A Statewide Assessment of Vermont's Wadeable Streams 2020-2022

INTRODUCTION

Biomonitoring is the use of biological community surveys to assess stream health. Biological communities, such as fish and macroinvertebrates, are influenced by the range of physical and chemical conditions in a stream over time and integrate impacts from stressors at local and watershed scales. As a direct measure of aquatic ecosystems, biological communities are a powerful tool for providing a **holistic assessment of stream health**. Biomonitoring is a primary tool of the Vermont Department of Environmental Conservation (VTDEC) Watershed Management Division (WSMD) for evaluating the status of Vermont's wadeable streams and informing management decisions. Water chemistry data and physical habitat observations are also collected to help interpret the biological condition.

Figure 1. State scientists conduct biological surveys of fish (top) and macroinvertebrates (bottom).

Probabilistic monitoring is one method that the WSMD can use to evaluate progress towards achieving its goals of **protecting, maintaining, enhancing, and restoring Vermont's waters.** Unlike a targeted monitoring approach, probabilistic monitoring relies on the random selection of sites that allows for an unbiased assessment of the **overall biological condition of Vermont's wadeable streams**, which represent approximately 90% of all stream miles in Vermont. Probabilistic monitoring can also help determine the extent to which biological condition in wadeable streams is changing over time and to help identify major stressors impacting biological condition across the state. These core tenets of the Water Quality Monitoring Program Strategy enable the WSMD to fulfill the requirements of Section 305(b) of the Clean Water Act and U.S. Environmental Protection Agency (EPA).

The current design of the Vermont probabilistic survey of wadeable perennial streams was implemented in 2018 and is based on a three-year rolling evaluation of around 48 sites (or 16 per year). A list of potential sample sites is provided by the EPA and stratified by small streams, large streams, and rivers using the National Hydrography Dataset. Sites are evaluated prior to data collection and are dropped if found to be non-target (impounded, non-wadeable, or intermittent) or in some cases, inaccessible. Dropped sites are replaced with the next randomly selected site on the list for that stream category. This report summarizes results from wadeable stream sites monitored in **2020**, **2021** and **2022**. Information on biomonitoring field and lab methods can be found in the WSMD Field Methods Manual and Biomonitoring Quality Assurance Project Plan. Detailed descriptions of the stream community types and applications of macroinvertebrate and fish metrics and indices can be found in the WSMD's biocriteria development documentation, and in Appendix G of the Vermont Water Quality Standards (VWQS).

DATA COLLECTION AND ASSESSMENT

A total of **63** sites were evaluated for the most recent statewide survey. Of these, **three** were not accessible and **12** were non-target based on initial desktop or field evaluation. These sites were replaced using the stratified random design to reach a total of **47** sites sampled for macroinvertebrates (Figure 2). Of these, fish were surveyed and assessed at **40** sites with **seven** sites being non-target, generally due to the lack of a biocriteria index for low gradient and/or warm-water fish communities. Estimates and confidence intervals for the percentage of Vermont stream miles in each assessment category were analyzed with help from the EPA using the R software package "spsurvey". Results exclude non-target stream miles and represent the percent of target/assessable stream miles for each biological community. Figure 2 shows a map of the sites evaluated with biological assessment ratings.

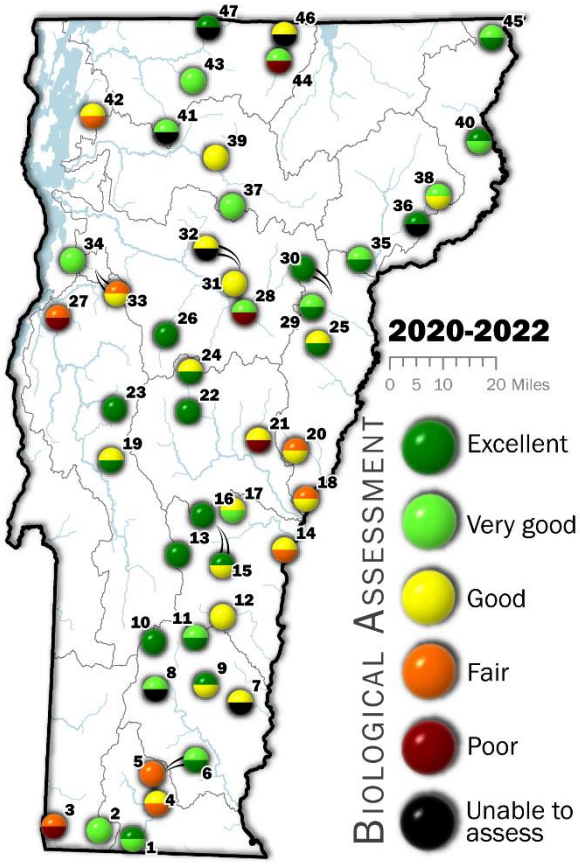

Figure 2. Location and assessment scores of each site for macroinvertebrates (top half) and fish (bottom half). Site information is listed in the Appendix.

