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Modeling urban phosphorus export to receiving waters: magnitudes, speciation, and management implications

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Scope

- ***Phosphorus (P):*** eutrophication, algal growth in waters, etc.
- ***Urban features impacting P:*** imperviousness and stormwater control measures
- Main research goal:
  Improve predictive understanding of P loading and speciation in urban catchments


Monitoring


Lab analyses


Simulation

- Study sites:

Ajax (AJE and AJW)

Richmond Hill (RH)

	AJE	AJW	RH
Drain. Area (ha)	140	110	10.5

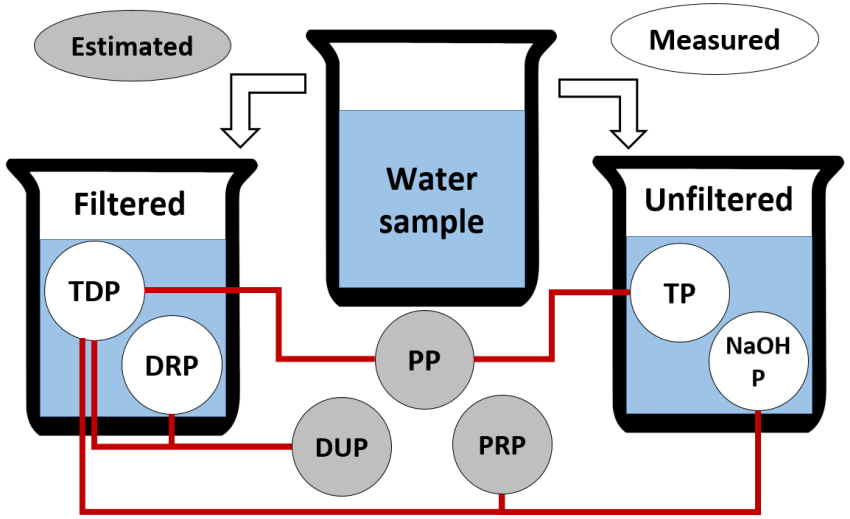
Stormwater pond (in RH)

P speciation analyses

- Analyzed water & sediment samples to quantify reactivity

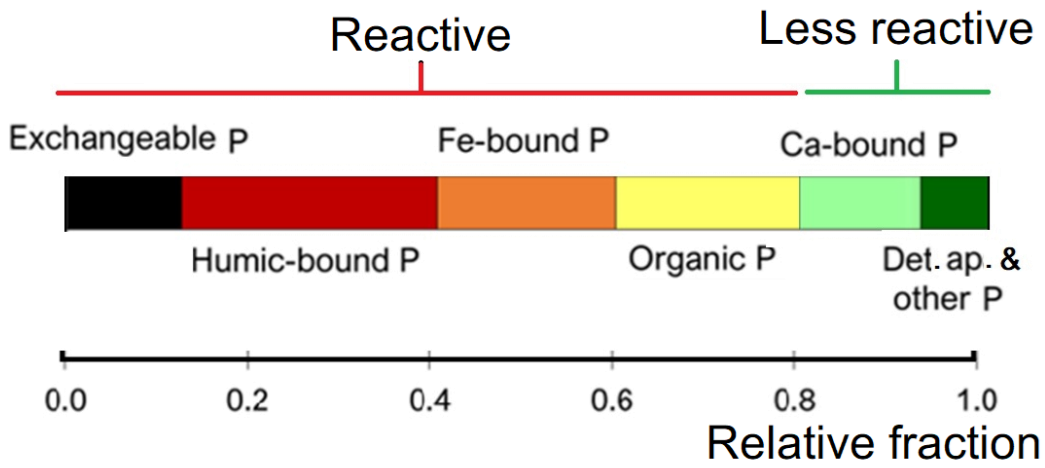
Water samples

Total P (**TP**)
NaOH extractable P (**NaOH-P**)
Total dissolved P (**TDP**)
Particulate P (**PP**)
Dissolved unreactive P (**DUP**)



