

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

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- **Land cover impacts on the central tendency in stream water nutrient concentrations**

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- **Long term trends in urban stream nutrient concentrations**

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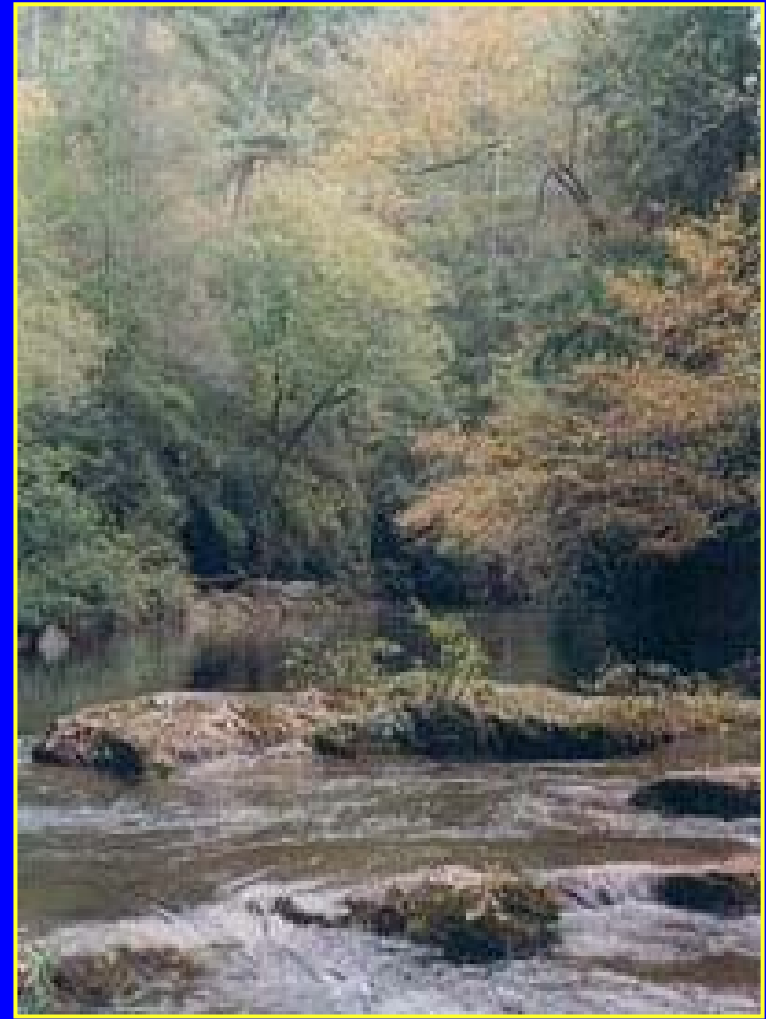
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- **Long term trends in urban stream nutrient concentrations**
- **Flow, seasonal and land cover impacts on daily phosphorus transport and speciation**
- **Storm event impacts on phosphorus transport for different land cover type streams**
- **Flow and land cover impacts on the bioavailability of phosphorus**



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

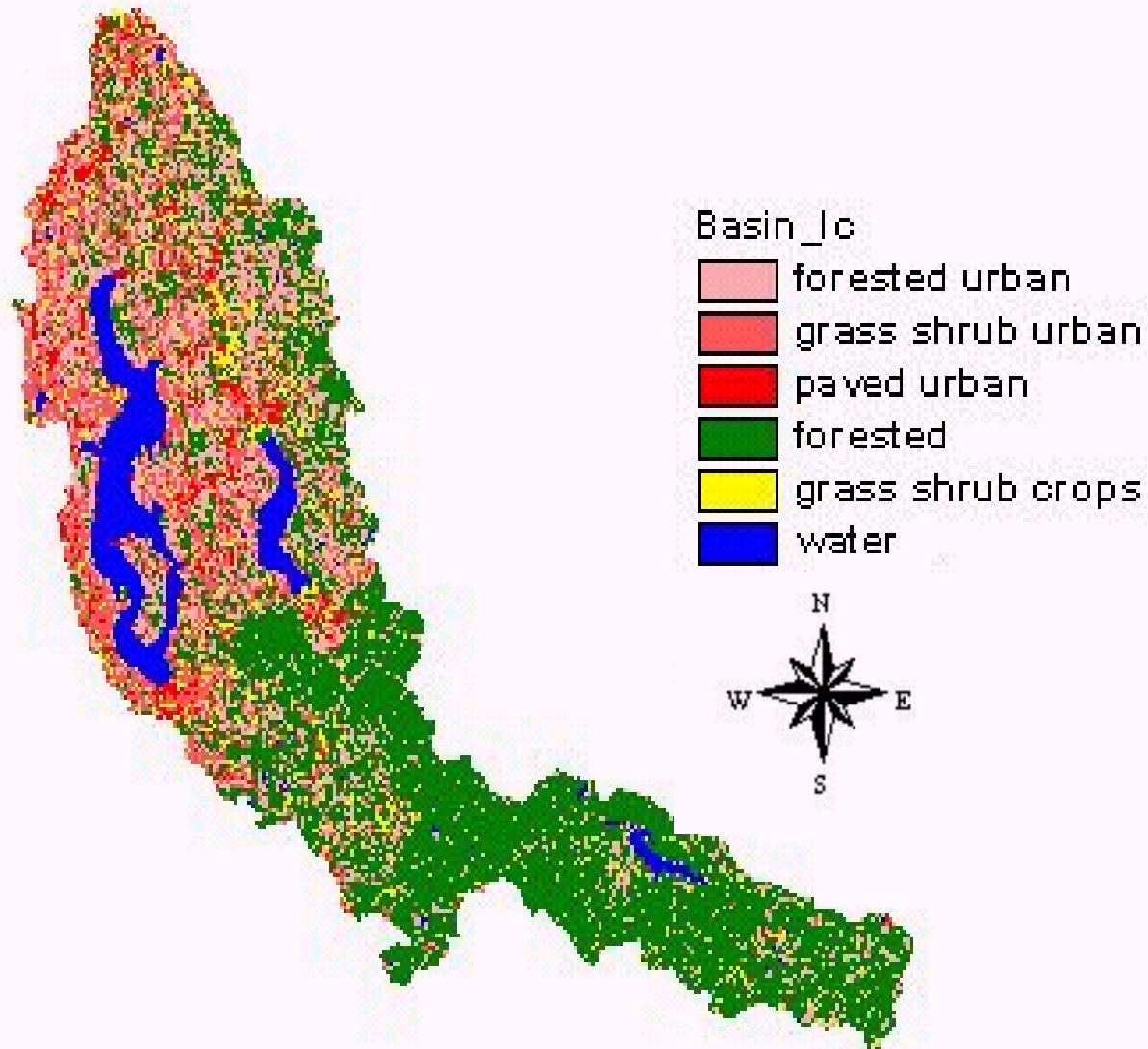
SCALES: Long term (decadal), seasonal (monthly), inter-annual (daily), and event based (hourly).



Lake Washington in the Past
(and the Future?)

Eutrophication
&
Surface WQ

Land Cover



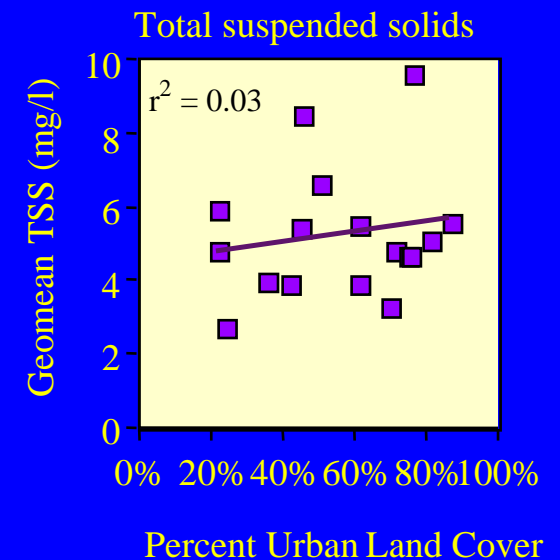
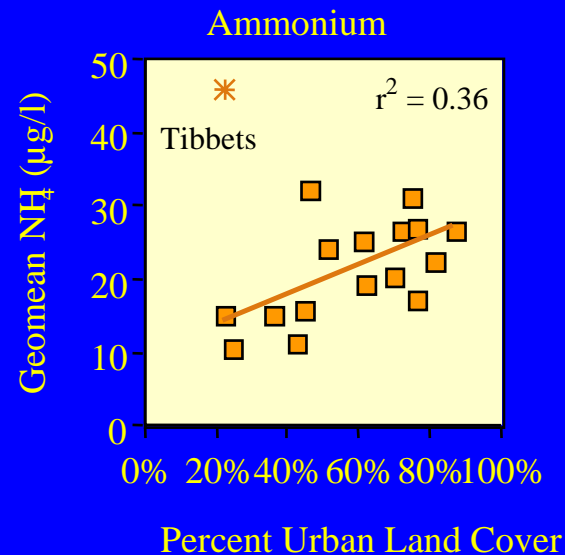
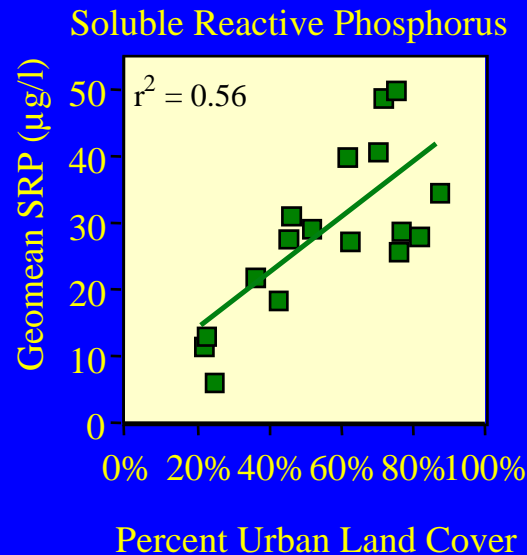
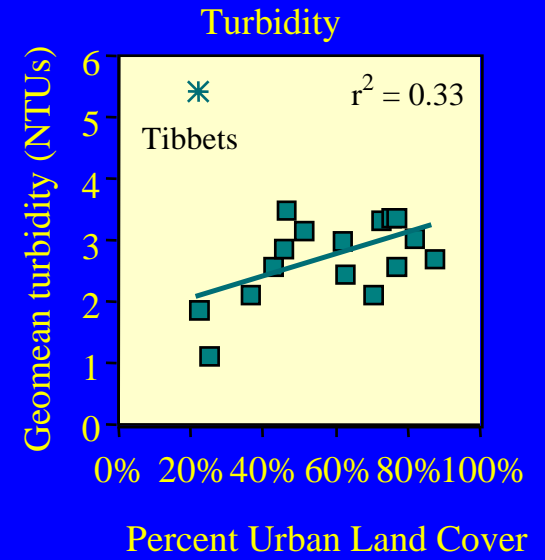
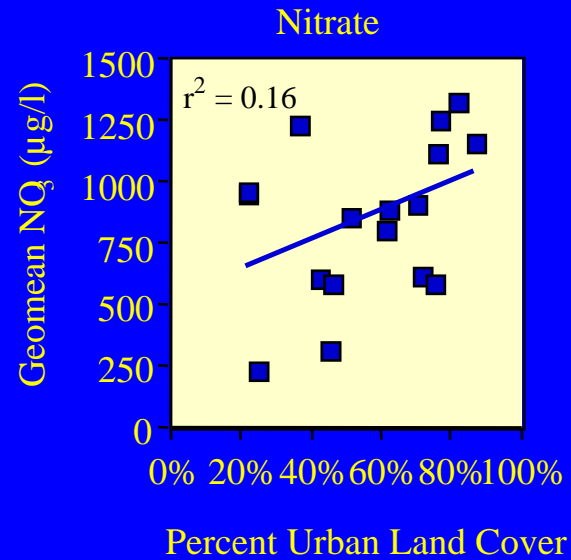
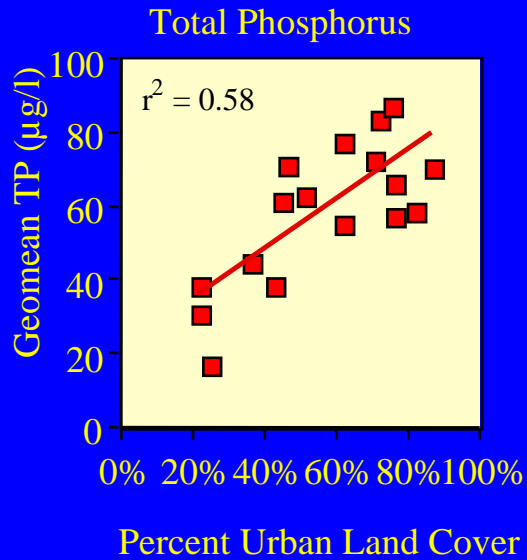
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0

20

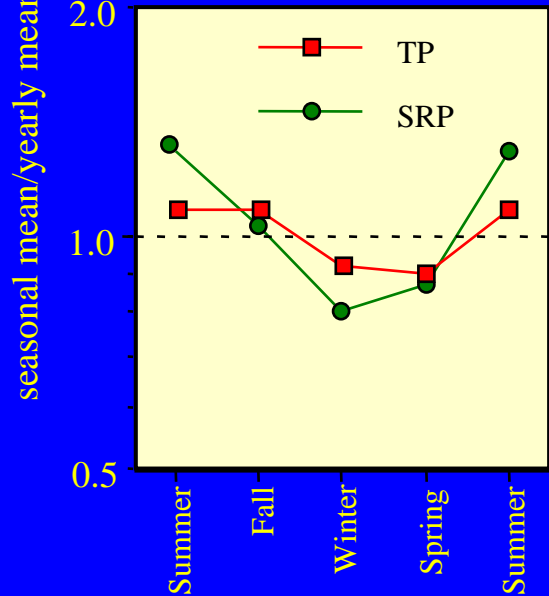
40 Miles

Land Cover Versus Stream Nutrients: Normal Flows

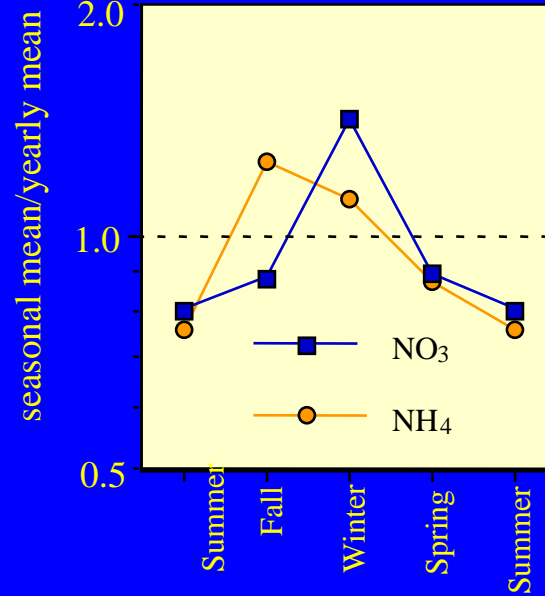


Seasonal Fluctuations in Stream Constituent Concentrations

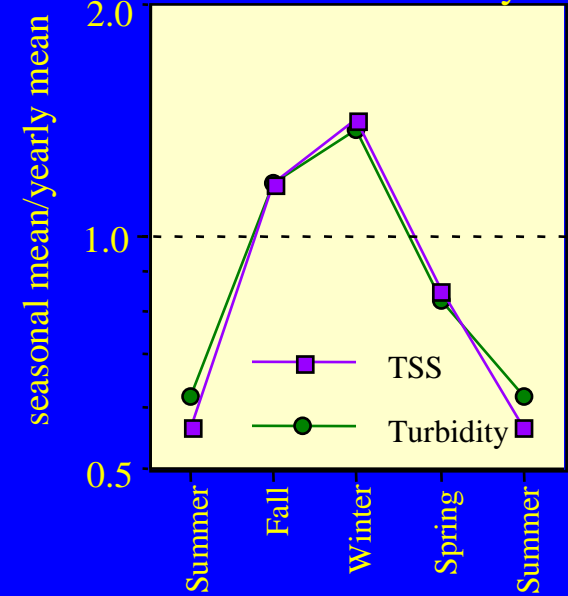
Total & Soluble Reactive Phosphorus



Nitrate & Ammonium



TSS and Turbidity



DIN:SRP ratio

Summer

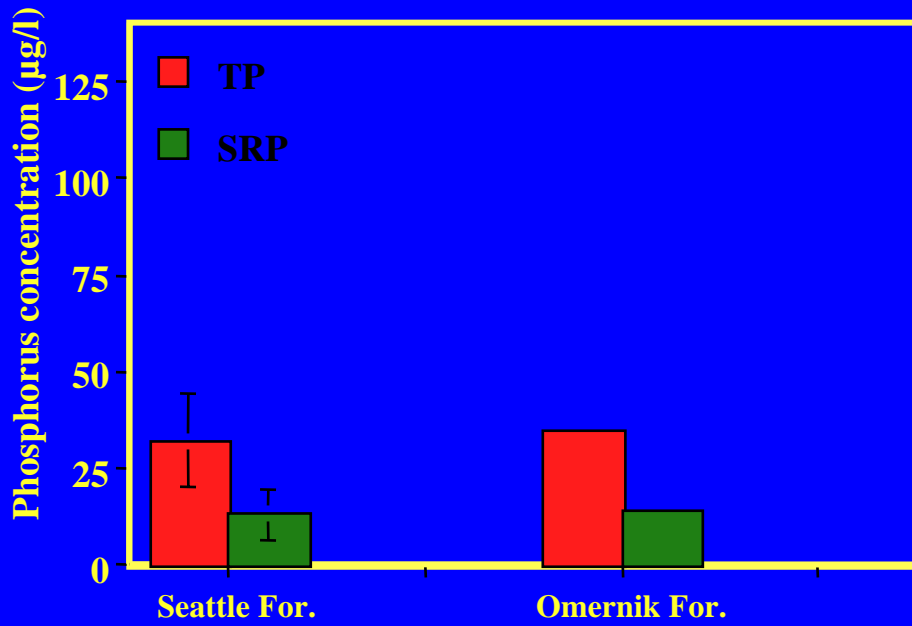
48

Winter

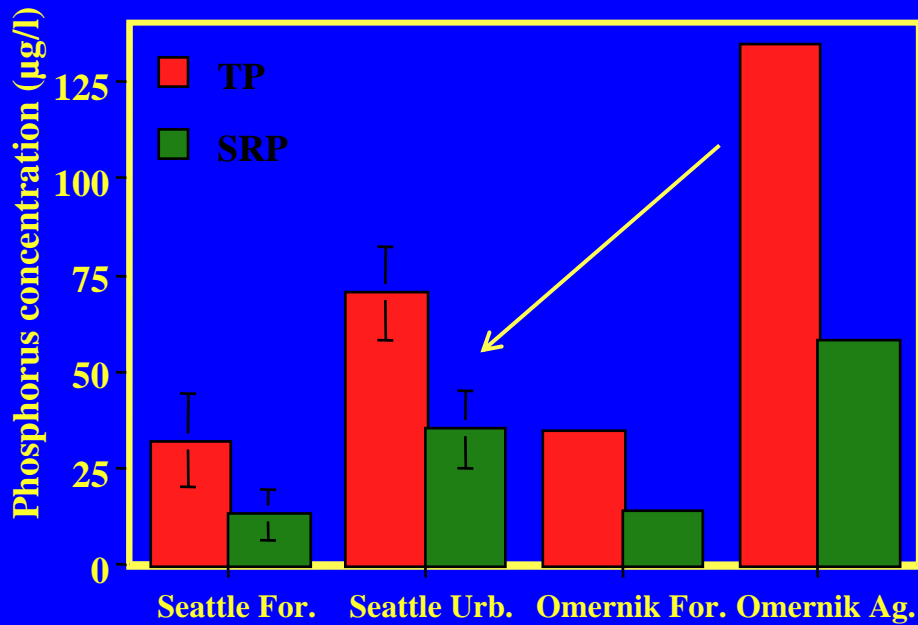
133

Percent Urban Enrichment

Constituent	Units	Average Forested	Average Urban	Percent Enrichment
Total Phosphorus	µg/l	32.3	67.8	109%
Soluble Reactive P	µg/l	13.1	33.4	154%
Total Nitrogen	µg/l	1065	1412	33%
Nitrate	µg/l	840	1088	29%
Ammonium	µg/l	13.7	24.8	81%
Turbidity	NTUs	1.71	3.01	77%
Total Susp. Solids	mg/l	4.33	5.90	36%

