

Appendix 5B-7: Emergent and Submerged Aquatic Vegetation Coverage in the STAs

Yaoyang Yan

The Everglades Stormwater Treatment Area (STA) vegetation mapping program has several objectives: (1) document areal coverage of emergent aquatic vegetation (EAV), submerged aquatic vegetation (SAV) and open water areas based on aerial images, (2) map dominant vegetation types on an as-needed basis, and (3) monitor changes in vegetation density in problematic cells. Ground-truthing via helicopter flights supplements the aerial imagery. Future goals include being able to relate vegetation coverage and density to STA performance, estimate phosphorus storage in plant biomass, and determine hydraulic effects of vegetation resistance.

INTERPRETATION OF THE 2014 AERIAL IMAGERY

The 2014 digital imagery was collected on May 6 (STA-5/6), and May 17, 2014 [STA-1 East (STA-1E), STA-1 West (STA-1W), STA-2, and STA-3/4] by Aerial Cartographics of America Inc. utilizing a Microsoft UltraCam Eagle digital camera mounted on a Cessna 206 aircraft. The aircraft was flying at an approximate altitude of 15,650 feet above ground level, with 60 percent end lap and 40 percent side lap. The images were collected under conditions minimizing shadows, maximizing light penetration within water bodies, and minimizing sun glare from water surface. The images are free of smoke, clouds, and cloud shadows. Acquisition took place when the sun angle was between 25 and 55 degrees above the horizon. The raw imagery has a ground sampling distance of 12 inches.

Raw images were processed using Vexcel UltraMap (version 3.0, Microsoft Corporation, Redmond, Washington) to Level 3 TIFFs. The four color bands are a four-band stack (red, green, blue, and intensity) of level 3 images. Vegetation cover maps for the six STAs were produced using unsupervised classification of the color infrared bands of this imagery. Image processing software (ERDAS Imagine, 2011, Intergraph Corporation, Huntsville, Alabama) was used to reclassify, filter, and aggregate the initial classification. Expert knowledge and ground-truthing of vegetation composition were employed to conduct final edits, calculate acreage, and output results cartographically using geographic information system software (ArcGIS version 10.2, ESRI, Redlands, California).

Among the limitations of STA aerial imagery, the most significant are the (1) photographic overflights are limited to once a year only during the dry season, and (2) inability to discriminate between areas covered with SAV versus open water areas. It is often impossible to distinguish actual SAV coverage in the aerial images; therefore, some portion of areas mapped as SAV in the STAs may include open water without plants. Since acquiring aerial imagery requires clear weather with a cloudless sky, flights often times occur during periods when the water levels in the STAs are receding (i.e., the dry season). Wetland vegetation coverage can change quickly depending on hydrologic conditions. For example, some areas covered with SAV and open water areas may be rapidly covered with EAV when the water level recedes and conditions become conducive for EAV growth and expansion. For the STA maps and data summaries presented in this appendix, coverage

is distinguished among areas covered with EAV, areas covered with open water or SAV, and bare areas. Bare area includes areas of exposed soil and dead grasses (often times less than 1 percent of total coverage; the largest area was observed in STA-1E Cell 2, with over 72 percent of the area covered in bare area) during the time of the aerial flight. The vegetation data is added for Cells 5 through 8 of STA-2, and Cells 5-4A, 5-4B, 5-5A, 5-5B, and 6-4 of STA-5/6 in this report.

STA-1E WATER YEAR 2015 VEGETATION COVERAGE

Table 1 and **Figure 1** describe vegetation coverage in STA-1E for Water Year 2015 (WY2015; May 1, 2014–April 30, 2015).

Table 1. Vegetation coverage in the STA-1E treatment cells estimated from the 2014 aerial imagery, categorized by the dominant vegetation communities (EAV SAV/open water) or exposed ground/dead grasses (bare area).

Cell	Coverage Type	Estimated Coverage (acres)	% Coverage	Cell Area (acres)
CELL 1	SAV/Water	19.4	3.6	540.6
	EAV	511.8	94.7	
	Bare Area	9.5	1.8	
CELL 2	SAV/Water	6.1	1.1	540.4
	EAV	144.8	26.8	
	Bare Area	389.6	72.1	
CELL 3	SAV/Water	56.9	9.9	572.1
	EAV	513.9	89.8	
	Bare Area	1.37	0.2	
CELL 4N	SAV/Water	352.1	55.5	634.8
	EAV	281.1	44.3	
	Bare Area	1.6	0.3	
CELL 4S	SAV/Water	440.9	60.3	731.6
	EAV	289.1	39.5	
	Bare Area	1.7	0.2	
CELL 5	SAV/Water	65.8	12.1	542.3
	EAV	476.6	87.9	
	Bare Area	0.04	0.01	
CELL 6	SAV/Water	457.1	44.3	1,033.0
	EAV	575.8	55.7	
	Bare Area	0.3	0.03	
CELL 7	SAV/Water	75.9	18.9	397.8
	EAV	322.1	81.0	
	Bare Area	0.38	0.10	

