Restoration Indicators of Success

Vermont Department of Environmental Conservation

Watershed Management Division

Wetlands Program

1 National Life Drive

Montpelier, VT 05620

October 1, 2019

Contents

Introduction

In Vermont, as with many areas, wetland restoration is gaining momentum. There are many benefits to restoring wetlands ranging from improved water quality and reduced flooding to expanded wildlife habitat and many other benefits. Restoration projects are being implemented throughout Vermont and are in various stages at this time. However, until this time there has not been a consistent, standardized method for efficiently and quickly documenting project success. The Restoration Indicators of Success described here aim to fill that role.

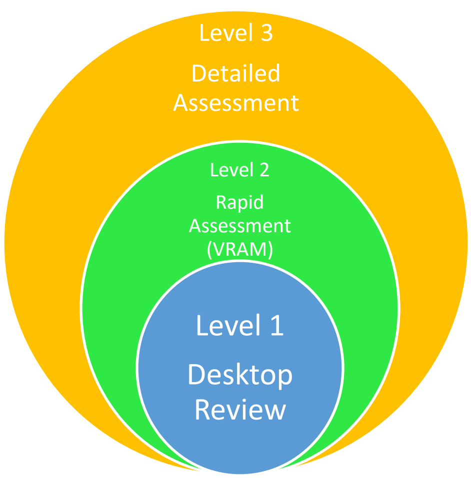
As part of this project, we examined many methods of documenting restoration success, including detailed plant surveys and rapid assessments. Our conclusion is that based on the urgent need for monitoring a large number of sites, the Vermont Rapid Assessment Method of wetland assessment, and an adapted set of data points collected using this protocol (The Indicators of Success) is the best tool to immediately implement to document restoration success. Over time as wetland restoration expands across the state, implementing more detailed but resource intensive surveys such as permanent vegetation plots may also be desirable.

This document summarizes our analysis that leads to this conclusion, and lays out a series of data points, based on the VRAM protocol, that can be used to document restoration success over time.

Background

In 2017 and 2018, the Vermont Wetlands Program initiated a pilot program of monitoring restoration sites and associated reference sites. The project focused on sites with recent restoration work and pre-restoration sites with the intent to return to the sites to monitor the success of restoration.

The restoration monitoring was conducted by the Vermont Wetlands Bioassessment Project according to assessment methodology applied across the state. This project includes sampling of hundreds of wetlands throughout Vermont, including vegetation data, water quality data, rapid assessments, and natural community mapping. The restoration site data will be compared with these other data points within wetlands of varying condition and function throughout the state. Monitoring is done at three levels described by the EPA (See figure below). Level 1 is a desktop analysis – review of air photos, LIDAR elevation data, and other map information to discern wetland type and boundary, hydrologic disturbances such as ditches, and surrounding landscape context. Level 2, in addition to Level I desktop analysis, employs an in-field rapid assessment – the Vermont Rapid Assessment Method (VRAM), which focuses on wetland condition and function. Level 3 includes the Level 1 and 2 assessments, and a detailed biological and chemical assessment. Vegetation plots are conducted in representative areas of the wetland, with all plant species recorded and cover of each estimated. At restoration sites, when possible, the plot is paired with a plot in a nearby 'reference' wetland in more natural condition. The soil is described according to the Army Corps Wetland Delineation



methodology. When suitable surface water is present that influences wetland ecology, water samples are also collected and tested for many parameters including pH, conductivity, and nitrogen and phosphorous levels.

