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Update on a New Statistical Tool for Chesapeake Bay Nontidal Network Data:

Weighted Regressions on Time, Discharge, and Season WRTDS

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Why a new method?

- Need flexible descriptions of change.
- Need to estimate concentration & flux.
- Need estimates of the actual history but also a flow-normalized history.
- Need to be able to use the data for diagnostic purposes as well as for measuring progress.

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To be published in the Journal of American Water Resources Association. It will go on line the week of September 13.

"Weighted regressions on time, discharge, and season (WRTDS), with an application to Chesapeake Bay River Inputs" (Robert Hirsch, Douglas Moyer, and Stacey Archfield)

Applies WRTDS for TP and NOx at each of the 9 RIM stations: 13,000 chemical measurements, 100,000 daily streamflow values, 31 years.

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Why multiple types of results?

Because there are multiple objectives

- Understanding the impact on the Bay ecosystem
- Measuring progress towards reducing loads from a watershed to the Bay
- Understanding changes in river ecosystems

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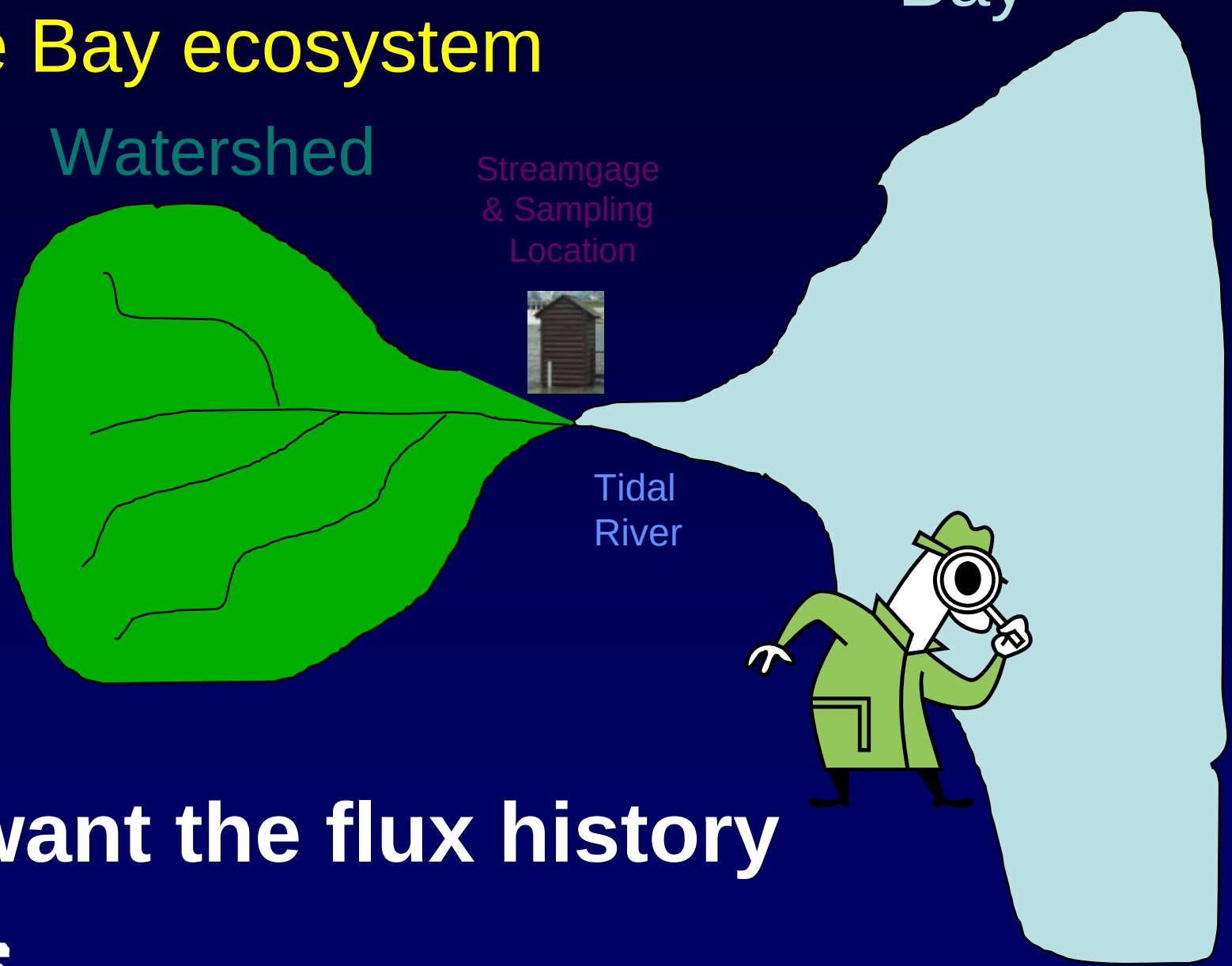
For understanding impact on the Bay ecosystem



