Vermont Wetlands Bioassessment Program Restoration Monitoring 2023 Update

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March 27th, 2024

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Introduction

Restoration of wetlands to enhance their condition and functions is an ongoing process in Vermont and are being implemented through the state in various stages. Wetland restoration has been shown to successfully improve the ecosystem services that they provide (1). Until recently, there had not been a consistent, standardized method for efficiently documenting project success. The Vermont Wetlands Program has developed protocols to assess wetland restoration success to fill this gap. These protocols are intended to be used to inform wetland restoration practitioners and stakeholders throughout Vermont, including the Vermont Department of Conservation (DEC) Wetlands Program, Vermont Department of Fish and Wildlife, and the Natural Resources Conservation Service (NRCS) on the success of individual restoration projects and to assess the efficacy of restoration practices.

As part of this project, the Wetlands Bioassessment Program ("Program") examined and utilized various methods of documenting restoration success, including the use of intensive biological surveys and rapid assessments. The Program concluded that the Vermont Rapid Assessment Method (VRAM, 2) and the VRAM-derived Restoration Indicators of Success (RIS, 3) are the best tools to assess and document restoration success, especially when there is a need to monitor many sites. Other plant species-based metrics, such as Coefficient of Conservatism (CoC), are valuable for more detailed assessments.

This report summarizes the cumulative findings of the Program's restoration site monitoring project through the end of 2023.

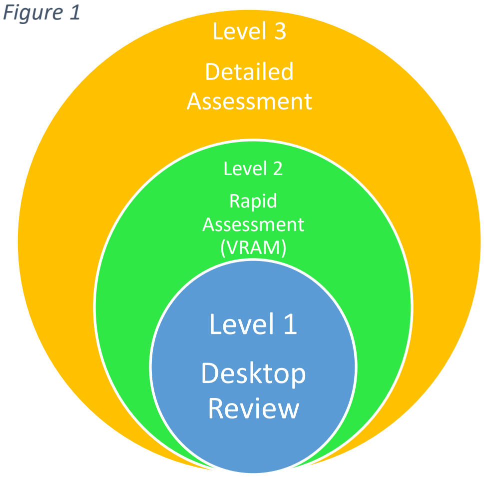
Background

In 2017, the Vermont DEC Wetlands Program initiated a pilot project of monitoring restoration sites and associated reference sites on NRCS Wetland Reserve Easements (WRES). Wetland Reserve Easements are permanent or 30-year easements on parcels that have wetlands which are degraded or converted due to agriculture (4). The project initially focused on collecting data from sites with restoration planned or in progress; however, since 2022 the focus has shifted to revisiting sites that have been previously surveyed. As of 2023, eight sites have been revisited within five years of the first assessment. The Program has also expanded to perform monitoring at other sites in addition to WREs, such as River Corridor Easements, dam removals, and VT DEC-funded Clean Water Initiative Projects.

Restoration monitoring was conducted by the Vermont Wetlands Bioassessment Program, according to standard assessment methodology applied across the state, per the current Quality Assurance Project Plan (QAPP, 5). The Program has sampled hundreds of wetlands throughout Vermont by collecting vegetation, soils, and water quality data; and by conducting rapid assessments and natural community mapping. The restoration site data is being compared with the entire pool of bioassessment data to interpret wetland condition and function metrics. With restoration monitoring taking place for the last 6 years, initial pre- restoration site data is being compared to 5-year follow-up surveys from 2022 and 2023.

Monitoring is conducted at three levels described by the EPA (Figure 1). Level 1 is a broad, landscape level desktop analysis that consists of reviewing air photos, LiDAR elevation data, and other spatial information. Level 1 review is used to discern wetland type and boundary, presence of anthropogenic stressors, and to identify surrounding landscape context. Level 2 assessments employ an in-field rapid assessment using the Vermont Rapid Assessment Method (VRAM), that focuses on wetland condition and function, and evaluates Restoration Indicators of Success. Level 3 assessments are site-specific detailed biological, physical, and chemical assessments. Vegetation plots are sampled in representative areas of the wetland, where all plant species within the plot are identified and the percentage of cover of each species is estimated. The soil is described according to the Army Corps of Engineers (ACOE) Wetland Delineation methodology (6). When surface water that is influential to the wetland's ecology is present, water samples are collected and analyzed at Vermont Agriculture and Environmental Laboratory (VAEL) for a suite of parameters including pH, conductivity, nitrogen, chloride, and phosphorous levels. When possible, restoration site plots are paired with a monitoring plot in a nearby 'reference' wetland that is in a more natural condition.

Figure 1



Analysis of Biocriteria

Preliminary analysis was completed on all restoration data collected from 2017-2023. This included 192 Level 2 rapid assessments and 78 Level 3 assessments (vegetation surveys and soil characterization). Water samples were collected at 11 Level 3 sites, as most Level 3 sites did not have enough surface water to sample. Level 2 and 3 assessment areas were assigned to one of four different wetland site categories:

- *Degraded*: sites with reduced wetland function and without active restoration, such as active agricultural fields within wetlands.
- *Recovering*: sites naturalizing from past disturbance without active restoration activities.
- *Restoration*: sites undergoing or about to undergo active restoration. Active restoration is defined in this study as changes in hydrology; native species planted; and/or invasive plant species control. When possible, both restoration and reference sites were sampled at each site.
- *Reference*: sites in natural, non-managed condition, though not necessarily in pristine condition. Reference sites were chosen to reflect natural community types that would be of the same type, or a similar type as the expected restoration outcome.

Coefficient of Conservativism (CoC)

Level 3 assessments use vegetation as an indicator of biological integrity. This is measured using an index known as the Coefficient of Conservatism (CoC). A CoC score has been assigned to each plant species by a regional expert or group of experts familiar with the flora of geographic region (7), ranging from 0-10, indicating the species' disturbance tolerance. The lower the score, the more tolerant the plant species is to disturbance. Nonnative and invasive species receive a score of 0. Specialist species, such as pitcher plants and rare orchids, receive a score of 10. CoC scores can be used to quantify ecological condition of a given plant community and can be used to assess changes in plant communities from restoration actions over time. For this monitoring project, Average CoC and Cover Weighted CoC (weighting relative cover of each plant species in the calculation) were the two indices used to calculate a score for each vegetation plot. Average CoC consists of the averaged number for all species observed in the plot without taking relative abundance into account, whereas Cover Weighted CoC proportionately weighs the CoC of each species based on its relative area covered in the plot. *For reasons of sample size and consistency, only Restoration and Reference sites are included in this portion of the analysis.*

The Average CoC value for the restoration sites is 3.15, while the average CoC of the reference sites is 3.83 (Figure 2). There is significant variation and some overlap between the highest-scoring restoration sites and the lowest scoring reference sites (See Appendix).

Figure 2: Average CoC of Reference and Restoration Sites

The difference is greater between Cover Weighted CoC scores for reference and restoration sites, with restoration sites averaging 2.69, and reference sites 4.56 (Figure 3). Overlap between the two wetland types was much lower than with Average CoC (the outlier restoration site had unusually high initial recruitment of native sedges).

Figure 3: Cover Weighted CoC of Reference and Restoration Sites

Data analysis from this project indicates that Cover Weighted CoC outperforms average CoC in differentiating reference and restoration sites. This suggests that average CoC may be insensitive to the high cover of specific invasive species often observed in new restoration sites, a factor that Cover Weighted CoC is able to consider.

