Aquatic Biocriteria Assessment of the Lake Fork and Upper Gunnison River Basin

Kevin Alexander, Ph.D.\textsuperscript{1,2} and Tim Lapello\textsuperscript{2}

\textsuperscript{1}Western State College of Colorado, Gunnison, CO

\textsuperscript{2}BioEnvirons, LLC.
Gunnison, CO

Partial funding from the Upper Gunnison River Water Conservancy District
Is the Upper Gunnison River Basin meeting proposed (2009) and then recently adopted (2010) water quality biocriteria?
What is Aquatic Biocriteria? And Why is it important?
EPA enforcement of the Clean Water Act became biological rather than purely physico-chemical.

State specific policy decisions to balance Economic and Ecological Health.
Aquatic Life Uses

- Legal definition = Wide variety of biota including sensitive species with no substantial impairment of abundance or diversity of species.

- State developed numerical standards to implement the legal definition above.
Aquatic Life Use Attainment

Methodology to Determine Use Attainment for Rivers and Streams

Policy Statement 10-1

Colorado Department of Public Health and Environment
Water Quality Control Commission
4300 Cherry Creek Dr South
Denver Colorado 80246-1530

Approved: October 12, 2010
Expires: December 31, 2013
Why Use Biological Criteria?

- Ultimately, we are most interested in how water is able to support life and not just descriptions of its physical characteristics.

- Organisms are more sensitive to the parameters that affect them than analytical instruments.
Why Use Macroinvertebrates for Biocriteria Instead of Fish or Water Chemistry?
Why Use Macroinvertebrates?

Diversity

- Large number of species
- Large numbers of individuals
- Numbers are good for conducting statistical analysis
Why Use Macroinvertebrates?

- Each species has a different ecology/physiology that can respond differently to stresses.

- Each species has the potential to provide more information about what is happening in the watershed.

- Food base.
Why Use Macroinvertebrates Instead of Fish?

Fish Swim

- Fish can avoid disturbances and return
- Stocking and Fishing

- Macroinvertebrates have limited abilities to move over distances thus they are exposed to all that occurs at the study sites
Take Home Message

Macroinvertebrates are numerous and variable so that they can be used by managers to effectively detect both acute and chronic stressors over a useful time frame.
Aquatic Life Use Attainment

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2009 Study Sites

- Assess proposed CDPHE criteria
- Based on locations of USGS or other physical water quality sampling sites
- Lower basin sites to indicate health of watershed rather than specific sites
All sites were Biotype 1 – Cold, mid-elevation; transitional
Explicit Protocols

How is the data collected?
Protocols

Followed Protocols adopted by the Water Quality Control Division (WQCD).
Lab Protocols

- Randomized removal of 300 individuals
- Identification
- QA/QC
- Entered into Database/EDAS
## Sample Spreadsheet for Data Input

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Species</th>
<th>Count</th>
<th>Size</th>
<th>Category</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Brillia</td>
<td>1</td>
<td>1</td>
<td>15</td>
<td>300 count</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Drunnella doddsi</td>
<td>2</td>
<td>1</td>
<td>15</td>
<td>300 count</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Drunnella grandis</td>
<td>1</td>
<td>1</td>
<td>15</td>
<td>300 count</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Enchytraeidae</td>
<td>29</td>
<td>1</td>
<td>15</td>
<td>300 count</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Ephemerella</td>
<td>4</td>
<td>1</td>
<td>15</td>
<td>300 count</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Heterlimnius corpulentus</td>
<td>7</td>
<td>L</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Hydropsyche</td>
<td>3</td>
<td>1</td>
<td>15</td>
<td>300 count</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Nais spp.</td>
<td>1</td>
<td>1</td>
<td>15</td>
<td>300 count</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Optioservus</td>
<td>2</td>
<td>L</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Optioservus sp. Adults</td>
<td>1</td>
<td>A</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Rhithrogena</td>
<td>1</td>
<td>1</td>
<td>15</td>
<td>300 count</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Rhyacophila pellisa</td>
<td>1</td>
<td>1</td>
<td>15</td>
<td>300 count</td>
</tr>
<tr>
<td>CO_DPHE 10115 Coal Creek at Crested Butte at Totem Pole Park</td>
<td>9/24/2010</td>
<td>Zaitzevia parvula</td>
<td>1</td>
<td>L</td>
<td>1</td>
<td>15</td>
</tr>
</tbody>
</table>
Multimetric Index Used for Calculations in Biotype 1