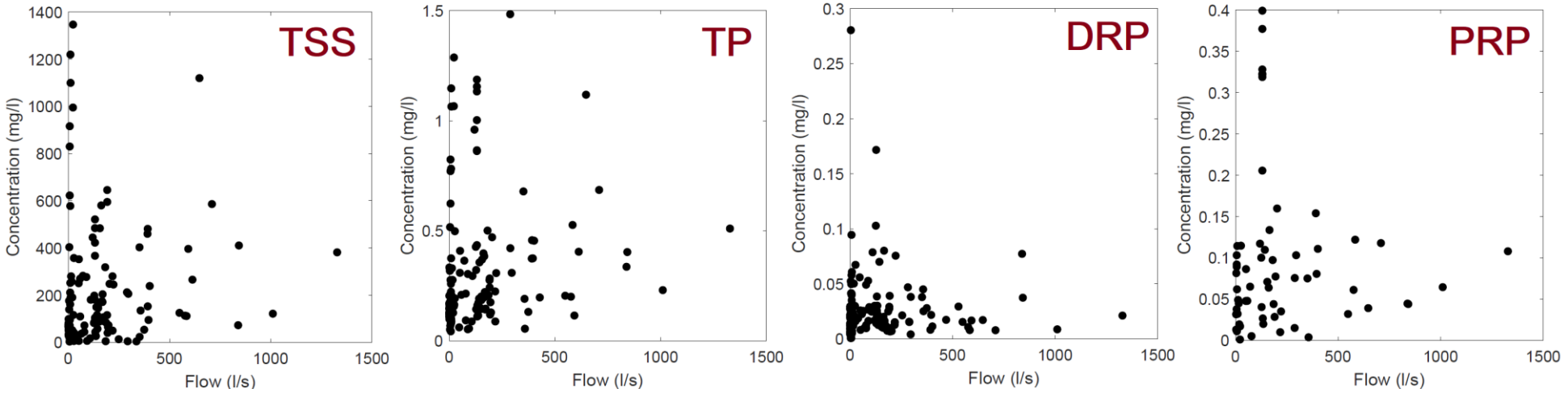
Reactive:
DRP
(dissolved reactive P)
PRP
(particulate reactive P)

Sediment

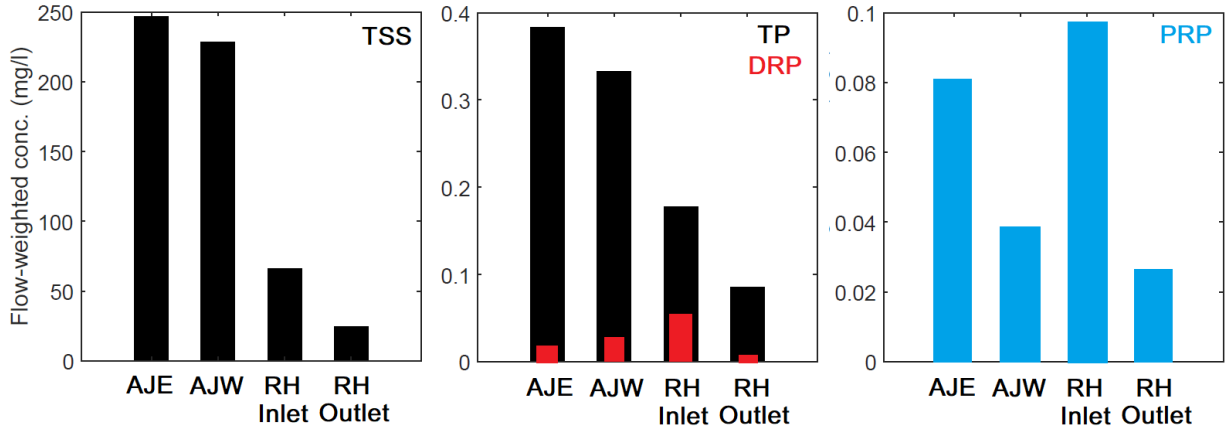


P speciation analyses

- Discharge-relationship not linear for almost all constituents



- Data reveals spatial difference in flow-weighted conc.