VRAM

Level 2 rapid assessment includes the use of the VRAM, which utilizes metrics to assess the condition, functions, and values of a surveyed wetland to provide an overall quality score. Scores can range from 12 to 100. Generally, the higher the score, the higher the quality of wetland. This rapid assessment tool has potential for use by practitioners as a metric of restoration success, as it is relatively simple to learn, and it is calibrated to Level 3 assessments.

As of 2023, 1104 VRAM assessments have been conducted on wetlands throughout Vermont. The highest scoring wetlands tend to be in remote locations and usually contain multiple natural community types. Natural communities are defined as “an interacting assemblage of organisms, their physical environment, and the natural processes that affect them” (8). By contrast, VRAMs conducted at restoration sites often score lower, because they are focused on a specific part of the wetland, rather than an entire wetland complex.

The Level 2 analysis included a wider range of sites and more data points to analyze. In total, 157 distinct VRAMs were conducted for this project, including 75 VRAMs in the *restoration* sites, 25 in *reference* sites, 21 in *recovering* sites, and 14 in *degraded* sites. Other types of sites that were also assessed but not included in the analysis include dam removal sites and mining restoration sites.

The restoration site types exhibit varying average VRAM scores (Figure 4).

Degraded sites averaged a score of 25, with a range of 13 to 46.

Restoration sites averaged a score of 41, with a range of 21 to 60.

Recovering sites (that had recovered from past disturbance with no restoration work) averaged a score of 57, with a range of 37 to 77.

Reference sites averaged a score of 70, with a range of 49 to 86.

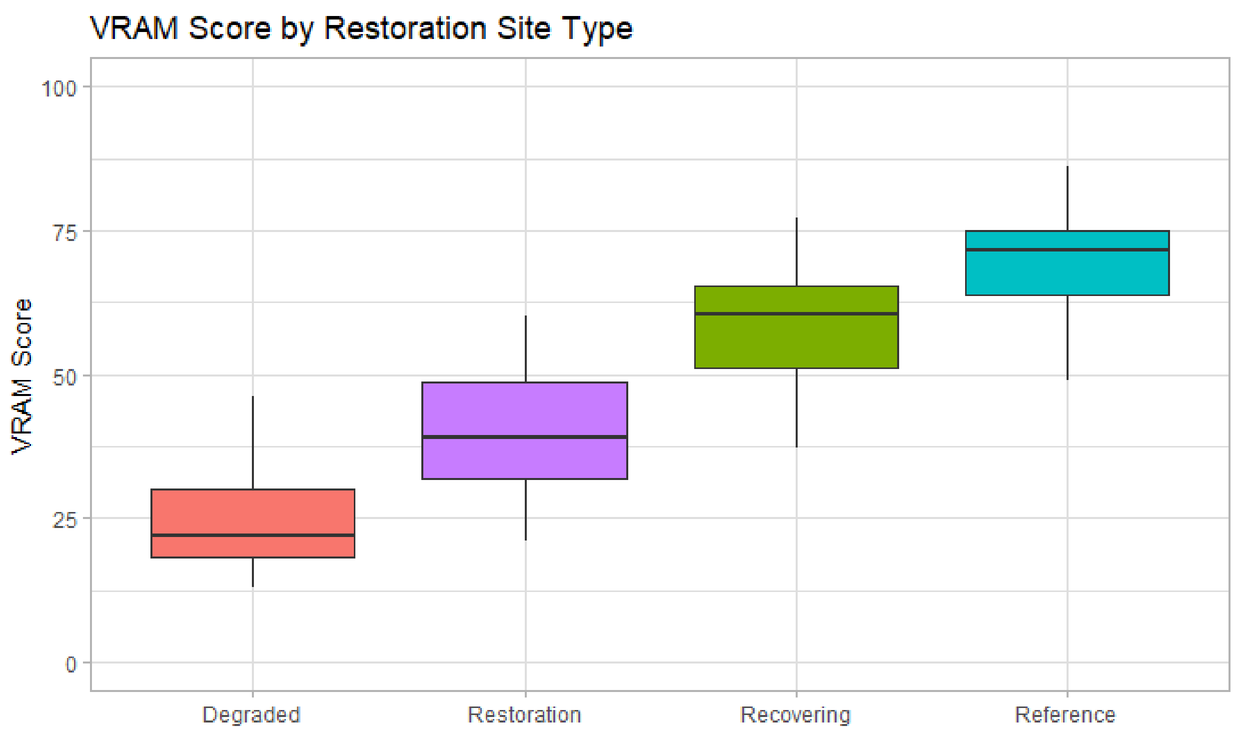


Figure 4: VRAM Score by Restoration Site Type

The range of VRAM scores within some of the restoration site type categories indicates the diversity in condition and function of sites in the same category. The restoration site types are widely varied in stage and success level. The *reference* sites consist of areas of intact habitat near the *restoration* sites, and as such support mature forest or other similar habitat but are also influenced by same landscape-level disturbance and past land use history. Most of the *reference* sites are influenced by disturbance such as edge effects. The best-condition reference sites in Vermont usually receive VRAM scores from 80 to 95, but these high quality sites are not typically found in the same landscape to compare directly with the project's restoration sites. The *recovering* sites were mostly shrub swamps of similar successional stage to each other, and therefore varied less (although sample size was also smaller).

Restoration Indicators of Success

The Restoration Indicators of Success (RIS) metric is calculated using VRAM metrics specifically relevant to and affected by restoration success, such as habitat development and alteration, presence of high-value habitat features, and intact hydrological regime (3). This removes most VRAM factors that are outside the scope of a restoration project (3).

The Restoration Indicators of Success metrics were calculated at every site with a VRAM. The highest possible score for RIS is 65. Sites with high scores possess habitat features of a reference-condition wetland, such as well-developed hummocks and hollows, coarse woody debris (for forested wetlands), diversity of vegetation cover types and little to no human disruption to their condition. Sites with low scores exhibit significant disturbance and/or a lack of important habitat features that are typically present and would benefit from habitat restoration. A successful restoration project should result in a significant increase in RIS score.

Degraded site types average RIS: 10, Range: 3 to 28

Restoration site types average RIS: 19, Range: 6 to 40

Recovering site types average RIS: 32, Range: 18 to 43

Reference site types average RIS: 42, Range: 32 to 54

There was no overlap in score between restoration and reference sites (Figure 5). These results provide additional evidence that the indicator is working as desired. Further calculation of this metric in the future will further verify how useful it is.