Macroinvertebrate composite samples were collected from representative riffle habitats in moderate to high gradient streams, and from best available habitat (e.g. macrophytes, woody debris) in low gradient streams. Samples were processed and identified at the Vermont Agriculture and Environmental Laboratory. Fish communities were surveyed using backpack electrofishers, with survey reach lengths based on average wetted width. Fish were identified, tallied and released in the field. Taxonomic data from both communities were used to calculate the suite of metrics that are used to evaluate biological condition. Additional information on biomonitoring field and laboratory methods can be found in the WSMD Field Methods Manual and Biomonitoring Quality Assurance Project Plan.

Macroinvertebrate and fish communities are individually assessed on a scale of *Poor* to *Excellent*, with assessment criteria dependent on the stream community type. Macroinvertebrate assessment ratings typically include "half steps" (e.g. *Good/Very Good*), however, to simplify analyses and comparisons for this survey, the more basic five-tiered rating scale (*Poor, Fair, Good, Very Good, or Excellent*) was used. Fish communities comprised of only Brook Trout (*Salvelinus fontinalis*) cannot be assessed using VTDEC indices but were assessed for this report by the WSMD fish biologist using population statistics, including Brook Trout density and age class distribution. Detailed descriptions of the stream community types and application of macroinvertebrate and fish metrics and indices can be found in the WSMD's biocriteria development documentation, and in Appendix G of the VWQS.

BIOLOGICAL CONDITION OF VERMONT'S WADEABLE STREAMS

Because it isn't feasible to sample each reach of every wadeable stream in Vermont, probabilistic monitoring of randomly selected sites throughout the state is used to infer statewide biological condition. Results from probabilistic monitoring sites are used to calculate estimates of the percent of all Vermont stream miles in each assessment category for two biological community types: macroinvertebrates and fish. These estimates are then used to determine the overall biological condition of Vermont's wadeable streams during the survey period. Each estimate is reported with a 95% confidence interval, which accounts for sample size and quantifies uncertainty and sampling variability (Figures 3 and 4). The lower and upper bounds of the confidence interval for each assessment level is important to consider when interpreting results. The interval is very likely to contain the true proportion of Vermont stream miles in each category.