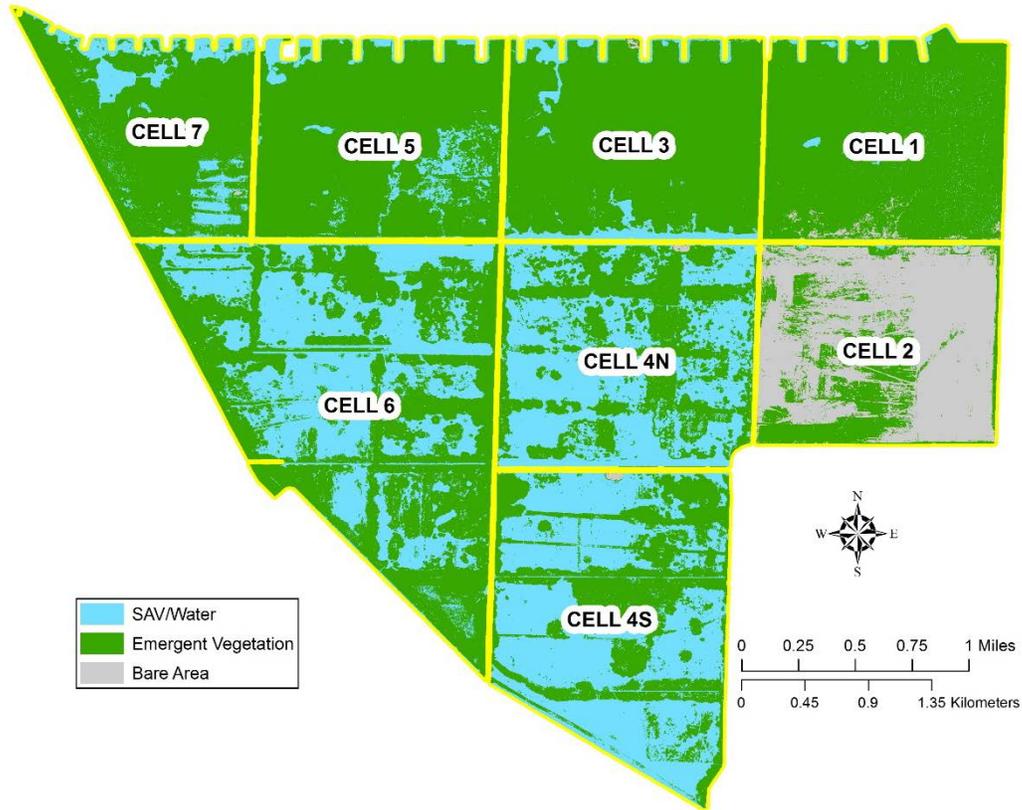


Figure 1. Vegetation coverage in the STA-1E treatment cells estimated from the 2014 aerial imagery, categorized by the dominant vegetation communities (EAV or SAV/open water) or exposed ground/dead grasses (bare area).

STA-1W WATER YEAR 2015 VEGETATION COVERAGE

Table 2 and **Figure 2** present vegetation coverage for STA-1W for WY2015.

Table 2. Vegetation coverage in the STA-1W treatment cells estimated from the 2014 aerial imagery, categorized by the dominant vegetation communities (EAV or SAV/open water) or exposed ground/dead grasses (bare area).

Cell	Coverage Type	Estimated Coverage (acres)	% Coverage	Cell Area (acres)
CELL 1A	SAV/Water	116.7	16.4	713.4
	EAV	596.8	83.7	
	Bare Area	0.03	0.00	
CELL 1B	SAV/Water	358.2	62.1	577.1
	EAV	219.0	38.0	
	Bare Area	0.01	0.00	
CELL 2A	SAV/Water	63.4	9.0	701.4
	EAV	635.9	90.7	
	Bare Area	2.2	0.3	
CELL 2B	SAV/Water	180.2	58.3	309.1
	EAV	128.9	41.7	
	Bare Area	0.02	0.01	
CELL 3	SAV/Water	400.1	45.4	880.8
	EAV	480.7	54.6	
	Bare Area	0.05	0.01	
CELL 4	SAV/Water	230.1	64.2	358.7
	EAV	128.6	35.9	
	Bare Area	0.03	0.01	
CELL 5A	SAV/Water	174.1	28.9	602.3
	EAV	428.4	71.1	
	Bare Area	0.03	0.00	
CELL 5B	SAV/Water	1,728.3	72.0	2,401.4
	EAV	673.7	28.0	
	Bare Area	0.04	0.00	

