The relationship between stream temperature and air temperature in Maryland streams

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Global climate change

• Greenhouse gases
  – CO₂ has increased globally by 100 ppm (36%) over the last 250 years
  – Fastest rate from 1995 – 2005

• Temperature
  – Global mean surface temperature has risen 0.74°C over the last 100 years
  – 1998 and 2005 warmest years on record
Potential impacts on aquatic biota

- Rates of many chemical & biological processes - function of temperature
- Reductions in biodiversity; loss of some cold and cool water species
- Lethal thermal limit may be exceeded for other aquatic species – extreme droughts and heat waves
- Range expansions/new invasions of invasive species
Stream/air temperature studies

- Midwest
  - Pilgrim et al. 1998
  - Mohseni and Stefan 1999
- West
  - Neumann et al. 2003
- Nationwide
  - Easton and Scheller 1996
  - Mohseni et al. 2003
  - Bogan et al. 2003
Primary question

How will a projected increase in air temperature impact stream water temperatures in Maryland?

Objectives

• Examine the relationship between air and water temperatures in unimpaired Maryland watersheds

• Determine how stream water temperatures can be explained by air temperatures
Temperature relationships

- **Physiographic region**
  - Highland, Eastern Piedmont, Coastal Plain

- **Stream order**
  - $1^{\text{st}}$, $2^{\text{nd}}$, $3^{\text{rd}}$

- **Drainage area**
  - <1000 acres, 1000-5000 acres, 5000-10000 acres, >10,000 acres
Temperature data

- Collected from 29 MBSS sites (20 Sentinel Sites)
- Unimpaired watersheds
  - % Development
    Mean - 3.1%
  - % Impervious surface
    Mean – 0.2%
Temperature data

- Temp logger data from June-August
- Average 3 day temperature
- Years (2005-2007)
- Water and air temp logger placed at each site
Physiographic region

Average summer air and water temperatures

- **Coastal**
  - Average Temperature (°C):
    - Water: 22.8
    - Air: 21.2

- **Piedmont**
  - Average Temperature (°C):
    - Water: 21.5
    - Air: 19.4

- **Highland**
  - Average Temperature (°C):
    - Water: 19.7
    - Air: 17.7
Physiographic region

Coastal – 15 pairs of data

Average 3 day air temp

Average 3 day water temp

\[ y = 0.6995x + 5.254 \]

\[ R^2 = 0.7108 \]
Physiographic region

Piedmont – 10 pairs of data

\[ y = 0.687x + 4.661 \]

\[ R^2 = 0.7236 \]
Physiographic region

Highland – 12 pairs of data

Average 3 day air temp

Average 3 day water temp

\[ y = 0.7224x + 3.4634 \]

\[ R^2 = 0.8184 \]
Physiographic region results

<table>
<thead>
<tr>
<th>Region</th>
<th>Water temp range (°C)</th>
<th>Slope</th>
<th>R-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highland</td>
<td>10.1 - 24.1</td>
<td>0.722</td>
<td>0.818</td>
</tr>
<tr>
<td>Piedmont</td>
<td>13.6 - 25.8</td>
<td>0.687</td>
<td>0.723</td>
</tr>
<tr>
<td>Coastal</td>
<td>15.2 - 25.7</td>
<td>0.699</td>
<td>0.711</td>
</tr>
</tbody>
</table>

**ANCOVA - No difference based on physiographic region**
## Stream order results

<table>
<thead>
<tr>
<th>Stream order</th>
<th>Logger pairs</th>
<th>Slope</th>
<th>R-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>18</td>
<td>0.781</td>
<td>0.802</td>
</tr>
<tr>
<td>2nd</td>
<td>14</td>
<td>0.756</td>
<td>0.777</td>
</tr>
<tr>
<td>3rd</td>
<td>5</td>
<td>0.908</td>
<td>0.874</td>
</tr>
</tbody>
</table>
## Drainage area results

<table>
<thead>
<tr>
<th>Drainage area (acre)</th>
<th>Logger pairs</th>
<th>Slope</th>
<th>R-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1,000</td>
<td>18</td>
<td>0.752</td>
<td>0.785</td>
</tr>
<tr>
<td>1,000 - 5,000</td>
<td>11</td>
<td>0.785</td>
<td>0.772</td>
</tr>
<tr>
<td>5,000 - 10,000</td>
<td>3</td>
<td>0.931</td>
<td>0.946</td>
</tr>
<tr>
<td>&gt;10,000</td>
<td>5</td>
<td>0.791</td>
<td>0.864</td>
</tr>
</tbody>
</table>
General results

• Linear relationship between air and water temperatures
• Air/water temperature rate is 0.7-0.8°C in unimpacted watersheds
• No difference in air/water temperature relationship based on physiographic region
• Potential increase in air/water temperature rate with increased stream size
Current work

- Air and water temperature loggers deployed at all 2008 MBSS sites
  - Sentinel sites (1 year)
  - MBSS (6 months)
- Examine air/water temperature relationship across range of watershed landscape conditions
Acknowledge

- Tony Prochaska
- Ann Schenk
- All MBSS field crews