Monitoring of Lake Ontario coastal wetland habitat in support of Adaptive Management

FINAL REPORT

Submitted to

Great Lakes –St. Lawrence River Adaptive Management Committee

March 2016

Environment Canada
Environnement Canada
Canadian Wildlife Service
Service canadien de la faune

Executive Summary

In the summer of 2015, 8 coastal wetlands were surveyed by the Canadian Wildlife Service - Ontario Region (CWS-ON) along the north shore of Lake Ontario to provide wetland vegetation data referenced to elevation to support the International Joint Commission's Great Lakes-St. Lawrence River Adaptive Management (GLAM) Committee validate model outputs of aquatic ecosystem impacts from changes in water level regulation. The objectives of this project were to support field surveys conducted in 2015 and to support the delivery of a coastal wetland monitoring dataset containing an additional 7 years of monitoring data to Committee.

The sites surveyed in 2015 were selected to be representative of wetlands in Lake Ontario, by geography, hydrogeomorphic type and level of disturbance; and included the largest number of new wetlands surveyed (5 of 8 sites) and the largest number of wetlands sampled in the western basin (3 of 8). To quantify disturbance, basic water quality information was collected at each wetland. Wetland vegetation was surveyed using an existing approach developed by CWS-ON using real-time kinematic (RTK) GPS that is also being implemented by colleagues in the United States.

In general, the water quality information collected indicates that the sites surveyed vary in disturbance from Very Degraded (West Pond) to Good (Wesleyville, Presqu'ile Bay, Sawguin Creek and South Bay). Wetland water quality generally follows an east-west gradient which is consistent with many other water monitoring programs in Lake Ontario. The collection of vegetation data at new sites and at sites in the western basin will greatly increase regional representation of wetland habitat in the larger dataset. Sampling disturbed wetlands in the western basin may not yield results illustrating diverse plant zonation however; these data are reflective of conditions experienced at a significant number of wetlands in Lake Ontario that should be incorporated into an adaptive management approach for the entire lake.

The utility of this approach to surveying habitat is that geospatial surfaces can be generated from the field-collected data. Local Digital Elevation Models (DEM) and interpolated distributions of each vegetation guild at each wetland sampled in 2015 were created. Also in 2015, new a GPS correction technique called real-time network (RTN) surveying was tested and allowed for the rapid establishment of new benchmarks including temporary benchmarks within a wetland. This means that wetlands that were previously inaccessible due to surrounding land use or topography can be surveyed in future monitoring efforts.

Moving forwards, CWS-ON sees this approach to monitoring wetland vegetation as a standard by which other regions in the Great Lakes could be assessed however; sustained financial support is urgently needed for ensuring that these data continue to be collected. This approach requires trained and experienced personnel in addition to specialized equipment. The support received in 2015-16 allowed the program to continue baseline activity and does not reflect the entire costs associated with the program.

Background

This purpose of this report is to complete Work Sheet 1-9, *Monitoring of Lake Ontario coastal wetland habitat in support of Adaptive Management*, undertaken by the Canadian Wildlife Service – Ontario Region (CWS-ON) under the International Watershed Initiative (IWI) for the Great Lakes Adaptive Management Committee.

In the summer of 2015, 8 coastal wetlands were surveyed along the north shore of Lake Ontario to provide wetland vegetation data referenced to water levels to support the modelling of aquatic ecosystem impacts from potential changes in water level regulation. At this time, all deliverables have been completed and work to date has included the completion of field data collection, 2015 survey data processing (data entry and quality-checking), synthesis of recent data (2009-2014), and the completion of reporting to outline project findings. The entire dataset (2009-2015) are housed in a database developed and maintained by CWS-ON. The data for the 8 wetlands surveyed in 2015 were provided to the committee in December 2015. The remaining data collected from 2009-2014 are included with this report and represent the majority the entire dataset. Both the field and analysis components of the project were completed without incident and no corrective action were necessary during the completion of this project.

Status of Deliverables

Table 1: The status of project deliverables with corresponding timelines

	Deliverable	Delivery date	Status
1.	Complete field surveys for 8 Lake Ontario wetlands sites on the Canadian shoreline	October 2015	Complete
2.	Field data is input to existing databases, post-processed, reviewed and summary results provided to the IJC's Great Lakes – St. Lawrence River Adaptive Management Committee	December 2015	Complete
3.	Preparation of Executive Summary and Final Summary Report describing key aspects of the field approach and general findings	March 2016	Complete
4	Support the GLAM Committee in synthesizing the field wetland data from 2009-2014 in a manner appropriate for comparing to the wetlands algorithm used in the LOSLR Study. Includes participation at two-day workshop	March 2016	Complete

Field Surveys

Vegetation Surveys

Vegetation monitoring followed Grabas and Rokitnicki-Wojcik (2015). CWS-ON has monitored vegetation using this approach at 21 wetlands from 2009-2014. In 2015, 8 wetlands were sampled (Figure 1) of which 5 were new sites to complement the existing database (Table 2). The sites surveyed in 2015 were selected to be representative of wetlands in Lake Ontario, by geography, hydrogeomorphic type and level of disturbance. Vegetation was monitored along 12 parallel transects at each of 20cm elevation increments beginning at 74.0m and ending at 76.0m referenced to the International Great Lakes Datum 1985 (IGLD85) (Figure 2). Elevation was determined using a real-time kinematic GPS system. At each targeted elevation, all species were identified and percent covers estimated within a 1m x 0.5m quadrat. Species information was summarized into vegetation guilds present in Great Lakes coastal wetlands as identified in Grabas and Rokitnicki-Wojcik (2015). Under ideal conditions, 11 quadrats are sampled along 12 transects which equals a maximum of 132 quadrats per wetland. Most wetlands have a combination of a robust shrub and tree cover at the upper elevations which interferes with GPS connectivity or a shallow aquatic basin that does not reach 74.0m. Therefore, most sites surveyed do not reach the maximum number of quadrats (Table 2), which is an indication of the morphometric, topographic and vegetative characteristics of the site and not related to any qualitative measures of condition.

Water Quality Data

Basic water quality information was collected using a multiprobe (YSI 6600 V2 or Hydrolab MS5) at each wetland for the following parameters: turbidity (NTU), specific conductance (µS/cm), pH and temperature (ºC). Measurements were collected at three stations within the aquatic portion of the marsh surveyed for vegetation (Figure 3). The data were screened for errors and the mean values for each of the four parameters are presented and were used to calculate an overall Water Quality Index score (WQI; Chow-Fraser 2006; Table 3). The WQI is an indicator of human-induced land use alterations, and can be used as a means of assessing the level of disturbance for a given wetland.

Water Levels

The water level of the wetland was measured at the time of vegetation surveys, and at a subset of wetlands, data loggers were deployed to record levels at 15 minute increments. These data can be made available to the GLAM committee should they be requested. These data were collected as described in Grabas and Rokitnicki-Wojcik (2015).

Figure 1: Location of the 8 coastal wetlands sampled for vegetation in Lake Ontario in 2015.

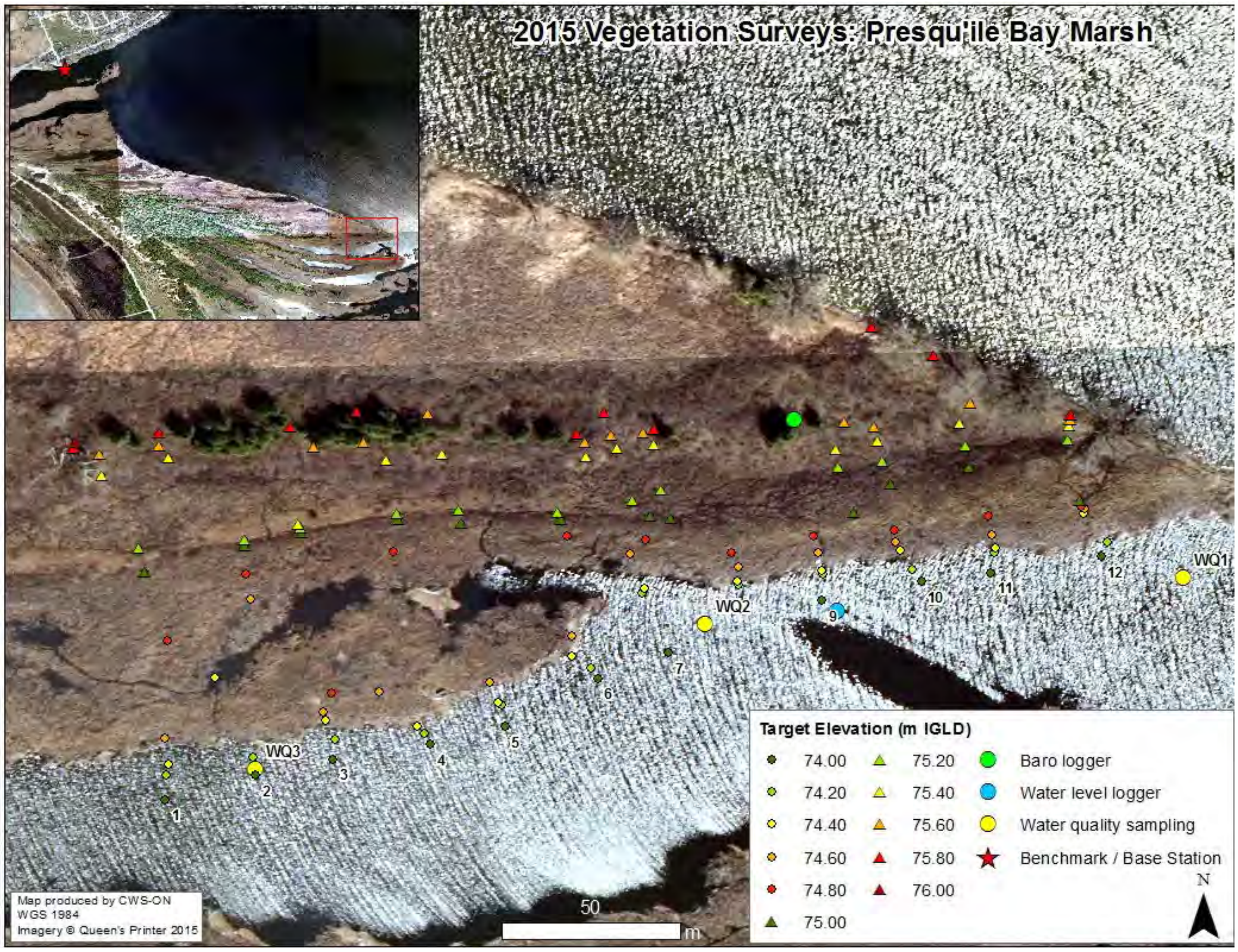


Figure 2: Presqu'ile Bay Marsh (PPP) points sampled, benchmark location and level logger locations.

Table 2: Summary of coastal wetland study sites sampled in the summer of 2015.

Wetland Name	Hydrogeomorphic Type	Date Sampled	Percent of Maximum Stations Surveyed*
Button Bay Marsh	Open Embayment	September 24	89.4
Credit River Marshes**	Drowned River Mouth	September 15	72.7
Presqu'ile Bay Marsh	Protected Embayment	September 21	90.2
Rattray Marsh**	Barrier Protected	September 14	84.1
Sawguin Creek Marsh**	Drowned River Mouth	September 22	87.9
South Bay Marsh	Open Embayment	September 23	98.5
Wesleyville Marsh**	Barrier Protected	September 17	67.4
West Pond (Cootes Paradise)**	Drowned River Mouth	September 16	79.5

*under ideal conditions (lack of treed canopy and sufficient depths) a maximum of 132 vegetation quadrats are surveyed at each wetland using this study design
** new site in database

To include a complete range of sites with respect to disturbance and hydrogeomorphology in the 2015 surveys, Credit River Marshes were selected to provide data for an urban drowned river mouth. This wetland is typical of impacted urban riverine wetlands common in western Lake Ontario. This wetland has a natural berm or levee near the shoreline, meaning that prior to reaching upland habitat, the wetland rises to a peak and drops down again. The study design calls for surveying along a transect from aquatic habitat to upland habitat on a continuous elevation gradient and so for the purposes of this study, those data collected up to the peak of the berm are included in the summarized data, and those data collected on the back slope of the berm to the upland are included for DEM creation and potentially other geospatial products. The back slope data are included as a separate site (site name and code are *Credit River Back slope* and *CRX*) in the data to aid with interpretation.

