Assessing the Statewide Biological Condition of Vermont Streams

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Probability Monitoring

For over three decades, the Vermont Department of Environmental Conservation (VDEC) has continuously operated an annual stream biomonitoring program. Between September 1st and October 15th, extensive fish surveys and macroinvertebrate sampling are conducted throughout the state. Fish IBI's and macroinvertebrate metrics are scored, and assessment ratings are given to each community based on those scores. **Assessments rated as "Poor" or "Fair" indicated a failure to achieve Vermont's aquatic life use standards, while ratings of "Good", "Very Good" or "Excellent" indicate aquatic life use support, and increasingly healthy communities**. VDEC also collects an abundance of data relating to stream chemistry, substrate, physical habitat, and riparian characteristics, which are used to help explain patterns in the biological community data.

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

The biomonitoring program uses a rotational sampling model, where annual efforts focus on a subset of major watersheds, and all watersheds of the state are monitored over a 5-year period. The probabilistic survey was designed to coincide with VDEC'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). By continuing probabilistic surveys on this cycle, **we can investigate long-term trends in Vermont's stream communities, principle environmental stressors, and compare Vermont streams to conditions found at regional and national scales**.

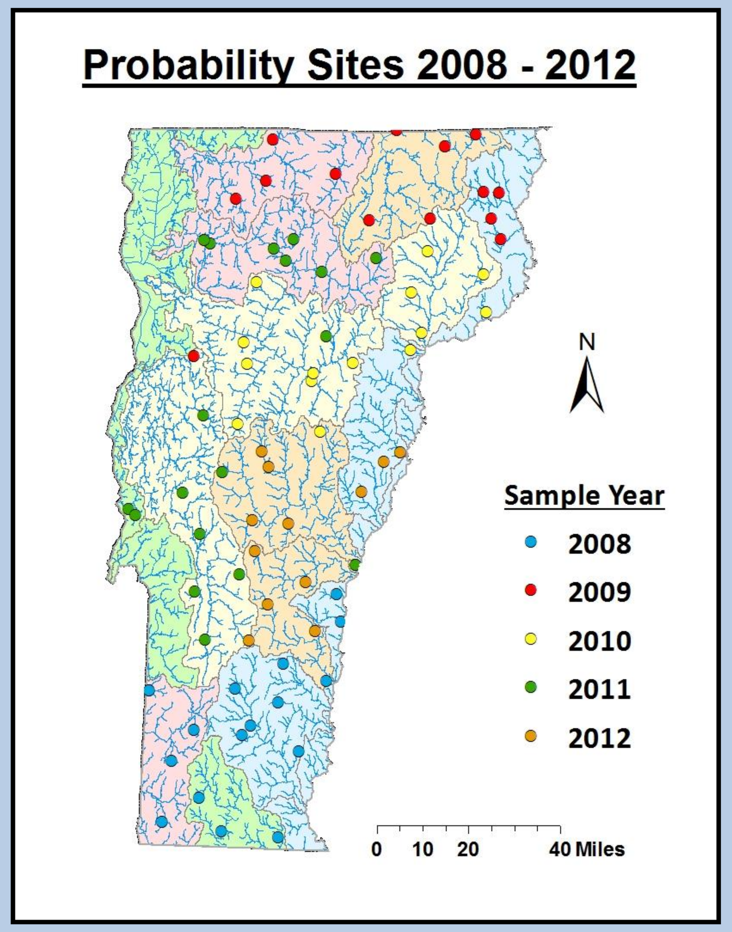

Figure 1: Probability sites sampled in the 2008-2012 rotation. Shaded watersheds indicate the current separation of the annual monitoring rotation. Sample sites do not line up precisely with the watersheds, due to recent changes in the rotational cycle