We want the flux history

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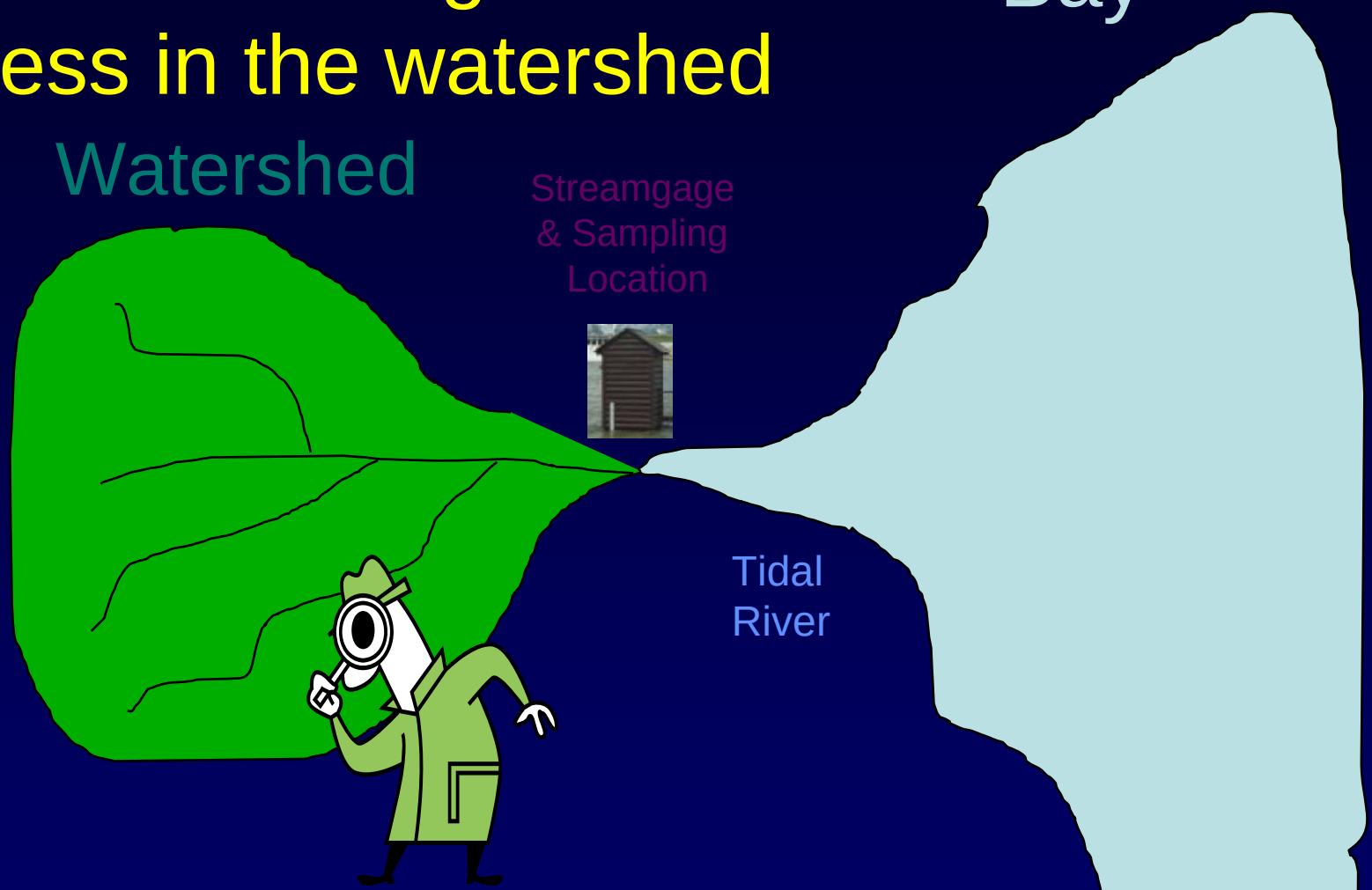
For understanding progress in the watershed



We want the flow-normalized flux history

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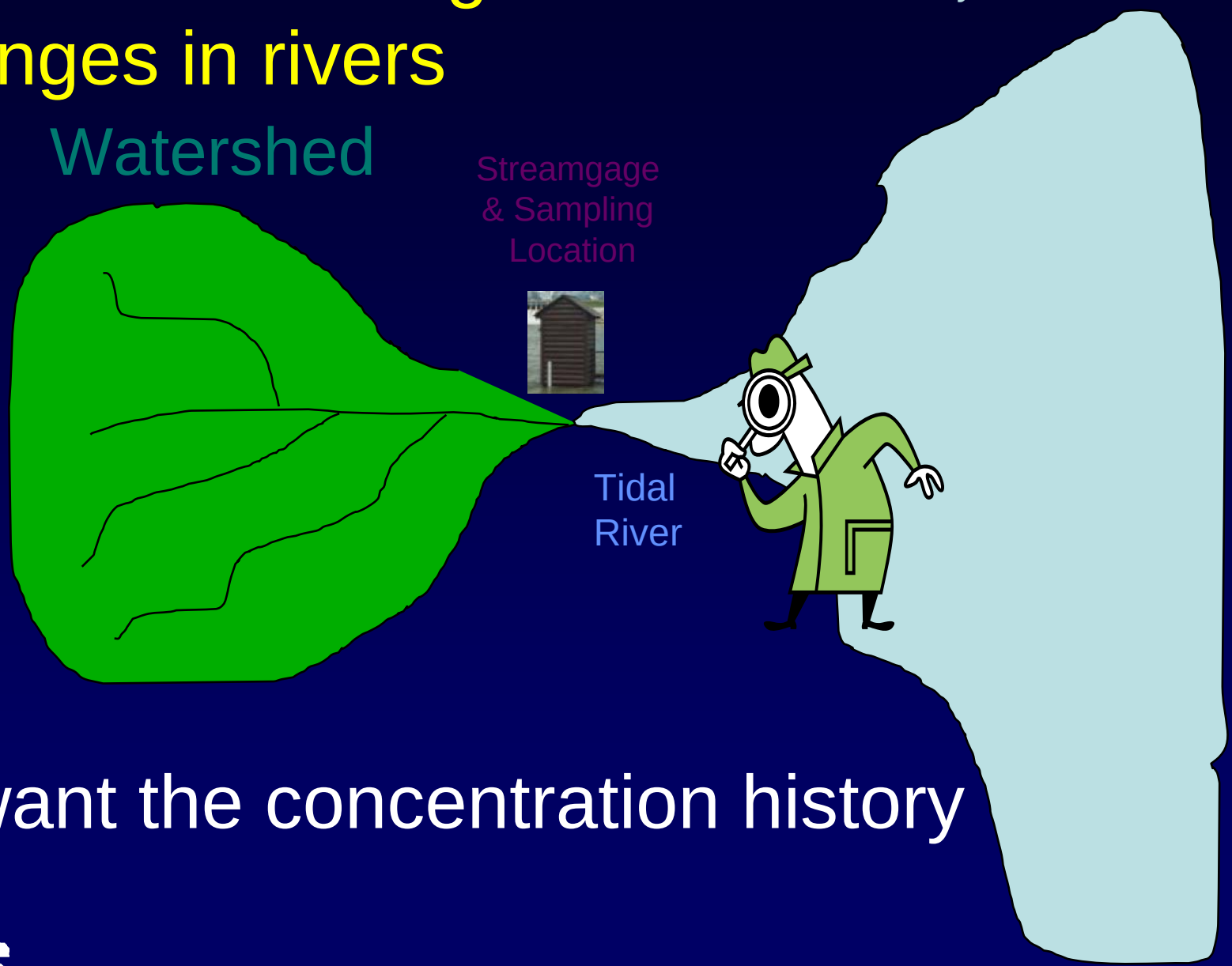
For understanding the changes in rivers



