Bioobjectives Scoring Tool: California Stream Condition Index (CSCI)
Biological indicators are the best way to assess biological integrity.

Challenge is to use them consistently across the state.

Photo courtesy John Sandberg
• Establishing Reference Conditions
• Developing the CSCI Scoring Tool
• Stressor Identification
Fundamentals of “Reference”

Reference condition is the foundation of bio-objectives

- *objective basis for setting biological expectations*
- *provides and “anchor” for bioassessment scoring tool*

- Use natural condition (or something close to it) as the desired state whenever possible
  - NOT defined based on biology, but landscape setting
Stream Sites with Low Levels of Human Activity
Defining Reference

**Tension of twin goals**

A. *Need sufficient numbers of sites to characterize reference across the full range of natural stream settings in California.*

B. *Stringent enough to ensure only high quality sites are included*

1. Identify candidate sites
2. Compile landscape-scale data on a wide range of stressors
3. Examine the distribution of stressors across the state
4. Set preliminary thresholds based on literature values and BPJ
5. Refine thresholds using statistical analysis
Many Candidate Sites, Many Variables Tested

- Approximately 1,700 sites
  - 800 probabilistic
  - 900 targeted

- 20 different programs
  - 8 probabilistic
  - 12 targeted

- More than 170 variables
  - Landscape scale measures of disturbance

- Statewide coverage

- Multiple scales
  - Watershed
  - Reach
  - 5 km
  - 1 km

- Statewide coverage
### Reference Thresholds

<table>
<thead>
<tr>
<th>Variable</th>
<th>Local Scale</th>
<th>Local Threshold (1k/ 5k)</th>
<th>Watershed Threshold (ws)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Agricultural or Urban</td>
<td>1k/5k</td>
<td>3 %</td>
<td>3 %</td>
</tr>
<tr>
<td>% Agricultural and Urban</td>
<td>1k/5k</td>
<td>5 %</td>
<td>-</td>
</tr>
<tr>
<td>% Code 21 (urban grasses)</td>
<td>1k/5k</td>
<td>7 %</td>
<td>10 %</td>
</tr>
<tr>
<td>Road Density</td>
<td>1k/5k</td>
<td>2 km/km²</td>
<td>2 km/km²</td>
</tr>
<tr>
<td>Road Crossings</td>
<td>1k/5k</td>
<td>5/10 per km</td>
<td>20 per km</td>
</tr>
<tr>
<td>Dam Distance</td>
<td>-</td>
<td>1 km</td>
<td></td>
</tr>
<tr>
<td>% Canals/Pipes</td>
<td>-</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Instream Gravel Mines</td>
<td>5k</td>
<td>0.1/km</td>
<td></td>
</tr>
<tr>
<td>Producer Mines</td>
<td>5k</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Conductivity</td>
<td>-</td>
<td>99/1 *</td>
<td></td>
</tr>
<tr>
<td>W1_Hall (riparian veg)</td>
<td>-</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>
Threshold Evaluation

TENSION: need to represent full range of stream types vs. not relaxing thresholds to include “non-reference streams”

1. **Sensitivity**: How many sites do you get when you adjust thresholds?

2. **Responsiveness**: Have we limited the biological response to stressors within the reference data set?

3. **Representativeness**: Have we captured important natural gradients within the reference data set?
Are Thresholds Appropriate?
Threshold Sensitivity

Percent possible reference sites vs. Road density km/km² for different PSA Regions:
- Chaparral
- Desert - Modoc
- North Coast
- South Coast
- Sierra Nevada
Responsiveness of the Full Range of Reference
Broad Geographic Coverage
Reference Representation in Challenging Areas
### Statewide Distribution of Reference

<table>
<thead>
<tr>
<th>REGION</th>
<th>n</th>
<th>% of region</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Coast</td>
<td>79</td>
<td>28</td>
</tr>
<tr>
<td><strong>Central Valley</strong></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Coastal Chaparral</td>
<td>87</td>
<td>18</td>
</tr>
<tr>
<td>Interior Chaparral</td>
<td>30</td>
<td>33</td>
</tr>
<tr>
<td>South Coast Mountains</td>
<td>96</td>
<td>68</td>
</tr>
<tr>
<td><strong>South Coast Xeric</strong></td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>Western Sierra</td>
<td>131</td>
<td>50</td>
</tr>
<tr>
<td>Central Lahontan</td>
<td>142</td>
<td>74</td>
</tr>
<tr>
<td>Deserts + Modoc</td>
<td>27</td>
<td>56</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>615</td>
<td>-</td>
</tr>
</tbody>
</table>
Reference Conclusions

- Established a robust reference network that can be used to set biological expectations statewide

- Majority of the state has good representation by reference network

- Reference network must be an ongoing effort

- Some problematic areas remain
  - Areas of relatively poor representation, e.g. Central Valley
  - Areas that are represented, but could use additional sites, e.g. low gradient S. CA
  - Other water body types (e.g. non-perennial streams)
Options for “Problematic” Areas

- Targeted investigations to try and find additional reference sites

- Redefine reference for problematic areas
  - Variable definitions of reference

- Address through adjustments to the scoring tool
• Establishing Reference Conditions
• **Developing the CSCI Scoring Tool**
• Stressor Identification
Why Do We Need A New Tool?

