Insights from 25 Years of Biomonitoring at Ranch Brook and West Branch Little River

A Comparative Analysis of the Benthic Macroinvertebrate Response to Shifting Hydrologic Conditions

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The findings and analyses presented are preliminary and may change as additional information becomes available or further analysis and validation is conducted.

Acknowledgements:

Aaron Moore,
Agency of Agriculture

Mary Nealon,
Bear Creek Environmental

BASS Team:

- Courtney Larson
- Steve Fiske
- Connor Quinn
- Heather Greene
- Jeff Merrell
- Jim Deshler (photo credit)

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- Benthic Macro-invertebrates
- Climate, Hydrology, & Biological Health
- Sampling & Assessment Methods

Comparison of Study Sites

- Watershed Characteristics
- Physical Habitat
- Assessment Scores
- Community Metrics

Trends and Relationships

- Assessment Scores
- Density
- Cumulative Flow Relationships

Insights & Key Take-Aways

- Factors Affecting Stream Health
- Long-Term Trends

Photo credit: Macroinvertebrates.org

Biomonitoring Overview

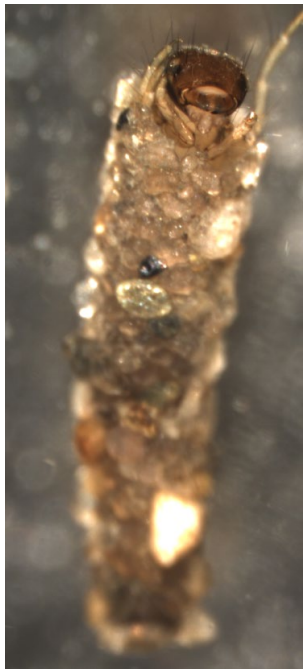


Photo credit: Macroinvertebrates.org

Biomonitoring Overview: Benthic Macroinvertebrates

Why monitor macroinvertebrates?

They are bioindicators that integrate and reflect the cumulative effects of stream health over time

- Responsive to many physical, chemical, and biological conditions
- Integral part of the food web
- Certain species have tolerances or sensitivities to particular stressors
- Provide a more holistic assessment of stream health over time rather than an instantaneous snapshot

Photo credit: Macroinvertebrates.org

Biomonitoring Overview: Benthic Macroinvertebrates

What is the Biomonitoring & Aquatic Studies Section (BASS)?

We sample fish and benthic macroinvertebrate communities to assess the overall health of Vermont's rivers and streams using biological criteria.

What does BASS do with the data?

Protect surface waters for supporting designated uses (aquatic life, recreation, etc.) as required by the Vermont Water Quality Standards.

- Identify high-quality waters for protection
- Identify polluted or degraded waters for restoration
- Evaluate effectiveness of management activities
- Determine overall status and trends of Vermont streams

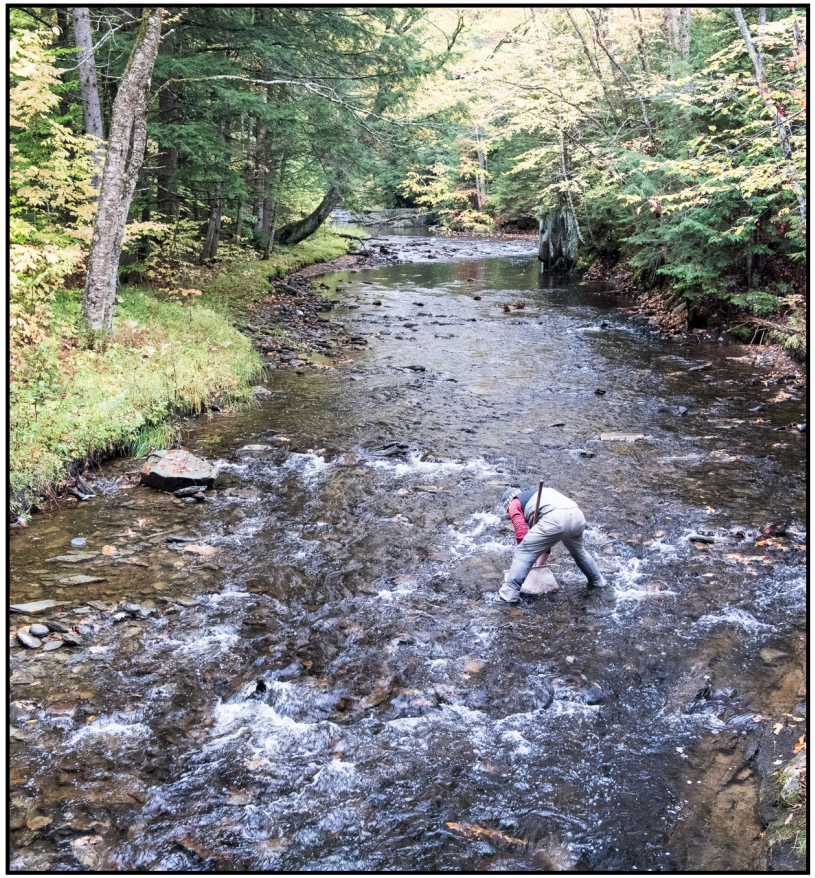
Photo credit: Macroinvertebrates.org

Biomonitoring Overview: Climate, Hydrology, & Biological Health

Anthropogenic stressors & changing climate patterns lead to hydrologic variability

Question: how do hydrologic factors impact biological assessments of stream health?

Comparative analysis of Ranch Brook & West Branch Little River



Biomonitoring Overview: Sampling Methods

At the lab: process, sort, and identify macroinvertebrate samples

Biomonitoring Overview: Assessment Methods

8 metrics specific to the stream type that measure community composition and tolerance to assess biological integrity

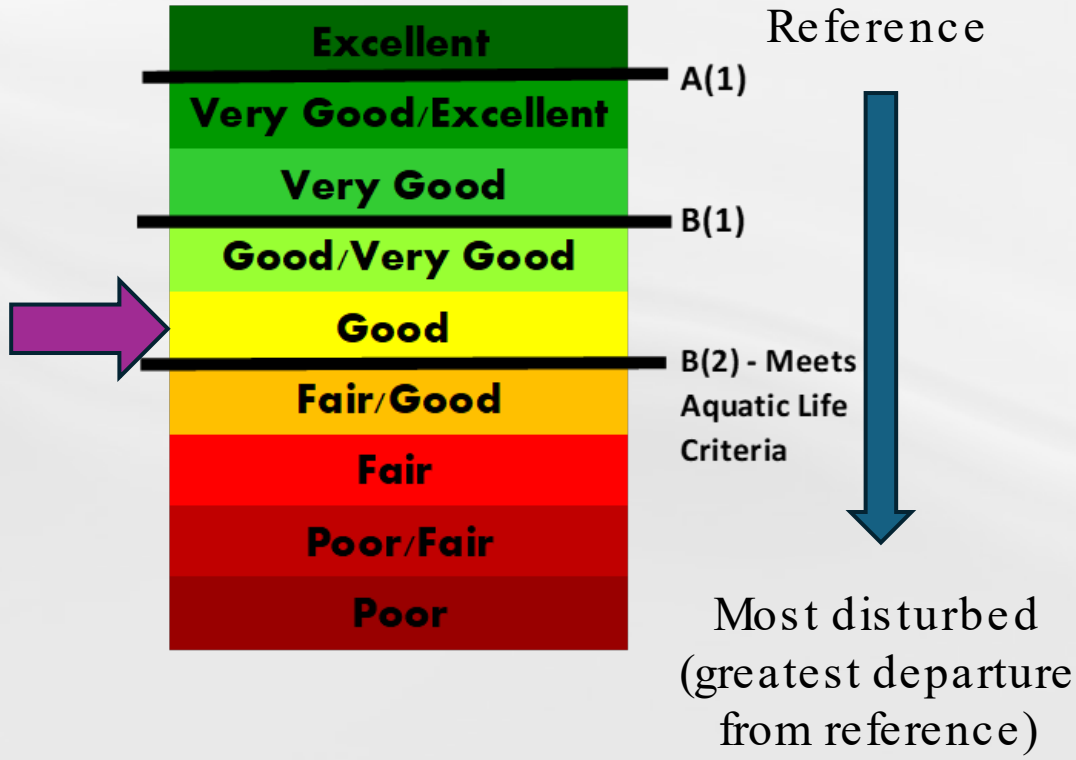
Metric	Description
Density	Number of invertebrates per square meter
Total Richness	Total number of unique taxa in sample
EPT Richness	Total number of unique Ephemeroptera, Plecoptera and Trichoptera taxa
PMA-Order	Percent Model Affinity–Order: Similarity to a model based on reference streams
PPCS-FFG	Pinkham Pearson Coefficient of Similarity based on Functional Groups: Similarity to a model based on reference streams
Biotic Index	Community tolerance to nutrient/organic enrichment
EPT/EPT+Chiro	Ratio of EPT abundance to combined abundance of EPT and Chironomidae
% Oligochaeta	Percent worms of total sample abundance

