BIOLOGICAL MONITORING OF VERMONT'S WETLANDS: AN EVALUATION OF THE CHEMICAL, PHYSICAL, AND BIOLOGICAL CHARACTERISTICS OF VERMONT WETLANDS 2018-2020

Vermont Department of Environmental Conservation
Watershed Management Division
Wetlands Program
1 National Life Drive
Montpelier, Vermont 05604

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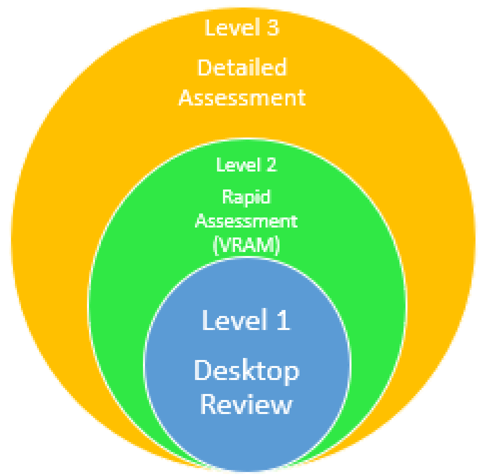
Contents

Introduction and Background:

The purpose of the Wetland Bioassessment and Monitoring Program ("Program") is to build a pertinent and practical program to assess wetland biological integrity and the physical and chemical condition of Vermont's wetlands. The 2018-2020 Program builds on the findings of the Wetland Bioassessment Program from 2006-2017 which includes (VT DEC, 2003, 2010, July 2015, March 2018) an Environmental Protection Agency (EPA) -funded pilot wetland bioassessment project involving vernal pools and northern white cedar swamps (VTDEC, 1999) and field methodologies used by Vermont Natural Heritage Inventory (NHI) natural community inventories, including EPA- funded inventories (The Nature Conservancy, 1993).



The Program has adopted the EPA's wetland monitoring methodology and is organized into three levels. Level 1 assessments are performed through desktop review and relies on coarse landscape-scale inventory information. Level 2 surveys are a "rapid assessment" at the specific wetland scale and uses simple and quick protocols to collect data. Level 2 protocols are to be calibrated and validated by more intensive assessments known as Level 3, which are rigorous biological assessments that derive multi-metric indices (Vermont DEC, 2018).

The specific objectives of the Program are to (1) conduct assessments of wetlands across a condition gradient; (2) record and gather biological, chemical, and physical data at wetland sites including vegetation, water quality, hydrology, soils, and landscape characteristics; (3) sample and describe vegetation to develop and apply vegetation-related metrics of wetland biological integrity; (4) sample wetlands where other ecological inventories are taking place to discern any possible parallels; (5) complete rapid assessments and evaluate the ability of the methods to reflect overall wetland condition; (6) expand the use of metrics in assessing the overall health of Vermont's wetlands; (7) continue monitoring for specific projects such as wetland restoration and solar farm development; (8) continue developing the Program's database; and (9): develop a broad, landscape-scale assessment methodology for desktop review use.

Over the long-term, it is expected that results may be used for improving permitting and regulatory decisions; providing significant information for mitigation and restoration projects; providing information to inform focus of wetland conservation efforts; coordinating with the NHI to add to the pool of knowledge of wetland natural community ecology in Vermont; discerning the connection between water quality, vegetation, and other potential indicators of wetland condition and function; broadening and expanding natural community mapping of wetlands throughout the state; and identifying the effects of environmental and anthropogenic stressors on wetlands.

This report focuses on the Project's findings from the 2018, 2019, and 2020 field seasons. The surveys during this time period were mainly conducted using modified NHI field methodology, with sites selected to correspond with concurrent DEC stream bioassessment sampling; NHI sampling; wetland restoration site sampling; investigation of potential Class I wetlands; filling data gaps; or to assess wetlands of other special concern or interest. In 2020, the Program began its participation in a solar farm monitoring project which looks at the effects of solar panels on wet meadow type wetlands.

Methods

Site Selection

Wetland sites are intentionally selected each field season using a wide range of criteria in order to build capacity. The Program adopted the NHI's natural community classification system that defines wetland type by plant natural community (Thomson and Sorenson, 2005). This classification system helps to refine site selection along a condition gradient to develop statistically robust biological metrices using plants. Site selection follows a rotational basin schedule like other Watershed Management Division monitoring programs and surveys within selected basins that are due for sampling. Site selection for rotational basin sampling uses a specific process involving multi-program coordination within the Watershed Management Division (WSMD), and a "Monitoring Summit" meeting is held annually for coordination purposes. The Program works with Basin Planners, staff from the Lakes & Ponds Program, Monitoring, Assessment and Planning Program (MAPP), Rivers Program, and others to identify priority sites in each basin due for sampling. The group works on identifying areas for integrated monitoring efforts, determining watershed-level needs, and "cross-pollination" opportunities (i.e., collecting data for a Program).

Generally, wetlands are selected based on priorities, data gaps, and specific monitoring projects. This includes (1) sites critical to filling data gaps for wetland type, condition, or region; (2) priority restoration and protection sites identified by Tactical Basin Plans; (3) sites identified by the Wetlands Program for regulatory purposes; (4) sites identified by the Annual Monitoring Summit for multi-program priorities and collaborations; (5) specific sites for monitoring studies, such as restoration and solar; (6) wetlands identified by NHI as important/exemplary natural communities; (7) sites supporting wetland mapping projects; and (8) sites requested by landowners, towns, and other local entities.

The Program sampled the following Basins from 2018 through 2020 (Figure 1): Missisquoi, Lamoille, Hoosic, and Battenkill (2018); Memphremagog, Poultney, Mettawee, Black, and Ottaqueechee (2019); Passumpsic, Winooski, and White (2020). In addition to the rotational basin sites, other wetlands were sampled due to participation in various projects. Throughout this period, the Program continued sampling efforts for the wetland restoration monitoring project on selected Wetland Reserve Easement (WRE) sites and other wetland restoration sites. Sampling in the Otter Creek basin also occurred in 2019 and 2020 at sites associated with a basin-wide wetland mapping project (EPA Grant: Mapping the Wetlands of the Otter Creek Basin 00A00560), and in 2020 the Program sampled specific sites that were participating in the solar farm development monitoring project.

Level 3 surveys were mostly limited to the rotational basin and restoration sites, whereas Level 2/rapid assessments were conducted opportunistically when Wetlands Program staff were visiting wetlands throughout the state for regulatory purposes, mapping efforts, landowner interest, or other reasons (Figure 2).