- Different scoring approaches for different regions
- Some parts of the State lack any scoring tools
- Inconsistent definition of reference

A new statewide index is needed
The California Stream Condition Index (CSCI)

- **Much better reference** data set
  - Bigger, broader, and more rigorously screened
  - Nearly double sites in S. CA compared to the IBI

- **Consistent meaning statewide**, without regionalization
  - A specific score means the same thing in all areas
  - Nearly all perennial wadeable streams can be assessed

- **Site-specific expectations** means that your site is held to appropriate standards
  - Each site is assessed relative to community that should be there based on site’s physical properties
Elements of the CSCI

- **Taxonomic completeness (O/E)**
  - Is a measure of species loss
  - Compares taxa found at similar reference sites

- **Ecological structure (MMI)**
  - Comprised of several metrics that represent community structure
  - Compares metric values observed at similar reference sites.

*Multiple elements provide complementary information about biological health*
The CSCI Uses a *Predictive* Approach

- The CSCI creates site-specific expectations for each site based on taxa found at **groups of similar reference sites**
- Groups of reference sites are defined by natural gradients
  - Have a major effect on the invertebrate community
  - Largely unaffected by human activity
  - Latitude
  - Elevation
  - Precipitation
  - Temperature
  - Watershed area

Expected invertebrate community under unaltered conditions
Scoring Relative to Site-specific Expectations

- Develop expected taxa list based on reference sites located in similar environmental settings $\rightarrow$ Expected
- Collect Taxa at site being evaluated $\rightarrow$ Observed
- Compare Observed vs. Expected taxa list

species and metrics measured at test site = Observed
species and metrics predicted at site = Expected

If O/E is $\sim 1.0$, biological integrity is intact
If O/E $<< 1.0$, biological integrity is altered
## Two Elements of CSCI

### Completeness

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mayfly species 1</td>
<td>43</td>
</tr>
<tr>
<td>Mayfly species 2</td>
<td>12</td>
</tr>
<tr>
<td>Mayfly species 3</td>
<td>2</td>
</tr>
<tr>
<td>Beetle species 1</td>
<td>1</td>
</tr>
<tr>
<td>Beetle species 2</td>
<td>1</td>
</tr>
<tr>
<td>Midge genus 1</td>
<td>65</td>
</tr>
<tr>
<td>Midge species 1</td>
<td>3</td>
</tr>
<tr>
<td>Midge species 2</td>
<td>10</td>
</tr>
<tr>
<td>Midge genus 2</td>
<td>3</td>
</tr>
<tr>
<td>Dragonfly species</td>
<td>2</td>
</tr>
<tr>
<td>Stonefly species</td>
<td>1</td>
</tr>
<tr>
<td>Stonefly species</td>
<td>14</td>
</tr>
<tr>
<td>Worm species 1</td>
<td>9</td>
</tr>
<tr>
<td>Worm species 2</td>
<td>2</td>
</tr>
</tbody>
</table>

### Ecological structure

- % mayfly, stonefly, caddisfly
- % beetle taxa
- Total number of taxa
- % clinger taxa
- # shredder taxa
- % sensitive individuals
Calculating the CSCI

- CSCI ranges from 0 – 1
- Mean of reference sites = 1.01 ± 0.12 sd
CSCI is responsive to stress
CSCI is consistent in all regions

CSCI scores at reference sites in major CA ecoregions
CSCI is consistent over time

CSCI scores at reference sites 2000 - 2011
Sample Application of CSCI

Saxon Creek:
Tahoe Basin Urbanized
CSCI = 0.63

Sweetwater:
Socal Xeric Open
CSCI = 1.09
Reference Sites Based on Setting
Far more taxa at Saxon Creek, but...
## Taxonomic completeness

<table>
<thead>
<tr>
<th>Sweetwater</th>
<th>Observed</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acari</td>
<td></td>
<td>Bezzia</td>
</tr>
<tr>
<td>Baetis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chironominae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthocladiinae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oligochaeta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanypodinae</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Saxon</th>
<th>Observed</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acari</td>
<td></td>
<td>Baetis</td>
</tr>
<tr>
<td>Chironominae</td>
<td></td>
<td>Drunella</td>
</tr>
<tr>
<td>Cinygmula</td>
<td></td>
<td>Malenka</td>
</tr>
<tr>
<td>Lepidostoma</td>
<td></td>
<td>Rhyacophila</td>
</tr>
<tr>
<td>Micrasema</td>
<td></td>
<td>Turbellaria</td>
</tr>
<tr>
<td>Orthocladiinae</td>
<td></td>
<td>Yoraperla</td>
</tr>
<tr>
<td>Paraleptophlebia</td>
<td></td>
<td>Epeorus</td>
</tr>
<tr>
<td>Simulium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweltsa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bezzia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oligochaeta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanypodinae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zapada</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lots of taxa missing at Saxon creek
Ecological structure

