Stream Biological Community Groupings

North of Yosemite
- Butte Willow McCloud
- EF Moosehead
- EF Nelson
- Cat Robinson
- Grassy Swale
- MF Cosumnes
- Sagehen1
- Sagehen2
- Nelson Warner

Southern streams are snowmelt-dominated (granite terrain) and so are more at-risk to drying and have less species diversity

Yosemite and South
- Cathedral Fk Echo
- U.Cathedral Fk Echo
- Deer Pitman
- Snow Corral
- Crown
- Tyndall
- Upper Bubbs
- Forester
- Upper Tyndall

SF Tamarack

Northern streams have significant groundwater inflows (volcanic terrain) and have greater species diversity but more to lose in the face of the greatest predicted loss of snowpack

~350 BMI taxa identified to date (genus/species)

Intermittent channel = shortest upstream length, snowmelt
Closer look at intermittent flow: stress of periodic summer drying
> perennial upstream length used as indicator of dependable flow

Short headwater streams most susceptible, having least taxa richness. But what protects some headwaters and not others?
> Groundwater inflows (higher SiO$_2$) sustain baseflow and resist drying
> low SiO$_2$ snowmelt-dominated streams risk drying but support more richness as channel length increases (= perennial flow)
Sentinel Streams: How does stream habitat change? Pools and Riffles, transition zones

**Average to +**

<table>
<thead>
<tr>
<th>Year</th>
<th>Riffle</th>
<th>Pool</th>
<th>Transitional</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>64.4%</td>
<td>21.5%</td>
<td>14.1%</td>
</tr>
</tbody>
</table>

**High Flow**

<table>
<thead>
<tr>
<th>Year</th>
<th>Riffle</th>
<th>Pool</th>
<th>Transitional</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>69.8%</td>
<td>21.2%</td>
<td>9.1%</td>
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</tbody>
</table>

**Drought**

<table>
<thead>
<tr>
<th>Year</th>
<th>Riffle</th>
<th>Pool</th>
<th>Transitional</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>58.2%</td>
<td>31.5%</td>
<td>10.3%</td>
<td>1.0%</td>
</tr>
<tr>
<td>2013</td>
<td>56.6%</td>
<td>30.2%</td>
<td>12.1%</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

Paired-comparison between years, within each stream (n=24), p<0.05

<table>
<thead>
<tr>
<th>Year 1 vs Year 2</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 vs 2011</td>
<td>ns</td>
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<tr>
<td>2010 vs 2012</td>
<td>*</td>
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<tr>
<td>2010 vs 2013</td>
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</tbody>
</table>

Wilcoxon paired signed-rank tests

**Significant increase in pools w drought, from 20% to 30% of habitat area.**

Slower-moving POOL habitats come to make up more of the stream environment as the drought progresses.

**Pools harbor less diversity than swift-flowing riffles.** More sediment deposition and less oxygen.
Yes, significant increase from average and high flow years to drought (from ~10 to 13°C). Last year some sites rising into the range of >20°C, can be lethal to some aquatic life.
2011: high / prolonged spring runoff (50%+ higher, 3wks+ later) and water chemistry change: lower pH (-0.75 mean)

Wilcoxon signed-rank paired comparison 2010 to 2011
p<0.0001 (22 of 24 streams), decrease from average of 7.22 to 6.47

pH decrease with runoff dilution of inflows, washout of acid-neutralizing capacity? Most severe at streams with initially lower pH

Biological Consequences? Duration of pH acidification?
Network shows fewer species & numbers as pH drops

pH rebounds in 2012-2013
Resource Base and changing flow regime
- Benthic algae percent cover increased during drought years compared to higher flows, and fine particulate organic matter retained then exported/consumed.

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*But no significant change in CPOM*
Sentinel Streams:
Does benthic invertebrate density change with drought?

**Overall density increases significantly** and becomes dominated by midges over other invertebrates:
Midges are small, and more tolerant of poor water quality