<table>
<thead>
<tr>
<th>Metric</th>
<th>Metric Adjustment for Elevation (Xa)</th>
<th>Scoring Formulae</th>
</tr>
</thead>
<tbody>
<tr>
<td>% non-insect taxa</td>
<td></td>
<td>100*(28.09375-X)/28.0937</td>
</tr>
<tr>
<td>Mayfly and Stonefly Taxa</td>
<td>(X-(-4.803+(0.00583)*Elevation))</td>
<td>100*(Xa+6.481)/2.870+6.481</td>
</tr>
<tr>
<td>% Chironomidae</td>
<td></td>
<td>100*(66.839-X)/(66.839-1.308)</td>
</tr>
<tr>
<td>% Sensitive Families Plains</td>
<td></td>
<td>100*X/61.812</td>
</tr>
<tr>
<td>Predator and Shredder Taxa</td>
<td></td>
<td>100*X/14</td>
</tr>
<tr>
<td>Clinger Taxa</td>
<td>(X-(-3.262+(0.00694)*Elevation))</td>
<td>100*(Xa+8.615)/(3.136+8.615)</td>
</tr>
</tbody>
</table>

These are not calculated by hand but are processed using Ecological Data Application System (EDAS) developed by TetraTech for use nationally and adopted by the Colorado Water Quality Control Commission.
### Benthic Macroinvertebrate Bioassessment Report

**Station ID:** Test  
**Waterbody Name:** Tomichi Creek  
**Location:** Tenderfoot  
**Latitude:** 38.53623  
**Longitude:** -106.90767  
**Biotype:** 1  
**Sample Date:** 9/30/2010  
**Reference Status:** Not Reference or Degraded  
**Benthos ID:** 3240  
**Replicate:** 1

#### Predictive Model Results

- CoE (p=half):  
- Model Test:

#### Multimetric Index Model Results

<table>
<thead>
<tr>
<th>Metric Name</th>
<th>Metric Value</th>
<th>Metric Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Taxa</td>
<td>20</td>
<td>N/A</td>
</tr>
<tr>
<td>Ephemeroptera + Plecoptera Taxa (adjusted with Elevation)</td>
<td>7</td>
<td>48.4</td>
</tr>
<tr>
<td>Chironomidae Pct.</td>
<td>1.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Sensitive Plains Familiies PCT</td>
<td>43.3</td>
<td>70.0</td>
</tr>
<tr>
<td>Predator+ Shredder Taxa</td>
<td>8</td>
<td>57.1</td>
</tr>
<tr>
<td>Clinger Taxa</td>
<td>10</td>
<td>N/A</td>
</tr>
<tr>
<td>Clinger Taxa adjusted with Elevation</td>
<td>10</td>
<td>47.0</td>
</tr>
<tr>
<td>Insect Taxa</td>
<td>20</td>
<td>N/A</td>
</tr>
<tr>
<td>Non-Insect % of taxa</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Ephemeroptera Pct</td>
<td>36.4</td>
<td>N/A</td>
</tr>
<tr>
<td>BeeliID</td>
<td>20.0</td>
<td>N/A</td>
</tr>
<tr>
<td>Dominant Taxon Pct</td>
<td>33.1</td>
<td>N/A</td>
</tr>
</tbody>
</table>
## Adopted Biocriteria Levels for Biotype I

<table>
<thead>
<tr>
<th>Proposed Thresholds for Aquatic Life Use Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Colorado Biotype (MMI Group)</strong></td>
</tr>
<tr>
<td><strong>Transitional (Biotype 1)</strong></td>
</tr>
<tr>
<td>Mid-elevation, semi-cold, low gradient and moist</td>
</tr>
</tbody>
</table>
Q. What happens if your site scores in the “Gray” zone?
A. Auxillary metrics.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Biotype I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shannon Index of Diversity</td>
<td>&gt;2.4</td>
</tr>
<tr>
<td>Hilsenhoff Biotic Index</td>
<td>&lt;5.4</td>
</tr>
</tbody>
</table>

\[ H_s = -\sum_{i=1}^{S} (p_i) \ln(p_i) \]

