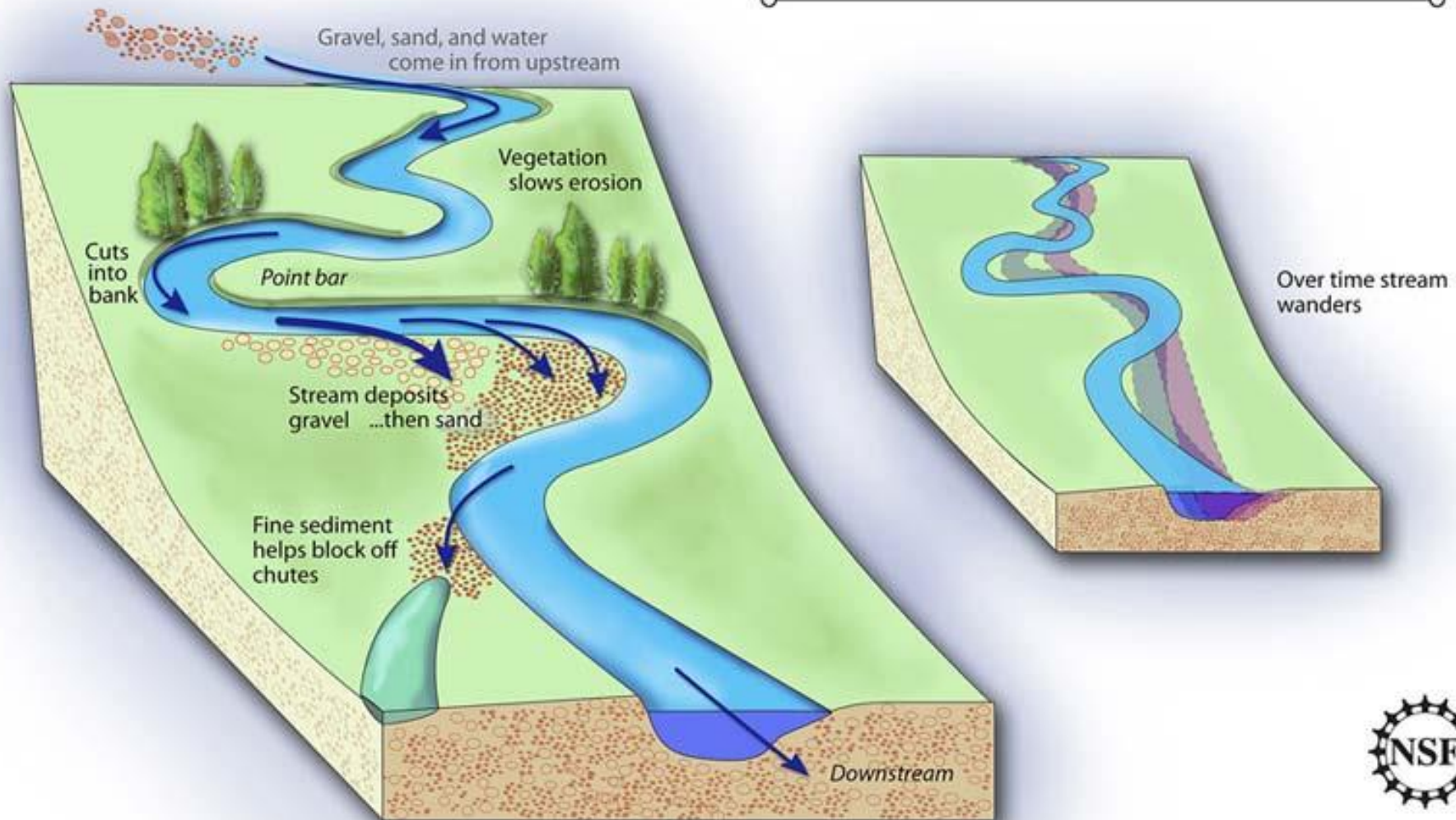


Evaluation of Legacy Sediment Removal and Floodplain Reconnection as a Restoration Technique