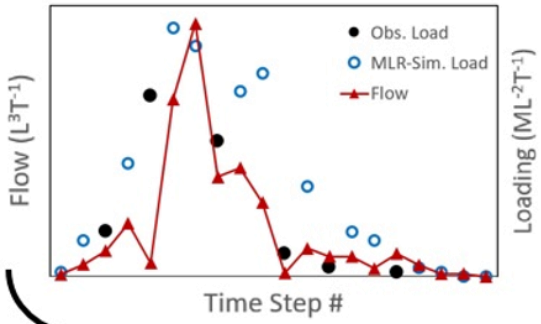
Statistical modeling:

Two-step Multiple linear regression (MLR):

Predictors include:

- ► Flow/Precipitation
- ► Time of sample/event
- ► Temperature
- ► # dry days prior to event

MLR Step 1: instantaneous load prediction



Calculate event loads by summing instantaneous loads

MLR Step 2: event load prediction

Applied to events with only meteorology data

Predict mean annual loads by summing and averaging event loads

Applied to events with flow, concentration, and meteorology data

- ► Models' performance was assessed in two phases:
  - 1. Training **Calibration**
  - 2. Testing **Verification**

Nash-Sutcliffe Efficiency (NSE)

Statistical modeling:

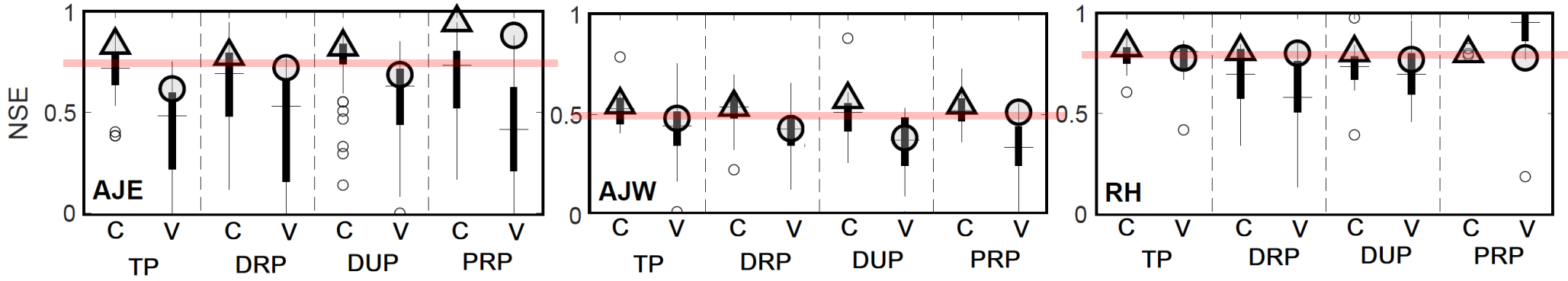
Multiple linear regression (MLR):

Performance:

