

The Great Urban Detritus Debate:

its OK if your mind is in the gutter
or how to increase your Leaf-Litter-acy

STAC Research Workshop

April 22 and 23, 2014

Background

Current CBP expert panel is looking at fate and transport of urban detritus from pervious areas (e.g. lawns) to the street, storm drain and urban stream as a potential manageable nutrient load



Photo Credit: Ken Belt

Your insights requested !

- Fascinating, cross-cutting issue that involves at least 15 different scientific disciplines
- Thanks to Ken Belt, Stu Schwartz, Bill Stack and others for their perspectives
- Opinions today are solely those of Law and Schueler
- Please provide us your feedback

The basic proposition being debated

" Organic matter produced from urban pervious areas that is delivered to impervious areas and the storm drain system contributes a significant fraction of the nutrient load generated by urban watersheds "

Pro: Neely Law

Con: Tom Schueler

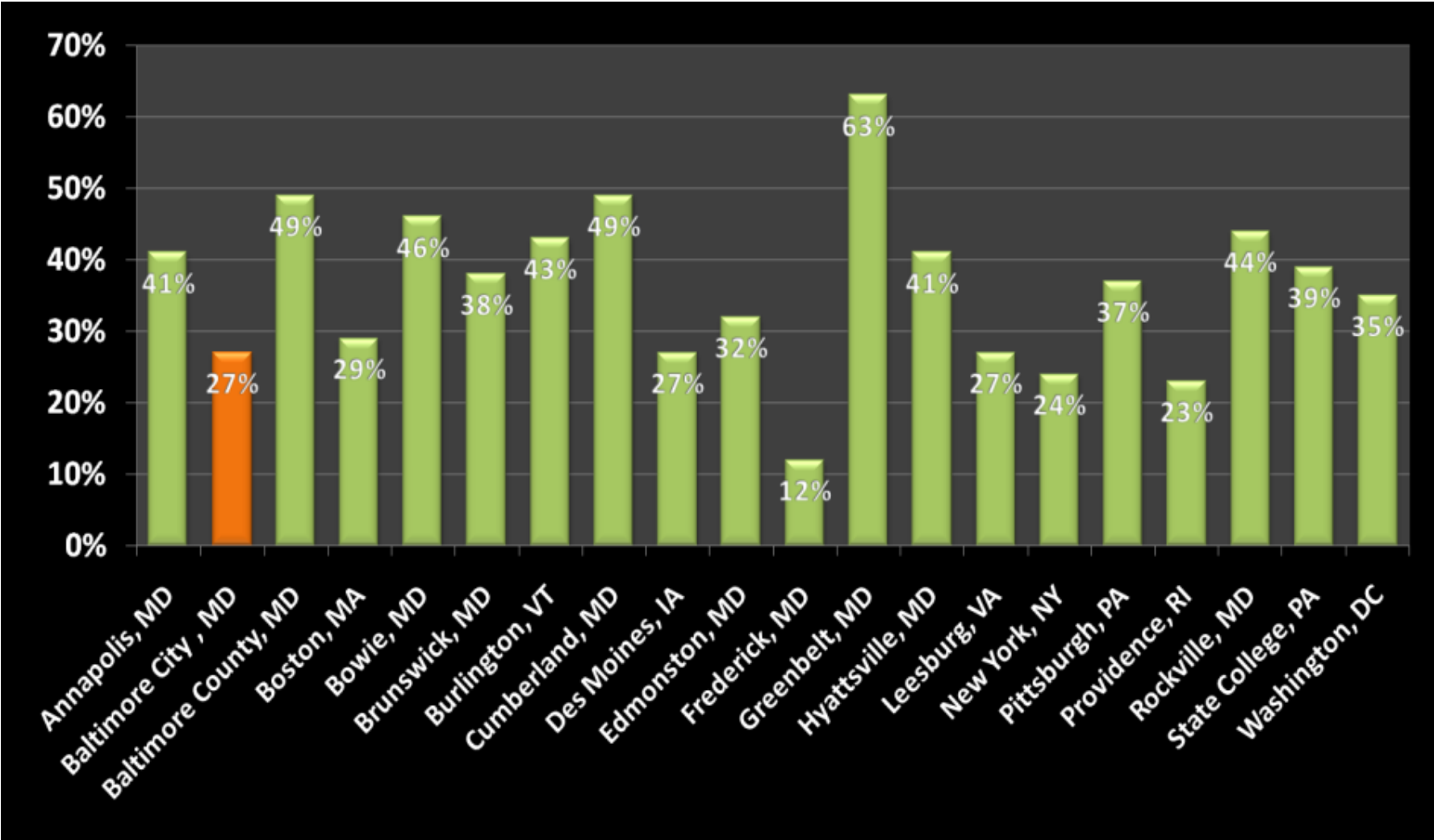
The Debate, in Three Parts

1. What is the organic matter load in the urban landscape and how much of it is delivered to storm drain inlets ?
2. What evidence do we have that carbon and nutrients are discharged from storm drain pipes ?
3. Do we have the practices to capture organic matter before it reaches the stream ?