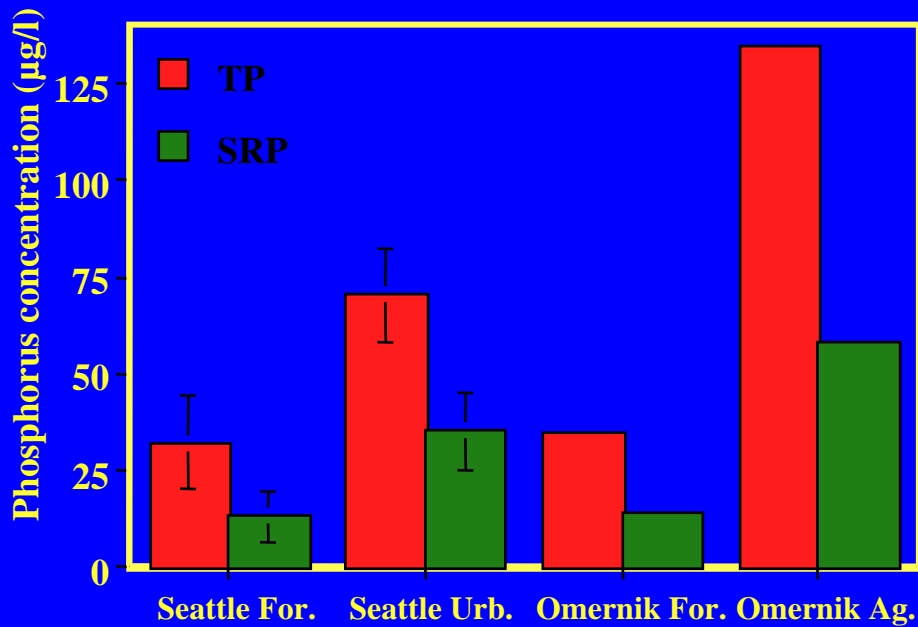


➤ Seattle forest streams have similar TP/SRP concentrations as forest streams in a national database



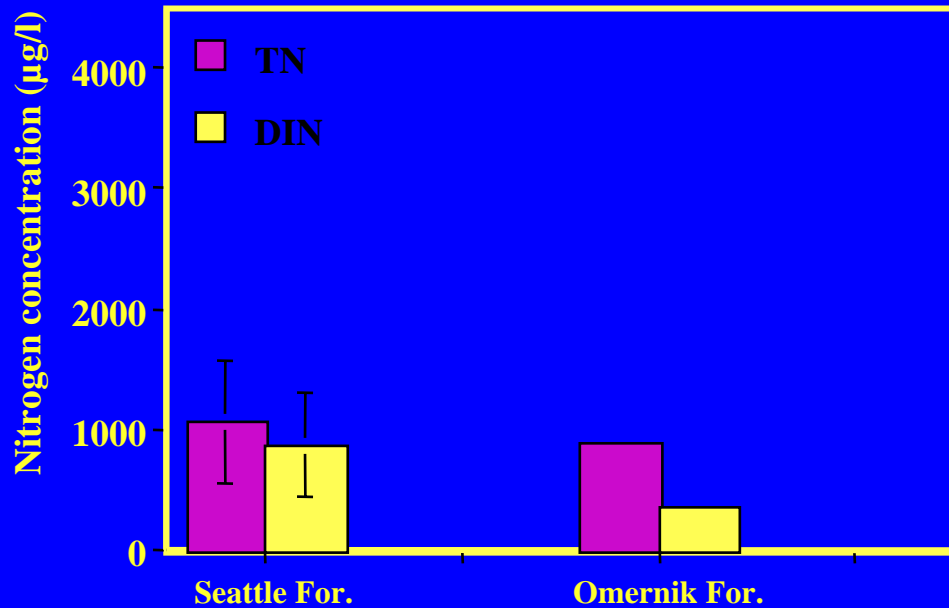
➤ Seattle forest streams have similar TP/SRP concentrations as forest streams in a national database

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

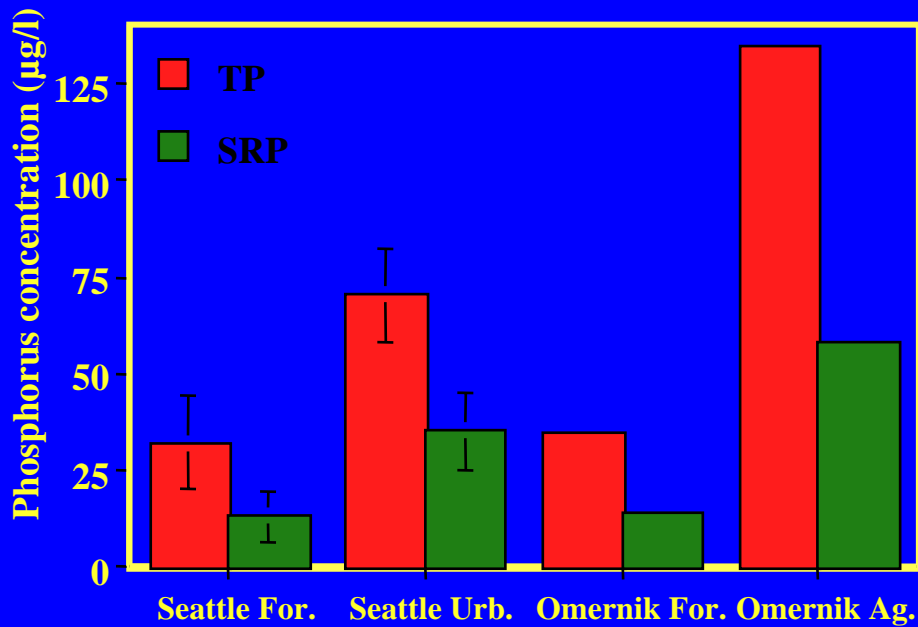


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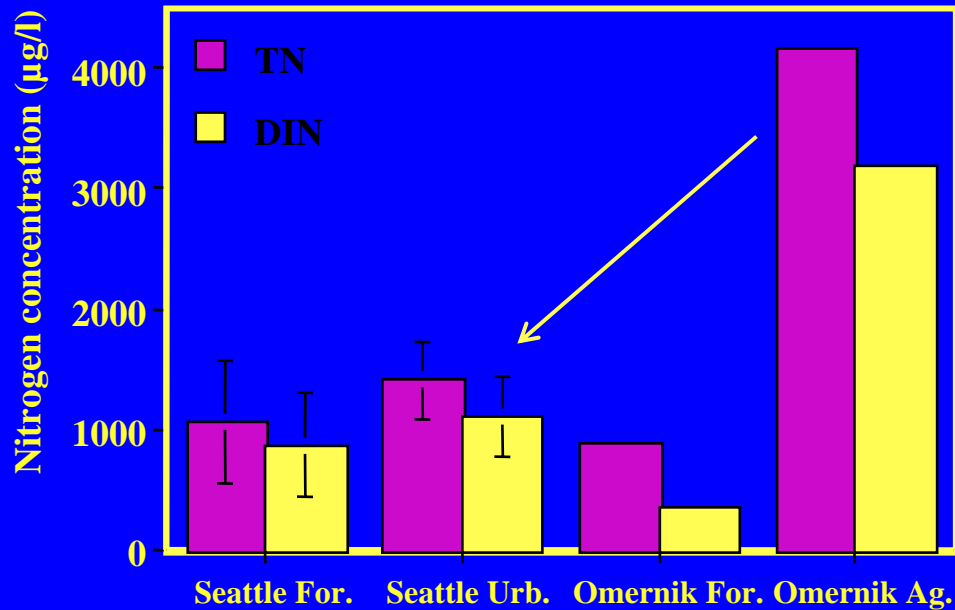


➤ Seattle forest streams have 150% more DIN than typical forest streams, but similar TN



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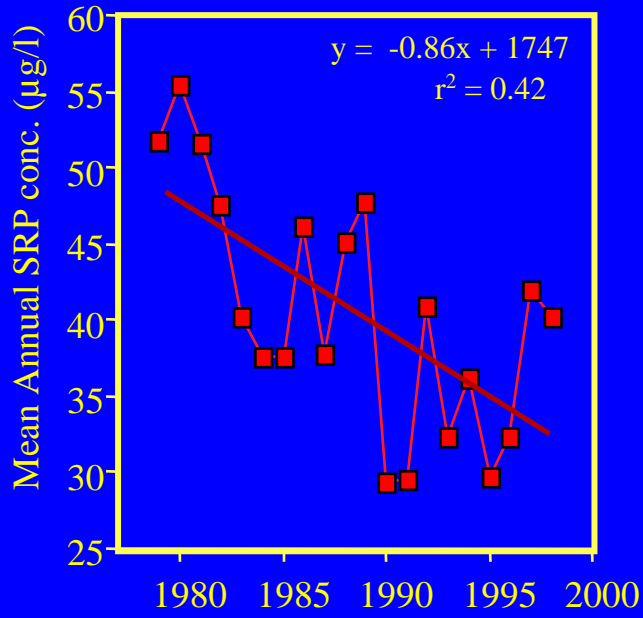


➤ Seattle forest streams have 150% more DIN than typical forest streams, but similar TN

➤ Seattle urban streams have about 35% as much nitrogen as typical agricultural streams

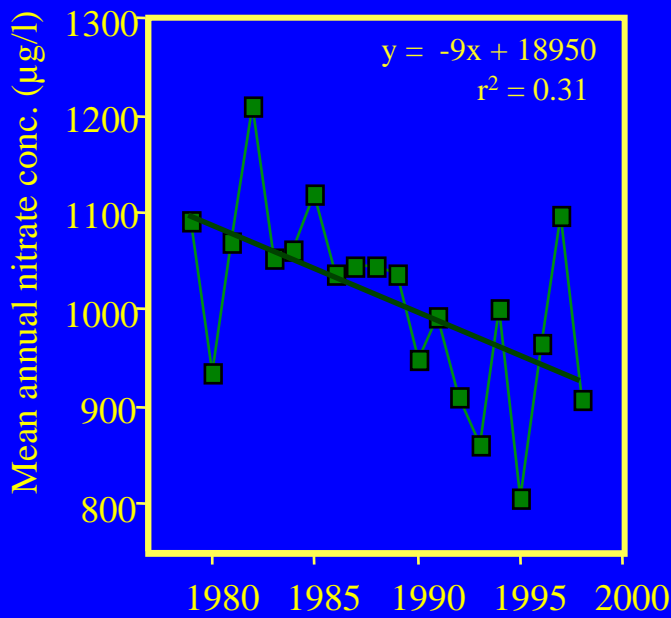
Averaged Change in SRP Concentrations for the most urban Seattle area streams (Thornton, Juanita, McAleer, Lyon, Forbes, Kelsey)

Urban stream SRP concentrations



36% decline in SRP

Urban stream nitrate concentrations

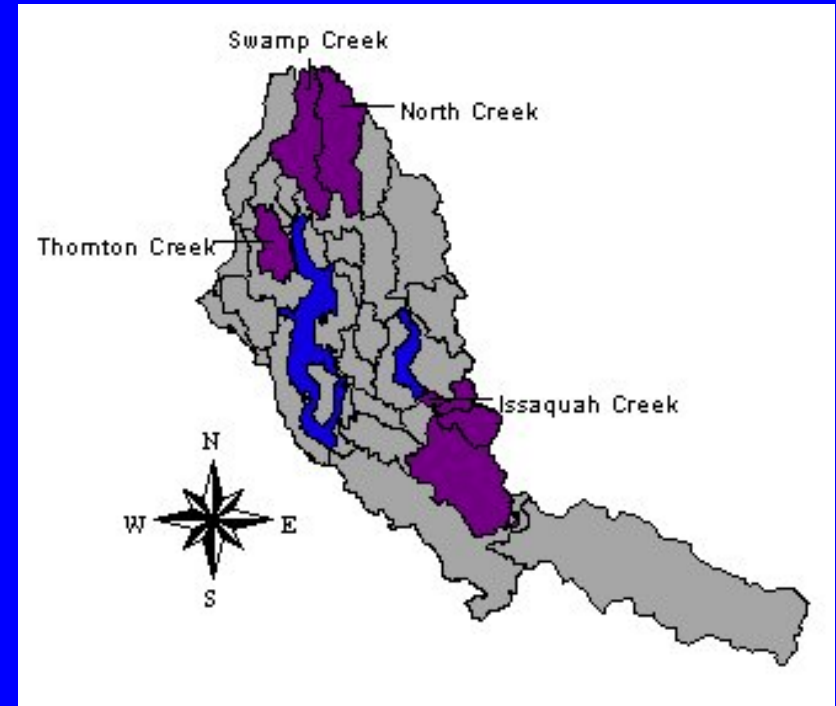


15% decline in NO₃

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



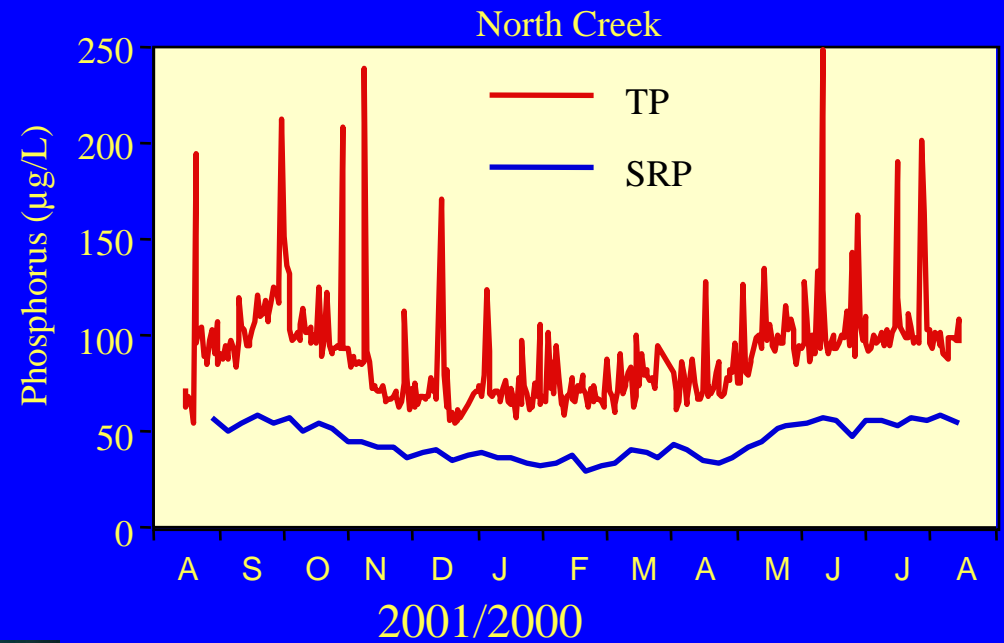
Objective: to collect a high resolution stream phosphorus concentration database in order to develop statistical time series models of stream phosphorus transport.



Model structure:

- Seasonal term
- Spikeness term
- Antecedent term
- Rainfall term

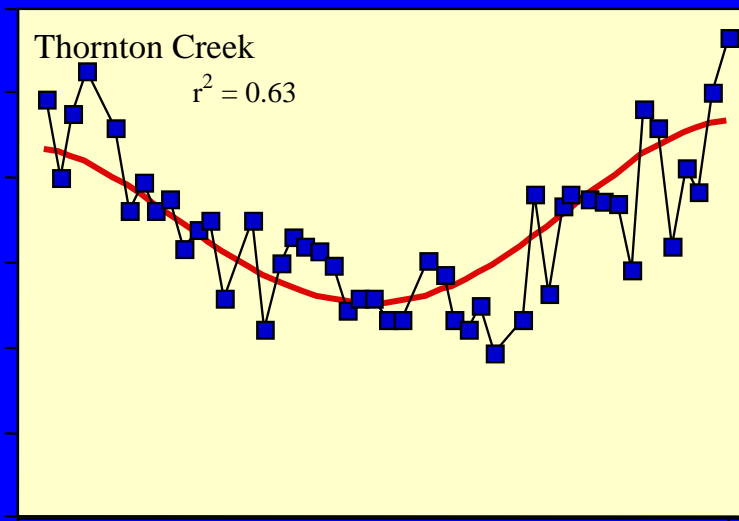
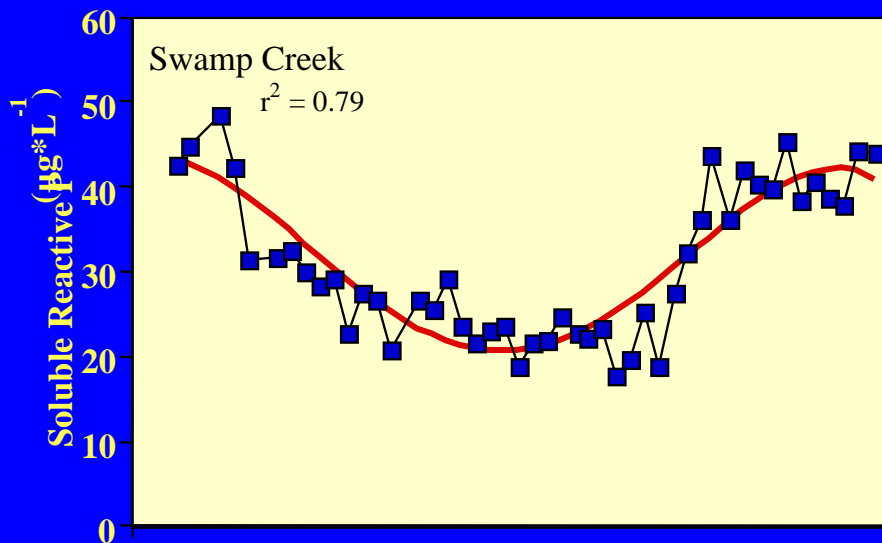
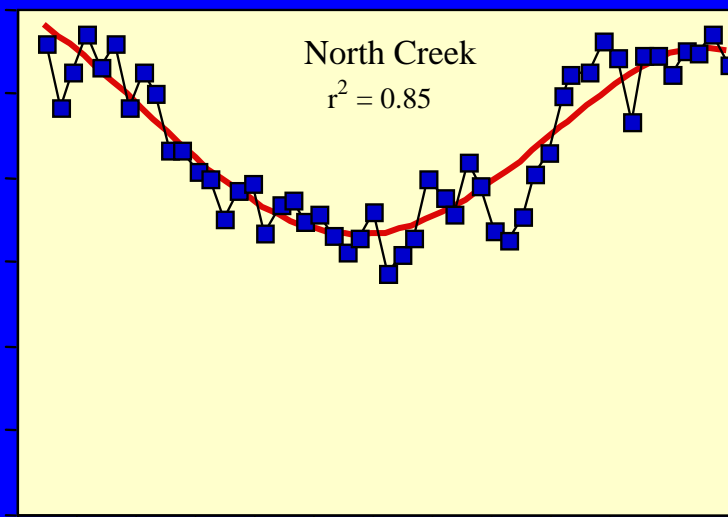
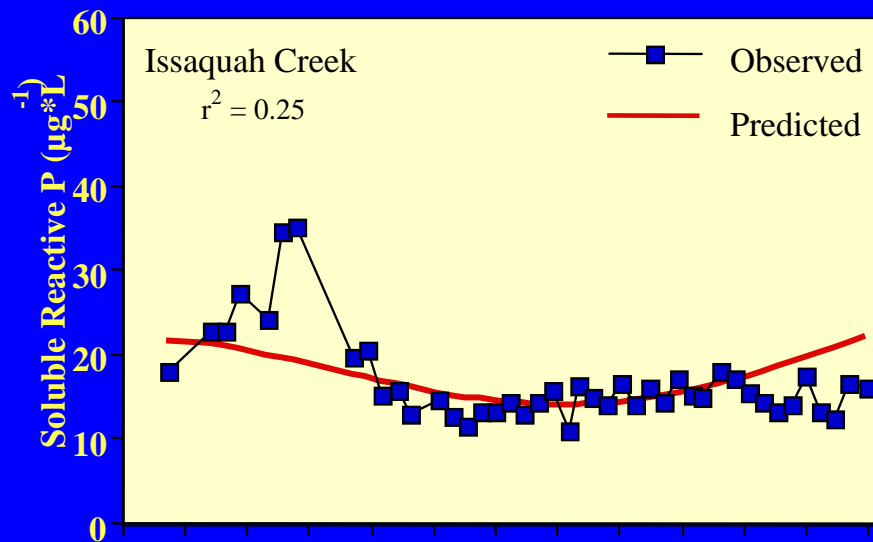
Overall TP varied by
 $\pm 50\%$ from week to week



