Urbanization in Southeastern NH: Does it impact stream temperature?

Jennifer Jacobs
Gary Lemay

Environmental Research Group
Department of Civil Engineering
University of New Hampshire

Funding: USGS WRRC and US EPA
Stream Temperature

- Spatial
  - Regional
  - Reach variations (< 1m)

- Temporal
  - Diurnal (daily) fluctuations
  - Long term trends
  - Storm events

Data Source: NH Fish and Game
Stream Temperature

- Primary stream health indicator
- Fisheries classification
- Limited knowledge
Urbanization Features

- Land use change
- Impervious surfaces
- Road crossings
- Stormwater BMPs
- Groundwater withdrawals
- Wastewater discharge
- Dams
Research Questions

How do **culverts** affect

a. diurnal temperature ranges?
b. mean temperatures?
c. storm temperature surges?

How does **impervious area** within a stream’s watershed effect

a. diurnal temperature ranges?
b. mean temperatures?
c. storm temperature surges?
Road Crossings

- Previous Research
  - Thermal impacts not yet studied
  - Stream channel changes
    (Bates, 2003)
    - Armoring
    - Bank erosion
- Over 16,500 in NH as of 2008
- Focus on culverts
Impervious Area

- **Previous Research**
  - Lowers stream health (Deacon et al., 2005)
  - Elevated runoff temperatures (Herb et al., 2009)
  - Stream temperature surges (Nelson and Palmer, 2007)

- **Coastal NH Imperviousness**
  - 4.00 % in 1990
  - 5.85 % in 2000
  - 6.91 % in 2005
Point Monitoring Experiment

- 9 study streams
  - 1.14 to 9.26 km²
  - 3.4 to 43% impervious
  - 1 to 11 road crossings

- Study period:
  7/08 to 12/09

- Data collection
  - Stream temperature (15 min)
  - Hourly weather data
  - Stage where possible
College Brook

[Map of College Brook with monitoring locations and study watershed]
Wednesday Hill Brook

Overview

Methods

Experimental

Modeling

Conclusions

Legend

- Monitoring Locations
- Stream Centerline
- Roads
- Study Watershed
Experimental Results
Point Monitoring Time Series

Temperature (°C)

College Brook Upstream
College Brook Downstream

Storm Events
### Q3 2009

#### Site-site and stream-stream variations

<table>
<thead>
<tr>
<th>College Brook</th>
<th>Hodgson Brook</th>
<th>Berry Brook</th>
<th>Reservoir Brook</th>
<th>Lee 5 Corners</th>
<th>Chesley Brook</th>
<th>WHB</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="chart.png" alt="Temperature (°C)" /></td>
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</tbody>
</table>

- Site-site and stream-stream variations
- **Overview**: Temperature variations at different sites.
- **Methods**: Analysis techniques used.
- **Experimental**: Data collection methods.
- **Modeling**: Statistical models applied.
- **Conclusions**: Interpretation and implications of findings.

**Temperature (°C)**

- **College Brook**
  - 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28
- **Hodgson Brook**
  - 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28
- **Berry Brook**
  - 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28
- **Reservoir Brook**
  - 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28
- **Lee 5 Corners**
  - 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28
- **Chesley Brook**
  - 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28
- **WHB**
  - 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28
Hypothesis 1a
Culverts will increase diurnal temperature ranges

Culverts do not appear to increase diurnal temperature ranges, refuting hypothesis
Hypothesis 1b
Culverts will not change mean temperatures

Some evidence of warming in winter, but generally inconclusive and cannot reject hypothesis
Hypothesis 1c
Culverts will not change storm temperature surges
Hypothesis 1c
Culverts will not change storm temperature surges

Road crossings are positively correlated with storm surge frequency and magnitude, refuting hypothesis
Hypothesis 2a
Impervious area will increase diurnal temperature range

Hypothesis reasonable for wintertime, not for summertime, inconclusive for other seasons
Hypothesis 2b
Impervious area will increase mean temperatures

\[
T_{Q3-2009} = 0.1813 \text{Area} + 0.1430\%\text{Impervious} - 0.0502\%\text{Stratified} + 14.33
\]

Hypothesis not rejected for Q2/Q3, rejected for Q1/Q4
Hypothesis 2c
Impervious area will increase storm temperature surges

![Graph showing the relationship between impervious area and temperature surge percentage and mean temperature surge over different quarters.](image-url)
Hypothesis 2c
Impervious area will increase storm temperature surges

Some evidence of increased surges, but impacts differed by analysis method, so hypothesis cannot be accepted or refuted.
## Summary of Findings

<table>
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<tr>
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<th>Road Crossing</th>
<th>Impervious Area</th>
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<tr>
<td><strong>Diurnal Range</strong></td>
<td>NO</td>
<td>YES: Q1</td>
</tr>
<tr>
<td><strong>Mean Daily</strong></td>
<td>NO</td>
<td>YES: Q2 and Q3 w/ stratified drift</td>
</tr>
<tr>
<td><strong>Storm Surges</strong></td>
<td>YES</td>
<td>MAYBE: weak relationship</td>
</tr>
</tbody>
</table>
New Research Questions

- What are the physical processes causing:
  - Culverts to impact temperature surges
  - Storm surges to differ among analysis methods
    - Gradients, magnitude, frequency
- How can we predict thermal impacts of urbanization?
  - Different issues for baseflow and stormflow
  - Thermal impact mitigation using BMPs
Results in Context

- **Aquatic Impacts**
  - Warming from impervious area reduces coldwater habitat during baseflow periods
  - Increased storm surge temperatures from road crossings have the potential to cause temperatures to exceed acute limits

- **Aquatic Impact Limitations**
  - Biota’s temperature tolerances not fully understood
  - Important temperature metrics are seldom available
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References

Questions?