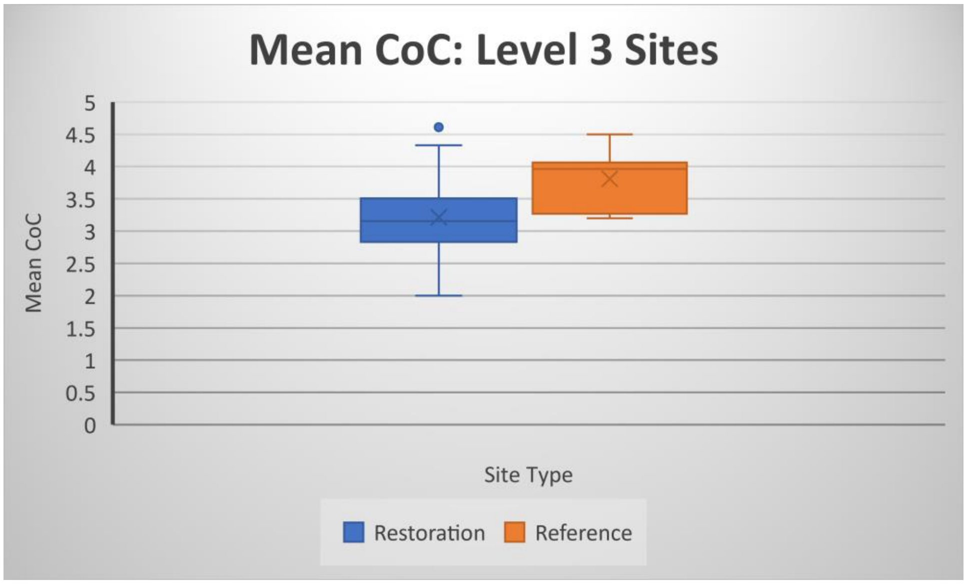
Analysis of Biocriteria

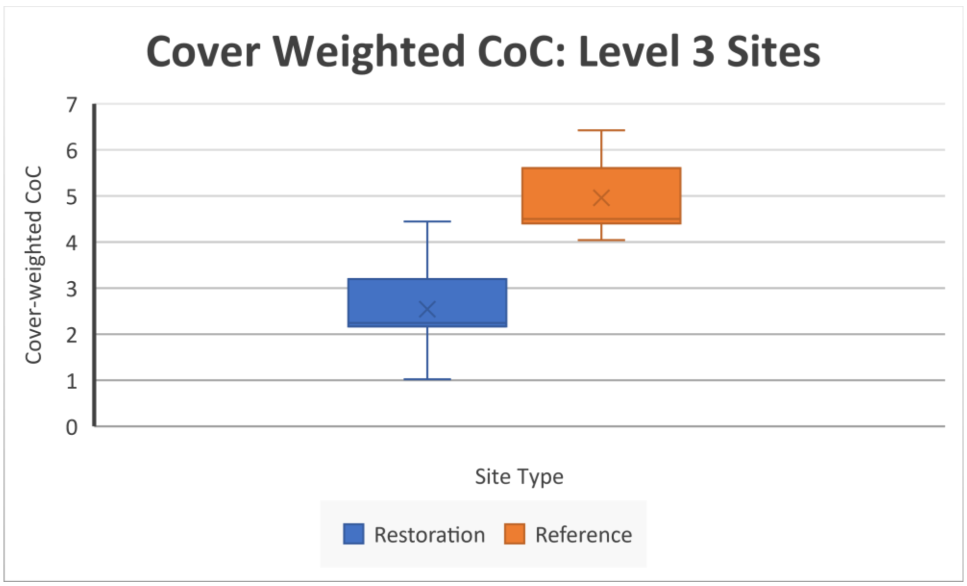
Coefficient of Conservativism (CoC)

Over the winter of 2018-2019, preliminary analysis was conducted on data from 76 sites including 25 Level 3 assessments and 66 VRAM assessments. Sites were categorized as *degraded* (areas with reduced wetland function which could be restored, such as farm fields within wetlands, but with no restoration planned), *recovering* (sites naturalizing from past disturbance, but without active restoration activities), *reference* (sites in mainly natural condition) and *restoration* (sites undergoing or about to undergo active restoration). Overall there were 7 degraded sites, 11 recovering sites, 15 reference sites, and 42 restoration sites assessed. Vegetation plots were conducted in many of the restoration and reference sites; however, for most (91%) recovering sites and all degraded sites only VRAM assessments were conducted.

