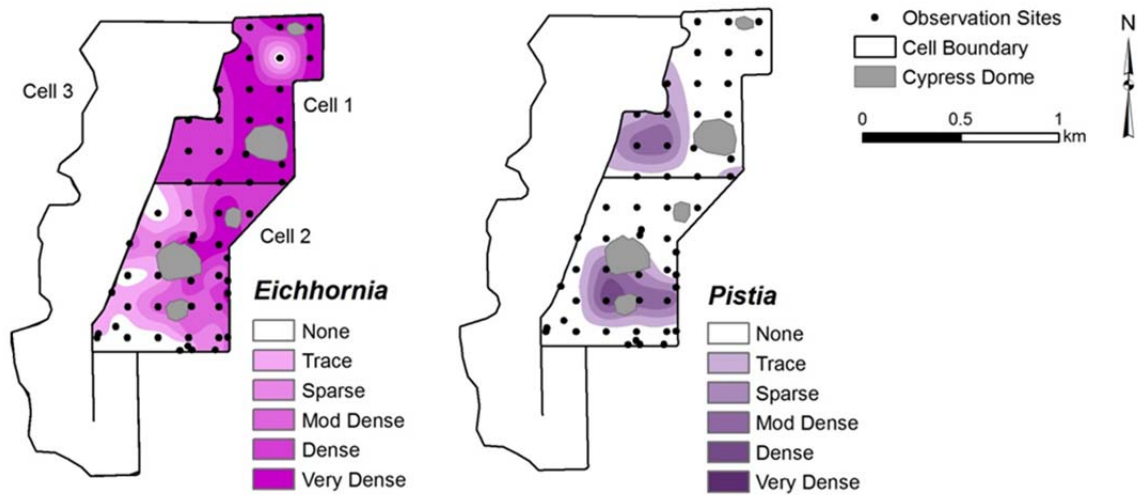


Figure 29. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during February 2016.

Hilliard FAVT FAV Survey Locations: March 2016

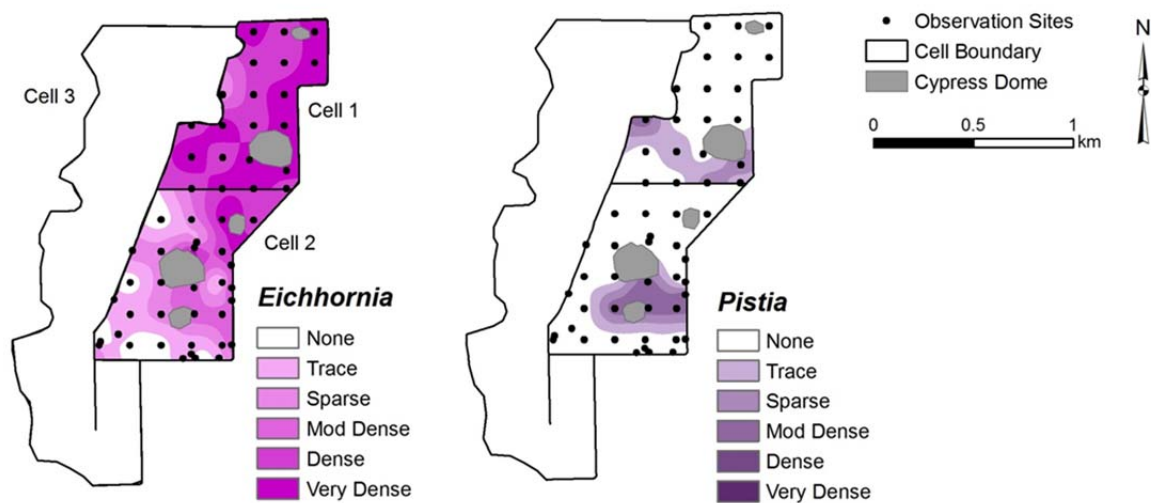


Figure 30. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during March 2016.

Hilliard FAVT FAV Survey Locations: April 2016

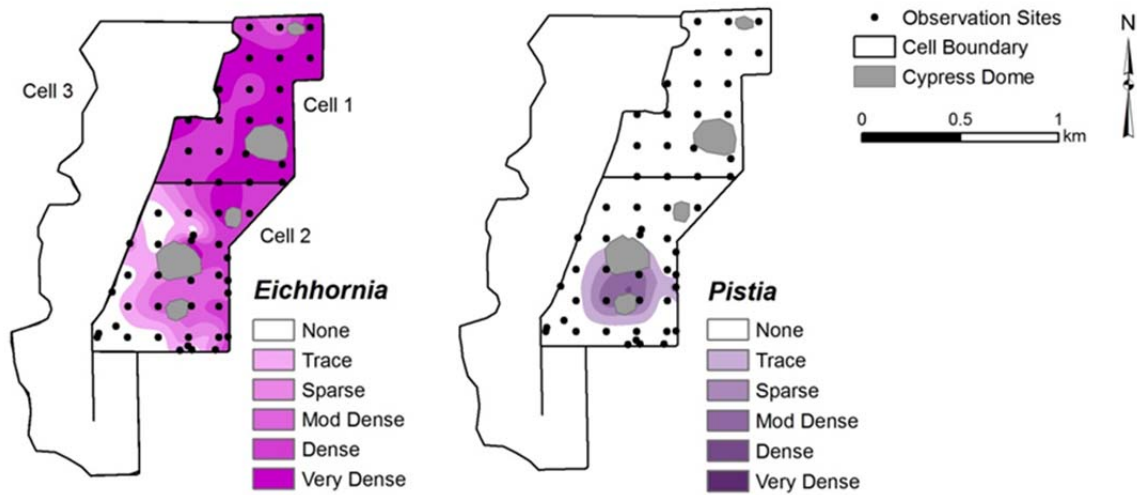


Figure 31. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during April 2016.

Hilliard FAVT FAV Survey Locations: May 2016

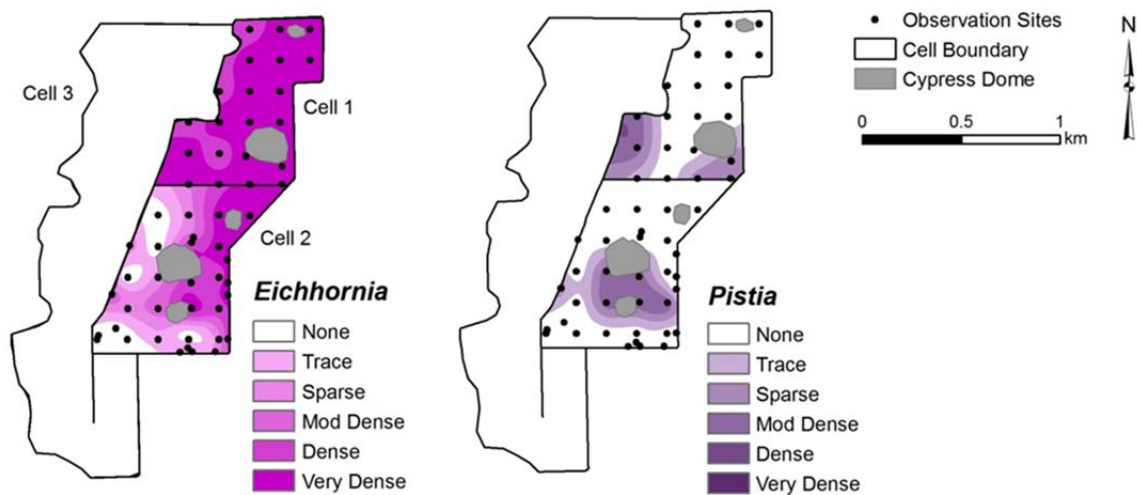


Figure 32. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during May 2016.

Hilliard FAVT FAV Survey Locations: June 2016

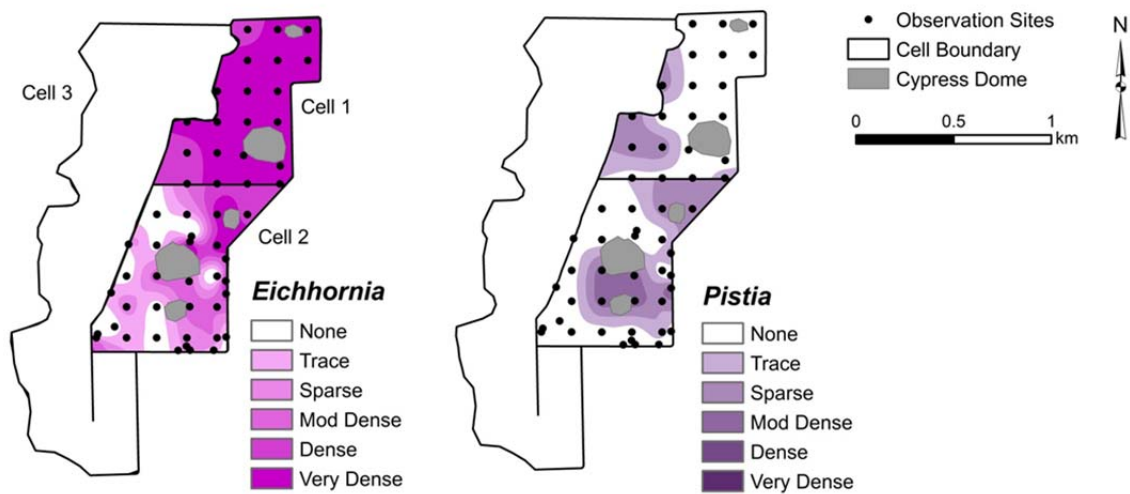


Figure 33. Relative cover of the FAV species *Eichhornia crassipes* and *Pistia stratiotes* in Cells 1 and 2 of the Caloosahatchee wetland during June 2016.