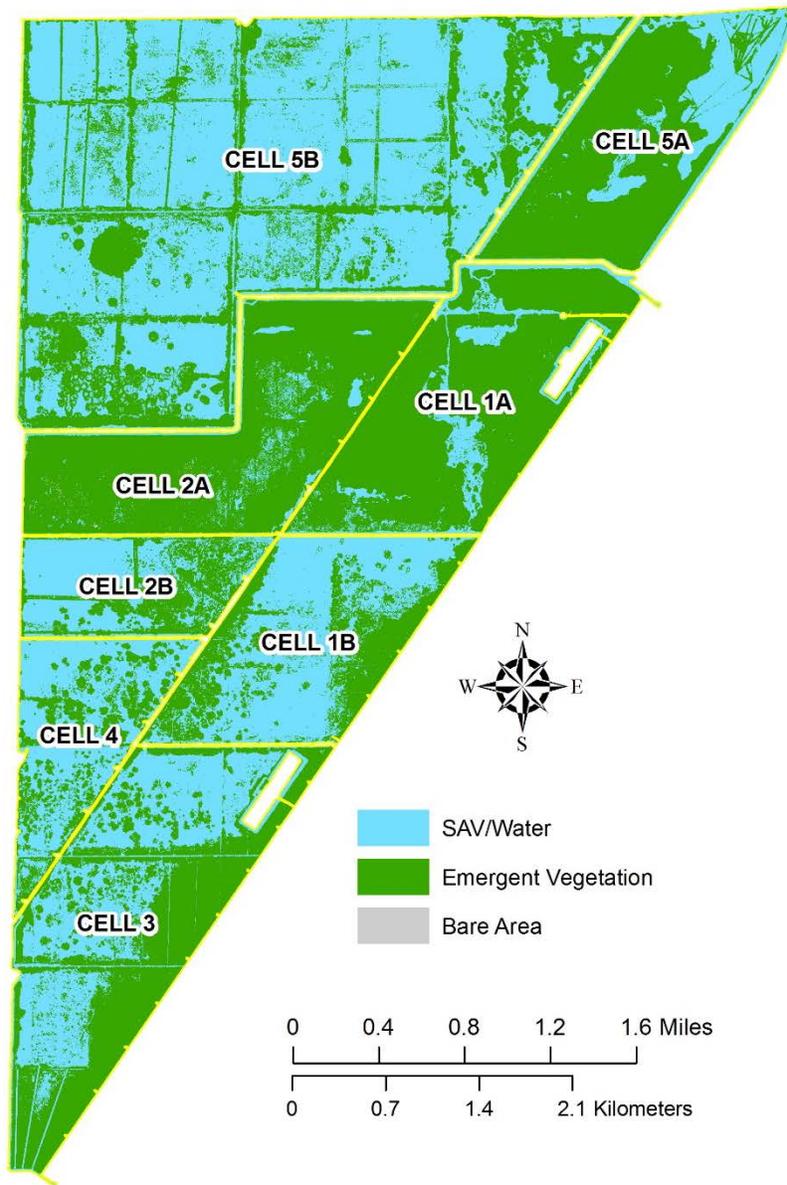


Figure 2. Vegetation coverage in the STA-1W treatment cells estimated from the 2014 aerial imagery, categorized by the dominant vegetation communities (EAV or SAV/open water] or exposed ground/dead grasses (bare area).

STA-2 WATER YEAR 2015 VEGETATION COVERAGE

Table 3 and **Figure 3** present vegetation coverage for STA-2 for WY2015.

Table 3. Vegetation coverage in the STA-2 treatment cells estimated from the 2014 aerial imagery, categorized by the dominant vegetation communities (EAV or SAV/open water) or exposed ground/dead grasses (bare area).

Cell	Coverage Type	Estimated Coverage (acres)	% Coverage	Cell Area (acres)
Cell 1	SAV/Water	88.7	4.4	2,032.6
	EAV	1,943.9	95.6	
	Bare Area	0.03	0.00	
Cell 2	SAV/Water	1,002.4	42.2	2,373.2
	EAV	1,370.5	57.8	
	Bare Area	0.2	0.01	
Cell 3	SAV/Water	1,282.4	55.9	2,296.3
	EAV	1,009.4	44.0	
	Bare Area	4.5	0.2	
Cell 4	SAV/Water	1,389.0	71.5	1,942.0
	EAV	553.0	28.5	
	Bare Area	0.1	0.0	
Cell 5	SAV/Water	1,149.2	50.0	2,300.4
	EAV	1,138.0	49.5	
	Bare Area	13.2	0.6	
Cell 6	SAV/Water	1,183.3	59.2	2,000.4
	EAV	803.5	40.2	
	Bare Area	13.6	0.7	
Cell 7	SAV/Water	71.5	4.4	1,614.2
	EAV	1,525.0	94.5	
	Bare Area	17.7	1.1	
Cell 8	SAV/Water	169.7	9.2	1,853.4
	EAV	1,661.6	89.7	
	Bare Area	22.0	1.2	