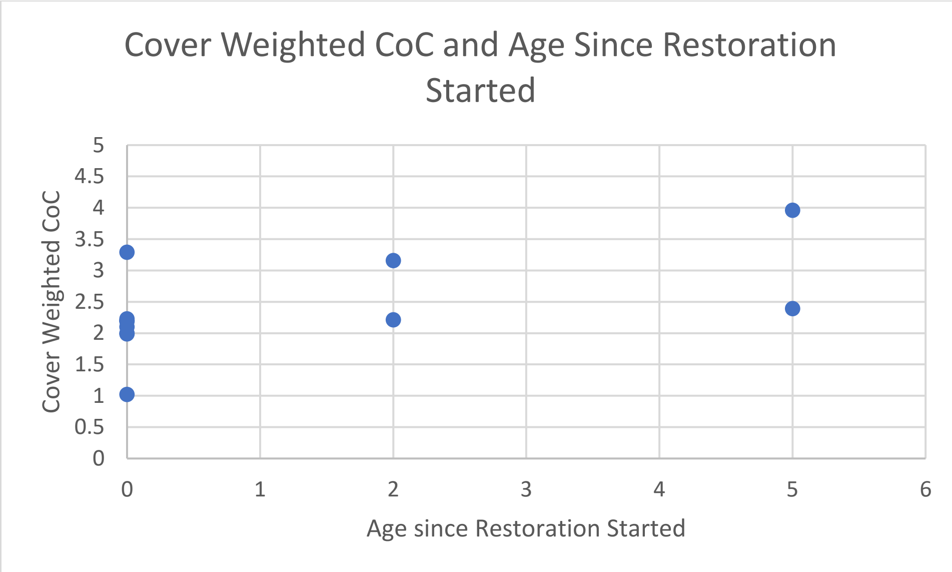
Sites employing a Level III assessment used vegetation as an indicator of biological integrity, using an Index known as the Floristic Quality Assessment Index (FQAI). This index is used to assess the level of "naturalness" of an area based on the tolerance for the species found and their specificity to a particular habitat type. It rates the degree of human disturbance to an area by accounting for the presence of native and nonnative taxa based on Coefficient of Conservatism (CoC) scores from 0-10, which indicates the disturbance tolerance of each plant species. The lower the score, the more "tolerant" the plant species is. Nonnative taxa receive a score of 0. CoC scores can be used to quantify ecological condition of a given plant community and could be used to assess changes in plant communities from restoration actions. For this project, Average CoC and Cover Weighted Average CoC (weighting relative cover of each plant species in the calculation) were the two indices used to calculate a score for each vegetation plot.

Broader scale studies in Vermont and elsewhere have showed that for measuring wetland condition, the mean CoC is more effective overall than the cover weighted CoC (see figures below). However, in the case of this project the Cover Weighted CoC significantly differentiated reference versus restoration sites than the average CoC. Cover weighted scores generally ranged from 4.5 to 5.5 in reference sites and between 2 and 3 in restoration sites, with very little overlap between the two.





Age since restoration implementation was also analyzed to determine its influence on the cover weighted CoC score to determine if the score is improving over time. Because the project has only included two field seasons, there was not enough time to discern changes to the wetlands, so a simple analysis was done to look at whether the CoC tended to increase as site age increased. Based on the data and graph below, there may be a trend but there is insufficient data to determine at this time. An expanded dataset over time will show whether cover weighted CoC tends to increase as site age increases.