In general, the water quality information collected indicates that the sites surveyed vary in disturbance from Very Degraded (West Pond) to Good (Wesleyville, Presqu'ile Bay, Sawguin Creek and South Bay). Wetland water quality generally follows an east-west gradient which is consistent with many other water monitoring programs in Lake Ontario. Button Bay Marsh in particular, was relatively windy during water quality sampling and is characterized by a clay-silt substrate which was re-suspended under the windy conditions. This is apparent in the elevated turbidity measured at the site which is not related to human induced disturbance at the site (Table 3).

Table 3: Summary water quality data for each of the study wetlands. Mean parameter values are presented. The Water Quality Index (WQI) score is also shown and shaded based on the qualitative descriptors outlined in Chow-Fraser (2006).

Wetland Name	Turbidity (NTU)	Specific Conductance (µS/cm)	Temperature (ºC)	pH	WQI
Rattray Marsh	4.23	1363	21.45	7.50	-0.78
Credit River	6.90	887	16.18	8.34	-0.68
West Pond	8.14	1008	21.98	8.35	-1.10
Wesleyville Marsh	1.07	396	21.33	7.82	0.85
Presqu'ile Bay	1.66	343	18.35	7.63	0.82
Sawguin Creek	2.09	296	18.84	7.91	0.72
South Bay Marsh	1.24	297	22.49	8.56	0.83
Button Bay Marsh	5.42	272	21.75	9.25	-0.05

Qualitative Descriptors:	Highly Degraded	Very Degraded	Moderately Degraded	Good	Very good	Excellent
WQI Score Range	-3 to -2	-2 to -1	-1 to 0	0 to 1	1 to 2	2 to 3

Vegetation Guild Interpolation

The utility of this approach to surveying habitat is that geospatial surfaces can be generated from the field-collected data. Local Digital Elevation Models (DEM) and interpolated distributions of each vegetation guild at each wetland sampled in2015 were created. The sampling design includes identifying vegetation along parallel transects, and so these data can be used to estimate the distribution of each vegetation guild between transects and survey stations. These data products can serve as baseline or verification data for modelling efforts. Presqu'ile Bay Marsh is presented here as an example with the remaining sites included in Appendix A. A local DEM (3D elevation surface) of the surveyed area was interpolated using the *Topo to Raster* tool in a GIS (Figure 3). Similarly, using the percent cover information of each guild at each sampled location, a 2D interpolation of the guild's distribution can be created. The guild interpolation can then be draped over the 3D elevation surface (DEM) to provide an estimated surface of the vegetation in the sampled portion of the wetland (Example in Figure 4a-f).

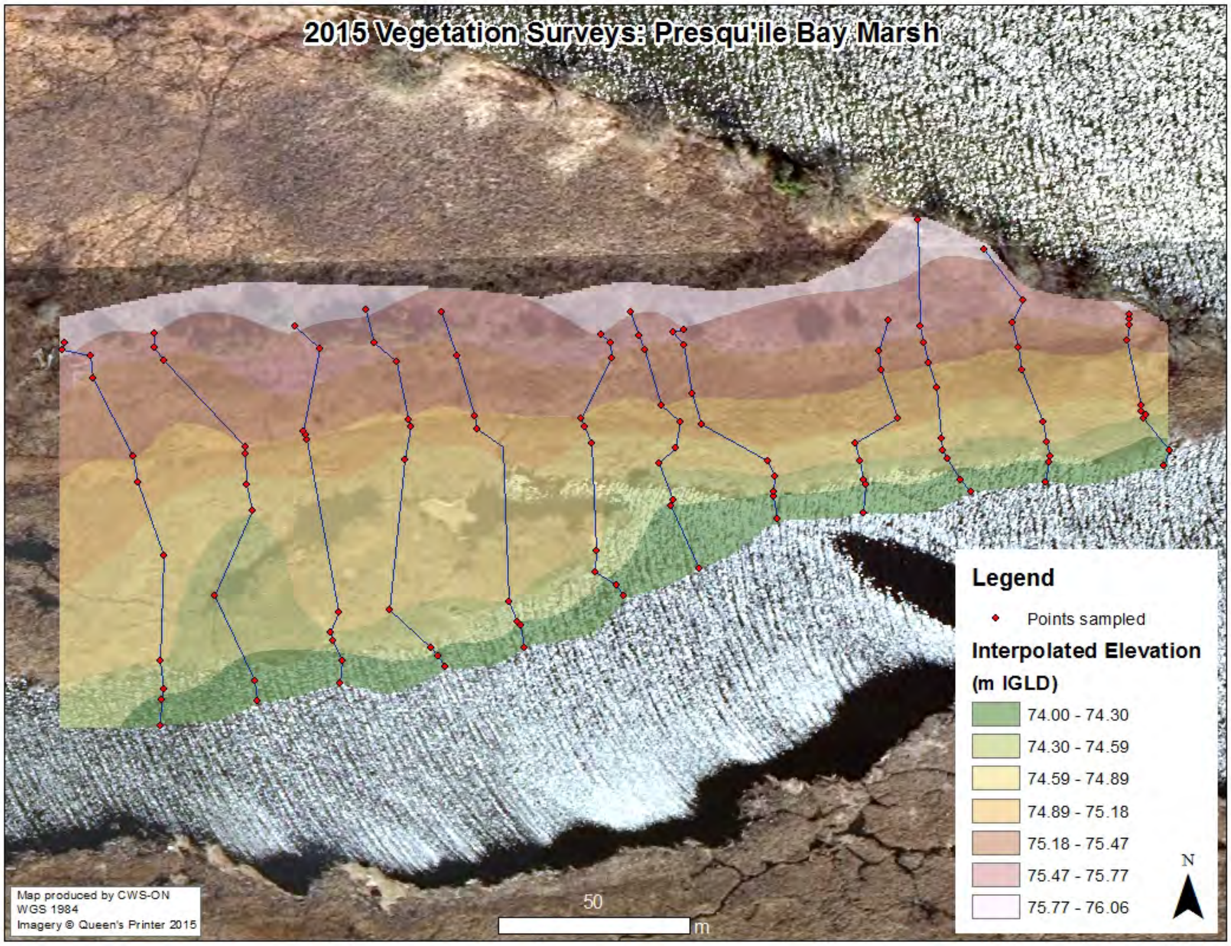
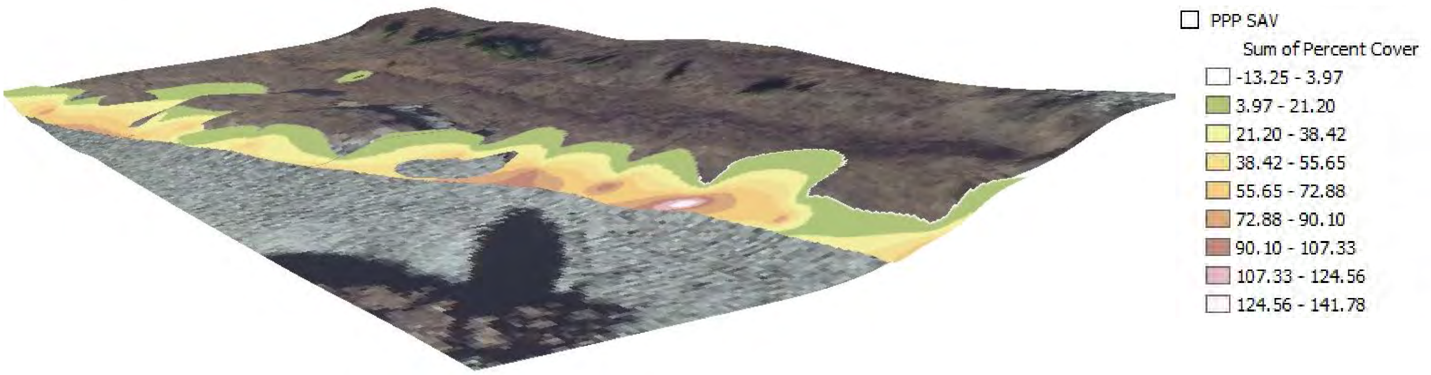


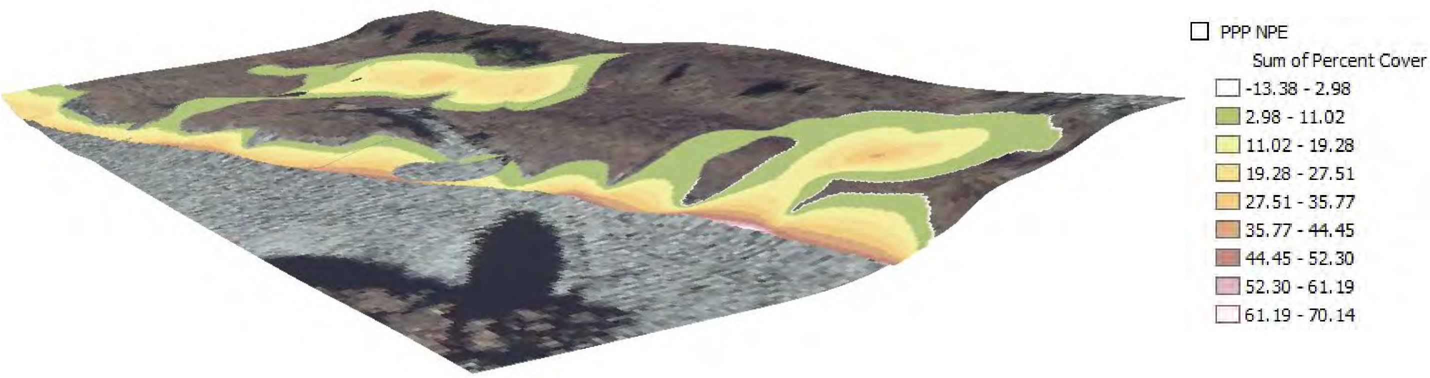
Figure 3: Interpolated DEM of area surveyed at Presqu'ile Bay Marsh. Vegetation survey stations are included with the general direction of each transect.

Interpolated distributions of each wetland vegetation guild are presented below for a single wetland. The cumulative sum of the percent cover of vegetation is used for this product. It can be greater than 100% due to overlapping of vegetation in three dimensional space that is common in wetlands.