Design and Methods

Two 5-year probability surveys have been completed (2002-2006 and 2008-2012). The analysis presented here focuses on results of the 2008-2012 survey. Seventy-four sites were randomly selected from all wadeable Vermont streams (1st-4th order) and monitored over this period. VDEC targets 12-15 sites per year for this survey, a number that allows for reasonable statistical inference while not unduly stretching the program's limited resources. Our macroinvertebrate assessment method uses categories that correlate to wadeable stream size; small high gradient (SHG), medium high gradient (MHG), and warm water moderate gradient (WWMG). Streams can also be classified as low gradient "slow winders" (SW), based the lack of "riffle" habitat and dominated by fine substrate (i.e. sand, silt, clay), irrespective of size. The percentages of stream miles assessed in each category demonstrates that the ratio of stream types were constant between surveys completed in 2006 and 2012 (**Figure 2)**. Macroinvertebrate samples were collected from riffles, or other available habitat in the case of SW streams. Fish were surveyed at 61 of these sites, with the remainder being to large to assess using VDEC methodology. Water chemistry and physical habitat data were also collected for all sites. Biological assessment ratings were then given to all sites based on community data. The results presented in this poster focus primarily on macroinvertebrate assessments and overall community assessments, and how these ratings compare to our previous probability survey and the recent national NRSA survey.

For more information on VDEC sampling and assessment methodology, please visit: **http://www.watershedmanagement.vt.gov/bass/htm/bs_biomon.htm**

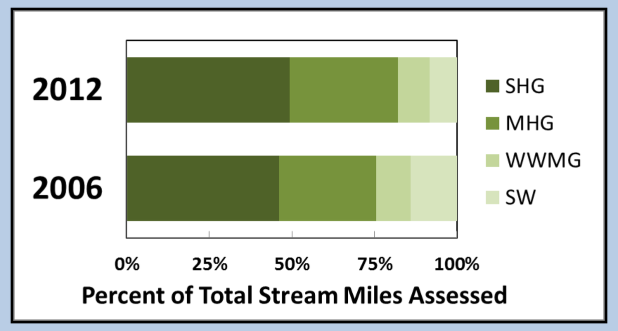

Figure 2: Proportions of assessments by stream type for the two probability surveys completed

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Overall Assessments

Overall assessments were determined by using the lesser of the fish or macro-invertebrate ratings, or the macroinvertebrate rating at sites where fish were not surveyed. Results show that in the probability survey ending in 2012, 30% of stream miles assessed failed to meet Vermont's standards for aquatic life use, compared 12% in 2002-2006 (**Figure 3**). The increase in failing assessments resulted from a decline in stream miles rated as "Good", which were down from 43% in 2006 to 25% in 2012. The ratio of stream miles receiving the highest ratings of "Very Good" and "Excellent" were identical in the 2006 and 2012 surveys (45%).

The shift in ratings lead to more sites failing to meet aquatic life use standards in 2008-2012, and it is important to understand what might be causing that change. Looking at community assessments at separately, it appears that there were indeed fewer "Good" macroinvertebrate assessments in the second survey (**Figure 4**). However, this decline coincided with a proportionately even increase in both the failing "Fair" ratings, *and* assessments indicating Very High Quality (VHQ) streams (i.e. "Very Good" and "Excellent").

In contrast, fish assessments showed a more systematic decline across the rating spectrum. Failing assessments increased in the 2008-2012 survey. "Good" fish assessments decreased slightly from 2006 to 2012, as did the total number of VHQ assessments. Also notable was a shift from "Excellent" to "Very Good" within higher quality fish communities. In general, **it appears that declining assessments in *both* communities may be contributing to the trend towards more failing sites in 2008-2012**.

Differences between the two surveys have not been shown to be statistically significant, and the addition of future probability surveys will help shed light as to whether these are genuine trends. However, a closer look at failing sites in the recent survey provides interesting information on the overall biological condition. Of the 19 sites that failed to meet aquatic life use standards, 5 were identified as having experienced flow related stress (scouring and/or low flows), and 5 were identified as being influenced by organic or nutrient enrichment. Other impacts attributed to failing assessments at these sites include thermal stress (profundal release from an upstream reservoir), acidification, and erosion. Interestingly, of 17 failing sites where both communities were assessed, only 6 sites had both failing fish *and* macroinvertebrate assessments. Three sites had "Fair" invertebrate assessments, but passing fish communities, while 8 sites have failing fish assessments and had passing macroinvertebrate communities (mostly VHQ).