9 possible ratings for stream health ranging from Poor – Excellent

Must receive an assessment rating of "Good" or better to meet Vermont Water Quality Standards

Metric	Thresholds			
	Non-Attainment Fair/Poor	B(2) Good	B(1) Very Good	A(1) Excellent
Density	<300	>300	>400	>500
Richness	<27	>27	>31	>35
EPT Richness	<16	>16	>19	>21
PMA-O	<45	>45	>55	>65
PPCS-FFG	<.40	>.40	>.45	>.50
Biotic Index	>4.5	<4.5	<3.5	<3.0
EPT/EPT+Chiro	<.45	>.45	>.55	>.65
% Oligochaeta	>12	>12	>5	>2

Assessment Ratings



Comparison of Study Sites

West Branch Little River (WBLR)

Photo credit: Mary Nealon

Ranch Brook

Comparison of Study Sites: Watershed Characteristics

Ranch Brook

Characteristic	Amount
Drainage area (km^2)	9.83
Elevation (ft)	1240
% Developed	1.001 %
% Forested	98.905 %
% Impervious Surface	0.303 %

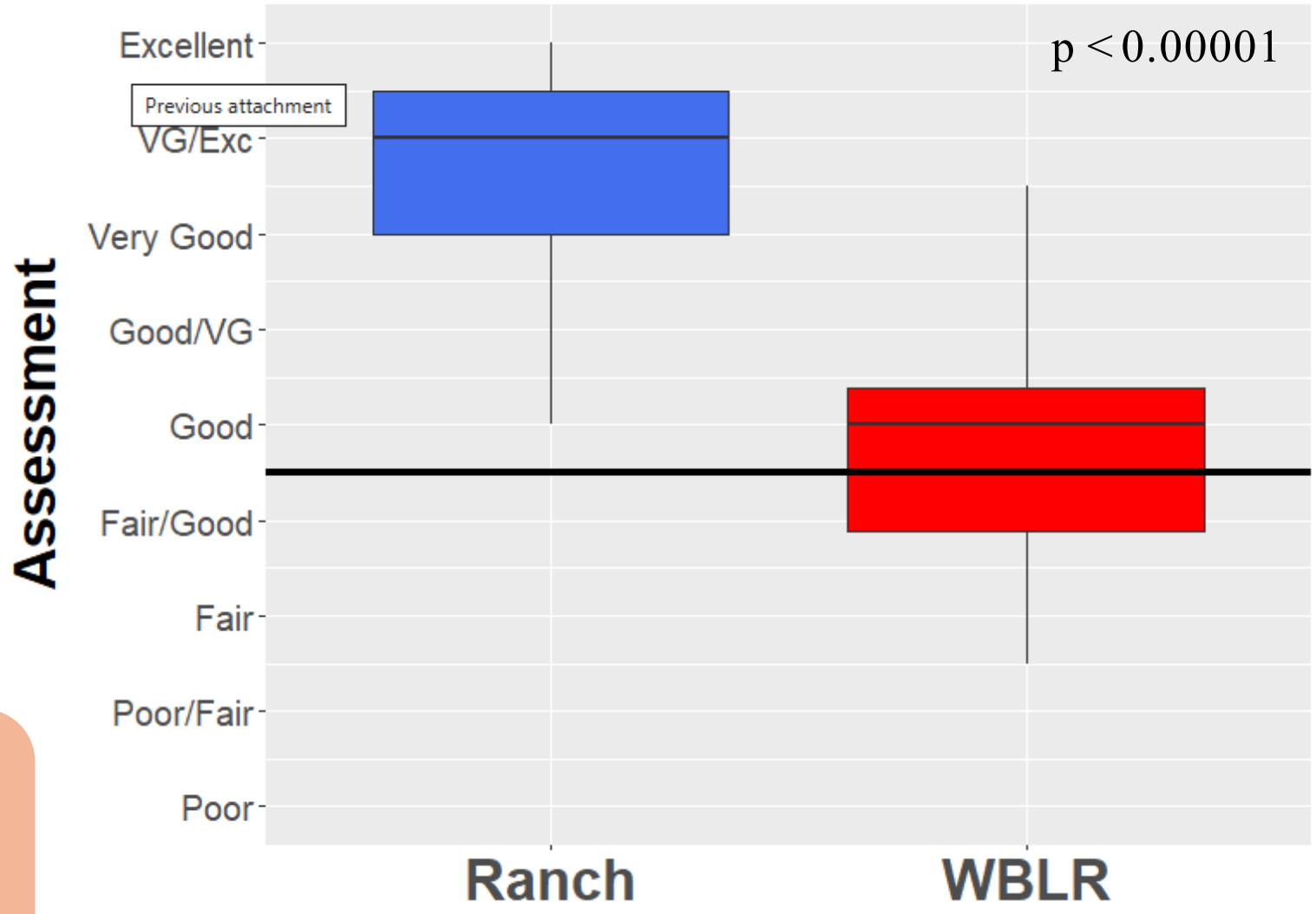
West Branch Little River

Characteristic	Amount
Drainage area (km^2)	12.08
Elevation (ft)	1260
% Developed	19.033 %
% Forested	69.045 %
% Impervious Surface	3.279 %

- 21% greater runoff overall during 20-year study
  - Nearly 8 inches more rain
  - More rapid "fill and spill" due to thinner soils

(Shanley et al, 2021)

Comparison of Study Sites: Assessment Ratings



WBLR consistently scores lower than Ranch over the 25-year study

Comparison of Study Sites: Community Metrics

What metrics are driving differences in assessment ratings?