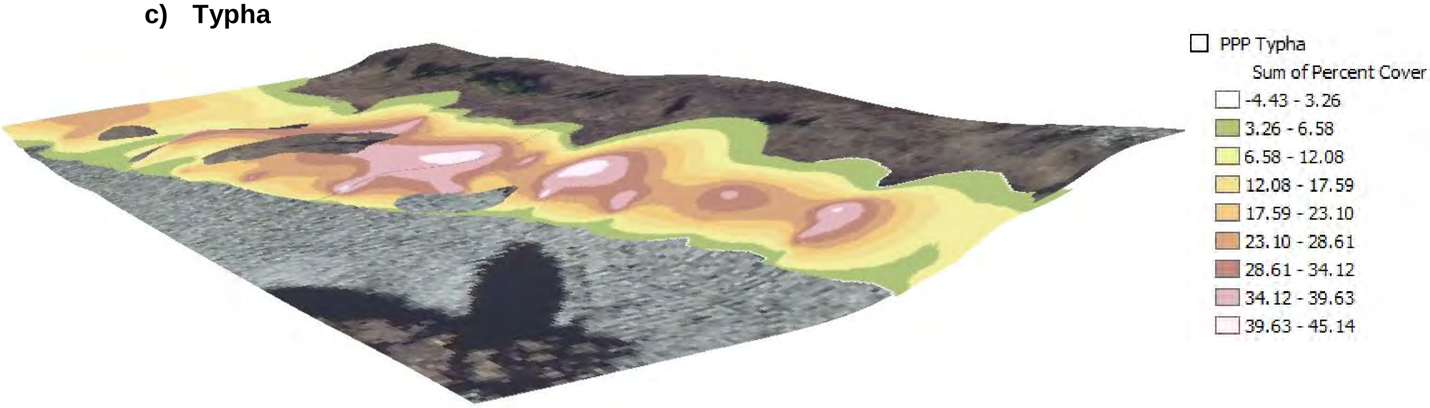
a) SAV (Submerged Aquatic Vegetation)



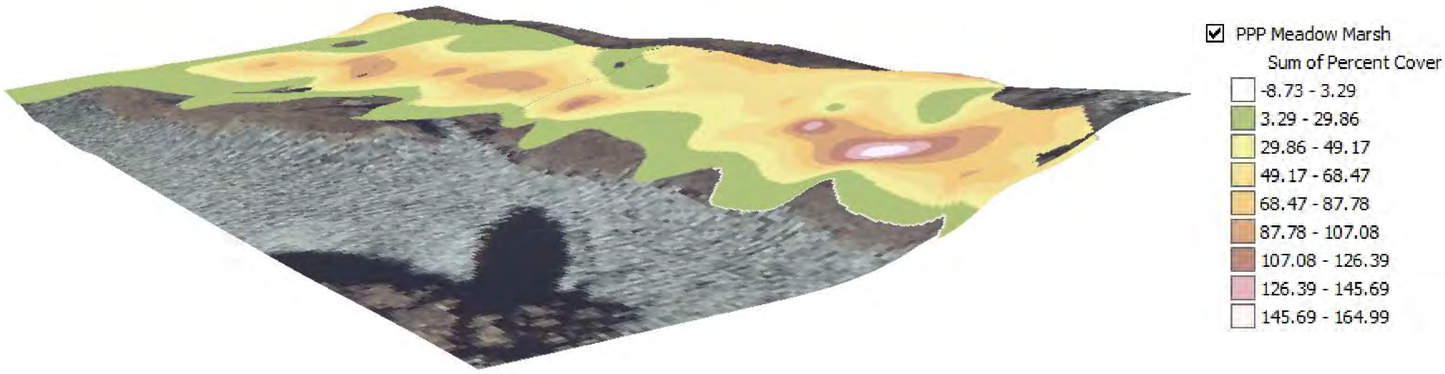
b) NPE (Non-Persistent Emergent)



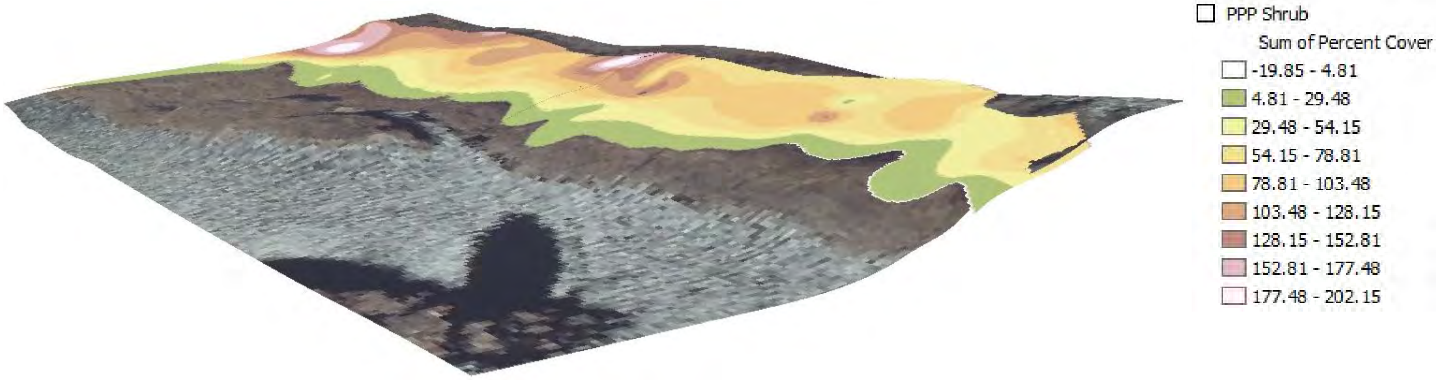
c) Typha



d) MM (Meadow Marsh)



e) SHB (Shrub)



f) UPL (Upland)

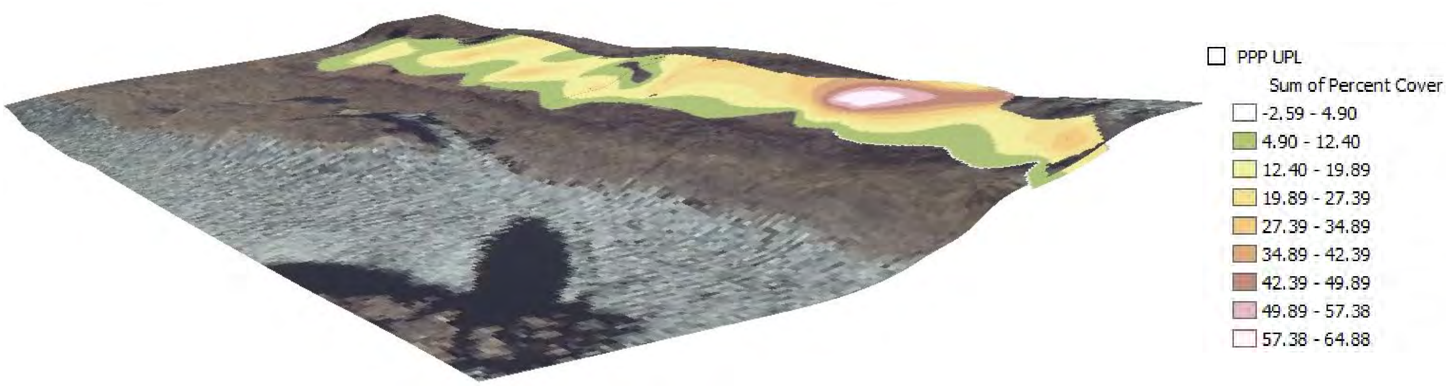


Figure 4: Interpolated guild distributions (sum of percent cover) draped over the site DEM for Presqu'ile Bay Marsh in 2015.

Highlights from 2015 Sampling

There were a number of highlights from the sampling completed in 2015 that are important to note for this project.

New Wetlands Surveyed

The distribution of coastal wetland habitat in northern Lake Ontario is heavily skewed to greater area of wetland in the northeastern portion of the lake, and it is not surprising that many of the wetlands surveyed since 2009 have occurred in this area. To provide the Committee with a complete representation of wetland habitat in the lake, an effort was made to sample more wetlands in western Lake Ontario. 2015 surveys included the largest number of new wetlands surveyed (5 of 8 sites) and the largest number of wetlands sampled in the western basin (3 of 8 sites: West Pond, Credit River and Rattray Marsh). To represent the central portion of the lake, access was secured to sample a new wetland situated on private land (Wesleyville Marsh).

Greater Representation of Wetlands

One of the general outcomes of the larger wetland monitoring program is to document and quantify wetland vegetation zonation and track changes in the extent of these zones. While wetlands in better condition typically have more robust and diverse vegetation communities that clearly illustrate zonation, the effort to sample wetlands in the western portion of the lake in 2015 included wetlands in poorer condition that can lack defined zonation.

Disturbed wetlands generally lack established submerged aquatic vegetation (SAV) and non-persistent emergent (NPE) vegetation zones due to low light penetration of the water column. These vegetation guilds grow either within (SAV) or through the water column (NPE). The lack of SAV and NPE at these sites is not entirely a reflection of water level regulation but a result of poor water quality as exhibited as elevated turbidity and specific conductance (table 3). These sites were specifically chosen to illustrate the variation in wetland habitat that exists in Lake Ontario so that these high impacted sites are included in wetland monitoring and subsequent modelling efforts.

An adaptive management approach for the Lake must include wetlands with various levels of disturbance especially with the strong gradient in condition between the east and west basins of Lake Ontario. This highlights the importance of collecting water quality data as part of ongoing monitoring efforts to provide data that can explain differences in vegetation such as water quality. Future modelling and model validation efforts may need to address wetland disturbance because it of its influence on the extent and condition of vegetation in wetlands.

Another consideration for future monitoring, modelling, and validation efforts are wetlands that have unique morphological characteristics such berms in the Credit River Marshes. As more new wetlands are monitored and especially in the western basin, where remaining coastal wetlands are typically associated with large riverine systems, wetlands that look and behave very differently than typical embayment wetlands will be captured in the dataset.

Adopting New Techniques

From a technical standpoint, sampling in 2015 showcased a new area in GPS data collection that will greatly enhance how the field program operates and will provide greater efficiency in establishing benchmarks and sampling wetlands that were otherwise not accessible in past surveys.

In the last decade, advances in cellular data networks have allowed for the development of commercial services that can correct GPS signals in real-time by referencing to existing stations that are continuously monitored. This is referred to as Real-Time Network (RTN) surveying and means that surveyors are now able to establish high accuracy benchmarks in as little as 3 minutes, as compared to the 24 hour occupancy required using traditional GPS techniques.

This technology was used to establish benchmarks at many new sites; reoccupy existing benchmarks for updating existing stations; and for sampling sites that were not accessible for surveys in past years because they were not suitable for establishing benchmarks using traditional techniques.

Sawguin Creek Marsh for example is surrounded by forested and agricultural lands with few roads and locations suitable for establishing benchmarks. This wetland is of high interest for this project as it is a large wetland complex that has high wildlife habitat value but is only accessible by water. Establishing a benchmark on a suitable location such as the nearest road would likely result in poor connectivity with the RTK GPS base station signal which would result in inefficient data collection. In 2015, surveyors established a temporary benchmark in the meadow marsh habitat of the wetland and occupied that benchmark with the RTK GPS equipment to complete the wetland survey. The successful use of establishing temporary benchmarks will make wetlands that were originally unsuitable, accessible to monitoring using this approach, and was used at a number of wetlands in 2015 (e.g. Figure 5).

Figure 5: Temporary benchmark established in meadow marsh habitat in a Lake Ontario coastal wetland.

2009-2014 Data Export

The second component of this project was to provide the Great Lakes Adaptive Management Committee with the entire ECCC-CWS coastal wetland monitoring dataset from surveys conducted from 2009-2014. This represents a tremendous amount of data collected over an additional 6 year period. This dataset is the only one of its kind in the Great Lakes basin that is able to provide baseline data for the environment for lake level regulation. To date, almost 6000 quadrats have been surveyed and over 23,000 species observations were recorded. These data, with those collected on the U.S. side of Lake Ontario and the St. Lawrence River by the New York Natural Heritage Program (NYNHP) represent a great asset to the Committee in implementing an adaptive management program with field verified information.

Data collected in 2013 did not include spatial precision values do to the internal survey style used in that year. Other samples lacking precision values are included in the dataset, and based on how the surveys are conducted; we feel that they should be retained for further use.

Data that do not have coordinates associated with them have been included in the dataset but have been flagged in a table should it be decided that they be removed. These flagged samples represent <1% of the dataset.

The 2009-2014 data were output in the same manner as the 2015 data supplied in December 2015:

- Raw Data
  - raw quadrat level data
- Summarized Data
  - crosstab summary of quadrat data by guild
  - Summarized data by guild and by target elevation
- Sample Sizes
  - sample size by wetland for a given elevation for a given year
- Geospatial data
  - shapefile of sampling locations
- QA/QC
  - table of flagged quadrats (missing coordinate and elevation data but have been included in tables above)

Each data table includes a metadata tab that provides a brief description of the data.

Project Implications and Future Direction

Moving forwards, ECCC-CWS sees this approach to monitoring wetland vegetation as a standard by which other regions in the Great Lakes could be assessed. In 2015, water level data loggers were deployed in select wetlands outside of Lake Ontario to lay the groundwork and develop the tools needed (benchmarks) to implement monitoring in other lakes in the Basin. Data loggers were deployed at wetlands in Lake Erie, the Detroit River, Lake St. Clair, and Lake Huron (eastern Georgian Bay) to initiate data collection in other systems. These are available to the Committee by request should it have a purpose for them.

Using RTN techniques, we are now able to establish benchmarks within existing RTN service areas (lower Great Lakes) for wetland monitoring purposes. Establishing benchmarks was a limitation in past efforts due to the time required to create each benchmark (24hr) and the cost associated with renting the equipment for this purpose.