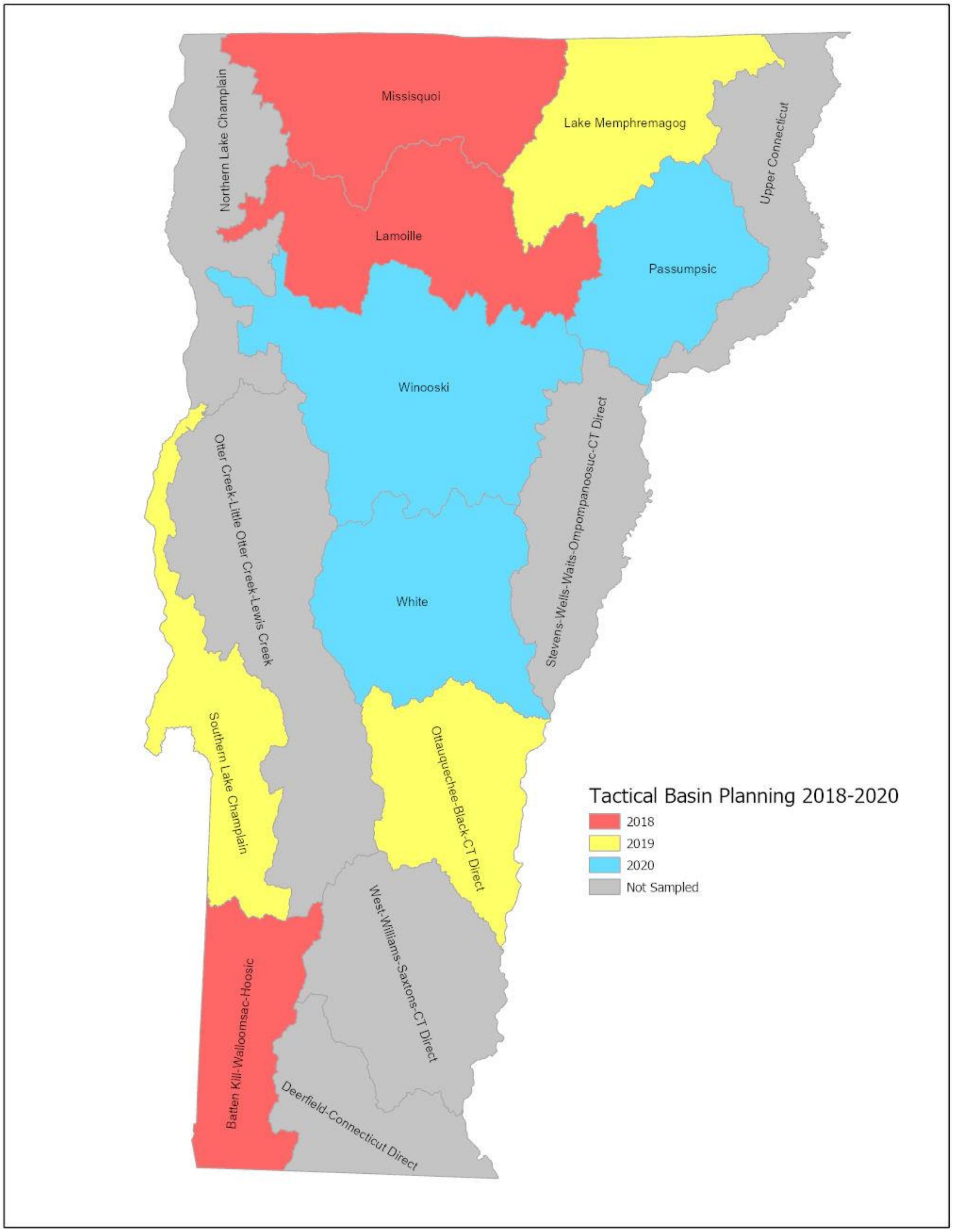


Figure 1: Basins sampled in the 2018-2020 period

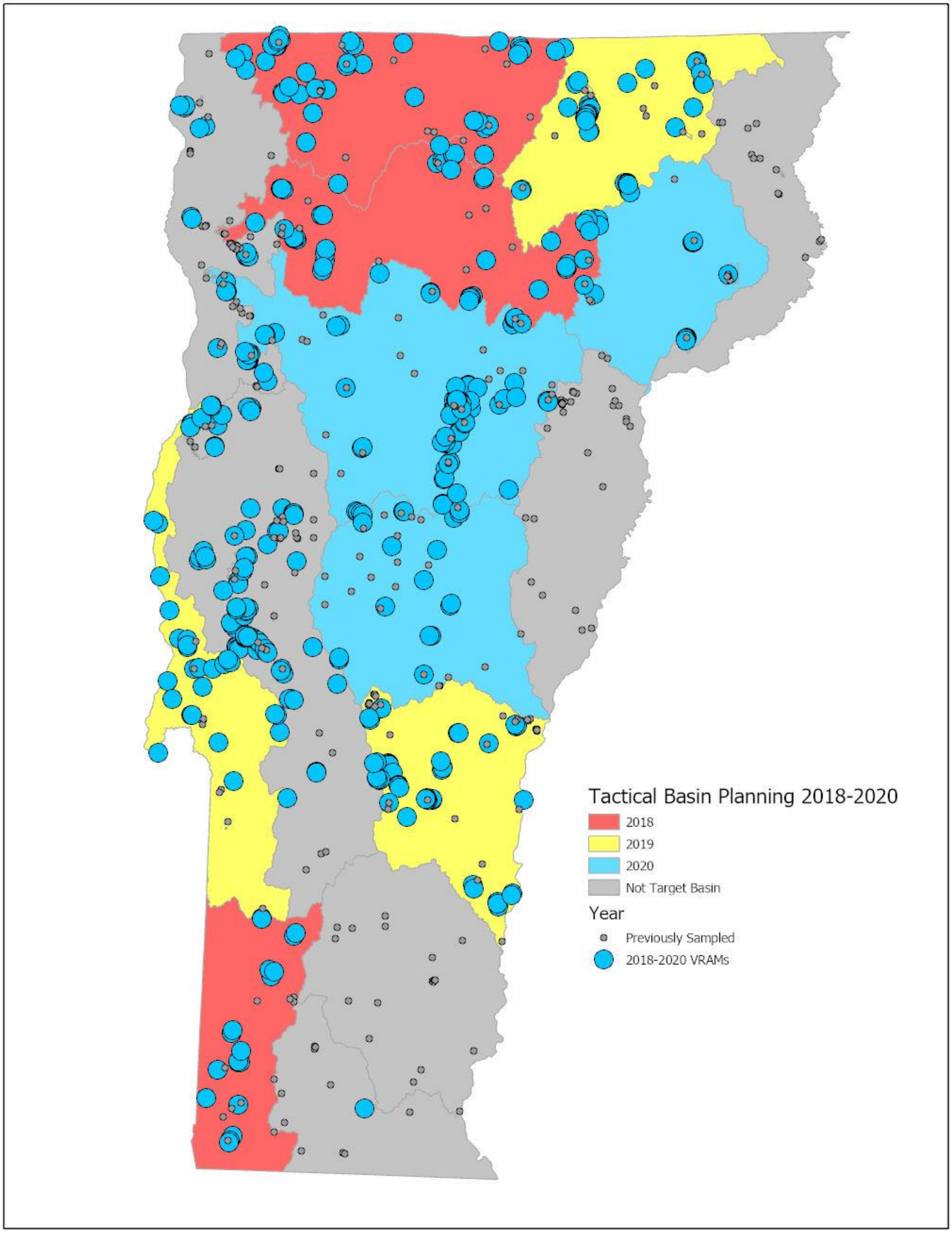


Figure 2: Map showing all VRAMs conducted in the sampling period and previously. This includes all Level 2 and 3 sites.

Soils, Hydrology, and Physical Habitat Measurements

Information about the physical environment in and surrounding each wetland site was recorded during Level 3 assessments. Soil data was collected using a soil auger. A soil core between 18-24 inches deep was pulled starting immediately below the surface and characterized. The depth, horizon, texture, color, structure, and redoximorphic features percentage was recorded for each layer observed in the profile. The cover composition of the unvegetated surface was recorded as well.

Unvegetated Surface (should equal 100%)			
	% Bedrock		% litter/duff
	% large rocks >10cm		% wood >1 cm
	%small rocks/gravel (0.2-10 cm)		% water
	% sand		% other (note below)
	% bare soil		

Soil Profile					
Depth ____	Horizon	Texture	Color	Structure	Redox %

Hydrology measurements such as surface water depth, water table depth, and saturation depth were recorded. Any other items of note relating to hydrology or physical characteristics were described in the notes.

Hydrology	
Sfc. H20 Depth	H20 Table depth (cm)
Saturation depth:	

Water Chemistry Sampling

When wetlands had sufficient surface water present, water samples were collected following the protocol outlined in the Vermont Wetlands Bioassessment Program Quality Assurance Project Plan (VTDEC, September 2019). A HydroLab™ Surveyor 4 and Minisonde 4 unit (Hach Environmental, Loveland, CO.) was used to assess pH, conductivity, dissolved oxygen, water temperature, and air temperature in the field. All other water quality parameters were collected using a grab technique. Parameters sampled included alkalinity, aluminum, calcium, chloride, chromium, cobalt, copper, iron, magnesium, manganese, nitrate and nitrite, total nitrogen, total phosphorus, filtered phosphorus, potassium, sodium, total suspended solids, sulfate, total calculated hardness, turbidity, color. Total dissolved organic and inorganic carbon was also sampled at some sites. Samples were transferred to an ice chest and transported to the Vermont Agricultural and Environmental (VAEL) Lab in Randolph. Samples were logged into the lab's tracking system and refrigerated until analysis. Color was measured at the Dewey Lab in Montpelier or at the VAEL lab in Randolph. No water samples were taken if suitable surface water was not available. During the 2020 field season there were moderate drought conditions across much of the state, where many sites did not have suitable water for sampling.

Biological Sampling – Vegetation

Quantitative vegetation sampling occurred each year between mid-June and mid-September. Sampling occurred when plant phenology was appropriate to identify most or all the plant species in a plot. A 10 x 10- meter plot was laid out for emergent and scrub-shrub wetlands and a 20 x 20- meter plot for forested wetlands (VTDEC, September 2019). Plots were placed in a representative area of the wetland that characterized the natural community type present. If a wetland contained more than one discrete vegetation community, separate plots were conducted in multiple wetland natural community types. Plots were modified to fit within the wetland and vegetation type if the wetland was irregular in shape or size and a conventional plot would not fit. Each plot location was recorded using a hand-held GPS unit (Garmin GPSMAP64 or equivalent).

Vascular and non-vascular plant species within the plot were identified to the species level in the field. Plants which could not be identified were collected for identification in the lab. Samples were collected with all diagnostic parts available for identification. Good quality plant specimens were retained for the Wetlands Program herbarium. Plant identification resources used include Flora Novae Angliae (Haines 2011) and the associated website gobotany.newenglandwild.org; Manual of Vascular Plants of Northeastern United States and Adjacent Canada (Gleason and Cronquist, 1991); Flora of the Northeast (McGee and Ahles, 2007); Newcomb's Wildflower Guide (Newcomb, 1977); the Northern Forest Atlas Guides from the Northern Forest Atlas Project, and Sedges of Maine (Arsenault, et. al 2013).

Other vegetation data was collected from the plots, including percent cover of each plant species identified, leaf type, leaf phenology, and ecosystem type. The cover was recorded by vegetation layer as well as by species. The strata that each species is in was also recorded for each plant species.

2017 Vegetation Plot Data

Plot Size (m):

Site Name: | Field Crew: | Date:

	Leaf Type
	Broad leaf
	Needle leaf
	Graminoid
	Forb

	Leaf Phenology
	Deciduous
	Evergreen
	Perennial
	Annual

Ecosystem Type			
	Forest		Woodland
	Sparse Woodland		Scrub thicket
	Shrubland		Sparse Shrubland
	Dwarf Shrubland		Dwarf Shrub Thicket
	Sparse Dwarf Shrubland		Herbaceous
	Non-vascular		Sparsely Vegetated

Vegetation Layers	height (m)	% cover
T1 - Emergent Tree		
T2 - Tree Canopy		
T3 - Tree Sub-Canopy		
S1 - Tall Shrub		
S2 - Short Shrub		
H - Herbaceous		
N - Non-vascular (moss etc)		
E - Epiphyte		
V - Vine/liana		

Plant List: Stratum, Species, and # Cover

Strata	Species	Cover %		Strata	Species	Cover %

Level 2/ VRAM Monitoring

Level 2 "rapid" assessments involved a Vermont Rapid Assessment Method (VRAM) survey and natural community mapping per the Wetland, Woodland, Wildland natural community classification system (Thomson and Sorenson, 2005). Many Level 2 assessments also included plant species composition information, and some included estimated percent coverage of species as well. Rapid assessments were done either concurrently with Level 3 assessments or on their own, depending on the site or time of year.

The VRAM is used to characterize the vegetation communities and anthropogenic stressors surrounding the assessment sites. The VRAM combines scores from six metrics assessing: (1) wetland area (size); (2) upland buffers and surrounding land use; (3) hydrology within the wetland; (4) wetland habitat alteration; (5) special wetlands; and (6) plant communities, interspersion, and microtopography. These six metrics combine the wetland's condition, function, and value numeric score for an overall quality score on a scale from 0-100. Scores can range from approximately 20 with significantly disturbed wetlands to 100 in a wetland that is in reference condition, along with high levels of several wetland functions like water filtration and habitat/biodiversity. Scores can also be separated to calculate only condition or function together (VTDEC, 2019). When a plant species list was collected, estimated biological metrics could be calculated as well.

The VRAM was conducted covering all parts of a wetland that were observed during sampling and walking through the site. In general, the VRAM was applied to the wetland area that was sampled during a Level III assessment and its survey “boundaries” were noted. While several vegetation plots may be conducted in one wetland, a VRAM covered the entire contiguous wetland or a subset of the wetland with one targeted vegetation type. In the case of large wetlands, a VRAM may assess only a subset of the wetland with a map indicating the area assessed.

Notes on the ecology and species composition of the site and associated GPS points were taken in the wetland to describe the different natural communities or different types of disturbed wetland found onsite. These were later used to create a natural community map of the survey area (Figure 3). In addition to GPS data, aerial photos and high-resolution LIDAR elevation data were used to establish boundaries of different natural community types. Natural community classification is per Thompson and Sorenson 2005 when possible; in some cases, natural communities were encountered that fell out of the current classification system and were given provisional names. Ecological data from these wetlands (and all other ecology data collected) will be shared with NHI for use in future natural community classifications.