Vanessa B. Beauchamp and Joel Moore
Towson University

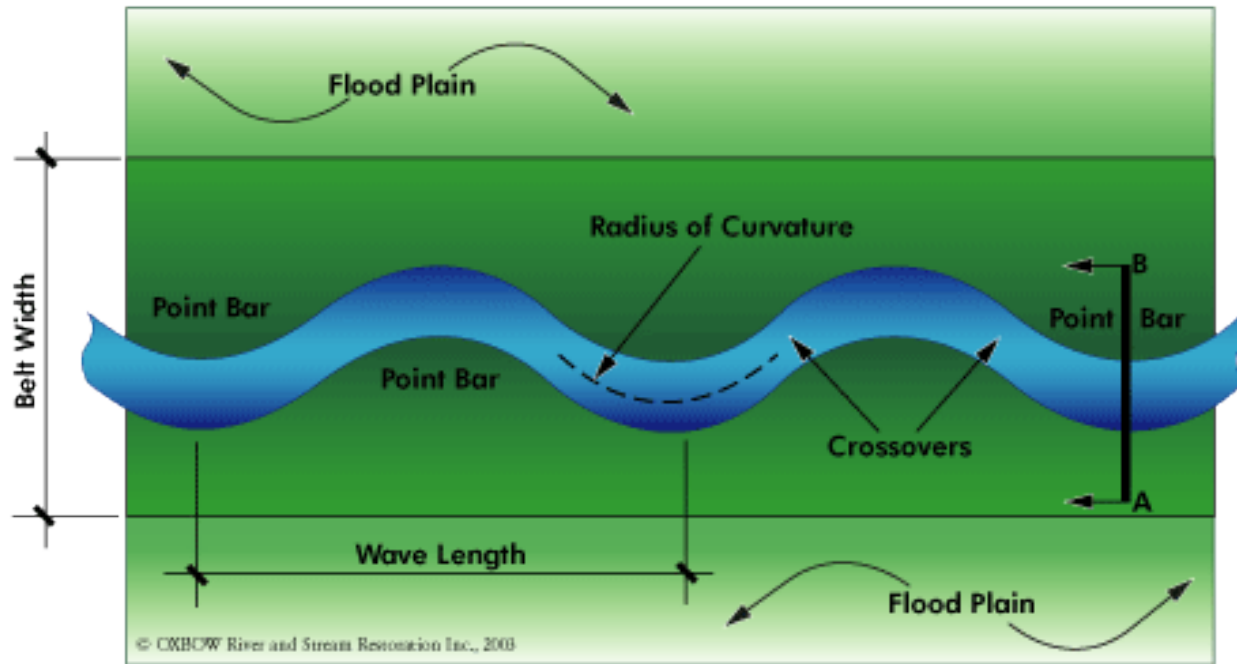
INGREDIENTS FOR A MEANDERING RIVER