The most striking finding of the submerged aquatic vegetation (SAV) surveys for the July 2015 – June 2016 period is the increasing extent and density of *Hydrilla* (Figure 34). During February of 2015 (previous reporting period), *Hydrilla* was found at only 5% of the monitoring stations, and at no station was it found to be even moderately dense. By June of 2016, *Hydrilla* was found to be at least moderately dense at 50% of the stations (Figure 35) and was present at 80% of the stations (Figure 36). This has been accompanied by large declines in *Utricularia* (Figure 37). During the September 2014 – June 2015 period, *Utricularia* density was relatively stable, with 40-70% of stations having densities of moderately dense or greater. By November 2015, this had declined to 2% of stations with moderately dense or greater *Utricularia* (Figure 35). Throughout the 2014 – 2015 period, *Utricularia* was found at approximately 80% of sampling stations. By June of 2016, that declined to only 30% of stations with *Utricularia* present. Thus, *Hydrilla* seems to have mostly replaced *Utricularia* in Cell 3. *Najas* (Figure 38) greatly increased in both areal extent and density in the previous September 2014 – June 2015 monitoring period and was found at 83% of stations, and 70% of stations had moderately dense or greater plant density. This extent and density has remained constant for the July 2015 – June 2016 period (Figure 35 and Figure 36).

The other surveyed SAV species *Ceratophyllum*, *Ludwigia repens*, *Potamogeton*, *Chara* and *Bacopa* tended to be a minor component of the Cell 3 SAV community. Those species were typically present at < 20% of monitoring stations and with <10% of stations reporting at least moderate densities. Overall, SAV coverage ranged from 83 to 100% of the area of Cell 3 (Figure 36)).

The spatial extent of the most prevalent SAV species, *Najas*, *Utricularia* and *Hydrilla*, exhibited unique spatial patterns during the monitoring period (Figure 39). For example, (as was found in the previous report) *Najas* tended to colonize the inflow and outflow regions of Cell 3 over time, while *Hydrilla* proliferated primarily in the mid-region of Cell 3. The final June 2016 survey suggests that *Hydrilla* is displacing *Najas* in the inflow and outflow regions as well. The sparse and irregular distribution of *Bacopa* had mostly disappeared from Cell 3 by March 2016. The decline in *Utricularia* began in the Cell 3

inflow region and progressed southward. By March 2016, *Utricularia* was limited to the western side of Cell 3, with some regions of trace-moderately dense *Utricularia* surviving in the southern outflow region of the cell. Changes in density and species composition during the early stages of system operation will likely continue during the short term as water and soil chemistry across the system stabilize. In addition, inter-specific competition as has been observed between *Hydrilla*, *Utricularia*, and *Najas* will play a large role in the eventual distribution of SAV species in Cell 3.

Continued monitoring of both SAV and FAV will be performed in FY 2017, in order to enhance system operations and management practices, and to facilitate our understanding of spatial and temporal patterns in TP removal performance.



Figure 34. *Hydrilla verticillata*, an invasive SAV species, at the Cell 2 culvert.

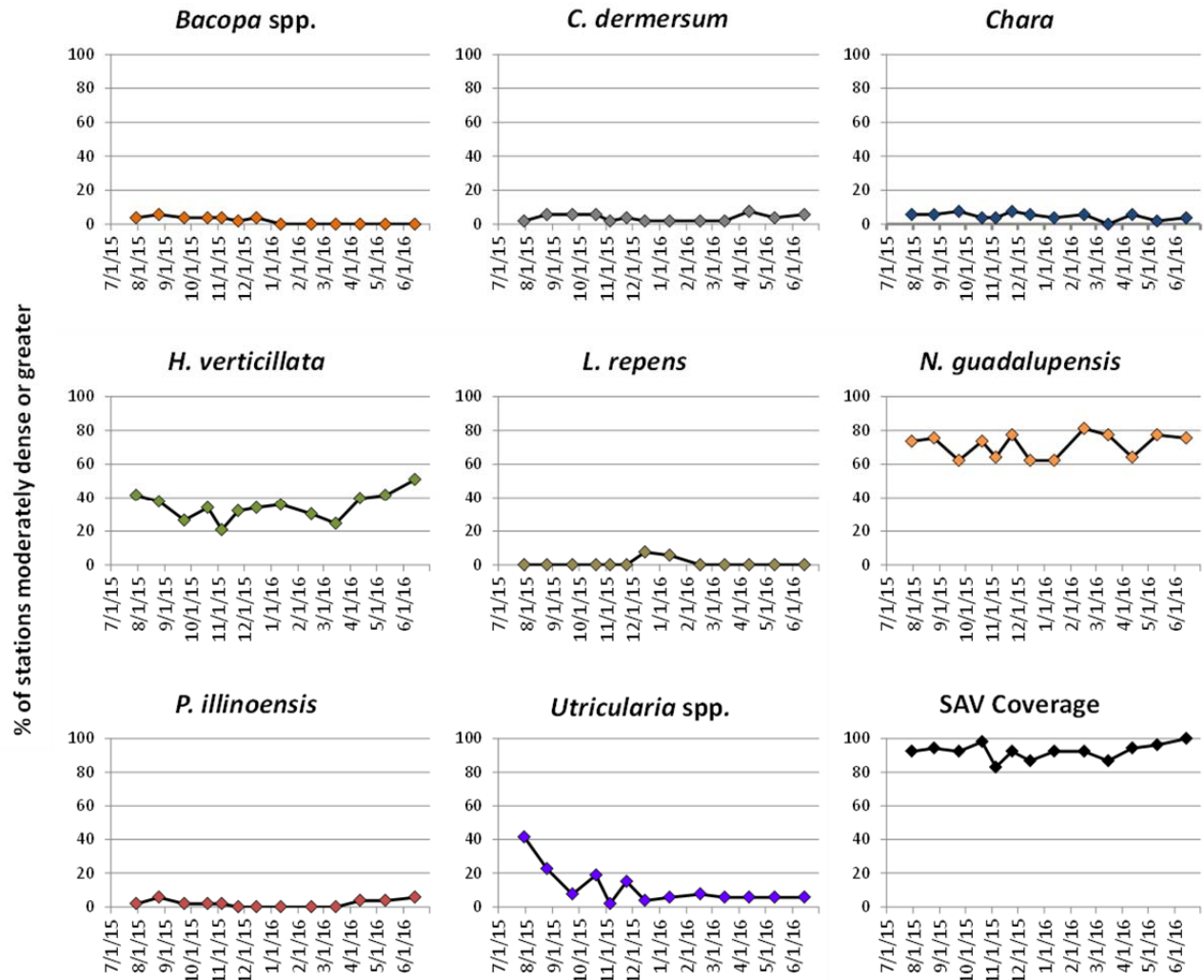


Figure 35. Time-series for SAV species within Cell 3 depicting the percent of stations that stations that was moderately dense or greater for each species.