Part 1

- What is the organic matter load in the urban landscape and how much of it is delivered to storm drain inlets ?

Urban Tree Canopy is Significant in Most Urban Areas



Does Fall Leaf Drop Represents a Big Subsidy of C, N, P to the Urban Landscape ?



Photo Credit: Stu Schwartz



Photo Credit: CWP

Leaf Drop Subsidy -Yes

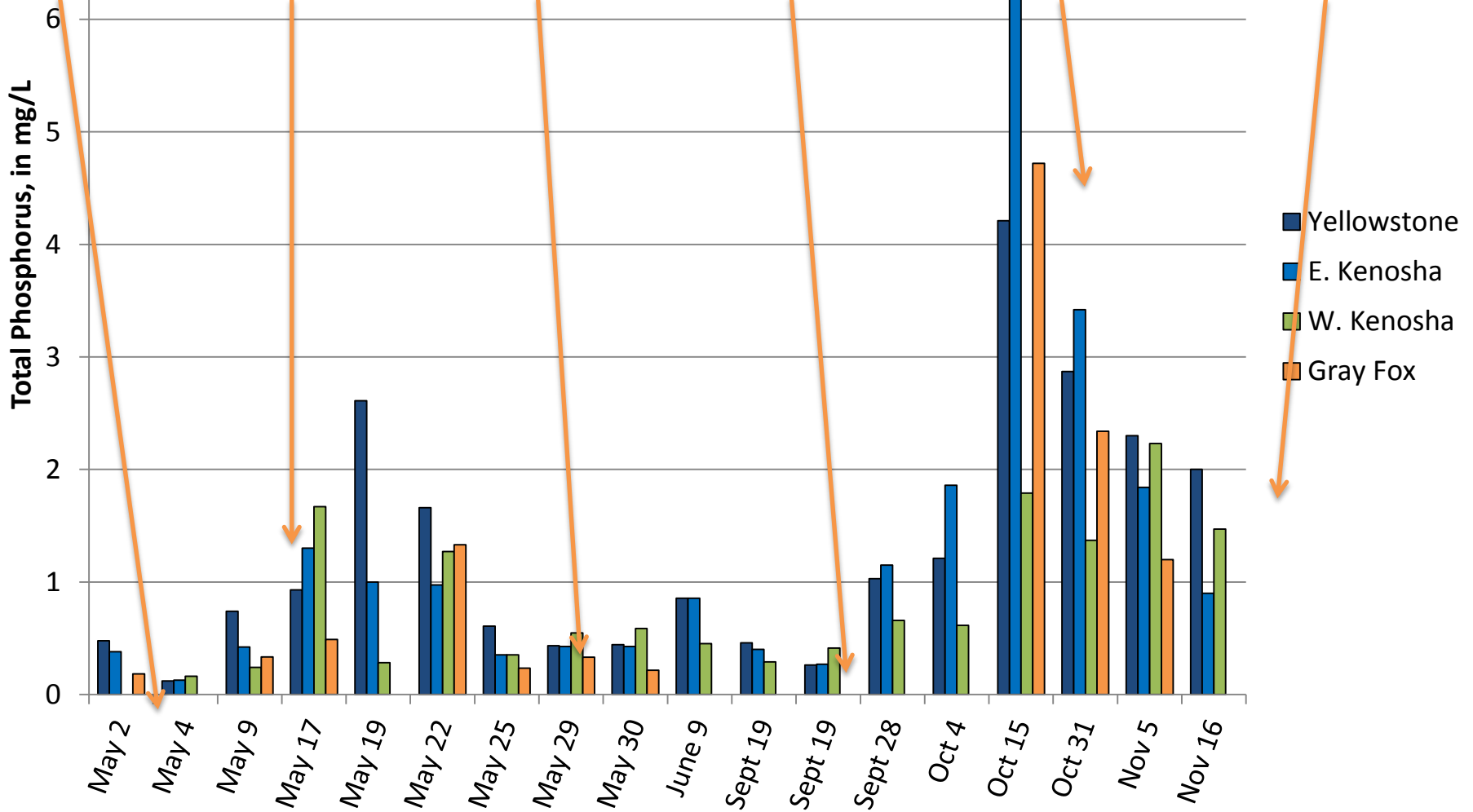
- The fall leaf drop may provide a large "gutter subsidy" in terms of the mass of organic carbon available for wash-off (Kaushal and Belt, 2012)
- Based on Nowak's Baltimore Tree Analysis:
 - 1194 lbs/acre/yr of TOC leaf drop
 - 28.8 lbs/acre/yr of TN leaf drop
 - 2.95 lbs/acre/yr of TP leaf drop