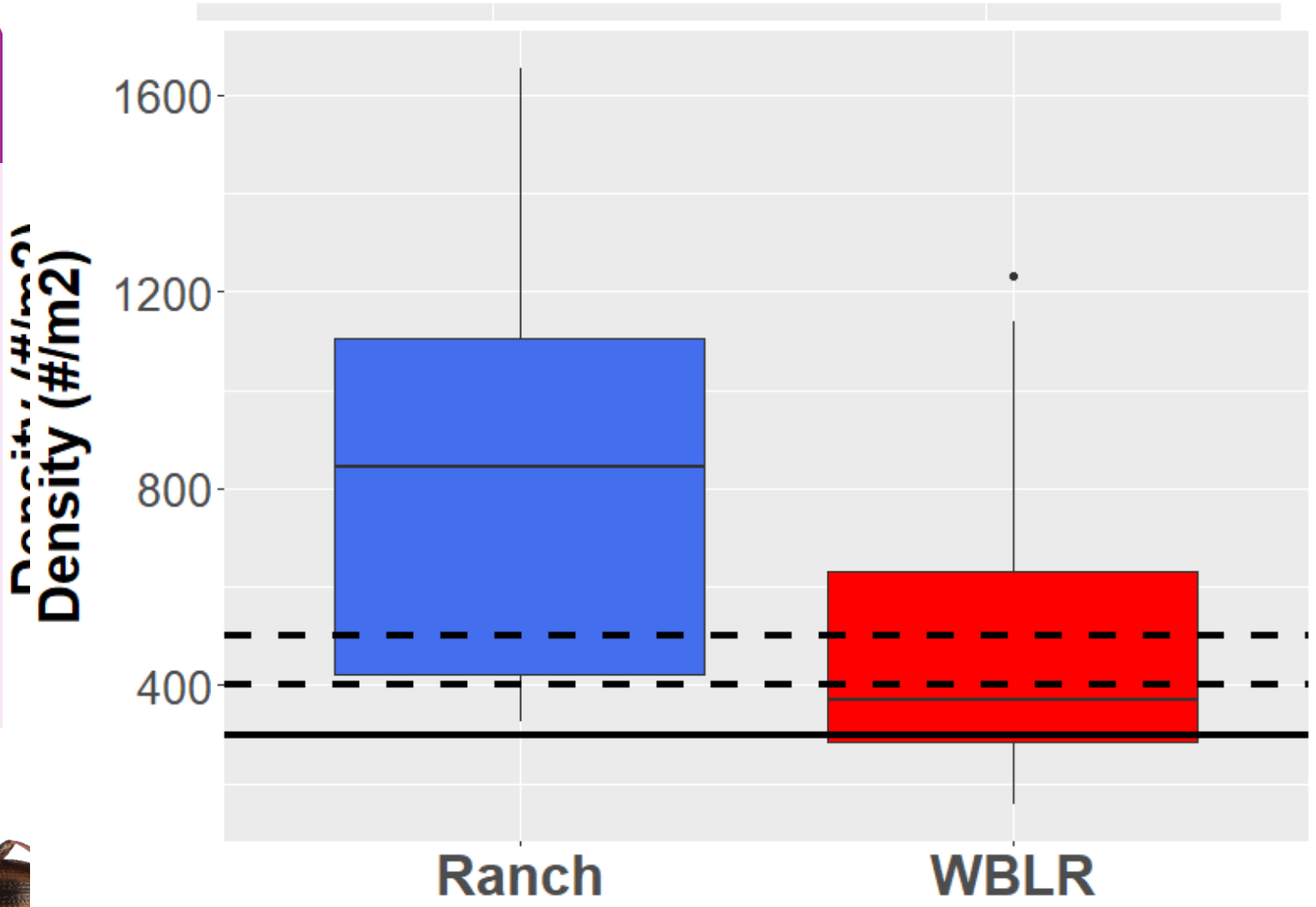
Density

% Baetidae mayflies

Comparison of Study Sites: Community Metrics

Density

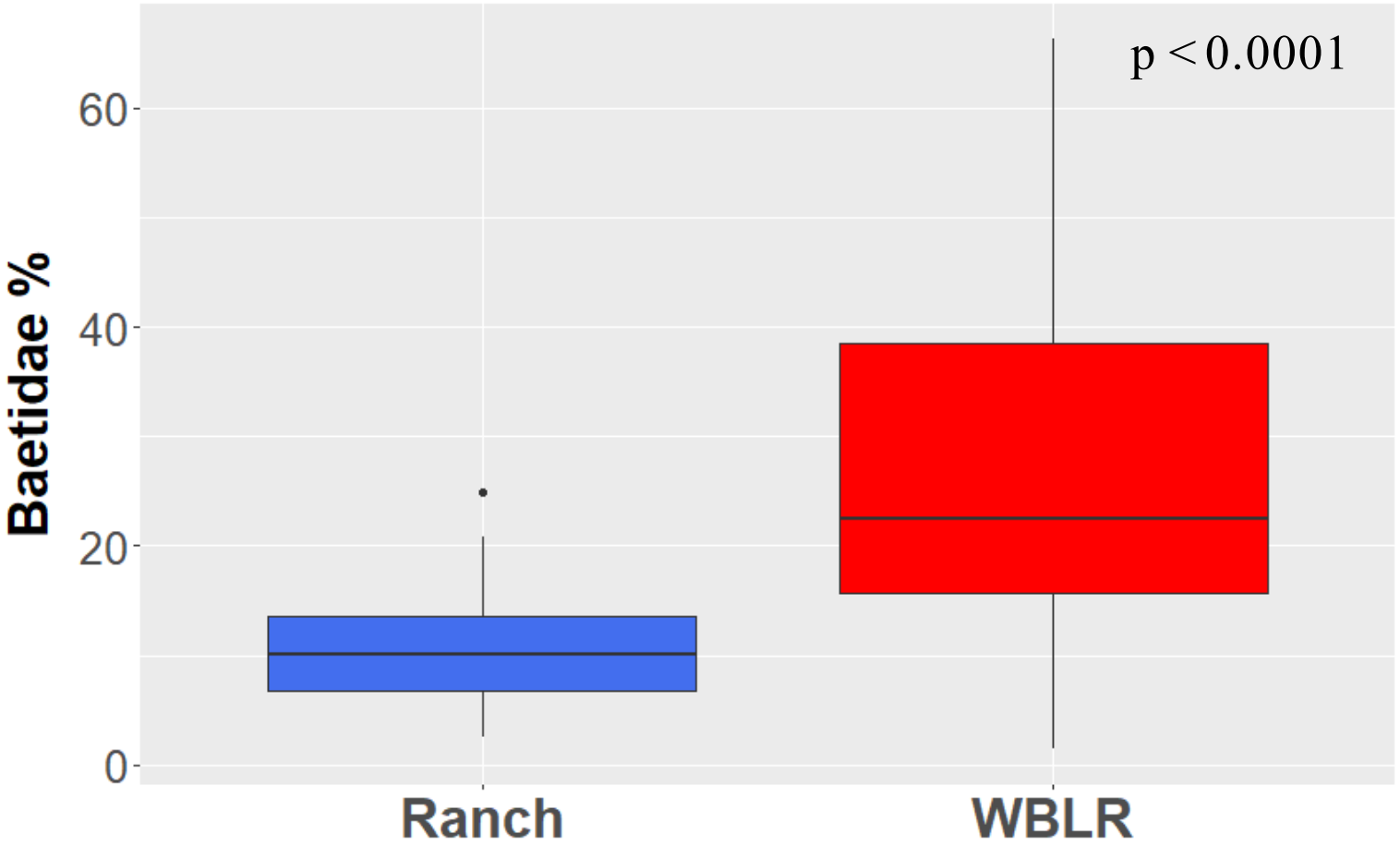
- Some WBLR samples fail to meet the B(2) threshold, directly impacting assessment ratings
- Density is frequently linked to impacts of high flow events and sedimentation



