Chapter 5. Monitoring, Evaluating Success, & Adaptive Management

Voluntary wetland restoration may not have monitoring or reporting requirements. However, a basic monitoring program is still a good idea and may be important if your project has sources of funding that require reporting. Monitoring allows you to understand how a restoration site changes over time and provides insight into the effectiveness of your treatments. Monitoring also helps you to catch issues early and respond accordingly.

Choose Your Monitoring Protocols

A good monitoring program is tailored to the project's goals, restoration practices, and reporting requirements. Start by figuring out what you need to know to evaluate success and avoid issues. Then choose a handful of monitoring protocols that give you the information you need without creating such a burden that monitoring becomes a waste of resources or fails to be completed.

If you choose to implement some of the more technical monitoring protocols, such as vegetation or wildlife surveys, it may be helpful to contact a state agency, local non-profit, or resource professional dedicated to environmental monitoring for assistance in establishing a useful and achievable design. When possible, try to use established methodologies and join monitoring efforts already occurring in Vermont. This will minimize the effort needed to design monitoring protocols while also ensuring reliable methods. Tapping into existing monitoring frameworks will also produce standardized data that can contribute to regional knowledge. Suggestions for ongoing monitoring programs to tie into are listed in the tables below.

Aerial drone photography of completed restoration sites, Ducks Unlimited

If You Do Nothing Else

At a minimum, you should include sufficient monitoring protocols to ensure your project is not causing more harm than good. Wetland restoration efforts can have unintended consequences, and it is better to catch potential problems before they get out of control.

Suggested Minimum Monitoring Protocols	
NNIS	NNIS monitoring is a specialized type of vegetation monitoring where only non-native invasive species are targeted. Because restoration practices usually disturb the soil or alter growing conditions in some way, all restoration projects should include NNIS monitoring. Any NNIS management efforts will also require follow-up monitoring for multiple years. NNIS monitoring can be as simple as walking the restoration site and noting or mapping where NNIS occur. iNaturalist can be a good tool for identifying unknown plants and documenting NNIS. An internet search of "Vermont invasive plant species" will turn up a lot of resources, and the VT Fish & Wildlife Department website is a good place to start.
Nearby Impact	Restoration projects taking place near other property boundaries or sensitive use areas will require regular monitoring to catch potential issues before they cause problems.
Erosion	Practices that involve disturbing soil, changing hydrology, or both, can result in unintended erosion. Some erosion is to be expected until successful plant establishment, but too much can cause water quality issues or lead restoration practices to fail. It is a good idea to regularly monitor fragile areas until they stabilize, especially during and after heavy rains or snowmelts. Be ready to implement adaptive erosion control practices as necessary.
Hydrology	Some of the practices involve altering a site's hydrology. In these cases, it is important to monitor the wetland and surrounding areas for ineffective treatments or unintended drying or flooding.
Maintenance	Some practices, such as BDA or PALS installation, may require maintenance until revegetation successfully stabilizes a site. These structures can also inadvertently send loose wood downstream, which may block culverts or cause other issues.

Restored depression, Ryan Creehan, USFWS

If You Want to Assess Overall Wetland Quality

Vermont Rapid Assessment Method for Wetlands (VRAM)

VRAM is a standardized and relatively rapid protocol designed to be used by a wide range of people to measure information about wetland function, value, and condition. It produces a repeatable and quantifiable metric of overall wetland quality that can be submitted to the state Wetlands Program and contribute to public research into wetland restoration. VRAM should be the first monitoring protocol considered for assessing overall wetland quality.

VRAM is supported by the Vermont Wetlands Program, and the most up to date protocol can be found with an internet search for "Vermont Rapid Assessment Method for Wetlands User's Manual and Scoring Form." It may also be possible to receive VRAM training, especially in the winter months when the Wetlands Program is a little less busy.

Vermont Rapid Assessment Method

VRAM VRAM can be used to compare and select potential restoration sites, establish the baseline condition of a wetland prior to restoration, determine which components of a wetland would most effectively be restored, and compare the change in wetland condition after restoration and over time. Collect a VRAM score before any restoration activities, and then again 3-5 years after.