Rapid Initial Leaching and Subsequent Decomposition

- Rapid loss of P once immersed (Dorney, 1986, Kalinsky, 2013 and Ostrofsky 1997)
- Decomposition rates faster on pavement than natural areas; 80% loss of initial mass within 1 yr (Hobbie et al. 2013)
- Leaf material emulsified from traffic; smaller particles easily entrained in runoff



Photo Credits: John Galli



Source William Selbig, USGS, 2014



Source William Selbig, USGS, 2014

Leaf Drop Subsidy: No !

- Most of the leaf drop is raked and collected and composted in the Fall
- Leaf litter is quite aerodynamic and much of it blows away and is trapped in pervious areas of the landscape where it helps build up urban soils
- Leaf Nutrient Recission Prior to Drop, so C:N ratio of fallen leaves is very high (about 60 or so -- Heckman and Kluchinski, 1996).

Some Leaching, but Low Delivery to Storm Drain

- While rapid initial leaching occurs, no easy practices to prevent it from reaching storm drains.
- Glass Half Empty: 30 to 50% of the leaf packs are not decomposed after 6 to 9 months, and consists of highly refractory lignins and other compounds that will not readily decompose
- Leaves and detritus packs are simply not mobile except under the most extreme storm events

Growing Season Drop: Pro

- Other organic subsidies occur during the growing season in the form of pollen (Banks and Nighswanda, 2000, Mladenov et al 2012), and herbivore-created green-fall (Risley and Crossley, 1988).
- In addition, atmospheric deposition of organic nitrogen in the form of dust, pollen, bacteria and spores is estimated to comprise about a third of the total N deposited from the atmosphere, based on a world-wide review (Neff et al 2002)
- Growing season biomass (esp. grass clippings) have low C/N ratios ~ 15 (Newcomber et al, 2012).

Does Growing Season Drop Provide Another Subsidy of C, N and P ?

- Lawn Clippings, Green Fall and Pollen

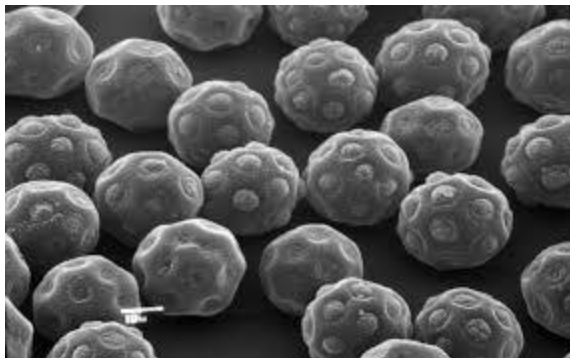


Photo Credit: CSN

Growing Season Drop: Con

- Nice try, Neely, but where is the urban data to document the magnitude of urban detritus ?”
- It doesn't seem to show up at urban atmospheric deposition monitoring stations
- Sorry, Tom, that's simply because it is considered sampling contamination !
- Sorry, Neely, hard to imagine how any practice could capture these short term pulses !

What Fraction of the Drop Gets Trapped in the Curbs ?



Photo Credit: Stu Schwartz



Photo Credit: Ken Belt

A Lot Does Gets Trapped in the Curb

- Storm drain system greatly increase the urban drainage density, and this increased "connectivity" could increase transport to streams (Ken Belt).
- Storm drains low point in landscape
- Street solids have a relatively high TOC content, particularly in the fine and coarse grained fractions (SPU 2009, Sorenson)--averages about 5 to 12% of total street solids, but can be higher during portions of the year, such as leaf drop (Sorenson, Kalinosky, 2013, unpublished).
- Leaves major P source (Washbusch et al. 1999)

Not Much Gets Trapped in the Curb

- Only a small fraction reaches the street and is trapped in the curb
- Large Particle size reduces mobility
- Much more likely that enlarged and incised urban stream channels are more effective in trapping RIPARIAN leaf litter
- Detritus a minor component of urban nutrient load (Allison, 1998)



Particle Sizes of Street Solids

Fines (<2mm)	Coarse Organics (≥2mm)
	Rocks (≥2mm)*



TP, TN, TOC
(Leached during
separation process)



TS, TP, TN, TOC, % Organic



TS, TP, TN, TOC, % Organic

Source: Kalinosky, 2013

Pro: Several Studies Indicate Most of the Nutrient Load is Associated with Leaves and Larger Particle Sizes !