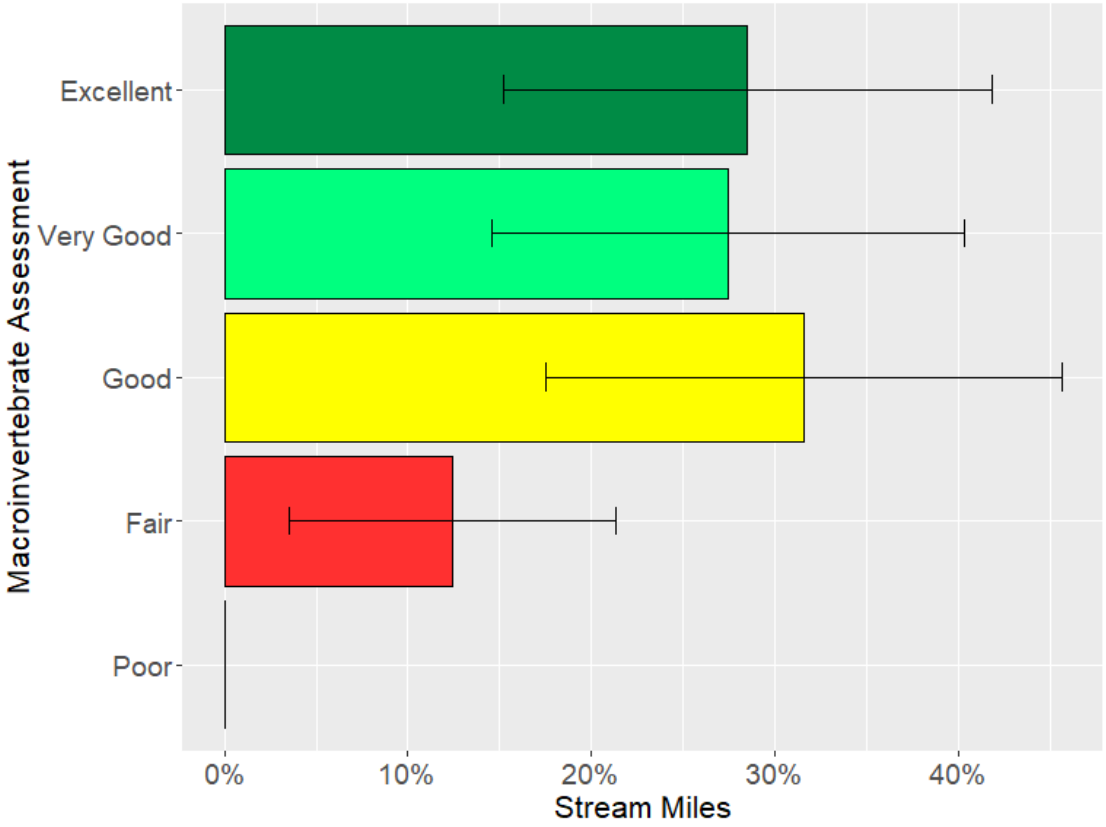

Figure 3. Estimates of the percentage of wadeable stream miles in each assessment category for macroinvertebrate communities. There were no macroinvertebrate communities assessed as 'Poor' in this survey.

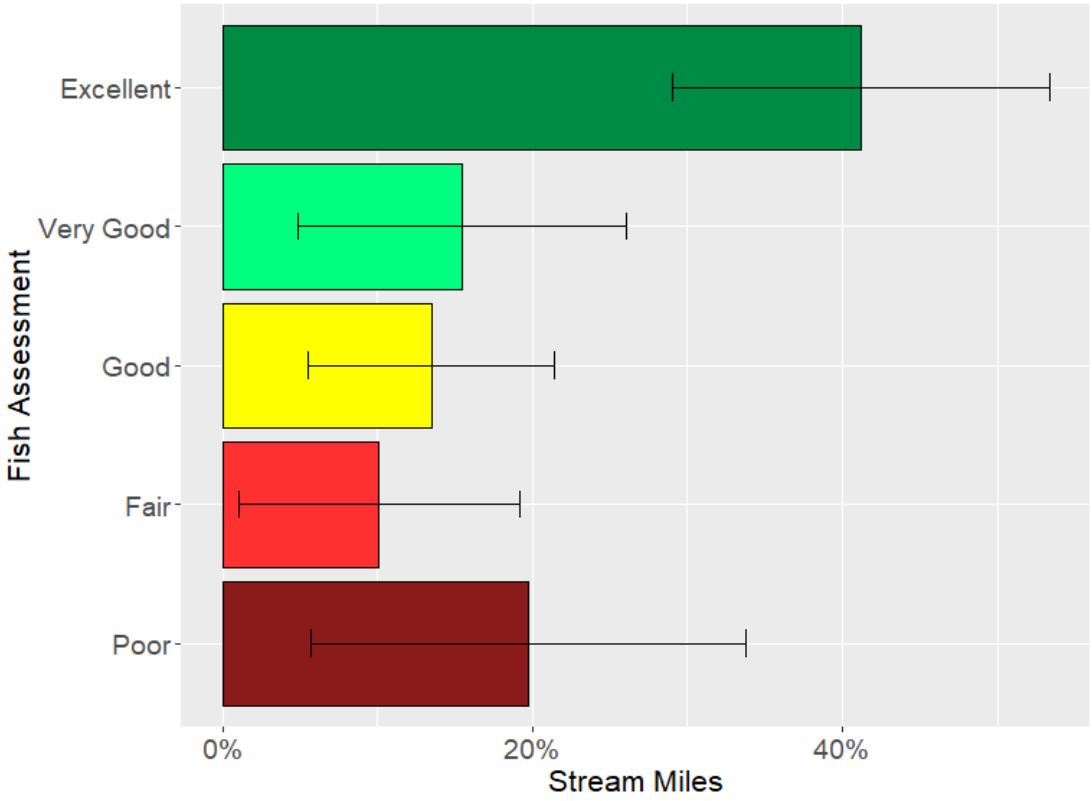

Figure 4. Estimates for the percentage of wadeable stream miles in each assessment category for fish

Biological communities that receive an assessment rating of *Very Good* or *Excellent* are referred to as "Very High Quality." This term represents streams in or minimally changed from their natural condition. **The results of this survey estimate that 56% of wadeable stream miles in Vermont are Very High Quality for macroinvertebrates and 57% are Very High Quality for fish.** Protecting both aquatic biota in streams in or near the natural condition (*Very Good* or better) will become increasingly important as climate change progresses and anthropogenic impacts increase. Strategies such as upward reclassification of streams that consistently meet Class A(1) or Class B(1) standards and management of these watersheds through the use of individual permits will help to ensure the protection of Very High Quality streams.

An assessment rating of *Good* (defined as a 'moderate' change from the natural condition) or better is required to meet minimum biological criteria for Class B(2) streams, as outlined in the Vermont Water Quality Standards (VWQS). **The results from this survey estimate that 88% of wadeable stream miles in Vermont meet or exceed Class B(2) criteria for macroinvertebrates, and 70% meet or exceed Class B(2) criteria for fish.** Establishing naturally vegetated riparian buffers and other best management practices that allow for infiltration of runoff from impervious surfaces and agricultural land, and conserving critical natural riparian and watershed areas can help maintain and enhance the biological condition in the majority of wadeable streams miles in Vermont that meet Class B(2) criteria.