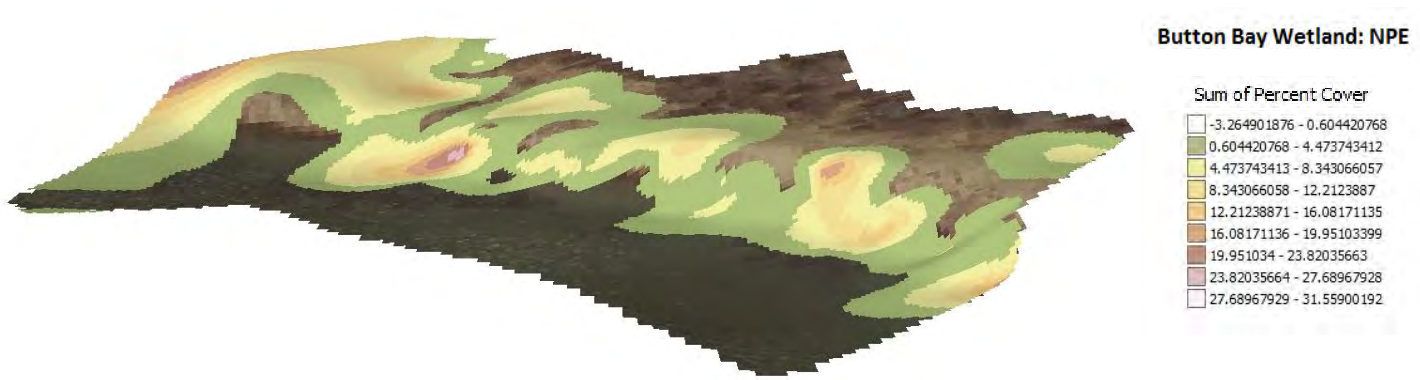
Now that the monitoring approach is well established, the overarching limitation is sustained financial support for ensuring that these data continue to be collected. This approach requires trained and experienced personnel in addition to specialized equipment. The support received in 2015-16 allowed the program to continue baseline activity and does not reflect the entire costs associated with the program.

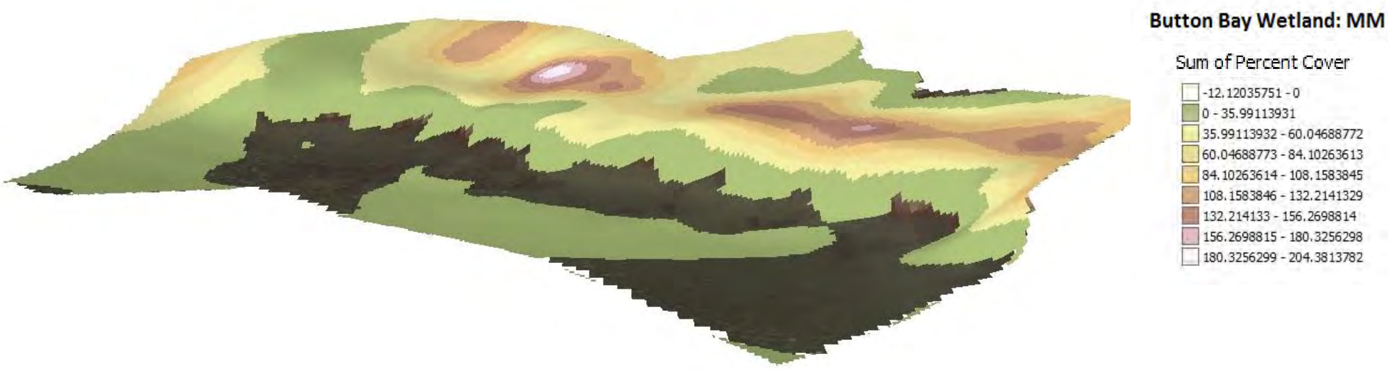
Literature Cited

Chow-Fraser, P. 2006. Development of the Water Quality Index (WQI) to assess effects of basin-wide land-use alteration on coastal marshes of the Laurentian Great Lakes. In: *Coastal Wetlands of the Laurentian Great Lakes: Health, Habitat and Indicators*. Eds. Simon, T.P. and Stewart, P.M. Authorhouse, Bloomington, Indiana.

Grabas, G.P., and Rokitnicki-Wojcik, D. 2015. Characterizing daily water-level fluctuation intensity and water quality relationships with plant communities in Lake Ontario coastal wetlands. *Journal of Great Lakes Research* 41, 136-144.

Appendix A – Vegetation Guild interpolations




Button Bay Wetland: MM
Sum of Percent Cover
-12.12035751 - 0
0 - 35.99113931
35.99113932 - 60.04688772
60.04688773 - 84.10263613
84.10263614 - 108.1583845
108.1583846 - 132.2141329
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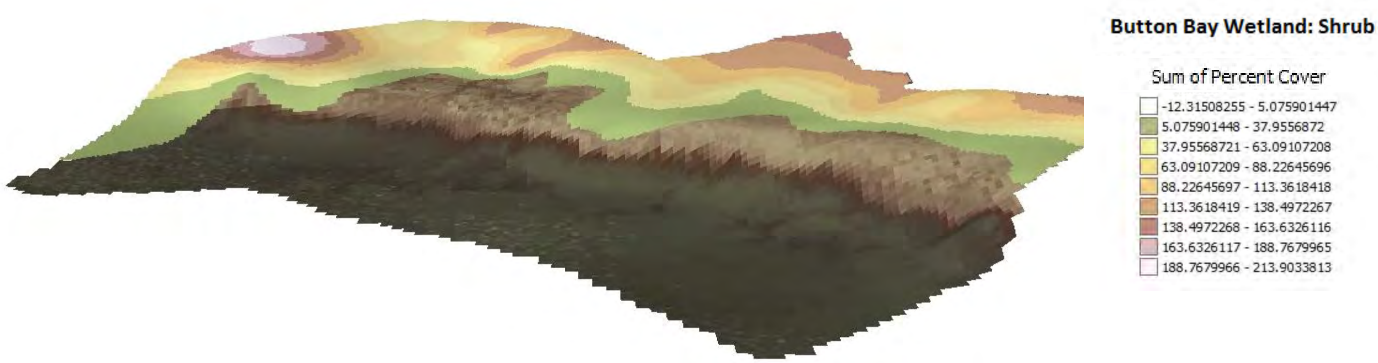
156.2698815 - 180.3256298
180.3256299 - 204.3813782


Button Bay Wetland: Shrub
Sum of Percent Cover
-12.31508255 - 5.075901447
5.075901448 - 37.9556872
37.95568721 - 63.09107208
63.09107209 - 88.22645696
88.22645697 - 113.3618418
113.3618419 - 138.4972267
138.4972268 - 163.6326116
163.6326117 - 188.7679965
188.7679966 - 213.9033813