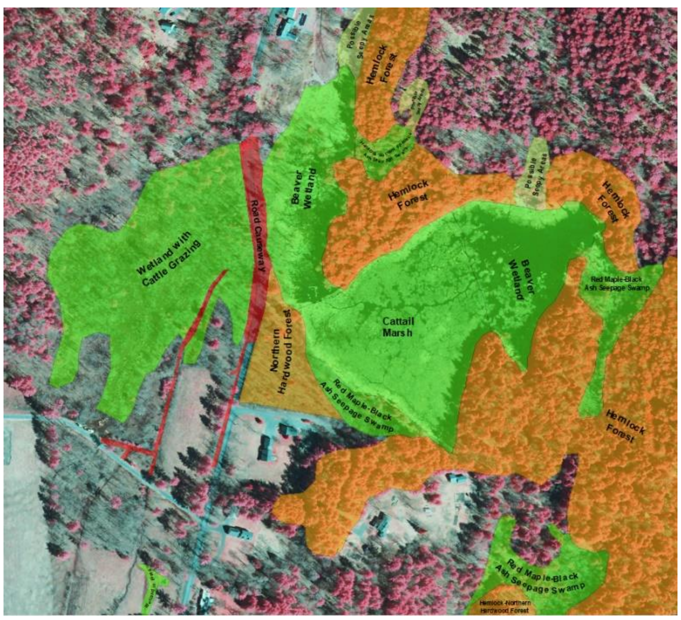


Figure 3: Example of a wetland natural community map. In this map, green areas are wetland, orange areas are upland, yellow may be wetland or upland (not field-verified), and red areas are human-constructed hydrologic modifications.

Special Monitoring Projects

The Program has been participating in several discrete projects since 2017, which includes (1) monitoring restoration sites; (2) monitoring solar development sites; and (3) collecting information for improved wetland mapping.

Wetland Restoration Monitoring

In 2017 the Vermont Wetlands Program initiated a pilot project of monitoring wetland restoration sites and associated wetland reference sites. The Program received funding to monitor, map, and track NRCS wetland reserve easement (WRE) sites using current bioassessment protocols (VTDEC, September 2019) and continued through the 2020 field season. The project focused on wetlands with recent restoration work and pre-restoration sites with the intent of returning to monitor the success of restoration. When available, nearby wetland 'reference' sites were also surveyed for comparative purposes. The goal of the project is to be able to compare restored wetlands with natural wetlands in varying stages of condition and type.

The restoration monitoring was conducted using existing Level 2 and Level 3 bioassessment methodologies. The project included over 100 sampling events throughout Vermont, collecting vegetation data, water quality data, rapid assessments, and creating natural community maps of the sites. An additional metric known as the Restoration Indicators of Success (RIS) was developed in 2019 by the Program and uses VRAM metrics to attain an index of how successful individual restoration sites are (VTDEC, October 2019).

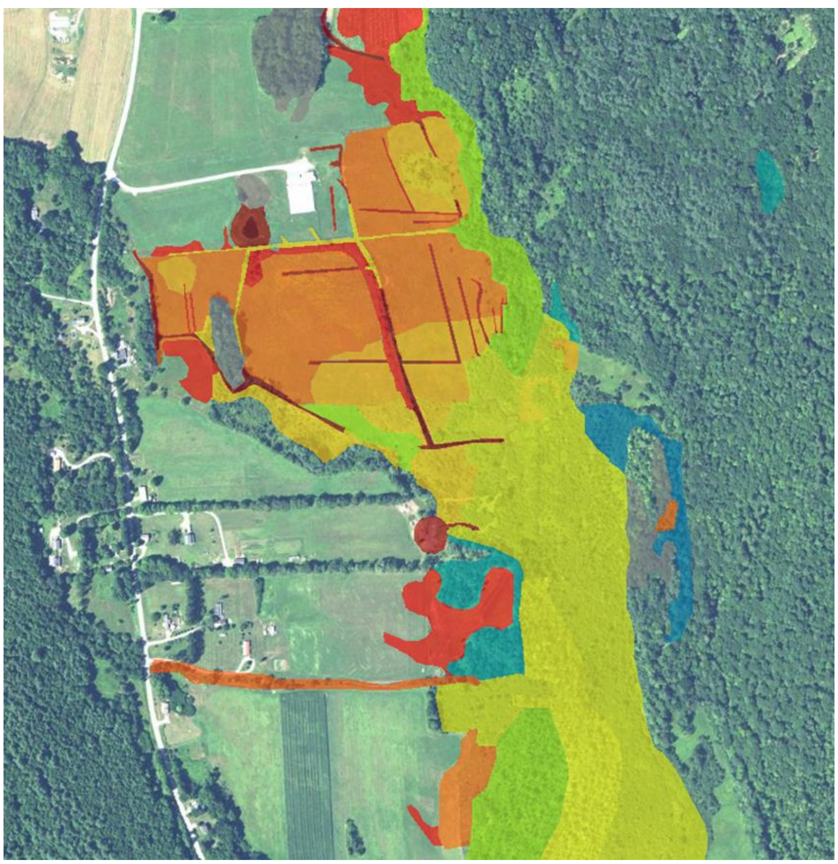


Figure 4: high-resolution mapping of a restoration site.

Solar Development Monitoring in Wet Meadows

In 2020, the Program was transferred sampling responsibilities from external consultants (Arrowwood Environmental; Fitzgerald Environmental Associates, LLC.) to continue monitoring the effects solar developments have on wet meadow type wetlands at permitted project sites. The study was implemented in 2018 to evaluate whether solar development impairs wetland function in agricultural settings (Lew-Smith and Bartlett, 2019). The methodology was designed to include the monitoring of vegetation, hydrology, and certain soil characteristics to determine if wetland function was impacted. Five wetland sites with permitted solar developments were used for the study. Vegetation monitoring required nine, 1 x 1 meter-squared study plots per site: three plots in the Wetland Shade Treatment area; three plots in the Wetland Sun Treatment area (for a total of six plots within the impacted sampling area); and three plots located in the reference vegetation area (outside of the impacted area). Plants were identified to the species level and total vegetation cover, species diversity, presence of Non-Native Invasive Species (NNIS), and plant form were collected. Hydrology monitoring comprised of location, size, and severity of surface runoff and erosion features were documented. In addition to characterizing the soil profile at each site, soil compaction and infiltration measurements were conducted, and representative composite soil samples were collected within the impacted area and reference area. Detailed natural community mapping and VRAM assessments were also conducted for each site. The vegetation data was compiled and added to the Bioassessment Database.

Ground Truthing for Wetland Mapping Projects

The Wetlands Program co-conducted an intensive NWI+ wetland mapping project for the Otter Creek Basin with external consultants in 2019 and 2020. As part of the effort for updated wetland mapping in the watershed, ground truthing was conducted by bioassessment staff. Most of the data was entered into an ArcGIS Collector map and/or observations on iNaturalist.org. However, VRAM and rapid assessments were conducted when time and conditions permitted, and these were added to the Bioassessment Database.

Data Analysis Methods

Precision and Accuracy

Quality Assurance/Quality Control (QAQC) was conducted per the Quality Assurance Project Plan (QAPP) (VTDEC, September 2019). Vegetation QAQC consisted of having more than one qualified botanist at over 10% of the sites. Both botanists reviewed the same plot and verified plant ID and percent cover.

Water chemistry QAQC occurred both during laboratory analysis and in the field at a sampling site. Samples for laboratory analysis were prepared by bioassessment staff, including using deionized water blanks and running a set of duplicate and ‘spiked’ samples. Results of the duplicates and spikes are compared with acceptable error limits as defined in the QAPP.

The Hydrolab was calibrated weekly for pH and conductivity in the lab. Dissolved oxygen was calibrated in the field before each measurement. Errors observed during calibration were noted. In addition, conductivity is measured both by the lab and with a HydroLab, allowing a comparison of results.

QAQC was also conducted on VRAM assessments by having several ecologists fill out VRAM forms independently and compare results.

Data Analysis

Data analysis was conducted on data collected during the 2018, 2019 and 2020 field seasons and included over 150 sets of Level 2 and Level 3 assessments and 395 VRAM assessments.

Data from previous sampling seasons and data from the NHI were also available for reference with a total of 1,773 data points from various sources. This analysis focused on VRAM and data collected from vegetation plots for 2018, 2019, and 2020. The Coefficient of Conservatism (CoC) score and VRAM score were used as indicators of wetland condition, with correlation coefficients and R squared values calculated for other metrics to discern correlations with wetland condition and function. Correlation between CoC and VRAM was used to calibrate their effectiveness as indicators. Additional statistical analysis including a greater number of indices and more powerful statistical tests is planned for winter of 2021.

Biological Data

Vegetation results were analyzed using a variety of biological metrics for the development of wetland biocriteria. One of the metrics used was the Coefficient of Conservatism (CoC) from the Floristic Quality Assessment (FQA) Index. The CoC is a numeric score assigned to every plant species on a scale of 0 to 10, with 0 representing species with a wide range of ecological tolerances and non-native taxa, and 10 representing species with a very narrow range of ecological tolerances. These values can be compiled and averaged from a plant community to provide a score that indicates the extent to which the wetland is tolerating and recovering from disturbance. The score can be adjusted to take into account relative percent cover of each species (cover-weighted CoC).

CoC scores are strongly influenced by wetland type. For example, peatlands attained very high scores and floodplain forests often scored poorly relative to other wetland types (Kutcher, 2013, Shappell et. al 2016, and data associated with this report). In order to account for this variation, all wetlands are classified using a the Vermont NHI system based on the book Wetlands, Woodlands, Wildlands (Thomson and Sorenson, 2005). This classification system primarily refers to natural ecosystems; provisional classification units were created for more disturbed sites such as successional sites and managed wetlands. This allows an individual wetland to be compared with other wetlands of similar vegetation type.

In addition to the CoC other metrics evaluated were based on environmental factors (temperature, substrate pH, wetness), and wetland functions and values (wildlife value, aesthetic appeal). These factors are in development and are used to compare with other data to discern whether they have useful predictive value.

Water Chemistry Data

Water chemistry data has been entered into the Access database. While metrics using water chemistry data have not yet been compiled, the data was analyzed to discern any correlations with other metrics, such as VRAM metrics, CoC, or other wetland traits. Maximum, minimum, and average numbers have also been calculated for each substance.