Percent of pollutants (by mass) in street dirt found in Madison, WI (Waschbusch et al. 1999).

	< 63 μm	63-250 μm	>250 μm	Leaves
Sediment	2.5	15.5	74	8
TP	5	15	50	30

See also, Kalinosky et al, 2013

Con: Not According to My Data !

- Numerous studies have shown the opposite, that the bulk of the nutrient load is associated with the finest particle sizes (Sansalone, Vaize and Chew, Migutanna, NURP etc).
- Much of current sweeper technology cannot pick up these smaller particles !

What is Trapped in the Curb Reaches the Storm Drain/Stream



The curb and gutter system in most urban roads has been engineered to be very efficient in moving sediment and urban detritus to the storm drain over the course of a year

Yes, High Delivery

- Both storm drains and catch-basins are designed to be self-cleansing so that what goes in is what goes out over the course of the year.
- Outfall nets capture large quantities of leaf and lawn clippings which have a high nutrient content (Law et al, 2013)

No, Low Delivery

- Much of what gets in the storm drain is trapped in catch-basins, which is further proof of the poor mobility of leaf detritus



Photo Credit: Ken Belt

Detritus Particle Size Decreases Over Time and a Downstream Direction

- The initial "grain size" of urban detritus is quite large (more than 1000 microns), but progressively becomes finer grained throughout the year, and through the urban landscape. This is caused by physical and mechanical fragmentation, leaching and decomposition