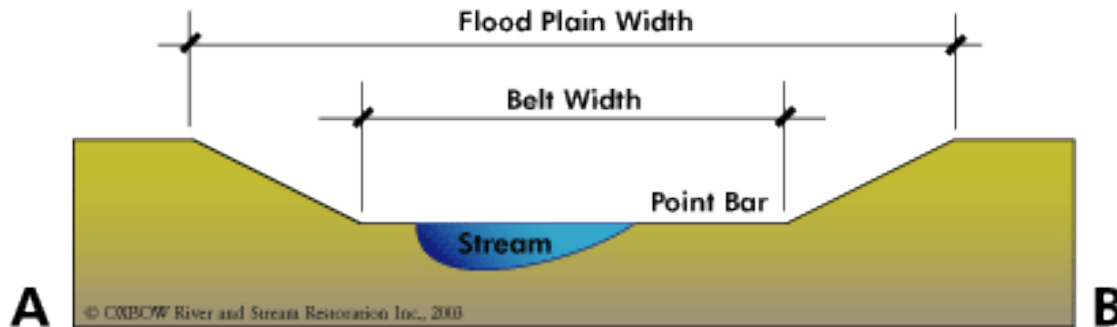


<https://lternet.edu/research/keyfindings/river-corridors>

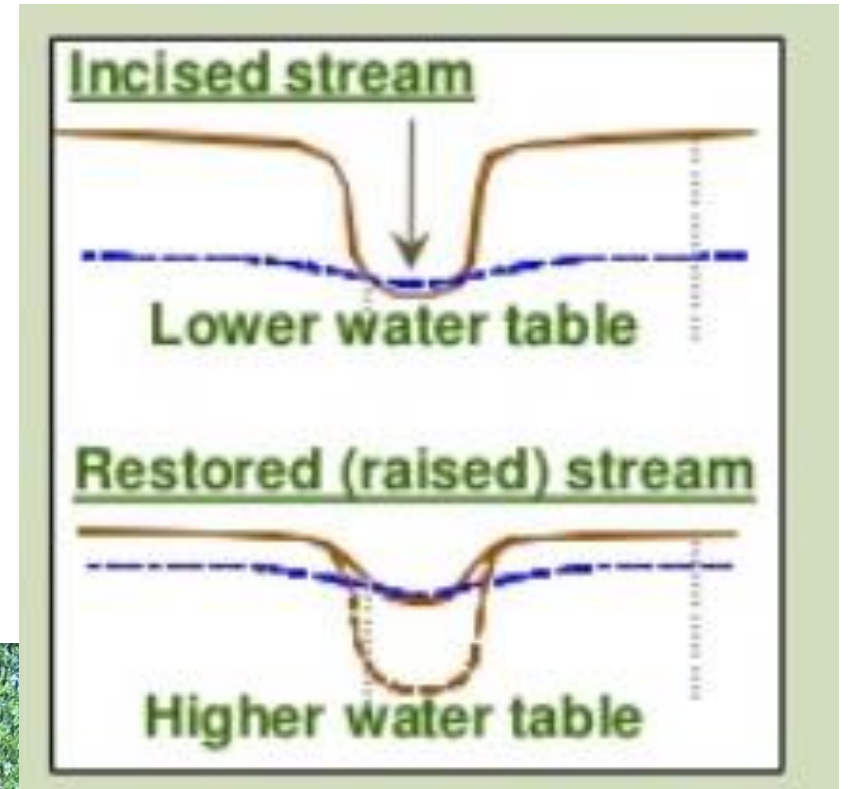