Streams that receive an assessment rating of *Fair* or *Poor* for at least one biological community failing to meet minimum biological criteria for Class B(2) streams outlined in the VWQS. **The results of this survey estimate that 12% of wadeable stream miles in Vermont fail to meet Class(B) standards for macroinvertebrates, and 30% fail to meet Class B(2) standards for fish.** These sites represent aquatic biological communities that have

been severely degraded by human-caused stressors and are in need of restoration and remediation actions. The percentage of fish communities that fail notably exceeds the estimate for the percentage of macroinvertebrate communities that fail. This could be influenced by the smaller sample size for fish communities due to a lack of an applicable biotic index for all wadeable stream types. This discrepancy could also be due to differences in how the two communities are evaluated, or it is possible that stressors such as encroachment, habitat degradation, and thermal influences are disproportionally impacting fish communities. There is value in evaluating both types of communities because they each vary in their level of tolerance to certain stressors, and discrepancies can shed light on different impacts.

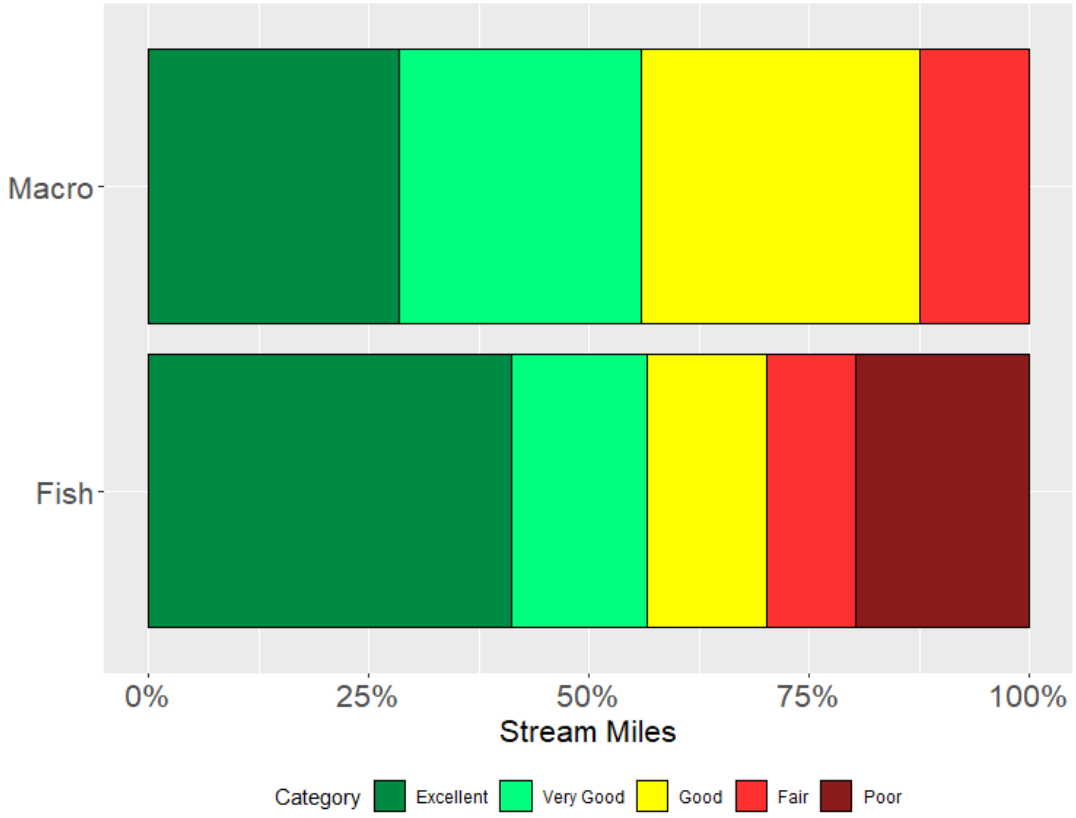

Figure 5. Estimates for the percentage of wadeable stream miles in each assessment category for both macroinvertebrates and fish

COMPARISON TO PREVIOUS SURVEYS

This is the sixth probabilistic stream survey completed by VTDEC, and the third using the three-year rolling average design. While the design of this survey will eventually enable VTDEC to statistically analyze differences over time, there is not sufficient data for this yet. However, each probabilistic survey contributes to the record of overall biological condition of Vermont's wadeable streams, and generalized observations can be made from the results. So far, the surveys suggest that that the majority of stream miles in Vermont meet or exceed VWQS for at least one biological community. Streams that fail to meet VWQS (Poor or Fair) typically account for a smaller percentage than the other assessment categories but are important indicators of stressors significantly impacting water quality and stream health in Vermont. Due to the relatively small sample size of 45-47 sites per reporting window, it is important to keep the error bars for each category (Figure 3 and 4) in

mind when interpreting the results. A change from one survey to the next is not enough to demonstrate a change in condition over that time, rather it is simply the variation in results between surveys.