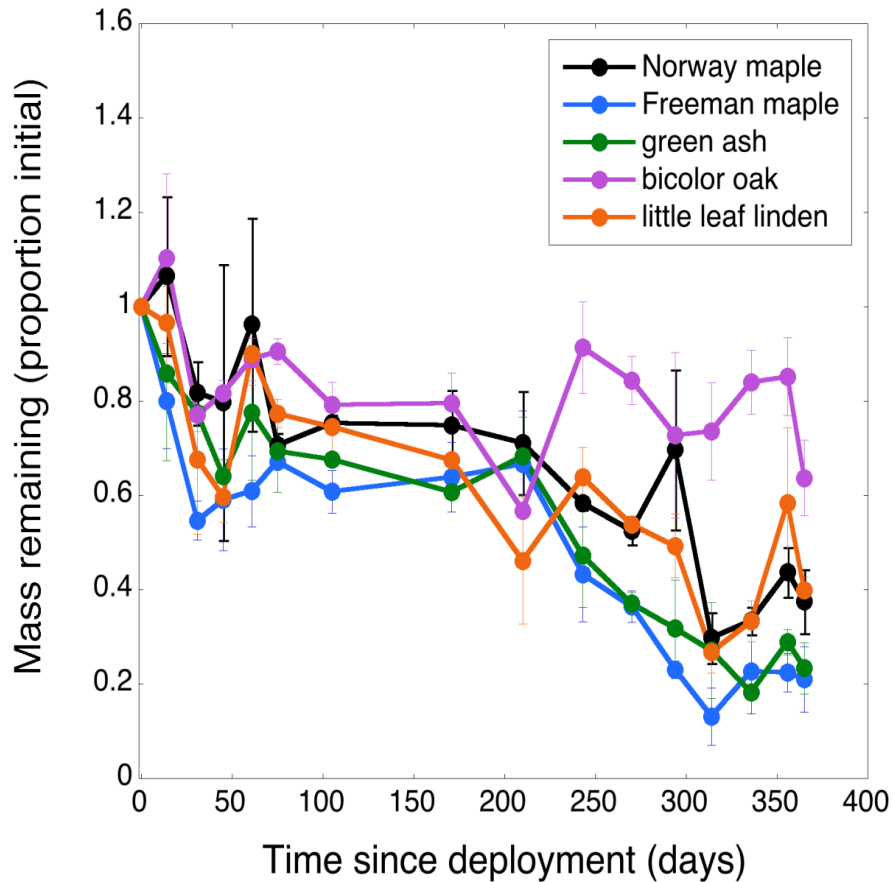


Yes, Particle Size Decreases

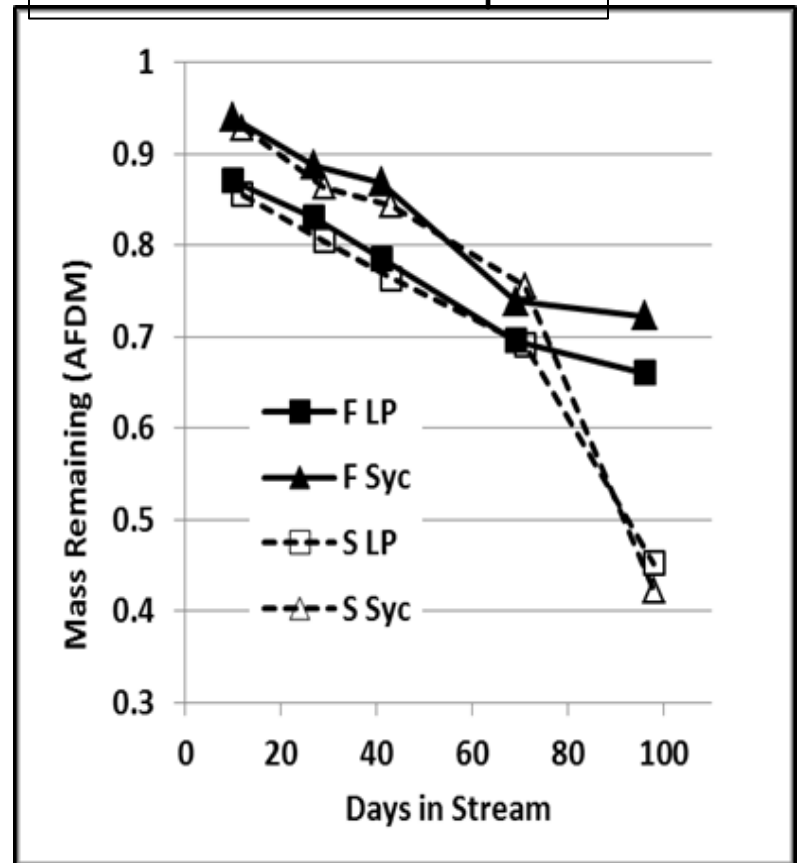
- Further fragmentation and decomposition occurs as organic carbon moves through catch basins, storm drains and urban streams (urban leaf pack experiments by Paul, 2000).
- Imberger et al (2008) note that higher decomposition rates in urban streams are primarily due to the greater microbial community present.

Pervious Area Leafpack

Leaf litter nitrogen content



Urban Stream Leafpack



Data Credit: Ken Belt

Rapid initial loss, followed by steady loss thereafter

No, Probably Not Delivered to Estuary

- Detritus should behave like coarse grained sediments and be trapped within the stream corridor and floodplain, and have a very low delivery ratio to the Bay
- The "shredder" community found in forest streams is noticeably absent in urban streams

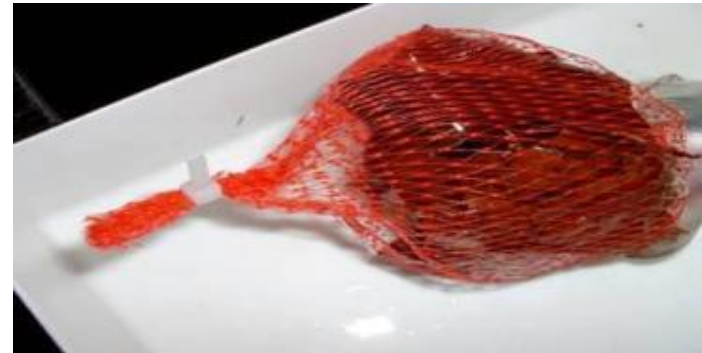
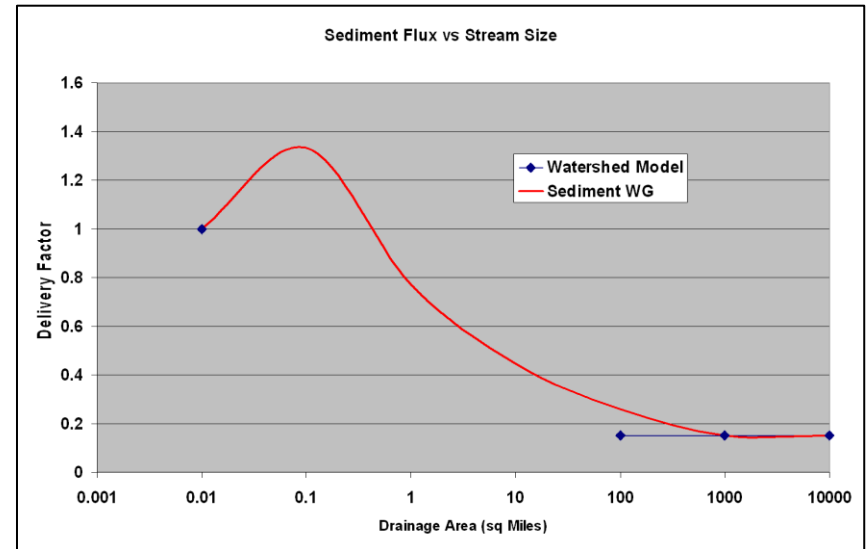