Wetness

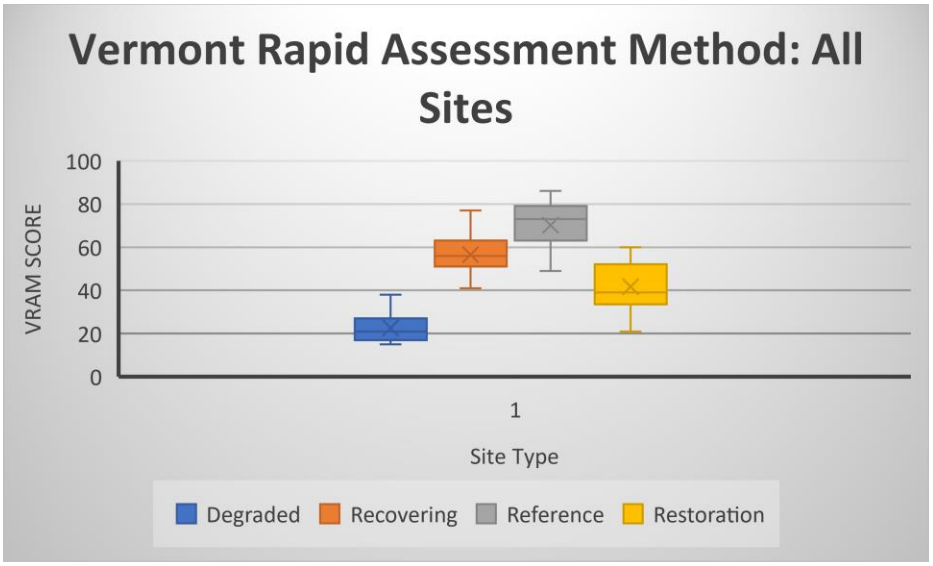
A Wetness Index based on the U.S. Fish and Wildlife Service Wetland Indicator Status of plant species was also calculated to compare hydrologic regimes of restoration sites and reference communities (see Table below). Restoration sites were found to be as wet or wetter than reference sites. It is unclear at this time if this indicates the sites are being restored to a wetter hydrologic regime than the reference communities, or if the plants that first appear in a restoration site trend more towards obligate wetland plants than those in a mature forested wetland. For example, better development of hummocks and hollows in a good-condition wetland might provide more habitat to plants that do not require very wet conditions, potentially indicating that a spectrum of wetness would indicate good wetland condition.

VRAM

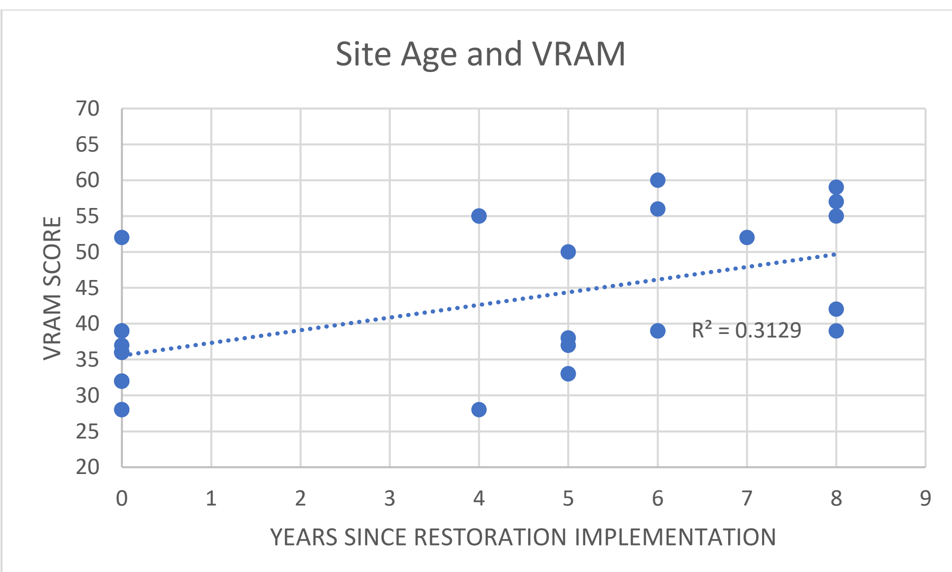
The Level 2 rapid assessment includes the use of the VRAM, which utilizes metrics to assess the condition, function and value of a surveyed wetland and provides an overall quality score. Scores can range from 12-100. Generally, the higher the score, the higher the quality of wetland. This rapid assessment tool has potential for use by practitioners as a metric of restoration success.

Over 550 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. By contrast, VRAMs conducted at restoration sites focused on a specific part of the wetland rather than an entire wetland complex in order to capture the condition of a particular vegetation cover type and often scored lower than VRAMS conducted by the broader bioassessment program which often covered larger assessment areas. The Level 2 analysis included a wider range of sites, allowing for more data and greater ability to detect trends.

The VRAM scores grouped strongly with site type as visible in the graph below. Degraded sites scored around 15-25 on average, recovering sites 50-60, and reference sites 65 to 80. The restoration sites, which varied in age since restoration started, had a broader range of VRAM scores from 35 to 50. When restoration sites were paired with reference sites, each restoration site always scored lower than its reference site, but the highest scoring restoration sites scored higher than the lowest scoring 'reference' sites, reflecting differences in wetland types and that some of the reference sites themselves are fragmented and disturbed.