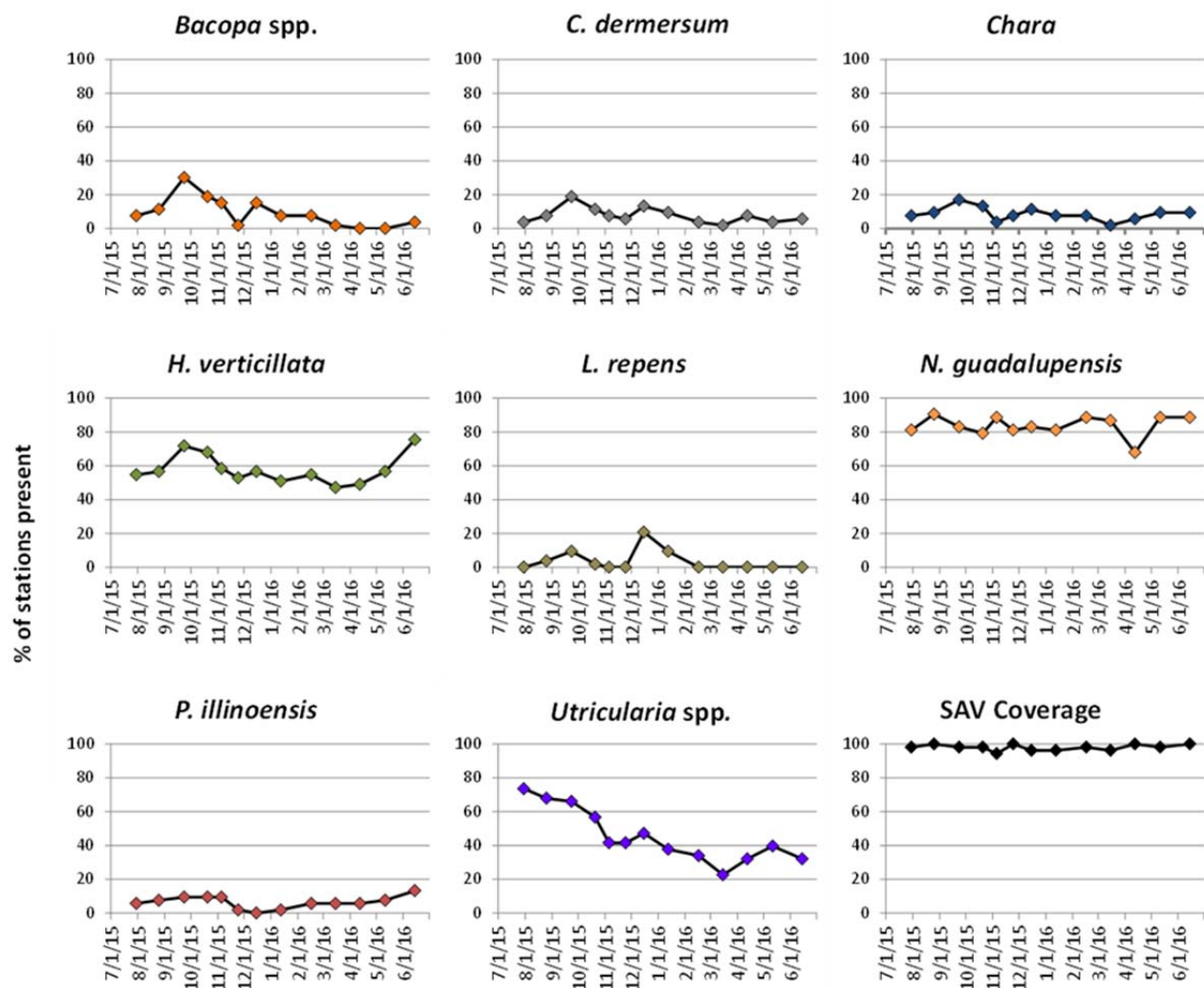


Figure 36. Time-series for SAV species within Cell 3 depicting the percent of stations that each species is present.

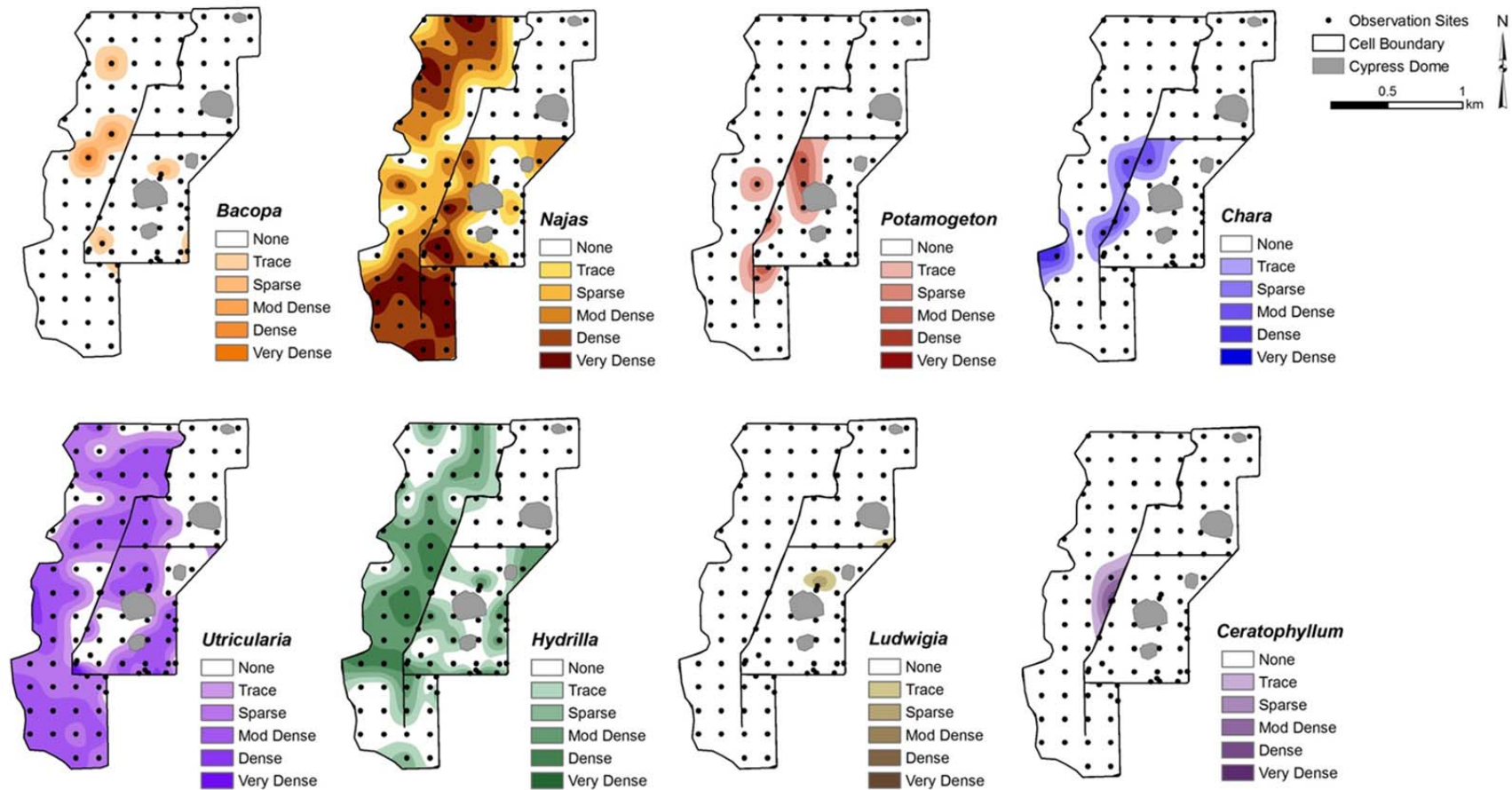


Figure 37. Mixed SAV assemblage containing *Utricularia* sp. (bladderwort) and other species in Cell 3.



Figure 38. *Najas guadalupensis* (southern naiad) growing near the outflow of Cell 3.

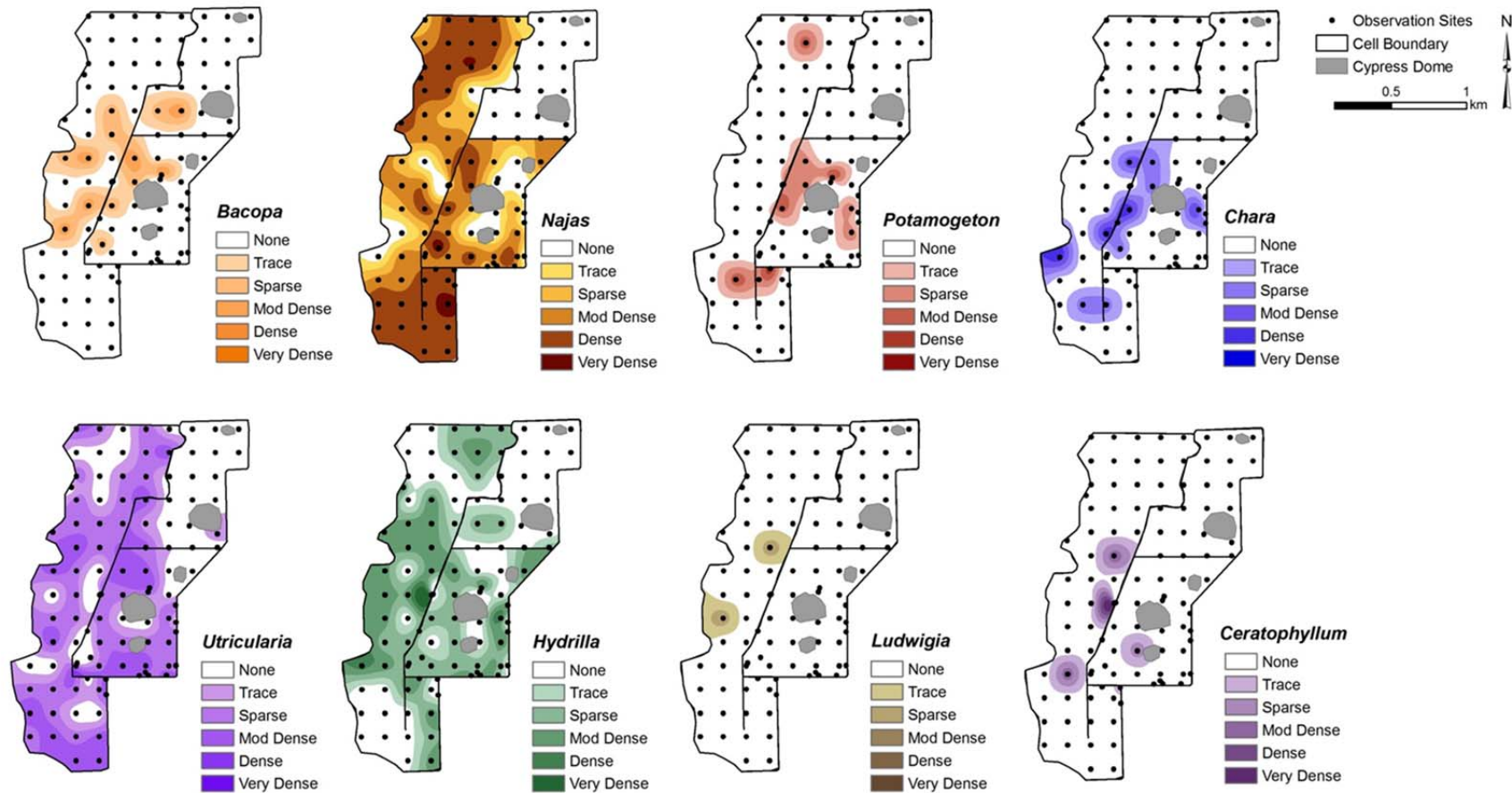
Hilliard FAVT SAV Survey Locations: July 2015



created: 9/8/15; July2015 FAVT Hilliard SAV Survey Map.mxd

Figure 39. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the July 2015 vegetation survey.