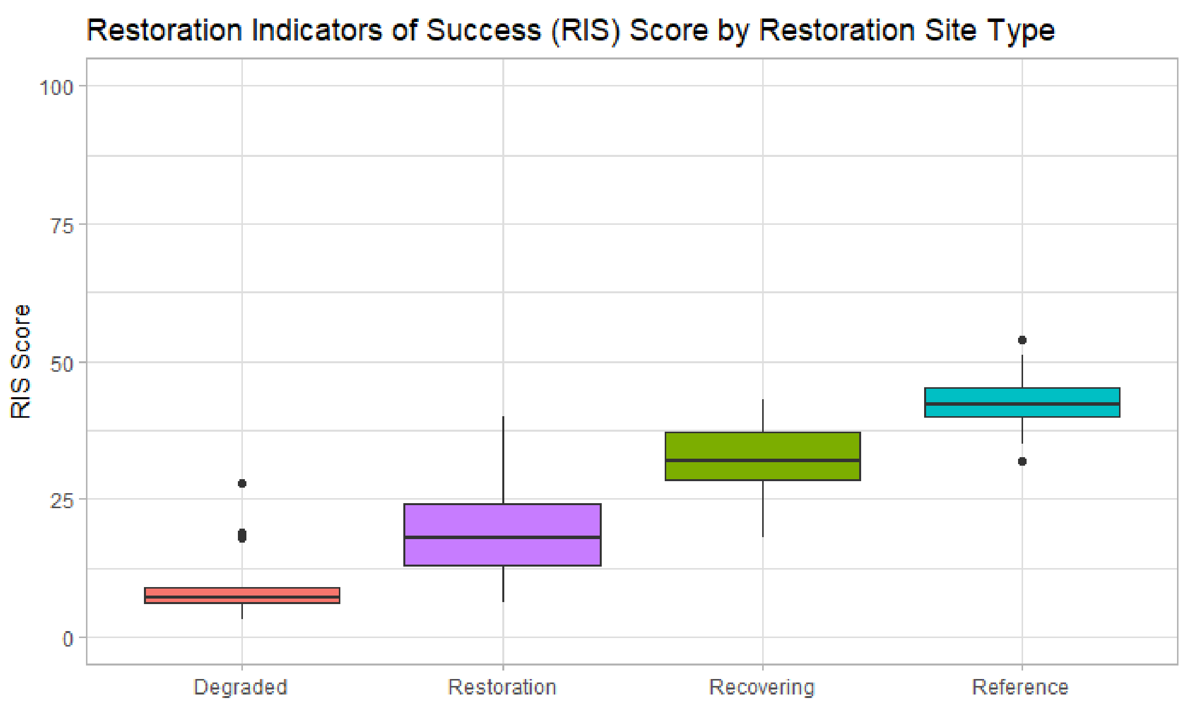


Figure 5: RIS Score by Restoration Site Type

Tetra Tech Multimetric Index

In 2022 and 2023, the Wetlands Program partnered with an external contractor (Tetra Tech) to develop a classification system to better compare wetlands of similar types. The resulting "Tetra Tech Score" analyzes vegetation plot data- specifically the species list, cover of each species, and native versus non-native status of each species (9). While the index is calibrated for good-condition wetlands, it was found valuable in assessing wetland restoration site condition, particularly when reed canary grass is tracked as an invasive species. Despite its technical status as a native species, a genetically distinct invasive form of reed canary grass is the dominant plant species in many wetlands in Vermont. It is important to note that for poor-condition wetlands, the Tetra Index score is often zero, making it less useful for discerning differences in condition in very disturbed sites. Since this is a newly developed metric, more use is needed to discern how it compares with CoC and Cover Weighted CoC for measuring wetland restoration success.

Figure 6 shows the Tetra Tech Score by visit number. Note that for most of the initial visits, the score was zero. This indicates a new, very disturbed restoration site. By the second visit, scores usually ranged between 2 and 10, showing improvements in the restoration site condition. Figure 7 shows the Tetra Tech Score by site type. Restoration sites usually score between 0 and 10 (with the higher scores usually from revisit plots). Reference sites score much higher, averaging around 25. The Recovering site type has a very wide range of scores from 0 to 40, indicating the variability in recovery success and timing amongst these sites.

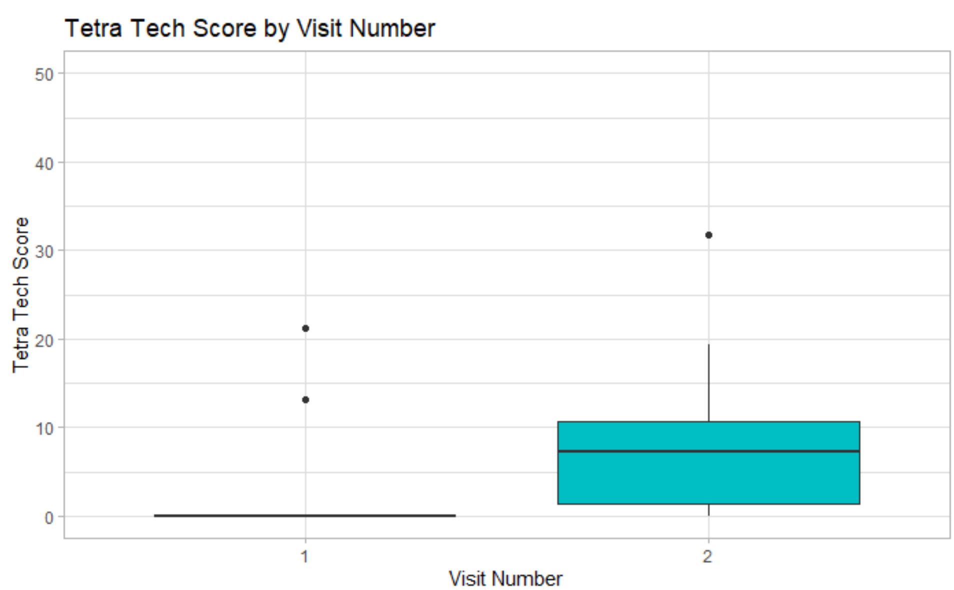


Figure 6: Tetra Tech Score by Visit Number

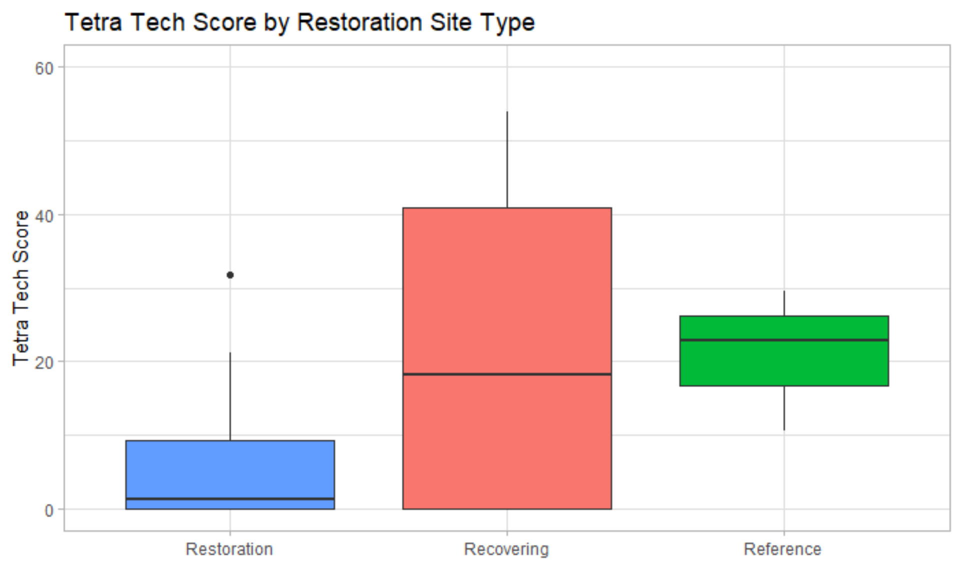


Figure 7: Tetra Tech Score by Restoration Site Type

Desktop Review

A Level 1 desktop review (characterizing a site based on mapping resources) provides much less information when it is not paired with a VRAM (Level 2) or other field-based monitoring (Level 3). However, in some situations, desktop review can be very valuable in establishing the initial conditions of a restoration site, determining reference communities, detecting hydrologic alterations, among other uses. Desktop review can be conducted at any time of year, can often be conducted quickly, and does not require property access or suitable weather or hydrologic conditions. The Wetlands Bioassessment Program has a Level 1 protocol used to generate estimated VRAM scores from desktop-only resources. While limited data exists, preliminary results suggest a robust correlation between a Level 1 score and field-verified VRAM score. Since restoration sites are highly dynamic, it is important to ensure that the age of the aerial imagery being used is chosen carefully.

