# Assessing the Statewide Biological Condition of Vermont Streams

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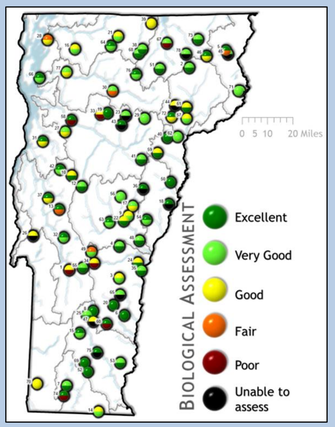
In collaboration with the VTDEC Biomonitoring Program

## Probabilistic Monitoring

For over three decades, Vermont's Department of Environmental Conservation (VTDEC) has operated a stream biomonitoring program. Extensive fish surveys and macroinvertebrate sampling are conducted annually throughout the state. Fish indexes and macroinvertebrate metrics are calculated, and assessment ratings are given to each community based on those scores. **Assessments of *Good* or better indicate a stream that fully supports a healthy community; ratings of *Fair* or below indicate a failure to meet Vermont's aquatic life use standards**. VTDEC also collects data relating to stream chemistry, substrate, physical habitat, and riparian characteristics, which are used to help explain patterns in the biological community data.


Biological assessment ratings and corresponding waterbody classification levels.




Probabilistic sites sampled in the 2013-2017 survey. The top half of each circle show the macroinvertebrate assessment rating, and the bottom half shows fish assessment rating.

Biomonitoring resources are typically directed towards streams of particular management interest. For example, impaired streams undergoing remediation, compliance monitoring below discharges, or sampling at long-term reference sites to observe climate change impacts. *Targeted monitoring* allows VTDEC to evaluate conditions within a specific watershed, but doesn't give an unbiased assessment of the overall condition of Vermont's flowing waters. To investigate this question, **VTDEC implemented probability-based surveys in 2002 in partnership with the USEPA, where annual biomonitoring includes a subset of randomly selected stream reaches throughout the state.**

The biomonitoring program uses a rotational sampling model, where annual efforts focus on three of Vermont's 15 major watersheds, and all watersheds of the state are monitored over a 5-year period. The probabilistic survey coincides with VTDEC's rotational cycle. **Every five years, biomonitoring assessments from randomly selected sites are used to examine the statewide condition of Vermont's streams**. These surveys are also designed to overlap with EPA's National Rivers and Streams Assessments (NRSA).

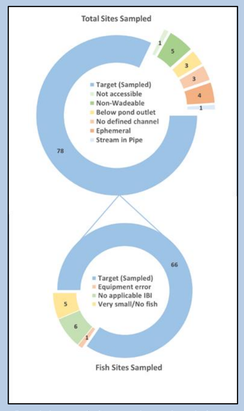
Through ongoing probabilistic surveys, VTDEC can:

- ***Determine status and trends in statewide stream health***
- ***Examine the principle stressors causing change in biological condition, and***
- ***Compare Vermont streams to conditions at regional and national scales.***

## Design and Methods

Vermont recently completed its third 5-year probabilistic survey (2013-2017). Ninety-five sites were randomly selected and evaluated from statewide perennial 1st-4th order (wadeable) streams. Of these, 78 sites were suitable for macroinvertebrate community sampling, and 66 sites were able to be surveyed for fish. The difference in the sampling of these groups reflects that some headwater streams with invertebrate communities are too small to support fish, and that fish communities in low gradient, soft bottomed streams can't currently be assessed with VTDEC biological criteria. Water chemistry and physical habitat data were also collected at all sites. Fish were identified and released in the field, and macroinvertebrates were collected and identified in the laboratory. Assessment ratings were then assigned based on the community data. Estimates of the percent of streams in each assessment category were analyzed using the R software package "*spsurvey*").

For more information on sampling and assessment methodology, see Appendix G of the Vermont Water Quality Standards: **https://dec.vermont.gov/content/vermont-water-quality-standards**




Breakdown of sites evaluated and sites sampled, including reasons for being unable to assess certain sites.

## Acknowledgements

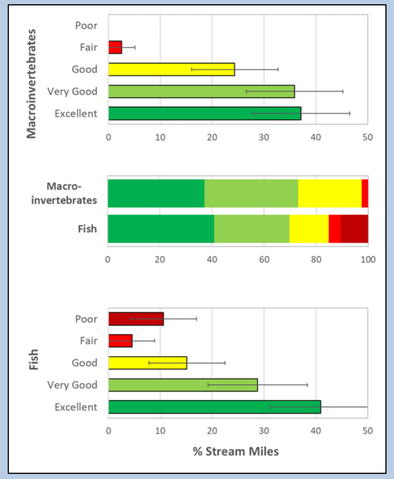
Thank you to the Vermont biomonitoring program and VDEC staff (past and present) for hours of field work, lab work, and help with mapping and data analysis. Thanks to USEPA staff Tony Olsen and Richard Mitchell, who provided vital help with site selection, sampling design, and data analysis. Jim Deshler provided all photos.