Where the information was available, VRAM scores were also compared with time since restoration implementation. Average VRAM scores did show an overall upward trend as time since implementation increased, although results varied. This variation is to be expected if the VRAMs are successfully tracking relative success of the restoration sites.



Choosing Indicators to determine successful restoration

Both VRAM and Cover Weighted CoC show promise as metrics for measuring wetland restoration success. However, plant identification to the species level is required to determine Cover Weighted CoC and accurate species identification is only possible during a short window of time (June-September). It is especially important and difficult to identify species correctly at restoration sites which tend to have high levels of grass and sedge cover. VRAM data can be collected any time of year except under deep snow cover. Cover weighted CoC also requires a defined plot to be established. Due to the multiple changes that occur at restoration sites (rapid plant growth, mowing, and in floodplain sites deep sediment deposition or erosion), establishing permanent plots to be assessed pre- and post- restoration into the future may be difficult but would be the ideal for quantifying changes at restoration sites.

Given logistics, and the results of our above analysis, VRAM is currently our best indicator of restoration success. The survey area should only include the restoration site or reference site. A VRAM that included both sites would indicate overall condition of the wetland complex instead of just the restoration site. More information on VRAM survey area and metrics is available in the VRAM Protocol and Citizen Science Manual.

VRAM looks at 6 metrics including both condition and function of wetlands, listed below with maximum possible scores for each.

1. Wetland Area (6 points)
2. Upland Buffers and Surrounding Land Use (14 points)
3. Hydrology (30 points)
4. Habitat Alteration and Development (20 points)
5. Natural Heritage Features (rare species and significant natural communities) (10 points)
6. Habitat structure and microtopography (20 points).

Some of the above metrics may not be useful for measuring restoration effects. These include the size of a wetland (1), whether a wetland is influenced by high-pH groundwater (3a), the level of intensity of surrounding human land use (2b) and the duration of saturation in the wetland (3d). For this reason, a subset of VRAM metrics that are likely to be affected most strongly by restoration activities was selected to be Restoration Indicators of Success (RIS).

Restoration Indicators of Success Descriptions

Metric 2A: Average wetland buffer width (7 points)

This metric ranks the width and quality of the 50-meter buffer around the wetland. While some wetland restoration sites may have no influence over the condition of the adjacent buffer, in many cases wetland restoration projects include conservation or restoration of adjacent upland buffer as well. Presence of an intact buffer correlates with other metrics indicating good wetland condition in the wider pool of Vermont wetland bioassessment data, and thus is likely to indicate higher levels of restoration success. Wetlands with a full buffer support greater habitat-related wetland function and may provide greater flood attenuation and water filtration.

Metric 3E: Human Modifications to Hydrology (12 points)

Restoration of a natural hydrologic regime is often the main goal of restoration actions. For instance, many restoration sites occur in places where ditches, drainage tiles, dams, levees, and other human constructed structures alter, reduce, or increase the amount of water in the wetland and leading to degradation of condition or loss of function. Over time, activities such as plugging ditches and removing dams will result in more intact hydrology in a successful restoration project. In turn, intact hydrology will result in higher levels of flood resiliency and water quality improvement values provided by the wetland. By contrast, the continuation of hydrologic degradation is indicative of an unsuccessful restoration project.

Metric 4A: Substrate Disturbance (4 points)

This factor measures whether the soil and other wetland substrates in a wetland are intact. Human activities such as plowing, vehicle use, unnatural sedimentation, and stormwater-related erosion lead to wetland degradation. Restoration should seek to remove or reduce these factors and allow the substrate of a wetland to recover. It should be noted that substrate disturbance may initially increase as the restoration activities may include plowing, digging of swales, or other earth moving. However, over longer time periods the restoration project should result in a net improvement in this metric in most cases. Wetlands with undisturbed substrates are less likely to be impacted by invasive plants and are more likely to result in decrease in sedimentation and erosion in associated streams.

Metric 4B: Habitat Development (7 points)

This factor measures biotic habitat development ranging from zero points for a highly disturbed area with no habitat function to 7 points for a mature, diverse habitat in a fully functional wetland. While natural hydrology is at least as important as this factor, this factor may be more challenging or slow to recover as the hydrology must be restored first. A high score here is expected to strongly correlate with higher habitat and ecosystem function and thus a successful restoration site.