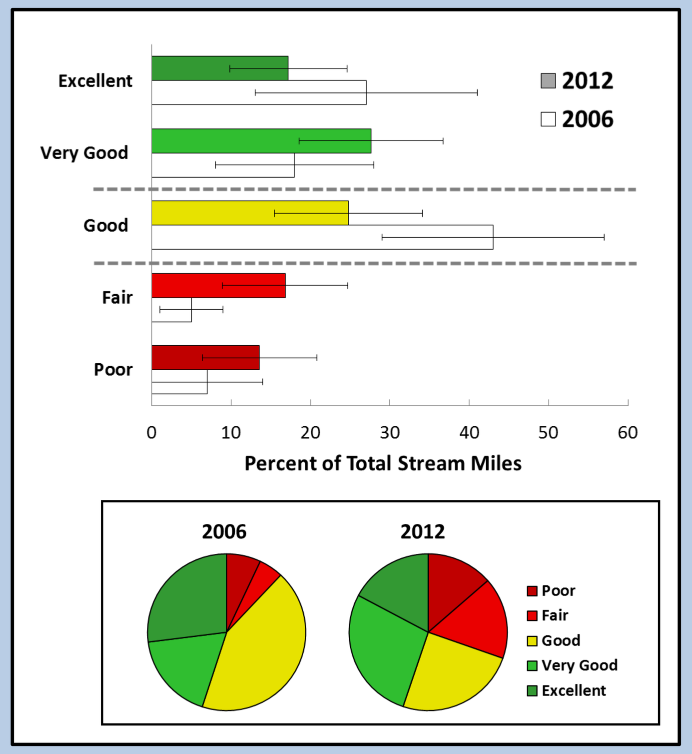

Figure 3: Overall stream miles in each VDEC assessment category. Error bars represent 95% confidence intervals. Dashed lines on the bar chart separate streams that fail to meet aquatic life use standards (red), as well as streams which can be classified as "very high quality" waters (green).

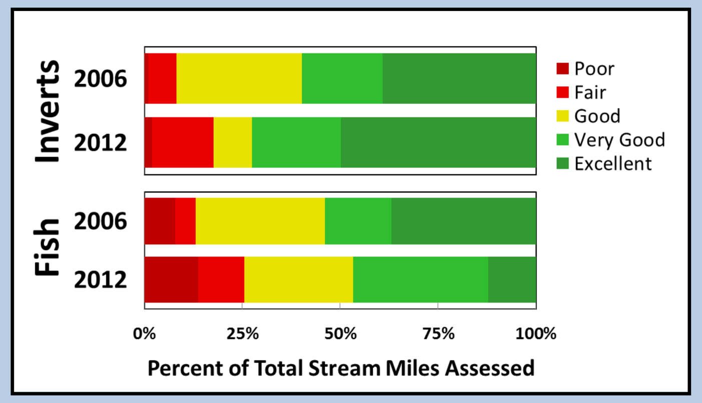

Figure 4: Stream miles in each assessment category for both surveys, separated by fish and macroinvertebrate ratings.

Invertebrate Assessments & Potential Stressors

To understand what is driving the overall biological condition of streams in Vermont, we need a deeper understanding of both the fish and macroinvertebrate communities. This includes how the assessments relate both stream types, as well as various chemical and physical stressors. As mentioned above, when fish and macroinvertebrate s are examined separately **it is quite common that one community will fail to meet aquatic life use standards while the other community fully supports aquatic life use. Examining each community separately and their relationship to potential stressors can help shed light community differences**. In this section we specifically examine the macroinvertebrate community; the complete analysis also includes the fish community, as well as a full suite of potential stressors.