Comparison of Study Sites: Community Metrics

% Baetidae Mayflies

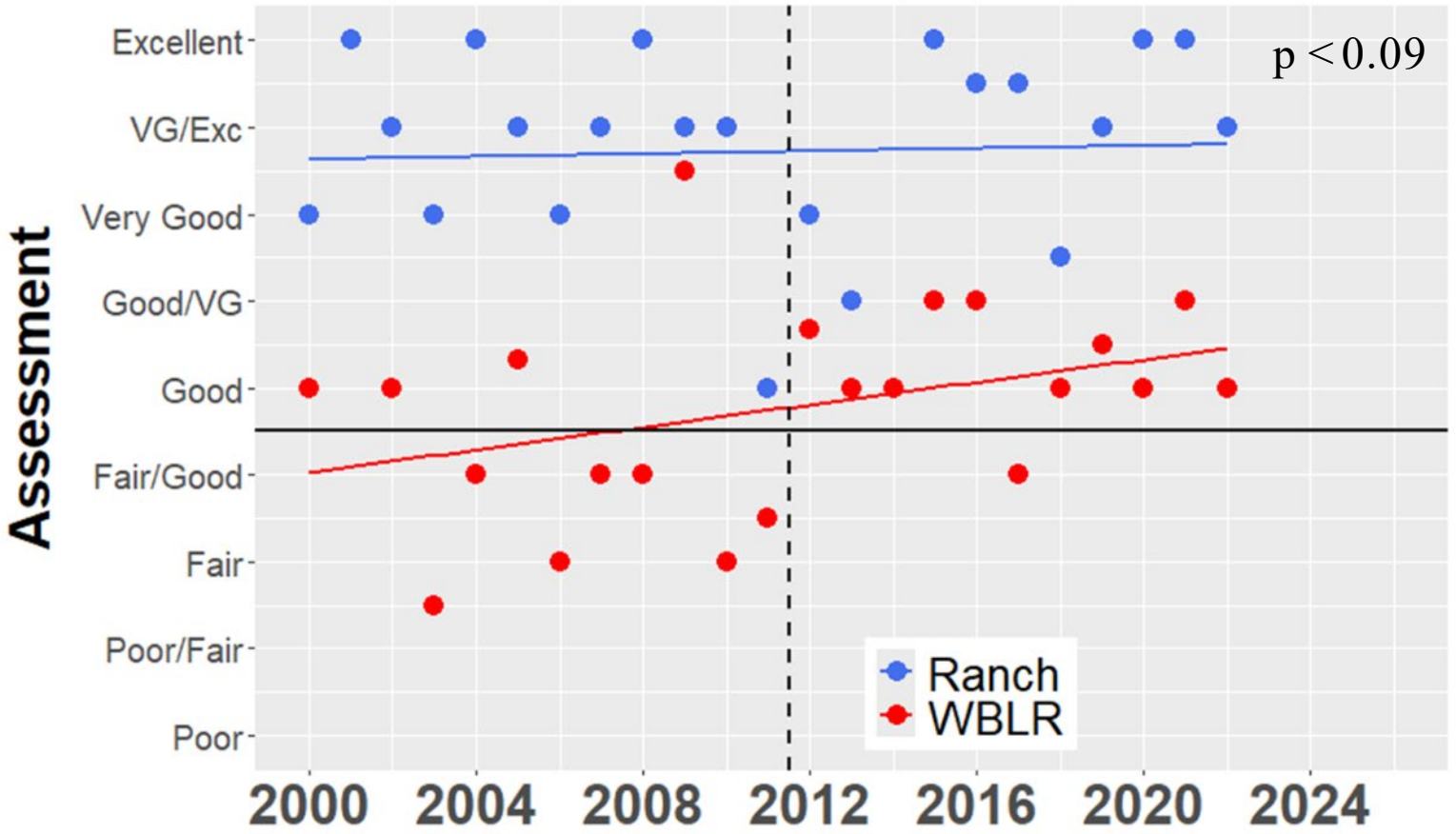
- Baetidae are rapid colonizers of disturbed/scoured substrate
- Evidence that hydrology may be impacting biological communities and contributing to lower assessment ratings at WBLR



Trends & Relationships

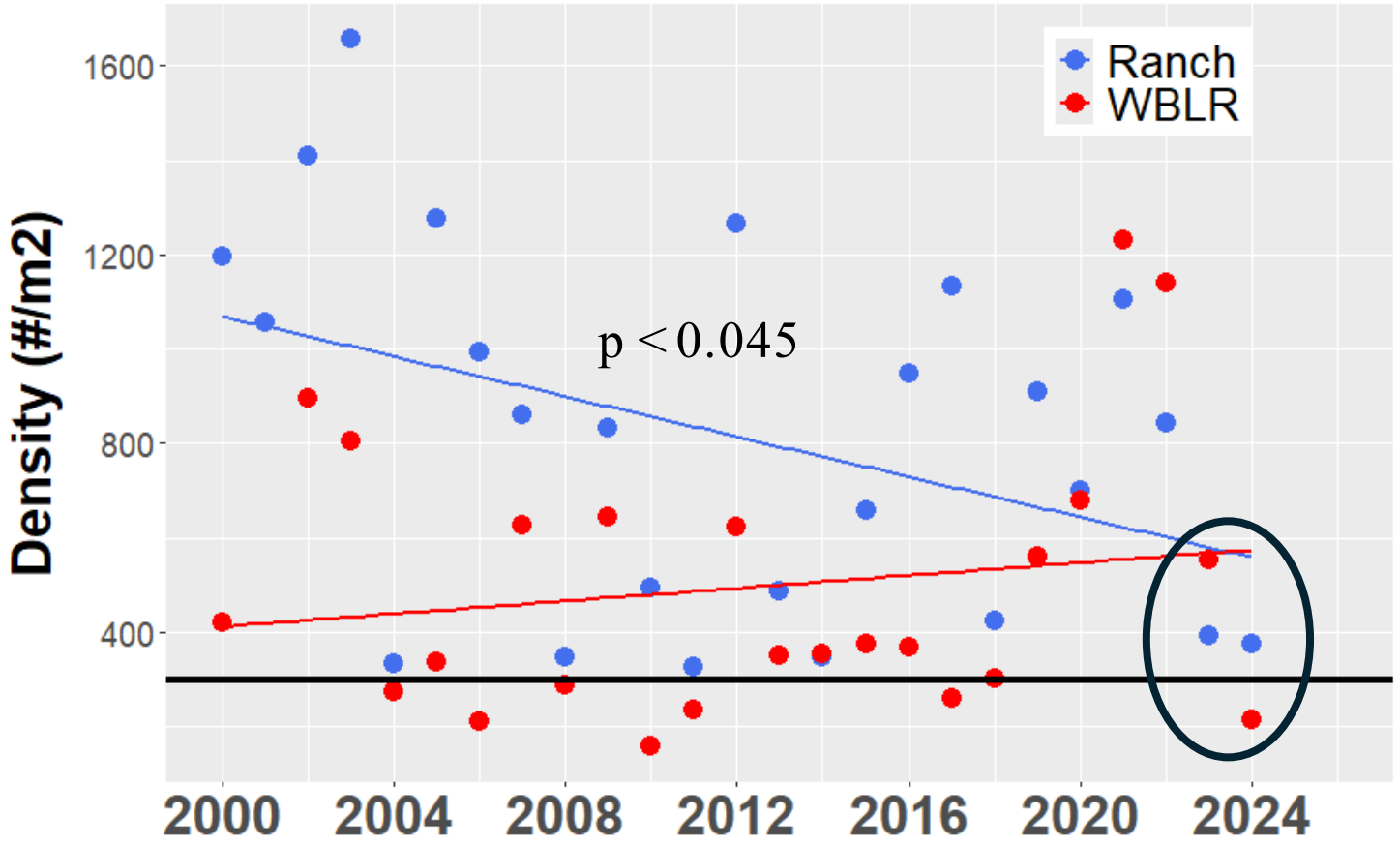
Assessment Scores

- No trend at Ranch
- WBLR shows weak positive trend over time if recent flood years are removed (2023, 2024)
- Significant t-test ($p < 0.04$) comparing pre- and post-2012 data ('23 & '24 removed)