SRP varied by $\pm 20\%$
from week to week

SRP was on average 48% of TP

Soluble reactive phosphorus times series



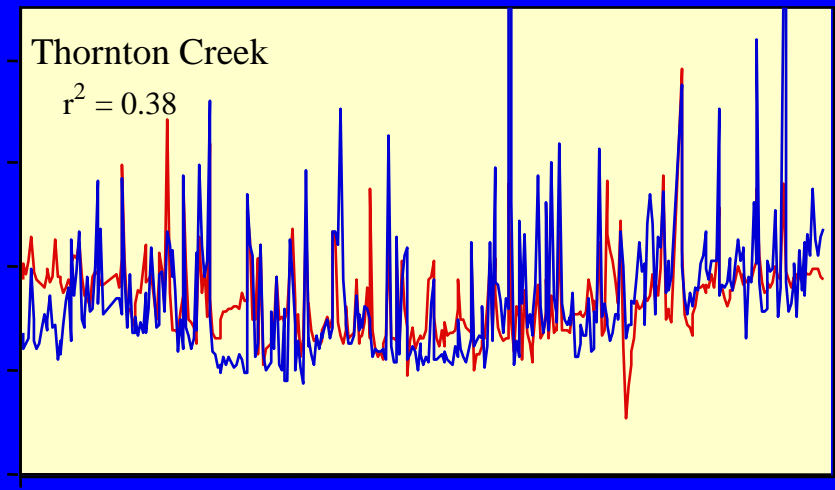
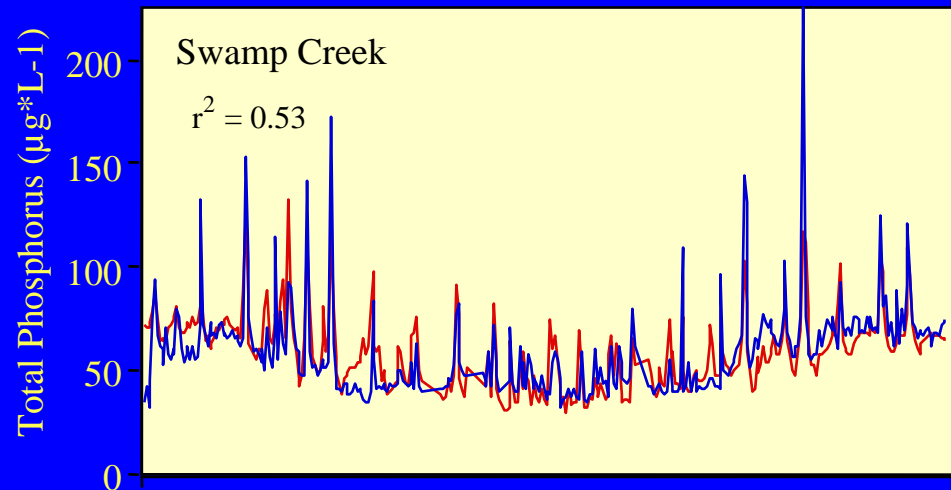
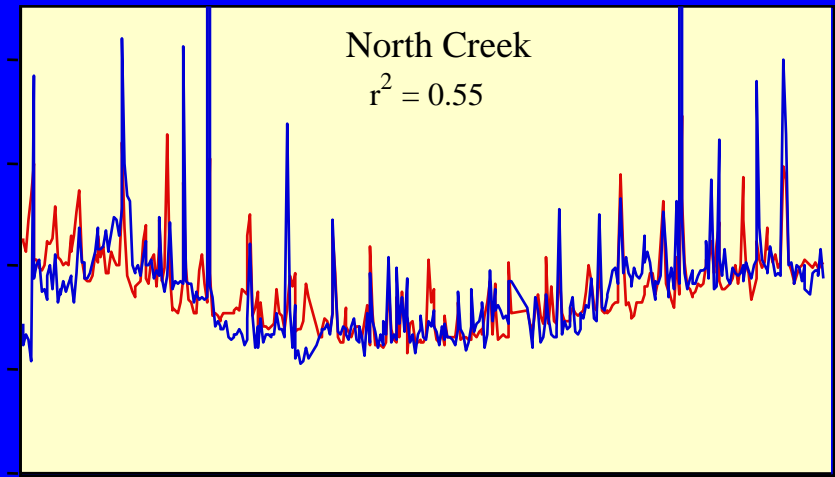
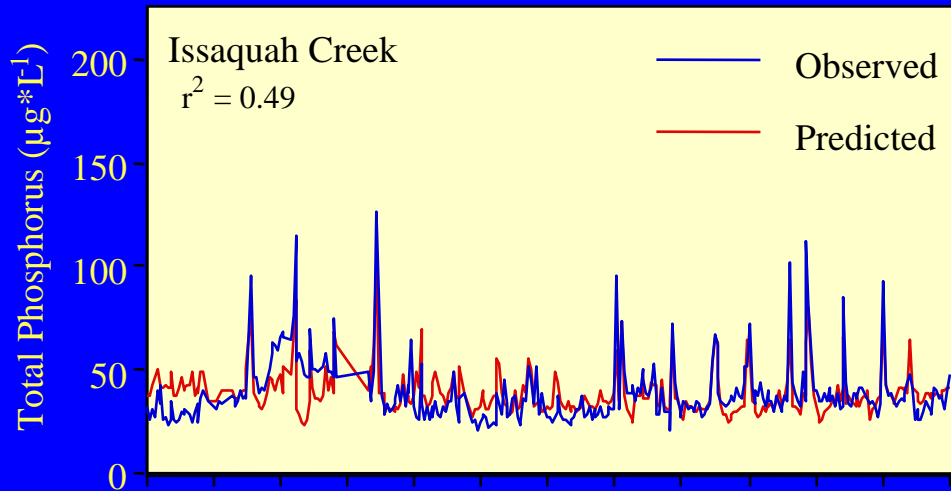
A S O N D J F M A M J J A

2001/2000

A S O N D J F M A M J J A

2001/2000

Total phosphorus times series



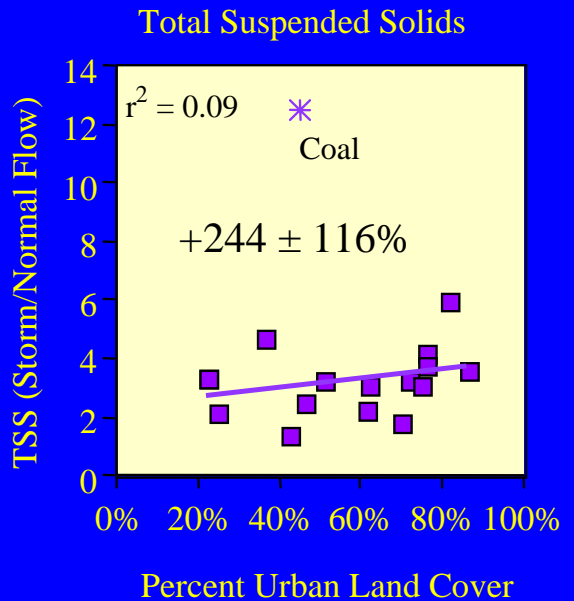
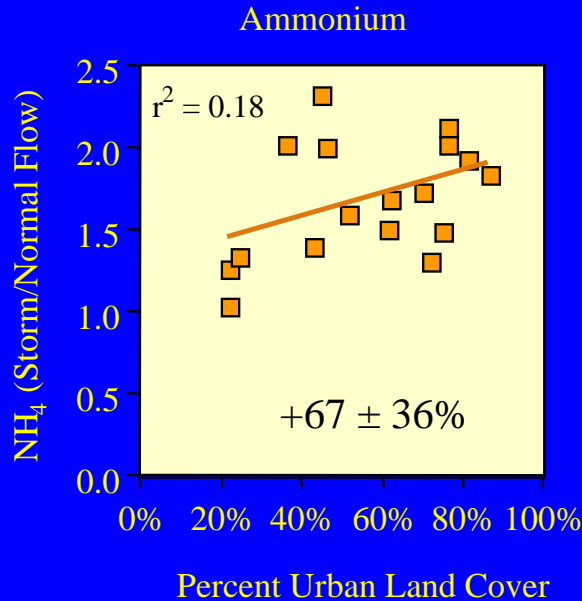
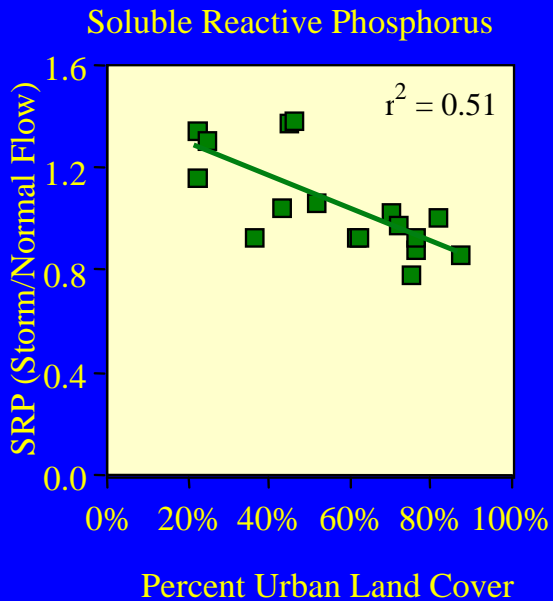
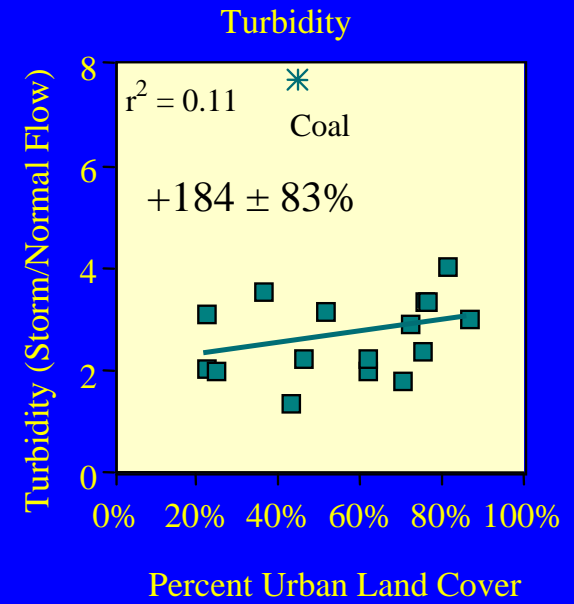
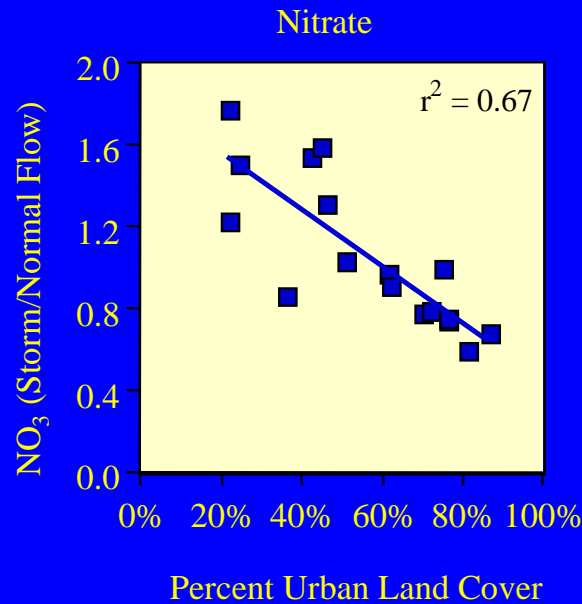
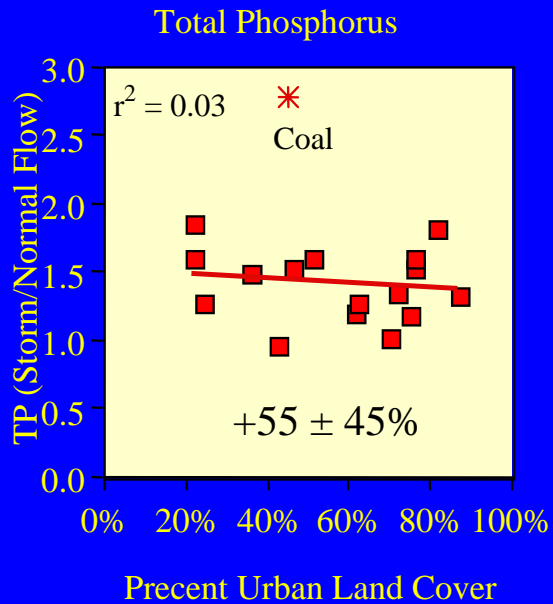
A S O N D J F M A M J J A
2001/2000

A S O N D J F M A M J J A
2001/2000

A photograph of a stream flowing over several large, smooth, grey rocks. The water is dark and turbulent, creating white foam and splashes as it moves downstream. The background is filled with dense, vibrant green foliage, including tall grasses and various shrubs, suggesting a forest or a well-wooded area. The overall scene is natural and serene.

