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

Progress Report - 2018 Vegetation Sampling

Submitted to

Great Lakes – St. Lawrence River Adaptive Management Committee

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Executive Summary

In the summer of 2018, 16 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 in validating model outputs of aquatic ecosystem impacts from changes in water level regulation. This project provides a means to track meadow marsh extent and understand how it relates to water level fluctuations, and to assess the performance of IJC's Plan 2014 in terms of vegetation response. The results of this study will add to the coastal wetland monitoring dataset which contains nine previous years of data collected by CWS-ON under this protocol.

To allow for a direct comparison between data collected under extreme high water levels in 2017 and data collected under typical water levels in 2018, the same sites were surveyed this year. These sites were selected to be representative of wetlands in Lake Ontario, with four wetlands from each hydrogeomorphic type (dynamic barrier beach, open embayment, protected embayment, and drowned river mouth). Wetland vegetation was surveyed using an existing approach developed by CWS-ON using real-time kinematic (RTK) GPS.

To quantify disturbance, basic water quality information was collected at each wetland on the Canadian side of Lake Ontario. In general, the water quality information collected indicates that the sites surveyed vary in disturbance from Very Degraded (Jordan Station Marsh, Corbett Creek) to Very Good (Blessington Creek Marsh). In addition, portable water level loggers were deployed in each site to capture local water level fluctuations at 15-minute intervals.

As recommended at the GLAM committee wetland experts meeting in 2017, regular monitoring should continue in order to develop a strong dataset to evaluate wetland conditions in the coming years as Plan 2014 begins to take effect. Moving forwards, CWS-ON sees this approach to monitoring wetland vegetation as a standard for continued monitoring efforts on Lake Ontario and basin-wide. 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 2018-19 allowed the program to continue baseline activity and does not reflect the entire costs associated with the program.

Background

In the summer of 2018, 16 coastal wetlands were surveyed along the north shore of Lake Ontario to provide wetland vegetation data referenced to elevation to support the modelling of aquatic ecosystems following recent changes in water level regulation. With the acceptance of this report, all deliverables have been completed and work to date has included the completion of field data collection, survey data processing (data entry and quality-checking), and the completion of reporting to outline project findings. The entire dataset (2009-2018) are housed in a database developed and maintained by CWS-ON.

Status of Deliverables

	Deliverable	Due date	Status
1.	Complete field surveys for 16 Lake Ontario wetlands on the Canadian shoreline	September 2018	Complete
2.	Field data is input into existing database, post-processed, and reviewed	October 2018	Complete
3.	Data is analyzed and summarized; key findings are presented in Final Summary Report	March 2019	In progress

Field Surveys

Vegetation Surveys

Vegetation monitoring followed Grabas and Rokitnicki-Wojcik (2015). CWS-ON has monitored vegetation using this approach at 26 wetlands from 2009-2015, selecting eight sites each year with many of the sites being revisited. In 2017, 16 sites were selected to be representative of wetlands in Lake Ontario by hydrogeomorphic type, geography, and level of disturbance. Four sites from each hydrogeomorphic (HGM) type were selected: dynamic barrier beach (BB), open embayment (OE), protected embayment (PE), and drowned river mouth (DRM). The same 16 sites were revisited in 2018. Based on the allocation of field staff, survey time, and technological resources, we were able to survey six transects at each site. An earlier power analysis of several years' data (not shown here) indicated that differences in species composition and vegetation zonation can be adequately captured by six transects. By expanding the range of sites, the resulting dataset was more robust for the purpose of assessing wetland conditions across the Canadian side of Lake Ontario.

Vegetation was monitored along six 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 each transect. However, 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 shallower than 74.0m. Therefore, most sites surveyed do not reach the maximum number of quadrats (Table 1), which is an indication of the morphometric, topographic, and vegetative characteristics of the site and not related to any qualitative measures of condition.

Table 1: Summary of transects completed along wetland elevation gradient in the summer of 2018.

Wetland Name	# Quadrats	% of Maximum Quadrats	Min Elevation Surveyed	Max Elevation Surveyed
12 O'Clock Point	45	68.18%	74.0	76.0
Bayside	43	65.15%	74.0	76.0
Blessington Creek	56	84.85%	74.0	76.0
Button Bay	58	87.88%	74.0	75.8
Corbett Creek	35	53.03%	74.4	75.6
Greater Cataraqui Creek	49	74.24%	74.0	75.6
Hay Bay North	49	74.24%	74.0	75.6
Hay Bay South	56	84.85%	74.0	76.0
Huyck's Bay	62	93.94%	74.0	76.0
Jordan Station	47	71.21%	74.0	75.8
Parrott's Bay	39	59.09%	74.0	75.2
Popham Bay	35	53.03%	74.4	76.0
Presqu'ile Bay	53	80.30%	74.0	75.8
Robinson Cove	66	100.00%	74.0	76.0
South Bay	62	93.94%	74.0	76.0
Wesleyville	36	54.55%	74.6	75.6

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 six stations to align with the outermost aquatic vegetation point from each transect. The data were screened for outliers and the mean values for each of the four parameters calculated and combined in an overall Water Quality Index score (WQI; Chow-Fraser 2006; Table 2). The WQI is an indicator of human-induced land use alterations, and can be used as an indication of wetland disturbance.

Table 2: Summary water quality data for each of the wetlands sampled. Mean parameter values are presented. The Water Quality Index (WQI) score is shaded based on the qualitative descriptors outlined in Chow-Fraser (2006).

Wetland Name	Turbidity (NTU)	Specific Conductance (µS/cm)	Temperature (°C)	pH	WQI
12 O'Clock Point	5.7	270.2	26.27	8.41	-0.03
Bayside	2.4	227.6	24.24	9.07	0.57
Blessington Creek	1.8	518.1	23.94	7.70	1.44
Button Bay	11.7	276.5	18.93	9.11	-0.28
Corbett Creek	10.0	2162.5	27.72	7.64	-1.75

Greater Cataraqui Creek	11.6	240.7	19.26	8.42	-0.20
Hay Bay North	4.3	417.8	23.82	8.48	-0.13
Hay Bay South	3.9	216.5	23.99	9.19	0.30
Huyck's Bay	1.5	218.5	23.35	8.17	1.00
Jordan Station	28.9	808.5	26.14	8.10	-1.77
Parrott's Bay	2.0	401.7	22.12	8.60	0.61
Popham Bay	7.7	303.8	24.62	8.35	-0.20
Presqu'ile Bay	1.9	296.3	24.04	8.21	0.59
Robinson Cove	7.6	252.7	19.27	8.40	0.04
South Bay	1.6	311.3	24.41	8.63	0.89
Wesleyville	9.9	455.8	23.64	7.76	-0.54

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

Local Water Level Data

Wetland water levels were measured at the time of survey using the RTK GPS and tied back to water-level readings from loggers that were deployed in April to record levels at 15 minute increments during the growing season (as described in Grabas and Rokitnicki-Wojcik 2015). The water level dataset can be made available to the GLAM committee should it be requested.

Fluctuation intensity (FI) is an integrated measure of the magnitude and frequency of daily water-level changes (mostly from wind tides and seiches) experienced in a wetland and is calculated as the back-transformed logarithmic mean of one-half the sum of daily water-level increments every 15 min for portable loggers (Grabas and Rokitnicki-Wojcik, 2015). These values vary among sites depending on the site's characteristics and hydrogeomorphic type (HGM), as sites that are more protected are less influenced by lake-level fluctuations. CWS has collected water level data for multiple years at many sites, and noted that fluctuations at the site level do not vary greatly from among years.

Table 3: Water levels at time of survey and fluctuation intensities from May – November WL data.
*Water levels in IGLD were not measured at these sites; however, relative water level fluctuations are available.