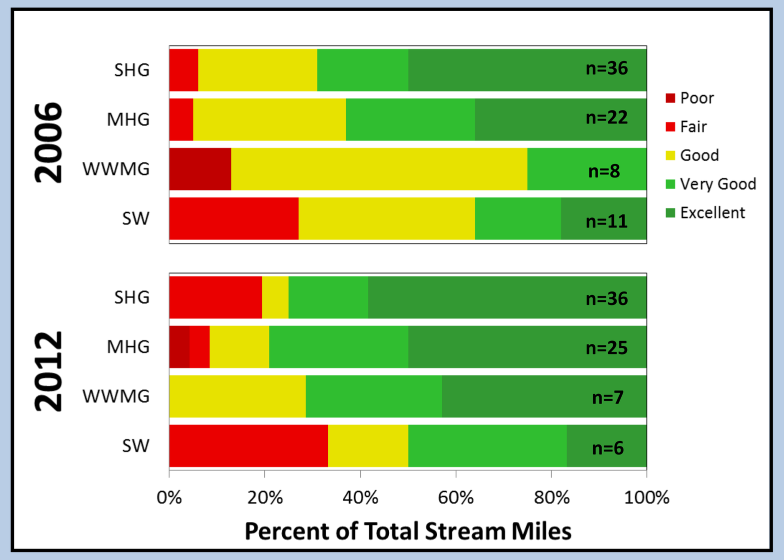

Figure 5: Percent of stream miles for macroinvertebrate assessments broken down by stream type , including both the 2002-2006 and 2008-2012 surveys.

An examination of macroinvertebrate assessments shows that there was in increase in streams rated as "Excellent" in both SHG and MHG streams in 2012, as well as an increase in failing stream assessments in SHG streams (**Figure 5**). While both WWMG and SW streams had more "Very Good" and "Excellent" assessments in 2012, it is important to remember that the sample sizes for these stream types is quite small.

When macroinvertebrate assessments are correlated with land use and environmental stressors, there is an indication of what might affecting biological condition (**Figure 6**). Watershed development, chloride, and sedimentation are at relatively low levels throughout these sites, and do not seem to be affecting macroinvertebrate community health. Nutrient enrichment in agricultural areas seems to decrease assessment scores, and this may be in part related to filamentous algae cover causing habitat deterioration. Variability in the stressor data however is very high, and finding significant trends will require the accumulation of more data.