Button Bay Wetland: UPL
Sum of Percent Cover
-3.224038124 - 3.557992723
3.557992724 - 10.34002357
10.34002358 - 17.12205442
17.12205443 - 23.90408527
23.90408528 - 30.68611611
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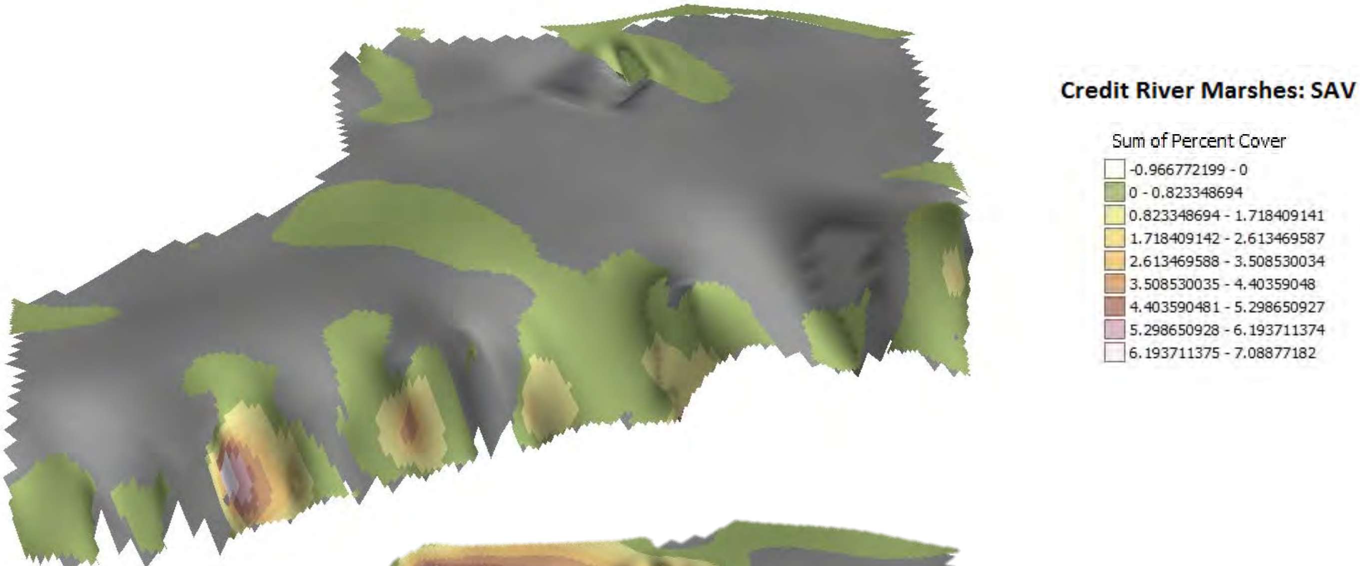
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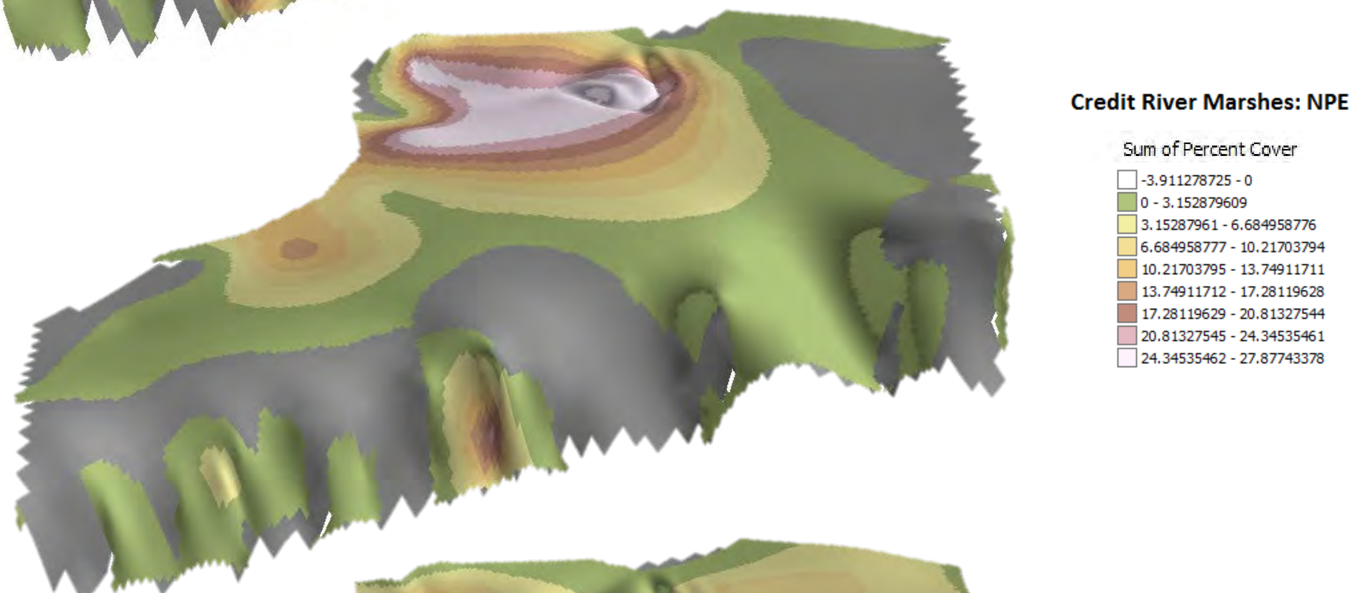
Credit River Marshes: NPE
Sum of Percent Cover
-3.911278725 - 0
0 - 3.152879609
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10.21703795 - 13.74911711
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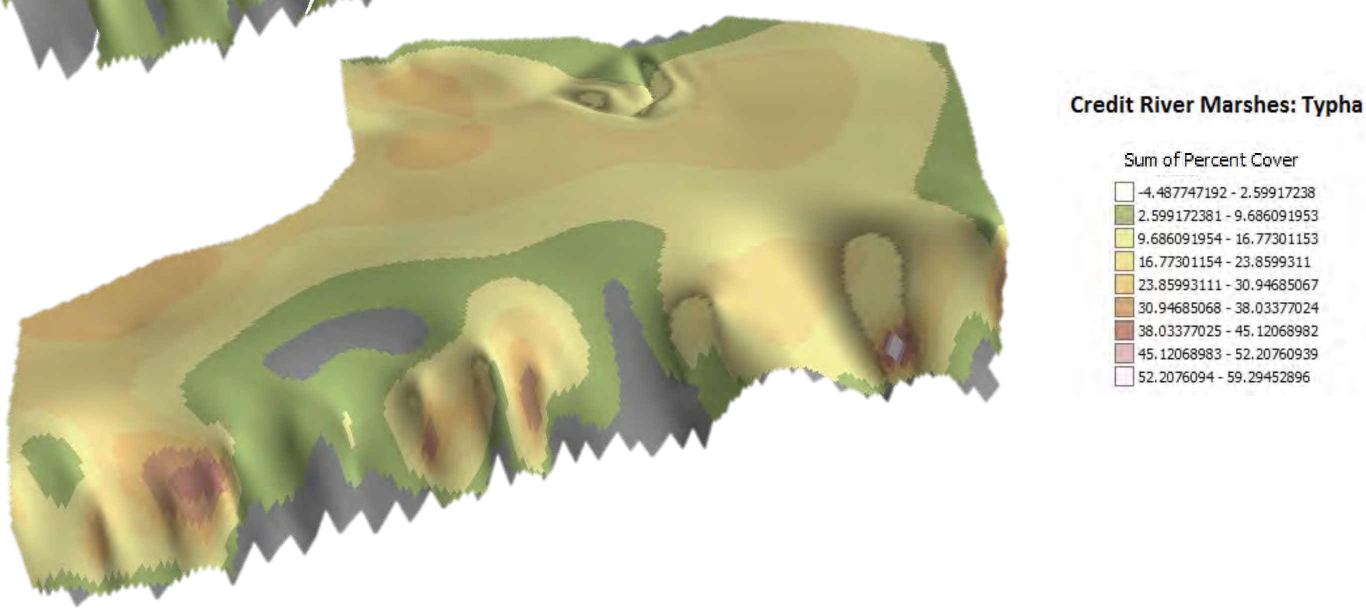
Credit River Marshes: Typha
Sum of Percent Cover
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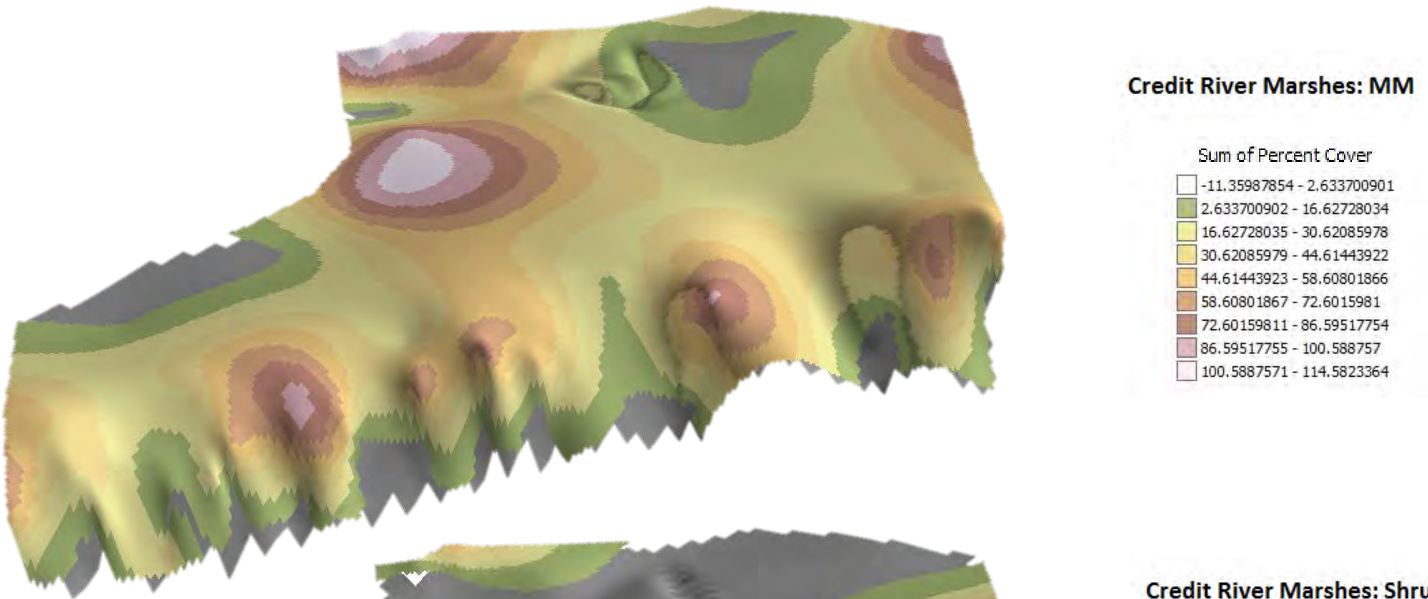
2.599172381 - 9.686091953
9.686091954 - 16.77301153
16.77301154 - 23.8599311
23.85993111 - 30.94685067
30.94685068 - 38.03377024
38.03377025 - 45.12068982
45.12068983 - 52.20760939