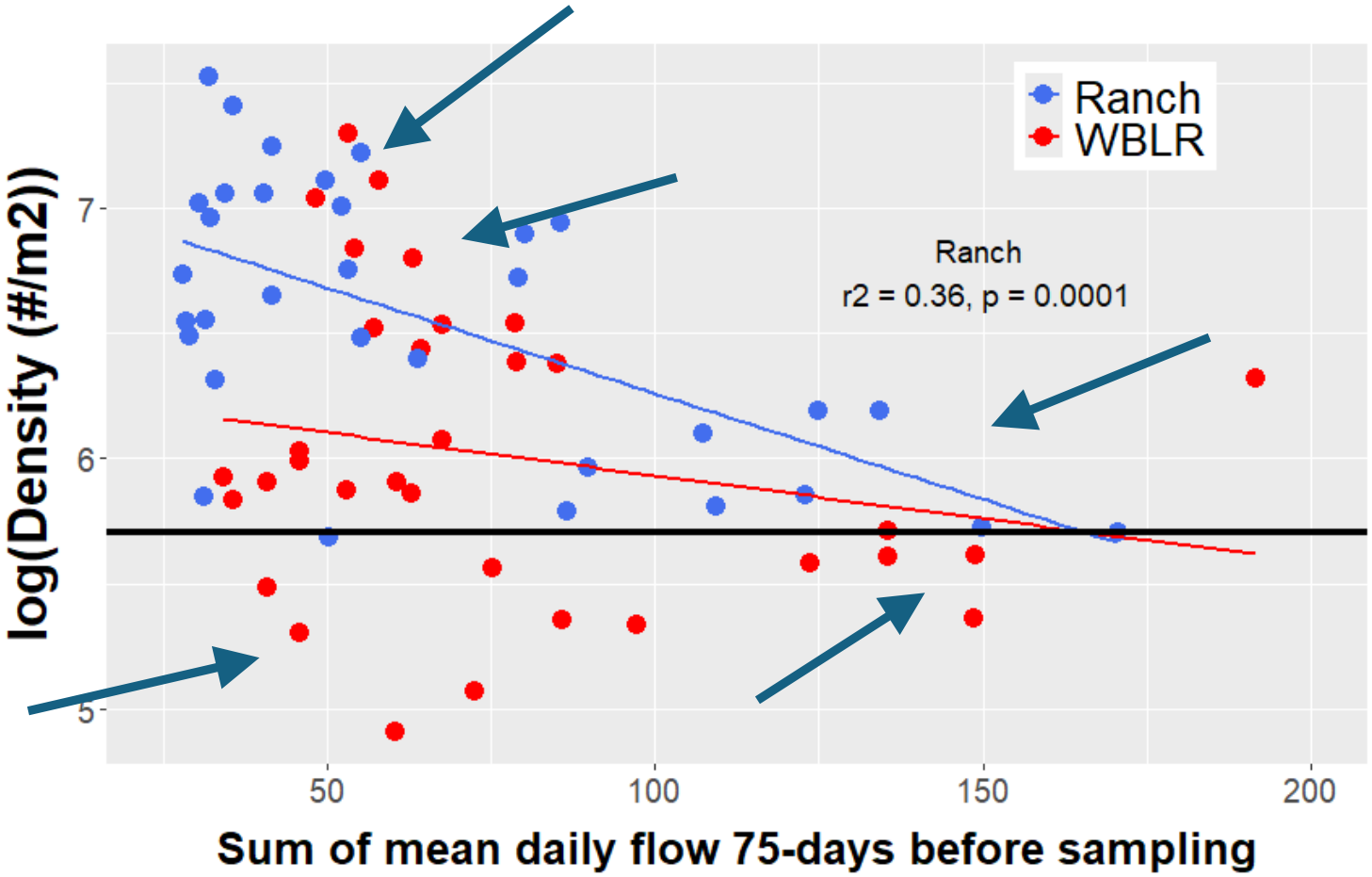
Trends and Relationships: Density

- Weak decreasing trend in density over time at Ranch driven by low density in recent flood years
- Density appears to be improving over time at WBLR, but not significantly



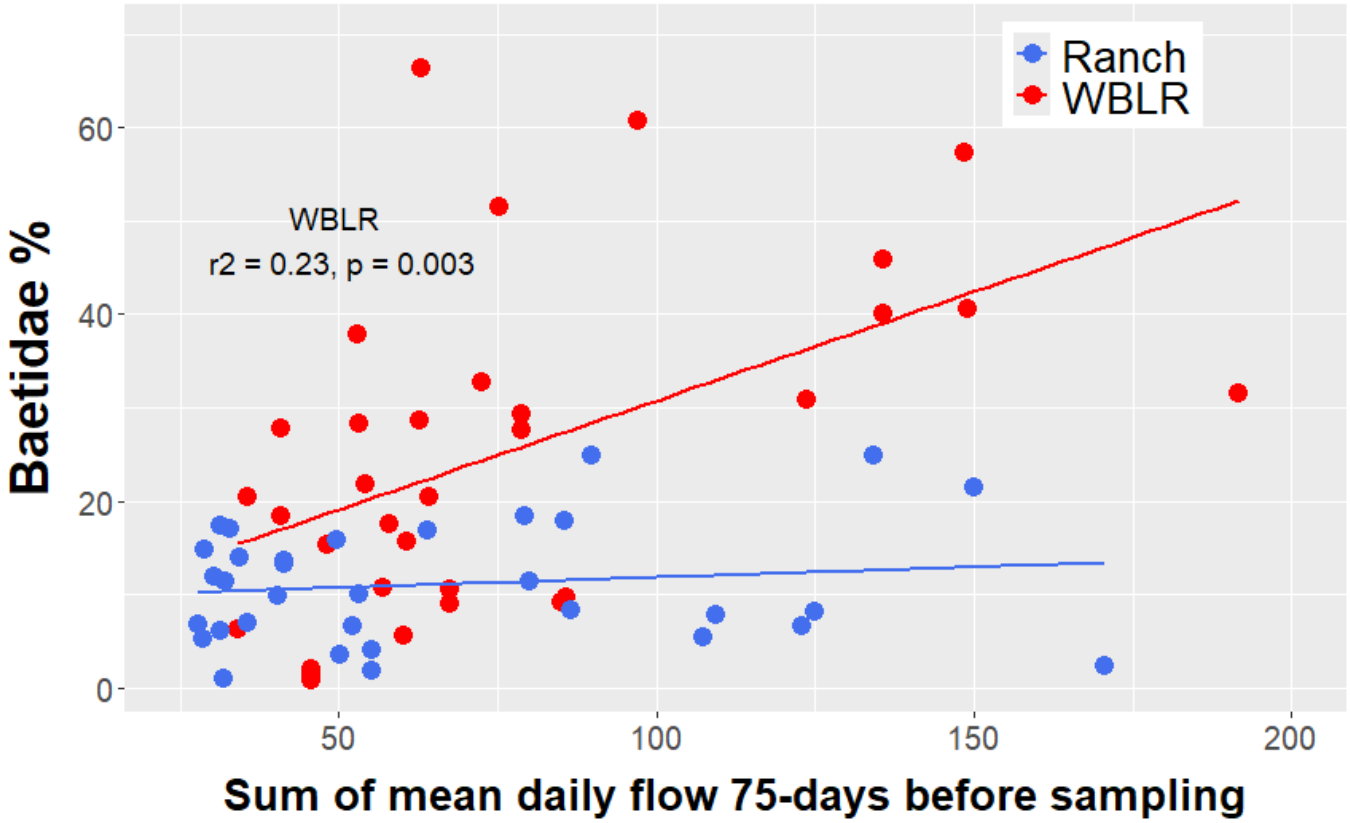
Trends And Relationships: Density & Cumulative Flow

- Decreasing relationship at Ranch between density and prior 75-day cumulative flow
- No relationship at WBLR
- Suggests that in low flow summers, watershed factors drive differences in densities, but climate and hydrologic factors have a greater effect after high flow summers



Trends And Relationships: % Baetidae & Cumulative Flow

- Increasing relationship in WBLR but not in Ranch between the relative abundance of Baetidae and the prior 75-day cumulative flow
- Suggests that WBLR is more prone to scour after high cumulative flows, while Ranch is more biologically resilient to similarly high flows



Insights and Key Take-Aways

How do hydrologic factors impact biological assessments of stream health?