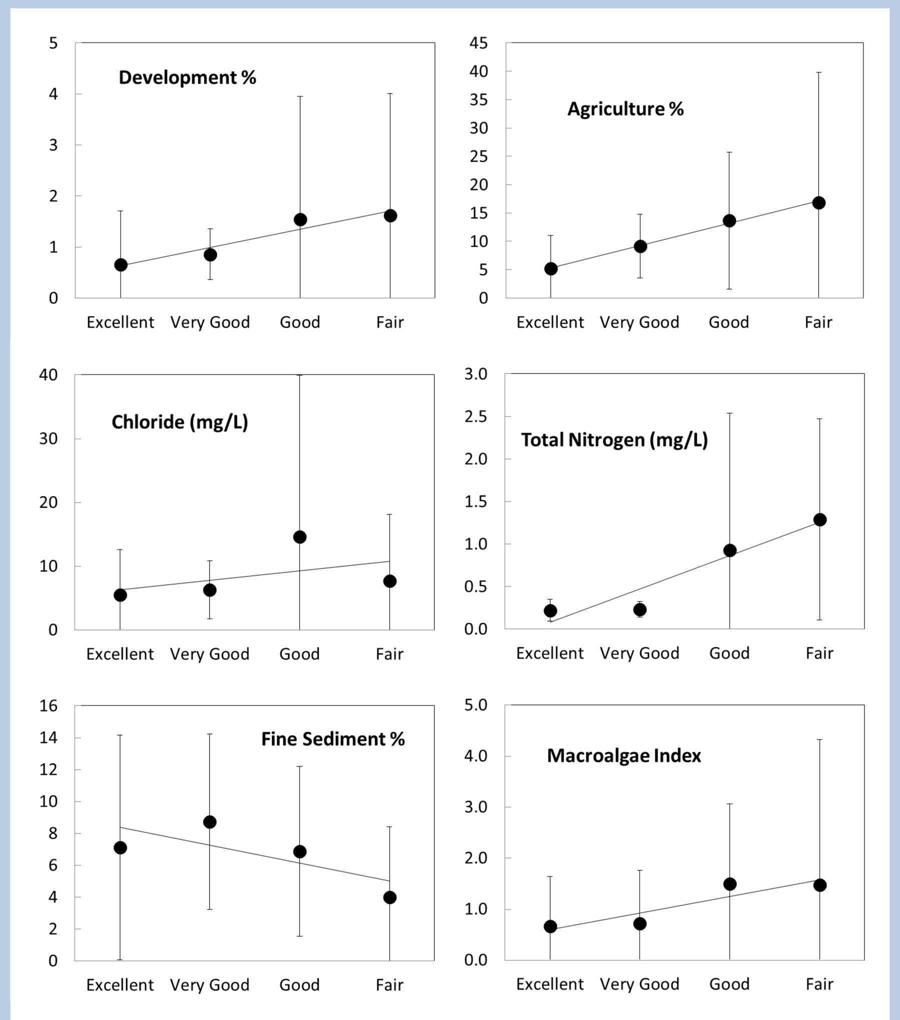

Figure 6: Watershed land use and a partial set of potential stressors for macro-invertebrate assessment ratings. "Poor" is not included, as only one site was rated as such (due to thermal stress.). Error bars represent standard deviation of the mean.

Comparisons to National Survey

Vermont's probability surveys are designed to overlap with EPA's National Rivers and Streams Assessments (NRSA). Chemical and biological data from VDEC's 2008-2012 probability survey and EPA's 2008-2009 NRSA survey can be used to draw direct comparisons to wadeable stream conditions at state, regional, and national scales. NRSA scales include the continental U.S., 3 major climatic regions, and 9 geographically distinct eco-regions. NRSA uses a three tiered assessment scale ("Poor", "Fair", and "Good"). For chemical parameters, VDEC assessments use the NRSA thresholds at the eco-region scale to maximize comparability. For macroinvertebrate comparisons, we've used the following scale:

- NRSA "Poor" assessments equate to VDEC's failing assessments ("Poor" and "Fair").
- NRSA "Fair" assessments equate to VDEC's "Good" (those sites just above the pass/fail threshold).
- NRSA "Good" assessments equate to VDEC's very high quality ratings of "Very Good" and "Excellent".

Comparisons of macroinvertebrate assessments show that Vermont has a dramatically lower proportion stream miles rated as "Poor", and a much higher percentage rated as "Good" than the national or regional scales.

A comparison of stressors scaled by NRSA shows that salinity in Vermont rates better than national or regional averages. In fact, none of the Vermont sites were rated "Poor", and only one site was above the 500 uS threshold to rate as "Fair". Similar trends were found in the nutrient comparisons. A vast majority of stream miles were rated as "Good" for nitrogen compared to national and regional data, with only 15 of 74 sites falling below this threshold. Phosphorus, which is viewed as a significant water quality problem in Vermont, showed more streams with "Poor" and "Fair" ratings, yet far less than all other scales. In fact the percent of stream miles rated "Poor" for phosphorus was nearly 3 times less in Vermont than in our eco-region (covering primarily NY and NE).

These comparisons give important information on how our State fits into a larger context. However, it is important to remember that there are caveats to this comparison as well. Our macroinvertebrate ratings follow different methodology and are rated on 5-tier scale, and VDEC monitoring is done during the September-October index period, while NRSA data is collected between June and September.