**Phosphorus transport during
storm events over a range of land
use conditions**

Change in Concentration: Storm/Normal Flow



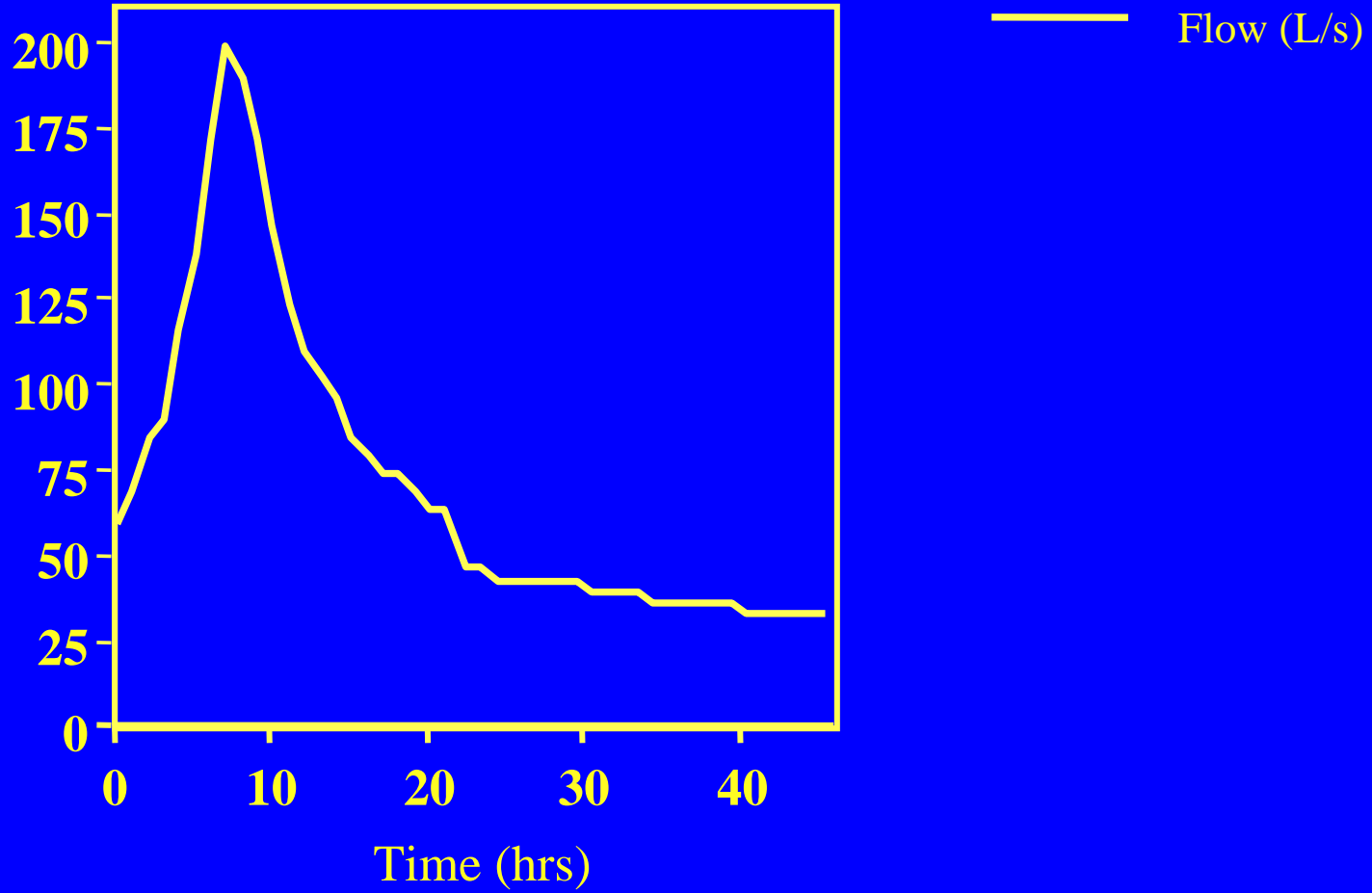
Study sites

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

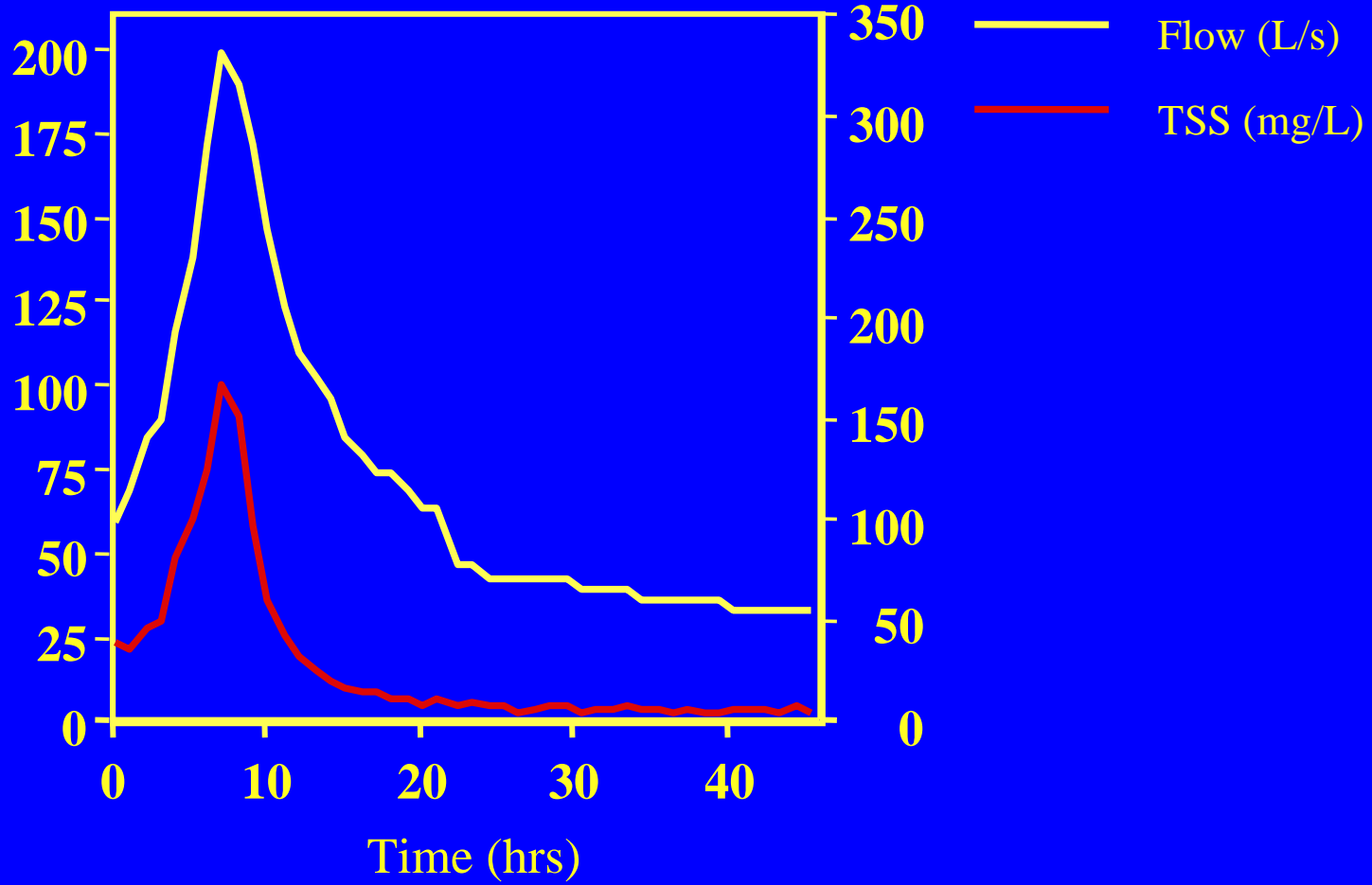


- All sampling sites were within Green-Duwamish River watershed

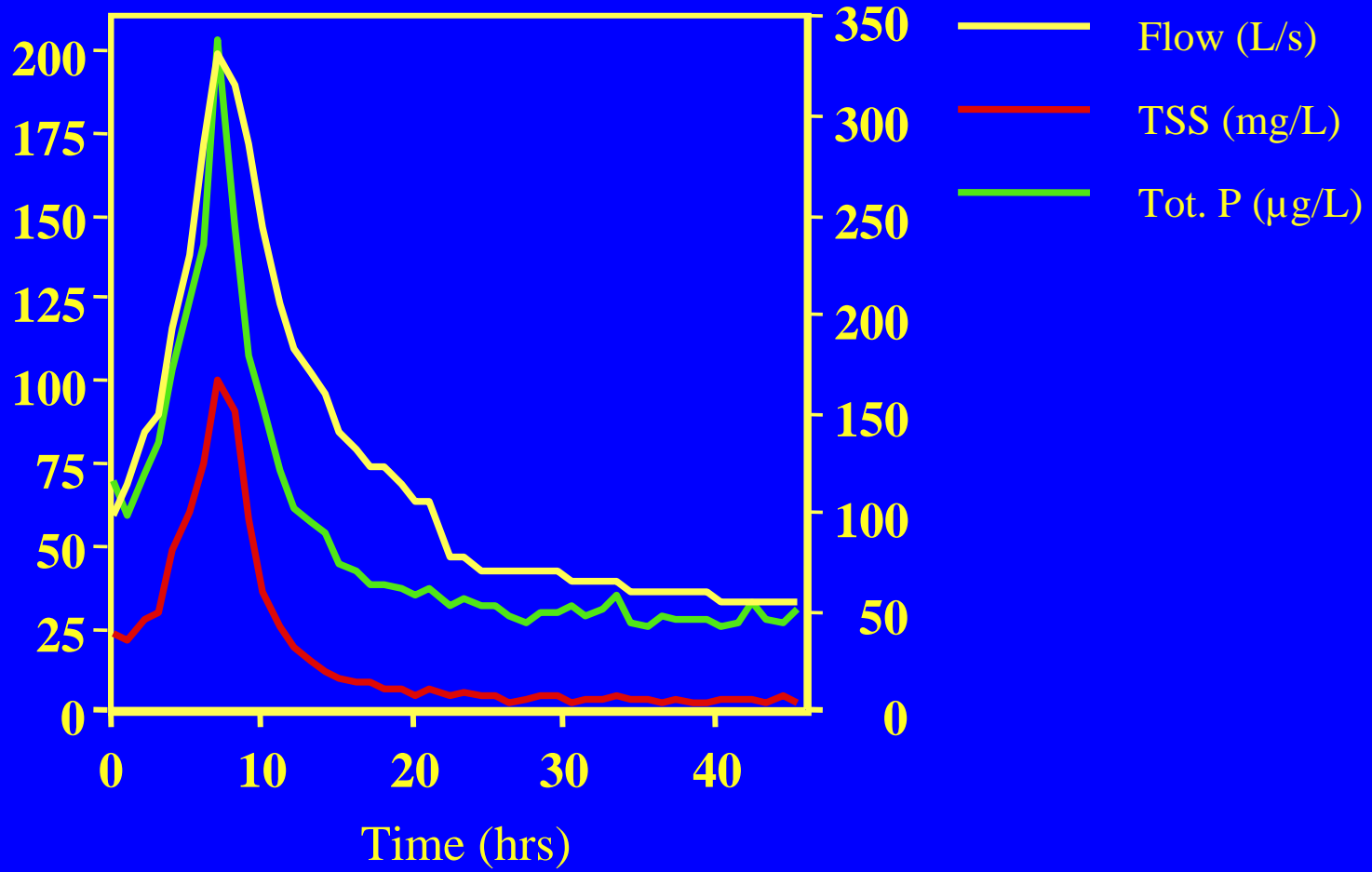
Forested Stream



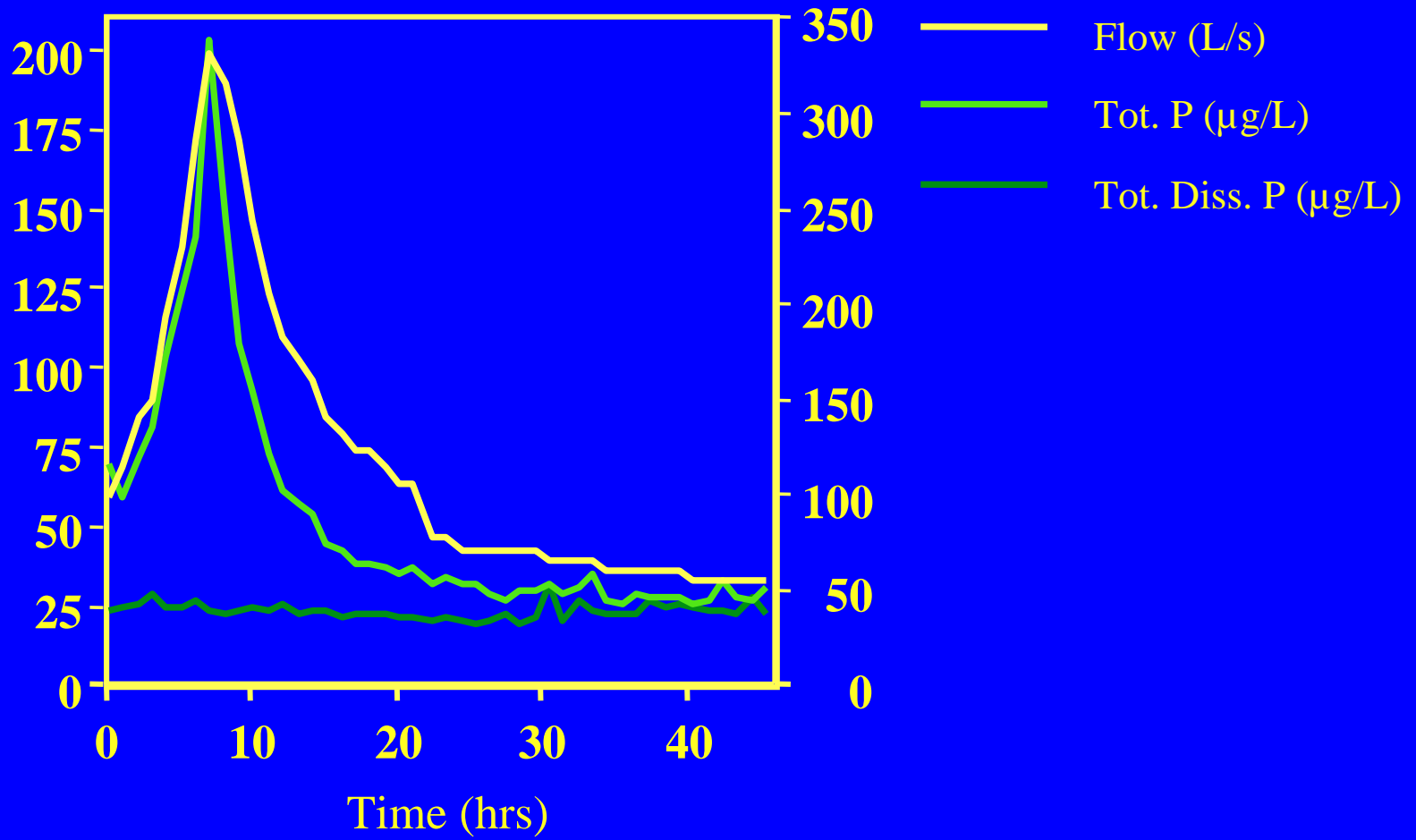