Wetland Name	Type	Date sampled	Water level during survey (m IGLD)	Fluctuation intensity (FI)
12 O'Clock Point	PE	14/09/2018	74.73	16.04
Bayside	OE	13/09/2018	74.70	18.09
Blessington Creek	DRM	12/09/2018	74.73	10.25
Button Bay	OE	20/09/2018	74.67	63.15
Corbett Creek	BB	17/09/2018	74.75	5.88
Greater Cataraqui Creek	DRM	20/09/2018	74.62	29.52
Hay Bay North	DRM	12/09/2018	74.65	39.51
Hay Bay South	OE	12/09/2018	N/A[1]	53.2
Huyck's Bay	BB	14/09/2018	75.15	3.96
Jordan Station	DRM	17/09/2018	74.78	26.35

Parrott's Bay	PE	19/09/2018	N/A[1]	25.67
Popham Bay	BB	13/09/2018	75.11	4.17
Presqu'ile Bay	PE	13/09/2018	74.67	44.97
Robinson Cove	PE	11/09/2018	74.70	18.11
South Bay	OE	18/09/2018	74.67	114.51
Wesleyville	BB	19/09/2018	75.11	3.56

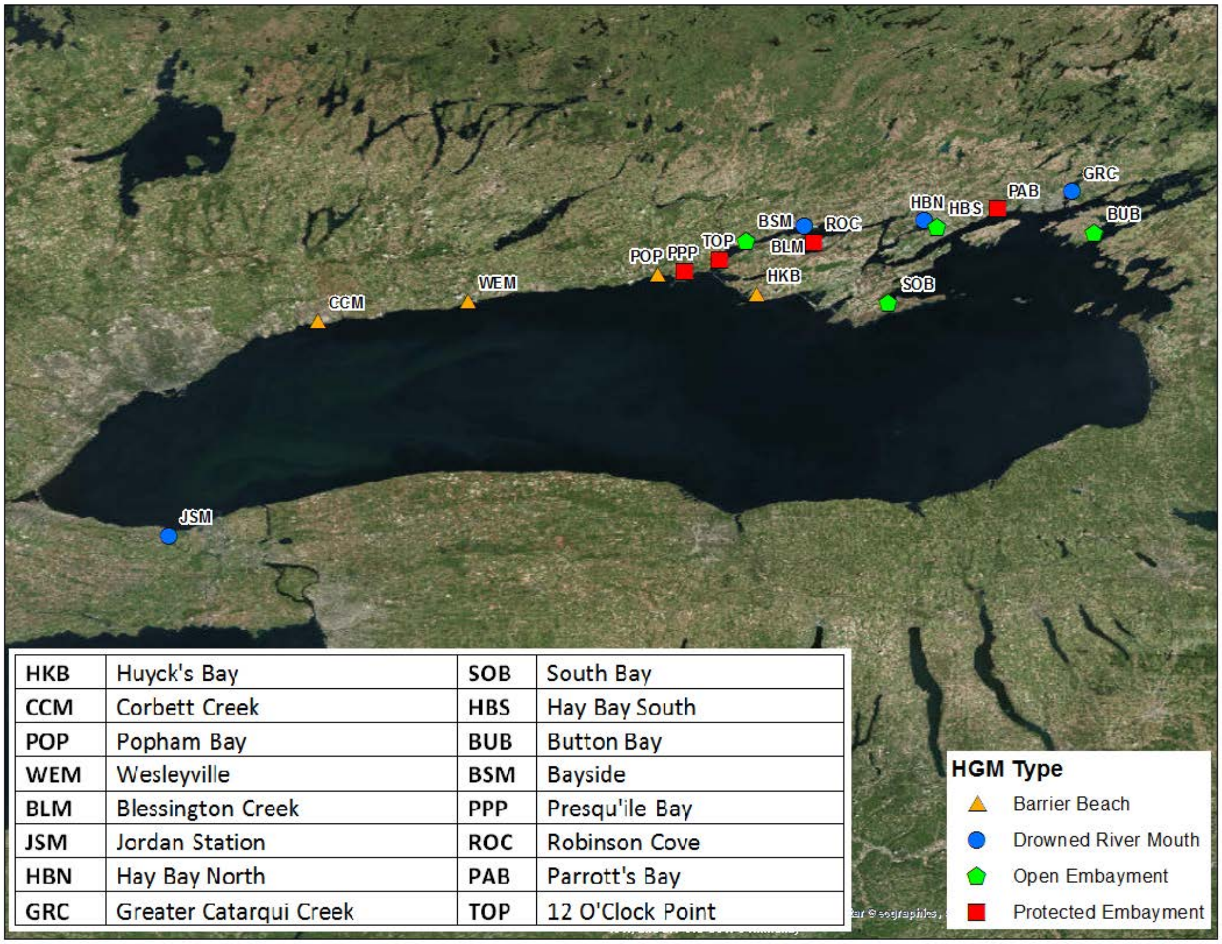


Figure 1: Wetland study sites surveyed by CWS-ON in 2018

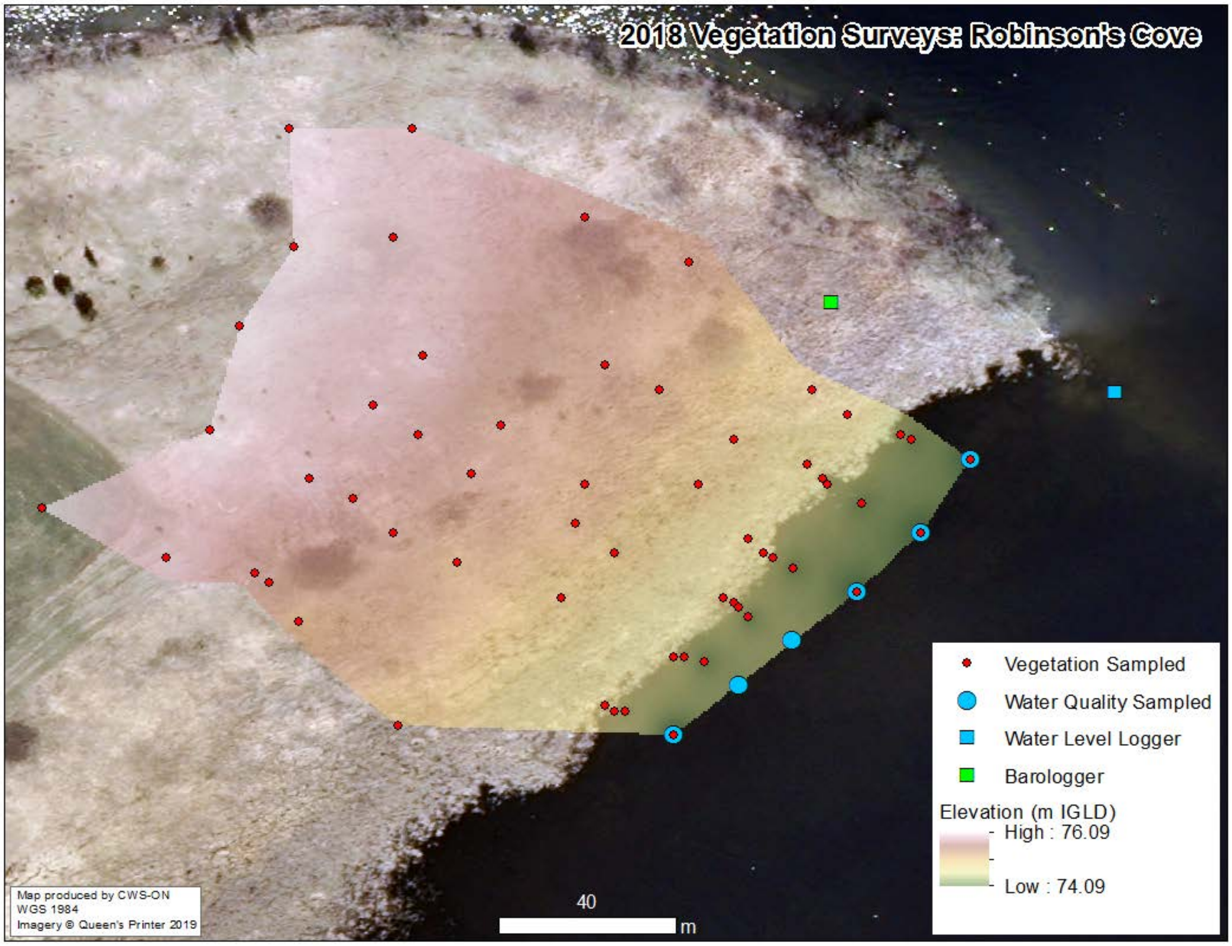


Figure 2: Robinson's Cove (ROC) vegetation quadrats sampled by elevation (six transects), level logger locations and water quality sampling locations. An interpolation DEM of the elevation data created using the Inverse Distance Weighted (IDW) method is overlaid.