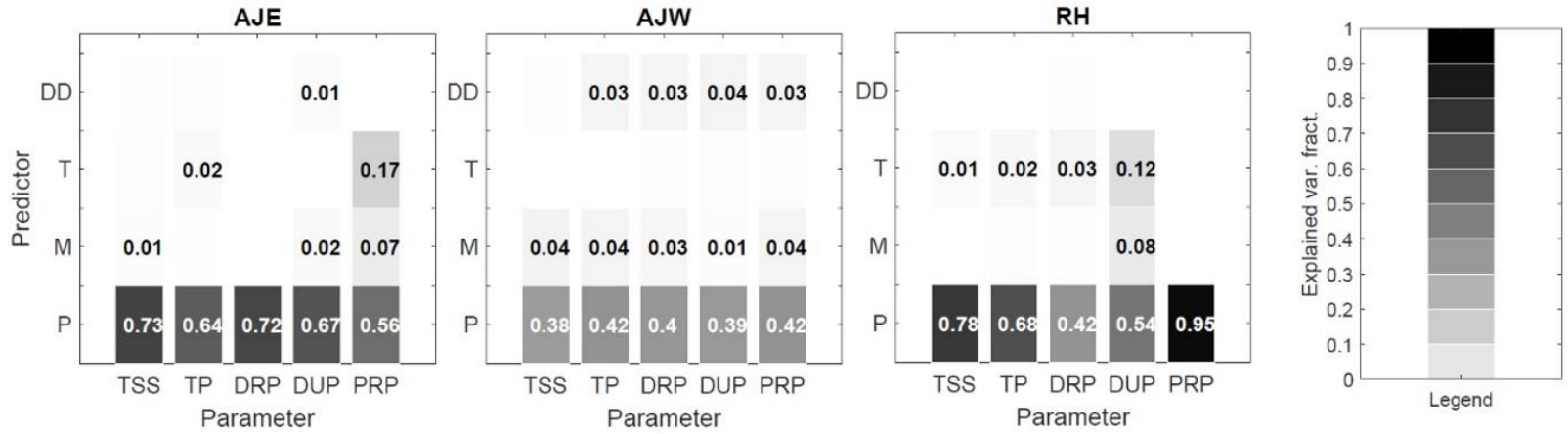
100 trials

C: Calibration
V: Verification

Lowest model performance in AJW



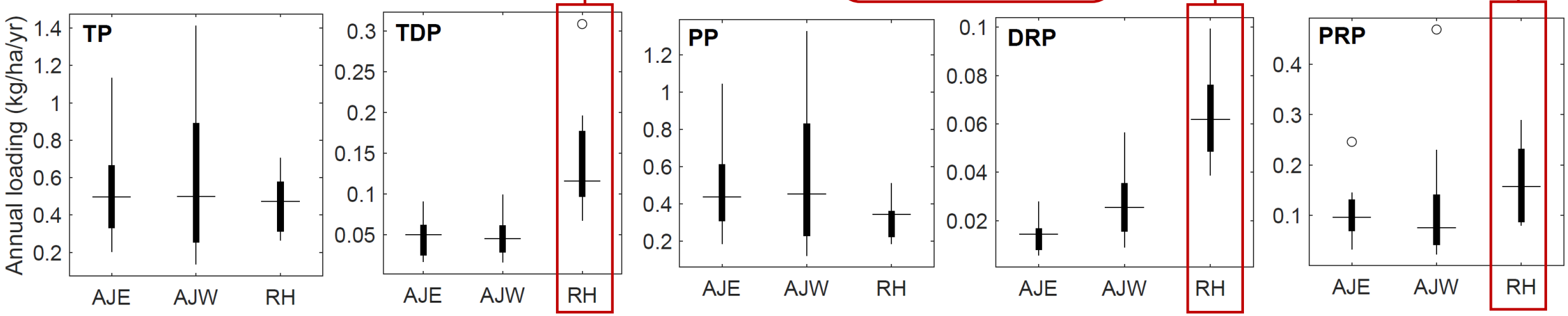
Despite many predictors, hydrology (precipitation/discharge) explained the majority of variations.



► Used models to simulate annual loadings of P species in the past 10 years.