We want the concentration history

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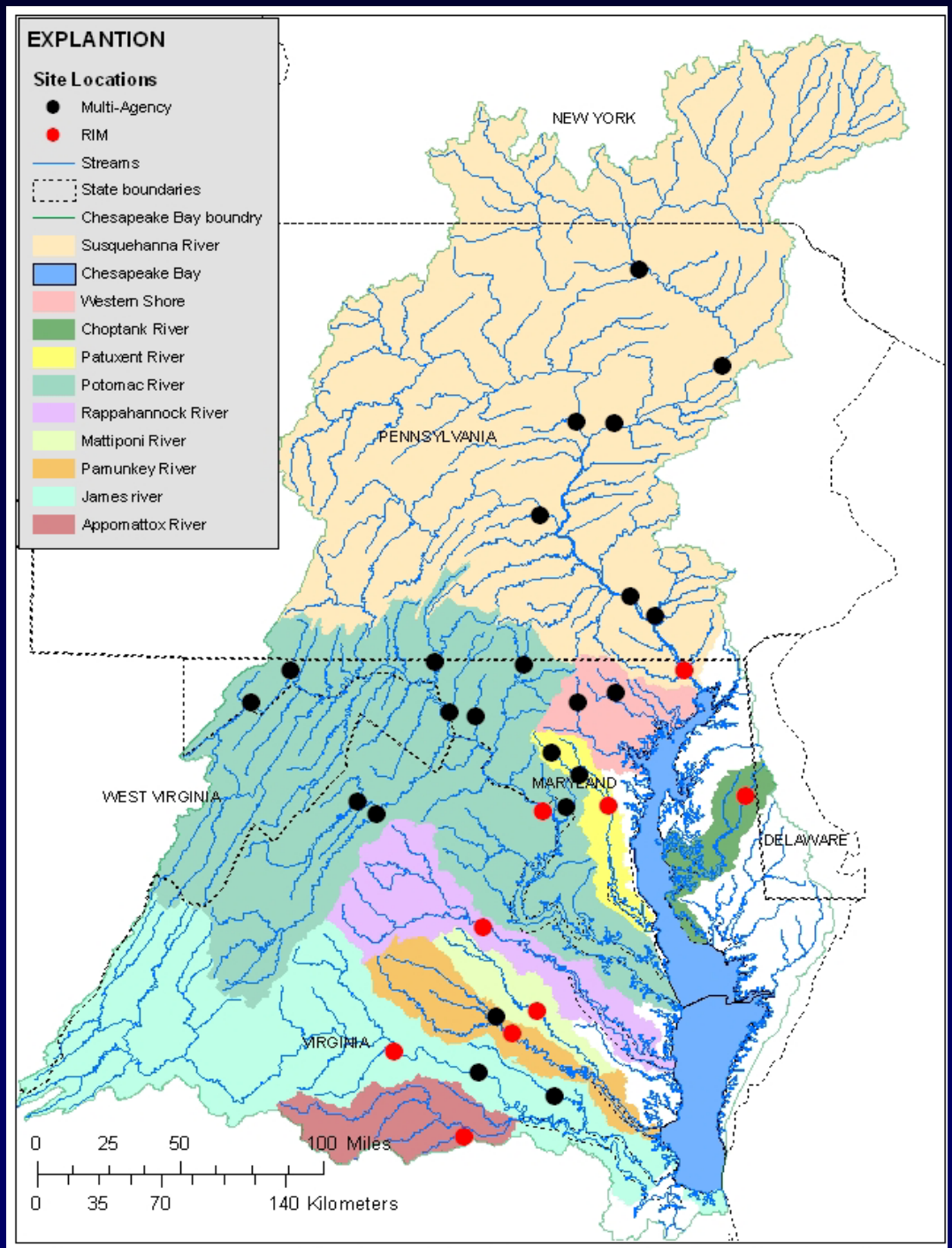
Two examples:

Rappahannock River

- Total Phosphorus

Choptank River

- Dissolved Nitrate plus Nitrite



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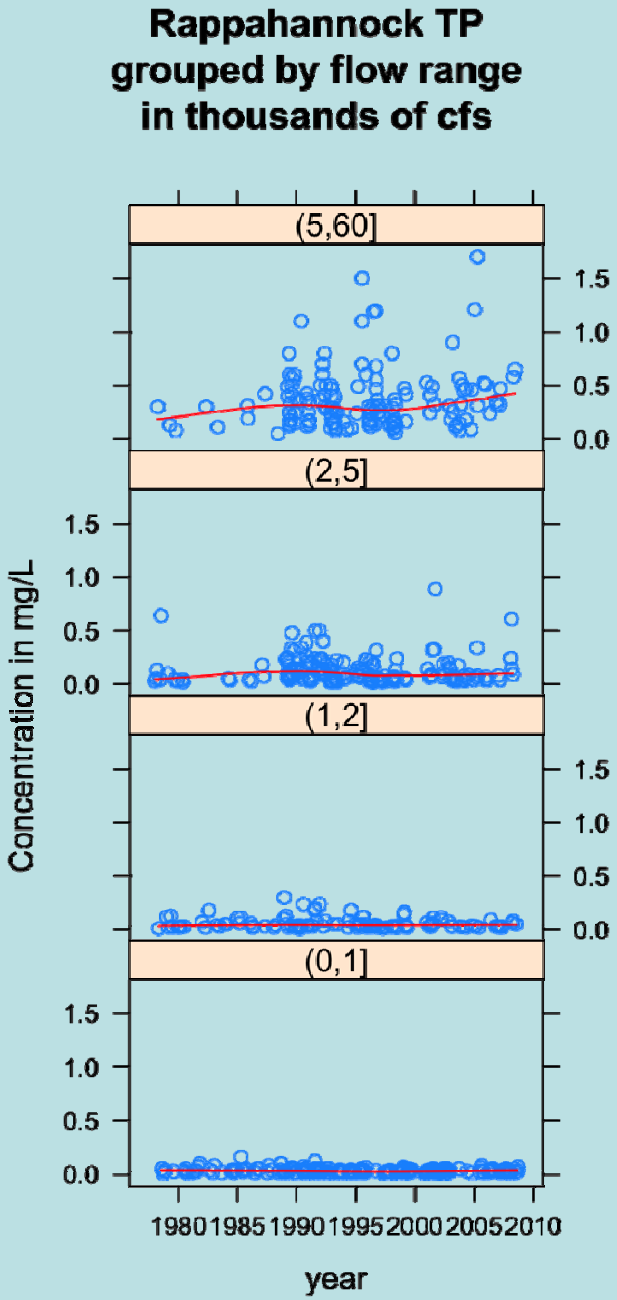
We can generalize what we see here with four groups, by flow range.
It suggests that the TP trends are at high flow.