Summary of 2018 Results

Water levels

In 2018, Lake Ontario water levels were fairly close to the historical monthly averages during the growing season, in contrast to the extreme high levels that occurred in 2017. With a large portion of the meadow marsh community being flooded during the 2017 growing season (maximum of 75.81 m IGLD reached in June), vegetative cover had decreased considerably. The 2018 data provides an indication of how these species responded when they were able to grow throughout the season unhindered by flooding.

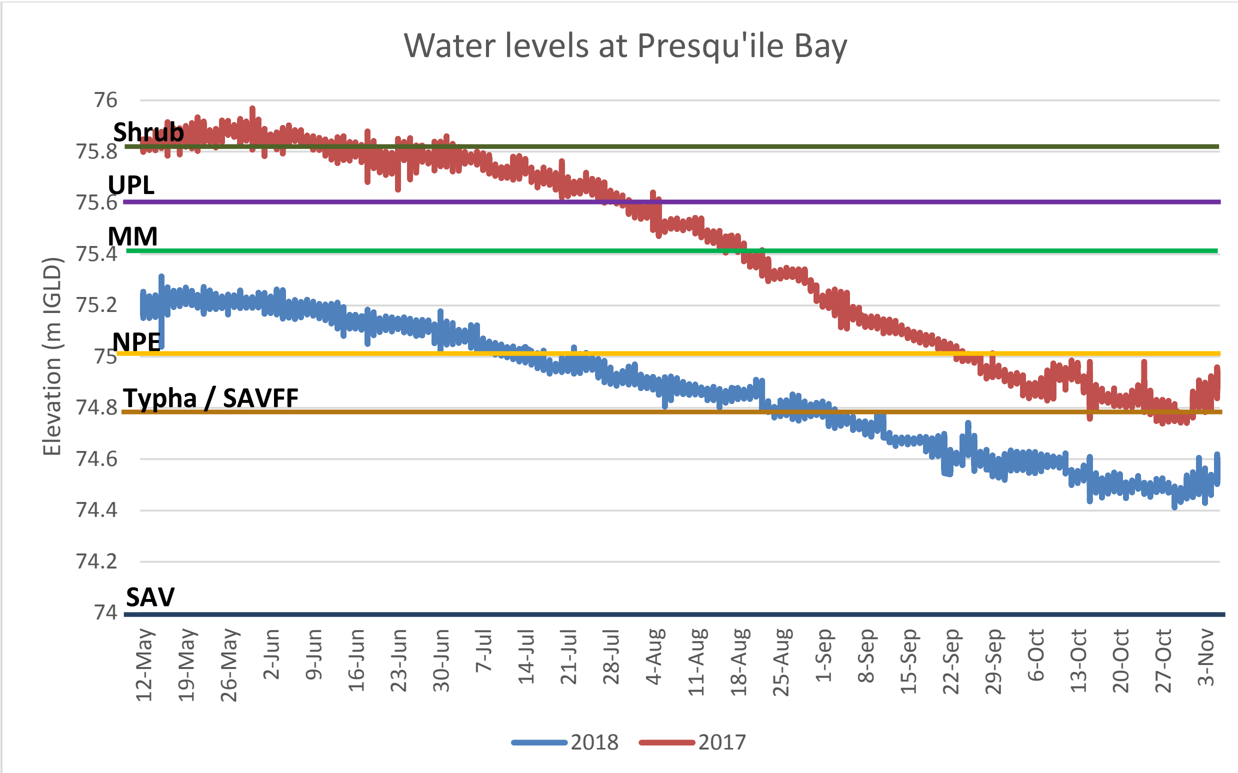


Figure 3: Local water level data captured at Presqu'ile Bay in 2017 and 2018. Horizontal lines indicate the elevation where each guild typically experiences its peak coverage.

Vegetation Guild Summary Data

Individual species data collected along the aquatic-upland gradient were summarized by vegetation guild and elevation. The sum of species percent cover per guild was calculated to provide a measure of the abundance of a vegetation type at each elevation for within a study site. Vegetation guilds occur in a distinct zonation determined by water level and species tolerance to flooding. In general, the range of elevations that a guild occupies has not changed since the monitoring began. However, we have observed changes in the elevations at which a guild has its peak coverage, likely as an effect of water level fluctuations from year to year. This was especially evident when comparing data from pre-2017 to 2017 and 2018 data.

Scatterplots for all guilds are presented in Appendix 1. Note that pre-2017, the site selection varied by year and fewer sites (eight) were sampled.

Observations by Guild

SAV (Submerged Aquatic Vegetation):
In general, the percent coverage of SAV showed little change from previous years. Excluding an outlier observation at 75.8m, SAV occupies the range from 74.0m to 75.0m, which is expected given the average water level during the growing season was approximately 75.0m. In 2017, SAV was pushed upland as high as 75.4m.

SAVFF (Free-floating):
The amount of SAVFF observed was similar to 2017. Since this community can easily shift with the water level, the elevation range that it occupies shifted lakeward this year with the peak coverage occurring at 74.6.

NPE (Non-persistent emergent):
Non-persistent emergent vegetation coverage is relatively low at all sites, and is less likely to be found at the more degraded wetlands on Lake Ontario. The range and coverage of NPE appears to be fairly consistent across years, with some variability likely explained by changes in the site selection.

Typha:
The distribution of Typha sp. follows the same pattern in all years, with coverage peaking at 74.8 or 75.0. Due to the resilience of Typha spp. to flooding or drought, longer periods of extreme high or low water levels are required to significantly alter their zonation and elevation range.

MM (Meadow marsh):
The meadow marsh guild was the most impacted by high water levels in 2017. Although the meadow marsh was not suppressed by flooding in 2018, the average cover for meadow marsh remained lower than pre-2017 sampling years (Figure 6), as these species were stressed by flooding for a large portion of the growing season. Peak coverage of meadow marsh occurs at 75.6m, suggesting a lakeward shift compared to the 2017 formation that peaked at 75.8m (Figure 4).

UPL (Upland):
The upland guild distinguishes vegetation that does not typically occur in wetlands. Coverage for UPL increased at the uppermost elevations (75.8m and 76.0m) compared to the previous year.

Shrub:
In 2017 and 2018, the average cover of shrub species at the high end of the elevation gradient was less than in previous years.