Where,
- \( H_s \) – Shannon Index of Diversity in a sample of \( S \) species or taxa
- \( S \) – the number of taxa in the sample
- \( p_i \) – relative abundance of \( i^{th} \) taxa measures, = \( n_i/N \)
- \( N \) – total number of individuals of all taxa
- \( n_i \) – number of individuals of \( i^{th} \) taxon
- \( \ln \) – log to base 2

Hilsenoff Biotic Index
- Weighted average of tolerance values
- 1 to 10 with higher being tolerant
### 2009 Results

Multimetric Index (MMI v.3)

- <36 Impaired (bad); ≥51 Attainment (good)
- changed to <42; >52 in 2010

#### Sites

<table>
<thead>
<tr>
<th>2009 Season</th>
<th>Gunnison River</th>
<th>Lake Fork</th>
<th>East River</th>
<th>Ohio Creek</th>
<th>Tomichi Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Flow (June)</td>
<td>68.0</td>
<td>77.5</td>
<td>58.0</td>
<td><strong>47.6</strong></td>
<td><strong>41.8</strong></td>
</tr>
<tr>
<td>Low Flow (September)</td>
<td>67.2</td>
<td>74.1</td>
<td>59.0</td>
<td>56.4</td>
<td><strong>41.5</strong></td>
</tr>
</tbody>
</table>

- Tomichi Creek does not clearly attain biocriteria thresholds
- Ohio Creek does not clearly attain biocriteria thresholds (Spring)
- Lake Fork had the highest scores!!!!!
## 2009 Results

### Auxillary Metrics – Shannon Index

<table>
<thead>
<tr>
<th>2009 Season</th>
<th>Gunnison River</th>
<th>Lake Fork</th>
<th>East River</th>
<th>Ohio Creek</th>
<th>Tomichi Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Flow (June)</td>
<td>3.47</td>
<td>3.42</td>
<td>3.77</td>
<td>2.57</td>
<td>3.34</td>
</tr>
<tr>
<td>Low Flow (September)</td>
<td>3.56</td>
<td>3.15</td>
<td>4.01</td>
<td>3.79</td>
<td>3.45</td>
</tr>
</tbody>
</table>

All sites exceed the threshold for the Shannon Index of Diversity. However, only relevant for Ohio Creek and Tomichi Creek but must also pass the threshold for the HBI.
2009 Results
Auxillary Metrics – Hilsenhoff Biotic Index (HBI) <6.1 Threshold (<5.4 in 2010)

<table>
<thead>
<tr>
<th>2009 Season</th>
<th>Gunnison River</th>
<th>Lake Fork</th>
<th>East River</th>
<th>Ohio Creek</th>
<th>Tomichi Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Flow (June)</td>
<td>3.72</td>
<td>2.23</td>
<td>2.20</td>
<td>2.94</td>
<td>3.50</td>
</tr>
<tr>
<td>Low Flow (September)</td>
<td>3.22</td>
<td>1.56</td>
<td>3.15</td>
<td>3.54</td>
<td>3.82</td>
</tr>
</tbody>
</table>

All sites exceed the threshold for the HBI. However, only relevant for Ohio Creek and Tomichi Creek.
Review – New 2010 Adopted Thresholds Biocriteria Levels for Biotype I

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<td>&lt;5.4</td>
</tr>
</tbody>
</table>

Where,

\[ H_s = - \sum_{i=1}^{N} (p_i \times \log_2(p_i)) \]

- \( H_s \) – Shannon Index of Diversity in a sample of \( S \) species or taxa
- \( S \) – the number of taxa in the sample
- \( p_i \) – relative abundance of \( i \)th taxa measures, = \( n_i / N \)
- \( N \) – total number of individuals of all taxa
- \( n_i \) – number of individuals of \( i \)th taxon
- \( \log \) – log to base 2

Hilsenhoff Biotic Index
- Weighted average of tolerance values
- 1 to 10 with higher being tolerant
## 2010 Study Sites