Restoration should aim to move a wetland towards the natural conditions expected for a site. Because VRAM is designed to assess the function of both intact and restored wetlands, not all indicators should be targets of restoration efforts. For example, a wetland receives a higher VRAM score if it is connected to a stream, but a restoration project should not force a stream connection that is not expected to occur naturally.

The table at right includes all the metrics and questions that make up a VRAM score. The table also marks the Restoration Indicators of Success, which are the useful and appropriate targets of restoration efforts.

VRAM Metrics and Restoration Indicators of Success	
Metric/Question	**Restoration Indicator of Success?**
Metric 1: Wetland Area	
Metric 2: Upland Buffers and Surrounding Land Use	
Question 2a: Average Buffer Width	**Yes**
Question 2b: Intensity of Predominant Surrounding Land Use(s)	
Metric 3: Hydrology	
Question 3a: Sources of Water	
Question 3b: Connectivity	
Question 3c: Average Maximum Water Depth	
Question 3d: Average Duration of Inundation/Saturation	
Question 3e: Human Modifications to Natural Hydrology	**Yes**
Metric 4: Habitat Alteration and Development	
Question 4a: Substrate/Soil Disturbance	**Yes**
Question 4b: Habitat Development	**Yes**
Question 4c: Habitat Alteration	**Yes**
Metric 5: Vermont's Natural Heritage	
Metric 5: Habitat Structure and Microtopography	
Question 6a: Vegetation Cover Types	**Yes**
Question 6b: Diversity of Habitat Types	**Yes**
Question 6c: Coverage of Invasive Plants	**Yes**
Question 6d: Microtopography	**Yes**

If You Want Specialized Information

You may want to include a small number of supplemental monitoring protocols and reporting metrics into your plans if you or your funders are interested in specific information. Examples are included below.

Other Potential Monitoring Metrics and Protocols	
Vegetation Monitoring	Vegetation monitoring can allow you to compare changes in vegetation before and after treatment, compare differences in vegetation between control plots and treatment plots, and quantify trends over time. A vegetation monitoring protocol based on a permanent plot system could provide more information about plant diversity, abundance, and structure than is collected in VRAM. GPS points, stakes, posts, or other markers are useful for establishing reliable locations. It is a good idea to place your plot in a representative part of your project area, or to pick a few different plot sites if conditions are variable. A simple vegetation monitoring method is to estimate a percent cover of the different vegetation layers (for example bare ground, herbaceous, shrub, tree). Another useful option is to create a plant list for each natural community type in your restoration area. If you are looking for more detailed methods, the Vermont Wetlands Program's Biological Monitoring of Vermont's Wetlands report provides an example of a standardized monitoring protocol in Vermont. Another option is to use the Vermont Fish and Wildlife Natural Community Citizen Reporting Form.
Revegetation Efforts	Documenting the quantity and species of plants planted can be useful for communicating your revegetation efforts. This could be number of stems, stems per acre, area seeded, or area treated with live stakes.
Plant Survivability	Expect that some percentage of a revegetation planting will die. Depending on the size of the treatment area you could monitor every plant or establish a sampling protocol. Plant survivability monitoring can be used to quantify revegetation success, direct replanting efforts, and discover trends in planting success.
Wildlife Monitoring	Wildlife monitoring protocols could include amphibian egg mass surveys, camera traps, track and sign observation, bird surveys, invertebrate surveys, or whatever suits your project needs. The Vermont Center for Ecostudies is a great resource for amphibian egg mass surveys, bird surveys, and invertebrate surveys, and other non-profits or agencies could be helpful resources as well. Even if you do not conduct formal surveys, pictures of wildlife and wildlife tracks can offer exciting evidence of wildlife use of a restored wetland. Creating ongoing observation lists using eBird, Merlin, and iNaturalist can also paint a rich picture of the biodiversity of your site.
Wetland Extent	Many of the wetland restoration practices will result in an increased extent of saturated soils and surface water. Surface area, number of pools created, and water storage volume can all be reported. These metrics can be used to confirm the completion of restoration treatments, document the extent of habitat enhancement, and describe potential stormwater mitigation or water infiltration. Some large projects may want to install monitoring wells to track hydrology patterns over time.
Treatments Completed	Completed restoration treatments should be documented. Depending on your treatments this could be the length of filled ditching, area of tile drain rendered ineffective, area treated with hummock/hollow creation, number of BDAs or PALS installed, etc.
Garbage Removed	The weight of refuse material (e.g. old buildings, infrastructure, fill, trash) removed from site can be a useful metric of restoration impact.
Repeat Photo Points	Photographs taken at the same location and angle across time can convey multiple qualitative features of a site before, during, and after restoration. GPS points, stakes, posts, or other markers are useful for establishing reliable locations.
Volunteer Input	Documenting volunteer hours or number of volunteers contributing to a restoration project can be useful for quantifying in-kind contributions and community engagement.
Educational Impact	Measures of student involvement, number of educational signs created, annual visitors, or the reach of any engagement material produced about the restoration can be used to quantify educational impact.