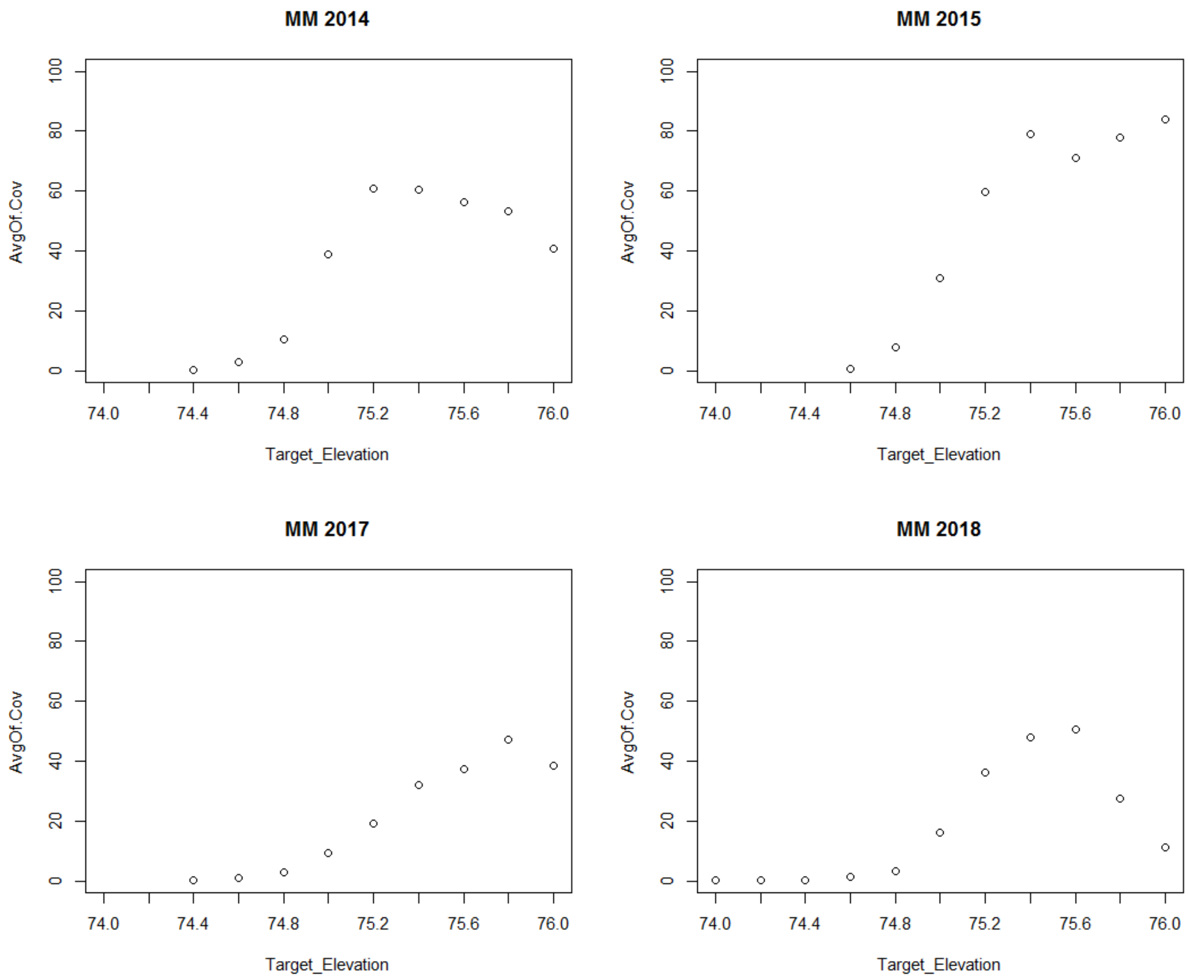


Figure 4: Meadow marsh (MM) average cumulative guild percent cover (AvgCov) by target elevation plotted for all wetlands sampled by CWS.

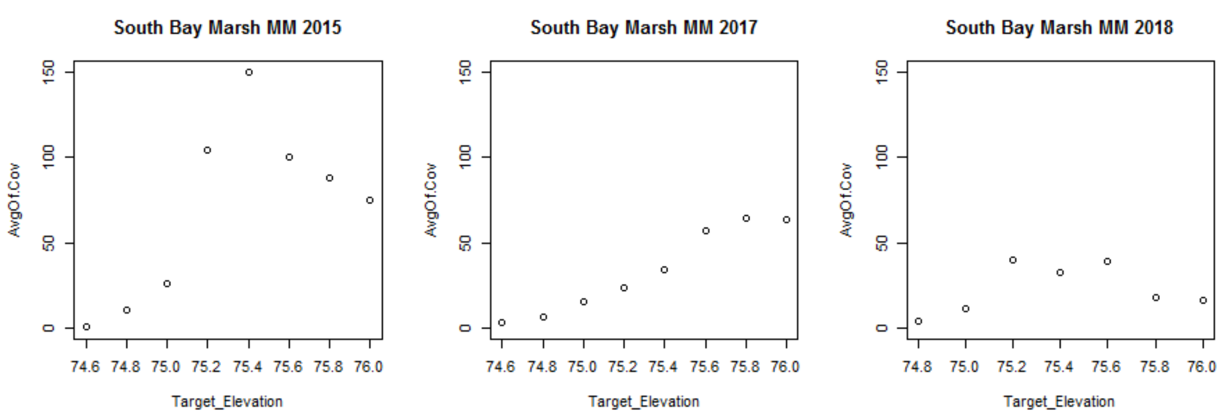


Figure 5: Meadow marsh (MM) average cumulative guild percent cover for a single site (South Bay) in 2015, 2017, and 2018.

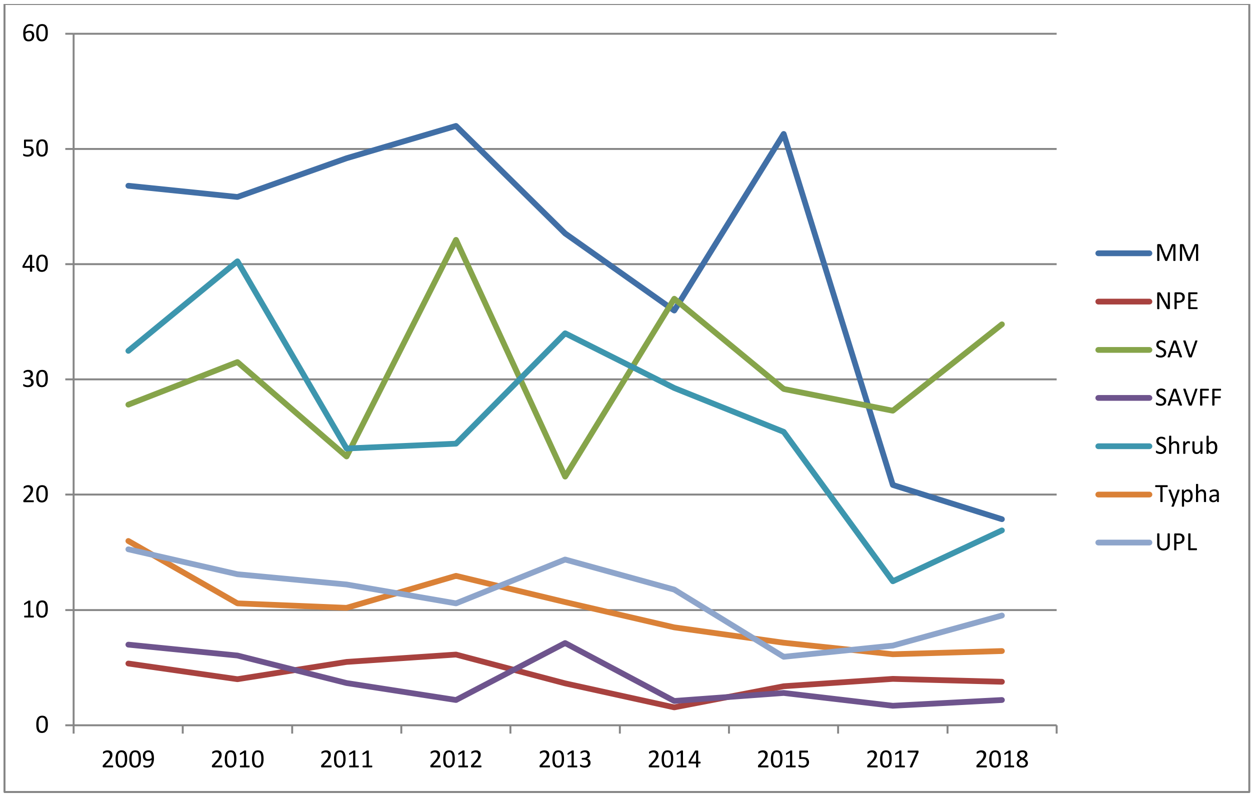


Figure 6: Average cumulative percent cover by quadrat per study site, by year.