MEANDER GEOMETRY



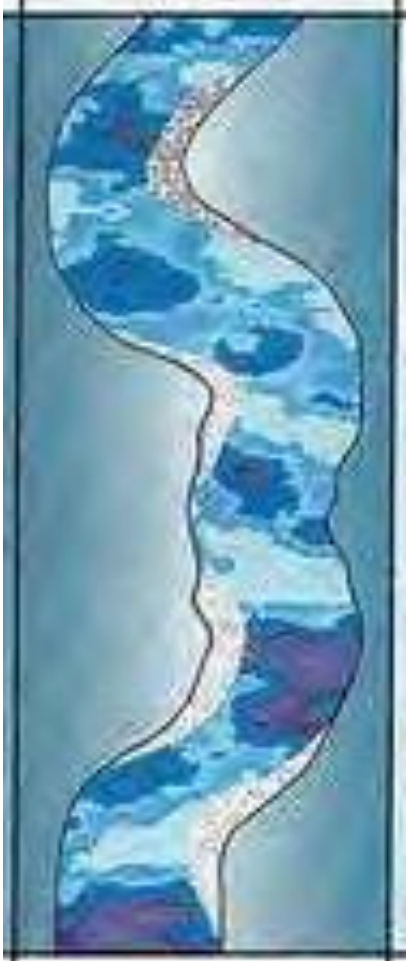
MEANDER CROSS SECTION AB

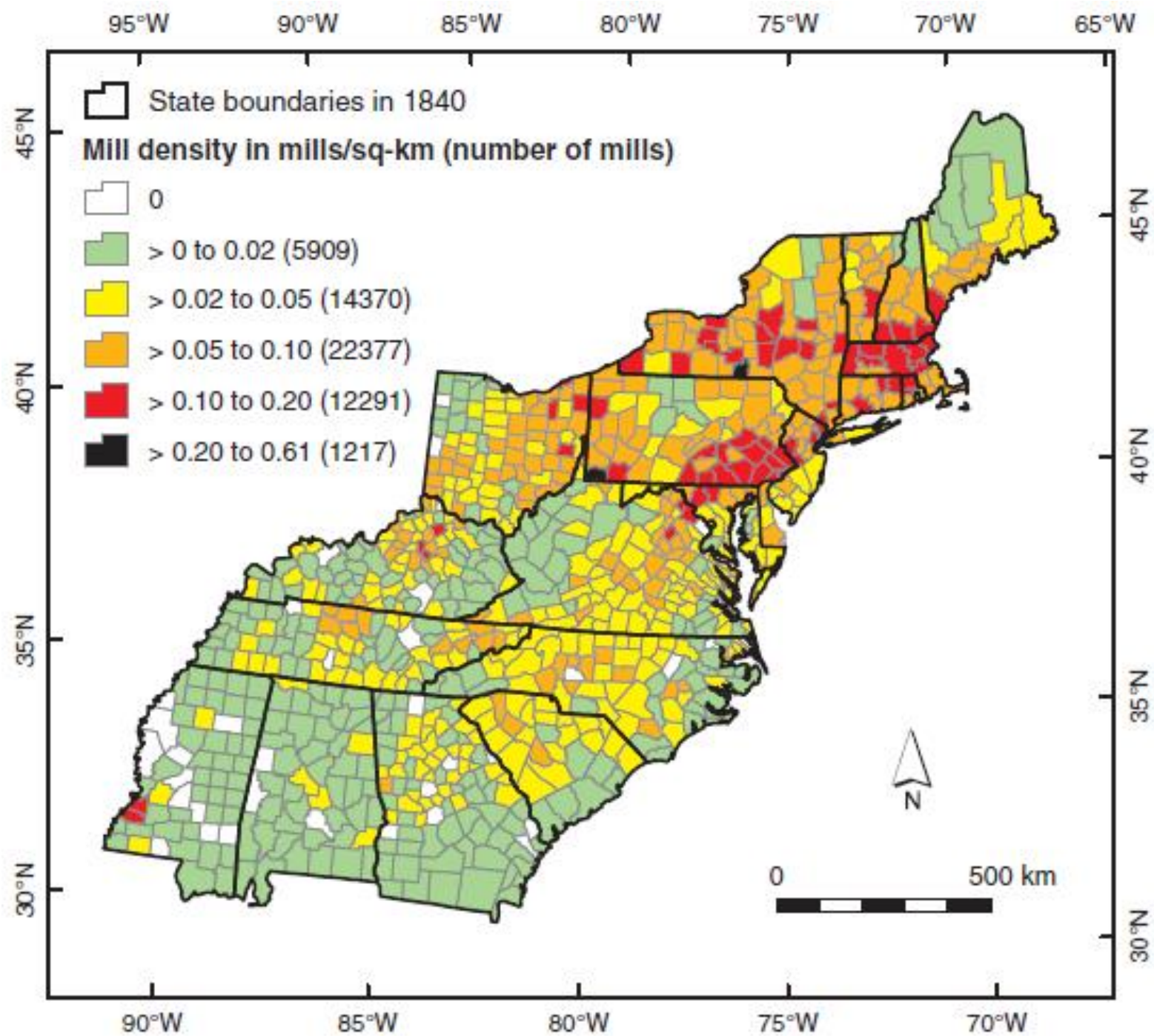