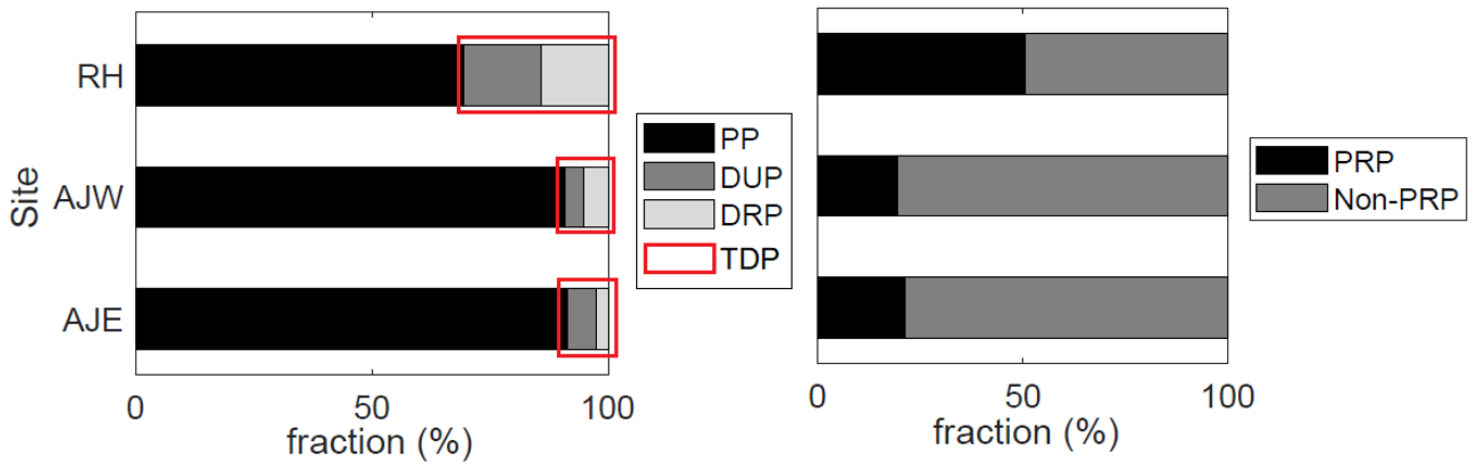
Simulations

- *Annual loads prediction:*



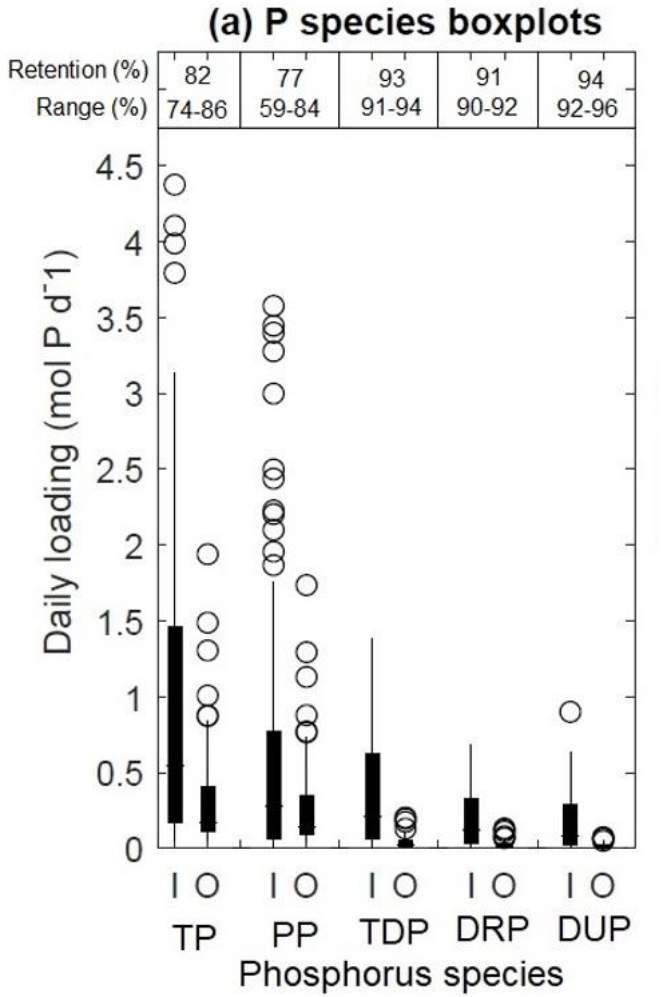
RH: fully residential