Timelines

Give each monitoring protocol or reporting metric a timeline, as appropriate. Some monitoring, such as erosion monitoring, should be completed regularly until the site is stabilized. Other metrics could be given a more formal timeline, such as a yearly plant survivability assessment for the first three years, or vegetation monitoring at years 0, 2, 5, and 10.

Make necessary assessments before restoration practices take place to establish a baseline, then follow up afterwards according to your timelines.

Evaluating Success

To reliably evaluate the success of your restoration project, set objective and verifiable goals that are based on conditions observed in a reference site.

Some components of a restoration project will be successful just by being completed. If you remove all the garbage and old buildings from a site, that is a success. Likewise, aiming to remove a certain amount of ditching, plant a certain density of plants, or increase the area of wetlands on a site, then completing those tasks is a success. Other components of restoration might show signs of success in a year or two. Sometimes a newly created shallow depression can start functioning as a vernal pool with successful amphibian breeding as soon as the next spring, while other components of a restoration project might take years, or even decades, of development before you know if you have been successful or not. Trees take a long time to grow to maturity, and plant communities go through many successional changes.

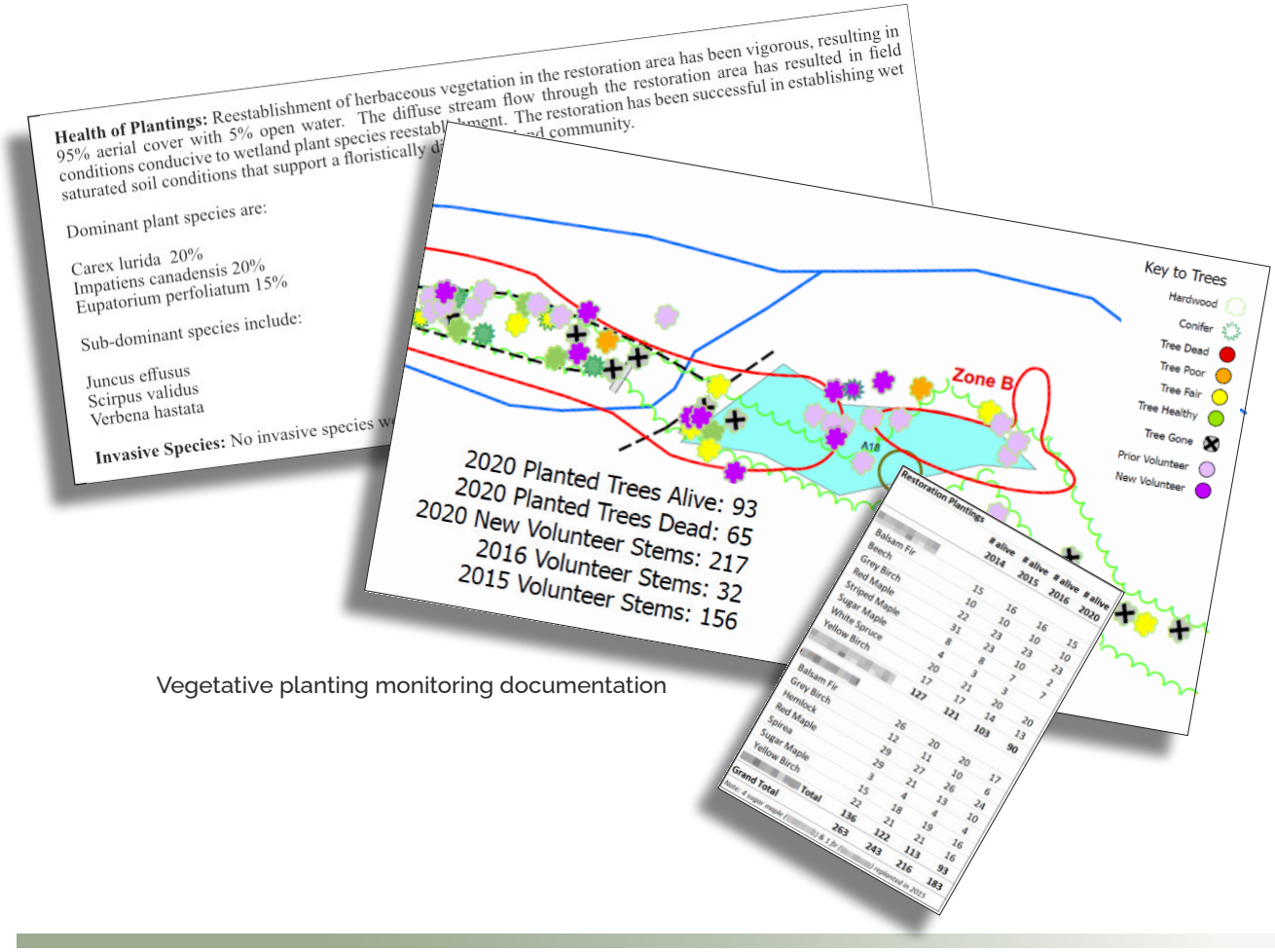
Example Measures of Success
All slopes, soils, substrates, and constructed features within and adjacent to the restoration site(s) are stable immediately after construction.
Target water depth and hydroperiod met within the first year after construction.
At least 500 surviving trees and shrubs per acre, by year 5, in the forested cover types.
>60% coverage by native species by the end of the first growing season, >85% by the end of the second growing season, and >95% by the end of the monitoring period.
Soil has documented evidence of redoximorphic features developing by the third year after construction.
NNIS target species are treated yearly and eliminated by year 5.