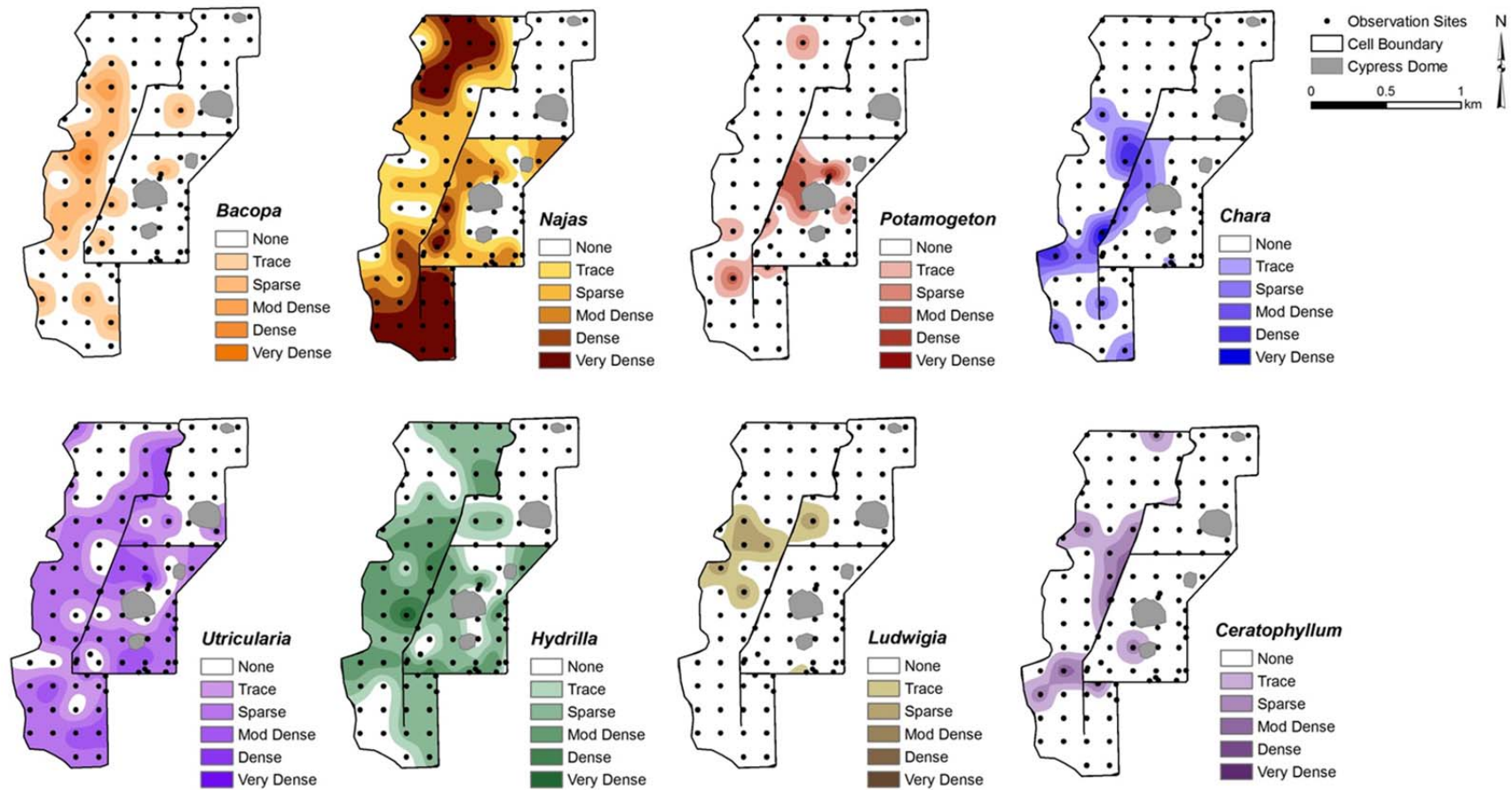
Hilliard FAVT SAV Survey Locations: August 2015



created: 9/9/15, Aug2015 FAVT Hilliard SAV Survey Map.mxd

Figure 40. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the August 2015 vegetation survey.

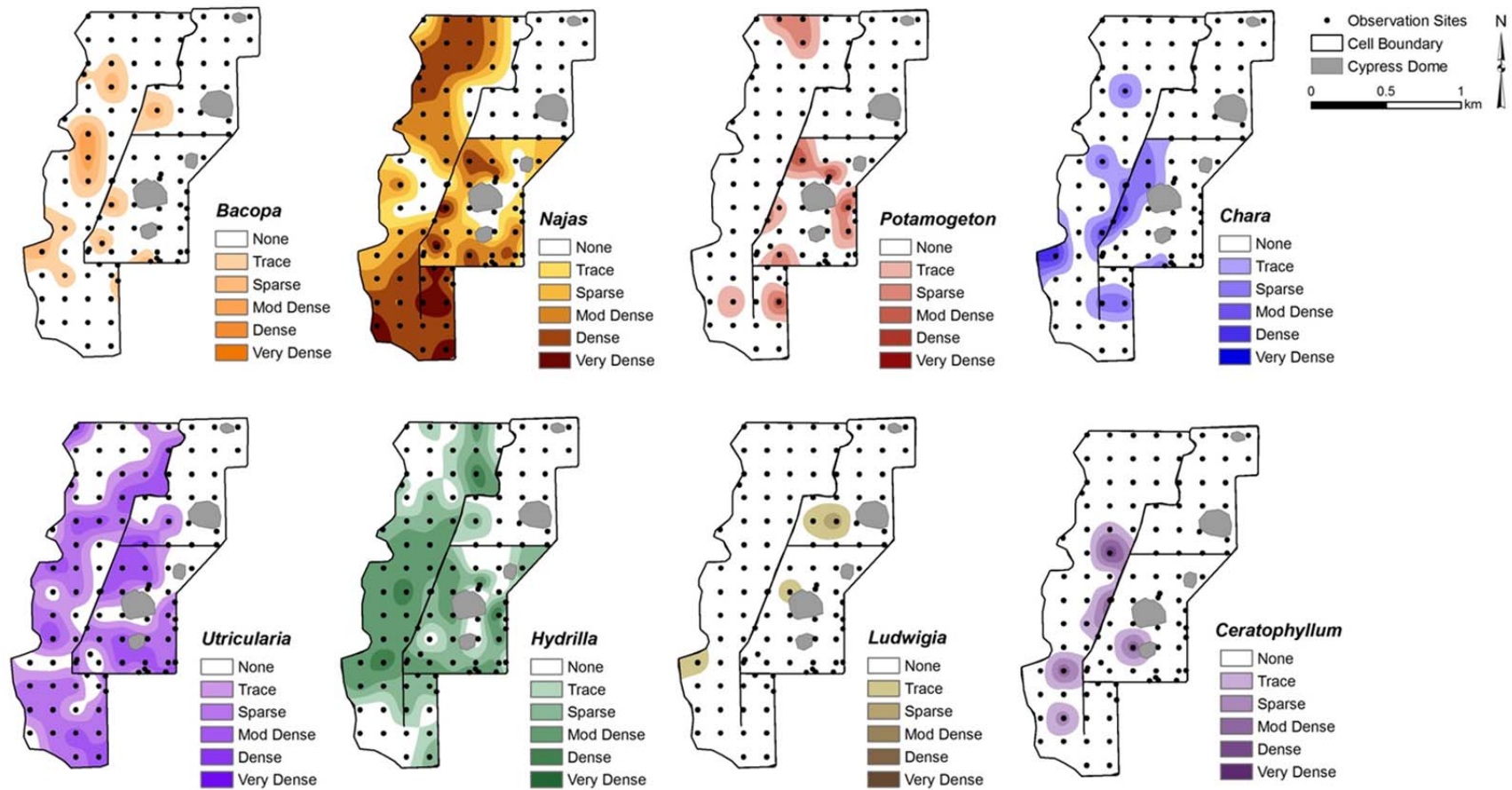
Hilliard FAVT SAV Survey Locations: September 2015



created: 9/30/15; Sep2015 FAVT Hilliard SAV Survey Map.mxd

Figure 41. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the September 2015 vegetation survey.