Statistical analysis

CWS-ON is currently developing linear mixed-effects (LME) models from the guild coverage dataset to assess significant changes in vegetation cover. Before 2017's high water event, there was relatively little variation in guild coverage from year to year. To focus on the more pronounced vegetation response to extreme water levels, we grouped the data into three temporal classes: pre-2017, 2017, and 2018. Results of this analysis will provided in a report to the GLAM Committee by March 2019. Capturing additional years of data will allow us to characterize changes in vegetation extent and better understand the effects of this year's water-level conditions.

2009-2018 Dataset

The complete CWS-ON coastal wetlands monitoring dataset from surveys conducted from 2009-2018 will be provided to the GLAM committee. These data, along with those collected on the U.S. side of Lake Ontario 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 due 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 updated data were output in the same manner as the dataset provided for the previous IWI project completed by CWS-ON in 2017:

- 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 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 provide a brief description of the data.

Future Considerations

Although we have observed the response of vegetation communities one year after the unprecedented high water levels in 2017, the effects may manifest themselves further in the following years. As we are in the early years of Plan 2014, ongoing implementation of this well-established approach to monitoring wetland vegetation will continue to provide valuable information to the GLAM Committee. The most recent bulletin issued by the US Army Corps of Engineers does not forecast extreme water levels for the 2018 growing season (USACE, 2018). Should lake levels reach extreme highs or lows, it would be especially important to detect changes to coastal wetland vegetation communities to provide information on Plan 2014 performance and inform vegetation modelling.

CWS-ON is limited by budgetary restrictions and sustained financial support is required 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 2017-18 allowed monitoring to continue and does not reflect the entire cost associated with this long term program.

Literature Cited

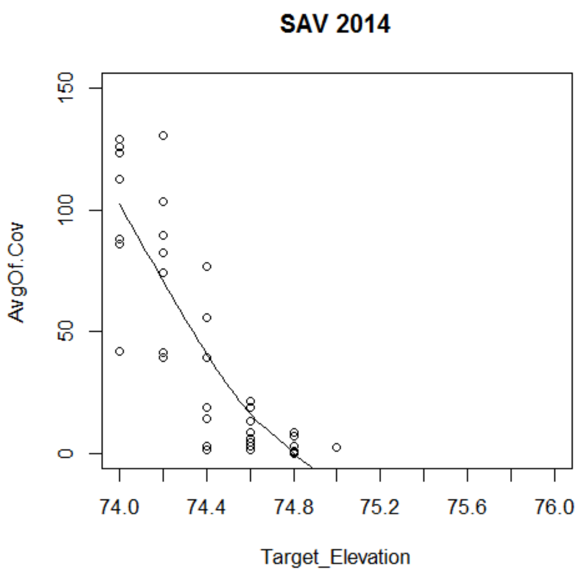
Chow-Fraser, P. 2006. Development of the Water Quality Index (WQI) to assess effects of basin-wide land-use alteration on coastal marshes of the Laurentian Great Lakes. In: Coastal Wetlands of the Laurentian Great Lakes: Health, Habitat and Indicators. Eds. Simon, T.P. and Stewart, P.M. Authorhouse,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

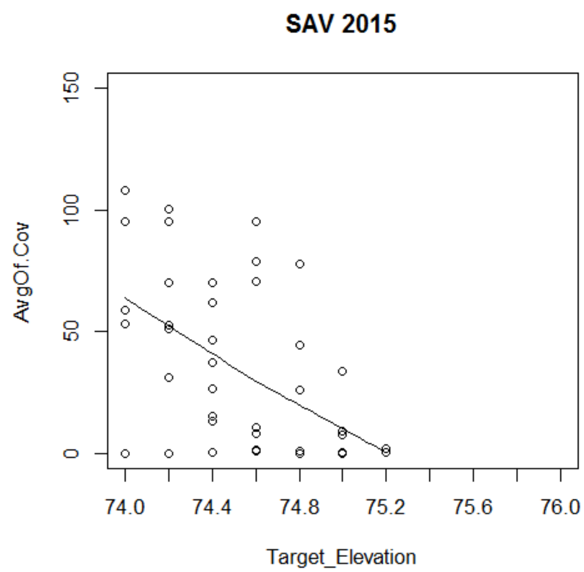
Grabas, G.P., and Rokitnicki-Wojcik, D. 2015. Characterizing daily water-level fluctuation intensity and water quality relationships with plant communities in Lake Ontario coastal wetlands. Journal of Great Lakes Research 41, 136-144.

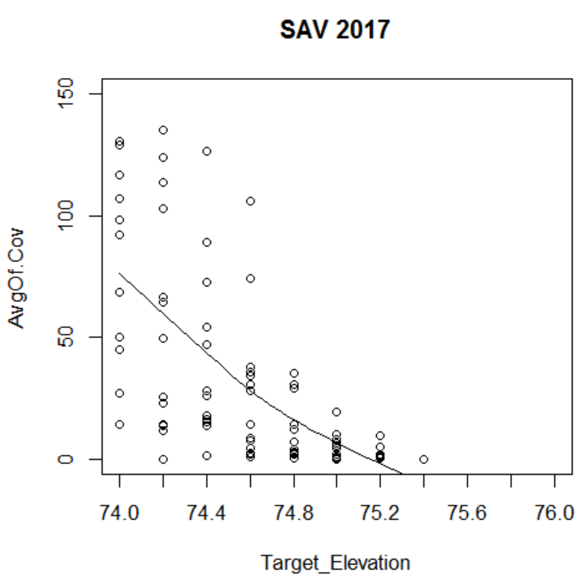
U.S. Army Corps of Engineers (USACE), 2018. Monthly Bulletin of Great Lakes Water Levels – February 2018.
http://www.lre.usace.army.mil/Missions/Great-Lakes-Information/Great-Lakes-Water-Levels/Water-Level-Forecast/Monthly-Bulletin-of-Great-Lakes-Water-Levels/