High-Resolution Wetland Mapping

Due to the availability of high-resolution aerial photos and LiDAR elevation data, detailed maps of the different vegetation types can be prepared for restoration sites. Mapping can be conducted based on natural community type, VRAM score, estimated wetland condition and resiliency, Cowardin vegetation type, or many other factors. See Appendix A map indicating the hydrologic regime of each wetland area, with blue areas usually or always inundated and yellow areas only temporarily flooded. The maps can help prioritize restoration and track its success over time and are also a powerful outreach and communication tool.

Revisits

Five years after initial assessment, eight Level 2 rapid assessment sites (VRAMs) and nine Level 3 sites (vegetation plots and soils) were revisited for evaluation. One site contained two vegetation plots and one VRAM assessment, while another site was examined after four years instead of five. These follow-up site assessments aimed to assess the effectiveness of wetland restoration projects by comparing initial and subsequent scores for VRAM, RIS, CoC, and the Tetra Index.

VRAM and RIS Trends

Notable increases in both VRAM and RIS scores were observed across all sites (Figure 8 and Figure 9). The RIS metric showed more significant changes over the five-year period, highlighting its use in assessing restoration progress. The greatest improvements were observed at sites with a very low initial score. Rate of improvement appeared to slow when scores reached 25 to 30, indicating that initial success after rapid restoration of hydrology is followed by slower response from habitat features and vegetation from the interplay of invasive species with native species. The Quesnel restoration site displayed the most significant improvement, while the Lomas site showed the least. Notably, the Quesnel site was a more highly disturbed cornfield at the start of restoration activities, whereas the Lomas site was a wet pasture with woody vegetation already repopulating the area at the start of restoration activities, starting in better condition.

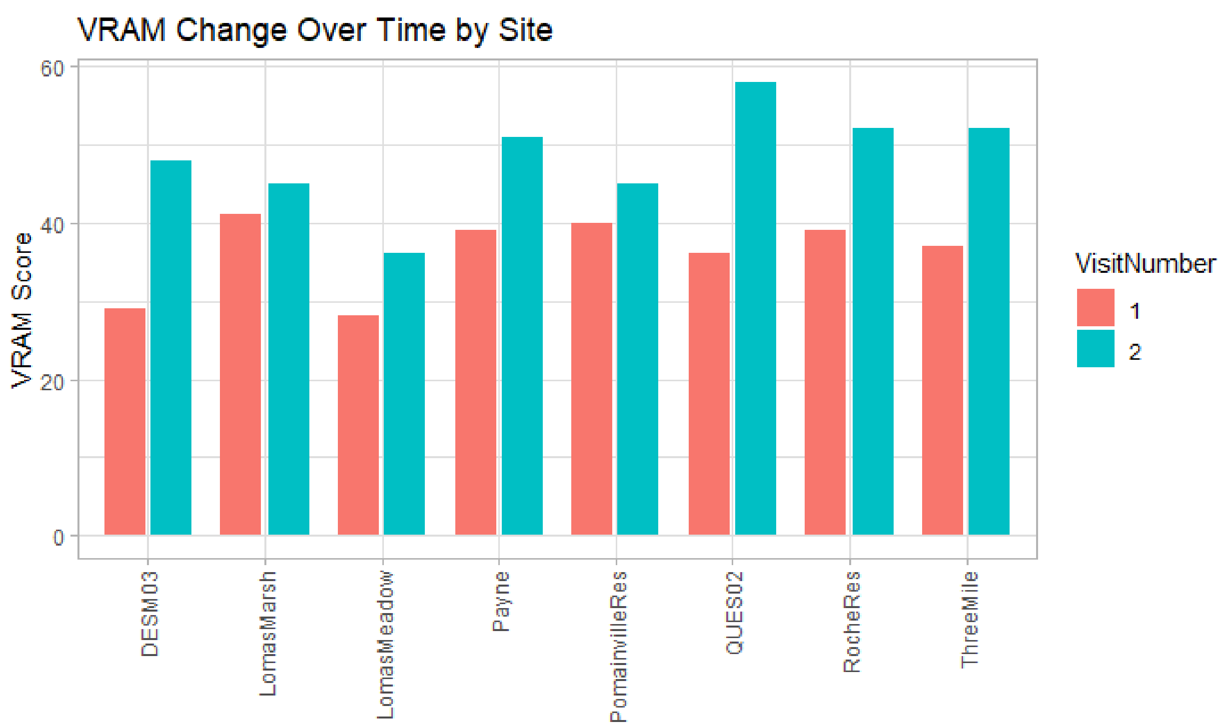


Figure 8: VRAM scores from initial visit and revisit.

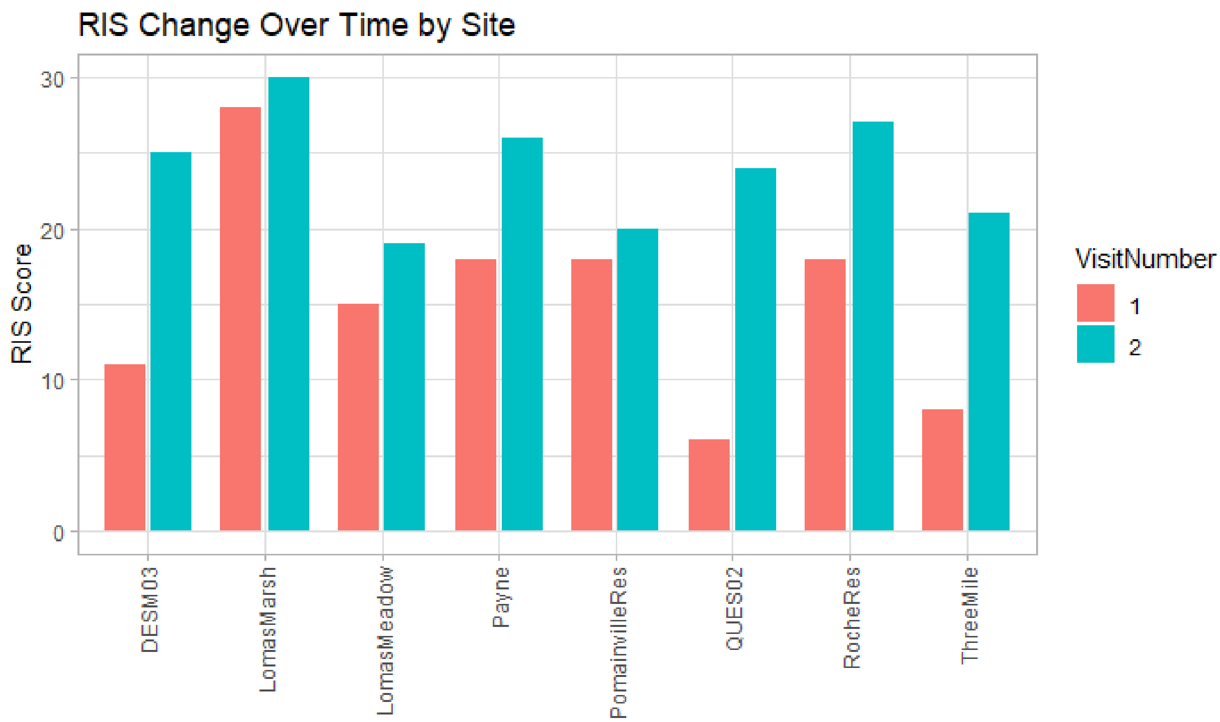


Figure 9: RIS scores from initial visit and revisit.