By year 5 there is evidence of expected natural colonization as documented by the presence of at least 100 volunteer native trees and/or shrubs at least 3 feet in height per acre.
Along any stream channel, to ensure stream shading, banks have >95% cover with native woody species which are >5' in height by the end of the 5th growing season.
The year 5 and year 10 monitoring reports contain documentation that all vegetation within the buffer areas is healthy and thriving and the average tree height of all established and surviving trees is at least 5 feet.
Site will have documented use by breeding populations of target species (e.g. spotted salamanders and wood frogs).
The site will have documented use by target macroinvertebrates by year 3 (e.g. caddis flies).

Adaptive Management

Further management will often be required after the initial restoration treatment, and this should be accounted for in timelines and budgets. Your chosen monitoring protocols will guide you here. Dead plants may need to be replaced, erosion issues may need to be fixed, and non-native invasive species will need follow-up treatments. When running water is involved, be prepared for the unexpected. Fragile banks may need to be fortified with additional plantings to control and/or prevent erosion. If things don't go as planned, it may not necessarily be a bad thing. Sometimes natural processes (for example, beaver activity) may take over, and expectations and management decisions will need to be updated to reach long-term goals.

Challenges & Solutions

- Monitoring can be time consuming, expensive, and require expertise. Find the balance between too little monitoring, which can lead to unaddressed issues and a poor understanding of restoration effectiveness, and too much monitoring, which may be unnecessary, costly, or performed poorly.
- Some metrics may benefit from pre-treatment monitoring to tell a full story, so plan accordingly.
- Monitoring goals may extend beyond funding timelines. Plan for this by setting aside money, finding other funding sources, or paring down your monitoring plans.
- Adaptive management should be expected and budgeted for.
- Forested Wetlands may take many decades to reach maturity, and evaluation measures will have to account for this. Try evaluating the trajectory of target species.



Vegetative planting monitoring documentation