To read the full report on this survey, visit:
**https://dec.vermont.gov/watershed/map/assessment**

## Biological Condition

Results from the 2013-2017 probabilistic survey show that **73% of stream miles had *Very Good* or *Excellent* macroinvertebrate communities, indicating conditions at or near reference.** Twenty-four percent of stream miles were assessed as *Good*, and **only 2.6% failed to meet aquatic life criteria for macroinvertebrates** (*Poor* or *Fair*).

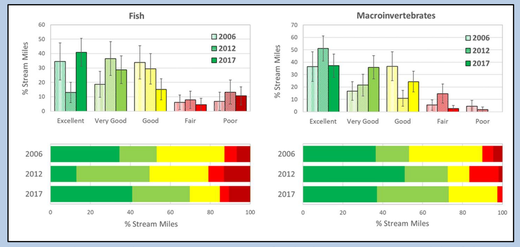
Similarly, **70% of stream miles were at or near reference condition for fish communities** (*Very Good* or better). Fifteen percent of stream miles were assessed as *Good* for fish, and 15% failed to meet criteria for a healthy community.




Stream miles in each biological assessment category. Error bars represent 95% confidence intervals.

Comparisons to the two previous probabilistic surveys show more miles with reference condition fish communities, and fewer miles with failing macroinvertebrate communities, in the 2013-2017. However, no statistically significant trends have been found. It was determined that the statistical design of the survey, where sites are stratified by rotational watersheds and results are compiled every five years, was not adequate for finding trends between surveys.

**VTDEC's probabilistic stream surveys have recently been redesigned for annual reporting of results and improved trend detection**. Beginning in 2018, scientists are visiting 15 completely randomized sites annually. After three years, a moving window of 45 sites will be used to make annual estimates of biological status and trends.




Stream miles in each assessment category for both surveys, separated by fish and macroinvertebrate ratings.

## Potential Stressors

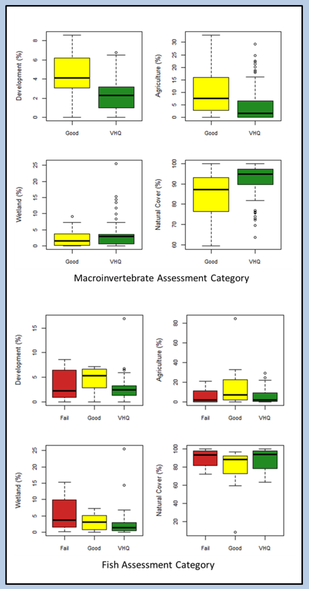
Watershed land use percent was significantly different when comparing macroinvertebrate communities assessed as *Good* with communities assessed as *Very Good* or *Excellent* (at/near reference level or "very high quality"). Percent development and agriculture were significantly higher, and natural cover (forest plus wetland) was significantly lower, at sites with *Good* condition. Failing sites were not included in this analysis due to small sample size (n=2). Land use was not significantly different between sites with fish communities in very high quality, *Good*, or failing categories.

Twelve out of the 78 sites failed to meet aquatic life criteria for either macroinvertebrates or fish communities. **At each of these 12 sites, one community failed to meet criteria, while the other showed full support. This suggests that local or watershed stressors affect these communities differently**. State biologists reviewed chemical, physical habitat and geographical data for each of these sites in an effort to determine the potential influence of each of the ten major stressors identified in Vermont Surface Water Management Strategy: (**https://dec.vermont.gov/watershed/map/strategy**).

**For the two sites with failing macroinvertebrate communities, chemical stressors were readily apparent**. Jewett Brook is on Vermont's list of impaired waters due to nutrients from agricultural runoff. Roaring Brook has a high concentration of chloride, and was sampled downstream of a ski resort where the stream is impaired for stormwater runoff.

**Among the ten sites with failing fish communities, thermal stress was the most frequently identified stressor, followed by channel erosion**. This isn't surprising, given that many fish species have narrow temperature tolerances and require cold water. Interestingly, warming of water due to upstream wetlands and ponds was implicated as the source of thermal change at each of the sites with thermal stress. Fish communities can not be considered impaired due to natural ponds and wetlands, but this does show the dramatic effect that warming can have on these communities. **These are important findings, given that both increased temperatures and channel erosion are predicted outcomes of climate change**. This also highlights the need for Vermont to create biological criteria for fish communities in natural warm-water habitats.

| Location | Macroinvertebrate Assessment | Fish Assessment | Potential Stressors |
|---|---|---|---|
| Airport Brook | Good | Poor | Thermal Stress |
| Black Branch Nulhegan River | Excellent | Fair | Thermal Stress |
| Dutton Brook | Excellent | Fair | Thermal Stress, Channel Erosion |
| Jewett Brook | Fair | Good | Encroachment, Nutrient Loading |
| Lamoille River | Very Good | Fair | Encroachment |
| Little River | Good | Poor | Channel Erosion, Thermal Stress, Encroachment |
| Madden Brook | Good | Poor | Channel Erosion |
| Roaring Brook (Killington) | Fair | Very Good | Channel Erosion, Toxic Substances |
| Snipe Island Brook | Excellent | Poor | Channel Erosion, Land Erosion |
| South Branch Williams River Trib | Excellent | Poor | Thermal Stress, Nutrient Loading |
| Trout Brook (Brownington) | Very Good | Poor | Thermal Stress |
| West Branch Deerfield River | Excellent | Poor | Thermal Stress, Acidity |



