URBAN NON-POINT SOURCE IMPACTS ON SEATTLE AREA STREAM PHOSPHORUS TRANSPORT

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How much does phosphorus transport differ in Seattle area urban and forest streams?

**SCALES:** Long term (decadal), seasonal (monthly), inter-annual (daily), and event based (hourly).
Lake Washington in the Past
(and the Future?)

Eutrophication
&
Surface WQ
Land Cover

- forested urban
- grass shrub urban
- paved urban
- forested
- grass shrub crops
- water
Seasonal Fluctuations in Stream Constituent Concentrations

**Total & Soluble Reactive Phosphorus**
- TP
- SRP

**Nitrate & Ammonium**
- NO₃
- NH₄

**TSS and Turbidity**
- TSS
- Turbidity

**SRP:DIN ratio**
- Summer: 48
- Winter: 133
## Percent Urban Enrichment

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Units</th>
<th>Average Forested</th>
<th>Average Urban</th>
<th>Percent Enrichment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Phosphorus</td>
<td>µg/l</td>
<td>32.3</td>
<td>67.8</td>
<td>109%</td>
</tr>
<tr>
<td>Soluble Reactive P</td>
<td>µg/l</td>
<td>13.1</td>
<td>33.4</td>
<td>154%</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>µg/l</td>
<td>1065</td>
<td>1412</td>
<td>33%</td>
</tr>
<tr>
<td>Nitrate</td>
<td>µg/l</td>
<td>840</td>
<td>1088</td>
<td>29%</td>
</tr>
<tr>
<td>Ammonium</td>
<td>µg/l</td>
<td>13.7</td>
<td>24.8</td>
<td>81%</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTUs</td>
<td>1.71</td>
<td>3.01</td>
<td>77%</td>
</tr>
<tr>
<td>Total Susp. Solids</td>
<td>mg/l</td>
<td>4.33</td>
<td>5.90</td>
<td>36%</td>
</tr>
</tbody>
</table>
Seattle forest streams have 150% more DIN than typical forest streams.

Seattle urban streams have about 50% as much phosphorus as typical agricultural streams.

Seattle urban streams have about 35% as much nitrogen as typical agricultural streams.
Averaged Change in SRP Concentrations for the most urban Seattle area streams (Thornton, Juanita, McAleer, Lyon, Forbes, Kelsey)

**Urban stream SRP concentrations**

\[ y = -0.86x + 1747 \]

**Urban stream nitrate concentrations**

\[ y = -9x + 18950 \]

\[ r^2 = 0.31 \]

36% decline in SRP  
15% decline in NO\(_3\)  

**WHY:** BMPs, human behavior, catchment surface disturbance?
An Annual Time Series of Stream Phosphorus Transport

- Issaquah - Forest
- North - Mixed
- Swamp - Mixed
- Thornton - Urban

- Daily TP
- Weekly SRP
- Daily TSS
**Objective:** to collect a high resolution stream phosphorus concentration database in order to develop statistical time series models of stream phosphorus transport.

**Model structure:**
- Seasonal term
- Spikeness term
- Antecedent term
- Rainfall term
Overall TP varied by ± 50% from week to week

SRP varied by ± 20% from week to week

SRP was on average 48% of TP
Soluble reactive phosphorus times series

Issaquah Creek
- Predicted
- Observed

North Creek
- $r^2 = 0.85$

Swamp Creek
- $r^2 = 0.79$

Thornton Creek
- $r^2 = 0.63$
Total phosphorus times series

- **Issaquah Creek**
  - Observed: blue line
  - Predicted: red line
  - $r^2 = 0.49$

- **North Creek**
  - Observed: blue line
  - Predicted: red line
  - $r^2 = 0.55$

- **Swamp Creek**
  - Observed: blue line
  - Predicted: red line
  - $r^2 = 0.53$

- **Thornton Creek**
  - Observed: blue line
  - Predicted: red line
  - $r^2 = 0.38$
Phosphorus transport during storm events over a range of land use conditions
Study sites

• Four watersheds
  – Agriculture, 392 ha
  – Urban, 123 ha
  – Forested, 497 ha
  – Suburban, 197 ha

• All sampling sites were within Green-Duwamish River watershed
Forested Stream

- Flow (L/s)
- Tot. Diss. P (µg/L)
- Cond. (µS/cm)
Urban Stream

- Flow (L/s)
- TSS (mg/L)
Urban Stream

- Flow (L/s)
- TSS (mg/L)
- Tot. P (µg/L)
Urban Stream

Time (hrs)

- Flow (L/s)
- Tot. Diss. P (µg/L)
- Cond. (µS/cm)
Agricultural Stream

- Flow (L/s)
- Tot. P (µg/L)
- Tot. Diss. P (µg/L)
Agricultural Stream

- Flow (L/s)
- TSS (mg/L)
- Tot. P (µg/L)
- Tot. Diss. P (µg/L)
- Cond. (µS/cm)

Time (hrs)
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Therefore:
We need to know how the bioavailability of the PP fraction varies with land use and flow conditions in Seattle Area streams!
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See Micaela Ellison’s poster