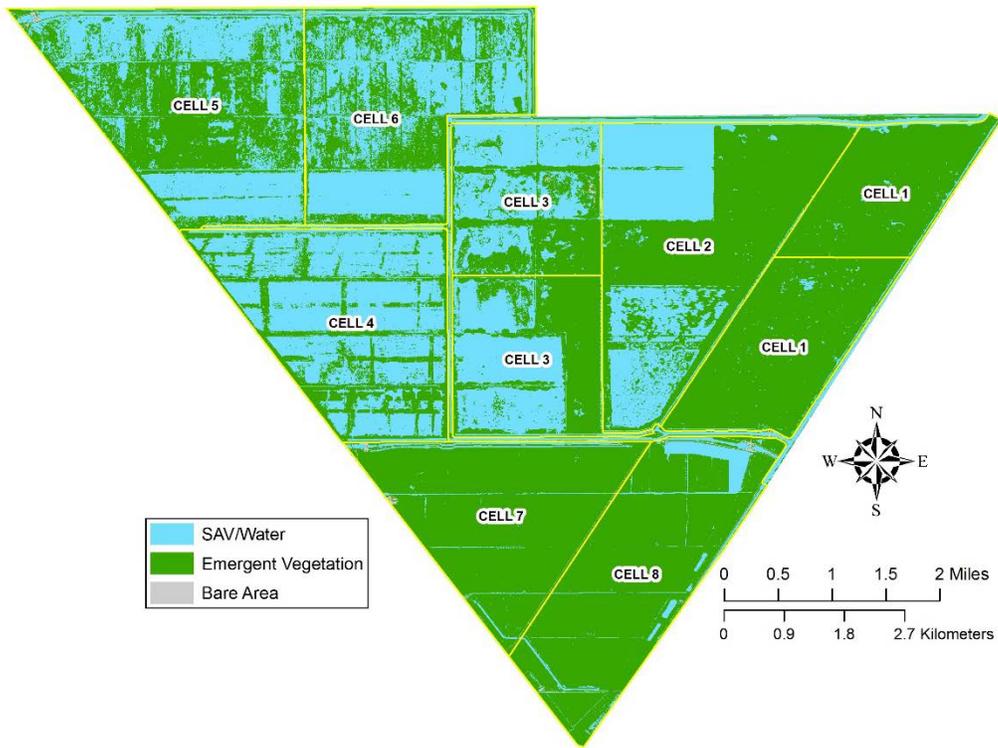


Figure 3. Vegetation coverage in the STA-2 treatment cells estimated from the 2014 aerial imagery, categorized by the dominant vegetation communities (EAV or SAV/open water) or exposed ground/dead grasses (bare area).

STA-3/4 WATER YEAR 2015 VEGETATION COVERAGE

Table 4 and **Figure 4** present vegetation coverage for STA-3/4 for WY2015.

Table 4. Vegetation coverage in the STA-3/4 treatment cells estimated from the 2014 aerial imagery, categorized by the dominant vegetation communities (EAV or SAV/open water) or exposed ground/dead grasses (bare area).

Cell	Coverage Type	Estimated Coverage (acres)	% Coverage	Cell Area (acres)
CELL 1A	SAV/Water	351.4	11.6	3,019.6
	EAV	2,665.2	88.3	
	Bare Area	3.0	0.1	
CELL 1B	SAV/Water	1,819.0	52.6	3,456.1
	EAV	1,608.4	46.5	
	Bare Area	28.8	0.8	
CELL 2A	SAV/Water	225.9	9.0	2,505.6
	EAV	2,269.7	90.6	
	Bare Area	10.0	0.4	
CELL 2B	SAV/Water	1,182.2	49.3	2,396.5
	EAV	1,208.6	50.4	
	Bare Area	5.7	0.2	
CELL 3A	SAV/Water	58.8	2.4	2,415.2
	EAV	2,353.6	97.5	
	Bare Area	2.8	0.1	
CELL 3B	SAV/Water	952.2	45.6	2,086.7
	EAV	1,133.3	54.3	
	Bare Area	1.2	0.1	

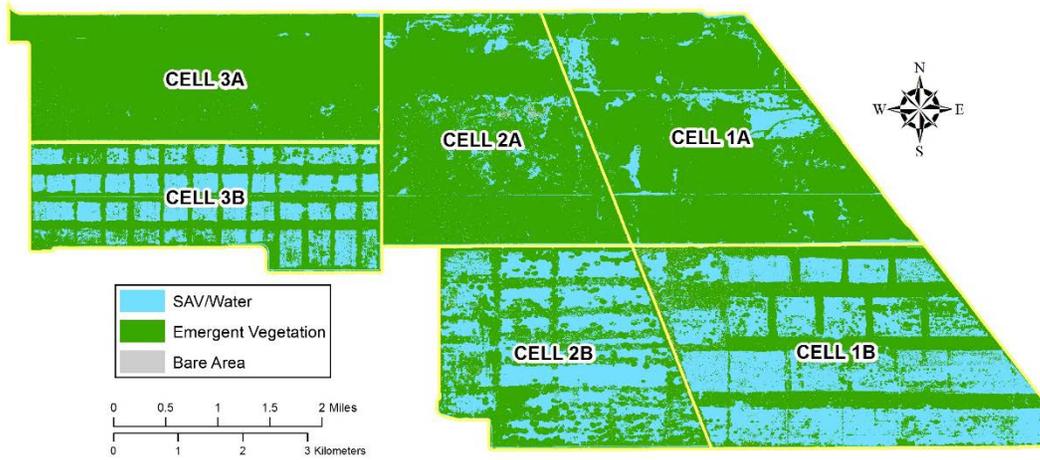


Figure 4. Vegetation coverage in the STA-3/4 treatment cells estimated from the 2014 aerial imagery, categorized by the dominant vegetation communities (EAV or SAV/open water) or exposed ground/dead grasses (bare area).

STA-5/6 WATER YEAR 2015 VEGETATION COVERAGE

Table 5 and **Figure 5** present vegetation coverage for STA-5/6 for WY2015.