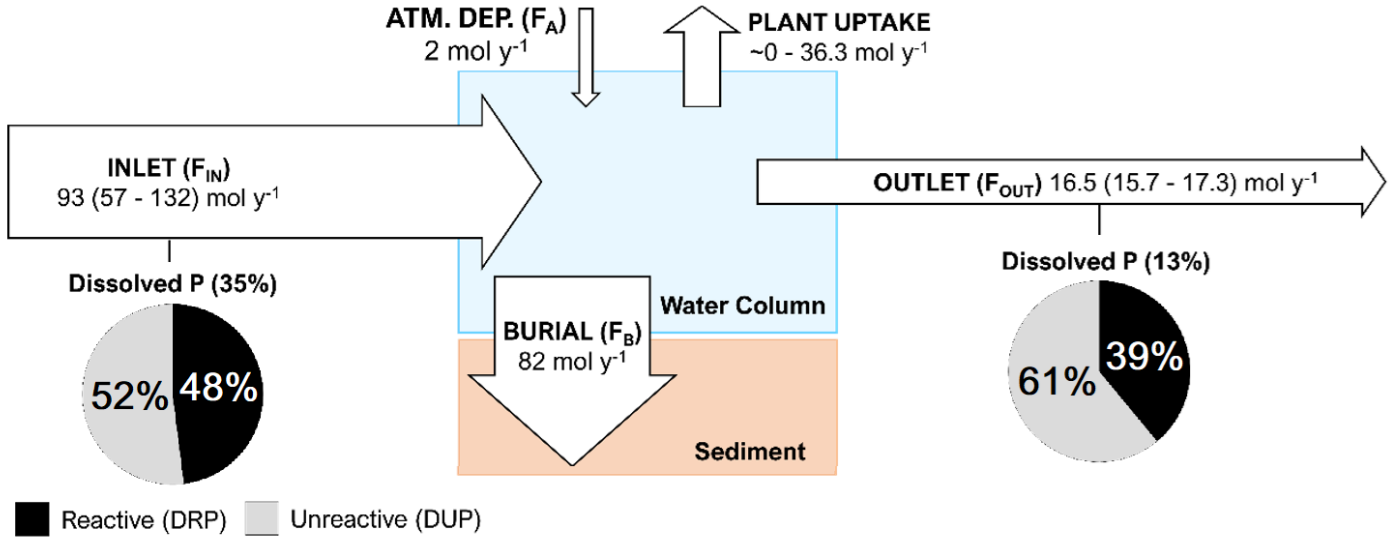
- *P species loadings:*



Findings for stormwater pond

- Significantly high retention of all species (77—94% for different species)