Site Reports

Site reports were prepared for each Level 3 site and a few selected Level 2 sites. The reports included a description of the vegetation, soils, and hydrology of the site; a plant species list; information on any human disturbance to the site; and management recommendations. Photos and maps were also be included.

Results

Physical & Chemical - Water Chemistry

Sixty sets of water samples from Level 3 assessment sites were collected between 2018-2020. Twenty seven sets were collected in 2018 and 25 in 2019; only 8 sets were collected in 2020 due to moderate drought conditions and staffing issues associated with the COVID pandemic.

Table 1: Water quality statistics

		Statistics:					Correlation coefficient with:	
	Sample Count	Max Value	Min Value	Average	Median	Standard Deviation	VRAM	CoC
pH	59	8.45	5.65	7.10	7.09	0.64	-0.21	-0.27
Temp (c)	58	29.05	11.00	20.25	20.21	3.92	.21	.22
Dissolved Oxygen %	51	137.00	0.00	67.84	73.90	34.11	-0.17	-0.14
Dissolved Oxygen MG/L	49	13.74	0.00	5.83	6.77	3.34	-0.19	-0.22
Conductivity	60	835.00	11.40	241.82	193.00	184.59	-0.04	-0.29
Alkalinity mg CaCO3/L	57	222.00	2.50	83.46	72.00	58.62	-0.32	-0.28
Aluminum ug/l	59	6180.00	20.00	194.66	45.90	801.57	-0.12	-0.06
Calcium mg/l	59	79.00	1.06	27.85	22.35	20.98	-0.28	-0.27
Chloride - Water mg/l	59	161.00	0.10	19.94	9.07	31.33	-0.06	-0.21
Iron ug/l	59	6813.00	50.00	1050.40	438.00	1622.40	-0.19	0.00
Magnesium mg/l	59	19.67	0.35	5.41	4.54	4.48	-0.39	-0.44
Manganese ug/l	59	1963.00	5.00	227.84	118.44	342.00	0.03	0.06
Nitrate + Nitrite mg-N/l	58	1.81	0.05	0.15	0.05	0.29	-0.15	-0.34
N total mg/l	60	2.89	0.14	0.73	0.49	0.68	-0.21	-0.15
P Digested ug P/l	59	725.00	5.00	63.99	30.10	113.04	-0.22	-0.09
P filtered/dig ug P/l	60	467.00	6.00	35.88	17.35	65.48	-0.22	-0.13
Potassium mg/l	59	8.44	0.12	1.20	0.88	1.36	-0.24	-0.31
Sodium mg/l	59	91.22	0.48	12.54	6.08	17.90	-0.10	-0.23
Solids, Total Suspended mg/l	58	79.40	2.00	8.07	3.70	12.19	-0.14	-0.21
Sulfate mg/l	59	17.93	0.25	3.78	2.50	3.93	-0.18	-0.29
Total Calculated Hardness mg CaCO3/L	59	250.87	4.09	91.80	71.15	66.00	-0.33	-0.34
Turbidity NTU	59	171.00	0.26	10.62	2.34	28.71	-0.01	0.04
Dissolved Organic Carbon	8	28.08	2.63	11.71	7.35	9.82		
Dissolved Inorganic Carbon	8	43.50	5.18	15.13	8.77	14.54		

Table 1 (above) provides a summary of the water chemistry data. The correlation coefficient between water chemistry parameters, VRAM, and CoC scores were calculated, and the P score of these correlation coefficients tested at the 0.05 threshold for statistical significance.

The pH levels ranged from 8.45 at Lake Carmi (a lake with impaired water quality) to 5.65 at an outflow to an acidic wetland near Little Elmore Pond. Based on previous sampling, the Program has observed high pH in some larger waterways with poor water quality such as Lake Champlain, Lake Carmi, and the lower Connecticut River valley; however, high pH is also known and has been observed to correspond with mineral-rich calcareous springs, as with cedar swamps and rich fens (Thompson and Sorenson, 2005). Low pH water was observed in wetlands such as bogs and spruce swamps; precipitation-fed wetlands with sphagnum moss and softwood cover are known to be the most acidic wetlands in Vermont (Thompson and Sorenson, 2005). There was no statistically significant correlation between pH and CoC or VRAM score.

Conductivity follows a similar pattern but may be associated with road salt, especially when paired with elevated levels of sodium and chloride. The highest conductivity of 835 ohms/cm was observed in a stream-fed wetland downstream from an urban area in Milton; this site also had the highest sodium and chloride measurements of any set of samples (91.22 mg/l sodium and 161 mg/l chloride). The site was sampled relatively early in the field season (July 2, 2018) and after a heavy rain; these factors may also have contributed to higher levels of road salt entering the wetland. Low sodium and chloride measurements under 2 mg/l were recorded for 18 sites, mostly including sites away from roads or other development. Higher conductivity had a statistically significant correlation with lower CoC score, but not with VRAM score.

Nitrogen and phosphorous levels in waterways can be elevated in areas where runoff enters the waterways from human sources such as farm fields, urban landscaping, and sewage treatment plants. , The highest levels of nitrogen and phosphorus were detected in sample locations as adjacent or influenced by Lake Champlain and the lower Otter Creek. The highest nitrogen and phosphorus measurements came from a Lakeside Floodplain Forest on an inlet of Lake Champlain, near Chimney Point, with measurements of 2.89 mg/l of nitrogen, 725 ug/l digested phosphorus and 4.67 ug/l filtered and digested phosphorous. Turbidity, a general measure of substances suspended in the water, was also very high at this same Lake Champlain site. Other sites that had high nitrogen and phosphorus values were taken from sites in the lower Otter Creek watershed in association with recently established restoration sites that had recent or on-going agricultural activities. Conversely, the lowest nitrogen and phosphorus values came from sites with primarily forested watersheds including a beaver wetland in the central Green Mountains near Shrewsbury and a seepage forest in the headwaters of Berlin Pond in Northfield. There were no statistically significant correlations between these metrics, CoC or VRAM, except a weakly significant connection between elevated nitrite levels and lower CoC scores.

The quantities of earth metals varied widely from site to site. The Lakeside Floodplain Forest at Chimney Point described above also had high levels of many metals, including 6180 ug/l of aluminum which is an order of magnitude higher than the next highest recorded amount, and the highest potassium reading of 8.44 mg/l. The iron and magnesium levels of this site were also very high. However, iron levels were also high at some relatively intact sites. The highest iron level of 6813 ug/l was observed in the headwaters of the Ottaqueechee River in Killington Flats. This may be related to substantial recent erosion and deposition just upstream associated with tropical storm Irene flooding. High iron values were also found at the Chimney Point site at 6504 ug/l. A peaty beaver wetland in good condition at Reading Pond also had high values of iron (6405 ug/l). The highest magnesium value of 19.67 mg/L was recorded at a disturbed wetland in Bennington but this is likely related to the presence of copious mineral springs. The highest levels of potassium were found at the Chimney Point site as well. Low levels of earth metals were found at less disturbed sites with low mineral content in the bedrock and groundwater. For example, the water samples collected from a small seep on the slopes of Belvedere

Mountain had low to undetectable quantities of allof the metals and most other parameters. Interestingly, a calcium-rich seep-fed stream in Dorset Marsh also had very low levels of most metals. Magnesium was found to have a statistically significant correlation with lower CoC and VRAM scores, but no this was not found with aluminum or iron.

VRAM

A total of 446 VRAM assessments were conducted from 2018 through 2020, as a combination of all Level 2 and all Level 3 assessments. VRAM score results provided condition ranges from 13 to 99 out of a maximum of 100 points (Figure 5). The VRAM indicates the lower the score, the greater degree of disturbance. Sites with scores between 85 and 100 are considered reference quality; moderate condition between 65 and 84; and disturbed condition 64 and lower.

The highest score was 99 at a wetland complex near Bruce Pond in Sheffield. The lowest score was 13 in a wetland in active row crop use in Charlotte. Mid-range scores between 58 and 84 were the most common scores. However, there was a localized maxima of wetlands scoring between 30 and 40, most likely related to the large number of recently initiated restoration sites that were included in the VRAM totals. The median VRAM score was 64.

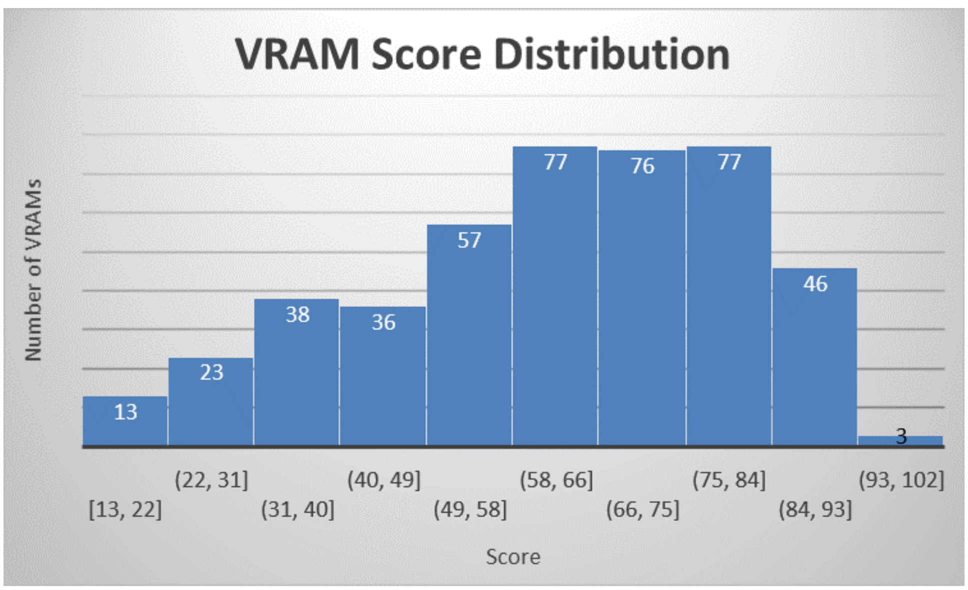


Figure 5: VRAM score distribution for 2018-2020 time period

The VRAM data represent a very small and non-random percentage of the wetlands in Vermont and cannot directly infer the condition or function of the state's wetlands. However, the data sheds some light on general wetland condition and function. For example, to achieve a score of 90 or more, a wetland must have both high function and condition and also contain rare species and/ or exemplary natural communities. Wetlands that meet all these criteria are uncommon. However, there are many wetlands with moderate to high function, value, and condition in Vermont, accounting for the high number of VRAMs (181) with scores from 65 to 85. Scores in the 50s and low 60s usually indicate wetlands with higher levels of human disturbance but still significant function, or conversely wetlands in relatively good condition but with very small size and lower levels of wetland function. Wetlands that score in the 30s and 40s tend to be abandoned fields and similar early successional sites but not fully modified settings. Scores lower than 30 usually indicate situations such as active farm field, pasture, or hayfield; constructed features such as stormwater ponds; and small urban wetland fragments. A summary of basic VRAM statistics is found in Table 2.