52.2076094 - 59.29452896


Credit River Marshes: MM
Sum of Percent Cover
-11.35987854 - 2.633700901
2.633700902 - 16.62728034
16.62728035 - 30.62085978
30.62085979 - 44.61443922
44.61443923 - 58.60801866
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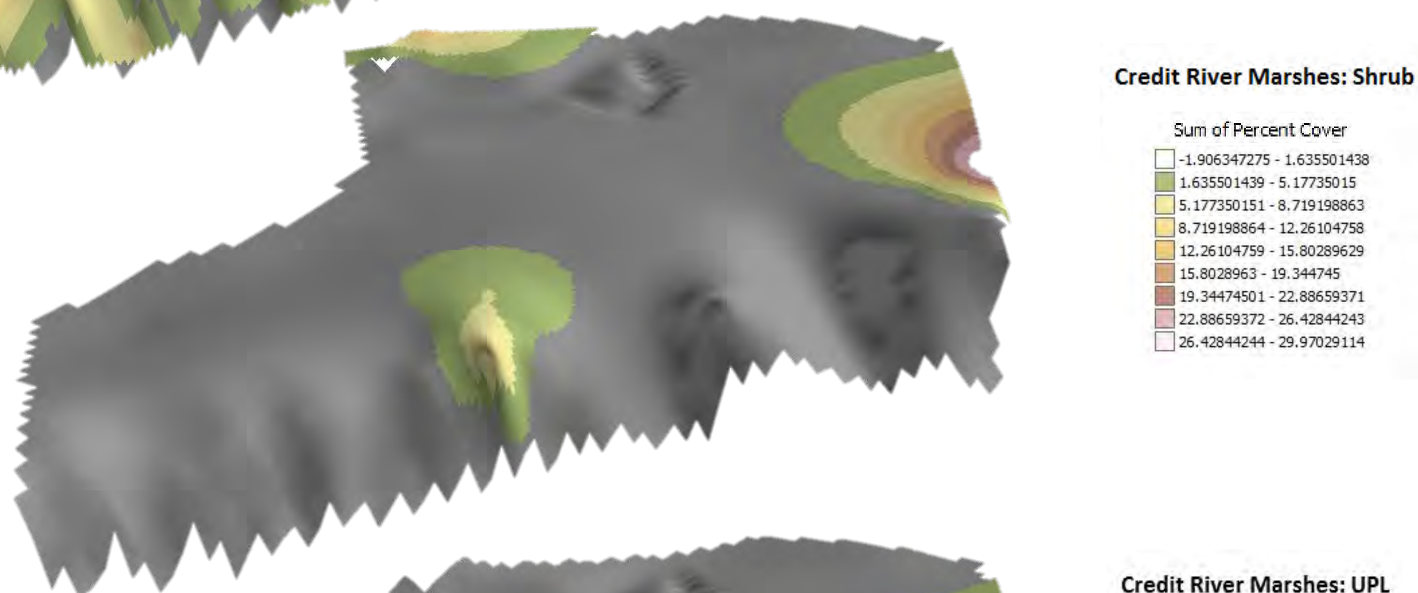
Credit River Marshes: Shrub
Sum of Percent Cover
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1.635501439 - 5.17735015
5.177350151 - 8.719198863
8.719198864 - 12.26104758
12.26104759 - 15.80289629
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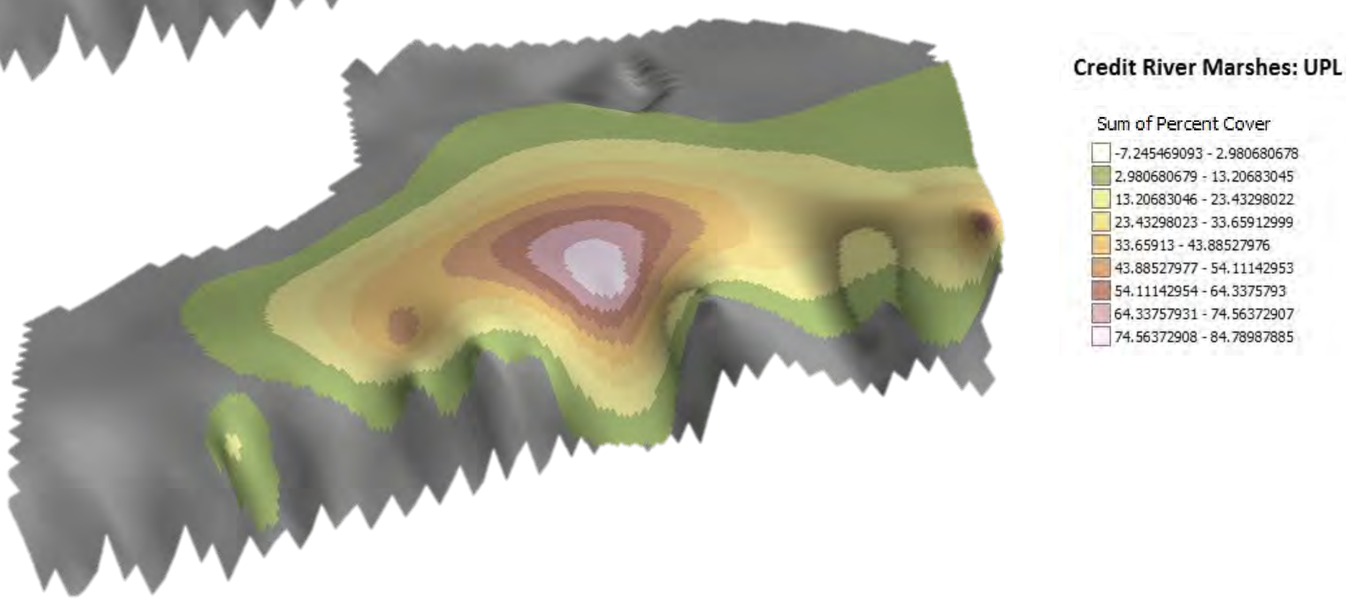
Credit River Marshes: UPL
Sum of Percent Cover
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33.65913 - 43.88527976
43.88527977 - 54.11142953
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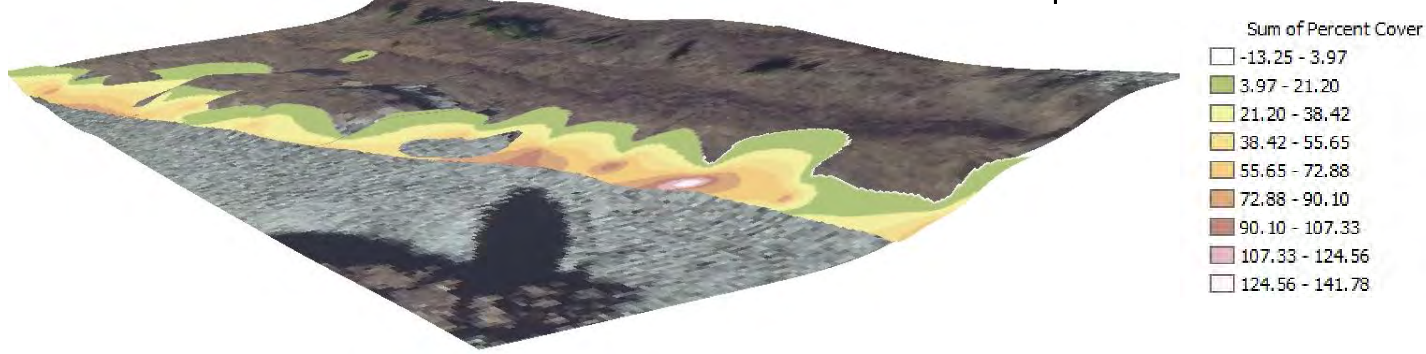
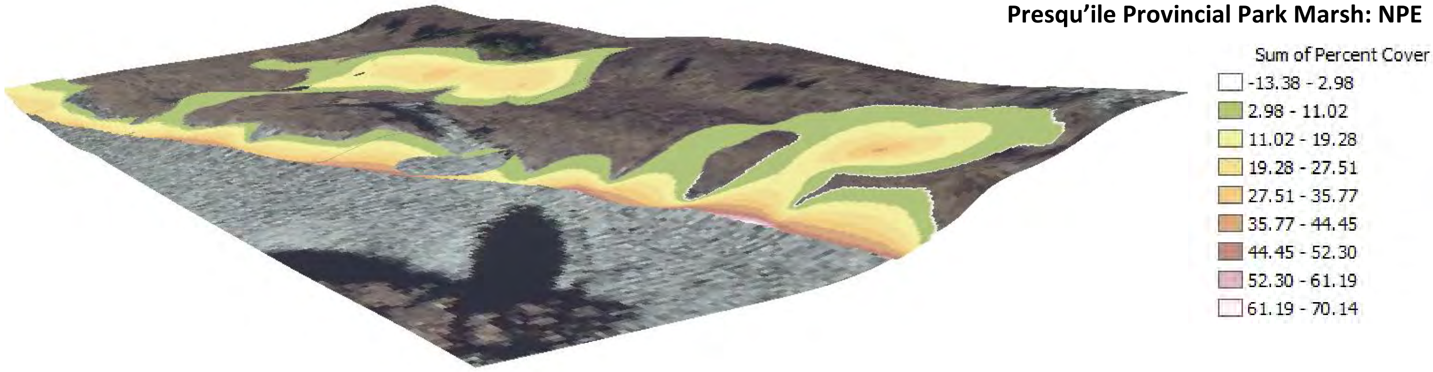
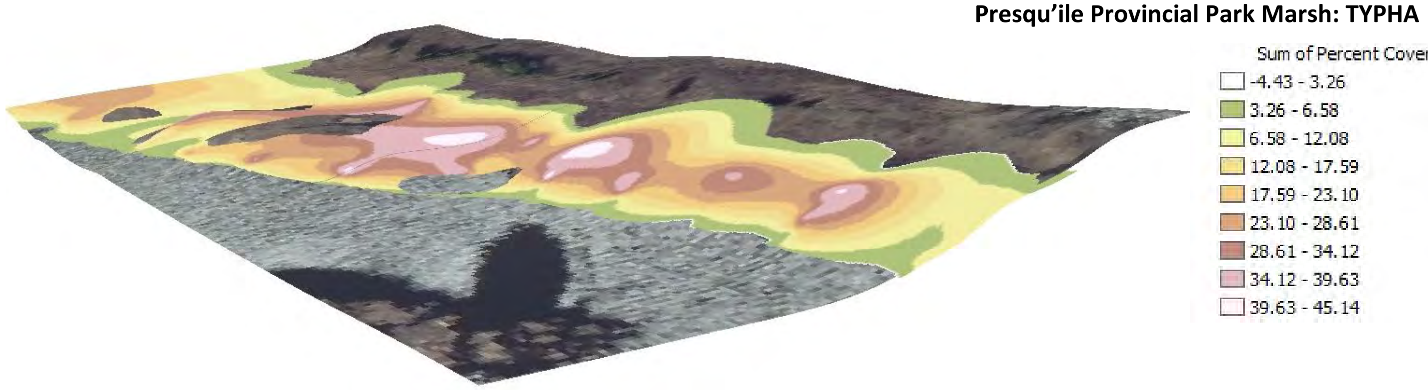
Presqu'ile Provincial Park Marsh: SAV