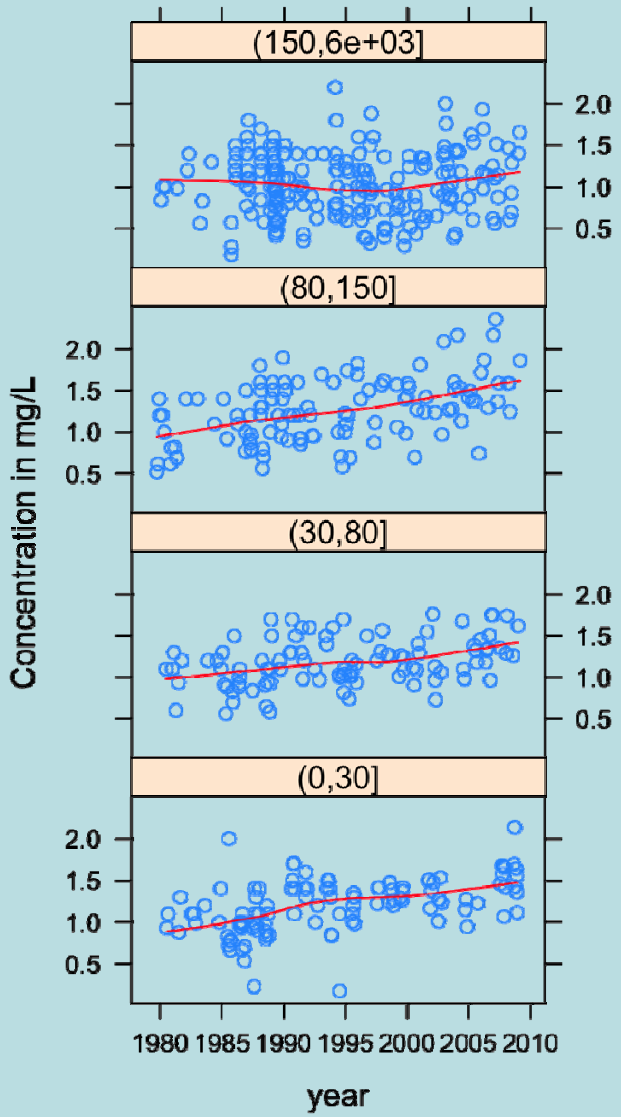


WRTDS is designed to identify these kinds of patterns, both in terms of flow as well as season.

These graphs are part of the diagnostic tools in WRTDS.

Another example: Choptank River.

Flows divided into four quartiles.



No substantial trend in highest quartile.

All the others show steady rise.

About a 50% increase over the record.

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Results:

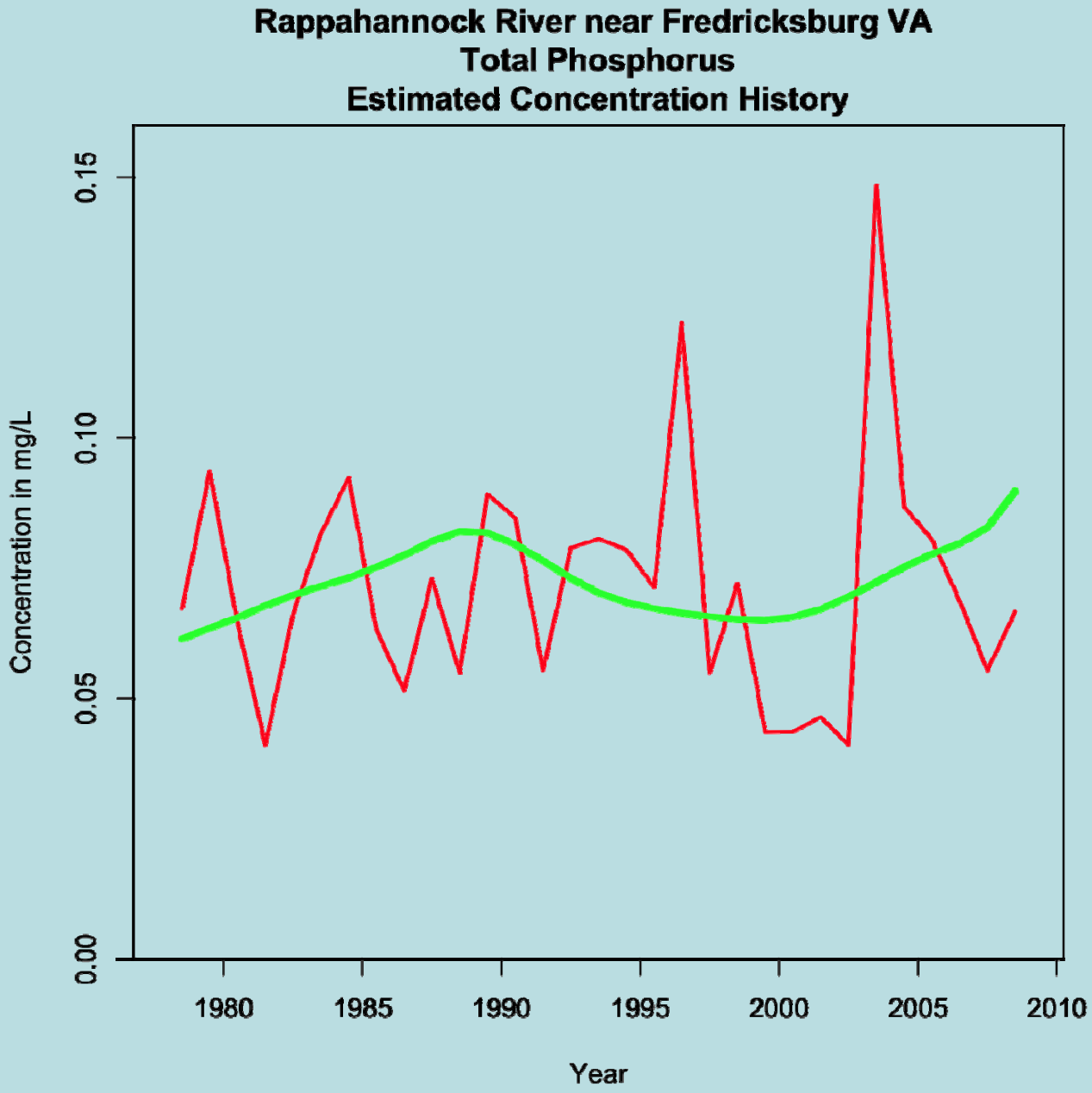
Red = estimated annual average concentrations