Forested Stream



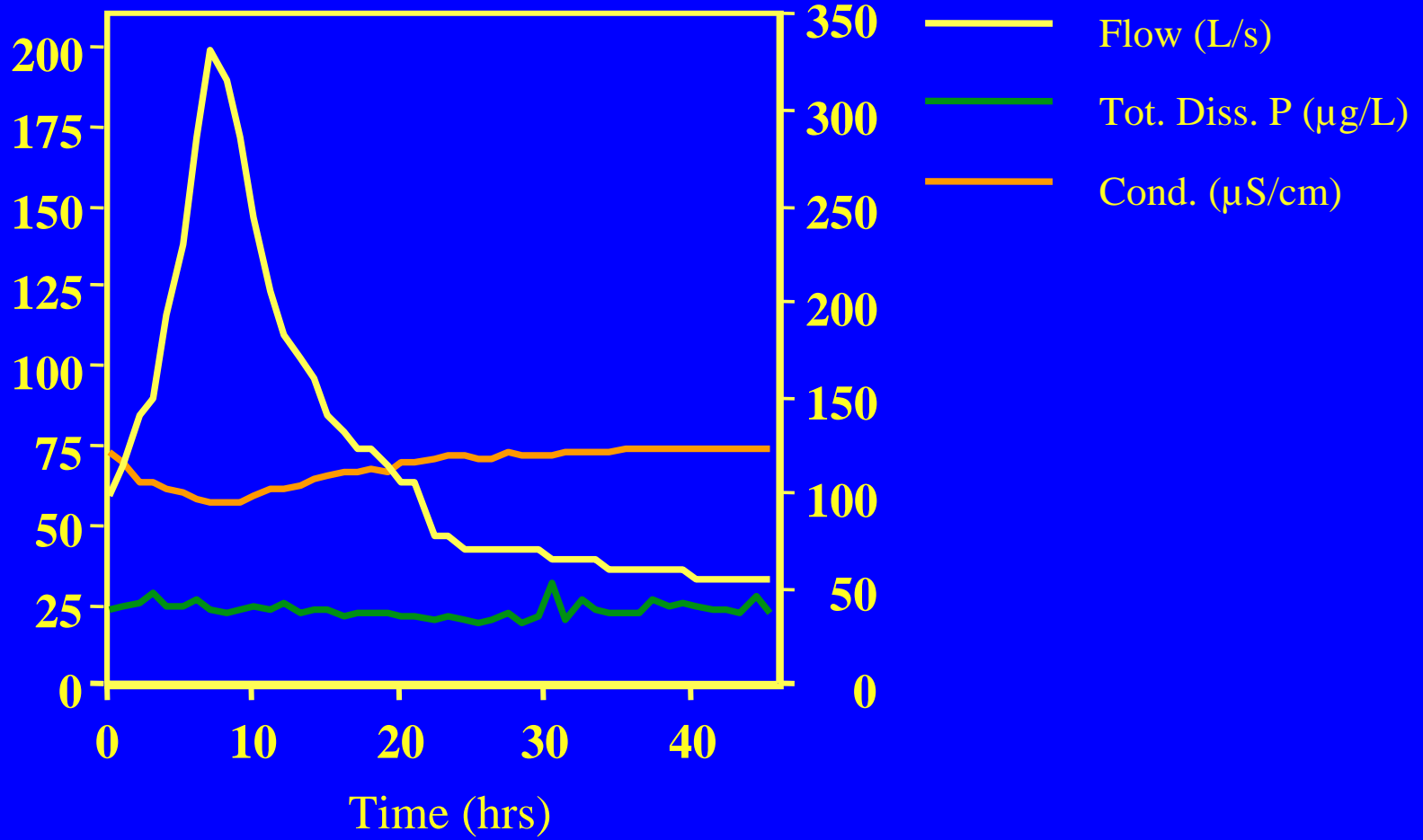
Forested Stream



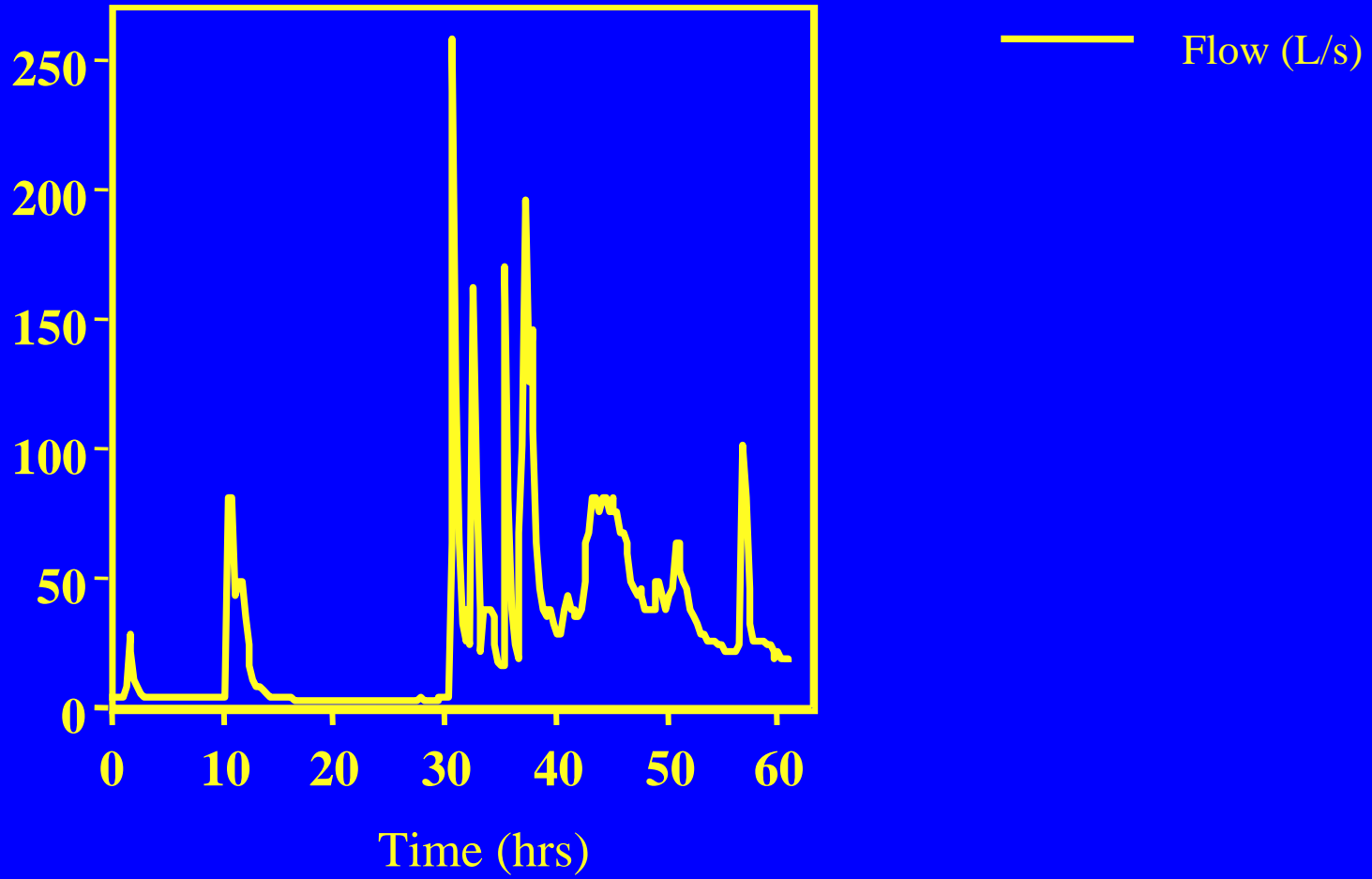
Forested Stream



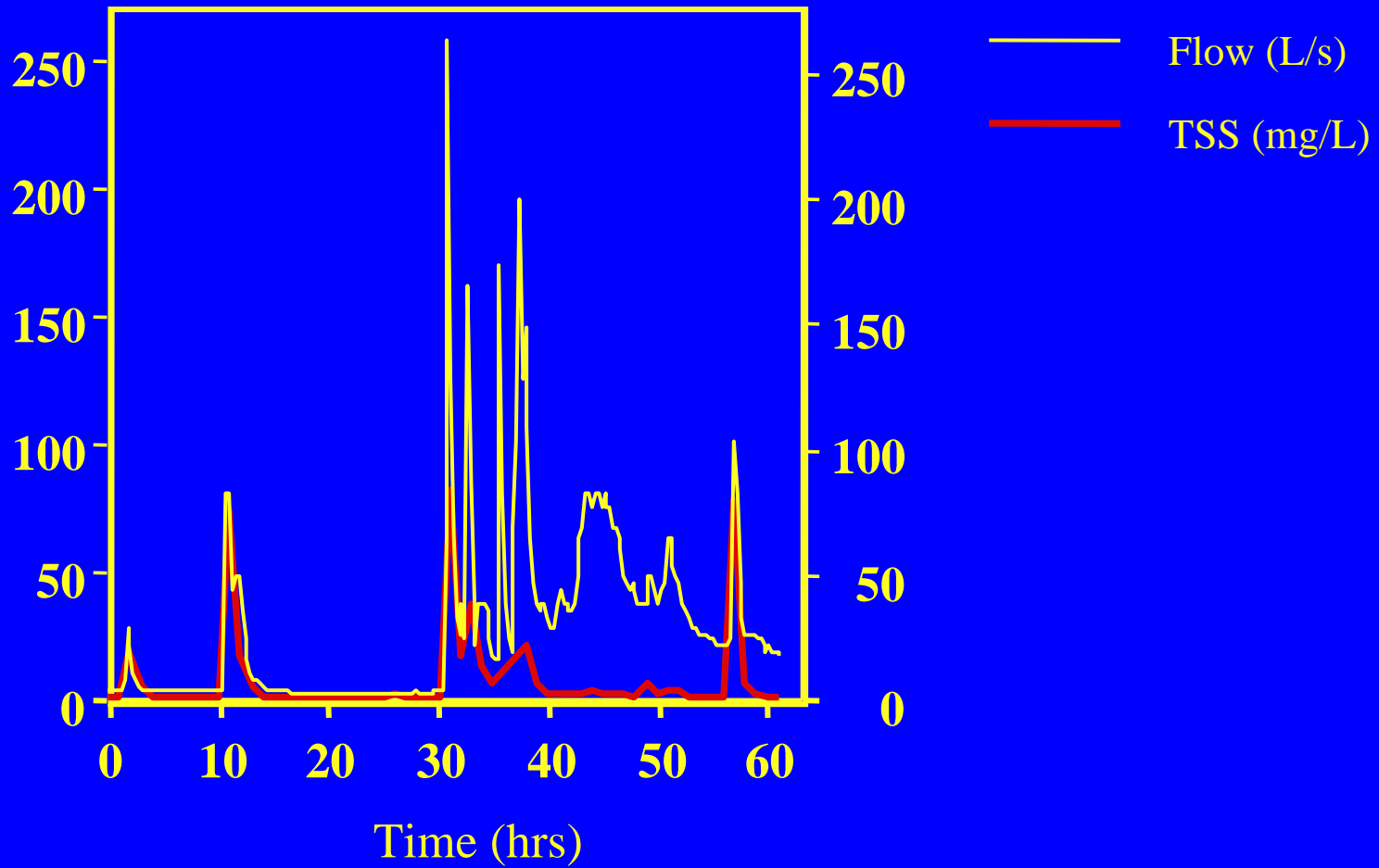
Forested Stream



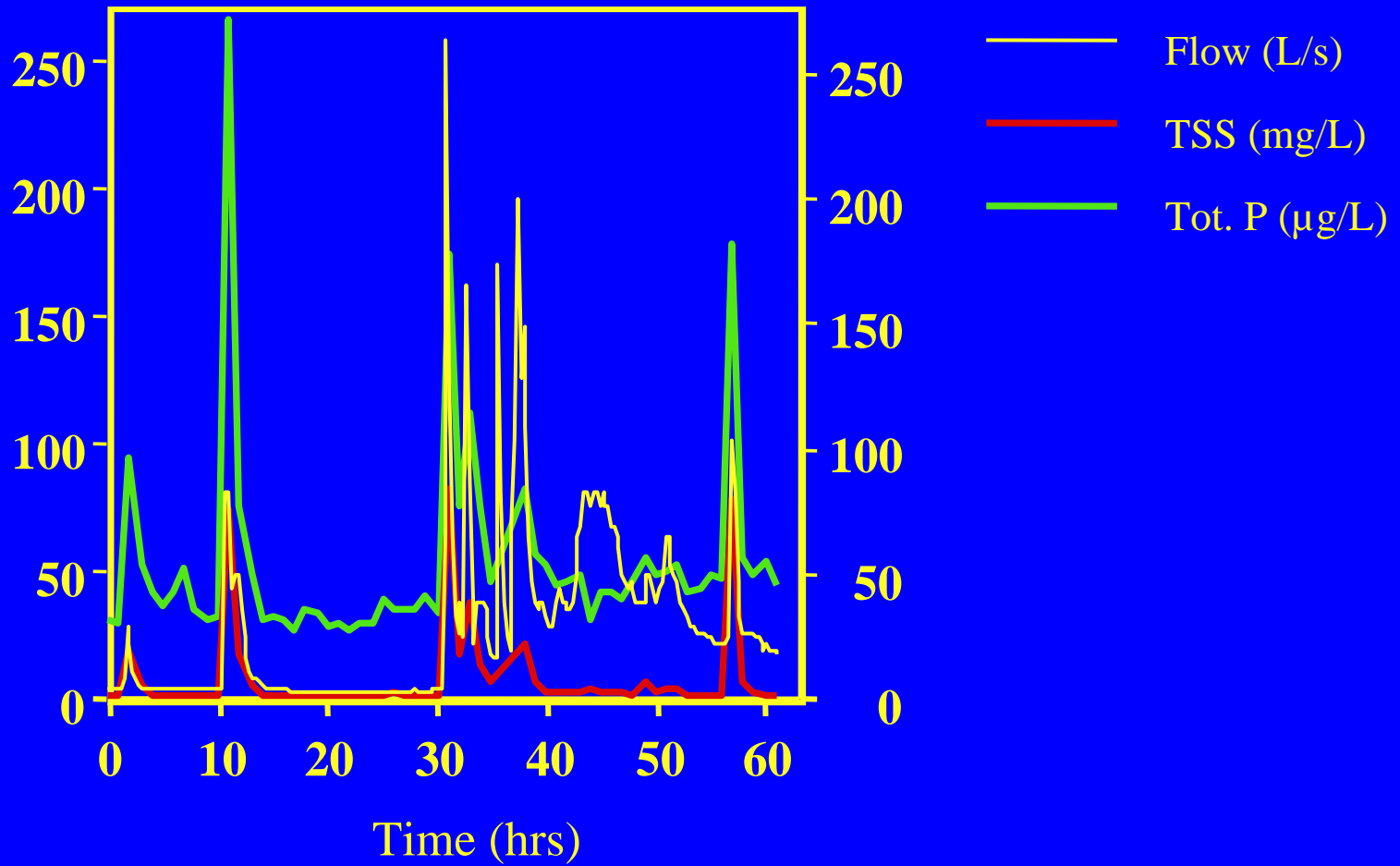
Urban Stream



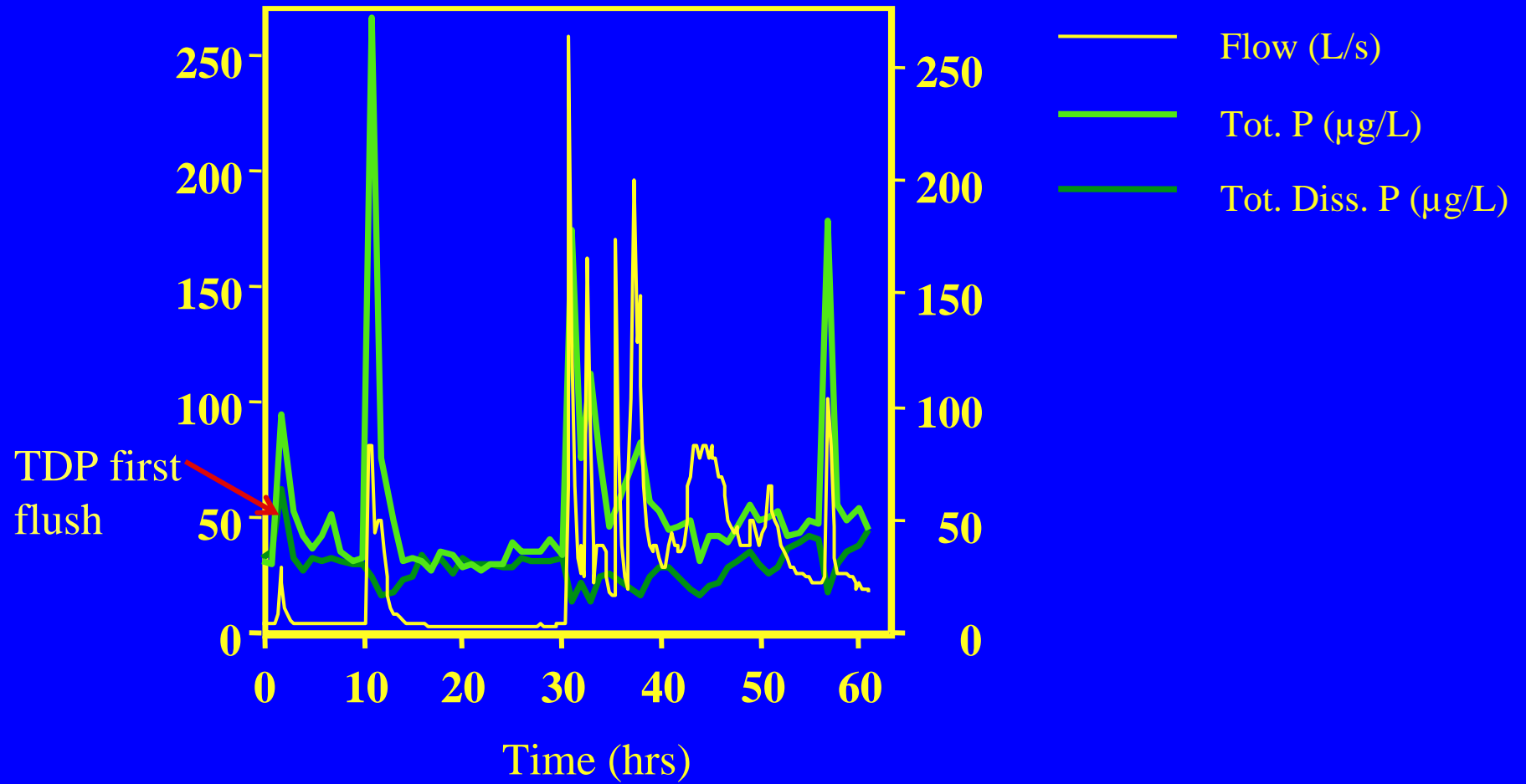
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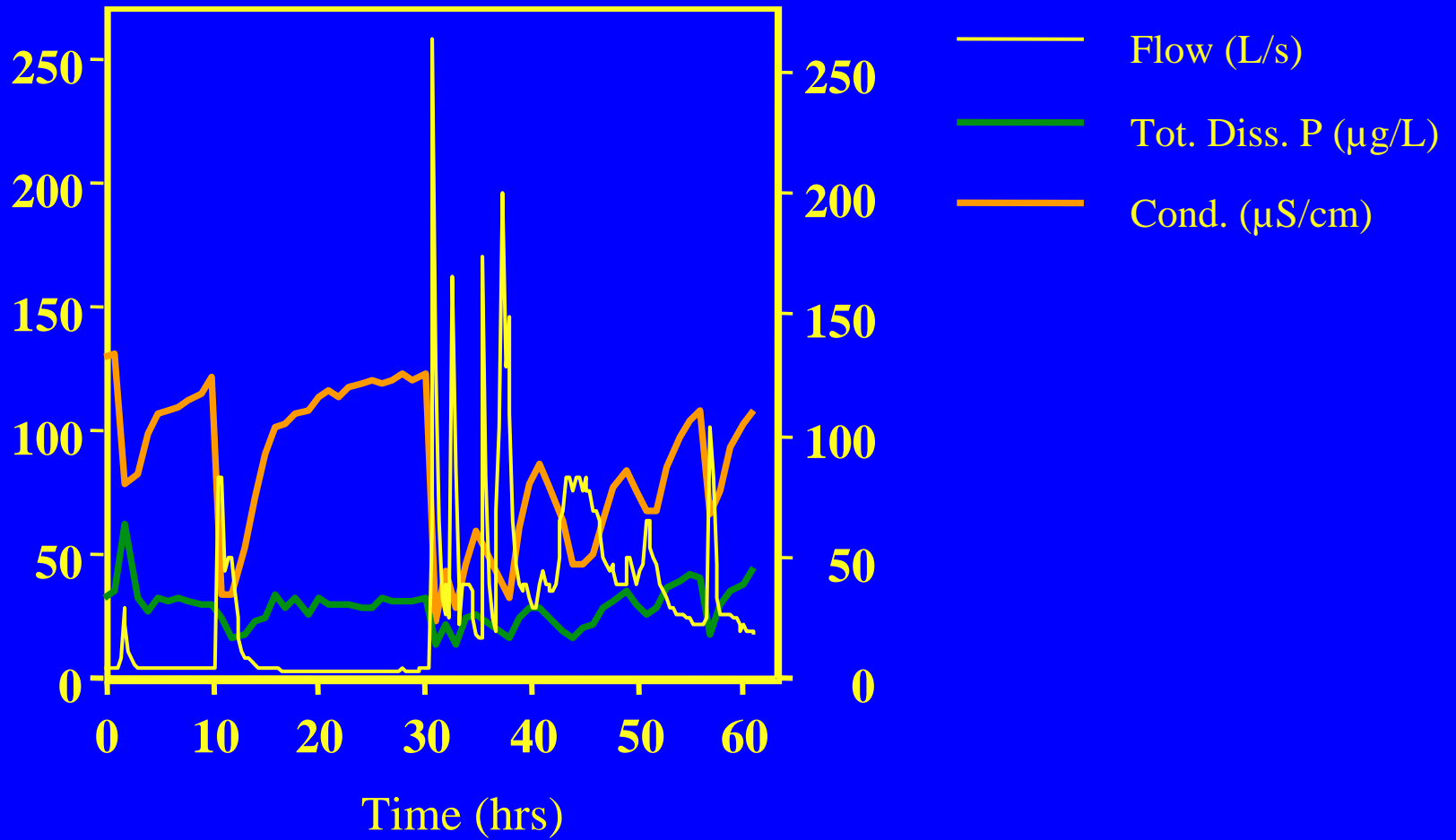
Urban Stream