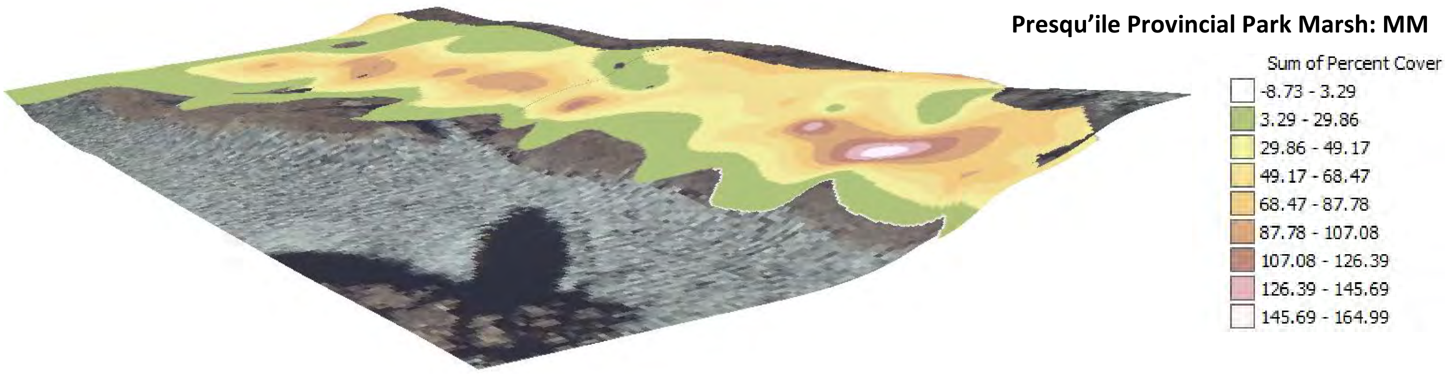
Presqu'ile Provincial Park Marsh: NPE



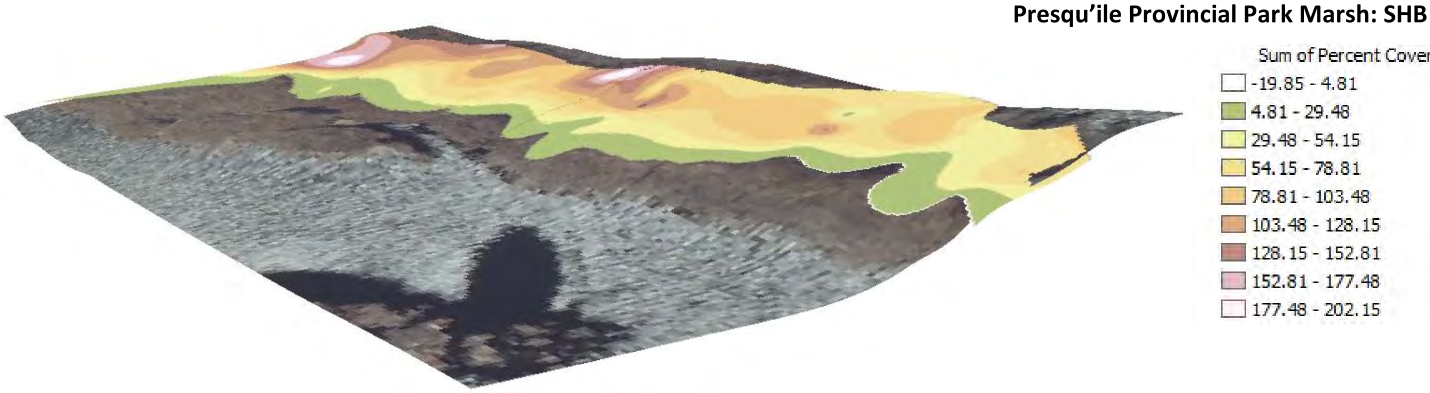
Presqu'ile Provincial Park Marsh: TYPHA



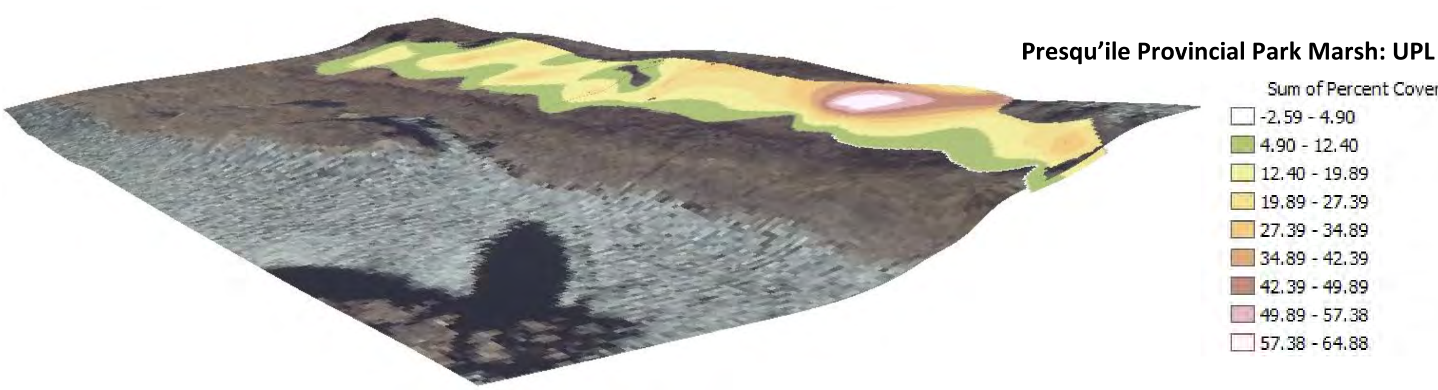
Presqu'ile Provincial Park Marsh: MM

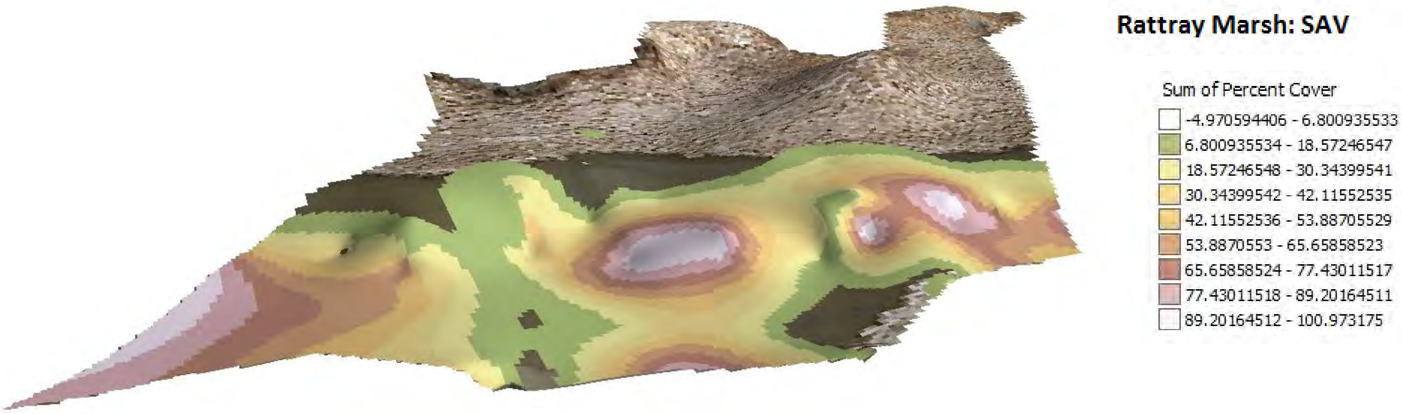


Presqu'ile Provincial Park Marsh: SHB

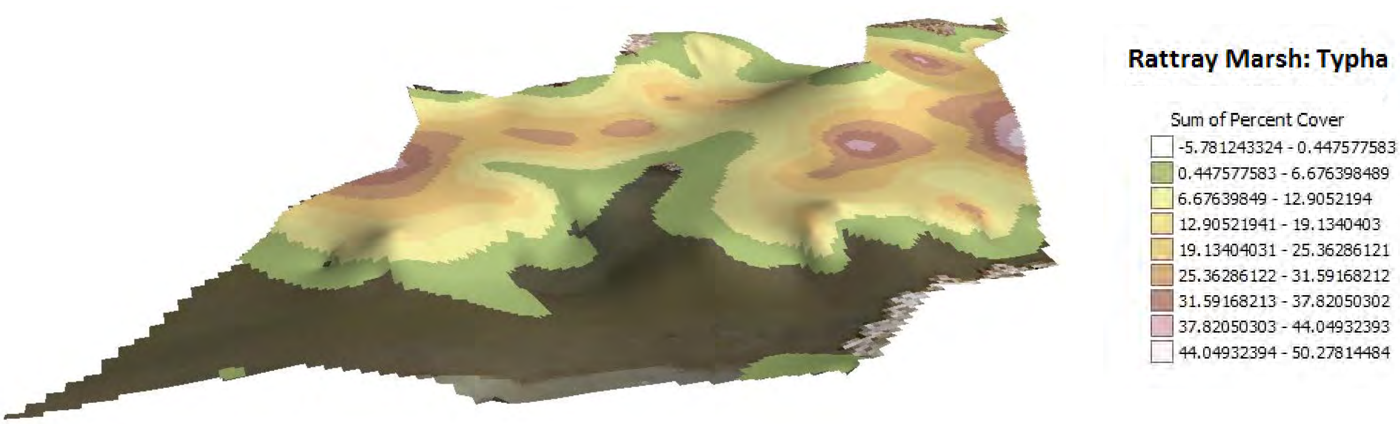


Presqu'ile Provincial Park Marsh: UPL




Rattray Marsh: SAV
Sum of Percent Cover
-4.970594406 - 6.800935533
6.800935534 - 18.57246547
18.57246548 - 30.34399541
30.34399542 - 42.11552535
42.11552536 - 53.88705529
53.8870553 - 65.65858523
65.65858524 - 77.43011517
77.43011518 - 89.20164511
89.20164512 - 100.973175

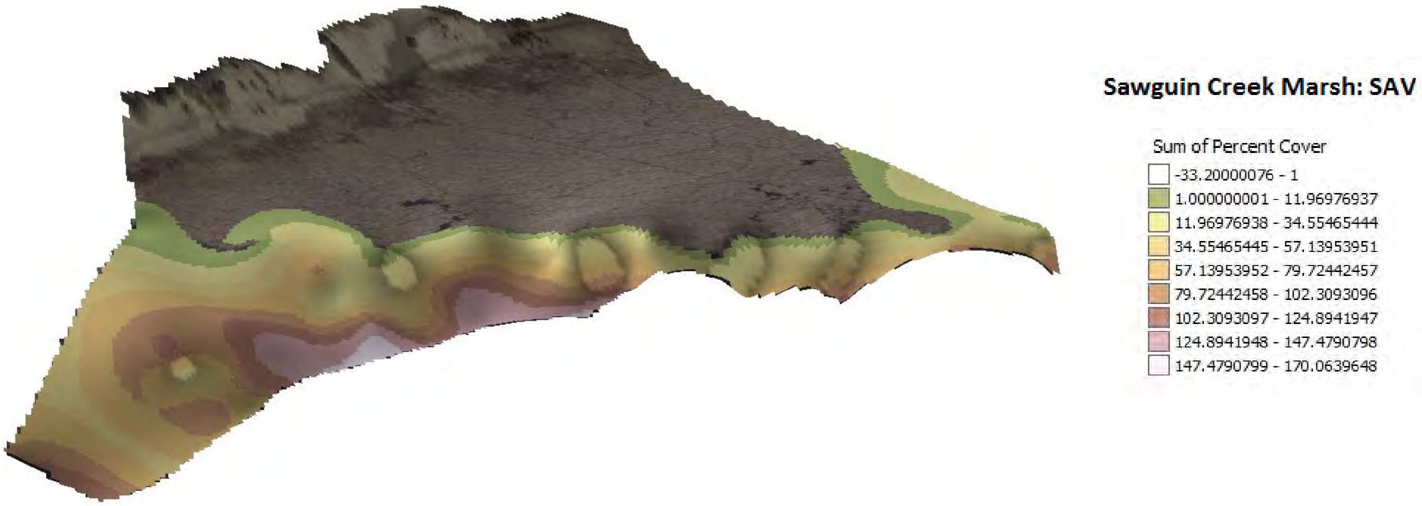

Rattray Marsh: NPE
Sum of Percent Cover
-0.949240983 - 2.239934656
2.239934657 - 5.429110295
5.429110296 - 8.618285934
8.618285935 - 11.80746157
11.80746158 - 14.99663721
14.99663722 - 18.18581285
18.18581286 - 21.37498849
21.3749885 - 24.56416413
24.56416414 - 27.75333977

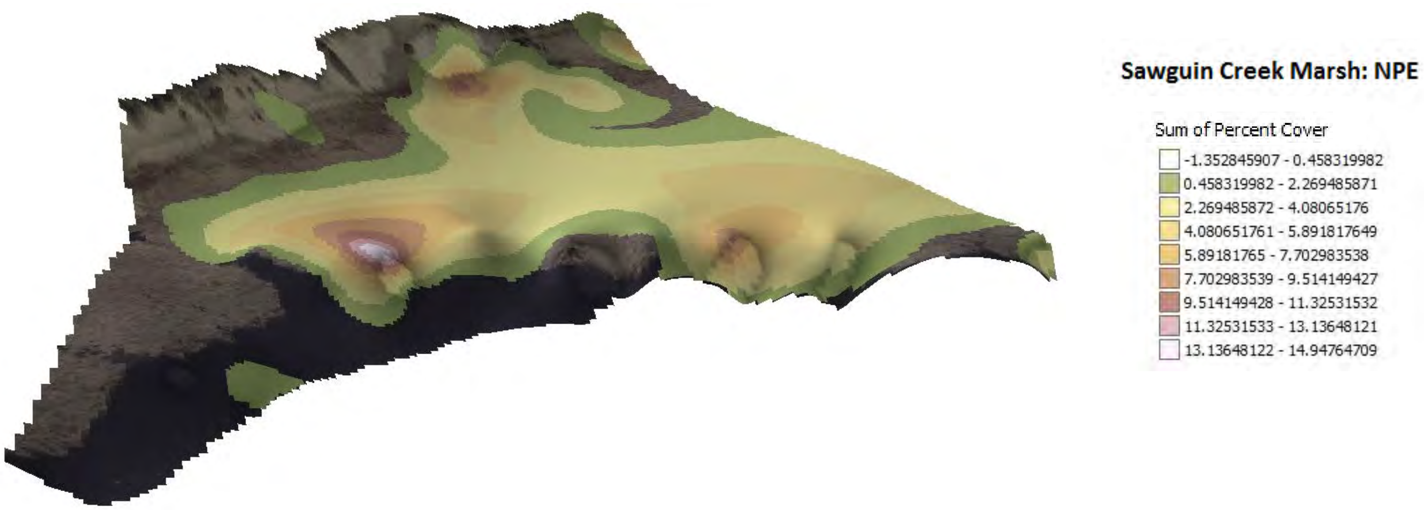

Rattray Marsh: Typha
Sum of Percent Cover
-5.781243324 - 0.447577583
0.447577583 - 6.676398489
6.67639849 - 12.9052194
12.90521941 - 19.1340403
19.13404031 - 25.36286121
25.36286122 - 31.59168212
31.59168213 - 37.82050302
37.82050303 - 44.04932393
44.04932394 - 50.27814484

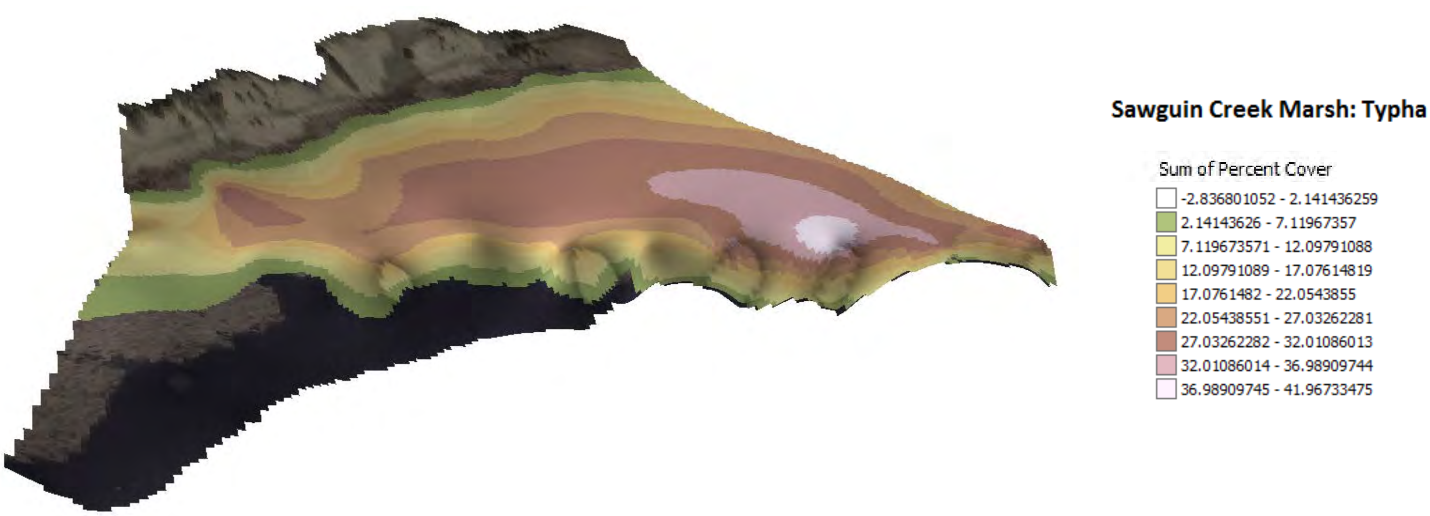

Rattray Marsh: MM
Sum of Percent Cover
-6.880978584 - 7.092799717
7.092799718 - 21.06657802
21.06657803 - 35.04035632
35.04035633 - 49.01413462
49.01413463 - 62.98791292
62.98791293 - 76.96169122
76.96169123 - 90.93546952
90.93546953 - 104.9092478
104.9092479 - 118.8830261


Rattray Marsh: Shrub
Sum of Percent Cover
-13.50963306 - 0.790145026
0.790145026 - 15.08992312
15.08992313 - 29.38970121
29.38970122 - 43.6894793
43.68947931 - 57.98925739
57.9892574 - 72.28903548
72.28903549 - 86.58881357
86.58881358 - 100.8885917
100.8885918 - 115.1883698


Rattray Marsh: UPL
Sum of Percent Cover
-2.132982492 - 3.106810464
3.106810465 - 8.34660342
8.346603421 - 13.58639638
13.58639639 - 18.82618933
18.82618934 - 24.06598229
24.0659823 - 29.30577525
29.30577526 - 34.5455682
34.54556821 - 39.78536116
39.78536117 - 45.02515411