Green = flow-normalized annual average concentrations

Slopes of Flow Normalized Concentrations

1978-2000 = 0.3%/year
2000-2008 = 4.6%/year

1978-2008 = 0.8%/year



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Results:

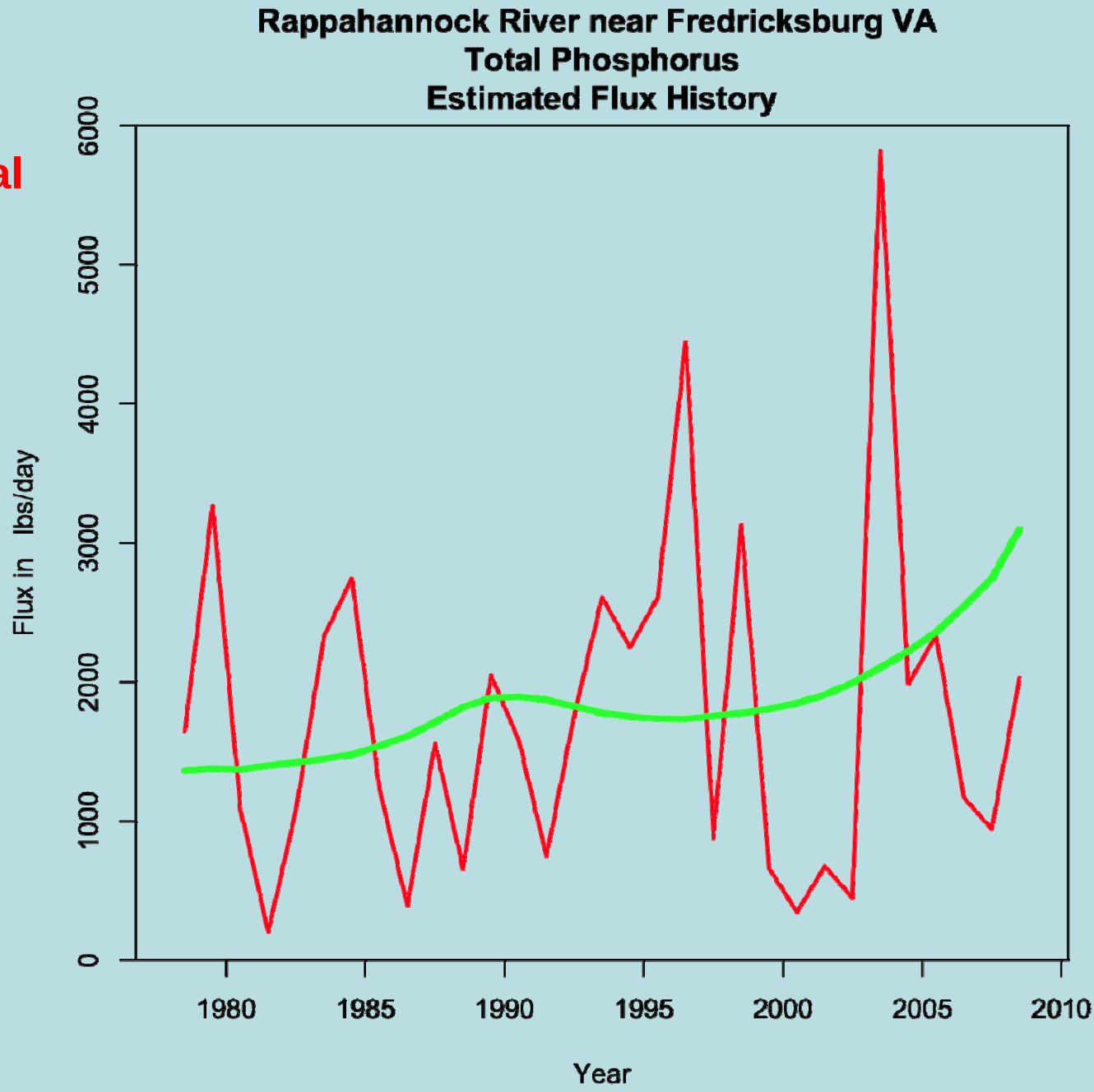
Red = estimated annual average flux

Green = flow-normalized annual average flux

Slopes of Flow Normalized Flux

1978-2000 = 1.6%/year
2000-2008 = 8.5%/year

1978-2008 = 4.2%/year



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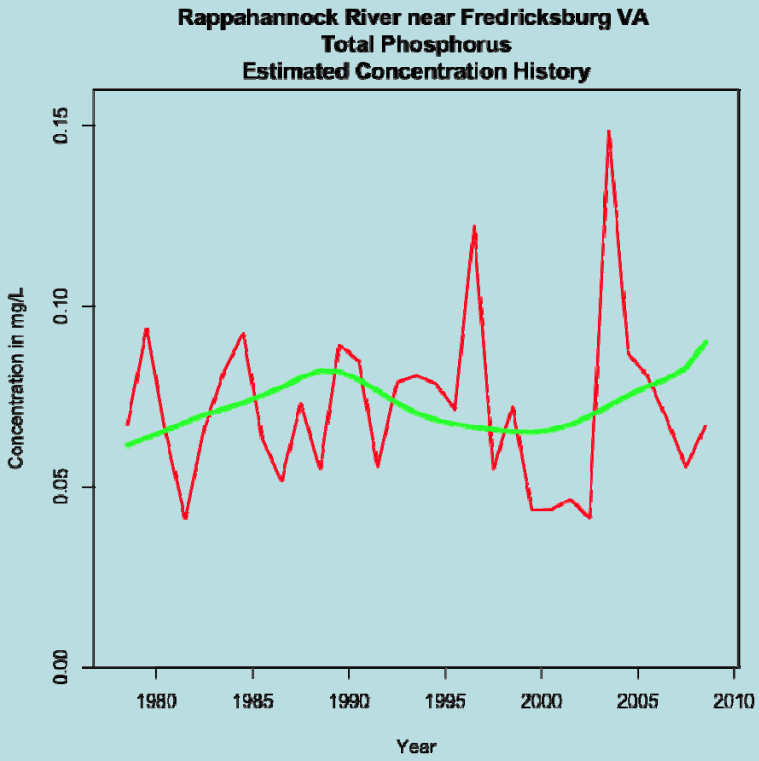