Photo Credit: Ken Belt

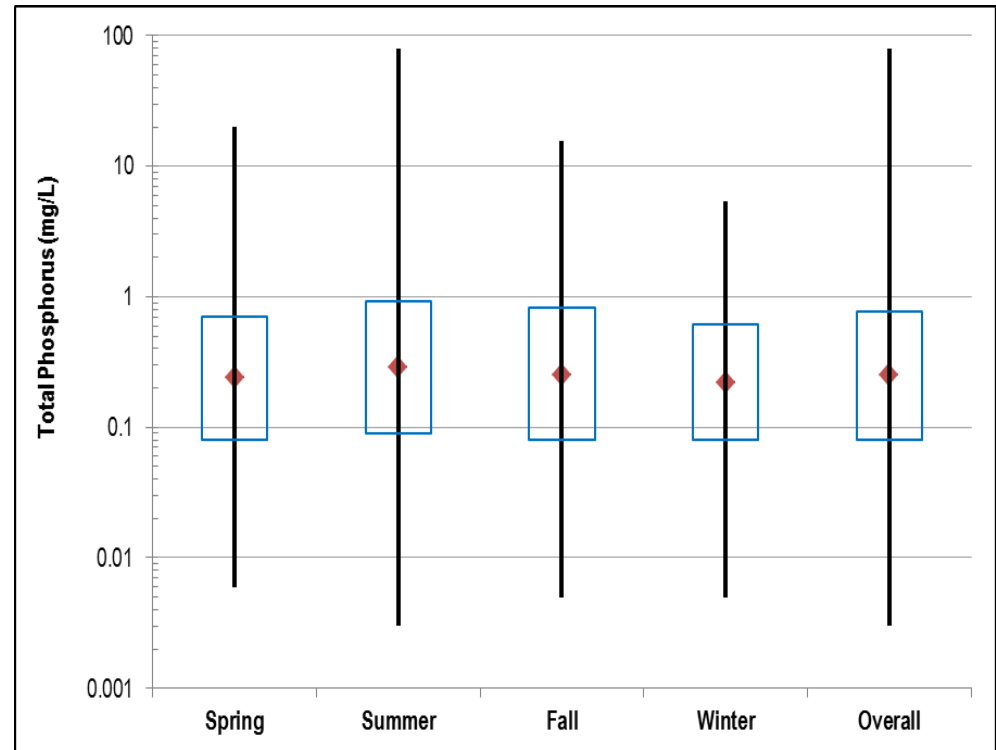
Part 2

- What evidence do we have that carbon and nutrients are discharged from storm drain pipes ?

Where's the Beef ?

30 years of stormwater sampling has failed to show:

- High nutrient levels in stormwater runoff
- Any seasonal pulses in nutrient levels



Source: Tetrattech, 2014

Well, Outfall Sampling Intakes Don't Measure the Detritus...But, We Know It's There



Photo Credit: Bill Selbig



Photo Credit: Bill Stack

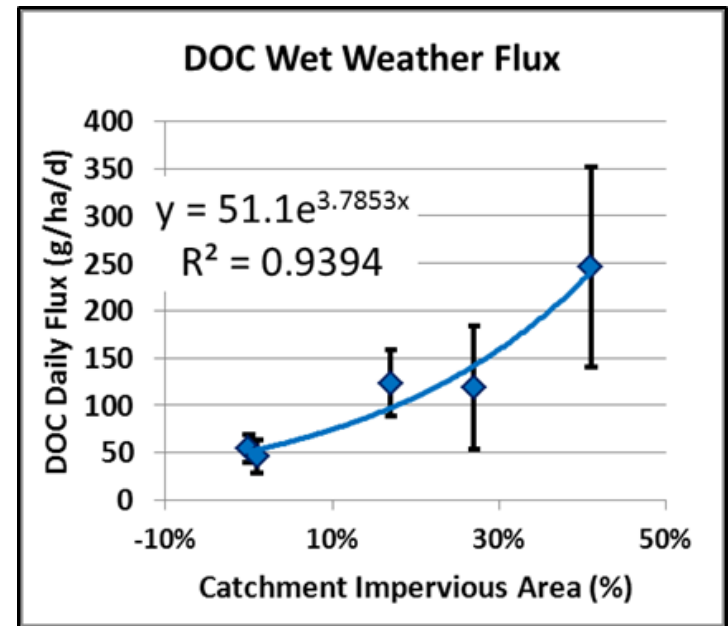
The small diameter and bottom location of automated sampler intakes ensures that the much of the floating, large diameter urban detritus is not measured !