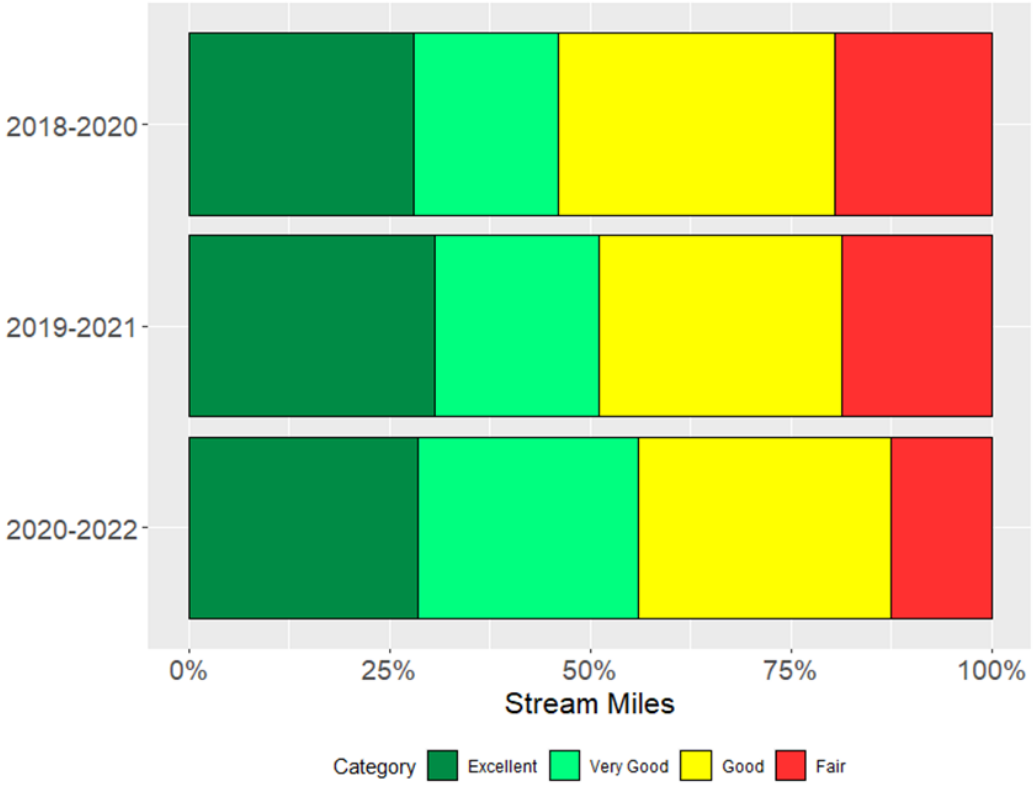

Figure 6. Estimates of the percentage of stream miles in each assessment category for macroinvertebrates from the past three probabilistic surveys.