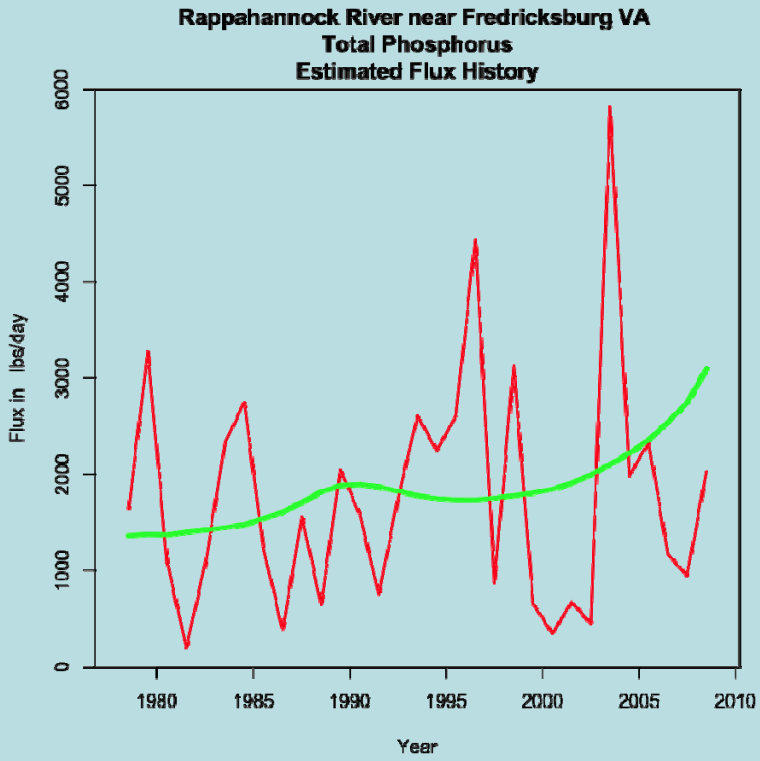

For 2000 – 2008 Flow-normalized:
Concentration is up by 4.6%/year,
but Flux is up by 8.5%/year

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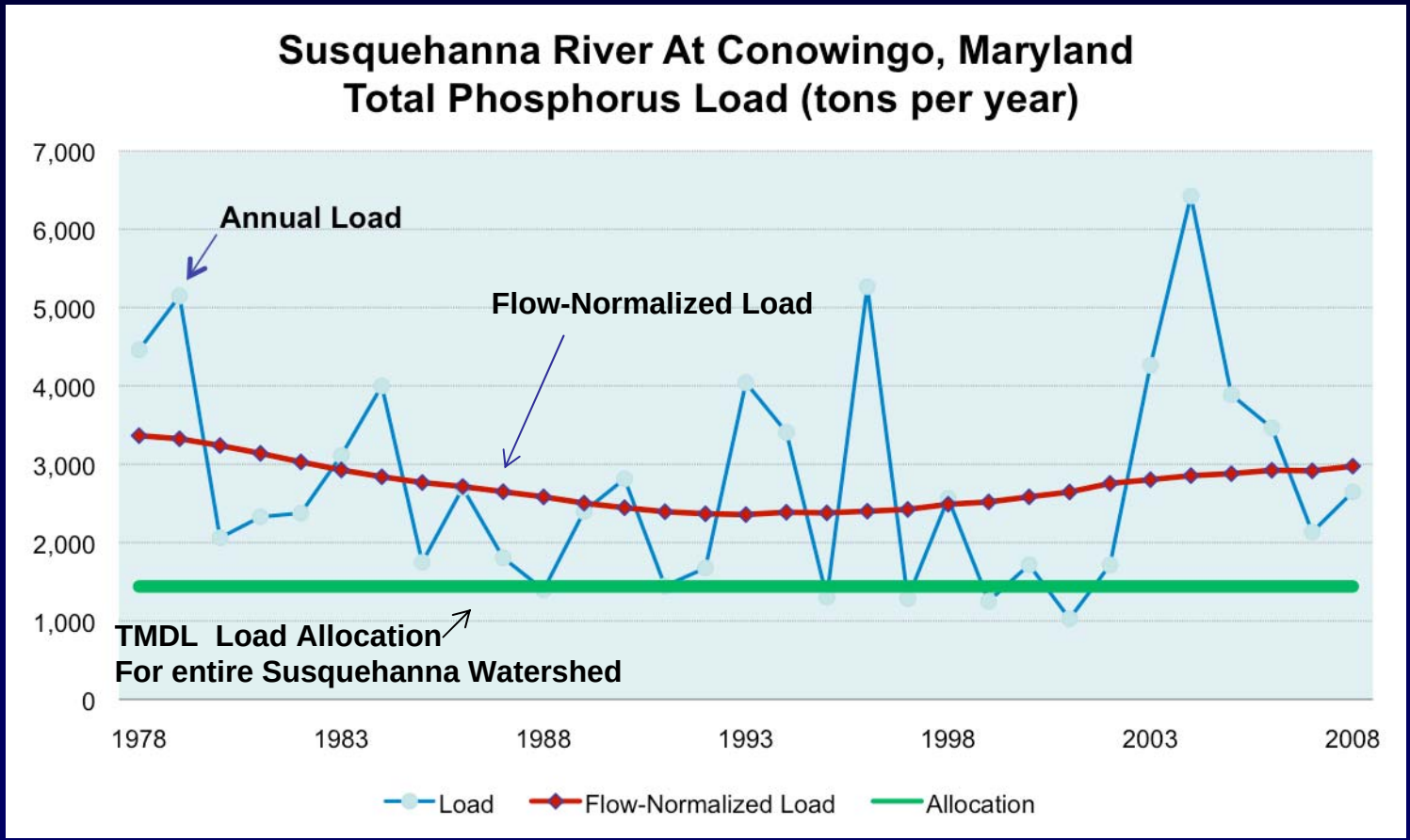
Progress Towards Nutrient Allocations