Evidence suggests that hydrology may have contributed to lower assessment ratings at WBLR where there was greater runoff and at Ranch Brook during high flow summers driven by decreasing macroinvertebrate density due to scour and its secondary effects (less algae/moss, more erosion/sediment) and higher abundance of Baetidae mayflies.

Evidence

- Lower assessment ratings driven by low densities at WBLR across years and at Ranch during flood years
- Baetidae, rapid colonizers of scoured substrate, in greater abundance at WBLR
- A decreasing relationship with density and prior 75-day cumulative flow at Ranch and consistently low densities at high cumulative flows at WBLR
- An increasing relationship with % Baetidae and prior 75-day cumulative flows at WBLR

Insights and Key Take-Aways

Trends over time at the watershed scale are likely confounded by extreme flow events and greater runoff

- Statistically significant improving trend in assessment scores at WBLR only when flood years were removed shows hydrology impacts assessment score trends over time at WBLR

- Decreasing trend in density over time at Ranch driven by flood years shows hydrology is impacting density trends over time at Ranch

- Regression of density and prior 75-day cumulative flow suggests that hydrologic factors drive decreased density at Ranch and at WBLR during high cumulative flow summers, but watershed factors drive differences in density during low flow summers

Thank you!

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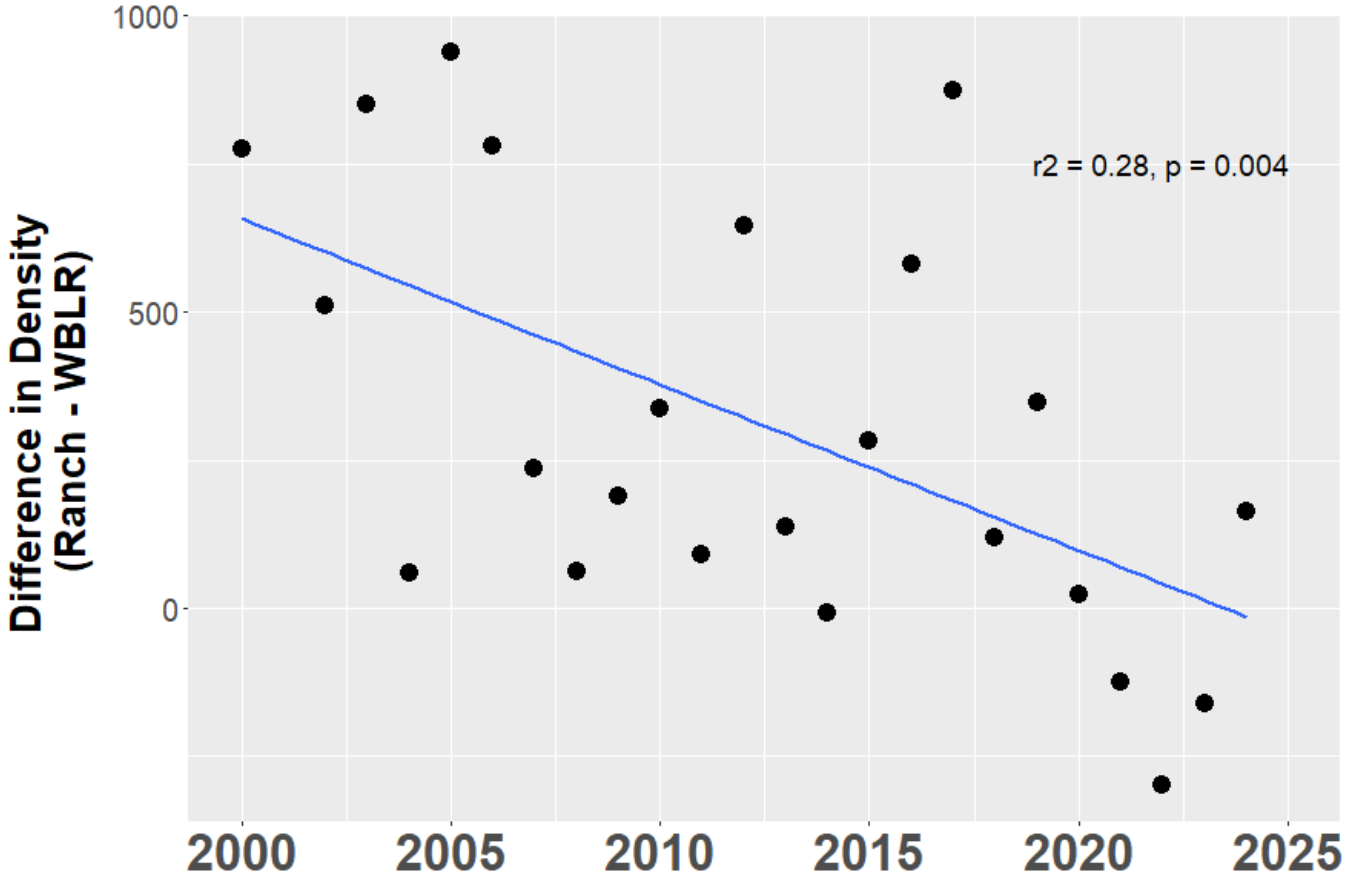
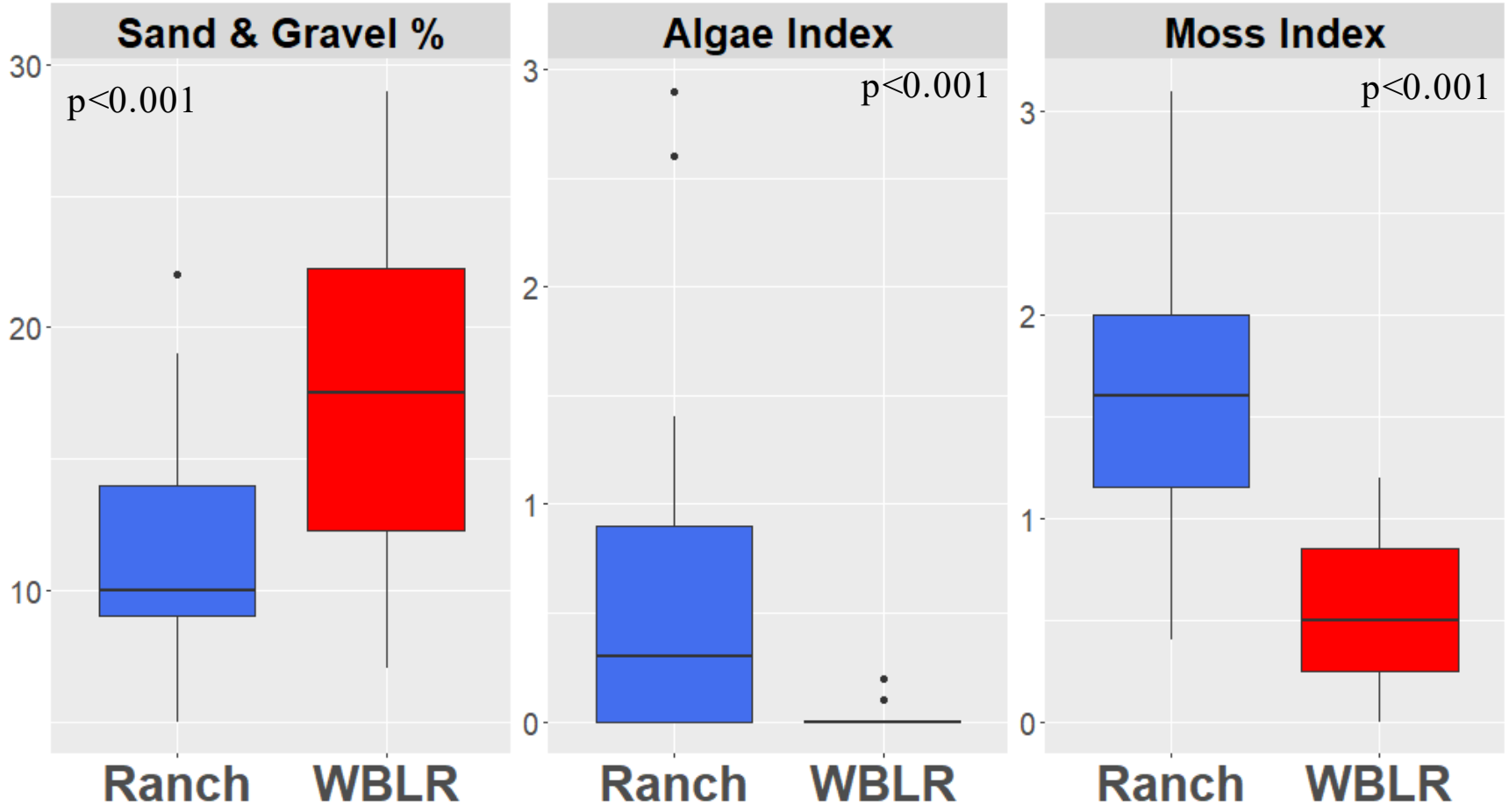
Extra slides