Sawguin Creek Marsh: SAV
Sum of Percent Cover
-33.20000076 - 1
1.000000001 - 11.96976937
11.96976938 - 34.55465444
34.55465445 - 57.13953951
57.13953952 - 79.72442457
79.72442458 - 102.3093096
102.3093097 - 124.8941947
124.8941948 - 147.4790798
147.4790799 - 170.0639648

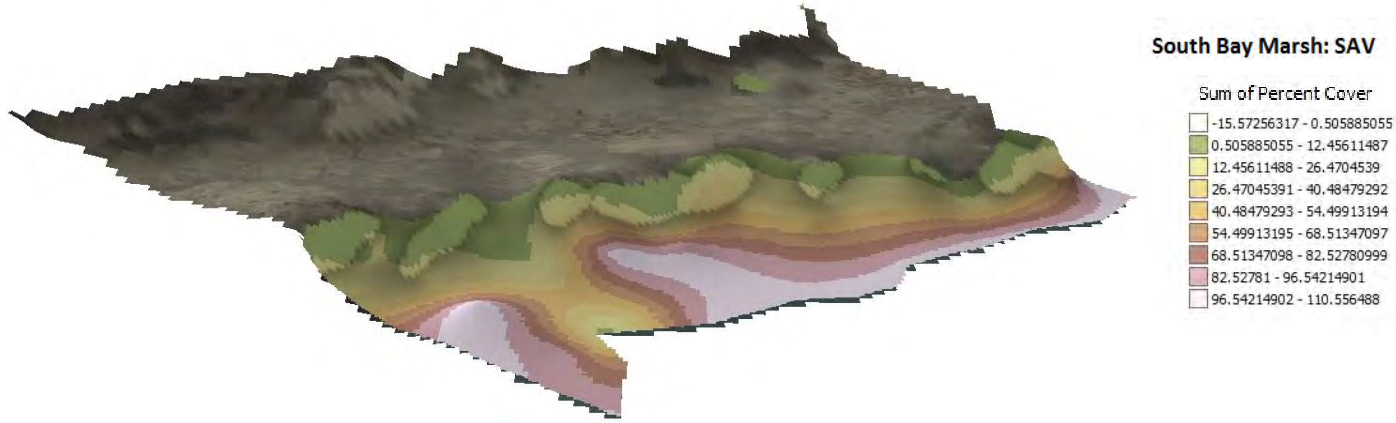

Sawguin Creek Marsh: NPE
Sum of Percent Cover
-1.352845907 - 0.458319982
0.458319982 - 2.269485871
2.269485872 - 4.08065176
4.080651761 - 5.891817649
5.89181765 - 7.702983538
7.702983539 - 9.514149427
9.514149428 - 11.32531532
11.32531533 - 13.13648121
13.13648122 - 14.94764709


Sawguin Creek Marsh: Typha
Sum of Percent Cover
-2.836801052 - 2.141436259
2.14143626 - 7.11967357
7.119673571 - 12.09791088
12.09791089 - 17.07614819
17.0761482 - 22.0543855
22.05438551 - 27.03262281
27.03262282 - 32.01086013
32.01086014 - 36.98909744
36.98909745 - 41.96733475


Sawguin Creek Marsh: MM
Sum of Percent Cover
-13.13884163 - 7.381284926
7.381284927 - 27.90141148
27.90141149 - 48.42153804
48.42153805 - 68.94166459
68.9416646 - 89.46179114
89.46179115 - 109.9819177
109.9819178 - 130.5020443
130.5020444 - 151.0221708
151.0221709 - 171.5422974


Sawguin Creek Marsh: Shrub
Sum of Percent Cover
-11.14110565 - 3.33088345
3.330883451 - 17.80287255
17.80287256 - 32.27486165
32.27486166 - 46.74685076
46.74685077 - 61.21883986
61.21883987 - 75.69082896
75.69082897 - 90.16281806
90.16281807 - 104.6348072
104.6348073 - 119.1067963


Sawguin Creek Marsh: UPL
Sum of Percent Cover
-10.27825165 - 0.474536114
0.474536114 - 5.906468709
5.90646871 - 13.99882889
13.9988289 - 22.09118907
22.09118908 - 30.18354925
30.18354926 - 38.27590942
38.27590943 - 46.3682696
46.36826961 - 54.46062978
54.46062979 - 62.55298996


South Bay Marsh: SAV
Sum of Percent Cover
-15.57256317 - 0.505885055
0.505885055 - 12.45611487
12.45611488 - 26.4704539
26.47045391 - 40.48479292
40.48479293 - 54.49913194
54.49913195 - 68.51347097
68.51347098 - 82.52780999
82.52781 - 96.54214901
96.54214902 - 110.556488


South Bay Marsh: NPE
Sum of Percent Cover
-3.482672215 - 5.626568688
5.626568689 - 14.73580959
14.7358096 - 23.84505049
23.8450505 - 32.9542914
32.95429141 - 42.0635323
42.06353231 - 51.1727732
51.17277321 - 60.28201411
60.28201412 - 69.39125501
69.39125502 - 78.50049591


South Bay Marsh: Typha
Sum of Percent Cover
-7.818950653 - 0.251189918
0.251189918 - 7.482253604
7.482253605 - 15.13285573
15.13285574 - 22.78345786
22.78345787 - 30.43405999
30.43406 - 38.08466212
38.08466213 - 45.73526425
45.73526426 - 53.38586638
53.38586639 - 61.03646851


South Bay Marsh: MM
Sum of Percent Cover
-12.09371948 - 14.7776591
14.77765911 - 41.64903768
41.64903769 - 68.52041626
68.52041627 - 95.39179484
95.39179485 - 122.2631734
122.2631735 - 149.134552
149.1345521 - 176.0059306
176.0059307 - 202.8773092
202.8773093 - 229.7486877


South Bay Marsh: Shrub
Sum of Percent Cover
-11.74985504 - 6.146035088
6.146035089 - 24.04192522
24.04192523 - 41.93781535
41.93781536 - 59.83370548
59.83370549 - 77.72959561
77.72959562 - 95.62548574
95.62548575 - 113.5213759
113.521376 - 131.417266
131.4172661 - 149.3131561


South Bay Marsh: UPL
Sum of Percent Cover
-8.569556236 - 0.581960545
0.581960545 - 8.396463924
8.396463925 - 16.879474
16.87947401 - 25.36248408
25.36248409 - 33.84549416
33.84549417 - 42.32850424
42.32850425 - 50.81151432
50.81151433 - 59.2945244
59.29452441 - 67.77753448


Wesleyville Marsh: SAV
Sum of Percent Cover
-17.1952858 - 7.014573839
7.01457384 - 31.22443348
31.22443349 - 55.43429311
55.43429312 - 79.64415275
79.64415276 - 103.8540124
103.8540125 - 128.063872
128.0638721 - 152.2737317
152.2737318 - 176.4835913
176.4835914 - 200.6934509


Wesleyville Marsh: NPE
Sum of Percent Cover
-2.94802475 - 1.287173801
1.287173802 - 5.522372352
5.522372353 - 9.757570903
9.757570904 - 13.99276945
13.99276946 - 18.227968
18.22796801 - 22.46316655
22.46316656 - 26.69836511
26.69836512 - 30.93356366
30.93356367 - 35.16876221


Wesleyville Marsh: Typha
Sum of Percent Cover
-2.240542173 - 0.797485563
0.797485563 - 3.8355133
3.835513301 - 6.873541037
6.873541038 - 9.911568774
9.911568775 - 12.94959651
12.94959652 - 15.98762425
15.98762426 - 19.02565198
19.02565199 - 22.06367972
22.06367973 - 25.10170746


Wesleyville Marsh: MM
Sum of Percent Cover
-5.591052055 - 6.669492086
6.669492087 - 18.93003623
18.93003624 - 31.19058037
31.19058038 - 43.45112451
43.45112452 - 55.71166865
55.71166866 - 67.97221279
67.9722128 - 80.23275693
80.23275694 - 92.49330107
92.49330108 - 104.7538452

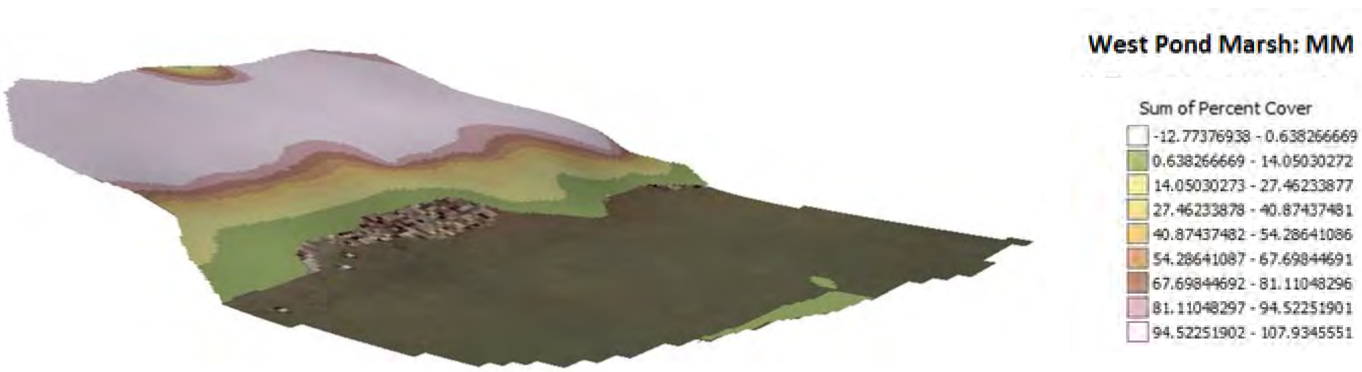

Wesleyville Marsh: Shrub
Sum of Percent Cover
-16.28178787 - 0.894285414
0.894285414 - 18.0703587
18.07035871 - 35.24643199
35.246432 - 52.42250527
52.42250528 - 69.59857856
69.59857857 - 86.77465185
86.77465186 - 103.9507251
103.9507252 - 121.1267984
121.1267985 - 138.3028717


Wesleyville Marsh: UPL
Sum of Percent Cover
-1.632293344 - 0.199814373
0.199814373 - 2.031922089
2.03192209 - 3.864029805
3.864029806 - 5.696137521
5.696137522 - 7.528245237
7.528245238 - 9.360352953
9.360352954 - 11.19246067
11.19246068 - 13.02456839
13.0245684 - 14.8566761


West Pond Marsh: SAV
Sum of Percent Cover
-6.434098244 - 3.18855879
3.188558791 - 12.81121582
12.81121583 - 22.43387286
22.43387287 - 32.05652989
32.0565299 - 41.67918693
41.67918694 - 51.30184396
51.30184397 - 60.924501
60.92450101 - 70.54715803
70.54715804 - 80.16981506


West Pond Marsh: NPE
Sum of Percent Cover
-0.470009744 - 0.130179829
0.130179829 - 0.730369402
0.730369402 - 1.330558976
1.330558977 - 1.930748549
1.93074855 - 2.530938122
2.530938123 - 3.131127695
3.131127696 - 3.731317268
3.731317269 - 4.331506842
4.331506843 - 4.931696415


West Pond Marsh: Typha
Sum of Percent Cover
-2.232171535 - 2.472340054
2.472340055 - 7.176851643
7.176851644 - 11.88136323
11.88136324 - 16.58587482
16.58587483 - 21.29038641
21.29038642 - 25.994898
25.99489801 - 30.69940959
30.6994096 - 35.40392118
35.40392119 - 40.10843277


West Pond Marsh: MM
Sum of Percent Cover
-12.77376938 - 0.638266669
0.638266669 - 14.05030272
14.05030273 - 27.46233877
27.46233878 - 40.87437481
40.87437482 - 54.28641086
54.28641087 - 67.69844691
67.69844692 - 81.11048296
81.11048297 - 94.52251901
94.52251902 - 107.9345551


West Pond Marsh: Shrub
Sum of Percent Cover
-6.090364456 - 5.735905117
5.735905118 - 17.56217469
17.5621747 - 29.38844426
29.38844427 - 41.21471384
41.21471385 - 53.04098341
53.04098342 - 64.86725299
64.867253 - 76.69352256
76.69352257 - 88.51979213
88.51979214 - 100.3460617