An example application of WRTDS results to track progress



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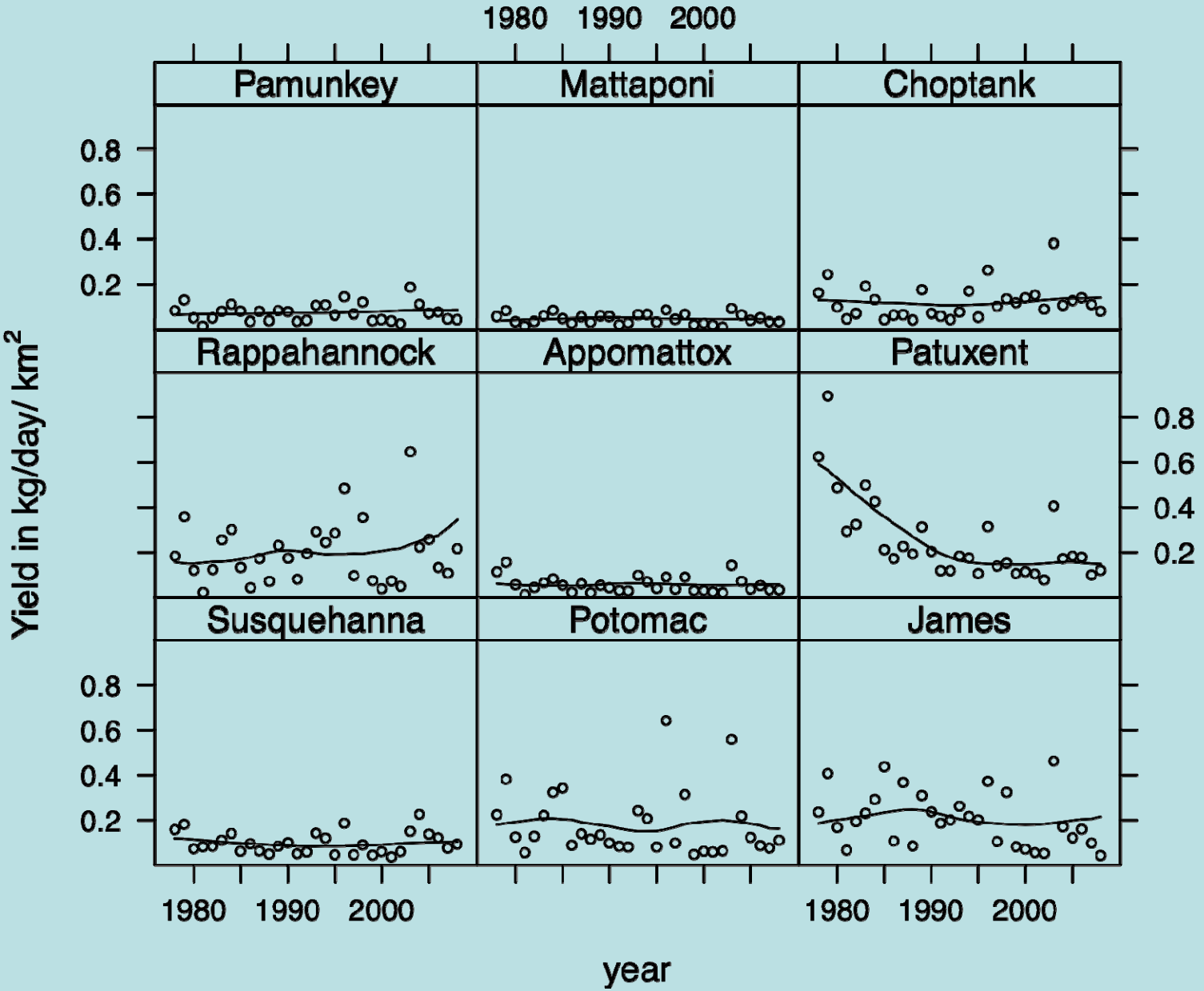
Total P Yield 1978-2008