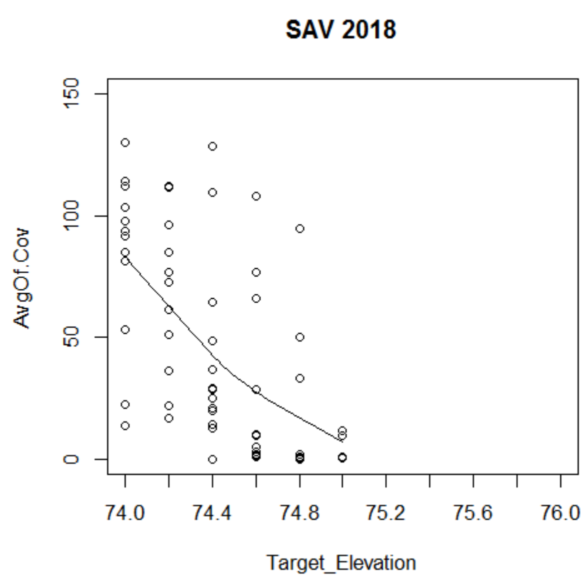
Appendix 1

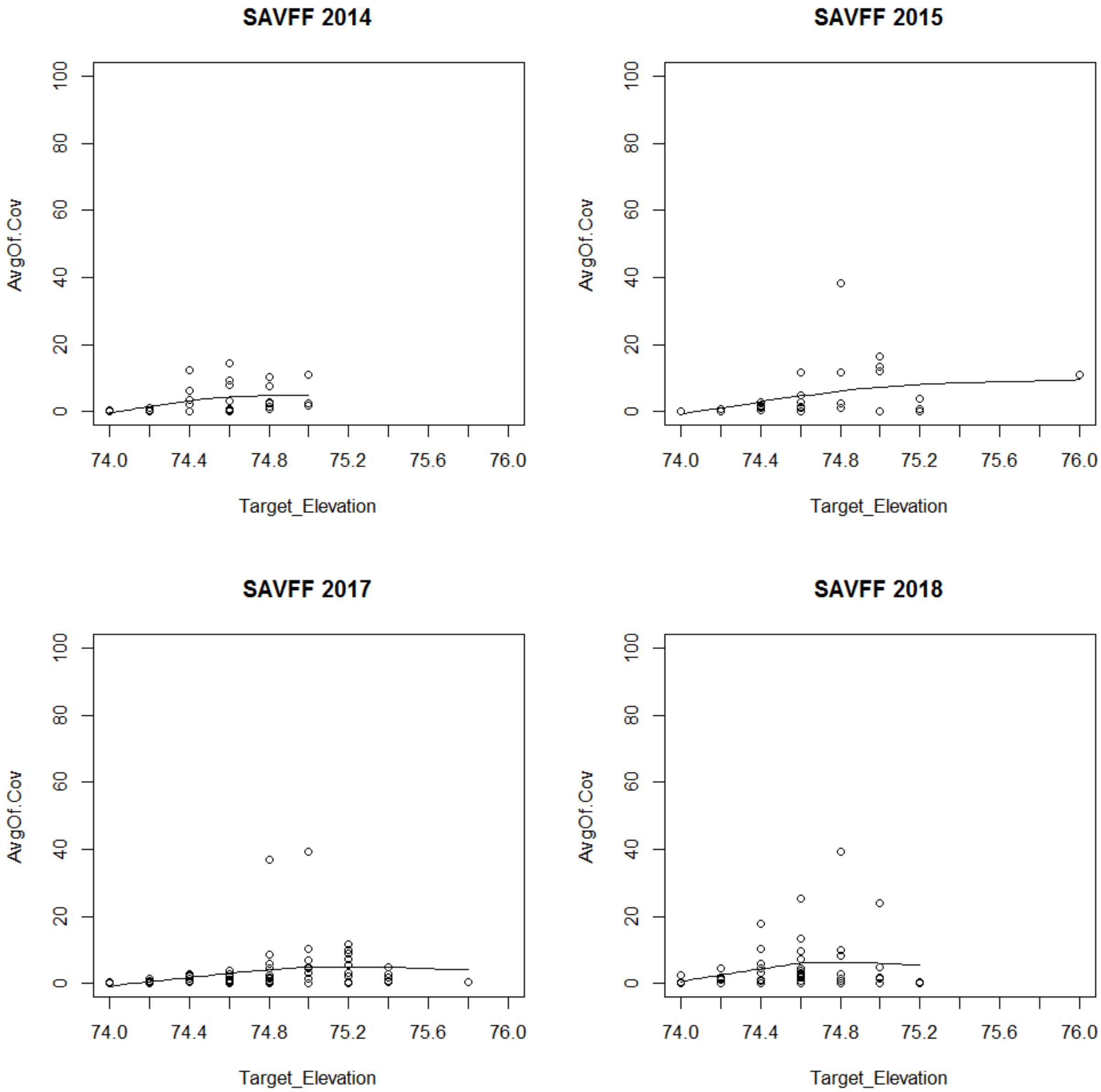
Scatterplots for each guild for the past four years of sampling are presented below. Along the x-axis is target survey elevation (m IGLD), and on the y-axis is average cumulative percent cover by quadrat. Each point at each elevation on the x-axis represents a study site containing that guild. The average cover can be greater than 100% due to overlapping of vegetation in three dimensional space which is common in wetlands.