Table 5. Vegetation coverage in the STA-5/6 treatment cells estimated from the 2014 aerial imagery, categorized by the dominant vegetation communities (EAV or SAV/open water) or exposed ground/dead grasses (bare area).

Cell	Coverage Type	Estimated Coverage (acres)	% Coverage	Cell Area (acres)
CELL 5-1A	SAV/Water	36.7	4.4	840.3
	EAV	803.6	95.6	
	Bare Area	0.02	0.00	
CELL 5-1B	SAV/Water	768.6	62.8	1,223.2
	EAV	454.6	37.2	
	Bare Area	0.01	0.00	
CELL 5-2A	SAV/Water	15.4	1.8	844.7
	EAV	829.4	98.2	
	Bare Area	0.00	0.00	
CELL 5-2B	SAV/Water	679.5	55.1	1,233.1
	EAV	553.6	44.9	
	Bare Area	0.04	0.00	
CELL 5-3A	SAV/Water	187.5	17.9	1,047.0
	EAV	859.6	82.1	
	Bare Area	0.00	0.00	
CELL 5-3B	SAV/Water	679.9	73.9	920.3
	EAV	240.4	26.1	
	Bare Area	0.04	0.00	
Cell 5-4A	SAV/Water	406.9	19.8	2,055.0
	EAV	1,639.9	79.8	
	Bare Area	9.2	0.4	
Cell 5-4B	SAV/Water	330.2	68.9	479.3
	EAV	145.5	30.4	
	Bare Area	3.6	0.8	
Cell 5-5A	SAV/Water	571.4	22.3	2,562.1
	EAV	1,978.7	77.2	
	Bare Area	12.0	0.5	
Cell 5-5B	SAV/Water	255.8	35.6	718.8
	EAV	457.6	63.7	
	Bare Area	5.4	0.8	

Table 5. Continued.

Cell	Coverage Type	Estimated Coverage (acres)	% Coverage	Cell Area (acres)
Cell 6-2	SAV/Water	166.8	12.3	1,361.4
	EAV	1,194.6	87.8	
	Bare Area	0.01	0.00	
Cell 6-3	SAV/Water	6.9	2.9	241.9
	EAV	234.9	97.1	
	Bare Area	0.01	0.00	
Cell 6-4	SAV/Water	73.3	12.6	583.1
	EAV	506.7	86.9	
	Bare Area	3.1	0.5	
Cell 6-5	SAV/Water	4.9	0.8	621.2
	EAV	616.1	99.2	
	Bare Area	0.1	0.02	

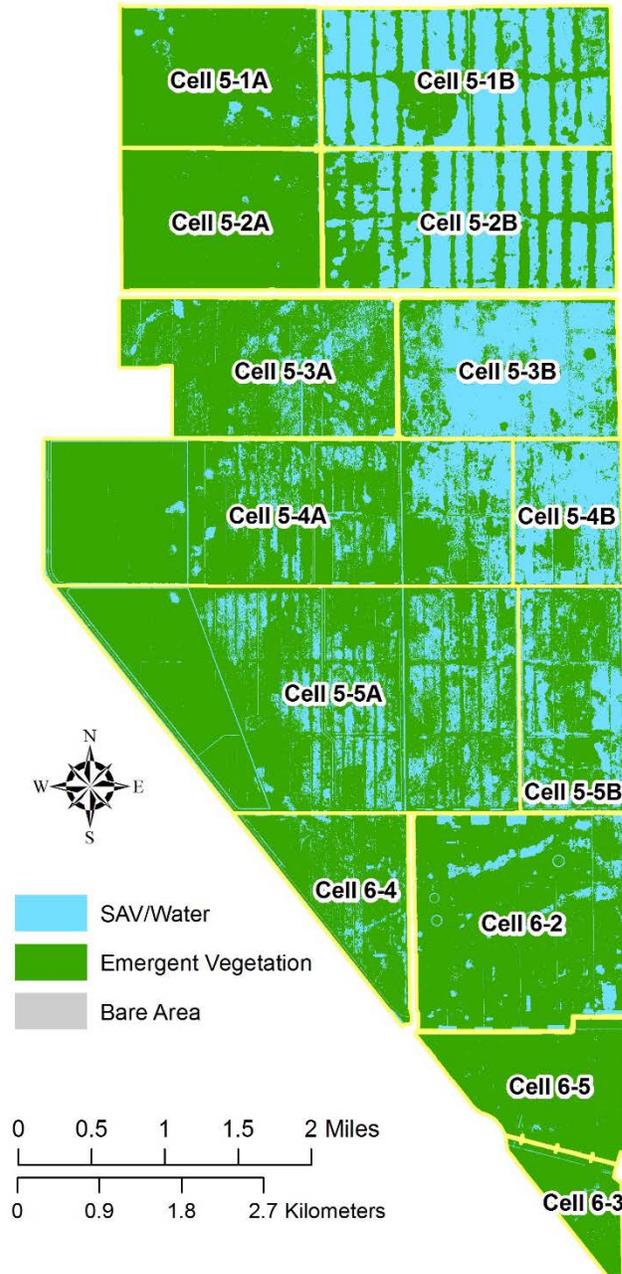


Figure 5. Vegetation coverage in the STA-5/6 treatment cells estimated from the 2014 aerial imagery, categorized by the dominant vegetation communities (EAV or SAV/open water) or exposed ground/dead grasses (bare area).