CoC Trends

Improvements in CoC were less consistent than what was observed in VRAM and RIS scores, with three sites showing a decrease (Figure 10). One of these sites was in a meadow at the Lomas site which already presented a diversity of native vegetation. It was affected by a ditch plugging between the two visits, but otherwise had not changed significantly. The other site, one of the Pomainville plots, may have declined as early successional woody vegetation crowded out some of the herbaceous vegetation, which may just be part of the successional trajectory of that site. A plot at the Roche site decreased in score slightly, apparently because of construction of a nearby swale in between visits, and seeding in of an early successional native species. These changes are expected of the normal progression of this particular restoration project. Conversely, one of the Quesnel restoration project sites increased substantially in score because an area of reed canary grass monoculture was replaced by a constructed swale that was growing in with native emergent wetland vegetation.

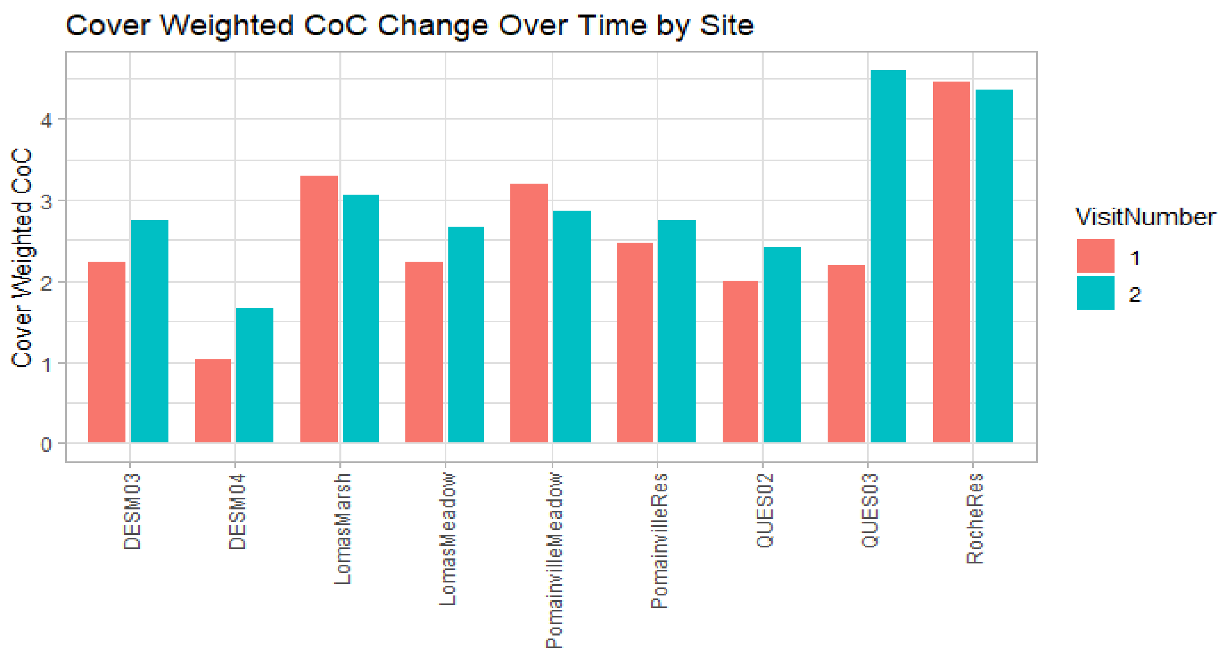


Figure 10: Cover Weighted CoC scores from initial visit and revisit. See Table 1 for the name of each site.

Table 1.

Site Number	Site Name
33	Three Mile Bridge (4-year revisit)
42	Des Marais Plot 3
44	Des Marais Plot 4
45	Quesnel Plot 2
46	Quesnel Plot 3
49	Lemon Fair Payne
53	Lomas Disturbed Meadow
55	Lomas Scirpus Marsh
56	Pomainville Plot 1
57	Pomainville Plot 2
58	Roche

Surface Water Sampling

The results of the surface water sampling at restoration sites are inconclusive. In general, the data indicates some level of degraded water quality at sampled sites, likely due to legacy impacts from previous land use and/or due to impacts from adjacent farms (Figure 11 and Figure 12). In addition, many sites are not yet very wet because they were sampled before hydrologic connectivity was established. Reference and restoration sites were selected to be adjacent to one another and generally shared the same hydrology source, so comparing the two types of sites using water chemistry parameters was not feasible.