.

Table 2: Basic VRAM Statistics

VRAM Basic Statistics: 2018-2020	
Count	446
Max Score	99
Min Score	13
Median Score	64
Mean Score	61.5

Biological – Vegetation

Throughout the 2018-2020 field seasons, data was collected from 158 vegetation plots at Level 3 sites. Some Level 3 sites had more than one plot to account for multiple vegetation communities present within the wetland. Sixty-three vegetation plots were conducted in 2018; 57 in 2019; and 38 in 2020. The lower sample number in the 2020 field season was due to the logistical issues created by the Covid-19 pandemic.

The mean Coefficient of Conservatism (CoC) score was calculated for each vegetation plot. The scores were generally lower in disturbed sites than undisturbed sites but can also be influenced by natural disturbance such as beaver activity. The highest-scoring sites were open peatland.

The lowest CoC score was 2.00 in a near-monoculture of reed canary grass (*Phalaris arundinacea*) at Munson Flats in Colchester, a pre-restoration site. The highest score was 7.63 at a pristine kettlehole bog in Morgan near the Pherrins River. The median CoC score was 4.18. In general, the CoC scores show a bimodal distribution with 37 sites scoring between 3.2 and 3.8; 41 sites scoring from 4.4 to 5.0; but only 29 sites from 3.8 to 4.4, with the greatest number of sites either being in the mid 3’s or the upper 4’s with a lower number of plots in the upper 3s and lower 4s (Figure 6).

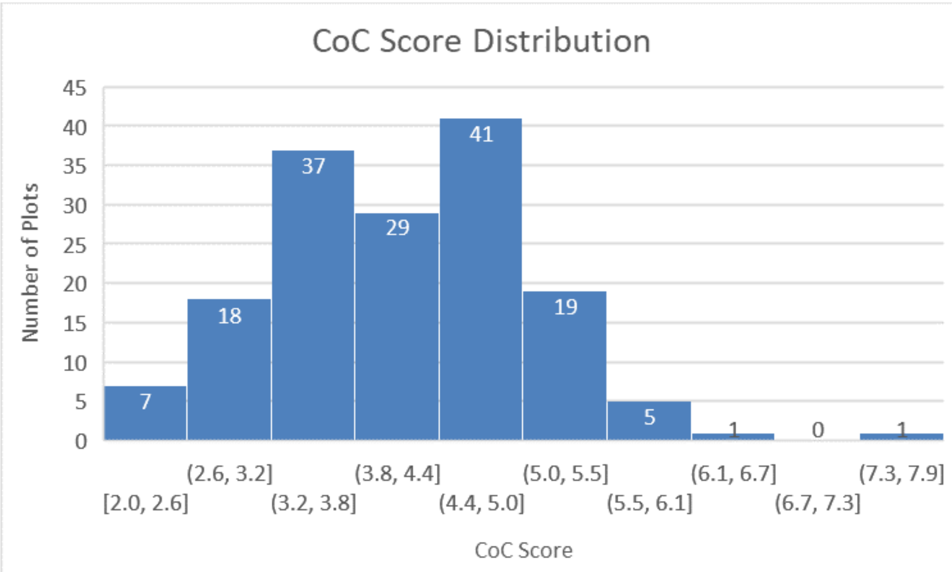


Figure 6: Average CoC for Level III Plots, 2018-2020

Based on field data and observations, scores below 3.0 indicate high levels of disturbance, usually in the form of early successional emergent or shrub wetlands with ruderal and often non-native invasive species. Scores between 3.0 and 4.0 generally indicate wetlands with moderate levels of human disturbance or very high levels of natural disturbance. Scores between 4.0 and 5.0 generally indicate good condition wetlands, but this varies based on natural community type. For example, a score of 4.5 for a bog would indicate very poor condition whereas such a score for a floodplain forest with abundant natural disturbance would indicate excellent condition. Scores above 5.0 generally only occur in wetlands with high numbers of specialized species including open peatlands, buttonbush swamps, wild rice marshes, and excellent-condition softwood swamps.

Table 3: Average CoC statistics for Level III plots over the 2018-2020 time period.

CoC Stats for 2018-2020	
Count	158
Max	7.63
Min	2
Median	4.18
Mean	4.09

An Army Corps of Engineers (ACOE) wetness number is also calculated using the ACOE National Wetland Plant List. Plant species are classified as obligate upland (-5); facultative upland (-3); facultative (0); facultative wetland (3); and obligate wetland (5). (Lichvar, et. Al 2016, ACOE 2018). An average of these numbers for all plant species in a plot can approximate how wet the site is.

A plot score of 5 indicates only obligate wetland plants are present. A score of 5 was attained at four lakeshore wetlands along Lake Champlain and Lake Carmi, including wild rice marshes at the Missisquoi Delta and at Ward Marsh near the outlet of Otter Creek. The lowest score of -1.63 was attained at a plot in a restoration site in Bethel. This site may not currently qualify as wetland based on the wetness score but is in an area proposed for hydrological restoration that will eventually make the site much wetter. Two high-gradient floodplain forests also scored below 0, which is not unusual for this natural community type which can be either wetland or upland depending on the floodplain's elevation relative to the waterway. The median score for the vegetation plots assessed between 2018 and 2020 was 2.97, with the highest number of plots in the range of 3 to 4 (Figure 7, Table 4).

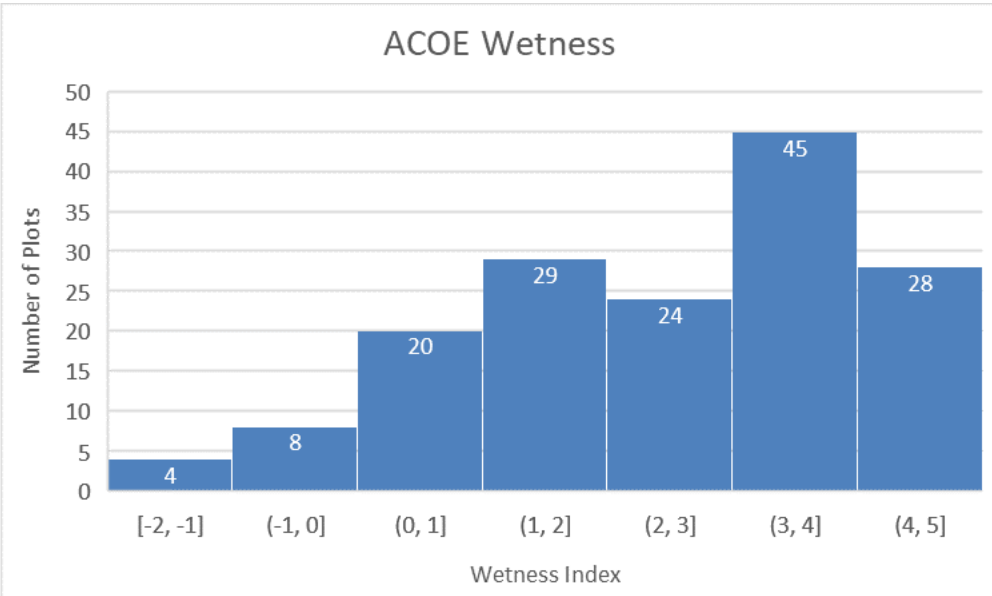


Figure 7: Average ACOE Wetness score for Level III plots, 2018-2020.

Table 4: Average ACOE Wetness statistics for Level III plots from 2018-2020.

Wetness Stats	
Count	158
Max	5
Min	-1.631579
Median	2.97
Mean	2.69

Correlations Between Assessment Metrics

Correlations between metrics derived from Level II and Level III assessments show patterns in wetland condition, function, and stressors. Correlation can also be used to verify different metrics are similarly tracking wetland condition and function. However, it is important to note that correlation alone cannot imply causation and more analysis is needed to define the significance of these results.

There were only a few weak correlations between water quality metrics and wetland condition during the 2018-2020 time period. The broader pool of all wetland water chemistry data points at a possible link between wetland condition (VRAM score, mean CoC) and levels of sodium, chloride, and turbidity. Further data collection and more robust statistical analysis is needed.

One notable correlation in the data is between the mean CoC score and the VRAM score. The correlation coefficient between the two metrics based on the 2018 data is 0.67 (out of a maximum of 1) with a P value of <0.00001 indicating strong statistical significance (the threshold of significance is 0.05). While the CoC scores are derived from Level 3 assessments and the VRAM scores are obtained by rapid Level 2 assessments, both can be used to estimate wetland condition. Although more analysis is needed, it appears that the Level 2 assessment protocols (VRAM) are validated by and calibrated to Level 3 assessments.

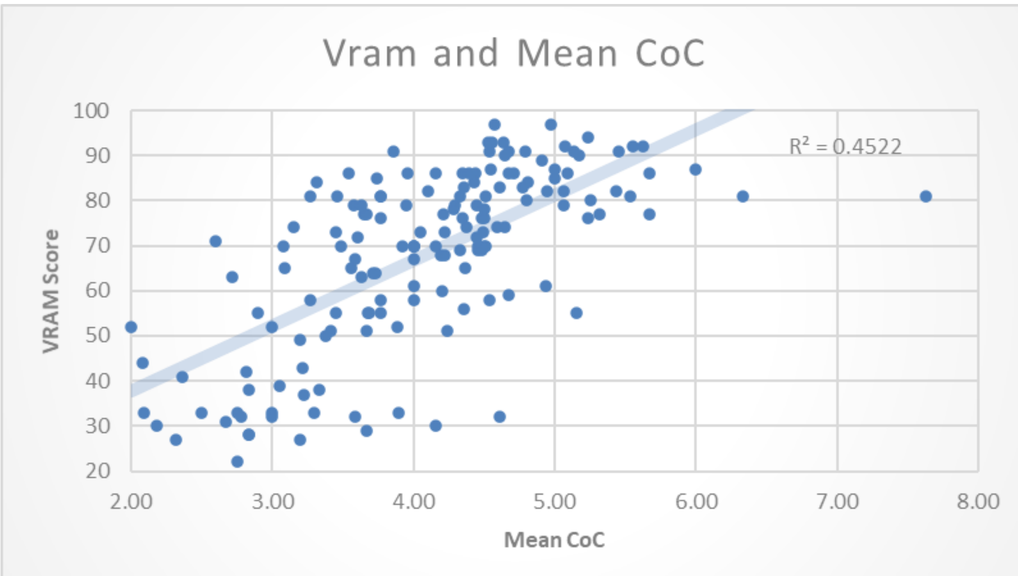


Figure 8: Scatter plot showing the correlation between VRAM and Mean CoC for the 2018-2020 vegetation plots.

