Spatio-Temporal Patterns of Stream Temperature in the Delaware Basin

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2020 Virtual Watershed Congress

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River & Stream Temperatures
Change in average temperature since 1990

Change in mean March-August temperature 1980-2018
Gauges chosen based on most consistent observational record
Source: USGS
**Warming Waters:**
Temperature controls on aquatic organisms

- Temperature effects on dissolved oxygen
- Temperature effects on algal growth/blooms
- Temperature effects on toxicity
- Temperature effects on fish populations

Temperature affects acute mayfly responses to elevated salinity: implications for toxicity of road de-icing salts

John R. Jackson and David H. Funk

Stream Water Research Center, 920 Spanker Road, Agawam, PA 19931, USA
Temperature effects on fish populations

Warming Out of Range
Trout temperature zones

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Brook Trout</th>
<th>Rainbow Trout</th>
<th>Brown Trout</th>
</tr>
</thead>
<tbody>
<tr>
<td>50°</td>
<td>Warning</td>
<td>Warning</td>
<td>Optimal</td>
</tr>
<tr>
<td>55°</td>
<td>Optimal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60°</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>65°</td>
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<td></td>
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<tr>
<td>70°</td>
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<td></td>
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<tr>
<td>75°</td>
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<td></td>
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<tr>
<td>80°</td>
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</tbody>
</table>

RANGE OF TOLERANCE FOR DISSOLVED OXYGEN IN FISH

<table>
<thead>
<tr>
<th>PARTS PER MILLION (PPM) DISSOLVED OXYGEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
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<tr>
<td>2</td>
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<tr>
<td>9</td>
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<tr>
<td>10</td>
</tr>
</tbody>
</table>

Source: Morzio, Jr. and Fischer, 2000

CLIMATE CENTRAL

Kings Bay Restoration Project
How does stream temperature vary OVER TIME?
How does stream temperature vary OVER TIME?

Diel Fluctuations (day/night)
How does stream temperature vary OVER TIME?

Seasonal Variation
How does stream temperature vary OVER SPACE?

Forest watershed
- 8.0 cm Precipitation
- 0.5 cm Evapotranspiration
- 0.0 cm Runoff
- 7.5 cm Infiltration

Agricultural watershed
- 8.0 cm Precipitation
- 0.6 cm Evapotranspiration
- 1.7 cm Runoff
- 5.7 cm Infiltration

Urban watershed
- 8.0 cm Precipitation
- 0.0 cm Evapotranspiration
- 5.9 cm Runoff
- 2.1 cm Infiltration

Source: UK Met Office
Model My Watershed  https://runoff.modelmywatershed.org/
How does stream temperature vary OVER SPACE & TIME?

Mean Temperature per Month

January

- Cobbs Creek: 8
- Broad Run: 4
- Hurricane Run: 4
- Aquashicola Creek: 3
- Wissahickon Creek: 3
- Rocky Run: 2
- Little Lehigh: 2
- Pickering Creek: 2

Temperature in degC | Data Source: DRWI
How does stream temperature vary OVER SPACE & TIME?
How does stream temperature vary OVER SPACE & TIME?

**Mean Temperature per Month**

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Cobbs Creek location
Summer Stream Temperature

50 watersheds of different size with varying land uses

Aquashicola Ck

Rocky Run

Pickering Ck

Chestnut Run
Land use and stream temperature

Average Summer Temperature

Forest | Agricultural | Mixed | Urban/Developed
--- | --- | --- | ---
18 | 19 | 20 | 23

The graph shows the average summer temperature for different land uses: Forested, Agricultural, Mixed, and Urban/Developed. The temperature increases from Forested to Urban/Developed.
Forest area and stream temperature

10% forested area yields a 0.5°C decrease
Land use and HOURLY stream temperature

Cobbs Creek

Aquashicola Creek
EnviroDIY sensor stations

Sentinels of thermal stress in cold-water fisheries

Guidance for trout stocking locations

21°C – 31°C
Hours/day exceeding Cold-Water Criteria
Hours/day exceeding Stocking Temperature Criteria

Little Lehigh
Aquashicola
Pickering
Rocky
Wissahickon
Cobbs
Punches
Hurricane
Broad
Marsh

Hours/day
8
6
4
2
0

Jun 2018  Jul 2018  Aug 2018  Sep 2018
In summary

• Sensor temperature data helps us understand the complex interaction between land use and temporal effects on stream temperatures.

• *At large scales:* we can identify significant ‘cooling effects’ of forested watersheds on stream temperatures

• *At fine scales:* Hourly resolution of temperature data allow us to better assess the compliance and exceedance of state criteria for Cold Water Fish and trout-stocking in streams of similar average temperatures.
Acknowledgments

• Citizen scientists
• Collaborators:
  – Diana Oviedo-Vargas
  – John Jackson
  – David Bressler
  – David Arscott
  – Charlie Dow