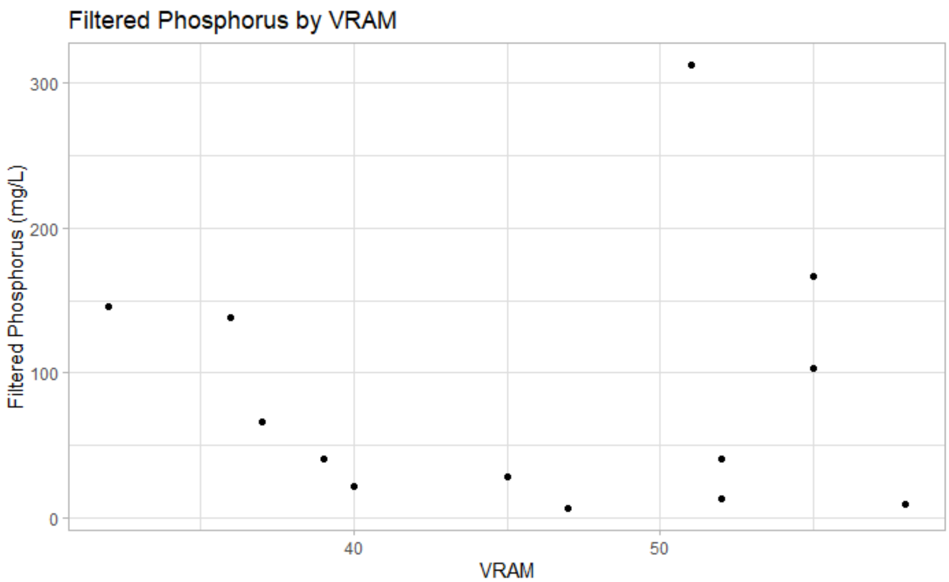


Figure 10

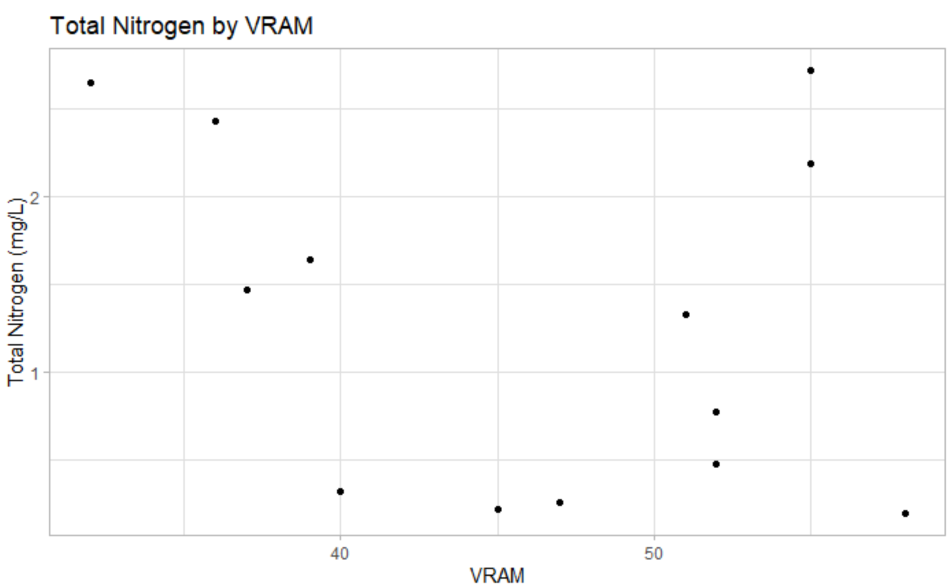


Figure 11

Discussion

Several important findings emerge from this project. It is visible in the CoC and RIS figures (Figures 4 and 5) that wetland condition increases along a continuum in this order: degraded wetlands in current agricultural use, active restoration sites, wetlands recovering from past disturbance, and reference sites. Establishing this trend makes it possible to determine whether individual restoration sites have been successful or not.

Successful restoration sites are expected to be on a trajectory towards higher VRAM, RIS, and CoC scores closer to those of reference wetlands. However, depending on wetland type, some may take years or decades to reach scores similar to reference wetlands. Restoration of certain types of wetlands can be a slow process, that may never yield a wetland that provides the same ecosystem services as a natural wetland (10). Success criteria should take this into account, while also respecting the high importance of restoring forested wetlands. In short, the speed of restoration success should only be compared with other restoration sites of similar projected wetland type.

It is important to note that wetland sites may be restored with different goals in mind, such as to improve wildlife habitat and connectivity, reduce phosphorus loading to waterways, sequester carbon, restore river corridor connectivity, increase resiliency to mitigate climate change effects and events, or to achieve a combination of objectives. Restoration implementation occurs in a variety of wetland types, with differing levels of resources, and often using different criteria to measure success. There isn't one index that will be a perfect fit for all restoration projects. Although additional metrics or criteria may be needed to fine tune how restoration success is defined at any particular site, the VRAM and RIS offer a broad overview of factors that are often considered important in restoration projects and allows for a comparison of restoration projects across the entire state.

Next Steps

Biocriteria Development

Restoration Indicators of Success is already being used along with VRAM to provide a metric to measure the success of restoration efforts throughout Vermont. Because the RIS is rapid and simple to conduct, it is recommended that this approach continues. The RIS index can also be retroactively applied to other sites where VRAM data is available. When appropriate, the RIS index can be supplemented with additional vegetation biocriteria based on species composition. Continued use of the CoC, Cover-Weighted CoC, and Tetra Tech Score will prove useful in cases where plot data is collected. Additional species-based biocriteria are also being developed by the Wetlands Program to potentially track factors influenced by climate change, water chemistry, changes in hydrology, and soil type. Over time these physical and chemical metrics may be significant for this project.

Vegetation Plots

Due to the detail that species lists can provide, vegetation plots may be valuable in measuring restoration success. Because these plots occur in a small (100 to 400 square meter) area, one must also account for spatial and temporal variation across the wetland when using this data. The plots are most useful in collecting information on the plant species composition of the wetland and in comparing this with the species assemblage in other restoration sites. It can also be valuable in tracking vegetation changes in small and discrete settings such as an individual constructed swale and permanent, repeatable vegetation plots.

Water Quality Sampling

Repeated water quality sampling of several sites may establish whether the restored wetlands are leading to improved water quality over time. Taking several samples throughout a year would provide data on the effects of seasonal water level fluctuations and storm events. Multiple samples collected over time could provide evidence as to whether restoration progress affects water quality. Therefore, it is recommended that in the next 5 to 10 years, repeated surveys including surface water collection are conducted in the same wetland areas where water samples were previously collected, to see if changes have occurred.

The specific effects of Vermont wetland restoration on water quality are an active area of research by several groups, including the University of Vermont and the DEC Wetlands Program, so specific water quality metrics of success are not yet established. However, metrics of note that are likely to be important include phosphorus, nitrogen, sodium and chloride, and turbidity. As further research occurs, a suggested protocol for water sampling may also be established. Ongoing communication with UVM may lead to more collaboration in sampling as well as an optimized sampling protocol for this project.

Photo Points

Photo points are a powerful visual tool to demonstrate restoration success and can be useful in noting important changes such as the spread of invasive species or tree mortality. Photo points are most useful when they can be conducted from an established, raised structure such as a roadbed or bridge. Therefore, photo points are not recommended as a main source for measuring restoration success, but they can be excellent tools that should be used to supplement long-term monitoring. As with permanent plots, photo points (photos repeatedly taken from the same place and declination) can be difficult to establish and maintain. The result of activities such as swale construction and ditch plugging are difficult to predict, so a photo point that seems appropriate may not be helpful once the project is implemented. In addition, one vigorous tree growing in front of the photo point location can render the photo point unusable in a few years.

Conclusion

Monitoring of restoration sites using VRAM, CoC, RIS, and other methods described has allowed for successful tracking of wetland restoration success. With almost 200 VRAM rapid assessments and nearly 80 Level III vegetation plots, the metrics show as excellent in differentiating restoration sites from reference sites and are also beginning to show a great deal of utility in gaging success over time both with individual projects and across the state as a whole. It is recommended that the primary focus is given to revisiting restoration sites to conduct Level 2 and Level 3 assessments to further monitor for success over the long term, with a secondary focus of conducting Level 2 assessments on degraded, recovering, and pre-restoration sites. With a robust, combined data pool further analysis will be possible over time.

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Appendix A: Wetland Mapping Example