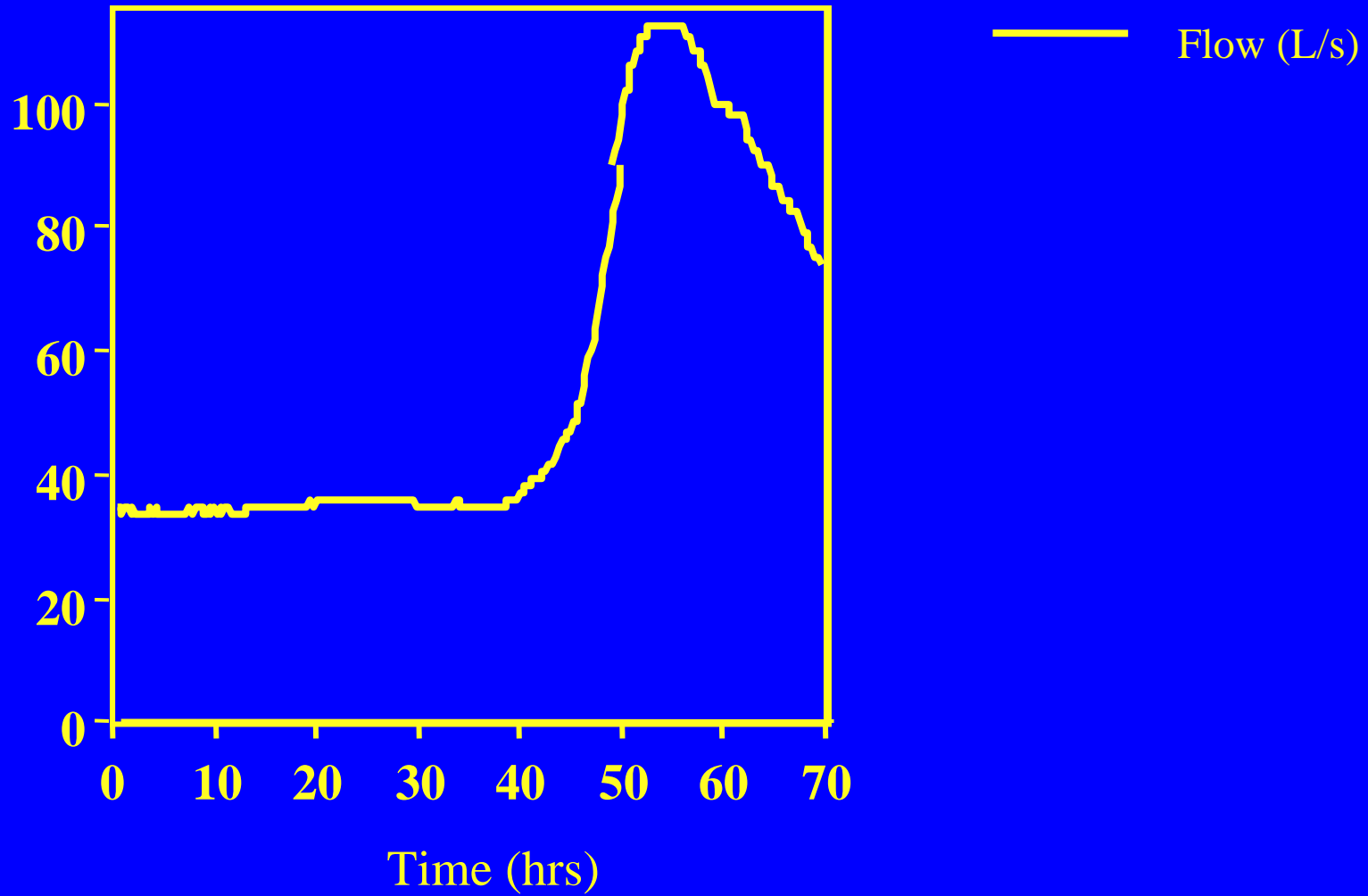
Urban Stream



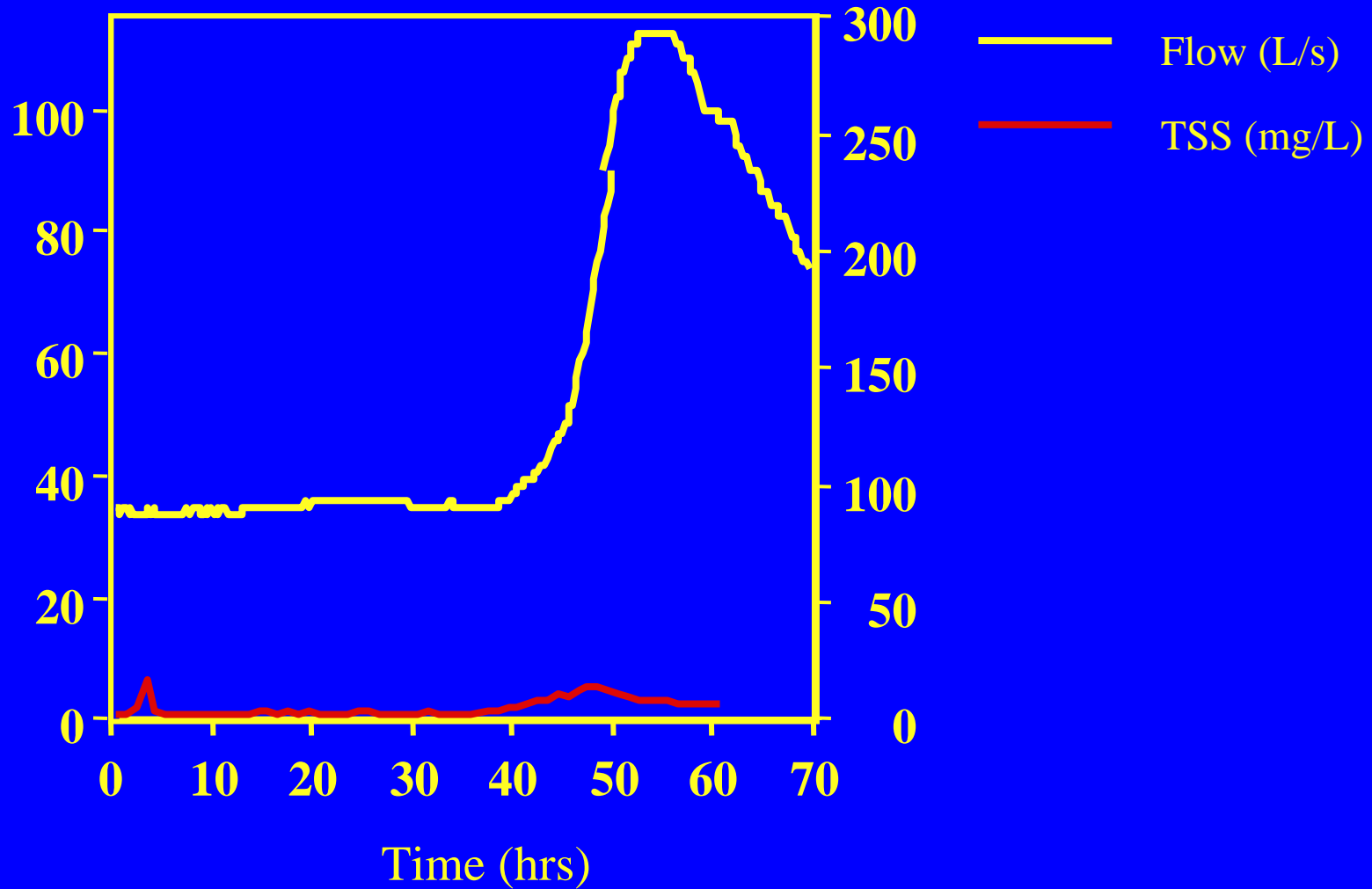
Urban Stream



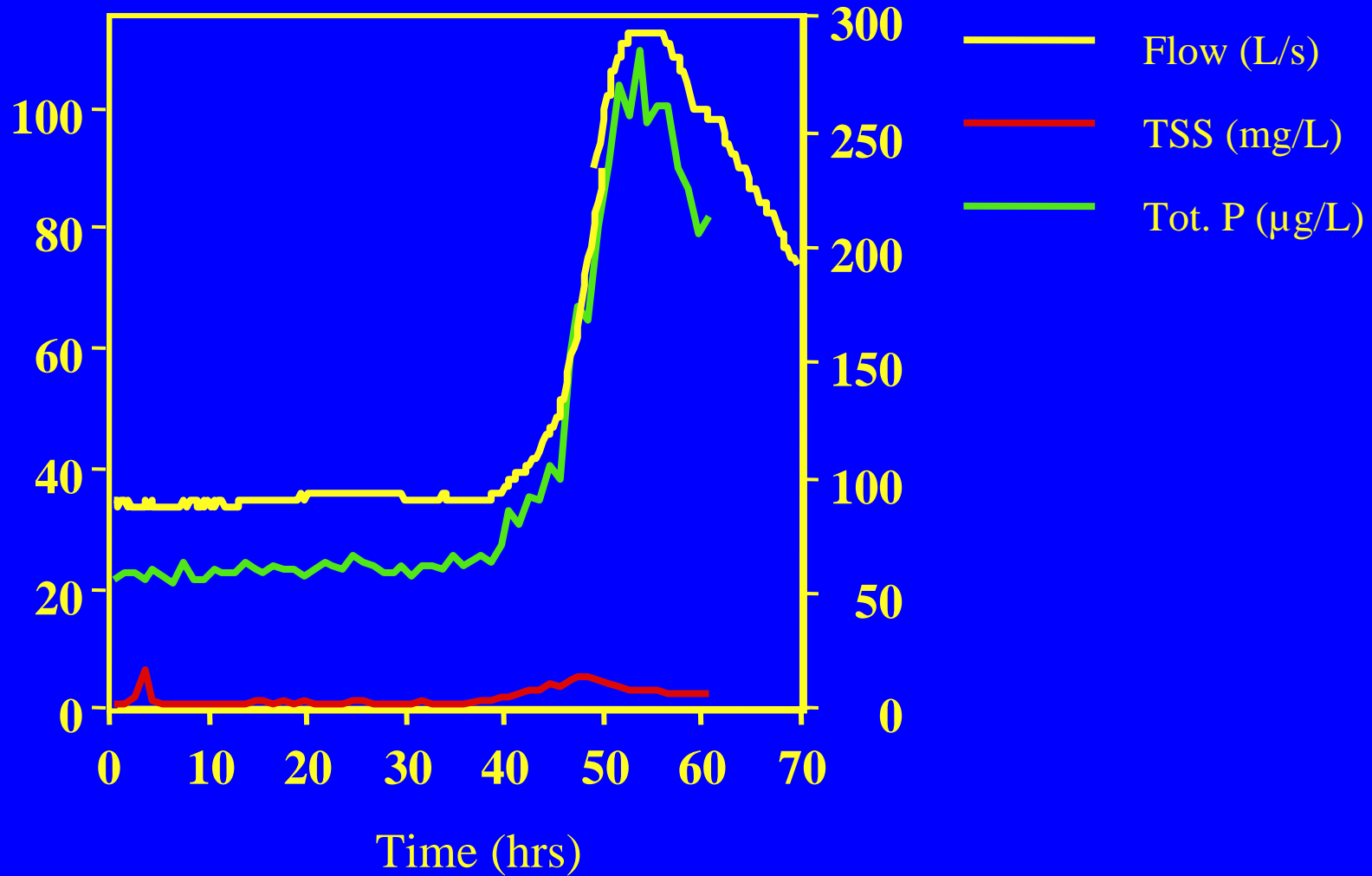
Agricultural Stream



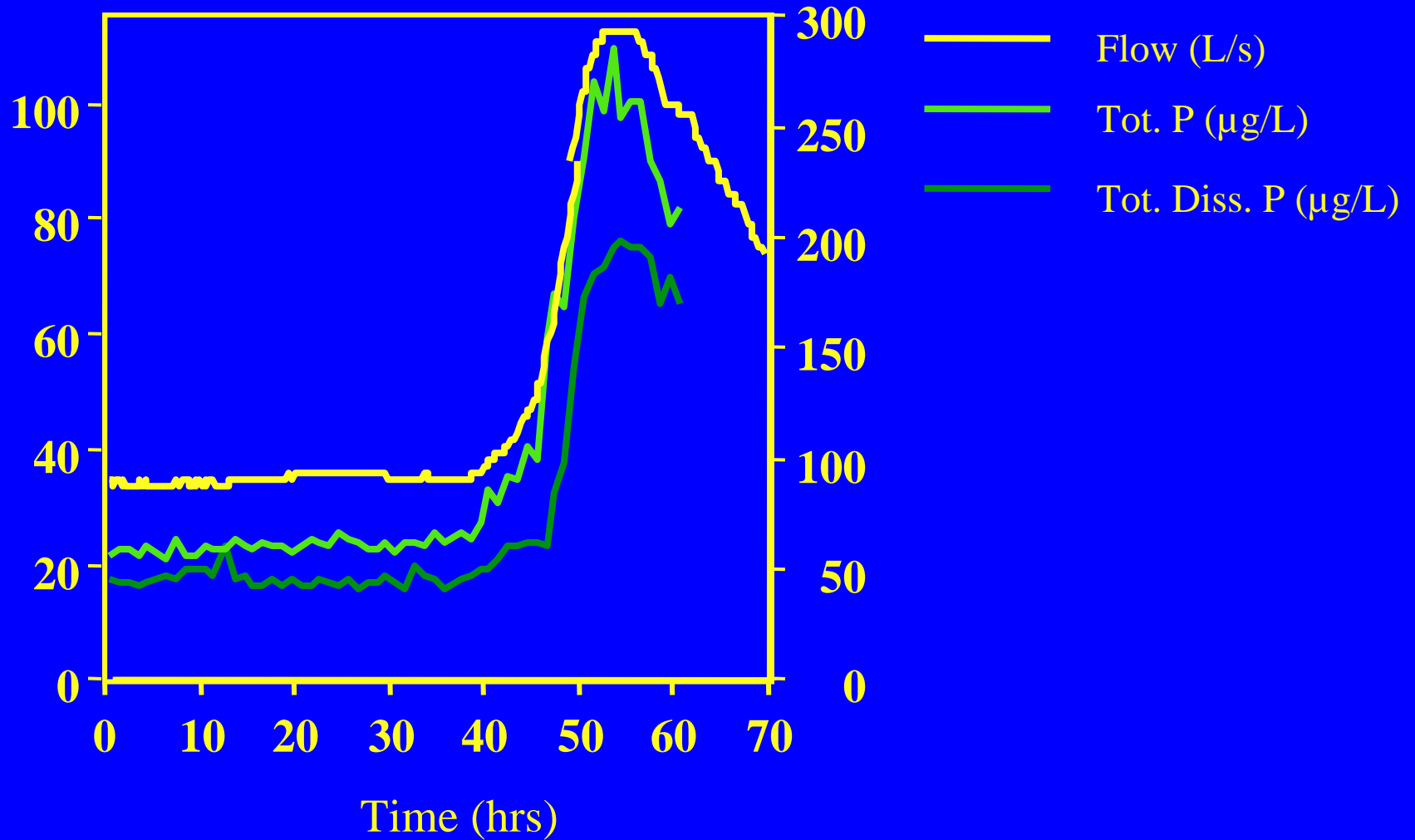
Agricultural Stream



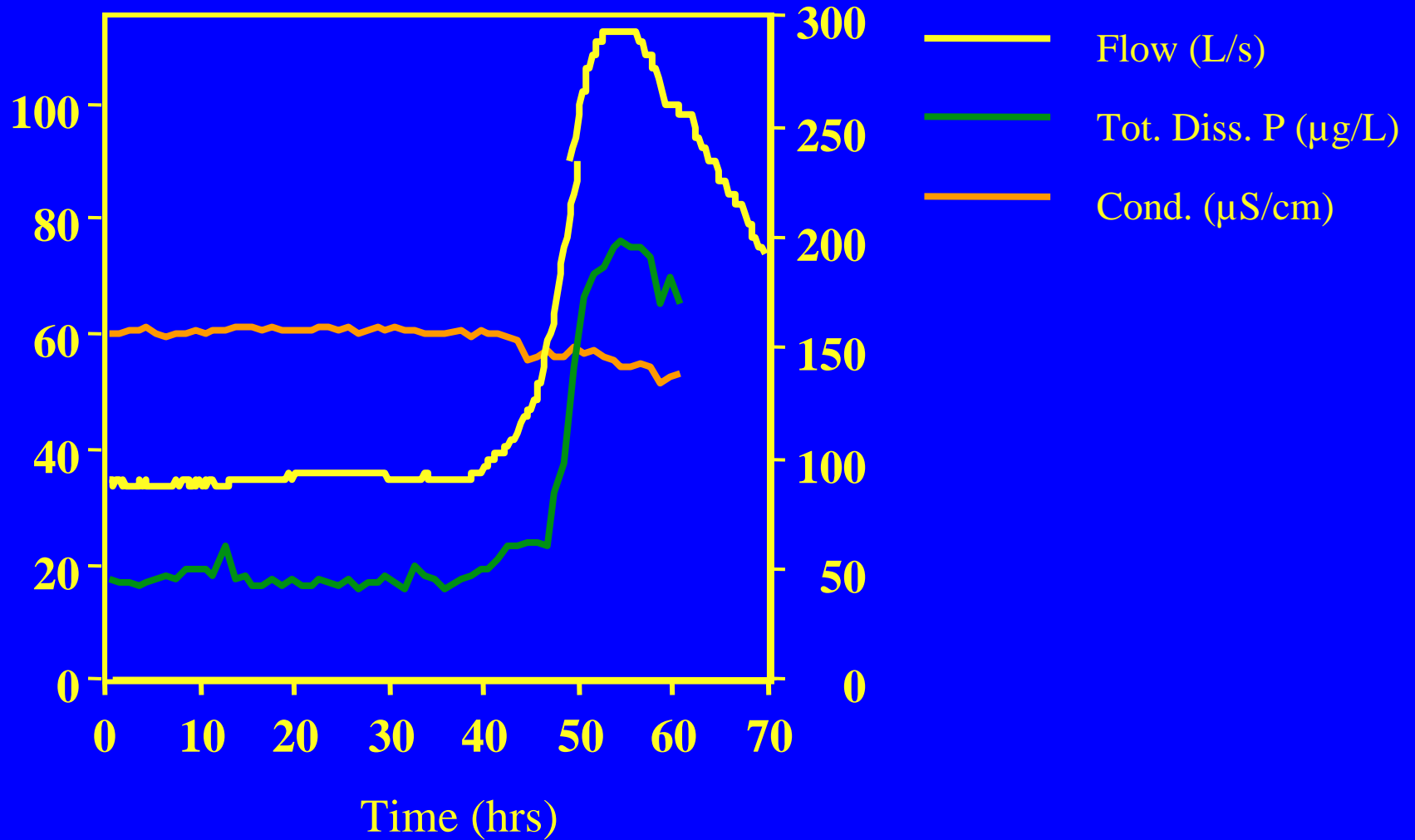
Agricultural Stream



Agricultural Stream



Agricultural Stream



Sampling Matrix



Two Flow States:

Baseflow

Storm

Four Land Types:

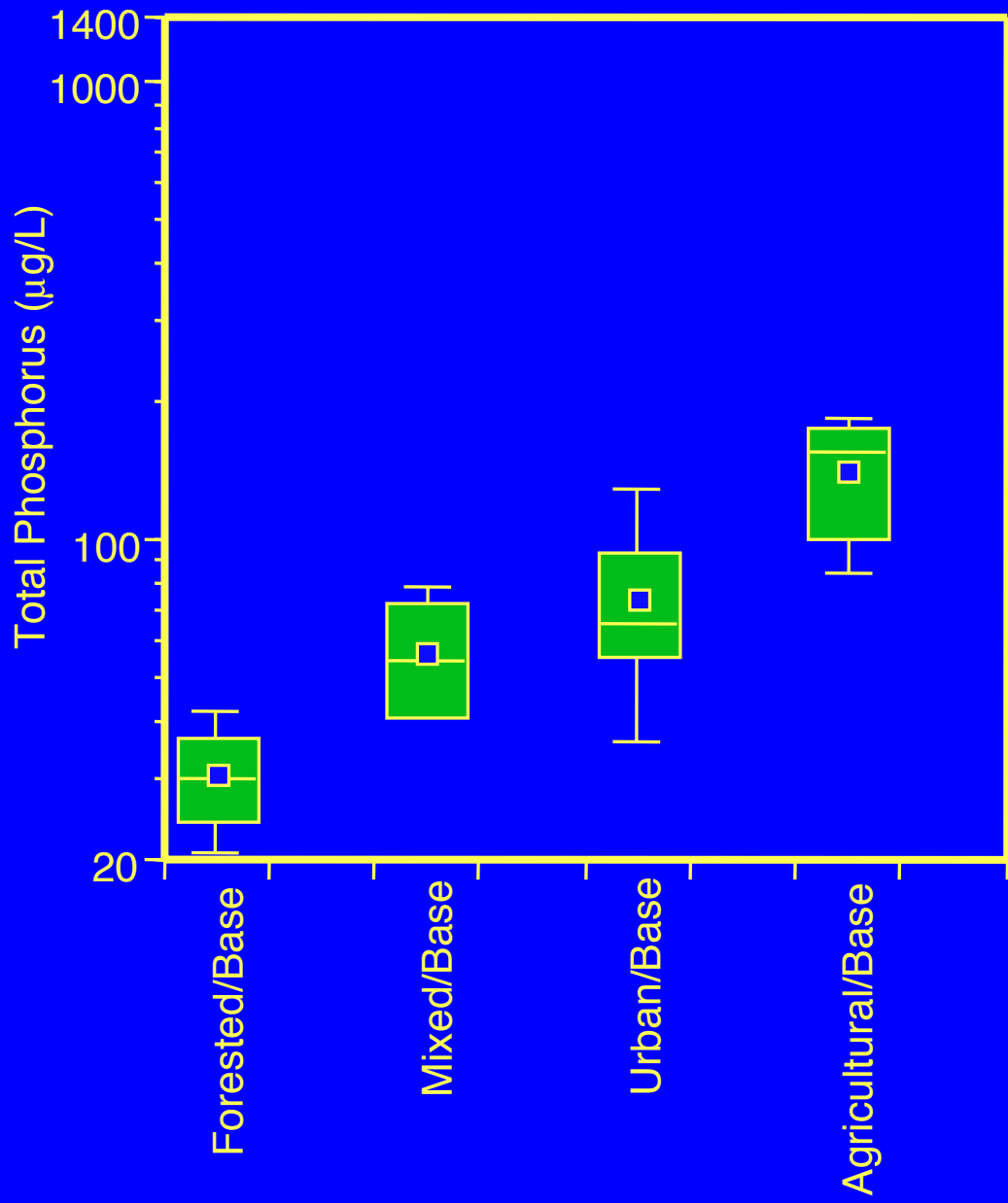
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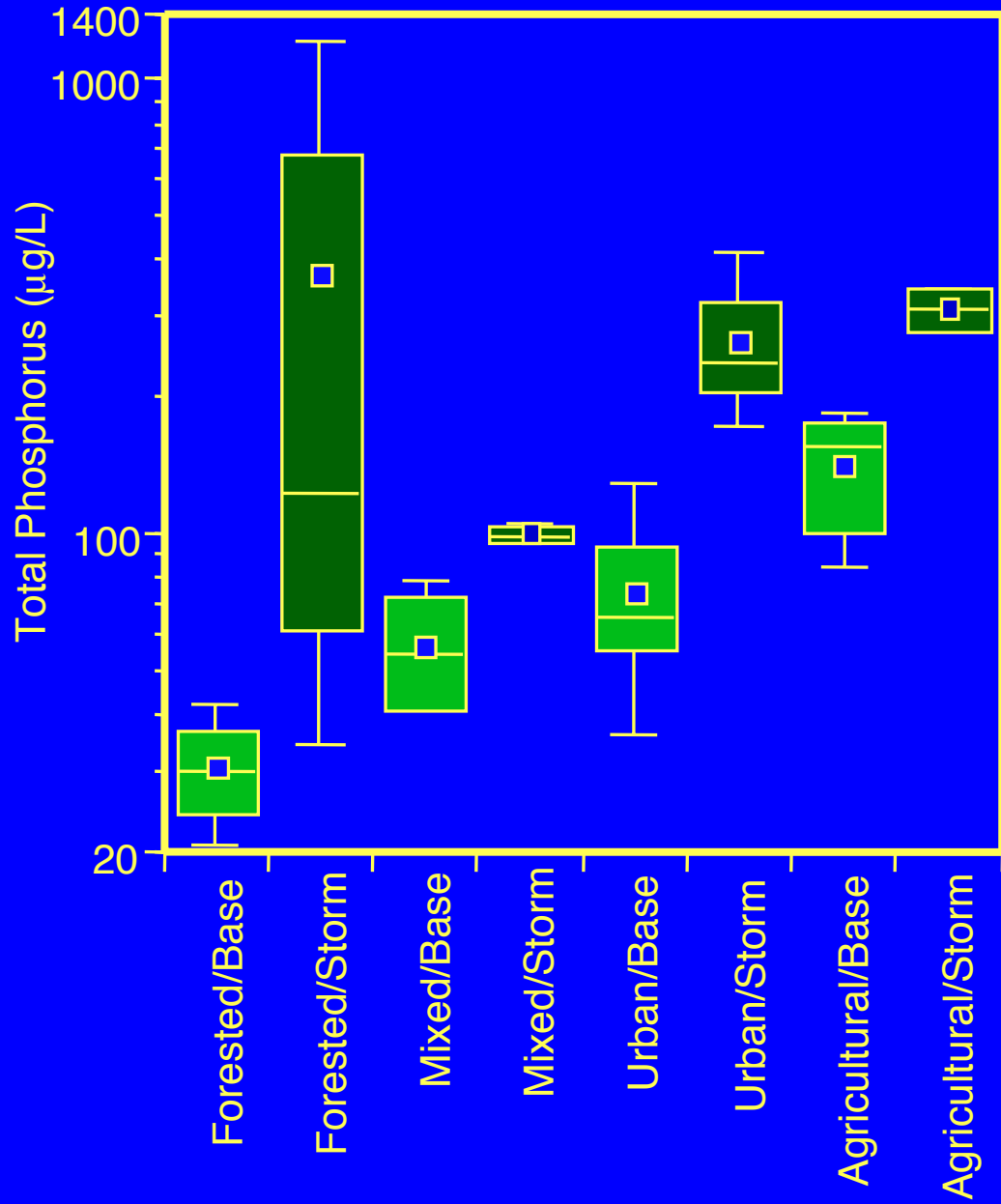
Urban