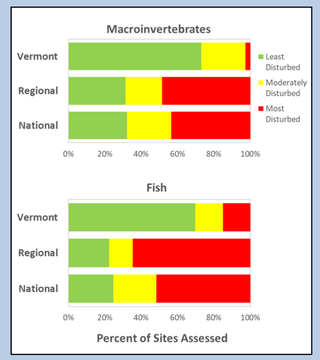

Differences in watershed land use between assessment categories for both macroinvertebrate and fish communities. "VHQ" refers to very high quality biological condition, combining *Very Good* and *Excellent* assessments. Communities that "Fail" have *Fair* or *Poor* assessments.

## Comparisons to National Survey

Vermont's probabilistic stream surveys are designed to overlap with the USEPA's National Rivers and Streams Assessments (NRSA). Chemical and biological data from VTDEC's 2013-2017 survey and the 2013-2014 NRSA survey can be used to draw direct comparisons of stream condition at state, regional, and national scales. NRSA uses a three-tiered assessment scale. Narratively, these convert well to VDEC biological ratings using the following:

- NRSA "**Least Disturbed**" condition is comparable to VTDEC assessments at or near reference condition (***Very Good*** or ***Excellent***).
- NRSA "**Moderately Disturbed**" condition equates to VTDEC's ***Good*** rating, described as a moderate departure from the natural condition.
- NRSA "**Most Disturbed**" condition compares to VTDEC's failure to meet minimum criteria for biological health (***Fair*** or ***Poor***).

**Comparisons of macroinvertebrate and fish assessments show that Vermont has a dramatically lower proportion of stream miles rated as "Most Disturbed", and a much higher percentage rated as "Least Disturbed" than at the national or regional scales**.




Comparison of biological assessments at the state, regional, and national scales. Regional assessments are from the Northern Appalachian ecoregion, including New England, New York and parts of Pennsylvania and Ohio.

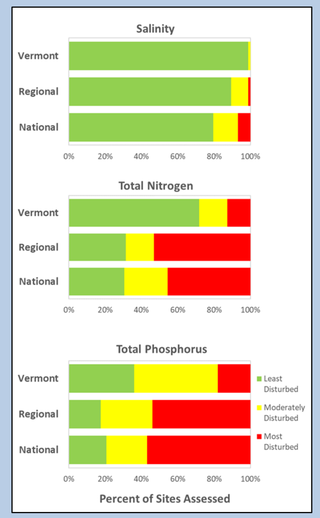
For chemical parameters, VTDEC uses the NRSA numerical thresholds for the Northern Appalachian ecoregion to maximize comparability. All but one Vermont site met the "Least Disturbed" condition for salinity.

Nitrogen showed similar results at the national and regional scales. Vermont has comparatively more sites in "Least Disturbed" condition, with 30% of sites in the moderately or most disturbed categories.

In contrast, **only 21% of Vermont sites had phosphorus concentrations in "Least Disturbed" condition, and 18% were in the "Most Disturbed" category**. Phosphorus loading to Vermont streams, and detrimental effects to lake water quality, is a topic of great concern. While concentrations are better than regional or national averages, the fact that it is a notable stressor in this context is not surprising.

| | Least Disturbed | Moderately Disturbed | Most Disturbed |
|---|---|---|---|
| Salinity (Conductivity) | < 500 uS | 500 - 1000 uS | > 1000 uS |
| Total Nitrogen | < 0.33 mg/l | 0.33 – 0.44 mg/l | > 0.44 mg/l |
| Total Phosphorus | < 8.2 ug/l | 8.2 – 15.7 ug/l | > 15.7 ug/l |

Ecoregional thresholds for three chemical parameters analyzed in EPA's national probabilistic survey




Comparisons of chemical results at the state, regional, and national scales.

## Conclusions

Incorporating probability-based surveys into VTDEC's monitoring program allows for an unbiased assessment of the biological condition of Vermont's wadeable streams. These ongoing surveys coincide with EPA's national surveys, allowing for comparisons to national and regional conditions. The completion of a third probabilistic survey in Vermont has provided some interesting insights:

- **Seventy-three and 70% of macroinvertebrate and fish communities, respectively, are at or near reference condition. This highlights the unique quality of Vermont's aquatic resources, and the importance of protecting these ecosystems.**
- **Chemical stressors resulting from agriculture and development led to degraded macroinvertebrate condition. Thermal stress and channel erosion were identified as major stressors to fish community condition, factors that will be exacerbated by climate change.**
- **Vermont has better biological community condition, as well as lower levels of chemical stressors, compared to results from national and regional surveys. Of parameters analyzed, phosphorus appears to be of the most significant concern, reinforcing Vermont's prioritizing of phosphorus reduction to improve water quality.**
- **The design of Vermont's first three probabilistic surveys has limited VTDEC's ability to observe long-term trends. A recent redesign of the survey will allow for both annual reporting of statewide biological condition, and more rapid trend detection.**