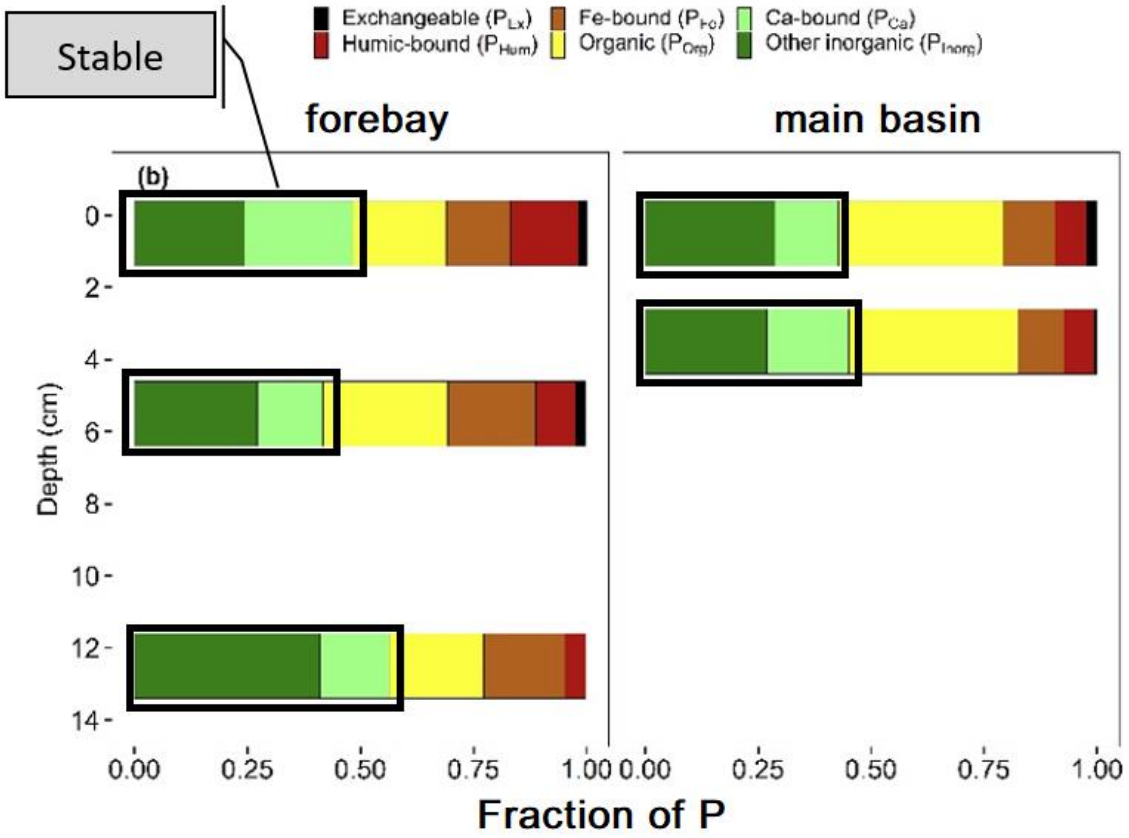


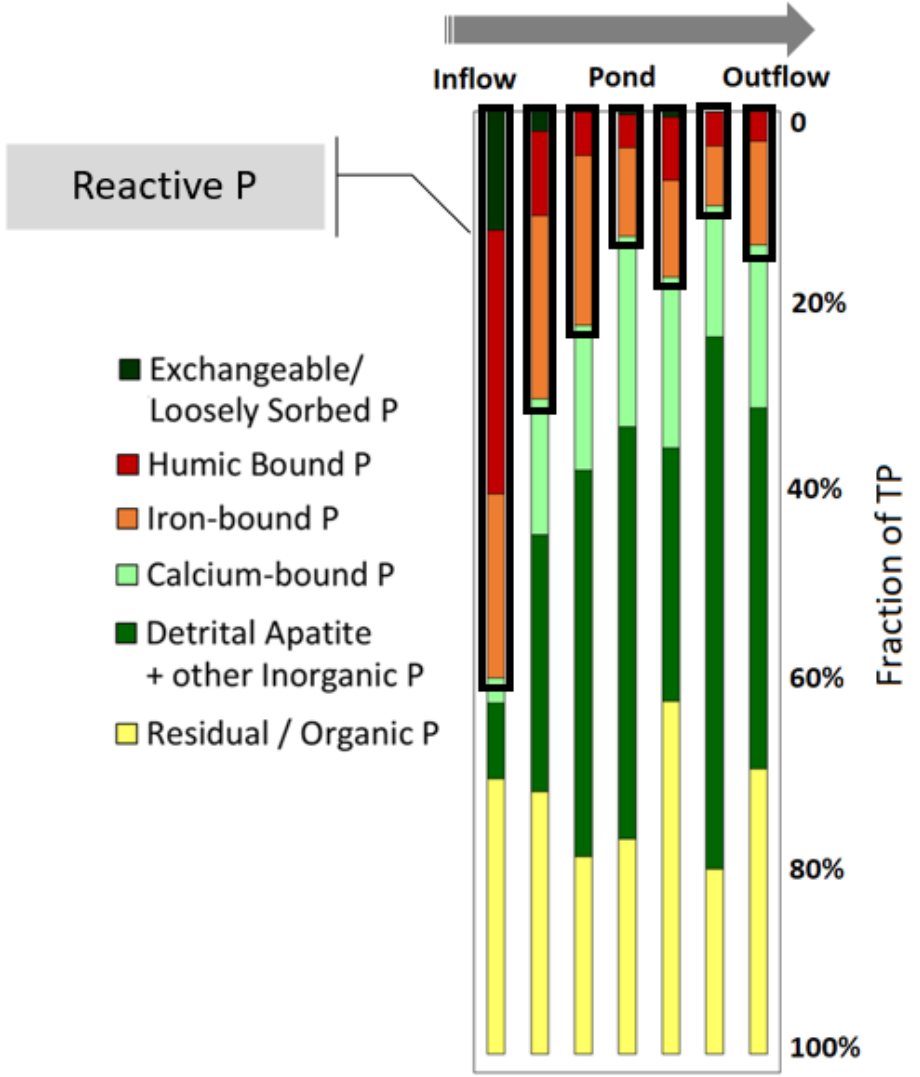
Mass balance analysis

(hydrological modeling + data)

Findings for stormwater pond

- Transformation from reactive P to unreactive/stable P in sediments





Implications for water management

- MLR models offered as a tool for P load estimation in impervious urban catchments
- Fully-residential young sewersheds (e.g., RH) as potentially major exporters of reactive P
- High urban particulate P export, with significant bioavailability potential
  - ► typically, an under-appreciated water pollution pathway
- Stormwater control measures a great tool for P load mitigation
  - ► transformation from reactive to less-reactive forms
  - ► chemical processes as underappreciated P retention mechanisms
- Making a case for P speciation analyses/modeling in other areas

Thank you!

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