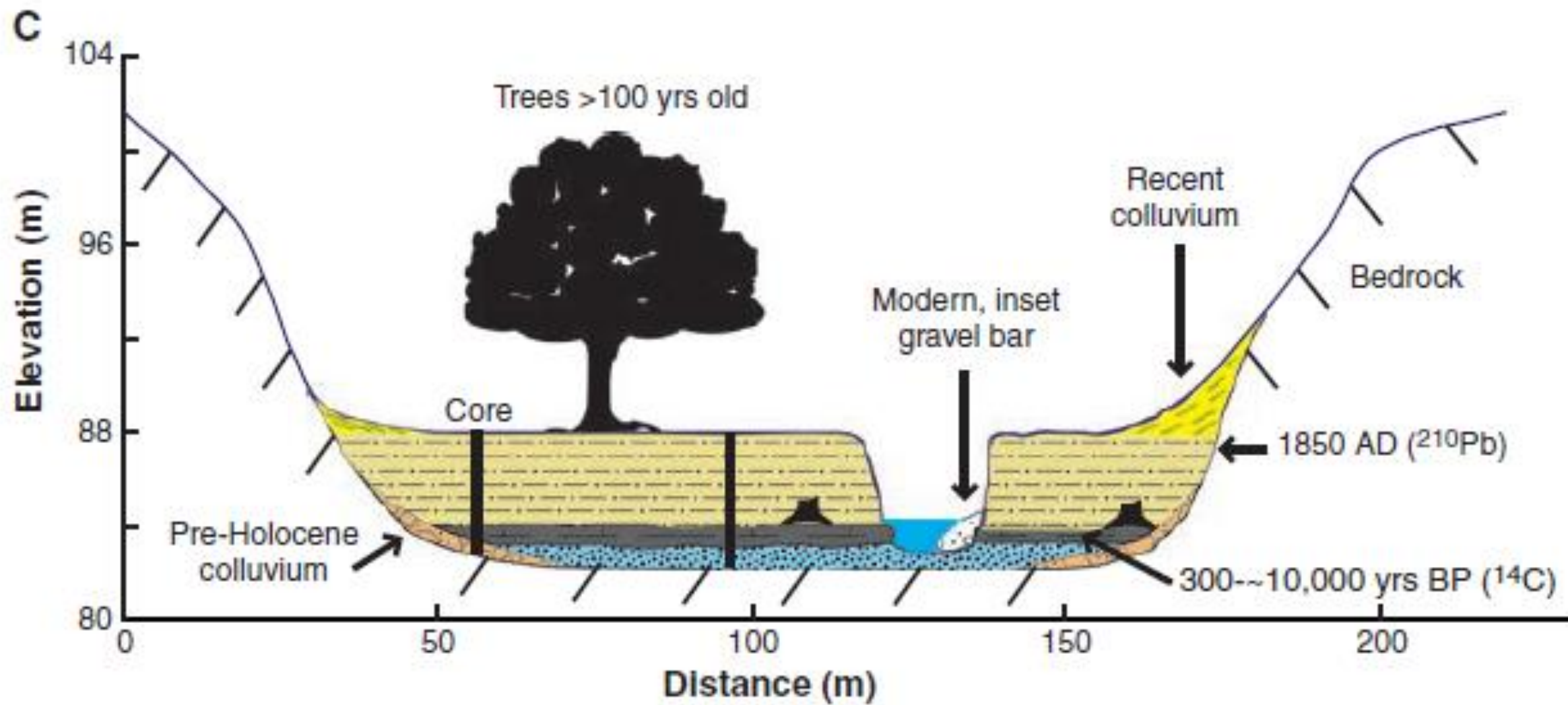
http://www.oxbowriver.com/Web_Pages/Services_Pages/Services_NCD/NCD_Meander.html