VEGETATION COVERAGE TRENDS (2007–2014)

STA-1E VEGETATION COVERAGE TRENDS

During the period from 2013 through 2014, there was little change observed in terms of vegetation coverage in Cell 3 and the EAV coverage is stabilizing in about 90 percent of the cell area. There were moderate increases (7–9 percent) in EAV coverage for Cells 1 and 5, and SAV coverage in Cell 4N. The largest increase in coverage (14–18 percent) occurred in EAV Cells 7, and SAV Cells 6 and 4N (Table 6 and Figure 6).

Table 6. Summary of EAV and SAV coverage in STA-1E based on aerial imagery during 2007–2014..

Year	Percent Coverage of Total Cell Area						
	EAV Cells				SAV Cells		
	1	3	5	7	4N	4S	6
2007	95.4	80.9	73.3	63.4	5.0	3.7	6.4
2008	90.1	89.1	87.7	63.4	6.0	3.4	7.8
2009	96.7	86.5	85.7	60.3	12.7	6.9	10.1
2010	92.6	85.0	85.0	55.5	39.8	11.0	16.7
2011	86.5	78.6	88.8	65.3	40.6	10.7	14.5
2012	94.4	88.0	78.8	65.8	43.9	18.2	31.0
2013	87.7	90.1	80.4	62.9	36.0	23.3	41.5
2014	94.7	89.8	87.9	81.0	44.3	39.5	55.7
Average	92.3	86.0	83.5	64.7	28.5	14.6	23.0

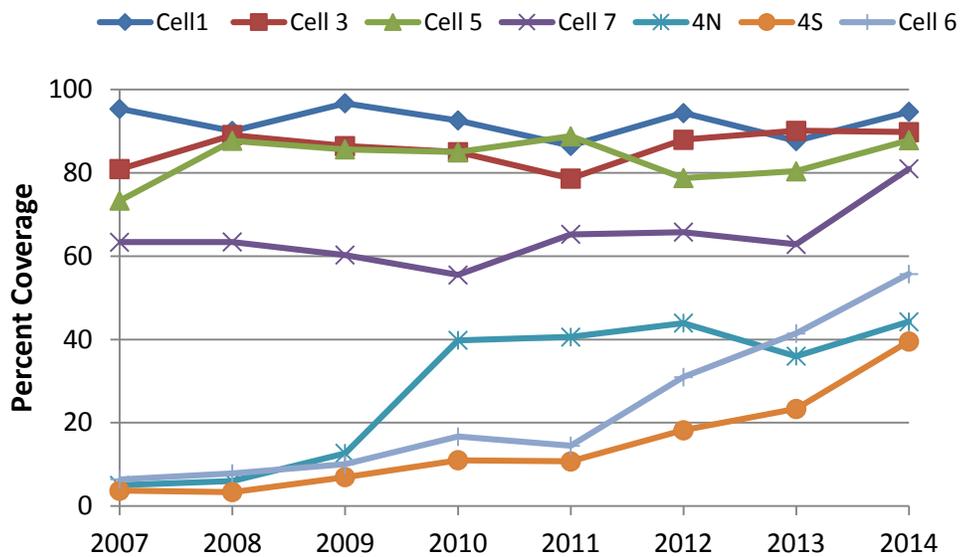


Figure 6. STA-1E EAV and SAV percent coverage over time.

STA-1W VEGETATION COVERAGE TRENDS

For the last two years (2013–2014), EAV coverages increased slightly (< 5 percent) for Cells 1A, 2A, and 5A (**Table 7** and **Figure 7**). SAV coverage in Cells 1B, 3, and 5B increased by 10 to 16 percent. However, SAV coverage in Cells 4 and 2B increased significantly with 24 percent and 34 percent total coverage, respectively. The coverage increases in Cells 2B and 4 were partially due to the lower water depths that existed at the time of the flights.

Table 7. Summary of EAV and SAV coverage in STA-1W based on aerial imagery during 2007–2014.

Year	Percent Coverage of Total Cell Area							
	EAV Cells			SAV Cells				
	1A	2A	5A	1B	2B	3	4	5B
2007	98.3	85.6	57.6	99.2	99.5	96.8	100.0	4.6
2008	58.6	84.4	61.3	15.0	6.5	42.4	7.2	6.0
2009	62.5	88.0	54.5	22.9	6.3	39.8	21.8	7.8
2010	80.0	94.2	53.7	20.3	4.5	45.2	18.5	11.7
2011	82.4	86.7	50.7	26.8	8.7	43.9	16.6	11.4
2012	79.0	73.5	65.2	23.7	7.7	36.6	9.3	26.2
2013	82.7	84.9	66.3	28.1	7.4	40.4	12.3	12.4
2014	83.7	90.7	71.1	38.0	41.7	54.6	35.9	28.0
Average	78.4	86.0	60.0	34.2	22.8	44.7	26.5	13.5