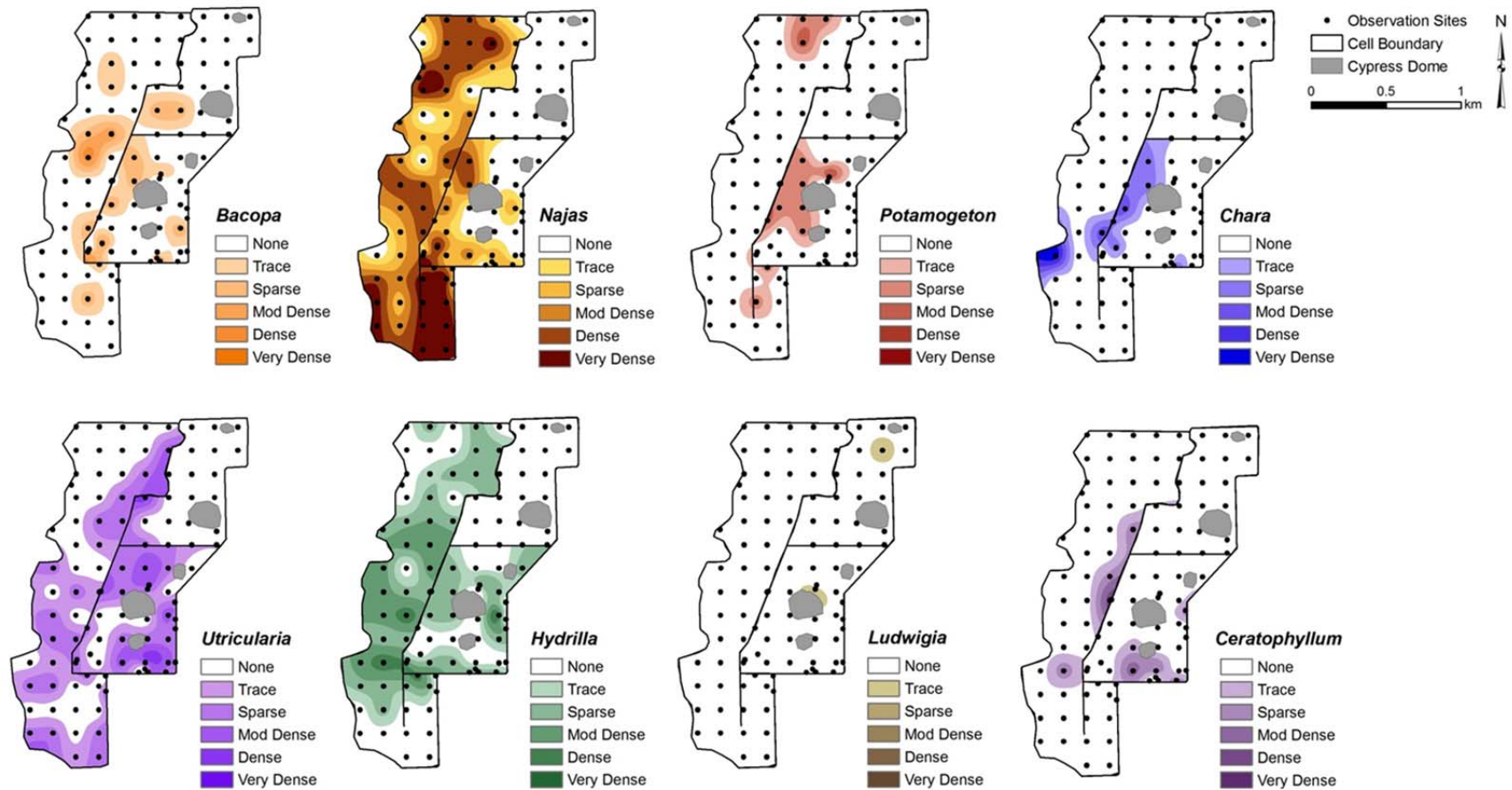
Hilliard FAVT SAV Survey Locations: October 2015



created: 10/23/15, Oct2015 FAVT Hilliard SAV Survey Map.mxd

Figure 42. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the October 2015 vegetation survey.

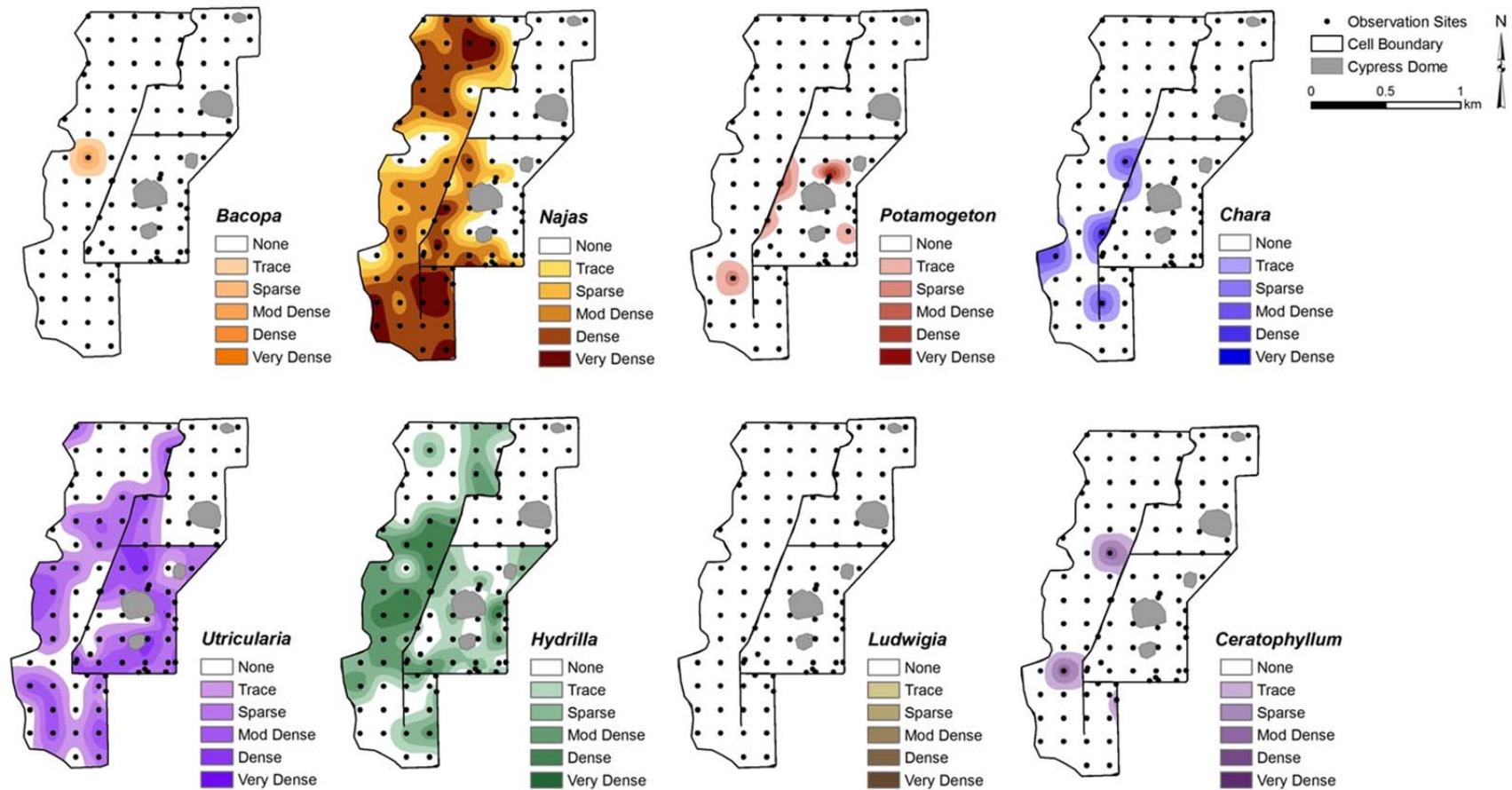
Hilliard FAVT SAV Survey Locations: November 5, 2015



created: 11/16/15; Nov-5-2015 FAVT Hilliard SAV Survey Map.mxd

Figure 43. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the early November 2015 vegetation survey.