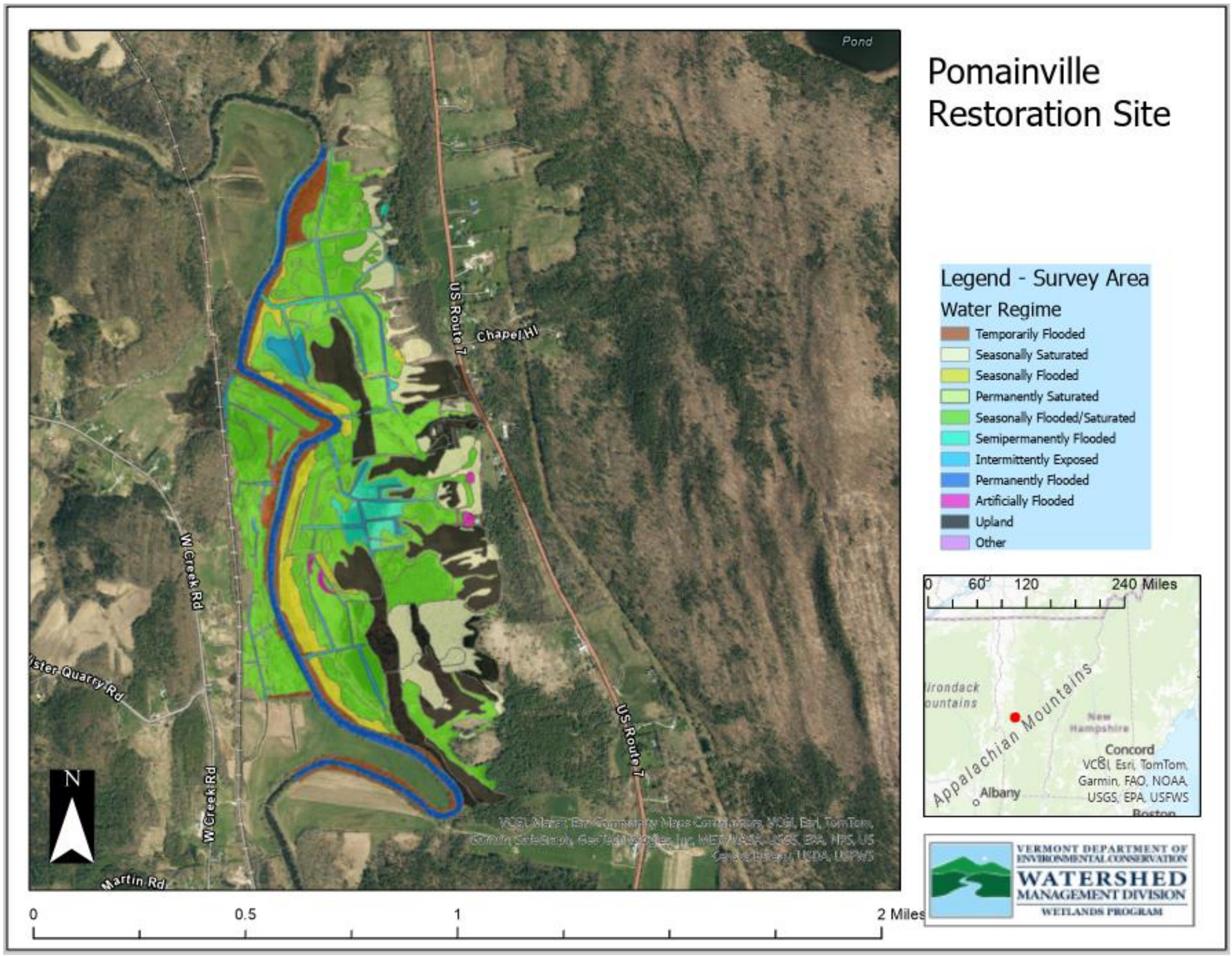

Figure 12: Map of a restoration site with colors indicating water regime.

Plot Name	Type	Mean CoC	Cover Weighted CoC
Basin Brook Meadow	Recovering	2.81	2.32
East Montpelier Alder	Recovering	2.53	2.10
Goose Pond Wetland	Recovering	4.12	4.46
Grenville Alluvial Shrub Swamp	Recovering	3.47	3.86
Lomas Green Ash Swamp	Recovering	2.40	3.48
Lomas Green Ash Swamp 2023	Recovering	2.17	3.80
MUFL02	Recovering	2.80	3.68
Roche Floodplain Forest/Sedge Meadow	Recovering	3.63	5.26
Roche Sedge Meadow 2023	Recovering	3.37	4.77
Barton Floodplain Forest	Reference	2.90	4.14
Cornwall Swamp Floodplain Forest	Reference	4.56	4.49
DESM01	Reference	4.50	6.42
DESM02	Reference	4.06	4.04
Fitzgerald Floodplain Forest	Reference	2.93	5.37
Goodrich E Ash Swamp (GOOD01)	Reference	3.27	5.60
Grenville Floodplain Forest	Reference	4.10	3.91
Hinesdale Floodplain Forest	Reference	3.74	4.86
Lemon Fair Green Ash Swamp	Reference	4.20	4.54
Pomainville Swamp (POMO01)	Reference	3.96	4.48
Rock River Reference	Reference	3.57	3.83
TMBR02	Reference	4.05	4.46
Twin Oaks Reference	Reference	3.49	3.57
DESM02 2022	Reference	4.35	4.14
Barton River Meadow	Restoration	2.07	2.10
Bethel Restoration Site	Restoration	1.78	2.42
Bethel Restoration Site 2	Restoration	2.18	2.07
Coolidge Beaver Meadow	Restoration	3.67	2.80
Coolidge Sedge Meadow	Restoration	3.50	4.73
Cornwall Meadow	Restoration	3.69	4.19
DESM03	Restoration	4.29	2.23
DESM03 2022	Restoration	4.07	2.74
DESM04	Restoration	3.00	1.03
DESM04 2022	Restoration	3.36	1.66
East Montpelier Mitigation Site 2	Restoration	3.77	3.24

Fitzgerald Field	Restoration	2.31	2.34
Fitzgerald Phalaris Field	Restoration	3.20	2.17
Goodrich Restoration Site (GOOD02)	Restoration	4.61	2.37
Hinesberg Restoration Site N	Restoration	3.00	2.02
Hinesberg Restoration Site S	Restoration	3.50	3.06
Hinesdale Restoration Site 1	Restoration	3.31	4.33
Hinesdale Restoration Site 2	Restoration	3.52	2.59
Hubbardton Cattail Swale	Restoration	3.67	3.32
Hubbardton Meadow	Restoration	2.67	2.25
Hubbardton Plugged Ditch	Restoration	2.00	2.72
Intervale Loosestrife	Restoration	2.50	1.71
Intervale Populus Patch	Restoration	3.29	2.57
Intervale Reed Canary Grass	Restoration	2.09	1.85
Lamoreau Meadow	Restoration	3.77	2.21
Lamoreau Mixed Herbaceous Meadow	Restoration	3.41	3.16
Lemon Fair Payne Bulrush Swale	Restoration	4.88	5.92
Lemon Fair Payne Reed Canary Grass	Restoration	2.00	1.98
Lemon Fair Restoration Site Burned Meadow	Restoration	3.33	3.93
Lemon Fair Restoration Site Canarygrass	Restoration	2.75	2.39
Lomas Disturbed Meadow	Restoration	2.72	2.23
Lomas Disturbed Meadow 2023	Restoration	3.37	2.66
Lomas Scirpus Marsh	Restoration	2.84	3.29
Lomas Scirpus Marsh 2023	Restoration	2.98	3.06
Middle Road Swanton Restoration Site	Restoration	3.24	2.16
Monument CEAP Site	Restoration	2.80	2.18
Monument CEAP Site	Restoration	2.80	2.18
MUFL01	Restoration	2.00	2.27
Pomainville Restoration Area (POMO02)	Restoration	3.21	2.46
Pomainville Restoration Area 2023	Restoration	3.89	2.75
QUES01	Restoration	3.11	2.10
QUES02	Restoration	2.91	2.00
QUES02 2022	Restoration	3.12	2.40
QUES03	Restoration	3.33	2.20
QUES03 2022	Restoration	4.47	4.60
Roche Restoration Site	Restoration	3.05	4.45