Figure 8 presents the correlation between VRAM and mean CoC. CoC Scores below approximately 2.5 are strongly correlated with low VRAM scores (below 50). CoC scores between 2.75 and 3.5 ranged widely in VRAM scores, from below 30 to over 80, and may be less predictive of wetland condition than other ranges of score. CoC scores between 3.5 and 4.5 typically have VRAM scores between 50 and 90 but the difference between VRAM scores associated with CoC scores ranging from 3.5-4.0 is minimal. There is also a subset of plots in this CoC range with low VRAM scores (score of 30) which may indicate pockets of relatively good-condition wetland within more disturbed wetlands. This may be due to the vegetation plots presenting a smaller subset of the larger Level II assessment area. CoC scores from 4.5 to 5 are generally associated with VRAM scores between 70 and 95, and CoC scores above 5 are almost always associated with VRAM scores above 75. This may indicate discrete categories of wetland metrics with 'breaking points' at which further disturbance can result in significant loss of condition, function, and value.

The correlation coefficient of 0.32 and R squared of 0.000042 between wetness and mean CoC score indicate a statistically significant correlation with "wetter" wetlands scoring higher for CoC. However, as Figure 9 shows there is not a strong trend. Notably, the correlation appears to be driven by plots with mean CoC above 5.0, most of which are saturated peaty wetlands and based on this data primarily support obligate wetland species.

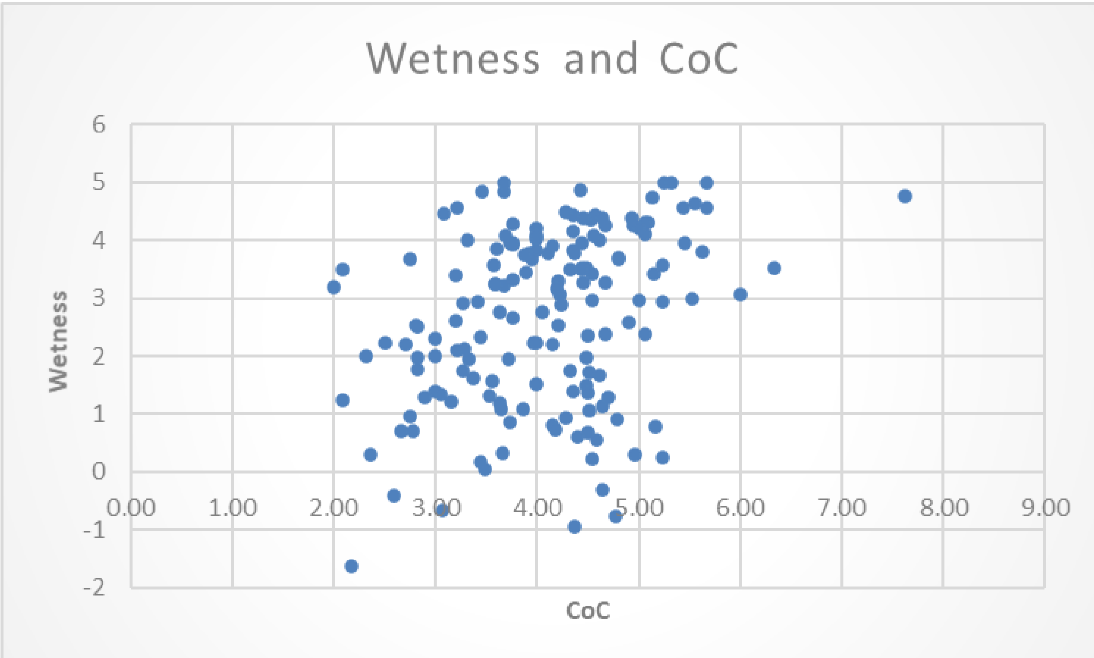


Figure9: Scatter plot of wetness index and CoC

Wetland Restoration Monitoring

A subset of Level II and Level III assessments were conducted in ongoing or proposed restoration sites and nearby 'reference' wetlands for the restoration monitoring project described earlier in this report. The Program was tasked with determining the best methods for tracking wetland restoration project success. Methods include VRAM assessments, collecting plant information, water chemistry sampling (when appropriate), and detailed wetland mapping for each site.

Over the winter of 2018-2019, preliminary analysis was conducted on data from 76 sites including 25 Level III assessments and 66 VRAM assessments. Our conclusion was based on the need for monitoring a large number of sites, the VRAM and an adapted set of data points collected using this protocol known as the "Indicators of Success" is the most appropriate tool for implementation in the short-term to document wetland restoration progress (VTDEC, October 2019). In particular, the Restoration Indicators of Success focus on wetland buffer; human alterations to habitat, substrate, and hydrology; diversity of habitat types; cover of invasive plant species; and microtopographic habitat features. As restoration projects expand across the state, implementing more detailed, but resource-intensive surveys such as permanent vegetation plots may also be desirable. Moving towards this goal, additional vegetation plots and VRAM assessments were conducted in and near restoration sites in 2019 and 2020.

In brief, wetlands were divided into degraded (disturbed fields with no restoration yet occurring); recovering (successional wetlands regrowing on their own, usually in the form of shrub swamps); reference sites adjacent to restoration sites but in mostly intact condition; and restoration sites usually in their early stages. The VRAM scores showed strong differentiation of scores based on this categorization (Figure 10). The VRAM scores also did show signs of increasing over time as restoration sites were implemented (Figure 11). A look at the Restoration Indicators of Success index from a subset of the wetlands surveyed showed an even stronger connection to management type (Figure 12). Further information is available in the October 2019 report with updated figures slated to be released along with a more detailed restoration monitoring report near the end of 2021.

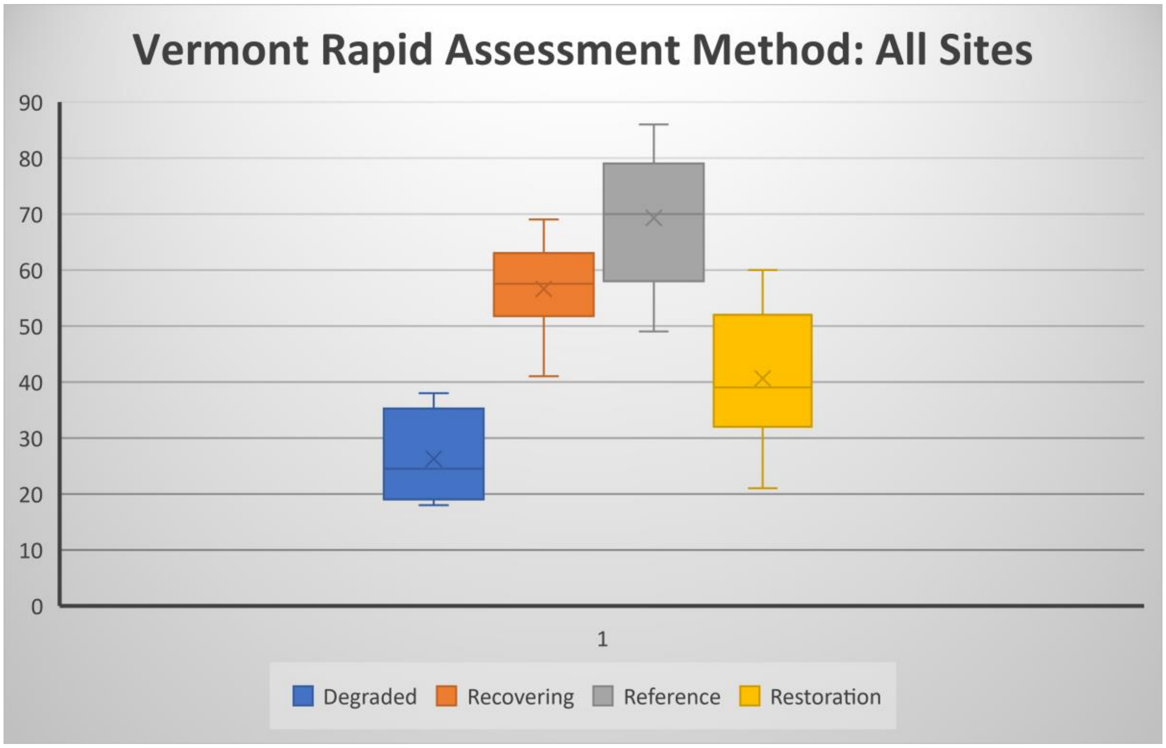


Figure 9: Average VRAM scores for different wetland types within the restoration sampling project, 2018-2020 time period.

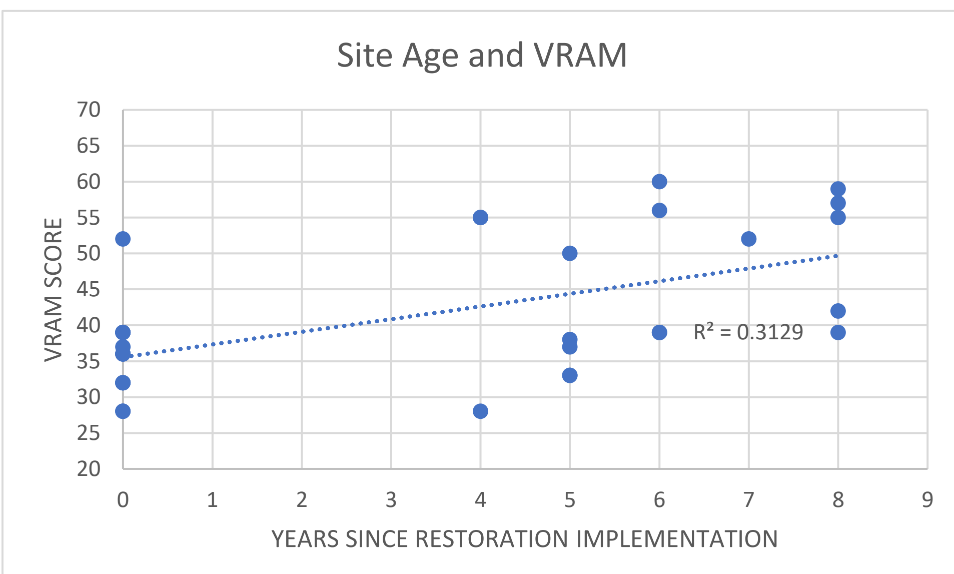


Figure 10: VRAM scores on average did increase over time as restoration proceeded

Figure 11: Restoration Indicators of Success numbers for reference and restoration sites.