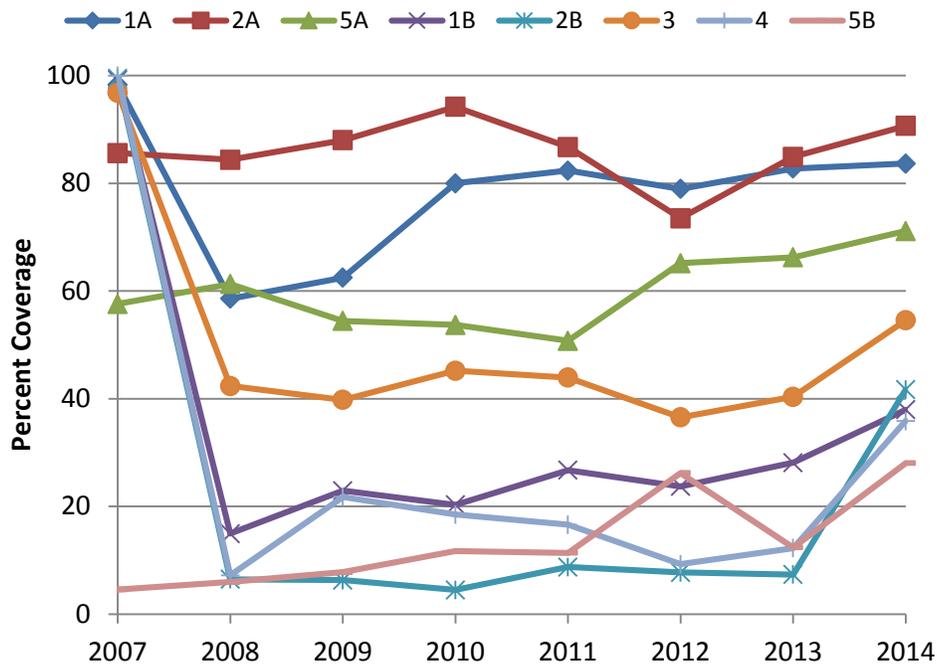


Figure 7. STA-1W EAV and SAV percent coverage over time.

STA-2 VEGETATION COVERAGE TRENDS

For the last two years (2013–2014), there was relatively no change in EAV coverages in Cells 1 and 4, with coverages differing by no more than 2 percent (**Table 8** and **Figure 8**). The most significant increase in SAV coverage occurred in Cell 3, with coverage increasing by over 9 percent from 2013 to 2014. In comparison to the other EAV cell, Cell 2 experienced a reduction in EAV coverage by 7 percent from the previous year.

Table 8. Summary of EAV and SAV coverage in STA-2 based on aerial imagery during 2007–2014.

[Note: some cells show ND indicating that no data is available for these years.]

Year	Percent Coverage of Total Cell Area							
	EAV Cells					SAV Cells		
	Cell 1	Cell 2	Cell 5	Cell 6	Cell 7	Cell 3	Cell 4	Cell 8
2007	96.9	73.9	ND	ND	ND	23.6	72.1	ND
2008	95.3	75.0	ND	ND	ND	26.0	4.6	ND
2009	99.1	75.8	ND	ND	ND	27.6	5.6	ND
2010	96.5	61.7	ND	ND	ND	28.8	12.2	ND
2011	96.9	65.0	ND	ND	ND	31.5	55.8	ND
2012	91.9	62.9	ND	ND	ND	30.7	45.6	ND
2013	94.4	65.1	ND	ND	ND	34.8	29.7	ND
2014	95.6	57.8	49.5	40.2	94.5	44.0	28.5	89.7
Average	95.8	67.1	49.5	40.2	94.5	30.9	31.8	89.7

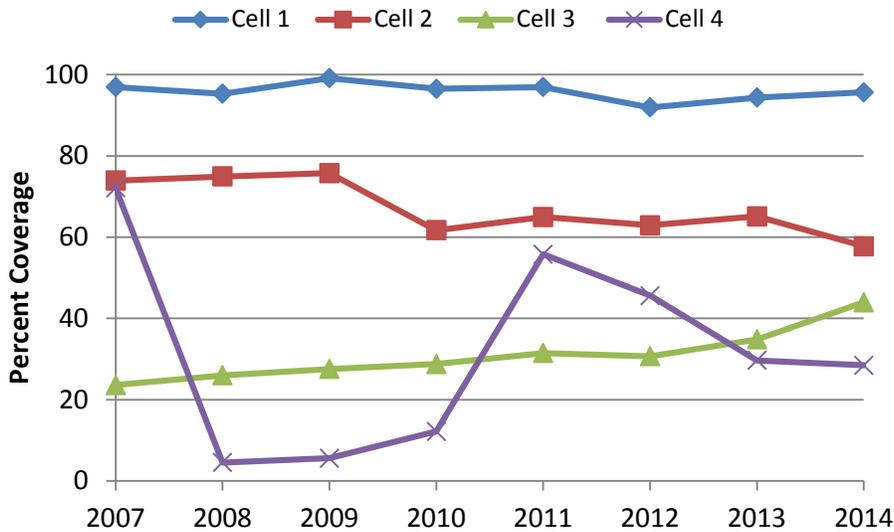


Figure 8. STA-2 EAV and SAV percent coverage over time.