Most metrics “better” at Saxon Creek, but much further from expectations
Sample Application of CSCI

Saxon Creek: Tahoe Basin Urbanized
CSCI = 0.63

Sweetwater: Socal Xeric Open
CSCI = 1.09
Setting Thresholds

CA Stream Condition Index Value

- 1st %: 0.72
- 10th %: 0.85

very likely altered
likely altered
likely intact
What About Channelized Streams?
Scoring Tool Conclusions and Future Efforts

- State has a new scoring tool for use in implementing bio-objectives
  - Predictive approach allows sites to be judged against site-specific expectations
  - Can be applied with a consistent interpretation statewide

- Through policy development, additional issues need to be addressed:
  - Setting thresholds
  - How to deal with special class streams
    - Streams with few appropriate ref sites (e.g., Central Valley floor streams)
    - Streams unlikely to achieve reference condition (e.g., permanently channelized streams)

- Need to develop support tools to ease/automate calculation of CSCI
• Establishing Reference Conditions
• Developing the CSCI Scoring Tool
• **Stressor Identification**
Stressor Identification

- What’s causing my site to be out of compliance?

- US EPA has a framework developed for stressor identification
  - [www.epa.gov/CADDIS](http://www.epa.gov/CADDIS)
  - Not vetted in California

- Our goal was to test CADDIS in four California case studies
  - Write an Evaluation and Guidance Manual
The Five Steps

- Define the case
- List candidate causes
- Evaluate data from the case
- Evaluate data from outside the case
- Identify probable causes
  - Refute causes
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- Define the case
  - List candidate causes
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  - Evaluate data from outside the case
  - Identify probable causes
    - Refute causes
The Five Steps

- Define the case

- List candidate causes

- Evaluate data from the case

- Evaluate data from outside the case

- Identify probable causes
  - Refute causes
CUMULATIVE LIST OF CANDIDATE CAUSES

- Flow alteration
- Physical habitat loss or alteration
- Temperature
- Dissolved oxygen
- Conductivity, TDS

- Sediment
- Nutrients
- Trace metals
- Pesticides
- PAHs
- Invasive species
The Five Steps

- Define the case
- List candidate causes

- Evaluate data from the case

- Evaluate data from outside the case

- Identify probable causes
  - Refute causes
TYPES OF EVIDENCE

- Spatial/temporal co-occurrence
- Exposure
- Biological mechanism
- Field based stress-response relationship
- Casual pathway
- Manipulation of exposure
- Laboratory tests of site media
- Temporal sequence
- Verified predictions
- Symptoms
Spatial-Temporal Co-Occurrence:
San Diego River

Chromium (ug/L)

<table>
<thead>
<tr>
<th>Test Site</th>
<th>Comparator</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>0.1</td>
<td>0.7</td>
</tr>
<tr>
<td>0.2</td>
<td>0.6</td>
</tr>
<tr>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>0.7</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Cyhalothrin (ng/L)

<table>
<thead>
<tr>
<th>Test Site</th>
<th>Comparator</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>30</td>
<td>25</td>
</tr>
</tbody>
</table>

![Graph showing Chromium and Cyhalothrin levels at Test Site and Comparator](image-url)
Stressor-Response from the Field: Garcia River

Garcia River Test Site

R=0.59
The Five Steps

- Define the case
- List candidate causes
- Evaluate data from the case

Evaluate data from outside the case

- Identify probable causes
- Refute causes
Co-Occurrence from Outside the Case: Santa Clara and San Diego Rivers
Species Sensitivity Distributions

Max Concentration at Salinas River Test Site
CADDIS Works, but It Isn’t Perfect

- CADDIS strengths
  - Already built and documented
  - Adept at ruling out causes
  - Wonderful communication tool

- CADDIS weaknesses
  - Nonpoint, cumulative stressors are difficult to diagnose
  - Challenges to find appropriate comparator sites
  - Uncertainty is problematic for decision making

- Because of California’s unique issues, implementing recommendations will be important
Guidance Manual Recommendations

- Take advantage of our large statewide data set for comparator site selection
  - Can be automated

- Reduce uncertainty by creating new data analysis tools
  - Will streamline analysis increasing speed and decreasing cost

- Post-identification steps need similar guidance
Questions