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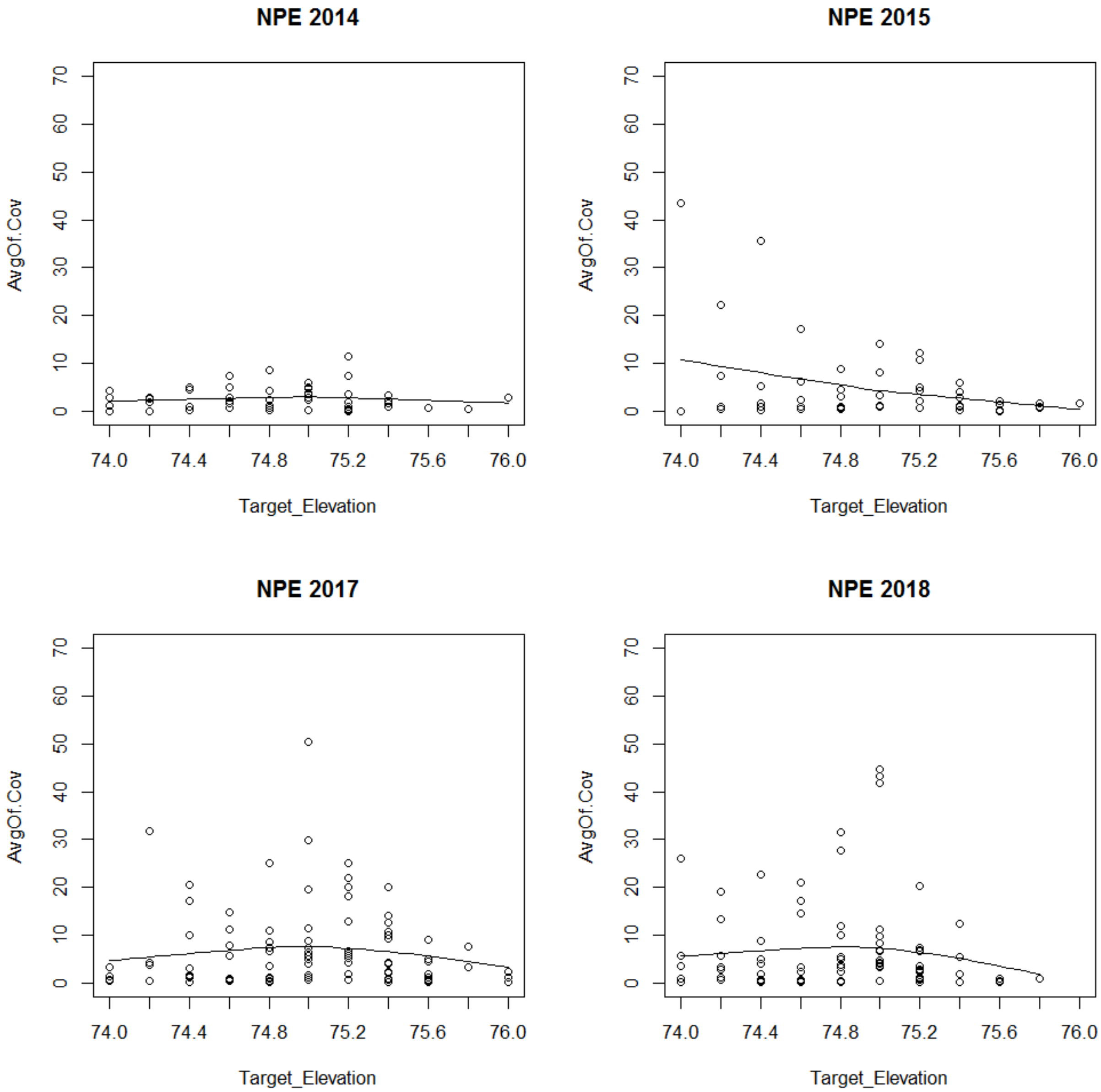
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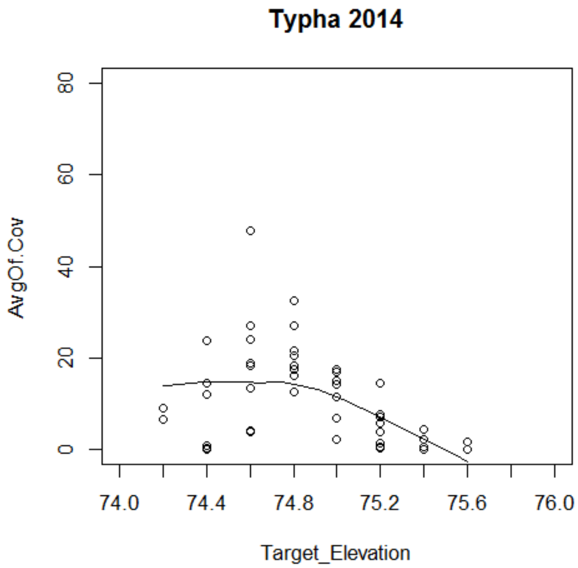
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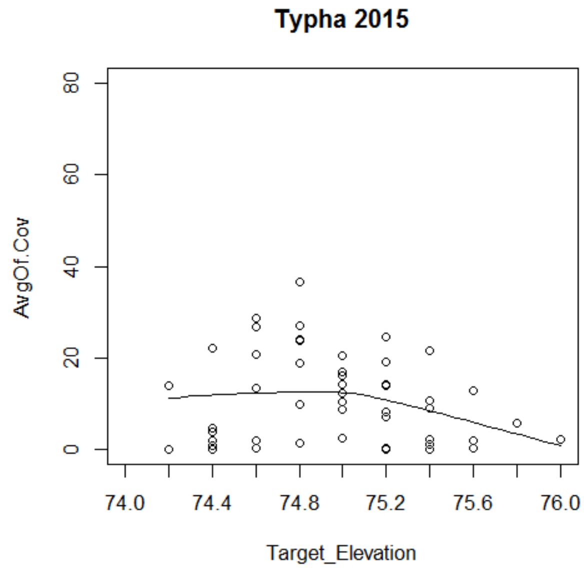
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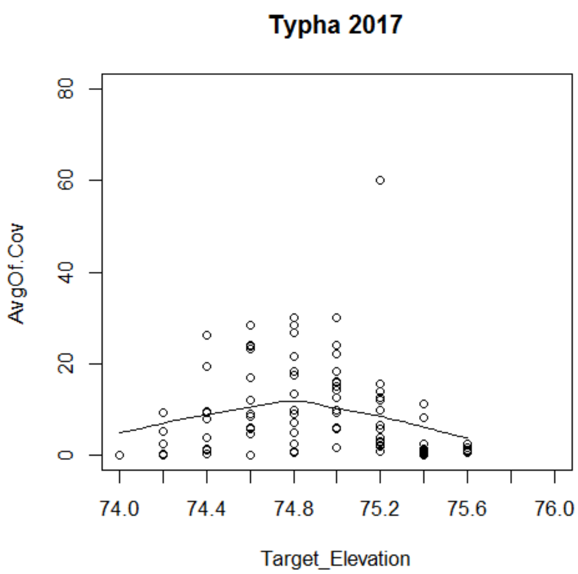
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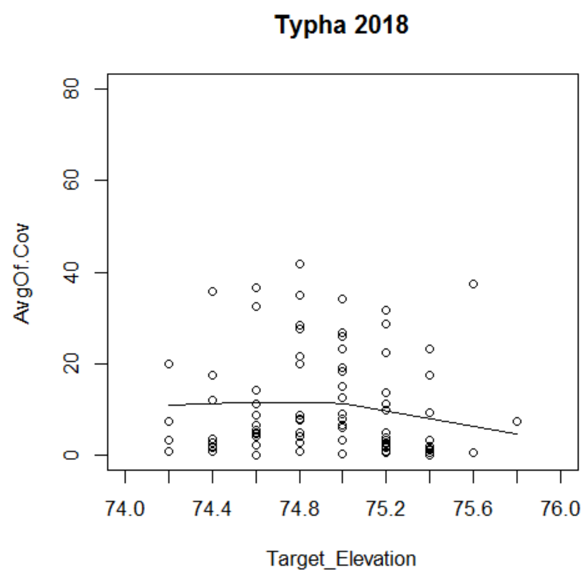
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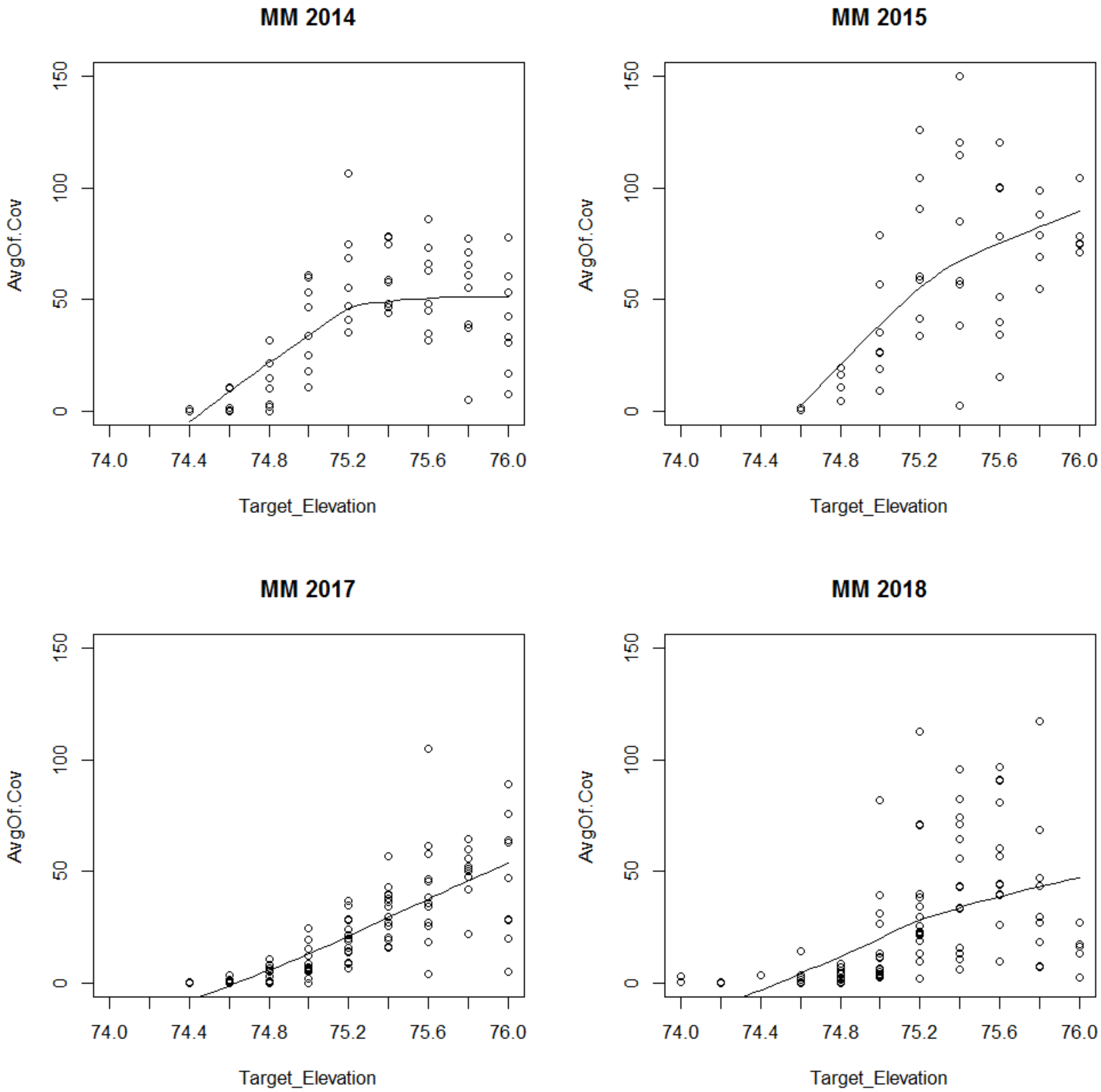