<table>
<thead>
<tr>
<th>UGRWCD</th>
<th>Water Quality Control Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomichi Creek, Gold Basin</td>
<td>Coal Creek in CB</td>
</tr>
<tr>
<td>Tomichi Creek, Tenderfoot</td>
<td>Slate River, Rozman*</td>
</tr>
<tr>
<td>Tomichi Creek, Bratton</td>
<td>Lake Fork, Independence Gulch</td>
</tr>
<tr>
<td>Tomichi Creek, Clark</td>
<td>Lake Fork, above Lake</td>
</tr>
<tr>
<td></td>
<td>Ohio Creek, CR48</td>
</tr>
<tr>
<td></td>
<td>Cebolla Creek, Powderhorn</td>
</tr>
<tr>
<td></td>
<td>Tomichi Creek, Sargents</td>
</tr>
<tr>
<td></td>
<td>Cochetopa Creek, mouth</td>
</tr>
<tr>
<td></td>
<td>Cochetopa Creek, MP16</td>
</tr>
</tbody>
</table>

*Indicates sites with duplicated samples.

# Indicates site conducted as student Honors project at Western State College.
## 2010 Results

<table>
<thead>
<tr>
<th>Sites</th>
<th>MMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Creek in CB</td>
<td>33.0</td>
</tr>
<tr>
<td>Slate River, Rozman</td>
<td>58.3</td>
</tr>
<tr>
<td>Slate River, Rozman</td>
<td>72.6</td>
</tr>
<tr>
<td>Lake Fork, Independence Gulch</td>
<td>61.3</td>
</tr>
<tr>
<td>Lake Fork, above Lake</td>
<td>64.9</td>
</tr>
<tr>
<td>Ohio Creek, CR48</td>
<td>72.5</td>
</tr>
<tr>
<td>Cebolla Creek, Powderhorn</td>
<td>74.6</td>
</tr>
<tr>
<td><strong>Tomichi Creek, Gold Basin</strong></td>
<td>52.5</td>
</tr>
<tr>
<td><strong>Tomichi Creek, Gold Basin</strong></td>
<td>38.5</td>
</tr>
<tr>
<td>Tomichi Creek, Tenderfoot</td>
<td>70.4</td>
</tr>
<tr>
<td>Tomichi Creek, Bratton</td>
<td>63.1</td>
</tr>
<tr>
<td>Tomichi Creek, Clark</td>
<td>70.8</td>
</tr>
<tr>
<td>Tomichi Creek, Sargents</td>
<td>77.1</td>
</tr>
<tr>
<td><strong>Cochetopa Creek, mouth</strong></td>
<td>36.0</td>
</tr>
<tr>
<td>Cochetopa Creek, MP16</td>
<td>75.7</td>
</tr>
</tbody>
</table>
Interpretation/Discussion

What does it all mean?
Main Results from 2009 and 2010 Biocriteria Data

- Metrics appear to effectively separate streams in the upper Gunnison basin.

- All sites in this study meet the adopted biocriteria except Coal Creek in Crested Butte and Cochetopa Creek at mouth which are both impaired. Both sites were already of concern to the WQCD.

- Biological measures of the three sites on the Lake Fork indicate excellent water quality.
Main Results from 2010 Biocriteria Data

- Upper Cochetopa, Tomichi in Sargents, and Cebolla Creeks had the highest scores. Lake Fork did not have the highest scores at these sites this year but still excellent.

- MMI $\geq 64$ protected from large declines of $>22$ points in more than 12 months. This includes: Slate River, Lake Fork above Lake, Ohio Creek, Cebolla Creek, upper Cochetopa Creek and upper Tomichi Creek*. Also, Gunnison River from 2009.
We know not all water in the Lake Fork drainage is of excellent quality.
Methodology

Photo stolen from Dennis Murphy.
2010 Data

Total Taxa Richness

<table>
<thead>
<tr>
<th>Site</th>
<th>PALM-01</th>
<th>PALM-04</th>
<th>PALM-05</th>
<th>PALM-06</th>
<th>PALM-16</th>
<th>LKFKUP</th>
<th>LKFKDWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxa</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>
2010 Data

Shannon's Diversity
2010 Data

# of Intolerant Taxa
Water quality trends remain the same. Water near mine outflows is impaired but lower areas appear to be good to excellent.

Restoration efforts should continue to improve water quality and monitoring should be used to assess the effectiveness of these efforts.
Thank you.