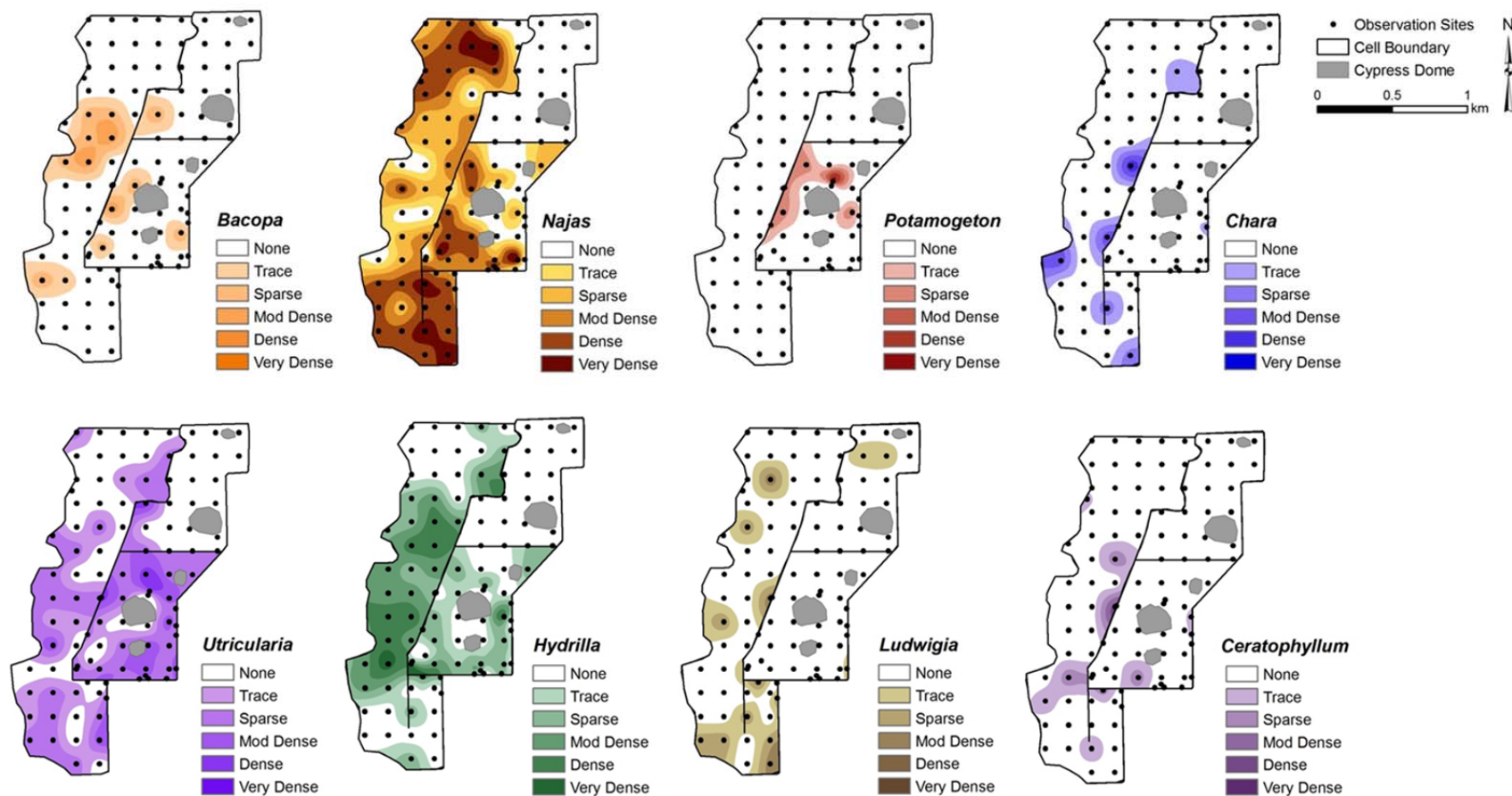
Hilliard FAVT SAV Survey Locations: November 24, 2015



created: 12/14/15; Nov-24-2015 FAVT Hilliard SAV Survey Map.mxd

Figure 44. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the late November 2015 vegetation survey.

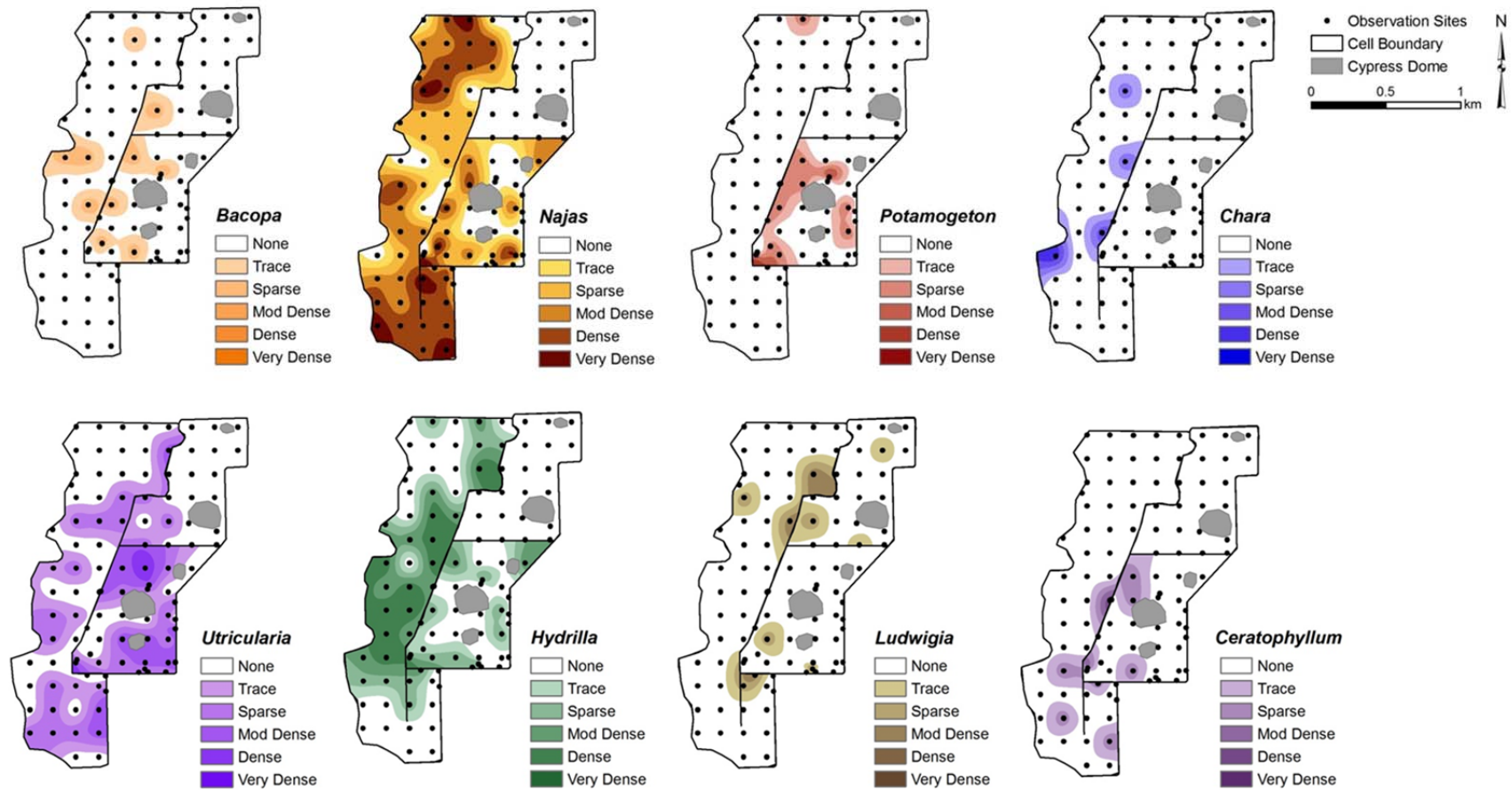
Hilliard FAVT SAV Survey Locations: December 2015



created: 1/11/16; Dec2015 FAVT Hilliard SAV Survey Map.mxd

Figure 45. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the December 2015 vegetation survey.

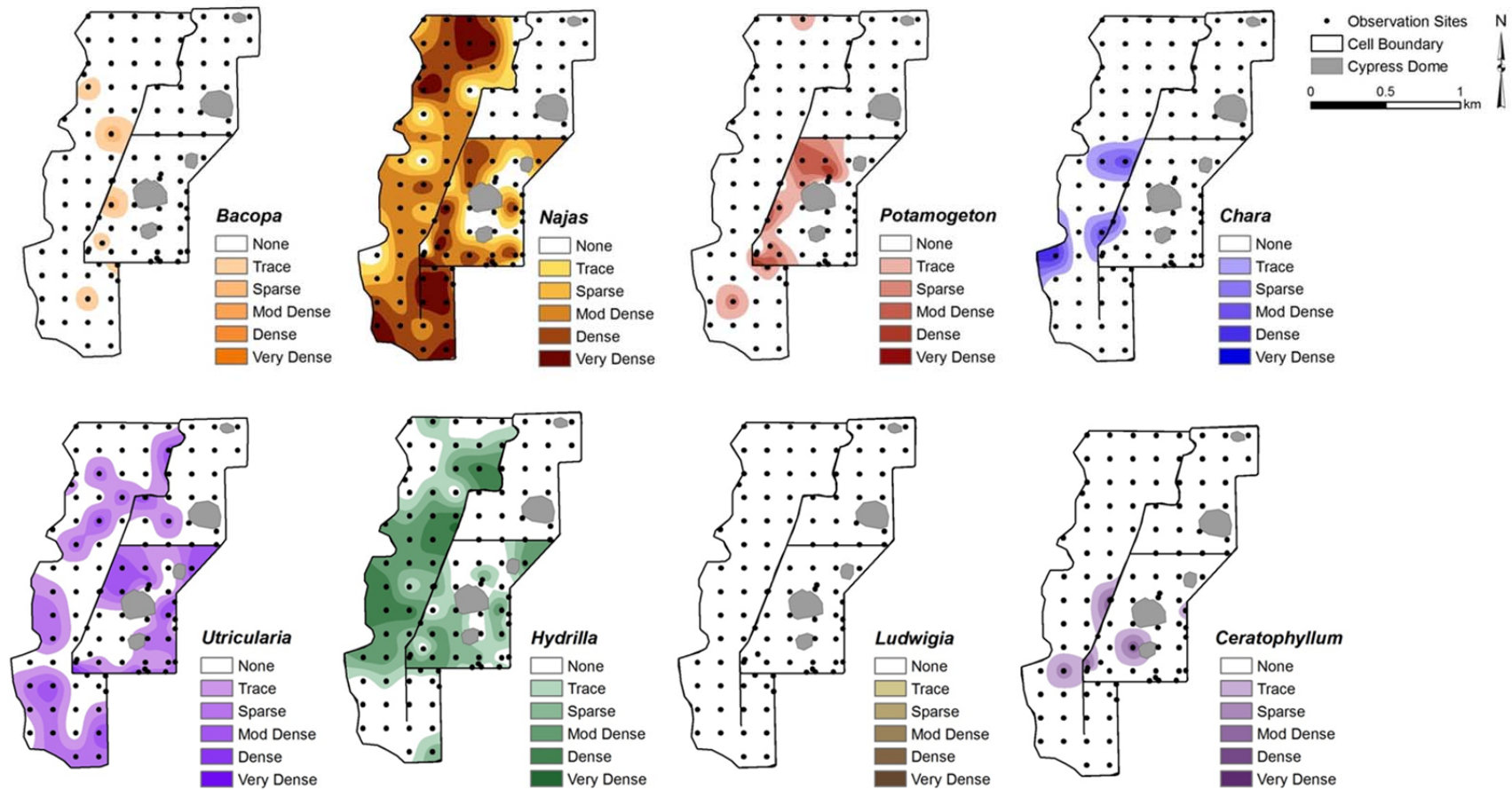
Hilliard FAVT SAV Survey Locations: January 2016