Solar Development Monitoring

Vegetation, hydrology, and soils data were collected at five study sites associated permitted solar development in wetlands. A report was prepared in 2020 based on the 2019 and 2020 data. Average vegetation percent cover was highest in Reference Plots (agricultural wetlands without solar panels), lowest in the Shade Treatment Plots, and intermediate in sites in the Sun Treatment Plots. Average species diversity was highest in the Sun Treatment Plots and similar but lower in the Shade Treatment and Reference Plots The shaded plots had a higher component of forb plant species and a lower component of graminoids compared with the other plot types. This may indicate the shading from the solar panels as well as proximity has some effect on the wetlands with the shade likely being the most substantial. However, the results at this point in time do not indicate what type of treatment is "better" or "worse" for wet meadow wetland vegetation. The mean CoC scores of the vegetation plots were calculated to determine if there were any differences in condition between the three treatment types. The average CoC for the sites within solar farms (Shade Treatment and Sun Treatment combined) was around 1.91. This was higher than the average CoC of 1.1 for wetlands in active hayfields (Reference), but significantly lower than that of successional meadows (Reference) that had been cleared in the past but were naturalizing with an average CoC score of 3.6. Since the solar sites were previously managed as hayfields or row crops, this may indicate the wetland's condition is better in solar sites than in active hayfields. However, it is unclear if the score of a solar site could reach that of a successional wet meadow. VRAM scores showed a similar trend.

The hydrological and soil monitoring have been less conclusive than the vegetation monitoring during this period. The hydrological monitoring did not show signs of significant erosion, though some areas of rutting and exposed soil were present perhaps linked to ongoing site maintenance. Most of the soil monitoring results have not yet yielded significant results either, but the soil compaction measurement showed significant variation with more compacted soils in hayfields than solar sites and within solar sites more compacted soils in the pathways between the panels than underneath them. Preliminary 2021 results echo this trend as well.

Anecdotally the condition of wetlands in solar sites varied widely based on management technique. For example, one site that was managed as a mowed lawn (frequent management) under solar panels scored very poorly (CoC of 1.2), lower than most of the hayfields), whereas sites where non-native species were managed with scattered woody species scored higher (CoC of 2.0) and were on average in better condition than the hayfield wetlands. At this point in the study, the results seem to indicate that the vegetation management of a wet meadow may have more impact on wetland condition than the physical presence of solar panels. More sites, data, and time is needed to verify these early findings.

Conclusions and Program Recommendations

The 2018-2020 time period presented significant challenges, including the COVID-19 pandemic, the state environmental lab and office facilities moving, and both essential bioassessment staff members going on parental leave during certain field season. Despite that, the period was very successful, with results exceeding grant requirements in all areas. Efforts continued with (1) Rotational basin sampling; (2) restoration monitoring (3) expanding biocriteria development;(4) creating a new and more versatile database; (5) solar site monitoring; (6) enhanced wetland mapping through map additions, modeling, and ground truthing; and (7) multiple outreach and education events, including many one-on-one visits to wetlands with landowners. Use of technology was expanded including increased use of data collection with smartphone apps and improvements in GIS mapping. The wide spectrum of the condition gradient was sampled from the most disturbed agricultural wetlands (including a lawn) to some of New England's most intact, pristine wetlands.

The results from the last three years of sampling continue to convey the same messages as previous years. CoC can be a useful tool in indicating wetland condition, but with caveats. VRAM is very useful for rapidly assessing wetland condition and function but cannot necessarily be used to imply condition on a watershed level. The importance of accurate and precise mapping was underscored. The value of restoration projects was reaffirmed.

Future plans include continuation of rotational basin and restoration site monitoring; continued work on improving and expanding wetland mapping; additional development of biocriteria including a wetland specific customized CoC index, wetness, temperature, and pH metrics for each plant species; expanded database functionality; and additional capacity for more advanced statistical analysis. Further connections with landowners, conservation entities, schools, town-level government, and other such groups will also improve not only the knowledge held by the Wetlands program but by the citizens and stakeholders of the state as well.

Two other survey methods sometimes employed for wetlands are stratified random sampling based on wetland maps and long-term sentinel plots. Stratified random sampling has not been feasible thus far because the wetland mapping in Vermont is very poor – a large number of wetlands are not represented in the mapping and certain wetland types such as softwood swamps are underrepresented leading to bias. It has been used to some extent through participation in the National Wetland Condition Assessment (NWCA), but this has been observed to skew towards certain wetland types and involve multiple site visits that result in no sampleable wetland found. However, with Vermont's wetland mapping undergoing updates and significant improvement, stratified random sampling may become more feasible, and by sing this method to chose some of the wetland sites, it would be possible to make more inferences as to the condition of wetlands by rotational basin. Long-term plots have also proven problematic when implemented for the solar study, because markers such as rebar are buried in thatch, removed by freeze-thaw processes, or even create hazards in areas of site maintenance; that being said it may be possible to anchor plots off of more permanent features or use rebar markers in less dynamic wetlands and establish such plots in some cases.

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Appendix 1: Index of survey sites, 2018-2020.

Level Surveys, 2018-2020			
PlotName	**Year**	**Date**	**Natural_Community**
TMBR01	2018	6/14/2018	Reed Canary Grass Meadow
TMBR02	2018	6/14/2018	Silver Maple-Sensitive Fern Riverine Floodplain Forest
MUFL01	2018	6/18/2018	Reed Canary Grass Meadow
MUFOL02	2018	6/18/2018	Early Successional Floodplain Forest
Pomainville Swamp (POMO01)	2018	6/20/2018	Red Maple-Black Ash Seepage Swamp
Pomainville Restoration Area (POMO02)	2018	6/20/2018	Reed Canary Grass Meadow
Lomas Green Ash Swamp	2018	6/21/2018	Disturbed Wet Clayplain Forest
Lomas Disturbed Meadow	2018	6/21/2018	Clayplain Meadow
Lomas Scirpus Marsh	2018	6/21/2018	Clayplain Meadow
Goodrich Restoration Site (GOOD02)	2018	6/25/2018	Reed Canary Grass Meadow
Goodrich E Ash Swamp (GOOD01)	2018	6/25/2018	Maple-Green Ash Swamp
Goose Pond Wetland	2018	6/27/2018	Shallow Emergent Marsh
Roche Floodplain Forest/Sedge Meadow	2018	6/28/2018	Sedge Meadow
Roche Restoration Site	2018	6/28/2018	Disturbed Sedge Meadow
Lamoille River Trib 4 (LMTR01)	2018	7/2/2018	Alluvial Shrub Swamp
McGowan Brook Wetland (MGBR01)	2018	7/9/2018	Alluvial Shrub Swamp
Hazens Notch Wetland - Seepage Swamp	2018	7/11/2018	Hemlock-Balsam Fir-Black Ash Seepage Swamp
Hazens Notch Wetland - Beaver Meadow	2018	7/11/2018	Beaver Wetland
Milton Town Forest Swamp	2018	7/12/2018	Red Maple-Sphagnum Acidic Basin Swamp
Lamoreau Mixed herbaceous Meadow	2018	7/16/2018	Successional Meadow
Lamoreau Meadow	2018	7/16/2018	Reed Canary Grass Meadow
Whipstock Hill Rich Fen	2018	7/18/2018	Rich Fen
Whipstock Hill Cattail Marsh	2018	7/18/2018	Purple Loosestrife Meadow
Basin Brook Meadow	2018	7/19/2018	Reed Canary Grass Meadow
Basin Brook Spring	2018	7/19/2018	Seep
Lost Nation Softwood Swamp - HBFBASS (LONA02)	2018	7/23/2018	Hemlock-Balsam Fir-Black Ash Seepage Swamp
Lost Nation Softwood Swamp - SFTS (LONA01)	2018	7/23/2018	Spruce-Fir-Tamarack Swamp
Swanton Village Riparian Corridor	2018	7/25/2018	Stream Channel
Swanton Village Meadow	2018	7/25/2018	Disturbed Sedge Meadow
Manchester Buttonbush Swamp	2018	7/26/2018	Buttonbush Swamp

Level Surveys, 2018-2020			
PlotName	Year	Date	Natural_Community
Page Brook Fen (PABR02)	2018	7/30/2018	Intermediate Fen
Page Brook Cedar Swamp (PABR03)	2018	7/30/2018	Northern White Cedar Swamp
Page Brook Beaver Meadow (PABR01)	2018	7/30/2018	Beaver Wetland
Bradford Putnam Wetland	2018	8/1/2018	Calcareous Red Maple-Tamarack Swamp
LKSH01 - Lake Shaftsbury Cattail Marsh	2018	8/2/2018	Cattail Marsh
Lake Shaftsbury Seep	2018	8/2/2018	Seep
Lake Shaftsbury Beaver Shrub Swamp	2018	8/2/2018	Beaver Wetland
Hubbardton Meadow	2018	8/6/2018	Clayplain Meadow
Hubbardton Cattail Swale	2018	8/6/2018	Constructed Swale
Missisquoi Delta Mud Shore (MSDL01	2018	8/8/2018	River Mud Shore
Missisquoi Delta Buttonbush Swamp (MSDL02)	2018	8/8/2018	Buttonbush Swamp
Missisquoi Delta Wild Rice Marsh (MSDL03) (Missquoi Delta)	2018	8/8/2018	Wild Rice Marsh
Little Elmore Beaver Wetland (LTEL01)	2018	8/9/2018	Beaver Wetland
Little Elmore Spruce Saddle (LTEL02)	2018	8/9/2018	Black Spruce Swamp
Belvedere Sedge Meadow	2018	8/13/2018	Sedge Meadow
Belvedere Scirpus Meadow	2018	8/13/2018	Beaver Wetland
Belvedere Beaver Wetland	2018	8/13/2018	Beaver Wetland
Bullhead Pond Poor Fen	2018	8/15/2018	Poor Fen
Little Mad Tom Brook Wetland	2018	8/15/2018	Willow Shrub Swamp
Youngman Brook Wetland (YNBR01)	2018	8/20/2018	Disturbed Beaver Wetland
Hildene Backwater Wetland (HIFP01)	2018	8/22/2018	Shallow Emergent Marsh
CRMI01 (lake carmi eelgrass)	2018	8/23/2018	Eelgrass-Water Stargrass Bed
CRMI02 (lake carmi rmnwcs)	2018	8/23/2018	Red Maple-Northern White Cedar Swamp
CRMI03 (lake carmi bog)	2018	8/23/2018	Black Spruce Woodland Bog
FLPD01 (Flagg Pond SGSS)	2018	8/27/2018	Sweet Gale Shoreline Swamp
Flagg Pond Fen	2018	8/27/2018	Poor Fen
Flagg Pond Woodland Bog	2018	8/27/2018	Black Spruce Woodland Bog
Dorset Marsh Seepage Swamp	2018	8/28/2018	Calcareous Red Maple-Tamarack Swamp
Dorset Kettlehole Shrub Swamp	2018	8/28/2018	Disturbed Calcareous Shrub Swamp
Fairfield Swamp N	2018	8/30/2018	Poor Fen
Belvedere Long Trail Seep 2	2018	9/5/2018	Seep
Belvedere Long Trail Seep 1	2018	9/5/2018	Seep
Lemon Fair Restoration Site Canarygrass	2018	9/12/2018	Reed Canary Grass Meadow
Lemon Fair Restoration Site Burned Meadow	2018	9/12/2018	Recently Burned Wetland Field