Is TOC Flux Higher During Storms in Urban Streams than Agricultural or Forest Streams ?



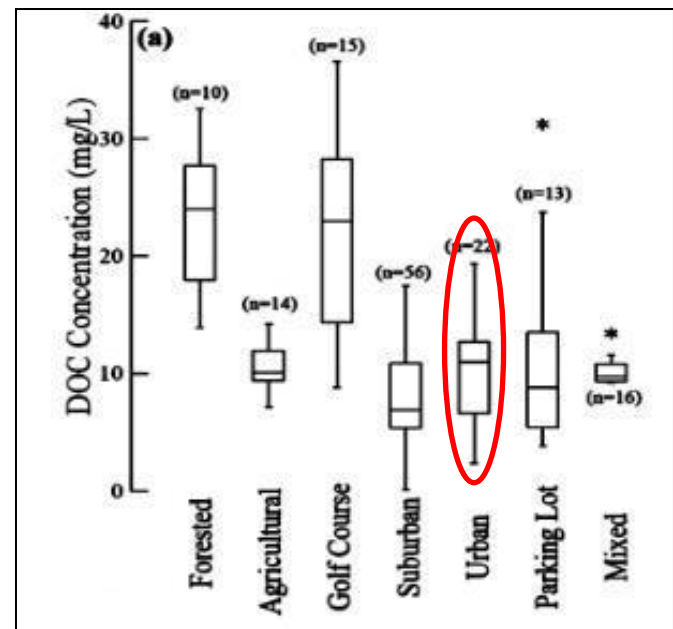
Storm DOC & TOC is Higher in Urban Streams

- Urban streams have much higher DOC and TOC EMCS and loads during storms than forested watersheds (Kaushal and Belt, 2012, Belt, unpublished, NSQD, 2004, historic monitoring of high BOD/COD levels in stormwater outfalls and urban streams).
- Carbon and nutrient flux increases with percent impervious cover in Baltimore watersheds (Duan and Kaushal, 2013).



DOC Flux Can be Higher in Agricultural or Forest Streams

- Other data show DOC Flux is due to soil flushing and may be higher in other types of streams, particularly during dry weather flows
- Need more comparative data to establish higher storm TOC loads for urban streams



Part 3

Do we have the practices to capture organic matter before it reaches the stream ?

- Seasonal Street Sweeping
- On-lot leaf composting
- Curbside leaf collection
- Catch basin cleanouts
- Outfall net filters

Seasonal Sweeping/Leaf Management Practices Can Effectively Remove Detritus From the Curb

- Agree that we currently lack a seasonally intensive sweeping program to remove urban detritus, but we do have the technology now to do so