created: 1/31/16; updated: 2/1/16; Jan2016 FAVT Hilliard SAV Survey Map.mxd

Figure 46. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the January 2016 vegetation survey.

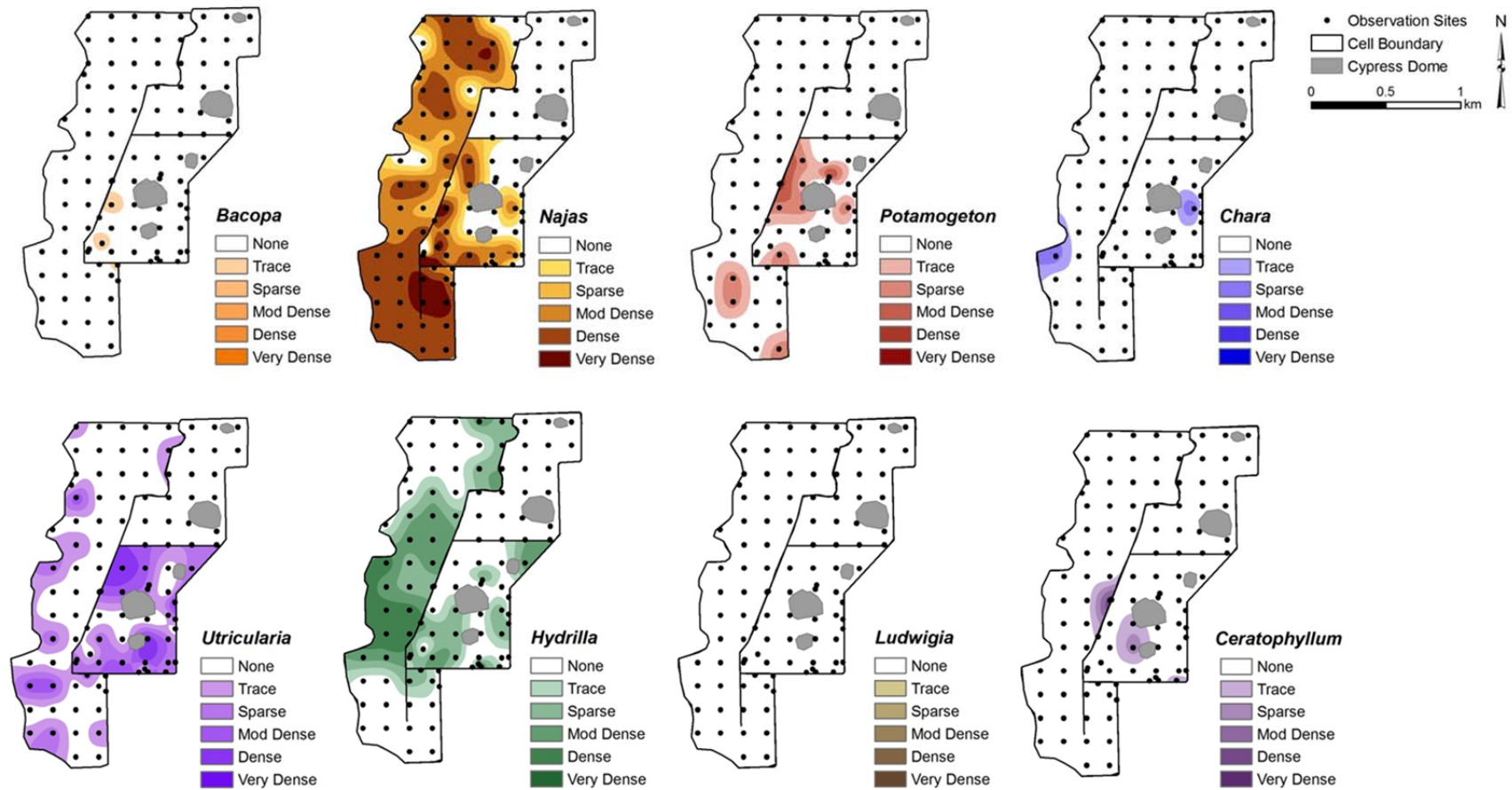
Hilliard FAVT SAV Survey Locations: February 2016



created: 2/27/16; updated: 2/28/16; Feb2016 FAVT Hilliard SAV Survey Map.mxd

Figure 47. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the February 2016 vegetation survey.

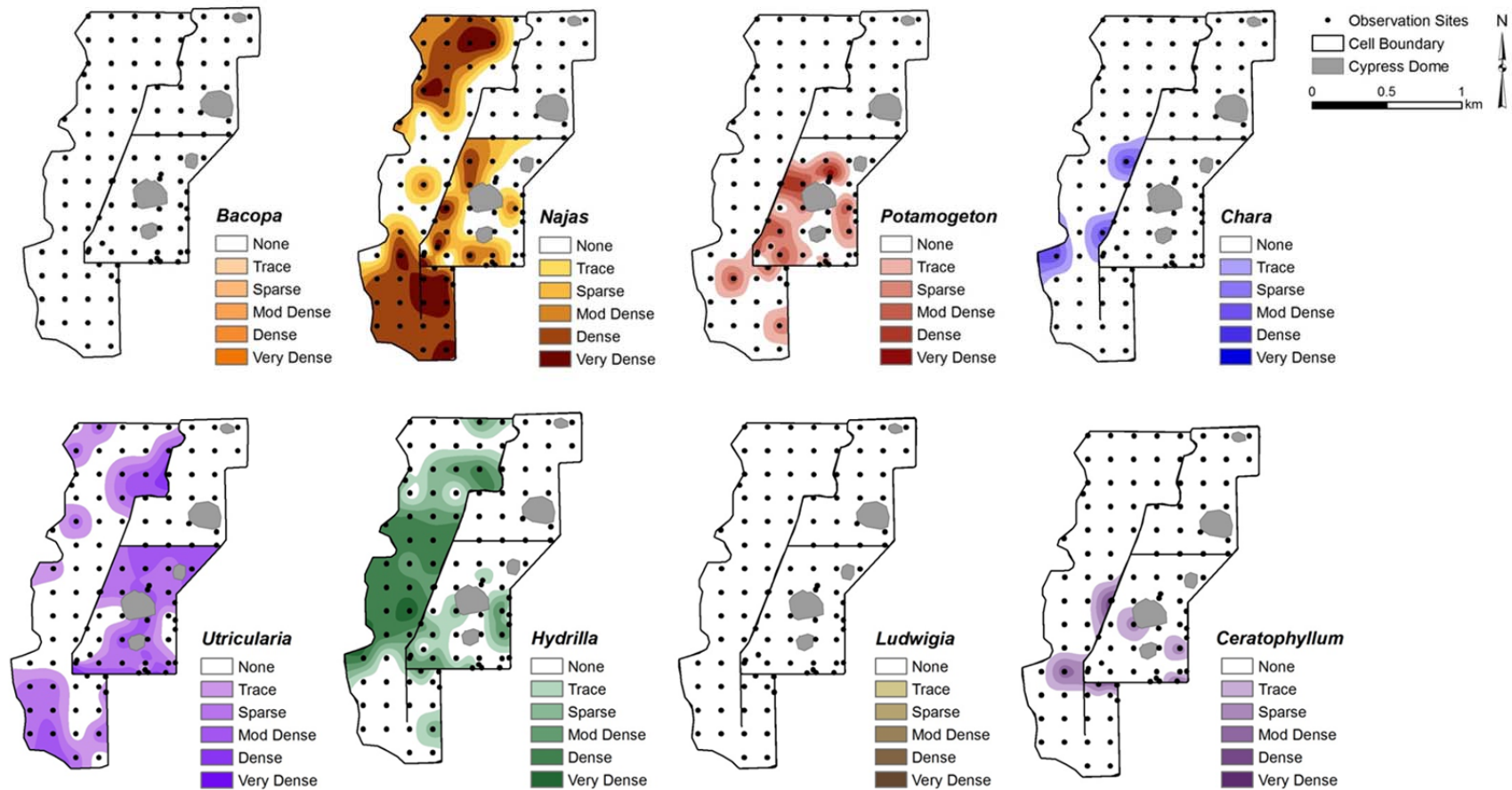
Hilliard FAVT SAV Survey Locations: March 2016



created: 3/30/16; updated: 3/31/16; March2016 FAVT Hilliard SAV Survey Map.mxd

Figure 48. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the March 2016 vegetation survey.

