An Introduction to the Algal Stream Condition Index (ASCI)

Susie Theroux (susannat@sccwrp.org)
ASCI development

• California's bioassessment toolbox
  • California Stream Condition Index (CSCI)
  • SoCal Algal Index of Biotic Integrity (IBI)
  • Algal Stream Condition Index (ASCI)

• ASCI development: approach

• ASCI development: status and deadlines
CA’s ecological indicators

**Multiple Indicators** – BMIs, algae, fish, riparian vegetation

**Multiple waterbody types** – large rivers, non-perennial streams, lakes, wetlands

**California focus** – perennial streams, bugs and algae
California’s bioassessment programs

- Over two decades of sample collection
- Standardized protocols and QA/QC
- Annual trainings and audits for all field crews
California stream bioassessment: bioindicators

Benthic macroinvertebrates

- Respond to physical habitat, pollutants, sediment, flow alteration
- Integrate ecological condition over time

Algae

- Direct link to water chemistry and nutrient stressors
- Short life span, rapid growth rate and rapid response to stress

Diatoms
Soft-bodied algae
Cyanobacteria
California Stream Condition Index (CSCI)

- Predictive index
- Site-specific reference expectations
- Statewide applicability
SoCal Algal Index of Biotic Integrity (IBI)

- Traditional (non-predictive)
- Separate indices developed for soft-bodied algae, diatoms, and a hybrid of the two
SoCal Algal Index of Biotic Integrity (IBI)

- Algal indices respond strongly to disturbance
- Hybrid index most sensitive
Algal Stream Condition Index (ASCI)

- Predictive index
- Consistent tool to use across state
- Landscape setting informs site-specific reference expectations
- Large dataset spans California ecoregions
ASCI: Development approach

Mirrors CSCI development approach
ASCI: Development approach

- Development dataset (Biology, GIS data)
- ID Reference sites
- Taxonomic completeness (O/E)
  - Diatoms
  - SBA
- Ecological structure (pMMI)
  - Diatoms
  - SBA

Calibration
Validation

Mirrors CSCI development approach
ASCI: Development dataset

~2000 stations, 3800 taxa
- Years 2008-2016
- Stormwater Monitoring Coalition (SMC)
- Perennial Stream Assessment (PSA)
- Reference Condition Management Program (RCMP)
- Regional Monitoring Coalition (RMC)
Defining reference expectations

What should the biology look like at a test site?
## ASCI: Reference site selection criteria

<table>
<thead>
<tr>
<th>Metric</th>
<th>Scale</th>
<th>Threshold</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>% agriculture</td>
<td>1k, 5k, WS</td>
<td>3</td>
<td>%</td>
</tr>
<tr>
<td>% urban</td>
<td>1k, 5k, WS</td>
<td>3</td>
<td>%</td>
</tr>
<tr>
<td>% agriculture + % urban</td>
<td>1k, 5k, WS</td>
<td>5</td>
<td>%</td>
</tr>
<tr>
<td>% Code 21 (developed veg)</td>
<td>1k, 5k, WS</td>
<td>7, 10</td>
<td>%</td>
</tr>
<tr>
<td>Road density</td>
<td>1k, 5k, WS</td>
<td>2</td>
<td>km/km²</td>
</tr>
<tr>
<td>Road crossings</td>
<td>1k, 5k, WS</td>
<td>5, 10, 50</td>
<td>crossings</td>
</tr>
<tr>
<td>Dam distance</td>
<td>WS</td>
<td>10</td>
<td>km</td>
</tr>
<tr>
<td>% canals and pipelines</td>
<td>WS</td>
<td>10</td>
<td>%</td>
</tr>
<tr>
<td>Producer mines</td>
<td>5k</td>
<td>0</td>
<td>mines</td>
</tr>
<tr>
<td>W1_HALL (rip. anthro. disturbance)</td>
<td>site</td>
<td>1.5</td>
<td>-</td>
</tr>
</tbody>
</table>

http://rpubs.com/stheroux/devdata
Dataset spans ecoregions in California.

Environmental variables

PC1 (31.8% variance explained)

PC2 (17.4% variance explained)

- Chaparral
- Central Valley
- Deserts Modoc
- North Coast
- South Coast
- Sierra Nevada
Reference sites capture geographic gradients

Environmental variables

PC1 (31.8% variance explained)

PC2 (17.4% variance explained)

- Chaparral
- Central Valley
- Deserts Modoc
- North Coast
- South Coast
- Sierra Nevada

Reference sites
## Reference sites by region

<table>
<thead>
<tr>
<th>Region</th>
<th>All sites</th>
<th>Reference Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Lahontan</td>
<td>125</td>
<td>53</td>
</tr>
<tr>
<td>Central Valley</td>
<td>79</td>
<td>1</td>
</tr>
<tr>
<td>Coastal Chaparral</td>
<td>353</td>
<td>55</td>
</tr>
<tr>
<td>Deserts Modoc</td>
<td>87</td>
<td>26</td>
</tr>
<tr>
<td>Interior Chaparral</td>
<td>84</td>
<td>30</td>
</tr>
<tr>
<td>North Coast</td>
<td>168</td>
<td>60</td>
</tr>
<tr>
<td>South Coast Mountain</td>
<td>236</td>
<td>39</td>
</tr>
<tr>
<td>South Coast Xeric</td>
<td>621</td>
<td>26</td>
</tr>
<tr>
<td>West Sierra</td>
<td>148</td>
<td>66</td>
</tr>
</tbody>
</table>
**ASCI: two component index**

- **Observed vs. Expected taxa (O/E)**
- **Predictive Multi-Metric Index (pMMI)**
  - % motile taxa
  - % Cu tolerant
  - % N-fixing

Who is there?  Who is there?  What are they doing?
How are we making predictions?