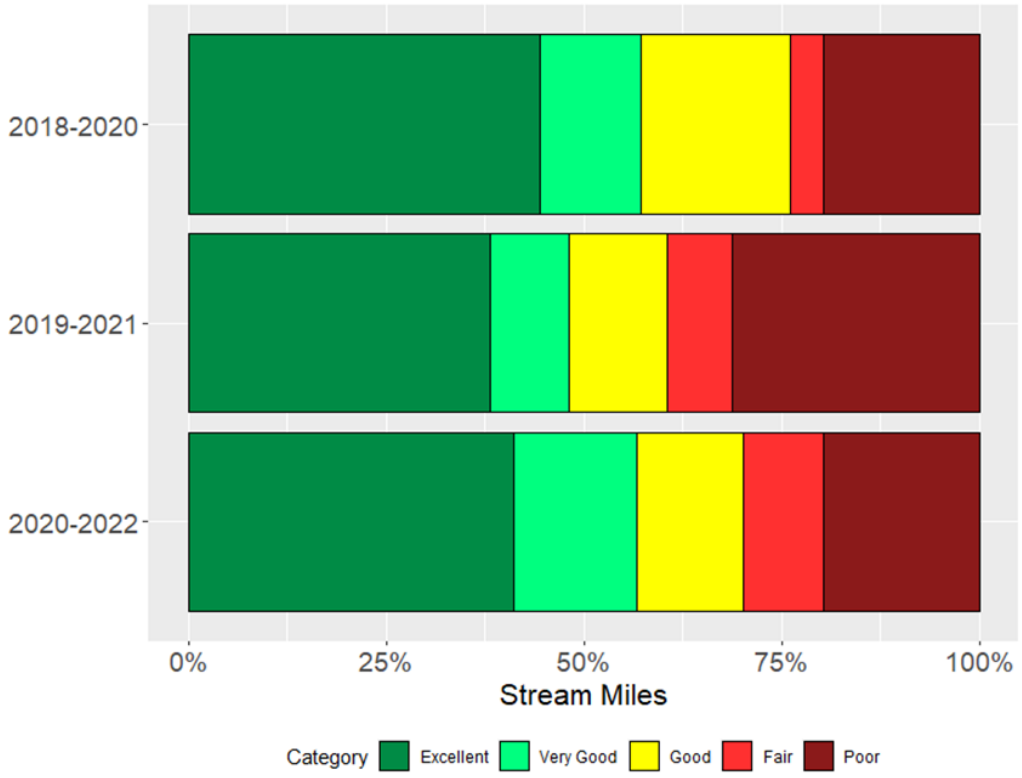

Figure 7. Estimates of the percentage of stream miles in each assessment category for fish from the past three probabilistic surveys.

STRESSOR ANALYSIS

Sites that failed for at least one biological community provide insight into stressors impacting wadeable streams across Vermont. State biologists closely examined biological data, water chemistry results, land use information, and physical habitat characteristics for these sites to pinpoint one or more of the ten stressors from the Vermont Surface Water Management Strategy that may be degrading biological condition. **Toxic substances, nutrient loading, and erosion** were implicated as significant stressors impacting macroinvertebrate communities. Impervious surfaces can contribute to these stressors by increasing stormwater runoff, transport of pollutants and groundwater contamination. Once watershed impervious surface reaches 2% or higher, it becomes increasingly unlikely that macroinvertebrate communities will meet Vermont Water Quality Standards (Figure 6). Chloride measurements collected concurrently with biological sampling provide insight into the toxic impacts of road salt on biological communities. Chloride concentrations of around 50 mg/L or more appear to prevent biological communities from meeting Vermont Water Quality Standards (Figure 7). Kruskall-Wallace non-parametrical statistical tests were run for the three assessment categories for both watershed impervious surface and chloride concentrations and yielded p-values <.005 for each parameter.

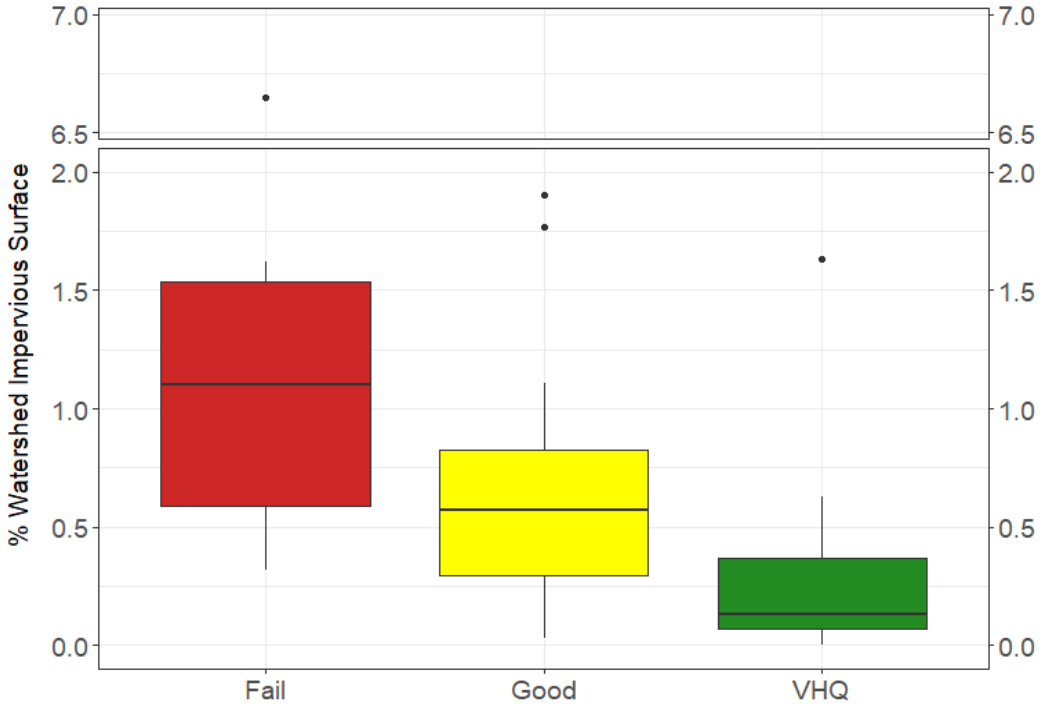

Figure 6. Percent watershed impervious surface by macroinvertebrate assessment category