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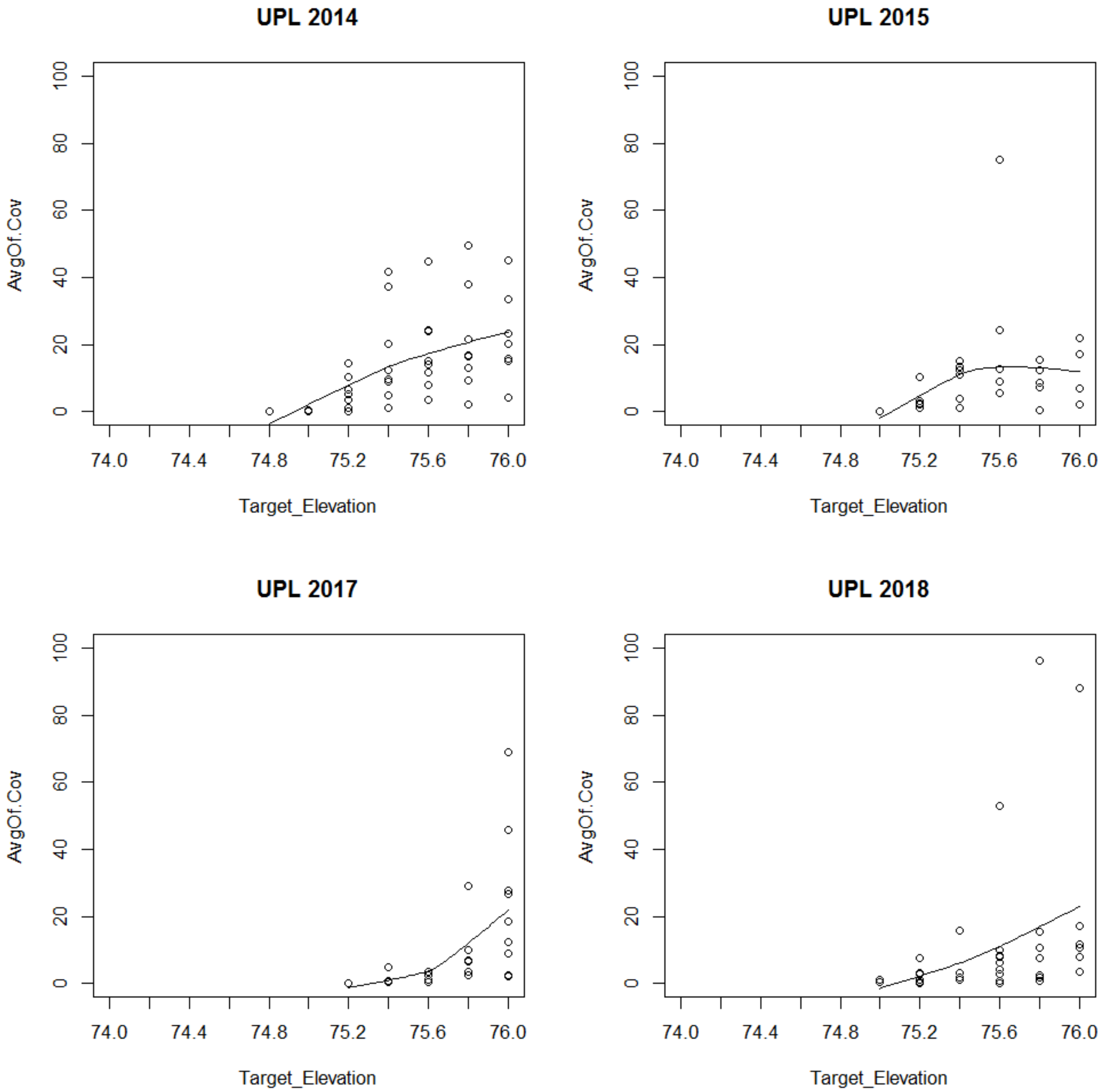
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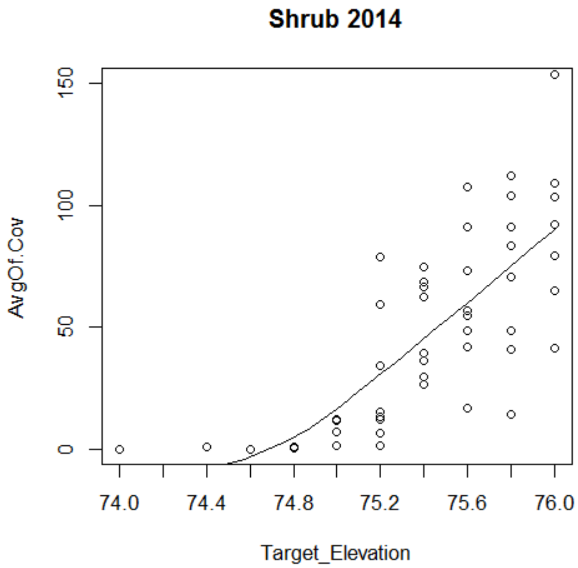
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AvgOf.Cov
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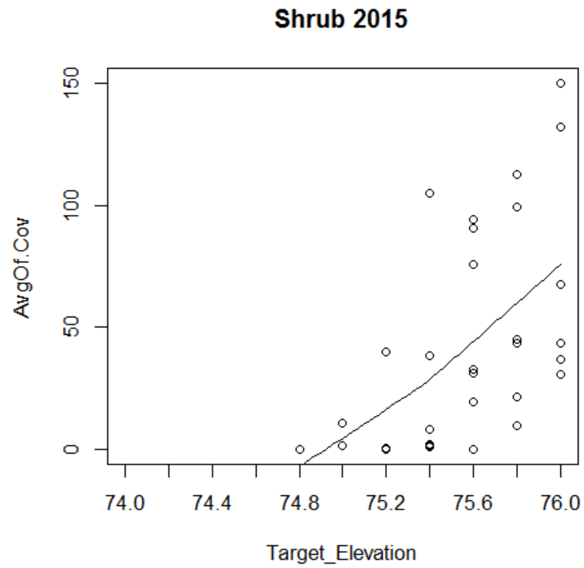
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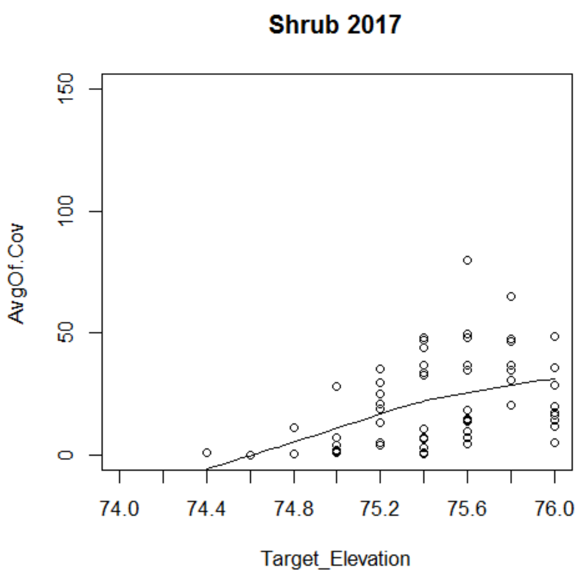
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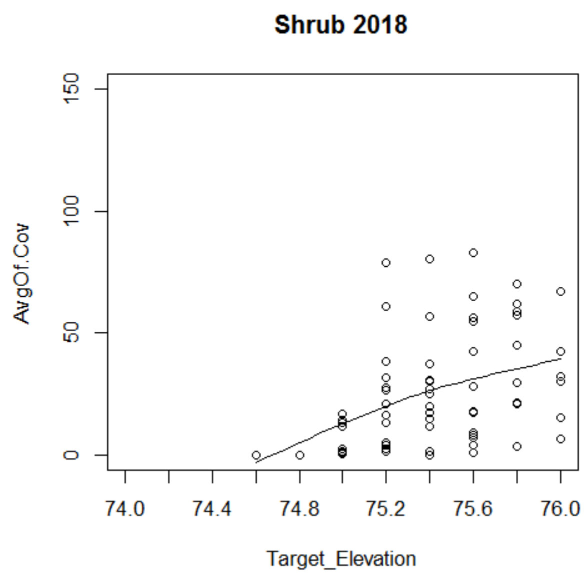
AvgOf.Cov
Target_Elevation


Shrub 2018
AvgOf.Cov
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