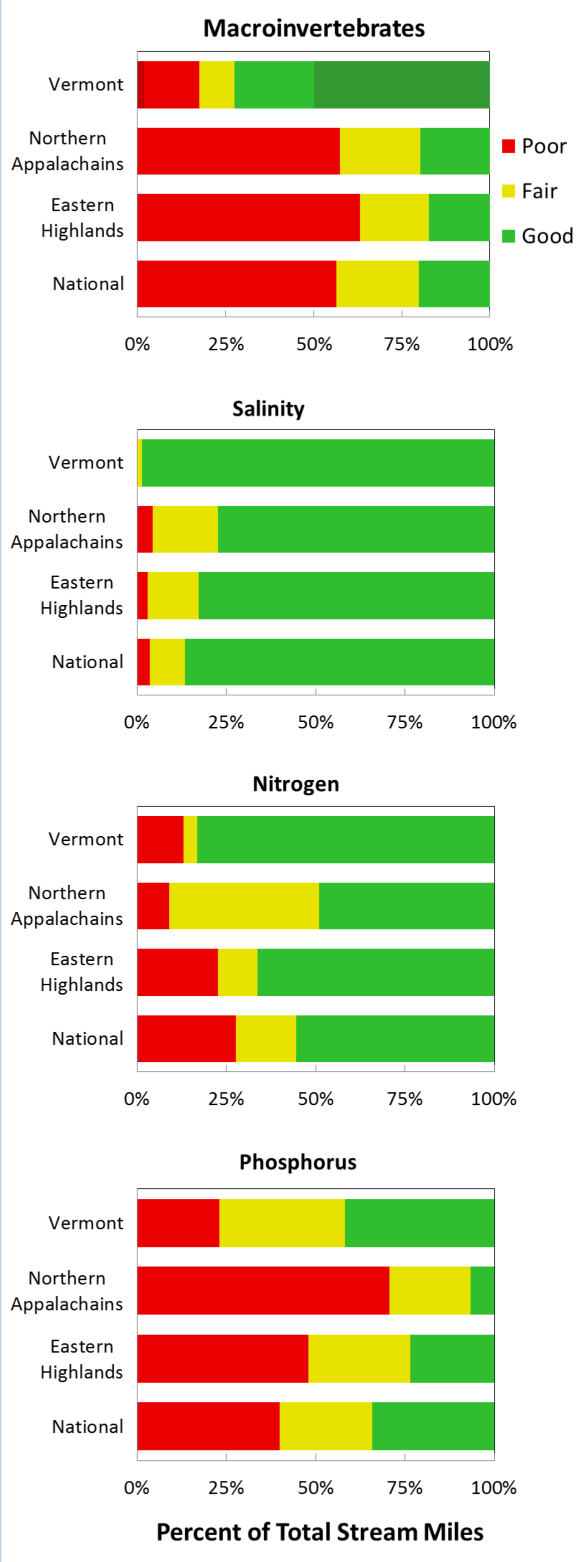

Figure 7: Comparisons of assessments at the state, eco-region (Northern Appalachains), major climatic region (Eastern Highlands) ,and national scales. For Vermont macroinvertebrate assessments, both shades of red equate to "Poor", while both shades of green are "Good".

Conclusions

Biomonitoring resources in Vermont often focus on streams for various management reasons. Incorporating probability based surveys into VDEC'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, and can track long-term biological trends and compare these to national and regional conditions. The completion of a second probability survey in Vermont has provided some interesting insights:

- **Differences between the 2002-2006 and 2008-2012 surveys show that there are more stream miles assessed as "Fair" (failing Vermont's aquatic life use standards), at the expense of sites rated "Good". Difference in both macroinvertebrate and fish assessments contributed to the shift over this threshold, though macroinvertebrates did show an increase in the highest rated sites. Whether this change is a genuine trend or a result of sampling variability will require the completion of future surveys.**
- **A comparison between EPA's national survey and VDEC's probability survey suggests that Vermont is achieving considerably better assessment ratings for both biological and chemical variables at multiple spatial scales, and that these proportional differences are substantial. This shows that Vermont is doing relatively well protecting water quality in a larger context, and demonstrates the utility of conducting a random survey that focuses on all areas of the state.**
- **An examination of macroinvertebrate assessments demonstrates that rating scores do not seem to be influenced by stream size or type. Small and medium streams show relatively equal ratings, and generally followed the same trends over time as seen in the overall assessments. Larger streams and low gradient streams have a small sample size, affecting our ability to look at assessment trends in these stream types.**
- **The true utility of these surveys will be a greater understanding of how chemical and physical stressors affect the biology of Vermont streams over time, and may also explain how fish and macroinvertebrates are affected differently by stressors. Environmental data shows that nutrient enrichment from agricultural areas may contribute to declining community health, but there is a lot of variability in the results. Understanding the complex connections between environmental variables and trends in the biological data is challenging. *We welcome your suggestions on feedback on analyzing these relationships*!**