Agricultural

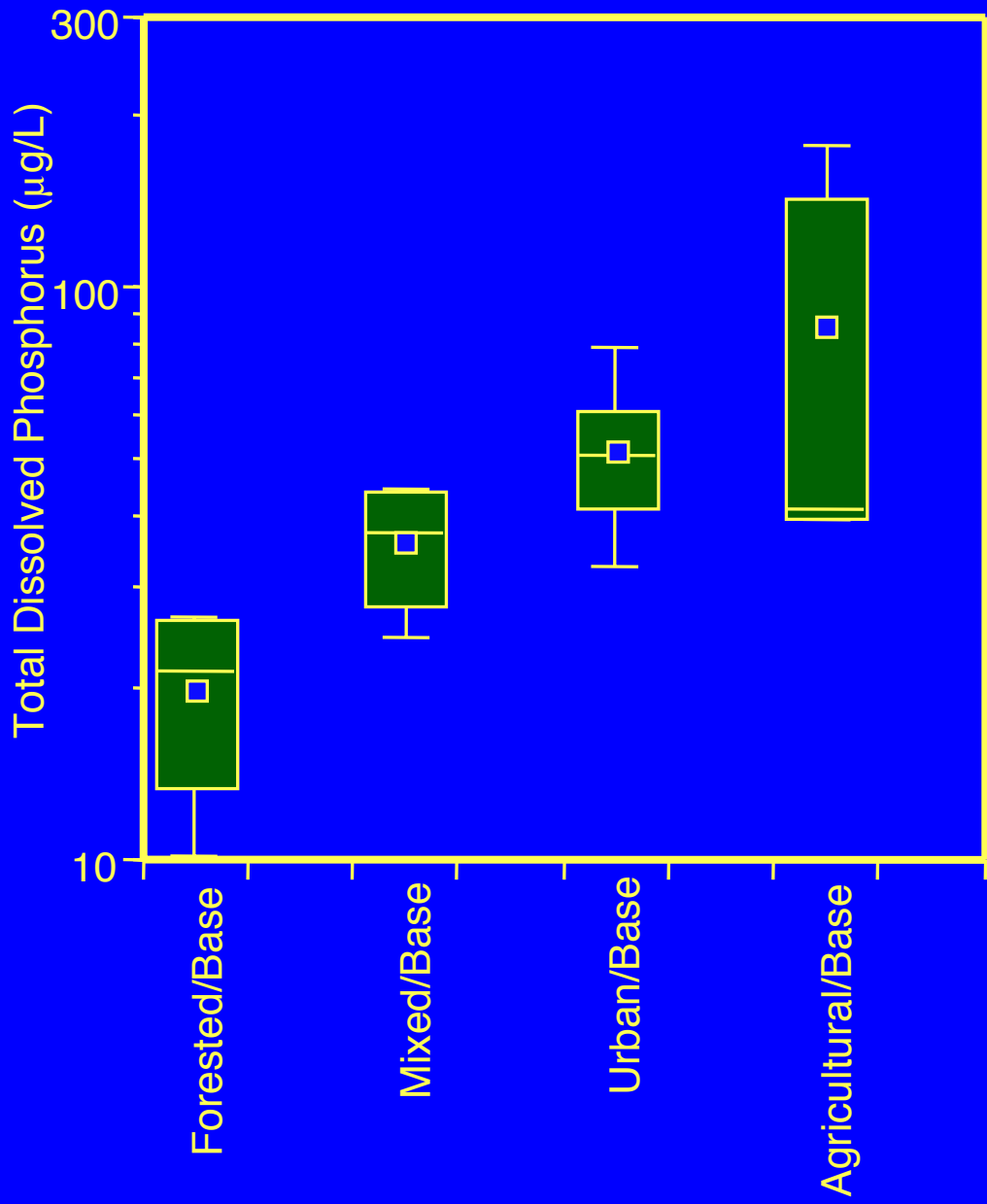
Mixed

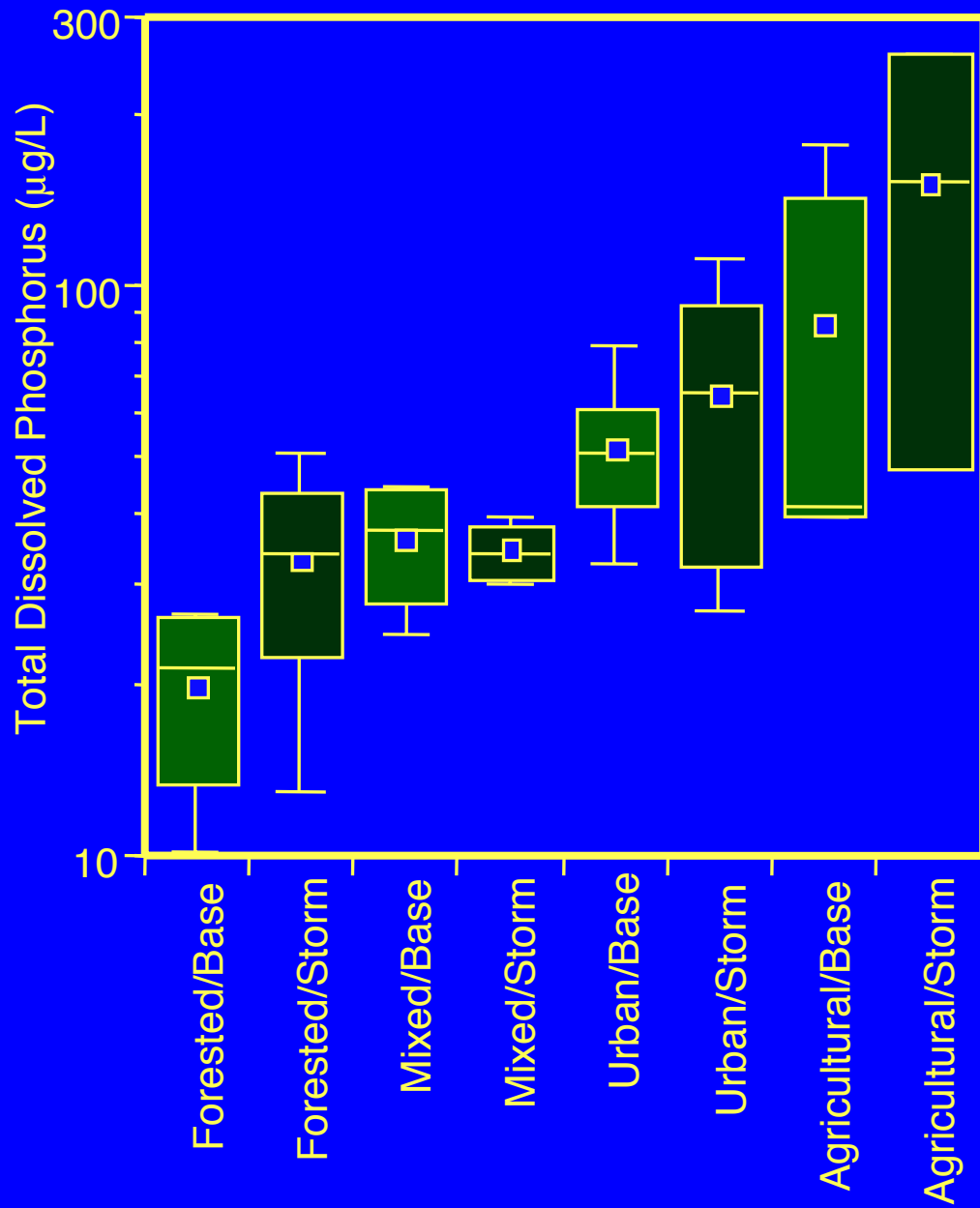
- Collected one of each flow state per site
- Sampled 3-5 streams per land type



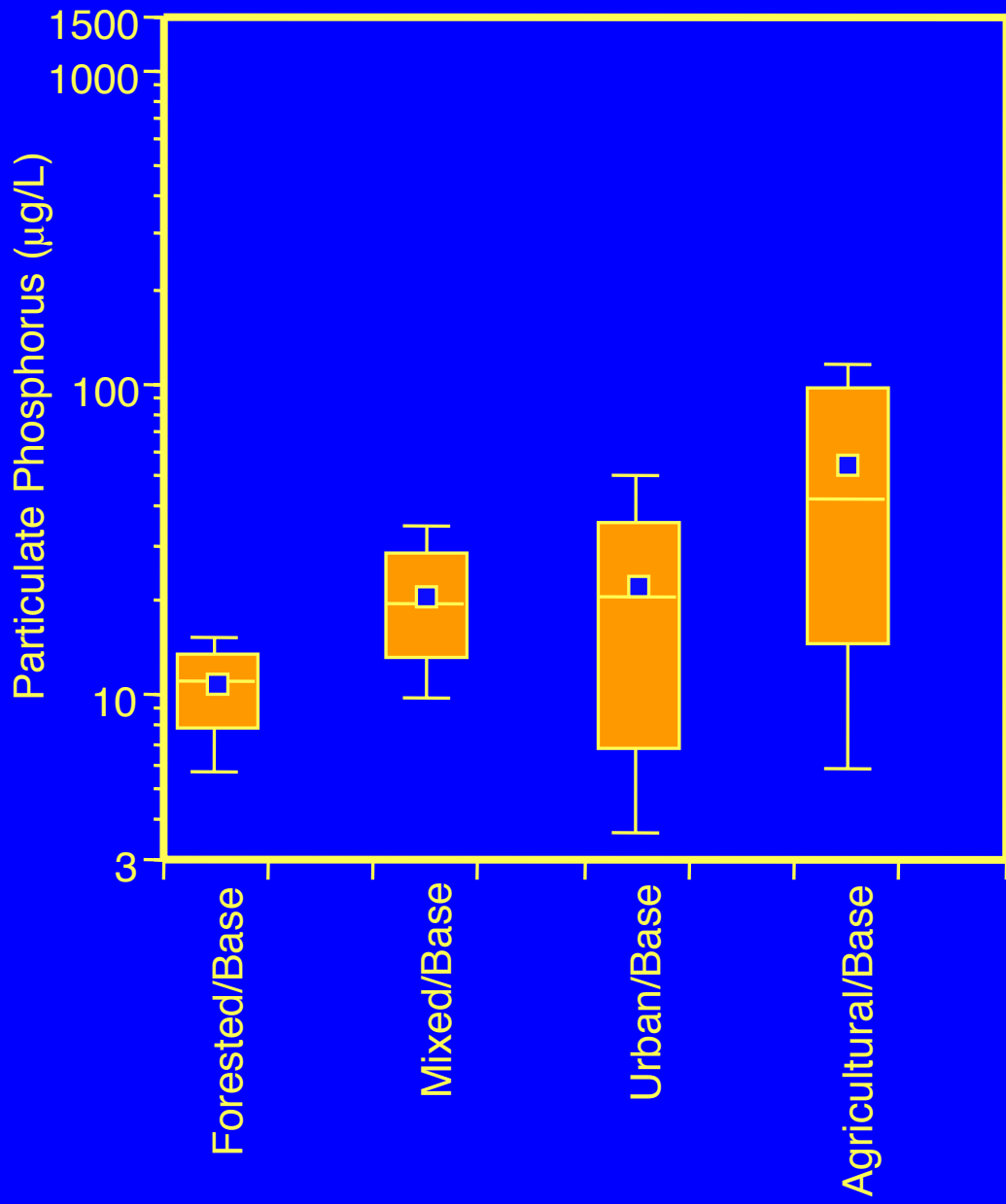


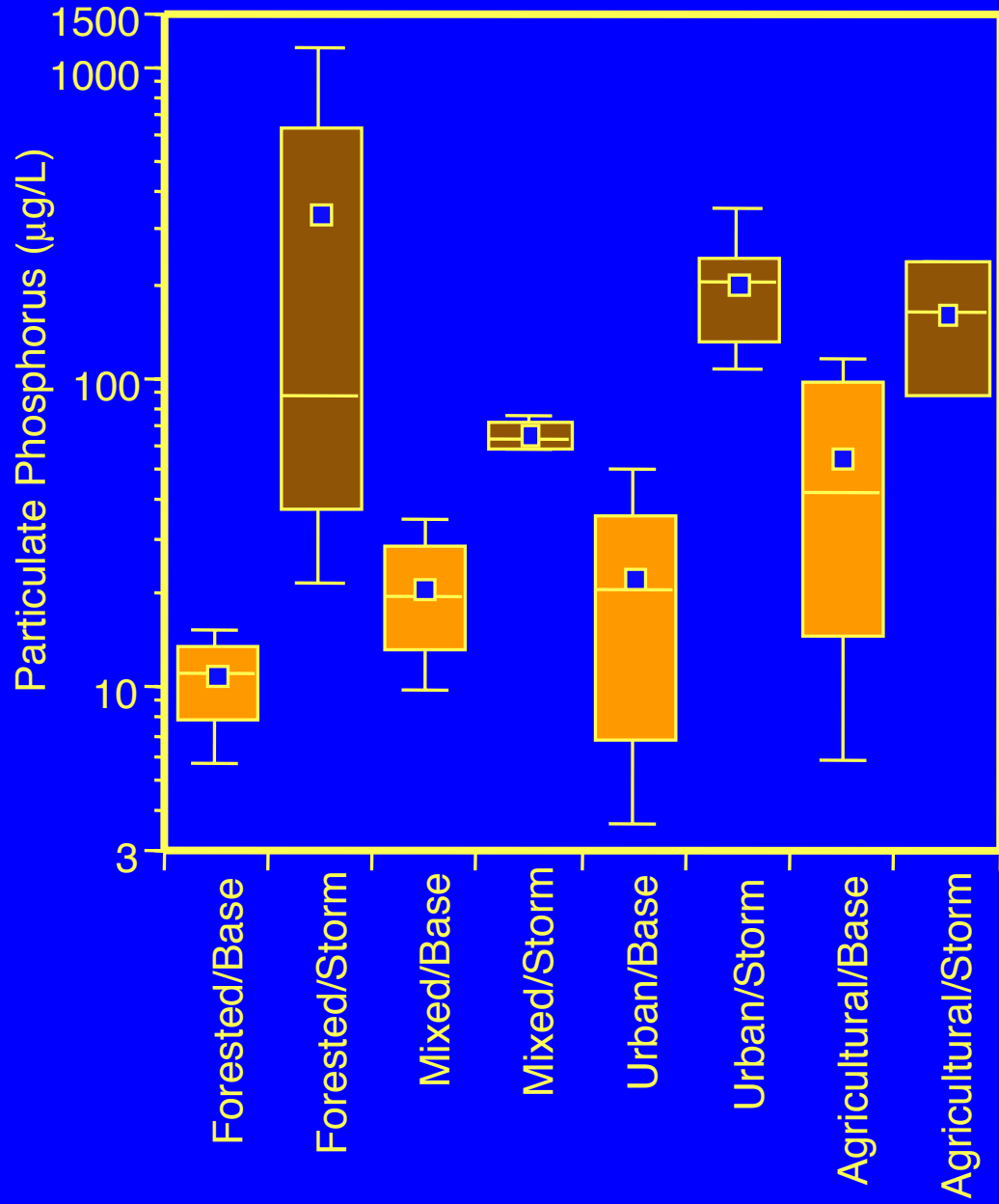
Average increase
of $200 \pm 182\%$
during storms