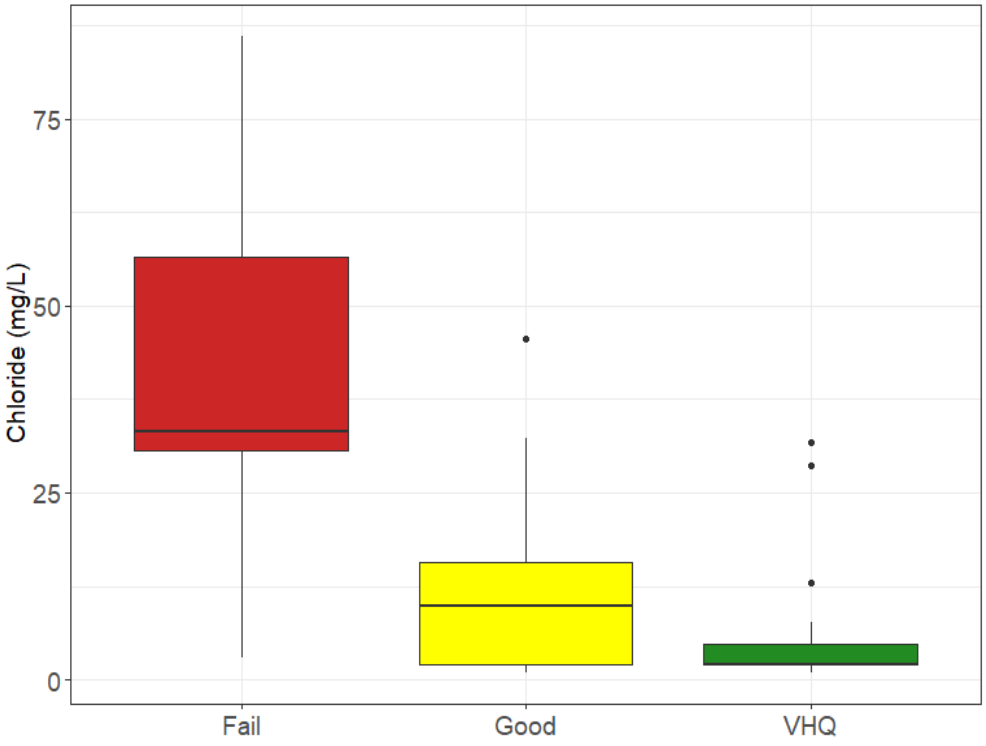

Figure 7. Chloride concentration by macroinvertebrate assessment category

Fish communities were found to be heavily impacted by factors influencing physical habitat, including **erosion, encroachment, and thermal stress.** In general, both thermal stress and channel erosion can be partially attributed to a lack of canopy cover, high percentage of impervious surfaces, and loss of riparian vegetation. This contributes to higher instream temperatures and increased loading of sediment that creates stress for biological communities. These impacts are exacerbated by the effects of climate change, including more extreme high flow events as well as prolonged periods of warm and dry weather resulting in higher temperature and lower flow levels. Our ability to detect major stressors impacting fish communities in Vermont is limited by the larger amount of non-target sites that are not able to be surveyed or assessed, resulting in a smaller sample size and larger error bars for estimates of fish community condition. These fish communities cannot be surveyed or assessed because they are located either within or immediately downstream of a wetland, where a natural increase in water temperature influences the fish population. Currently, VTDEC does not have a biocriteria index developed to evaluate these streams.

CONCLUSIONS & RECOMMENDATIONS

Nearly half of wadeable stream miles in Vermont support Very High-Quality macroinvertebrate or fish communities.

Maintaining streams in or near their natural condition will become increasingly important for the protection of aquatic biota as climate change progresses and anthropogenic impacts increase. Results from national probabilistic survey data suggest the proportion of waters in Very High-Quality condition in Vermont is nearly double compared to the rest of the region and the country. **Proactive protection strategies** will be necessary to protect the health of Vermont's streams into the future.

The majority of wadeable stream miles in Vermont have macroinvertebrate or fish communities in Good condition or better.