Comparison of Study Sites: Difference in Density



- Significantly decreasing trend in difference between Ranch and WBLR densities over time
- Assuming that Ranch and WBLR are both being affected similarly by high flows each year
- Could be indicative of improvement in density at WBLR

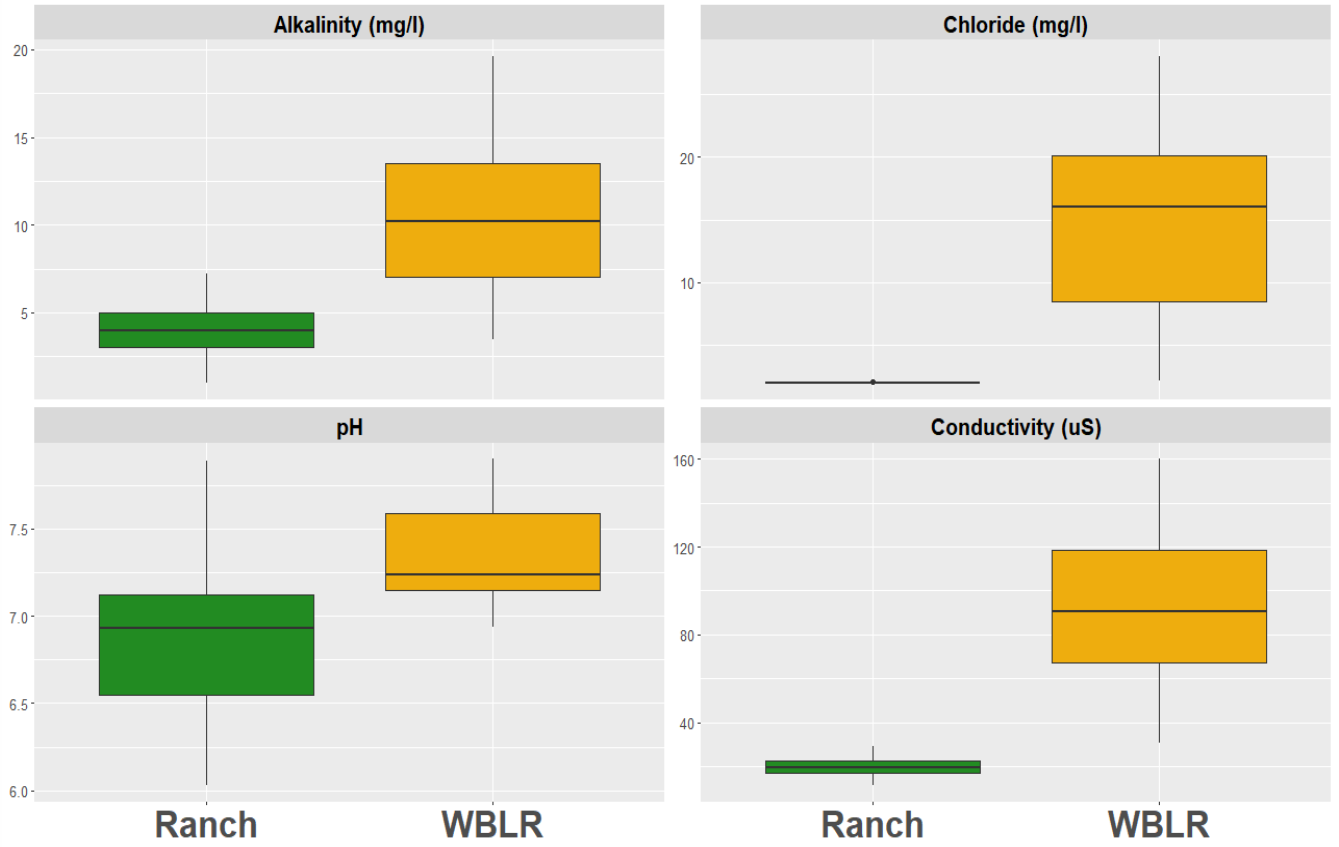
Comparison of Study Sites: Physical Habitat



- Sediment – % sand and gravel is higher at WBLR
- Periphyton – macroalgae and moss are much higher at Ranch
- Could be indicative of increased scouring and erosion at WBLR