Metric 4C: Habitat Alteration (9 points)

This factor addresses whether the wetland is of a type and structure like what is believed or known to have been on the site before the initial disturbance occurs (or when possible is compared with a nearby reference community). For instance, along Otter Creek, most of the restoration sites occur on farm fields that previously were floodplain forests or backwater swamps dominated by silver maple and/or green ash. If the landscape and restoration sites show that a wetland would have likely been a Red or Silver Maple-Green Ash Swamp (as described in Wetland, Woodland, Wildland by Sorenson, Thompson, and Zaino 2019), this metric would score well if the plant species and growth form of the wetland is very similar to what would naturally occur in that wetland type. If the wetland had instead grown into a cattail marsh, this metric would not score high, even if the habitat development of the cattail marsh was good. Less altered wetland habitat will usually result in higher levels of ecosystem function as the full suite of species adapted to these conditions are able to use the wetland.

Metric 6A: Vegetation Communities (9 points)

This metric ranks several vegetation types from 0 (absent or insignificant) to 3 (high quality and abundant) based on the VRAM methodology. Tree, shrub, and herb cover are each independently ranked from 0 to 3. Floating/aquatic bed vegetation and open water, which are less relevant to the wetland restoration projects we sampled, were not included, nor were bryophytes. These metrics are important because they show a robust regrowth of native vegetation in several layers, essential to wetland function and condition in the case of the wetlands included in this study (mostly consisting of hardwood swamps). Note however that with some types of wetland, a robust mix of all three vegetation types would not actually be desirable – for instance, a wild rice marsh or a bog would generally not have a tree layer naturally, so presence of trees here would not indicate greater wetland success. At the current time there are no restoration projects in those habitat types, but if some are being monitored using this approach a revised version of this methodology may be desired.

Metric 6B: Diversity of Habitat Types (5 points)

This metric measures the spatial diversity of habitat types, looking from a 'bird's eye view'. For instance, a wetland with a spatially mixed and varied matrix including cattail swamp, alder swamp, and green ash swamp would score much higher than a wetland consisting only of a uniform area of cattail swamp. This metric is important because varied habitat types provides more habitat function than presence of just one single habitat type. Though, as with the vegetation layers, certain wetland types may naturally not have high diversity of habitat types. For instance, a poor fen might naturally consist primarily of cottongrass, sphagnum moss, and leatherleaf over a uniform area. Broadly, wetlands with higher diversity of habitat types will provide a broader mix of wetland functions and values, though this may not be true in the cases of some wetlands as mentioned above.

Metric 6C: Cover of Invasive Plants (1 to -5 points)

This metric measures the absolute (rather than relative) cover of invasive plant species in the survey area. Unlike other metrics, this metric can include negative numbers for scoring purposes. Invasive plant species can both indicate and be a cause of poor ecosystem condition and reduced levels of some wetland functions, and their removal in favor of native vegetation types is an important part of many restoration types.

Metric 6D: Microtopography (12 points)

This metric tracks several features of microtopography which are important to wetland function. Each is rated from 0 (not present in significant quantities) to 3 (present and significant at high quality). Hummocks or Tussocks are mounds in wetlands, usually created either by tree tip-ups or dense growth of vegetation such as sedges or ferns. These mounds provide a wider diversity of habitat for both animals and plants, as they offer relatively dry habitat and the associated hollows between them offer much wetter habitat nearby. Coarse woody debris refers to stems and logs at least 6 inches in diameter, which offer habitat for many animal species and are important to the formation of organic soils in many wetlands as well as creating wetland hydrology. Standing dead wood refers to standing tree trunks at least 10 inches in diameter. These provide for nesting and roosting habitat for a wide range of animals ranging from great blue herons to native bees. Vernal pool features refer to small, usually seasonal pools that do not contain fish and are suitable for breeding of vernal pool specialist amphibians such as spotted salamanders.