Level Surveys, 2018-2020			
PlotName	Year	Date	Natural_Community
Lemon Fair Green Ash Swamp	2018	9/12/2018	Maple-Green Ash Swamp
Queechee Gorge Beaver Wetland	2019	6/20/2019	Disturbed Beaver Wetland
Queechee Gorge Seepage Swamp	2019	6/20/2019	Red Maple-Black Ash Seepage Swamp
Old Plymouth Mixed Seepage Spruce Swamp	2019	6/24/2019	Softwood-Shrub Seepage Swamp
Old Plymouth Beaver Wetland	2019	6/24/2019	Beaver Wetland
Chimney Point Floodplain Forest	2019	6/26/2019	Lakeside Floodplain Forest
Benson Direct Emergent Marsh/Iris Meadow	2019	7/1/2019	Lakeside Emergent Marsh
Benson Direct Floodplain Forest	2019	7/1/2019	Lakeside Floodplain Forest
Tyson Road Rich Fen	2019	7/3/2019	Rich Fen
REPO01 revisit	2019	7/3/2019	Beaver Wetland
East Creek Deep Marsh	2019	7/8/2019	Lakeside Emergent Marsh
East Creek Lakeside Floodplain Forest	2019	7/8/2019	Lakeside Floodplain Forest
Skitchewaug Basin Swamp	2019	7/10/2019	Hemlock-Sphagnum Acidic Basin Swamp
Skitchewaug Black Gum Swamp	2019	7/10/2019	Red Maple-Black Gum Swamp
Coventry Village Sedge Meadow	2019	7/11/2019	Sedge Meadow
Coventry Village Swale Shore	2019	7/11/2019	Cattail Marsh
Ward Marsh Wild Rice	2019	7/15/2019	Wild Rice Marsh
Ward Marsh Peltandra	2019	7/15/2019	Deep Broadleaf Marsh
Hurricane Brook Boreal Acidic Northern White Cedar	2019	7/18/2019	Boreal Cedar-Sphagnum Swamp
Norton Pond Poor Fen	2019	7/18/2019	Poor Fen
North Clyde Cedar Swamp	2019	7/22/2019	Northern White Cedar Swamp
North Clyde Lakeside Fen	2019	7/22/2019	Intermediate Fen
Cornwall Meadow	2019	7/24/2019	Sedge Meadow
Cornwall Swamp Floodplain Forest	2019	7/24/2019	Silver Maple-Sensitive Fern Riverine Floodplain Forest
Bean Pond Cedar Swamp	2019	7/25/2019	Northern White Cedar Swamp
Bean Pond Floating Shrubs	2019	7/25/2019	Alder Swamp
Killington Flats Meadow	2019	7/29/2019	Sedge Meadow
Killington Flats Shrub Swamp	2019	7/29/2019	Acidic Shrub Swamp
LANI01/ Lake Nineveh Wetland Revisit	2019	7/31/2019	Beaver Wetland
Lake Nineveh Fen	2019	7/31/2019	Intermediate Fen
Barton River Meadow	2019	8/1/2019	Reed Canary Grass Meadow
Barton Floodplain Forest	2019	8/1/2019	Cottonwood-Box Elder-Black Willow Floodplain Forest
Huff Pond Drowned Swamp	2019	8/5/2019	Drowned Swamp
Ferrisburg/Porter Bay Wetland Deep Marsh	2019	8/7/2019	Lakeside Emergent Marsh

Level Surveys, 2018-2020			
PlotName	Year	Date	Natural_Community
Ferrisburg/Porter Bay Wetland Buttonbush	2019	8/7/2019	Lakeside Buttonbush Swamp
Ferrisburg/Porter Bay LFF	2019	8/7/2019	Lakeside Floodplain Forest
Runaway Pond Wetland	2019	8/8/2019	Shallow Emergent Marsh
EACR01 Sedge Meadow	2019	8/12/2019	Sedge Meadow
EACR01 Revisit - Alder Swamp	2019	8/12/2019	Alder Swamp
Paradise Park Sedge Meadow	2019	8/14/2019	Sedge Meadow
Coaticook Clearing (HUBR01 Revisit)	2019	8/19/2019	Acidic Beaver Meadow
Hartland Hill Road Seepage Meadow	2019	8/21/2019	Hemlock-Balsam Fir-Black Ash Seepage Swamp
CCC Seepage Forest	2019	8/22/2019	Seepage Forest
CCC Road Chelone Meadow	2019	8/22/2019	Seepage Meadow
West Rutland Phragmites Forest	2019	8/26/2019	Common Reed Marsh
West Rutland Cedar Swamp	2019	8/26/2019	Northern White Cedar Swamp
West Rutland Alder Swamp	2019	8/26/2019	Alder Swamp
Shaw Marsh Meadow	2019	8/28/2019	Intermediate Fen
Breese Pond Outlet	2019	8/29/2019	Clayplain Meadow
Binding Site Wetland	2019	8/29/2019	Clayplain Meadow
Pico Pond Seepage Swamp	2019	9/5/2019	Hemlock-Balsam Fir-Black Ash Seepage Swamp
Pherrins Saddle	2019	9/6/2019	Circumneutral Beaver Meadow
Pherrins Bog	2019	9/6/2019	Dwarf Shrub Bog
East Creek WMA Cattail Marsh	2019	9/11/2019	Cattail Marsh
East Creek WMA Willow Shrub Swamp	2019	9/11/2019	Willow Shrub Swamp
Poultney Floodplain Forest	2019	9/12/2019	Disturbed Floodplain Forest
South Bay Sweetgale Shoreline Swamp	2019	9/16/2019	Sweet Gale Shoreline Swamp
Hands Cove Floodplain Forest	2019	9/20/2019	Lakeside Floodplain Forest
Round Beaver Wetland	2020	6/17/2020	Acidic Beaver Meadow
Deane Streamside	2020	6/18/2020	Streamside Seep
East Montpelier Mitigation Site 2	2020	6/25/2020	Successional Meadow
Wrightsville Spillway 2	2020	6/29/2020	Rich Meadow
Bruce Pond Bog	2020	7/1/2020	Dwarf Shrub Bog
Grenville Floodplain	2020	7/6/2020	High Gradient Floodplain Forest
Grenville Alluvial Shrub Swamp	2020	7/6/2020	Alluvial Shrub Swamp
Kettle Pond Alder Dollop	2020	7/9/2020	Alder Swamp
Kettle Pond Spruce Dollop	2020	7/9/2020	Black Spruce Woodland Bog
Kettle Pond Beaver Dollop	2020	7/9/2020	Acidic Beaver Meadow
MPV City Forest Sloping Seep	2020	7/13/2020	Seepage Forest

Level Surveys, 2018-2020			
PlotName	Year	Date	Natural_Community
Irish Hill Meadow	2020	7/15/2020	Rich Meadow
Berlin Pond Cedar Swamp	2020	7/16/2020	Northern White Cedar Swamp
Berlin Pond Ash Swamp	2020	7/16/2020	Red Maple-Black Ash Seepage Swamp
Telephone Gap Beaver Meadow	2020	7/20/2020	Bluejoint Beaver Meadow
Telephone Gap Seepage Swamp	2020	7/20/2020	Seep
Irish Hill Willows	2020	7/22/2020	Willow Shrub Swamp
Intervale Populus Patch	2020	7/23/2020	Early Successional Floodplain Forest
Intervale Reed Canary Grass	2020	7/23/2020	Reed Canary Grass Meadow
Intervale Loosestrife	2020	7/23/2020	Purple Loosestrife Meadow
Intervale Silver Maple	2020	7/23/2020	Silver Maple Plantation
Steam Mill Softwood Swamp	2020	7/27/2020	Spruce-Fir-Tamarack Swamp
Hands Mill Alluvial Meadow	2020	7/29/2020	Alluvial Meadow
Randolph Floodplain Forest	2020	7/30/2020	Sugar Maple-Ostrich Fern Riverine Floodplain Forest
Stiles Pond Poor Fen	2020	8/3/2020	Poor Fen
Stiles Pond Beaver Meadow	2020	8/3/2020	Circumneutral Beaver Meadow
Rest Stop Swamp	2020	8/12/2020	Hemlock-Balsam Fir-Black Ash Seepage Swamp
Median Fen	2020	8/12/2020	Intermediate Fen
Hinesberg Restoration Site S	2020	8/13/2020	Successional Meadow
Hinesberg Restoration Site N	2020	8/13/2020	Reed Canary Grass Meadow
Bethel Restoration Site 2	2020	9/2/2020	Alluvial Meadow
Rock River Reference Wetland	2020	9/11/2020	Red or Silver Maple-Green Ash Swamp
Rock River Restoration Site	2020	9/11/2020	Successional Meadow
Fitzgerald Floodplain Forest	2020	9/18/2020	Silver Maple-Ostrich Fern Riverine Floodplain Forest
Fitzgerald Phalaris Field	2020	9/18/2020	Reed Canary Grass Meadow
Fitzgerald Field	2020	9/18/2020	Successional Meadow