Roche Restoration Site 2023	Restoration	3.15	4.36
Rock River Restoration Site	Restoration	2.75	2.66
TMBR01	Restoration	3.60	2.00
Twin Oaks Active Restoration	Restoration	3.00	2.11
Twin Oaks Passive Restoration	Restoration	3.25	1.37

Appendix B: List of Sites

Plot Name	Site Name	Type
Swanton Village Meadow	Swanton Village	Degraded
Hyde Mill Farm Field	Hyde Mill	Degraded
Mad River Knotweed	Mad River	Degraded
MARI01	Mad River	Degraded
Marsh Brook Franklin Restoration Site	Marsh Brook	Degraded
Williams Woods Farm Field	Williams Woods	Degraded
Munson East of Route 7	Munson Flats	Degraded
Carmi Farm Field	Carmi	Degraded
Phelps South	Phelps	Degraded
Webster Road Farmed Wetland		Degraded
Town Line Farmed Wetland	Town Line	Degraded
Raven Ridge Farmfield	Raven Ridge	Degraded
Lomas Farmed Wetland	Lomas	Degraded
Goose Pond Wetland	Goose Pond	Recovering
Basin Brook Meadow	Basin Brook	Recovering
Hinesburg Garage Cattail Marsh	Hinesburg Garage	Recovering
East Montpelier Alder	East Montpelier Mitigation Site	Recovering
Black River Backwater	Black River	Recovering
Lomas Green Ash Swamp	Lomas	Recovering
MUFOL02	Munson Flats	Recovering
Lake Carmi Access Wetland	Carmi	Recovering
Ketcham South	Ketcham	Recovering
Adams Successional Swamp	Adams	Recovering
Perkins Seral Swamp	Perkins	Recovering
Messier Wetland Fragment	Messier	Recovering
Leicester Junction Ash Swamp		Recovering
Daniels Ash Swamp	Daniels	Recovering
Roscoe and Rotax Wetland	Raven Ridge	Recovering
Lamoille River - Fairfax East	Goose Pond	Reference
Saunders Floodplain	Saunders	Reference

Hinesburg Garage Reference Floodplain	Hinesburg Garage	Reference
Hinesdale Floodplain	Hinesdale	Reference
Fitzgerald Floodplain Forest	Fitzgerald	Reference
Rock River Reference Wetland	Rock River	Reference
Williams Woods Swale	Williams Woods	Reference
Barton Floodplain Forest	Barton River	Reference
Cornwall Swamp Floodplain Forest	Cornwall Swamp	Reference
Lemon Fair Green Ash Swamp	Lemon Fair	Reference
Roche Floodplain Forest/Sedge Meadow	Roche	Reference
Goodrich E Ash Swamp (GOOD01)	Goodrich	Reference
Pomainville Swamp (POMO01)	Pomainville	Reference
TMBR02	Three Mile Bridge	Reference
Isle LaMotte Marsh West	Isle Lamotte	Reference
Isle LaMotte Marsh East	Isle Lamotte	Reference
Stone Paul Ash Swamp	Stone Paul	Reference
Imhof Swamp		Reference
Lemon Fair Floodplain Forest	Payne	Reference
Neighborhood Farm Floodplain Fragment	Neighborhood Farm	Reference
Coventry Station Floodplain Forest	Coventry Station	Reference
DesMarais Swamps	DesMarais	Reference
DESM02	Des Marais	Reference
DESM01	Des Marais	Reference
Northfield Fema Site	Northfield	Restoration
Mad River Restoration Site	Mad River	Restoration
Saunders New Floodplain	Saunders	Restoration
Wild Branch Restoration Site	Wild Branch	Restoration
Hinesburg Garage Restoration Site	Hinesburg Garage	Restoration
Murray Rich Meadow 2021	Murray Rich Meadow	Restoration
Murray Rich Meadow 2018	Murray Rich Meadow	Restoration
Murray Rich Meadow 2016	Murray Rich Meadow	Restoration
Hinesdale Restoration Site 2	Hinesdale	Restoration
Hinesdale Restoration Site 1	Hinesdale	Restoration
East Montpelier Mitigation Site	East Montpelier Mitigation Site 2	Restoration
Fitzgerald Phalaris Field	Fitzgerald	Restoration
Fitzgerald Field	Fitzgerald	Restoration
Hinesburg Restoration Site S	Hinesburg	Restoration
Hinesburg Restoration Site N	Hinesburg	Restoration
Rock River Restoration Site	Rock River	Restoration
Bethel Restoration Site 2	Bethel	Restoration
Bethel Restoration Site	Bethel	Restoration

Intervale Loosestrife	Intervale	Restoration
Intervale Reed Canary Grass	Intervale	Restoration
Intervale Populus Patch	Intervale	Restoration
Barton River Meadow	Barton River	Restoration
Cornwall Meadow	Cornwall Swamp	Restoration
Black River Willow Swamp	Black River	Restoration
Hubbardton Cattail Swale	Hubbardton	Restoration
Hubbardton Meadow	Hubbardton	Restoration
Lemon Fair Restoration Site Burned Meadow (SD Ventures)	Lemon Fair	Restoration
Lemon Fair Restoration Site Canarygrass (SD Ventures)	Lemon Fair	Restoration
Lamoreau Mixed herbaceous Meadow	Lamoreau	Restoration
Lamoreau Meadow	Lamoreau	Restoration
Roche Restoration Site	Roche	Restoration
Goodrich Restoration Site (GOOD02)	Goodrich	Restoration
Lomas Scirpus Marsh	Lomas	Restoration
Lomas Disturbed Meadow	Lomas	Restoration
Pomainville Restoration Area (POMO02)	Pomainville	Restoration
Pomainville Disturbed Meadow (POMO02	Pomainville	Restoration
Munson Northeast Restoration Site (leblanc-wickmann)	Munson Flats	Restoration
MUFL01	Munson Flats	Restoration
TMBR01	Three Mile Bridge	Restoration
Potvin Restoration Site	Potvin	Restoration
Stone Paul Restoration Site	Stone Paul	Restoration
Bertrand Restoration Site	Bertrand	Restoration
Phelps North Restoration Site	Phelps	Restoration
Ketcham North Restoration Site	Ketcham	Restoration
Adams Restoration Site West	Adams	Restoration
Adams Restoration Site East	Adams	Restoration
Leavitt Restoration Site	Leavitt	Restoration
McKirryher Restoration Site	McKirryher	Restoration
McKirryher Successional Floodplain	McKirryher	Restoration
Lemon Fair/Payne Restoration Site	Payne	Restoration
Martin Bridge Wetland	Martin Bridge	Restoration
Perkins Restoration Site	Perkins	Restoration
Neighborhood Farm Restoration Site	Neighborhood Farm	Restoration
Neighborhood Farm Reed Canarygrass Meadow	Neighborhood Farm	Restoration
Messier Restoration Site	Messier	Restoration

Rayla Restoration Site	Rayla	Restoration
Maroney Backwater	Maroney	Restoration
Raven Ridge Restoration Site	Raven Ridge	Restoration
Palmer Restoration Site	Palmer	Restoration
Quesnel South Site C	Quesnel	Restoration
Quesnel South Site B	Quesnel	Restoration
Quesnel South Site A	Quesnel	Restoration
DESM04	Des Marais	Restoration
DESM03	Des Marais	Restoration
QUES03	Quesnel	Restoration
QUES02	Quesnel	Restoration
QUES01	Quesnel	Restoration

Appendix C: Map of Site Locations