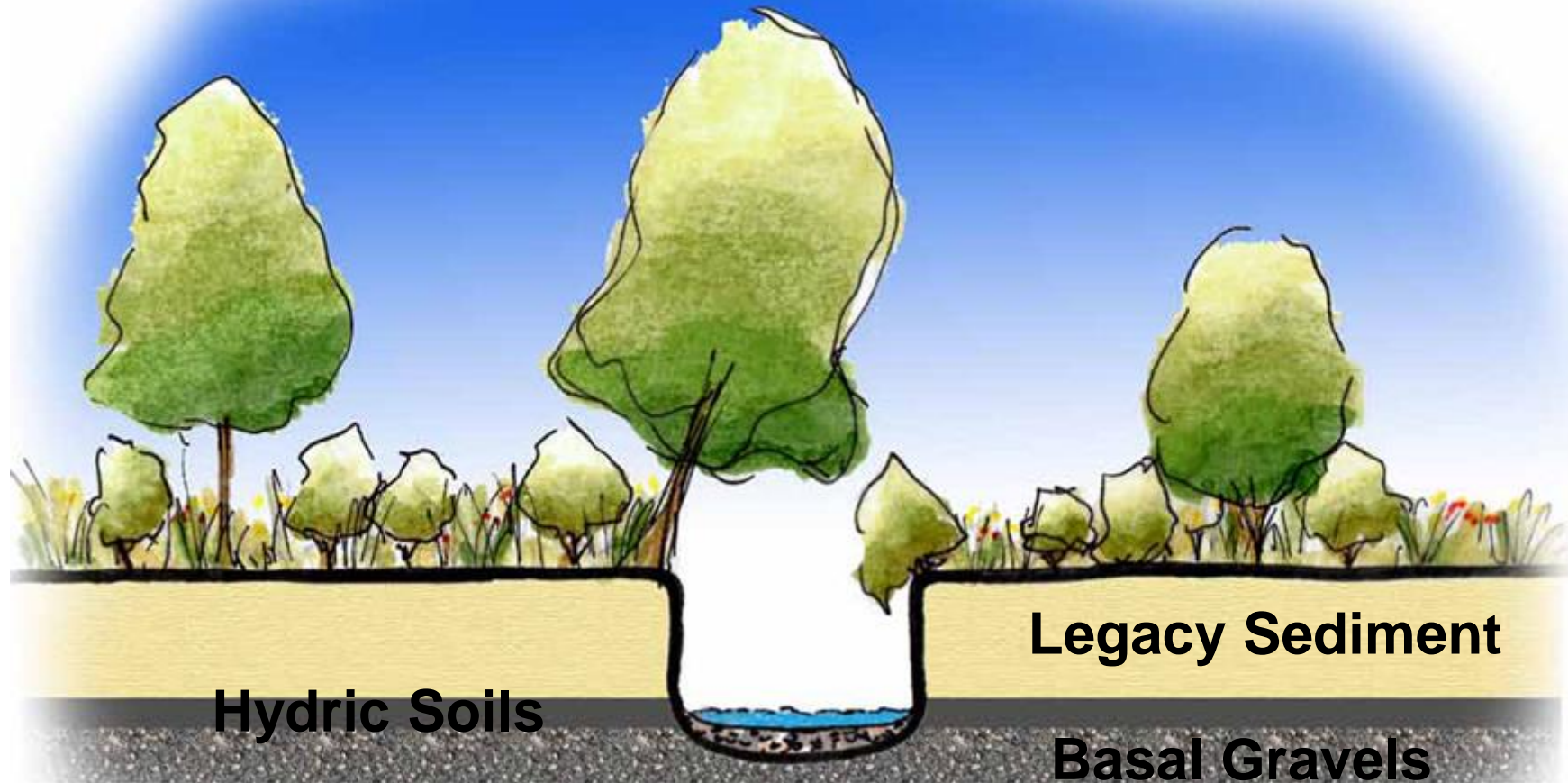






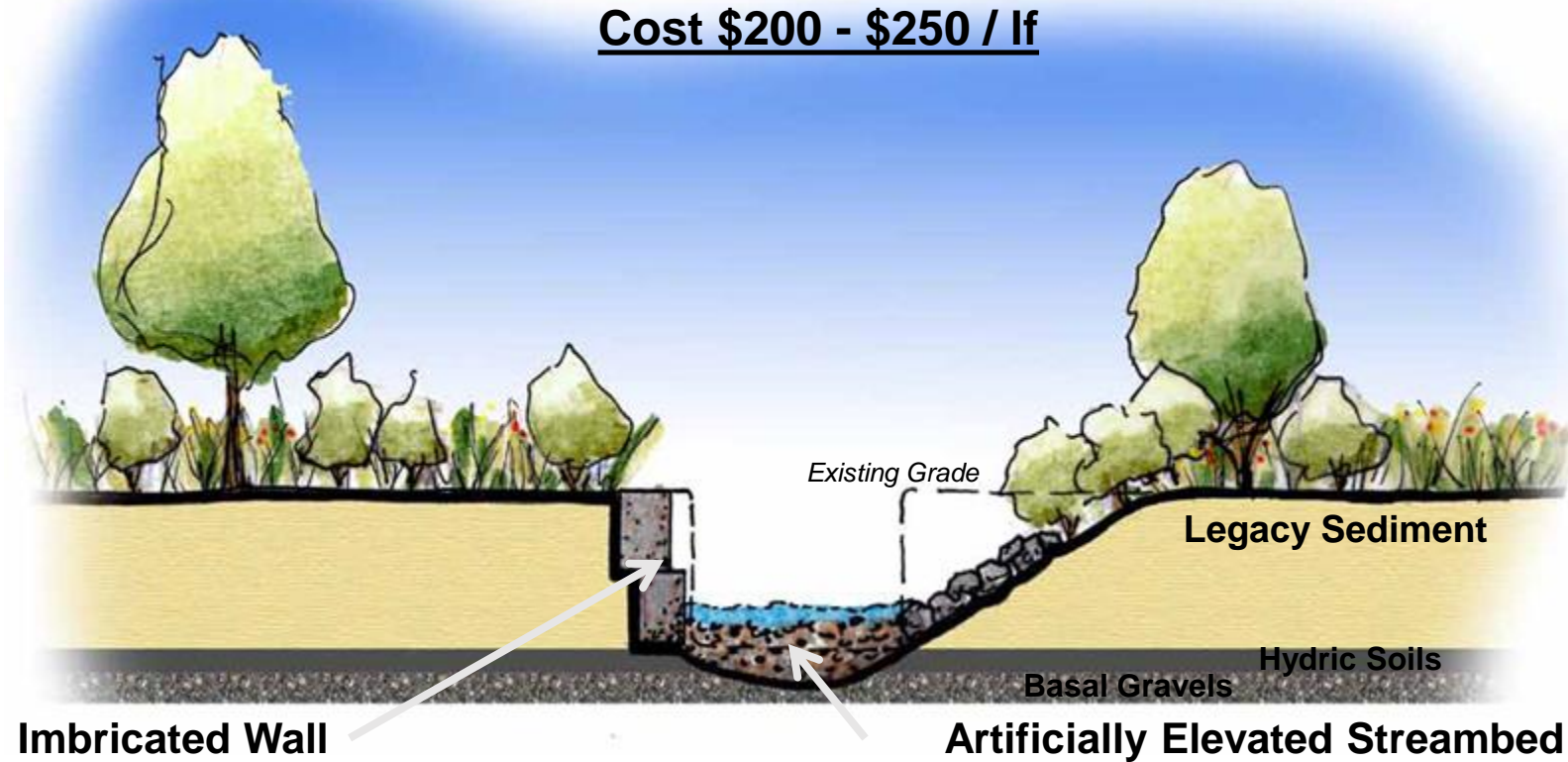


Existing Conditions



Legacy Sediment is the impairment to the aquatic resource