Streams with biological communities in *Good* condition meet minimum biological criteria but indicate some level of anthropogenic impact and are vulnerable to degradation. The biological condition of these streams can be **maintained and enhanced through establishing naturally vegetated riparian buffers, reducing runoff from impervious surfaces and agricultural land through best management practices, and the conservation of critical riparian buffers and watershed areas.** Vegetated buffers decrease erosion and nutrient loading, improve habitat conditions for fish and maintain cooler water temperatures through shading. The data from this survey also indicates that toxic substances such as chloride are degrading the biological integrity of Vermont's streams. Recent research has shown that the current EPA and Vermont chloride thresholds (230 mg/L chronic and 860 mg/L acute), established in 1988, are not fully protective of aquatic biota (Hintz et al. 2022), particularly when elevated chloride co-occurs with related stressors like elevated stormwater flow and erosion. Analysis by VTDEC indicates that sensitive mayfly species are eliminated at concentrations well below the current threshold, and the findings from this survey show substantial impacts around 50 mg/L. To address this stressor and the concerning phenomenon of freshwater salinization due to road salt (Hintz et al. 2021), **WQS should be updated to reflect 35 years of additional data collection, and measures should be taken to reduce excessive road salt application.**

Biological condition is degraded in a small but notable percentage of Vermont stream miles that fail to meet Vermont water quality standards.

Protecting, maintaining, and enhancing waters before they degrade to *Fair* or *Poor* condition is the most efficient, effective, and economical management strategy. When persistent land use practices and multiple anthropogenic stressors on the landscape prohibit protection, maintenance, and enhancement strategies, stressor-specific restoration efforts are needed to restore biological integrity. Streams that consistently fail to meet minimum biological criteria are reported to the EPA via the 303(d) List of Impaired Waters and require a Total Maximum Daily Load for the identified pollutant. **Restoration efforts should target major stressors such as nutrient loading, toxic substances, thermal stress, and channel erosion; and should anticipate and plan for the exacerbation of stressors due to the progression of climate change.**

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APPENDIX

Information for sites surveyed 2020-2022. Map ID corresponds to the number in Figure 2.

Survey Year	Site Name	Macroinvertebrate Assessment	Fish Assessment	Map ID
2022	West Branch Deerfield River 0.6	Excellent	Very Good	1
2022	Roaring Brook 4.1	Very Good	Very Good	2
2021	Cedar Hill Brook 2.1	Fair	Poor	3
2020	North Branch Deerfield River 2.0	Good	Fair	4
2020	North Branch Deerfield River 11.0	Fair	Fair	5
2021	Ellis Brook 2.9	Very Good	Excellent	6
2020	Weaver Brook 0.2	Good	Unable to Assess	7
2020	Eddy Brook 1.8	Very Good	Unable to Assess	8
2022	Saxtons River 20.5	Excellent	Good	9
2020	Mount Tabor Brook 1.4	Excellent	Excellent	10
2022	Williams River 26.8	Very Good	Excellent	11
2021	Black River 22.3	Good	Good	12
2021	Tinker Brook 2.5	Excellent	Excellent	13
2021	Shepherd Brook 0.7	Good	Fair	14
2021	North Branch Ottauquechee River 4.0	Excellent	Good	15
2020	North Branch Ottauquechee Trib #15 0.1	Excellent	Excellent	16
2022	Gulf Stream 5.0	Good	Very Good	17
2022	Bloody Brook 0.2	Fair	Good	18
2022	Jones Brook Trib 2 1.6	Good	Excellent	19
2020	West Branch Ompompanoosuc River 6.0	Fair	Good	20
2021	Belknap Brook 0.7	Good	Poor	21
2021	Riford Brook 2.6	Excellent	Excellent	22
2021	Goshen Brook 0.9	Excellent	Excellent	23
2020	Third Branch White River 21.5	Good	Excellent	24
2020	Tabor Branch 7.5	Good	Excellent	25
2022	Folsom Brook 0.2	Excellent	Excellent	26
2020	Little Otter Creek 4.2	Fair	Poor	27
2021	Stevens Branch Trib 6 0.2	Very Good	Poor	28
2022	South Branch Wells River 4.3	Very Good	Excellent	29
2022	Red Brook 1.2	Excellent	Excellent	30
2020	North Branch Winooski River 3.4	Good	Good	31
2020	Long Meadow Brook 0.9	Good	Unable to Assess	32
2021	Patrick Brook 0.7	Fair	Good	33
2021	LaPlatte River 5.8	Very Good	Very Good	34
2022	Rake Factory Brook 2.3	Very Good	Excellent	35
2021	Kirby Brook 1.1	Excellent	Unable to Assess	36
2021	Bedell Brook 2.7	Very Good	Very Good	37
2020	Moose River 20.6	Very Good	Good	38
2021	Gihon River 2.8	Good	Good	39
2022	Paul Stream 3.4	Excellent	Very Good	40
2022	Black Creek 24.6	Very Good	Unable to Assess	41
2022	Mill River 5.2	Good	Fair	42
2020	Tyler Branch 6.1	Very Good	Very Good	43
2021	Coburn Brook 0.3	Very Good	Poor	44
2022	Clay Brook 0.7	Very Good	Excellent	45
2020	Missisquoi River 69.9	Good	Unable to Assess	46
2022	Missisquoi River 46.9	Excellent	Unable to Assess	47