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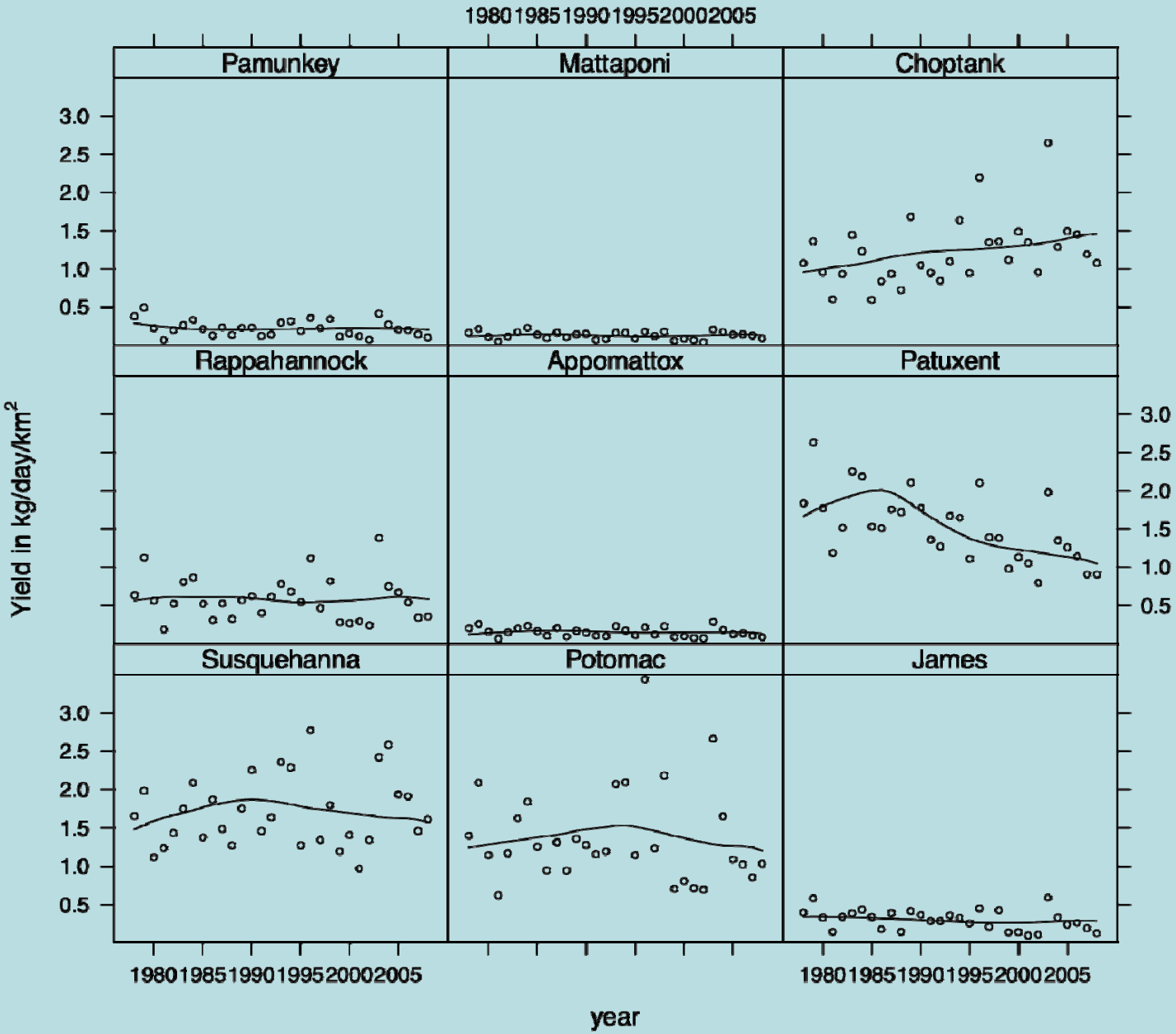
NO_2 plus NO_3 Yield 1978-2008



The paper presents tables describing changes:

-flow normalized concentrations (TP and NOx)
-flow normalized flux (TP and NOx)
-for each of the river-input stations
-for the full period 1978-2008 and for 2000-2008
-in real units (mg/L or tons/day) & as % change

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Final Notes

- Where the trends are complex, WRTDS results may differ substantially from prior estimates
- WRTDS doesn't present "significance levels" for trends – change is a given and these are our best estimates of the change (like economic indicators)
- Also like economic indicators, new information will result in some revision of recent-year results.
- Work is underway using WRTDS in Lake Champlain, and Mississippi River watersheds

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Final Notes

- Next steps in Chesapeake Bay watershed, include 2009, more long-record stations, and add total N, dissolved P, and sediment.
- Goals of this work will be to describe, and to the extent possible, explain the changes taking place and compare to Chesapeake Bay Watershed Model outputs.
- WRTDS enhancements underway (for “less-than” values, and for uncertainty analysis)
- We are looking for science and policy feedback on the method and its presentation.
- Contacts: rhirsch@usgs.gov, dlmoyer@usgs.gov

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Flow-Normalized Total Phosphorus Flux Results

Time period	1978-2008		2000-2008	
River	slope, % per year	flux change, kg/day	slope, % per year	flux change, kg/day
Susquehanna	-0.4%	-990	+1.9%	+970
Potomac	-0.3%	-530	-2.0%	-940
James	+0.5%	+480	+2.5%	+590
Rappahannock	+4.0%	+780	+8.4%	+580
Appomattox	-0.2%	-10	+0.8%	+12
Patuxent	-2.5%	-400	+0.2%	+2
Pamunkey	+1.2%	+64	+1.1%	+19
Mattaponi	+0.7%	+12	+0.1%	+0
Choptank	+0.3%	+3	+1.9%	+5

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Flow-Normalized Total Phosphorus Concentration Results

Time period	1978-2008		2000-2008	
River	slope, % per year	concentration change in mg/l	slope, % per year	concentration change in mg/l
Susquehanna	-0.5%	-0.01	+0.3%	+0.00
Potomac	-1.0%	-0.03	-3.9%	-0.03
James	-1.2%	-0.04	-3.0%	-0.24
Rappahannock	+1.5%	+0.03	+4.7%	+0.03
Appomattox	+0.9%	+0.01	+1.6%	+0.01
Patuxent	-2.9%	-0.74	-0.7%	-0.01
Pamunkey	+1.3%	+0.02	-0.9%	-0.01
Mattaponi	+0.1%	+0.00	-0.2%	-0.00
Choptank	+0.2%	+0.00	+0.9%	+0.01

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Flow-Normalized NOx Flux Results

Time period	1978-2008		2000-2008	
River	slope in % per year	flux change, kg/day	slope in % per year	flux change, kg/day
Susquehanna	+0.2%	+6,400	-0.9%	-8,600
Potomac	-0.1%	-1,200	-1.5%	-4,800
James	-0.5%	-880	+1.2%	+400
Rappahannock	+0.1%	+69	+0.4%	+71
Appomattox	+0.2%	+21	-1.3%	-55
Patuxent	-1.2%	-560	-1.9%	-160
Pamunkey	-1.0%	-240	-1.4%	-73
Mattaponi	+0.3%	+17	+0.7%	+10
Choptank	+1.8%	+147	+1.6%	+48

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Flow-Normalized NOx Concentration Results

Time period	1978-2008		2000-2008	
River	slope in % per year	concentration change in mg/l	slope in % per year	concentration change in mg/l
Susquehanna	+0.3%	+0.08	-0.4%	-0.04
Potomac	-0.1%	-0.04	-1.5%	-0.14
James	-0.6%	-0.05	+4.4%	+0.06
Rappahannock	+0.7%	+0.09	+4.3%	+0.14
Appomattox	+0.0%	+0.00	1.9%	+0.03
Patuxent	-1.5%	-0.93	-1.9%	-0.21
Pamunkey	-0.4%	-0.04	-1.5%	-0.04
Mattaponi	+1.0%	+0.04	+2.3%	+0.03
Choptank	+1.5%	+0.44	+1.8%	+0.18

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