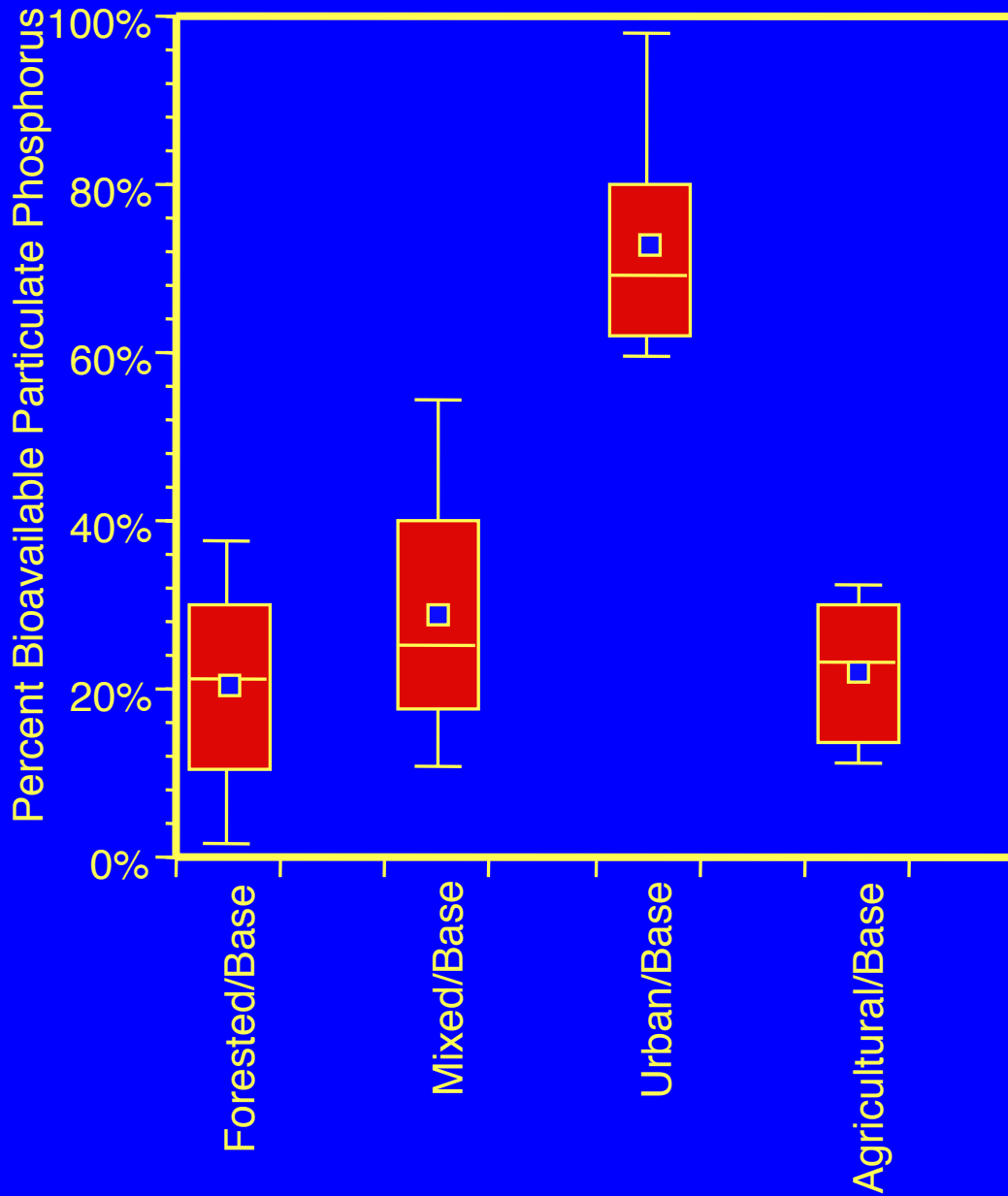


Average increase
of $24 \pm 26\%$
during storms

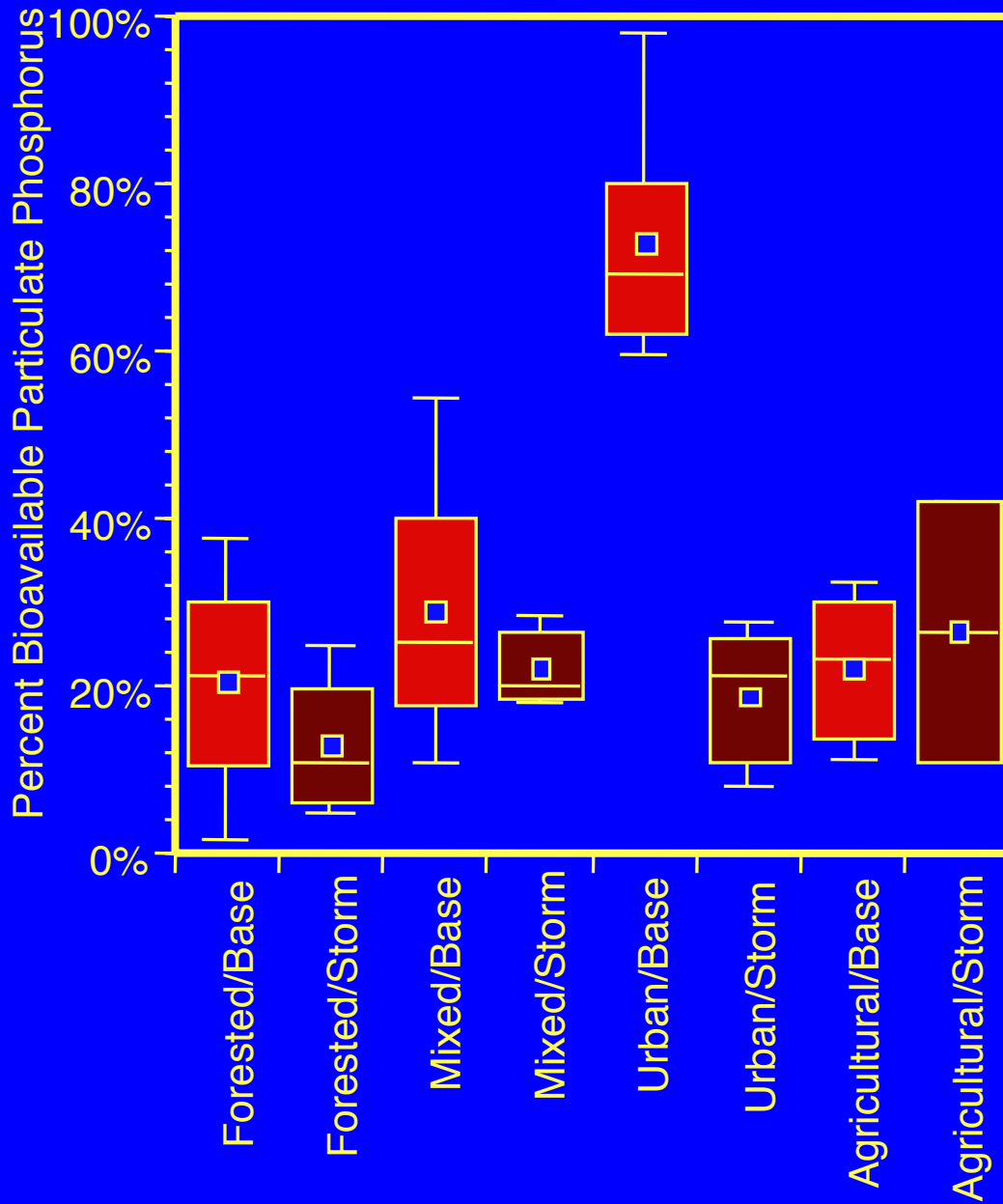




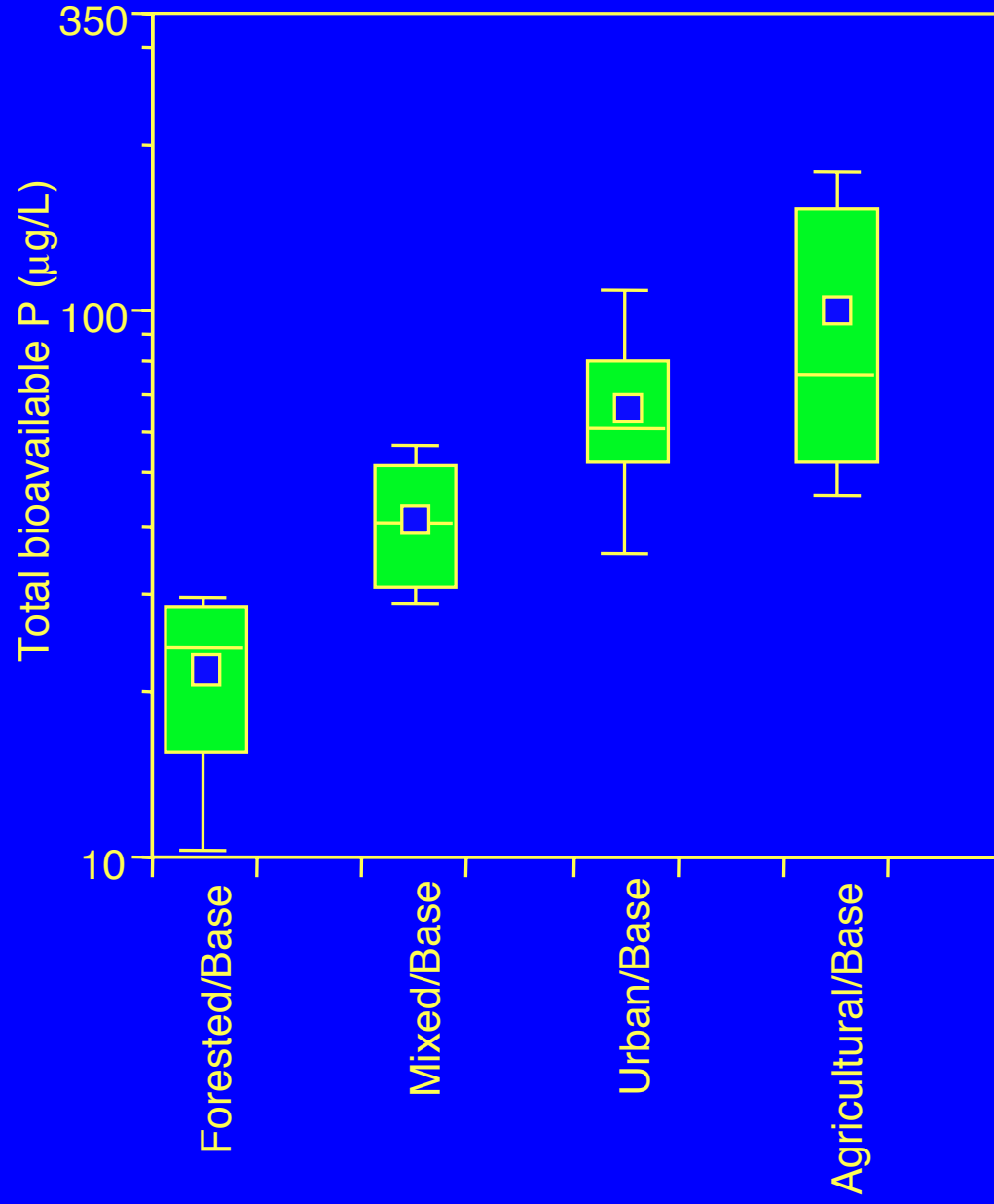
Average increase
of $614 \pm 513\%$
during storms

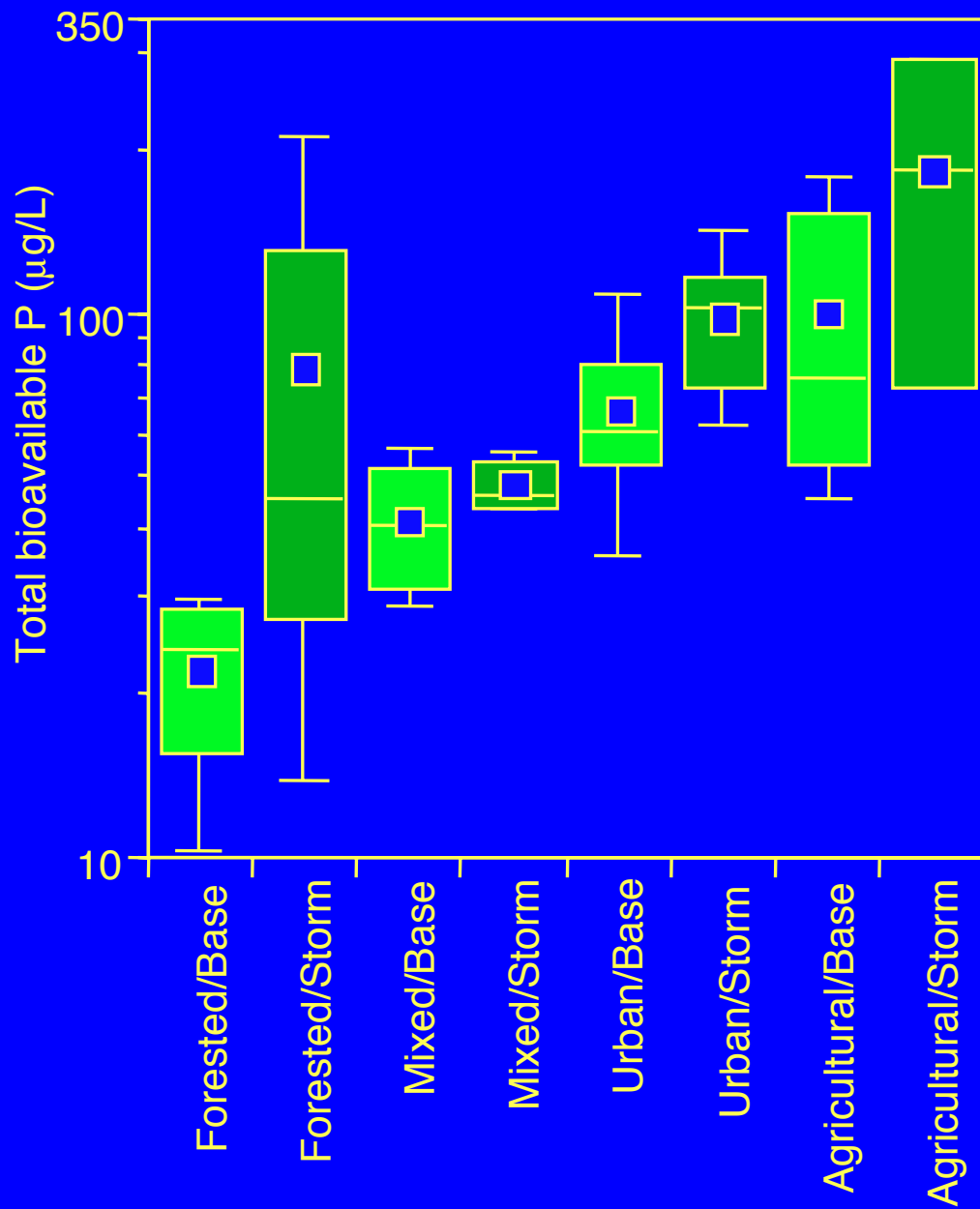


Average decrease
of $24 \pm 36\%$
during storms



Average decrease
of $24 \pm 36\%$
during storms





Average increase
of $72 \pm 52\%$
during storms

During storms:

- Part. P increases by 610%
- Tot. P increases by 200%
- Tot. Diss. P increases by 24%
- BUT Tot. BAP only increases by 72%

Summary:

- It is easy to characterize the between and within stream TDP dynamics
- It is generally agreed that TDP is nearly 100% bioavailable
- Variation in stream particulate P concentrations is very difficult to predict
- The bioavailability of PP increased with urbanization during Baseflows and declined during storms
- Tot. BAP ($= \text{TDP} + \text{PP} * \% \text{BAPP}$) only increase 74% during storms, whereas P increases 710%

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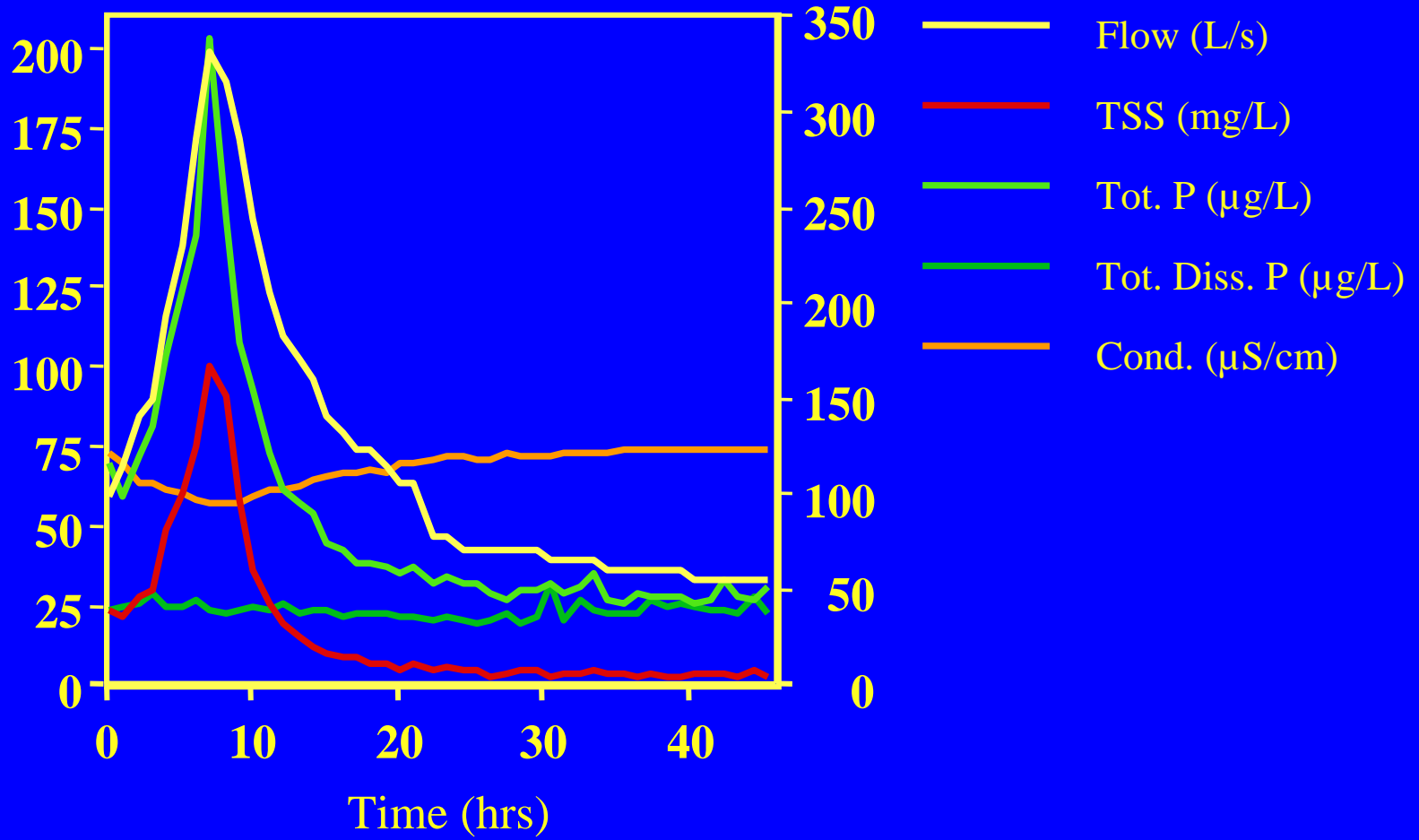
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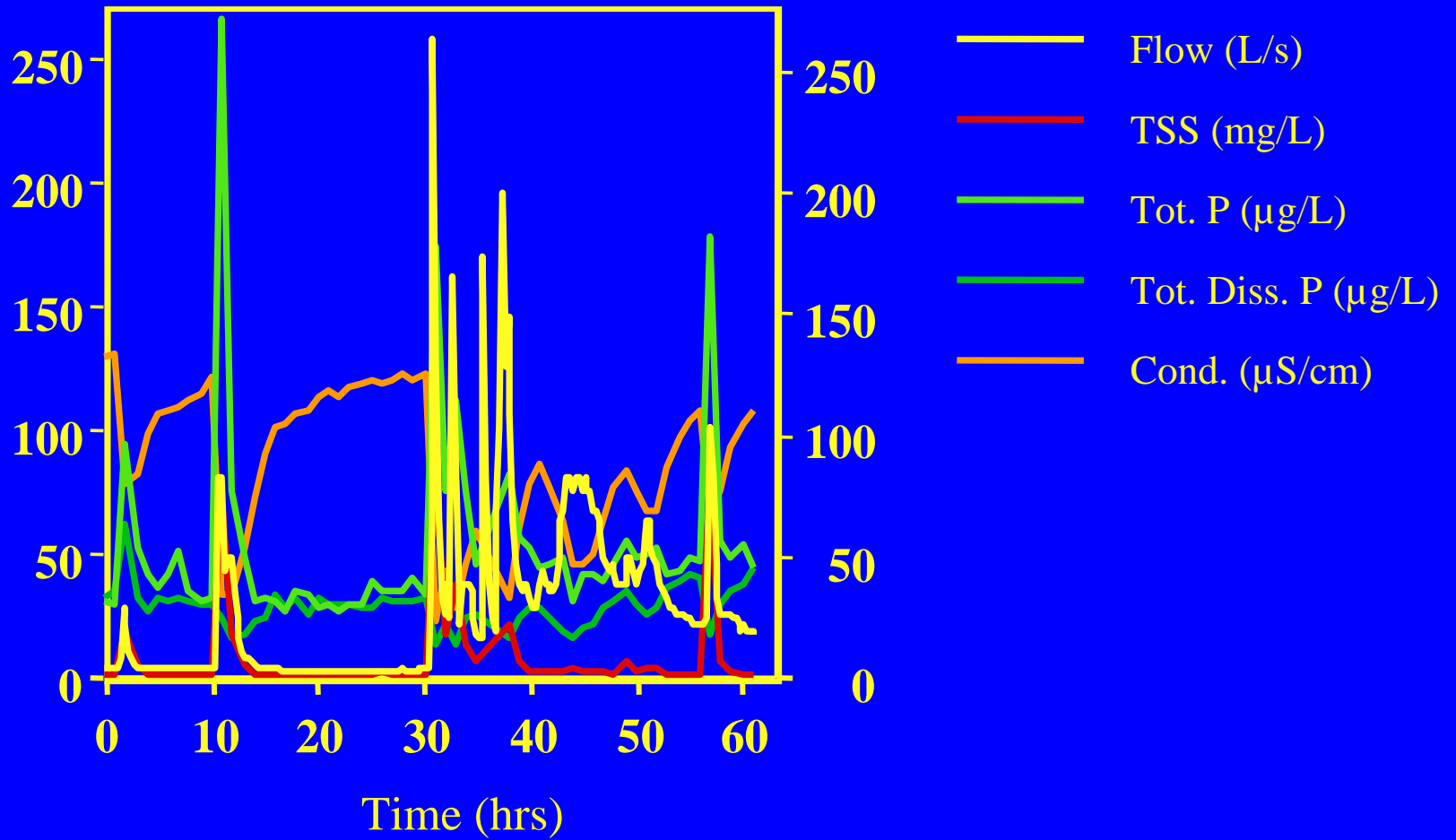
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Forested Stream



Urban Stream



Agricultural Stream