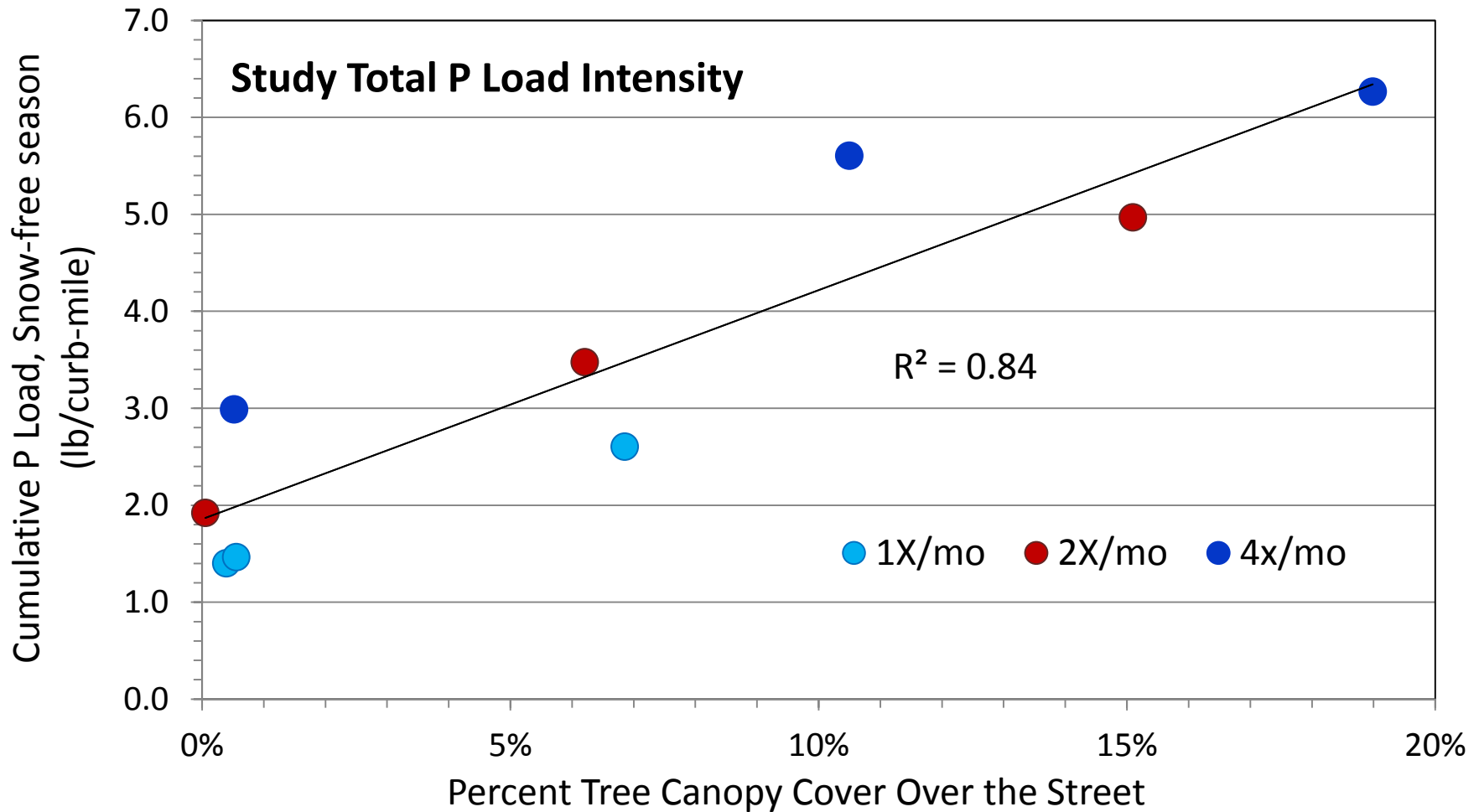


Photo Credit: Roger Bannerman/Bill Selbig

3: Seasonal Sweeping/Leaf Management Practices COULD BE EFFECTIVE in Removing Detritus

- Targeted sweeping on streets with high tree canopy shortly after leaf drop and at the end of winter by vacuum assisted-regenerative air sweepers has shown promise in Upper Midwest
- Can be measured based on the organic and nutrient content of sweeper waste collected

Correlation between Tree Canopy Cover and Recovered Nutrients



Seasonal Sweeping NOT EFFECTIVE in Reducing Nutrient Loads

- What is collected by sweepers does not reach the stream
- No detectable improvement in stormwater nutrient EMCs has ever been demonstrated in any monitoring study !
- Most sweeper technology in Bay can't really get to the curb to get to the detritus

Other Practices May Work

- Innovation can lead the way!
- Use of bag filters and leaf litter pick-up programs can reduce load to urban streams
- Stream restoration to enhance in-stream processing



Photo Credits: Law et al 2013



Photo Credits: MWCOG 2009

Comparison on average nutrient concentration of organic debris gross solid samples.

Study	TN (mg/kg)	TP (mg/kg)
Tred Avon net filters (current study)	9,592	799
Rushton et al., 2006 ¹	8,050	556
City of Baltimore, 2003 ²	2,728	183
Berretta et al. 2010 ³	1,439	426

¹ Represents average of whole and sieved analysis of leaf material taken from CDS unit stored. TKN only. Material collected from CDS unit after 6 to 12 months. Samples sent to lab “as is” after air dried

² Organic debris collected from street sweeper. Material sent to lab without a drying period

³ Represents 'biogenic material' collected from street sweepers in 27 MS4 localities, residential areas in Florida

Source: Law et al, 2013

Catch-basin Cleanouts Don't Work

- Ah, but much of the effectiveness of BMPs is IF the material is captured
- Much of what gets in the storm drain is trapped in catch-basins, which is further proof of the poor mobility of leaf detritus



Photo Credit: Ken Belt

Baltimore County Catchbasins

	Sediment (mg/kg)	Leaves (mg/kg)
Nitrate	12-18	<5
TKN	2,500 - 4,800	500 - 1,500
TP	800 - 1,200	200 - 800
Ortho-P	10 - 110	100 - 220

The catch basin bias effect:

Most catch basins surveyed in Baltimore did not have any deposits of any kind (Stewart, 2008)

Summary and Q & A