- Use environmental variables to predict species assemblages (O/E) and metric values (pMML)

- Candidate predictors (partial list):

<table>
<thead>
<tr>
<th>Location</th>
<th>Topography</th>
<th>Long-term climate</th>
<th>Soils</th>
<th>Minerology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>Watershed area</td>
<td>Catchment precip</td>
<td>Bulk density</td>
<td>MgO content</td>
</tr>
<tr>
<td>Longitude</td>
<td>Elevation range</td>
<td>Local precip</td>
<td>Erodibility</td>
<td>CaO content</td>
</tr>
<tr>
<td>Elevation</td>
<td></td>
<td>Local temp</td>
<td>Permeability</td>
<td>S content</td>
</tr>
</tbody>
</table>
### ASCl: evaluate performance

<table>
<thead>
<tr>
<th>Performance aspect</th>
<th>How do we measure?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>Big differences between reference and stressed</td>
</tr>
<tr>
<td>Precision</td>
<td>Low SD for reference sites</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Validation reference sites</td>
</tr>
<tr>
<td>Bias</td>
<td>No bias from natural gradients</td>
</tr>
</tbody>
</table>

![Mock ASCI charts]

- **Left**: Box plots showing Mock ASCI for Reference vs. Stressed sites.
- **Right**: Box plots for Mock ASCI across different PSA regions.
  - PSA regions include CHco, CHin, CV, DM, NC, SCm, SCx, SNcl, SNws.
Status of ASCl: draft O/E

1. Biological characterization ✓
2. Predict cluster membership and capture probabilities for each taxon ✓
3. Selection of expected taxa
4. Combining of taxa into an index
Status of ASCI: pMMI in progress

1. Calculate metrics ✔
2. Predict metric values at reference sites ✔
3. Screen metrics
4. Select metrics
5. Combine metrics into an index
Status of ASCl: pMMI in progress

Metrics we have calculated (partial list):

<table>
<thead>
<tr>
<th>Autoecological</th>
<th>Community structure</th>
<th>Ecological guild</th>
<th>Tolerance/Intolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>N uptake metabolism</td>
<td><em>Achnanthidium minutissimum</em></td>
<td>High motility</td>
<td>ISA: most sensitive</td>
</tr>
<tr>
<td>Saprobic class</td>
<td>CRUS taxa</td>
<td>Low motility</td>
<td>ISA: most tolerant</td>
</tr>
<tr>
<td>Oxygen requirement</td>
<td>ZHR taxa</td>
<td>Nonmotile</td>
<td>Sediment tolerant</td>
</tr>
</tbody>
</table>

BCG derived metrics:

<table>
<thead>
<tr>
<th>BCG Levels</th>
<th>BCG id’ed taxa of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 taxa</td>
<td><em>Achnanthidium minutissimum; Hannaea arcus</em></td>
</tr>
<tr>
<td>Level 3/4 taxa</td>
<td><em>Planothidium sp.; Surirella sp.; Pleurosira sp.</em></td>
</tr>
<tr>
<td>Level 6 taxa</td>
<td><em>Cyclotella meneghiniana, Gomphonema parvulum, Nitschia inconspicua</em></td>
</tr>
</tbody>
</table>
## Timeline

<table>
<thead>
<tr>
<th>Description</th>
<th>Estimated Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index development - Graphs and tables summarizing O/E model, MMI model and ASCI model and validation</td>
<td>6/2017</td>
</tr>
<tr>
<td>Oral presentation on comparison of ASCI performance to other indices</td>
<td>6/2017</td>
</tr>
<tr>
<td>Graphs and tables summarizing ASCI use in context of other bioindicators</td>
<td>9/2017</td>
</tr>
<tr>
<td>Draft final report</td>
<td>9/2017</td>
</tr>
<tr>
<td>Final report</td>
<td>12/2017</td>
</tr>
</tbody>
</table>
Summary: ASCI applications

- Algal Index will leverage years of algae taxonomy and environmental data
- ASCI will be integrated into in State and Regional ambient wadeable stream bioassessment toolkit
- Provide complementary information to CSCI and other biointegrity measures
- Support State Water Board combined biostimulatory and biointegrity amendments
Questions?

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Reference sites have few sources of human stress.

- **Infrastructure**: roads, railroads
- **Population density**
- **Hydromodification**
  - manmade channels, canals, pipelines
- **Landuse**
  - Ag/Urban development
  - Timber Harvest, Grazing
- **Fire history, dams, mines**
- **303d list, known discharges**
- **Water chemistry**