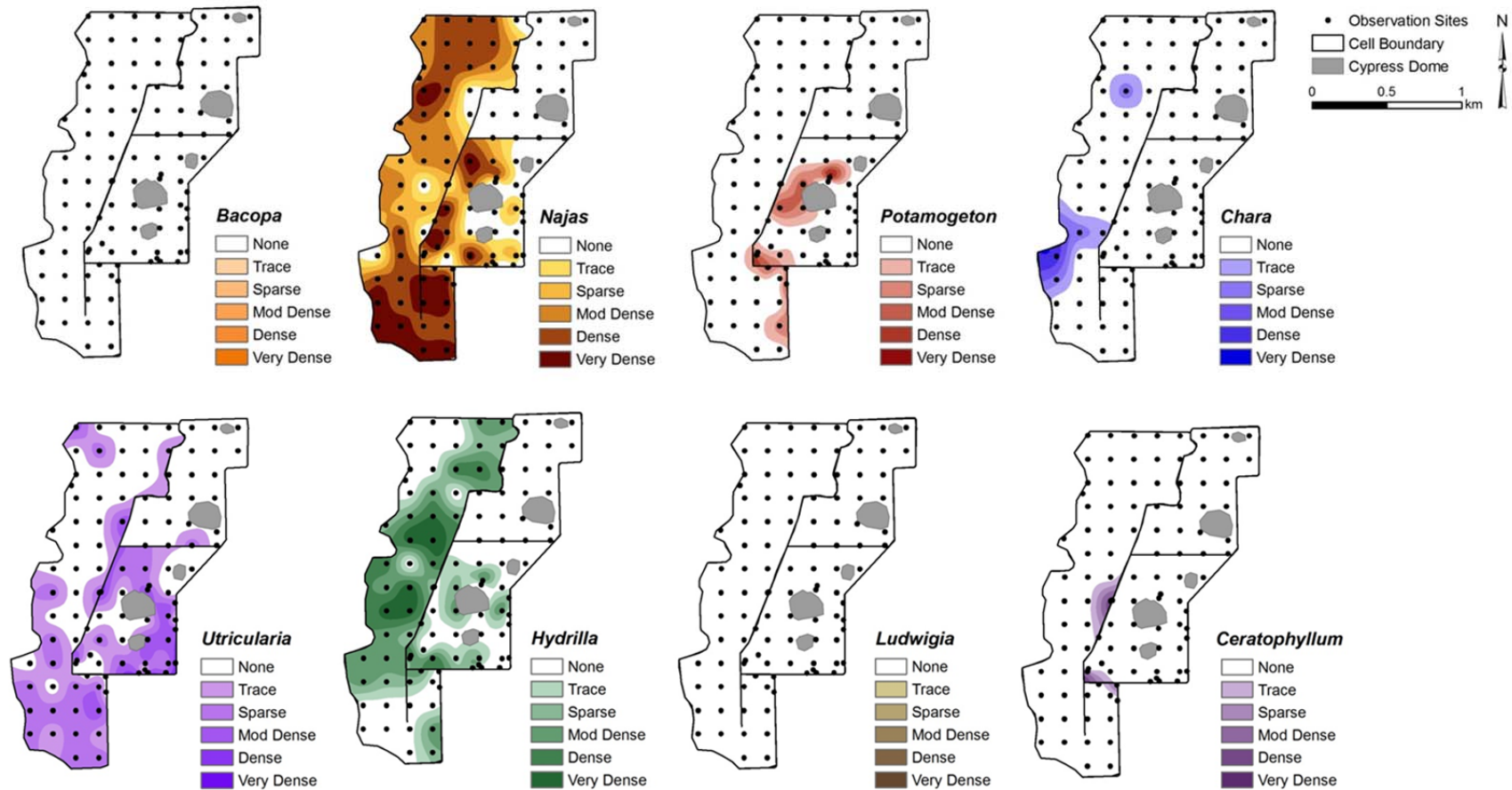
Hilliard FAVT SAV Survey Locations: April 2016



created: 4/28/16; updated: 4/29/16; April 2016 FAVT Hilliard SAV Survey Map.mxd

Figure 49. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the April 2016 vegetation survey.

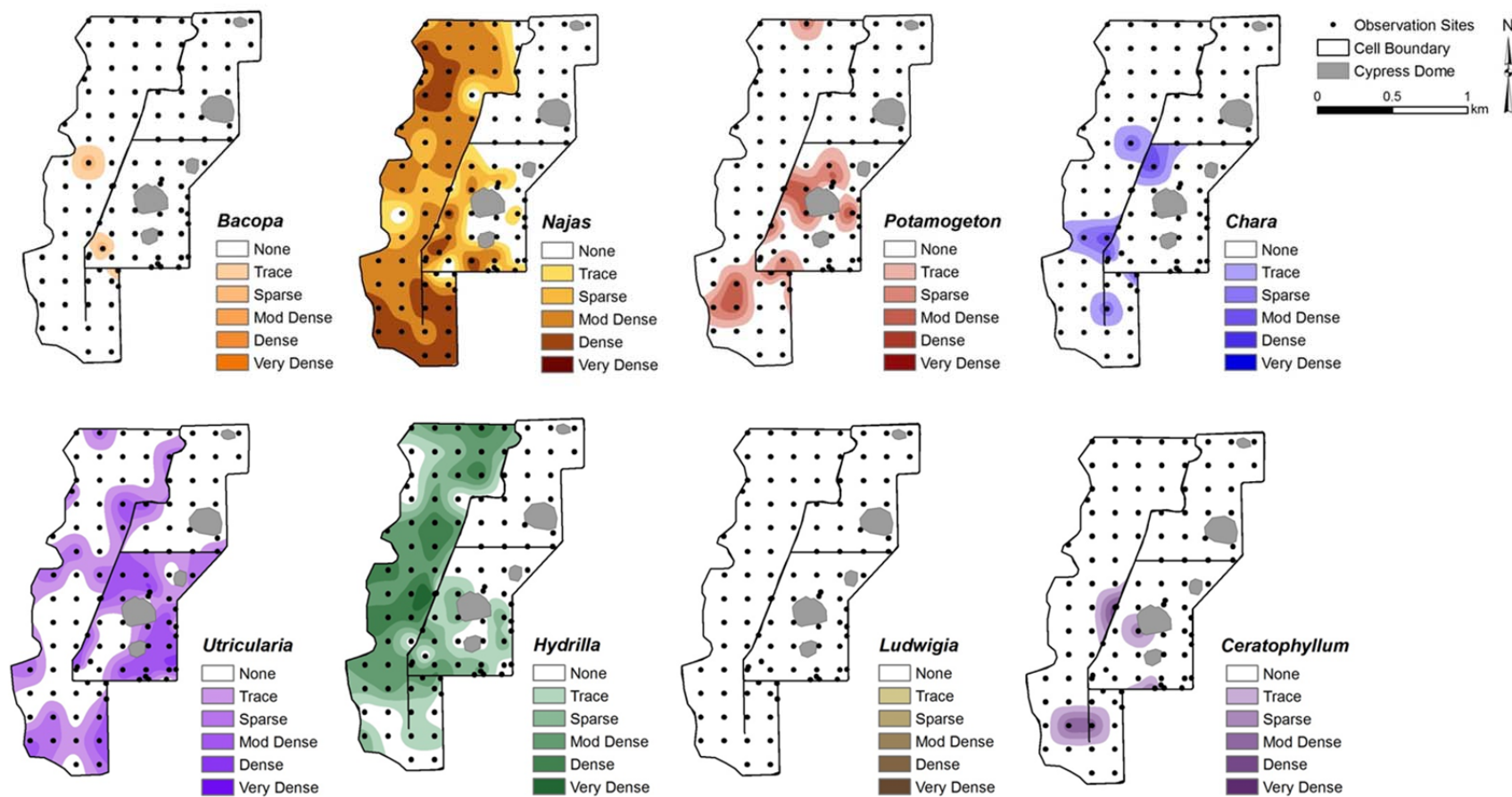
Hilliard FAVT SAV Survey Locations: May 2016



created: 6/2/16; updated: n/a; May2016 FAVT Hilliard SAV Survey Map.mxd

Figure 50. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the May 2016 vegetation survey.

Hilliard FAVT SAV Survey Locations: June 2016



created: 6/25/16; updated: n/a; June2016 FAVT Hilliard SAV Survey Map.mxd

Figure 51. Relative cover of SAV species in Cell 3 of the Caloosahatchee wetland during the June 2016 vegetation survey.