STA-3/4 VEGETATION COVERAGE TRENDS

For STA 3/4, the most significant changes occurred in Cells 2B and 3B, which both showed a 10 percent increase in SAV coverage from the previous year. There was a moderate increase in SAV coverage in Cell 1B (6 percent). There was little change in EAV coverage for Cells 1A, 2A, and 3A, which all showed a coverage increase of only about 1 percent (**Table 9** and **Figure 9**).

Table 9. Summary of EAV and SAV coverage in STA-3/4 based on aerial imagery during 2007–2014.

Year	Percent Coverage of Total Cell Area					
	EAV Cells			SAV Cells		
	1A	2A	3A	1B	2B	3B
2007	62.3	80.8	93.7	72.5	16.3	38.3
2008	71.6	75.5	94.4	71.4	22.8	31.9
2009	72.8	83.0	92.8	58.6	25.6	36.8
2010	65.4	77.6	94.8	58.8	25.8	33.6
2011	78.8	80.4	94.8	47.7	24.7	31.6
2012	81.8	83.2	94.3	31.1	27.9	38.0
2013	87.2	89.4	96.1	40.2	39.6	44.2
2014	88.3	90.6	97.5	46.5	50.4	54.3
Average	76.0	82.5	94.8	53.3	29.1	38.6

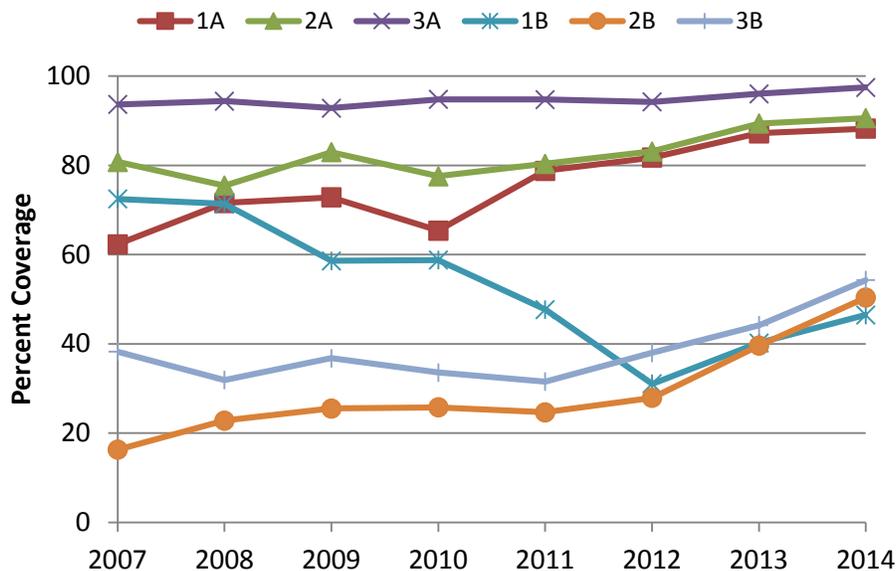


Figure 9. STA-3/4 EAV and SAV percent coverage over time.

STA-5/6 VEGETATION COVERAGE TRENDS

During 2013–2014, the most significant change observed was in Cell 5-3B, with a 30 percent decrease in SAV coverage. Cells 5-1A and 6-3 showed increases in EAV coverage by 10–14 percent. There was a moderate decrease in SAV coverage by 7 percent shown in Cell 6-2. There were no significant changes in vegetation coverage for Cells 5-1B, 5-2A, 5-2B, 5-3A, and 6-5 over the last two years (**Table 10** and **Figure 10**).

Table 10. Summary of EAV and SAV coverage in STA-5/6 based on aerial imagery during 2007–2014.

[Note: some cells show ND indicating that no data is available for these years.]

Year	Percent Cover of Total Cell Area													
	EAV Cells									SAV Cells				
	5-1A	5-2A	5-3A	6-3	6-5	5-1B	5-4A	5-5A	6-4	5-2B	5-3B	6-2	5-4B	5-5B
2007	70.3	95.9	ND	98.8	99.5	5.4	ND	ND	ND	19.8	NA	90.2	ND	ND
2008	72.6	92.8	70.8	96.7	97.7	9.3	ND	ND	ND	25.0	79.5	41.0	ND	ND
2009	100.0	96.6	82.8	98.3	99.6	12.0	ND	ND	ND	18.3	92.8	78.6	ND	ND
2010	63.7	85.2	83.1	83.2	92.3	12.3	ND	ND	ND	19.3	93.5	60.5	ND	ND
2011	88.3	90.8	71.9	86.0	97.0	20.6	ND	ND	ND	30.1	90.6	80.4	ND	ND
2012	88.9	94.1	83.6	95.5	98.7	25.3	ND	ND	ND	33.2	88.1	85.9	ND	ND
2013	81.6	93.7	82.7	87.6	97.2	34.9	ND	ND	ND	42.4	57.0	80.7	ND	ND
2014	95.6	98.2	82.1	97.1	99.2	37.2	79.8	77.2	86.9	44.9	26.1	87.8	30.36	63.67
Average	82.6	93.4	79.6	92.9	97.7	19.6	79.8	77.2	86.9	29.1	75.4	75.6	30.36	63.67