Value of VRAM

The approach outlined here allows for increased versatility and rapid assessment of wetlands. We recommend that an entire VRAM assessment be conducted for the wetland site – a process which, if one is already visiting the wetland, can be conducted in around 15 minutes. However, an observer could collect just the specific metrics used in the Restoration Indicators of Success index above. By collecting a full set of VRAM data, one can also calculate total VRAM score, VRAM condition percent, VRAM function score, and potentially other indices as well such as changes to functions and values. Any full VRAM assessments can be included in the growing pool of hundreds of assessments that have already been conducted throughout the state and should be sent to the VT Wetlands Program.

It is important to note that wetland sites are restored for different reasons, in diverse wetland types, with differing levels of resources and various success criteria. Wetland sites for restoration may be chosen due to improving the wildlife habitat function and connectivity, reducing phosphorus loading to waterways, restoring river corridor connectivity, etc., or a combination of various goals. As such, there is no one index that will be a good fit for all restoration projects. VRAM offers a broad overview including many factors often considered important in restoration projects, and allows for a comparison across the entire state, but in many cases, additional metrics or criteria will also be desirable to monitor restoration success.

Next Steps

Version 1 of the Restoration Indicators of Success index is already being used along with VRAM score to provide a guide to the success of various restoration efforts throughout the state of Vermont. Because it is rapid and simple to conduct, it is recommended that this approach continues. However, with available time and resources, more detailed sampling can also be conducted. The following are several additional steps that may be used as indicators of success in the future as well.

Vegetation Plots

As described above, vegetation plots and CoC scores may be valuable in measuring restoration success, but because these plots only occur in a small (100 to 400 square meter) area one must also account for spatial and temporal variation across the wetland in using this data. In addition, as described above permanent plots are logistically difficult and expensive to implement in restoration sites or on a broad scale. Though difficult, the establishment of long-term, sentinel wetland monitoring sites in the future could be immensely valuable.

Water Quality Sampling

Water sample collection may provide information on both the need for restoration (as the wetlands may improve water quality) and the success of restoration (if the restoration results in improved water quality). The specific effects of wetland restoration in Vermont on water quality is an active area of research by several groups including the University of Vermont and the Wetlands Program, so specific water quality metrics of success are not yet established. However, metrics of note that are likely to be important include phosphorous level, nitrogen level, sodium and chloride levels (indicators of road salt), and turbidity (indicator of erosion). As further research occurs, a suggested protocol for water sampling may also be established.