Comparison of Study Sites: Water Chemistry

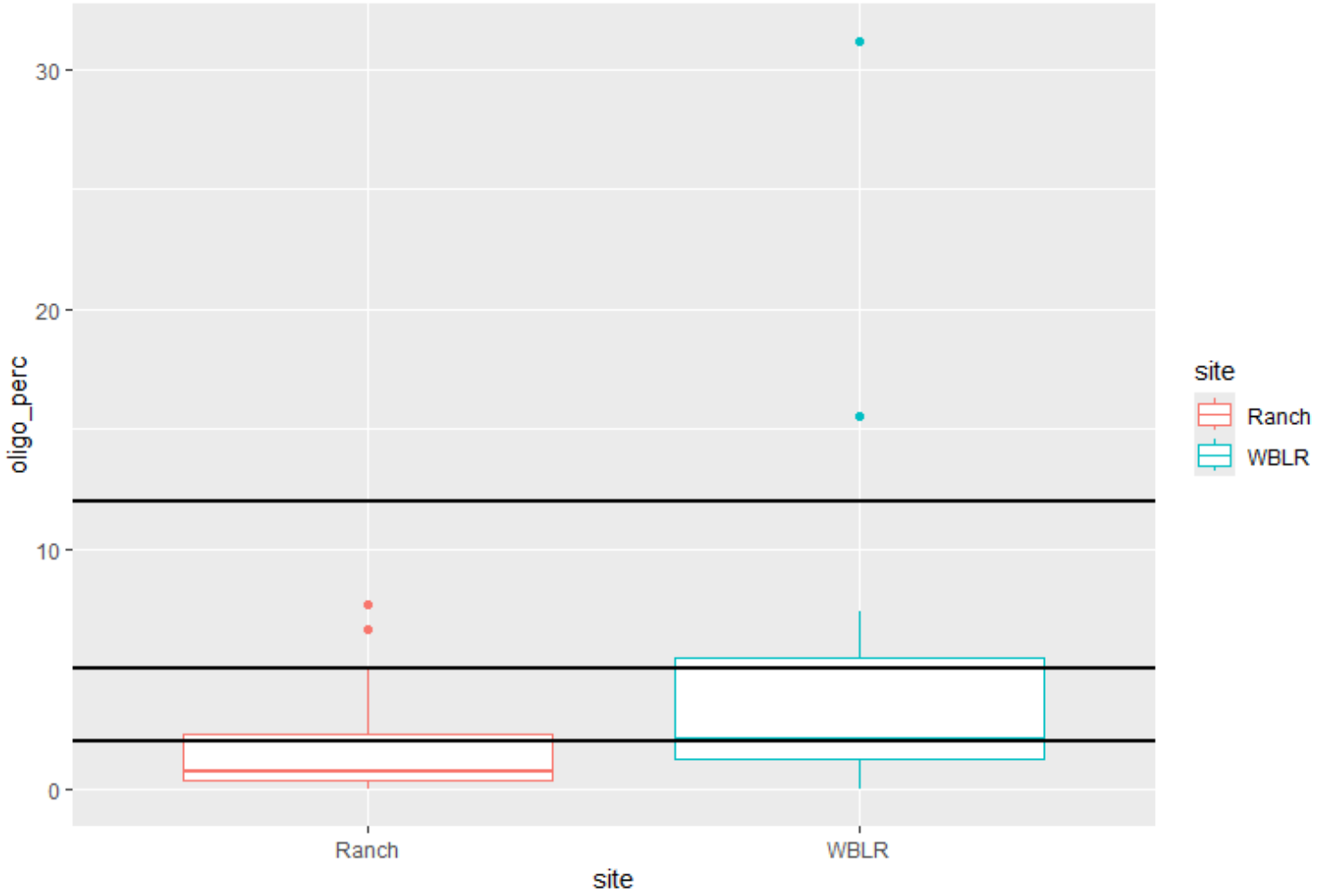
- Alkalinity/pH lower at Ranch
- Chloride/conductivity higher at WBLR
- Statistically significant ($p < 0.001$)
- Differences not enough to see biological impacts



Comparison of Study Sites: Community Metrics

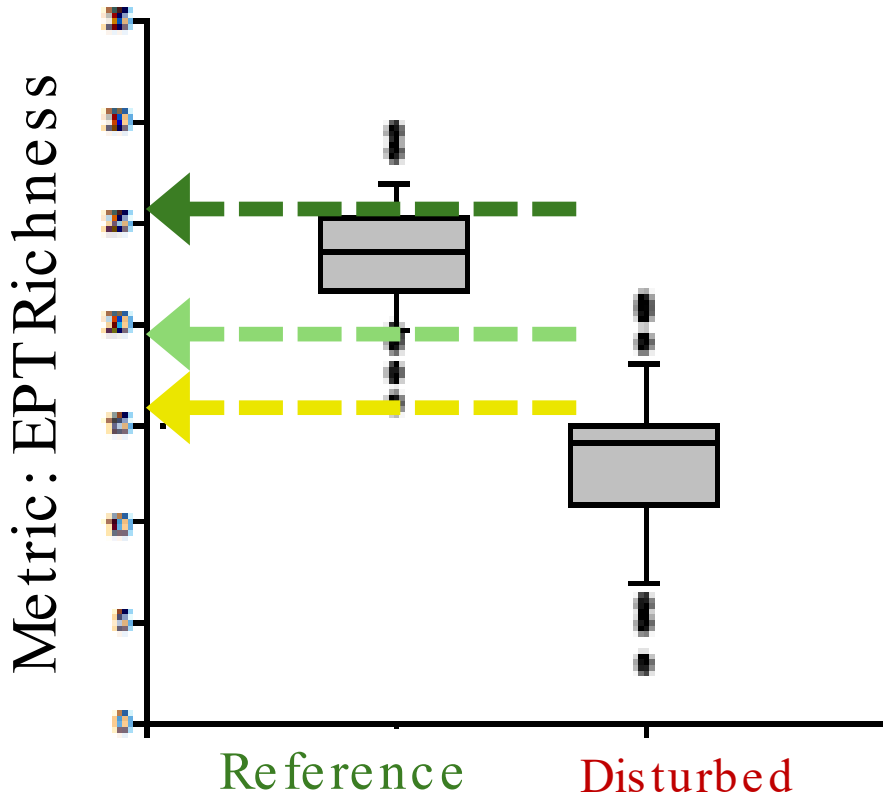
% Oligochaeta

- This metric can limit the attainment of higher assessment ratings
- High oligochaete abundance is frequently linked to issues with sedimentation of stream bed



Tiered thresholds for each metric based on departure from **reference** (natural) condition

Metric	Example Thresholds			
	Non-Attainment Fair/Poor	B(2) Good	B(1) Very Good	A(1) Excellent
Density	<300	>300	>400	>500
Richness	<27	>27	>31	>35
EPT Richness	<16	>16	>19	>21
PMA-O	<45	>45	>55	>65
PPCS-FFG	<.40	>.40	>.45	>.50
Biotic Index	>4.5	<4.5	<3.5	<3.0
EPT/EPT+Chiro	<.45	>.45	>.55	>.65
% Oligochaeta	>12	>12	>5	>2

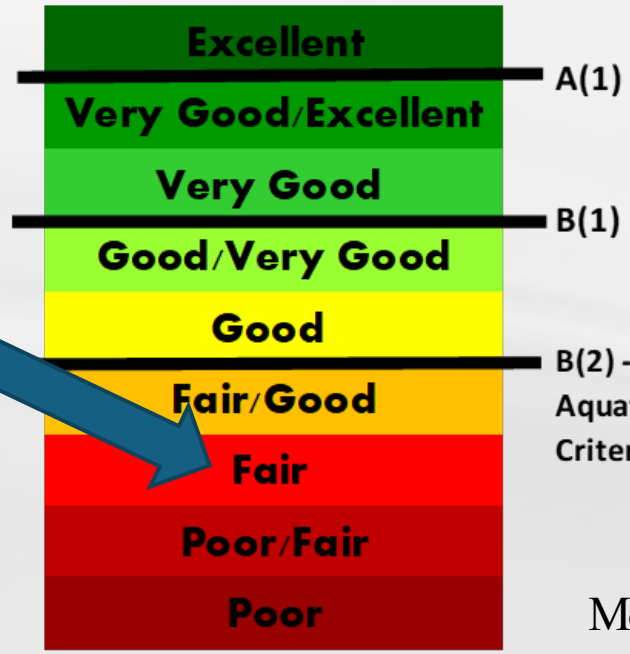


9 possible ratings for stream health ranging from Poor – Excellent

Must receive an assessment rating of "Good" or better to meet Vermont Water Quality Standards

METRIC	THRESHOLDS				
	Non-Attainment Fair/Poor	B(2) Good	B(1) Very Good	A(1) Excellent	EXAMPLE BROOK
Density	<300	>300	>400	>500	375
Richness	<27	>27	>31	>35	29
EPT Richness	<16	>16	>19	>21	13
PMA-O	<45	>45	>55	>65	72
PPCS-FFG	<.40	>.40	>.45	>.50	0.47
Biotic Index	>4.5	<4.5	<3.5	<3.0	4.0
EPT/EPT+Chiro	<.45	>.45	>.55	>.65	0.82
% Oligochaeta	>12	>12	>5	>2	0.5

Assessment Ratings



Reference

Most disturbed (greatest departure from reference)