Photopoints

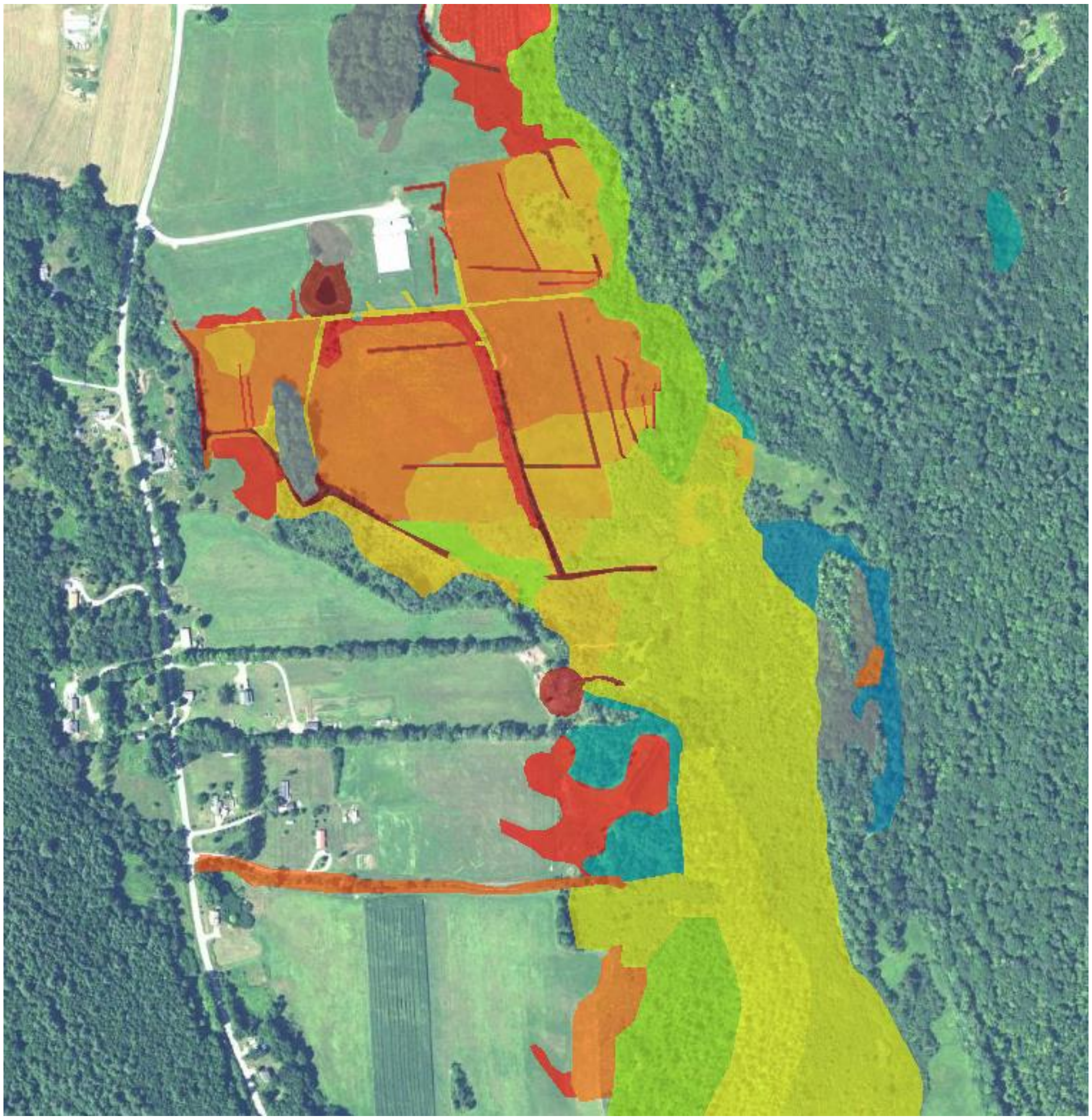
As with permanent plots, photopoints (photos repeatedly taken from the same place and declination) can be difficult to establish and maintain. The result of activities such as swale construction and ditch plugging are difficult to predict, so a photopoint that seems appropriate may end up less desirable after the project is implemented. In addition, one vigorous tree growing in front of the photopoint location can render the photopoint unusable in a few years. Photopoints are a powerful visual tool to demonstrate restoration success and can also be useful in noting important changes such as spread of invasive species or tree mortality. Photopoints are most useful when they can be conducted from an established, raised structure such as a roadbed or bridge. Other features such as trees and river bends may change or move to the point that the photopoint is no longer useful or repeatable.

Desktop Review

A desktop review (characterizing a site based on mapping resources) provides much less information when it is not paired with a VRAM or other field-based monitoring. However, in some situations or at certain times of year, desktop review can be very valuable in establishing the initial conditions of a restoration site, determining reference communities, detecting hydrologic alterations, and many other factors. Desktop review can be conducted any time of year, can often be conducted quickly on demand, and does not require property access or suitable weather or hydrologic conditions. The Wetlands bioassessment program has a protocol it uses to generate estimated VRAM scores from desktop-only resources. While this estimated score is of less value than a field-generated VRAM score, it can still be a useful tool when a field visit is not possible.

High-Resolution Wetland Mapping

Thanks to high-resolution aerial photos and LIDAR elevation data, detailed maps can be prepared of the different vegetation types in restoration sites. Mapping can be conducted based on natural community, VRAM score, estimated wetland condition and resiliency, Cowardin vegetation type, or many other factors. Below is a map approximating condition and 'irreplaceability' of wetlands. Red and orange areas are very disturbed; yellow areas are somewhat disturbed or early successional, and green and blue areas are more mature, intact wetland ecosystems. Note the ditches (which will be plugged for restoration purposes) and the difference between the disturbed areas and more intact areas. Maps like these can help both prioritize restoration and track its success over time.



Conclusions

The VRAM (or a derivative of VRAM) is currently the most suitable tool available for evaluating restoration success in Vermont, but is a qualitative assessment and does not necessarily allow quantification of impacts such as would be required for Payment for Ecosystem Services.