Hard Armor Approach



Short Term Benefit

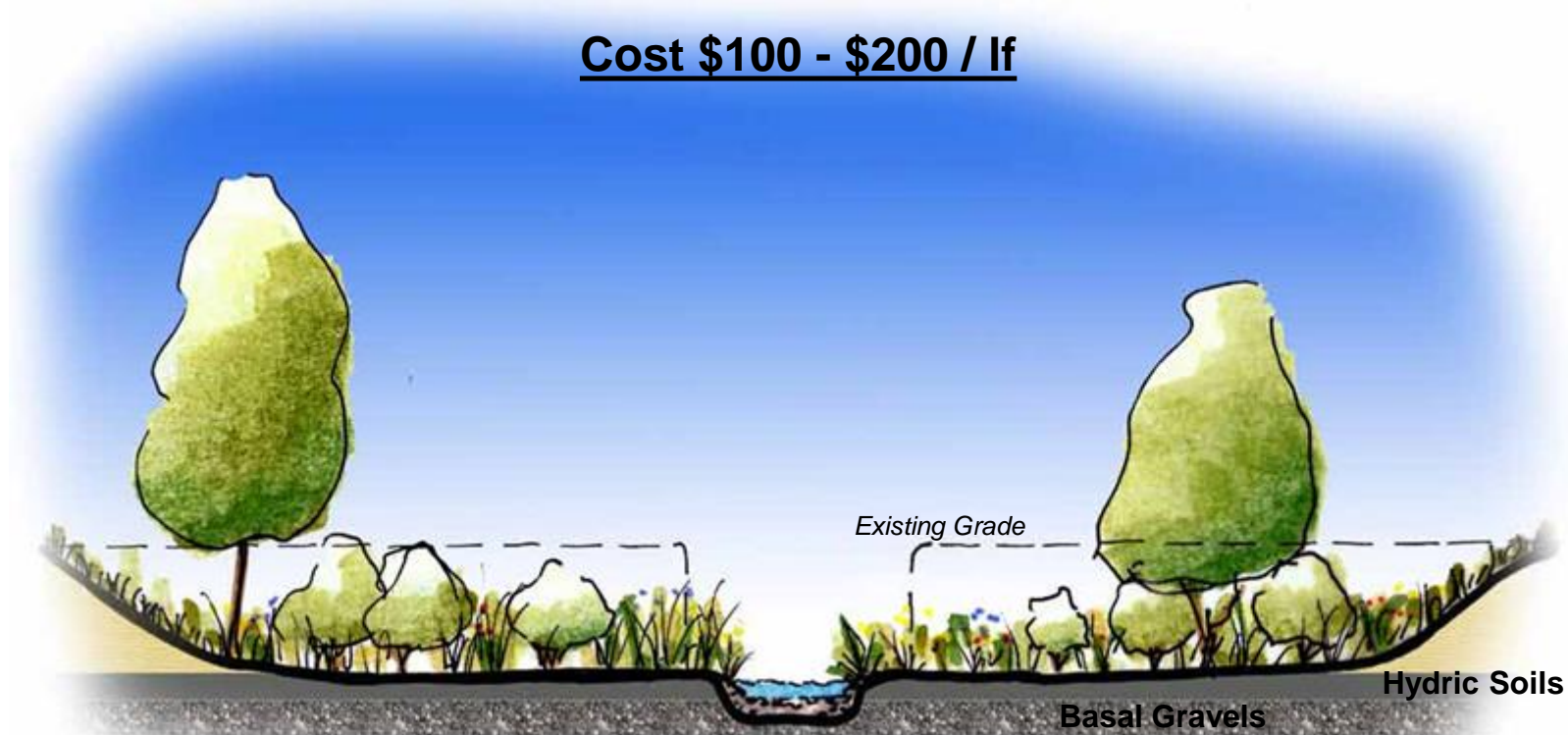
- Reduced erosion of impairment
- Minimal improvement to aquatic resource

Long Term Risk

- Failure of armoring resulting in renewed erosion of impairment

Floodplain Restoration

Cost \$100 - \$200 / lf



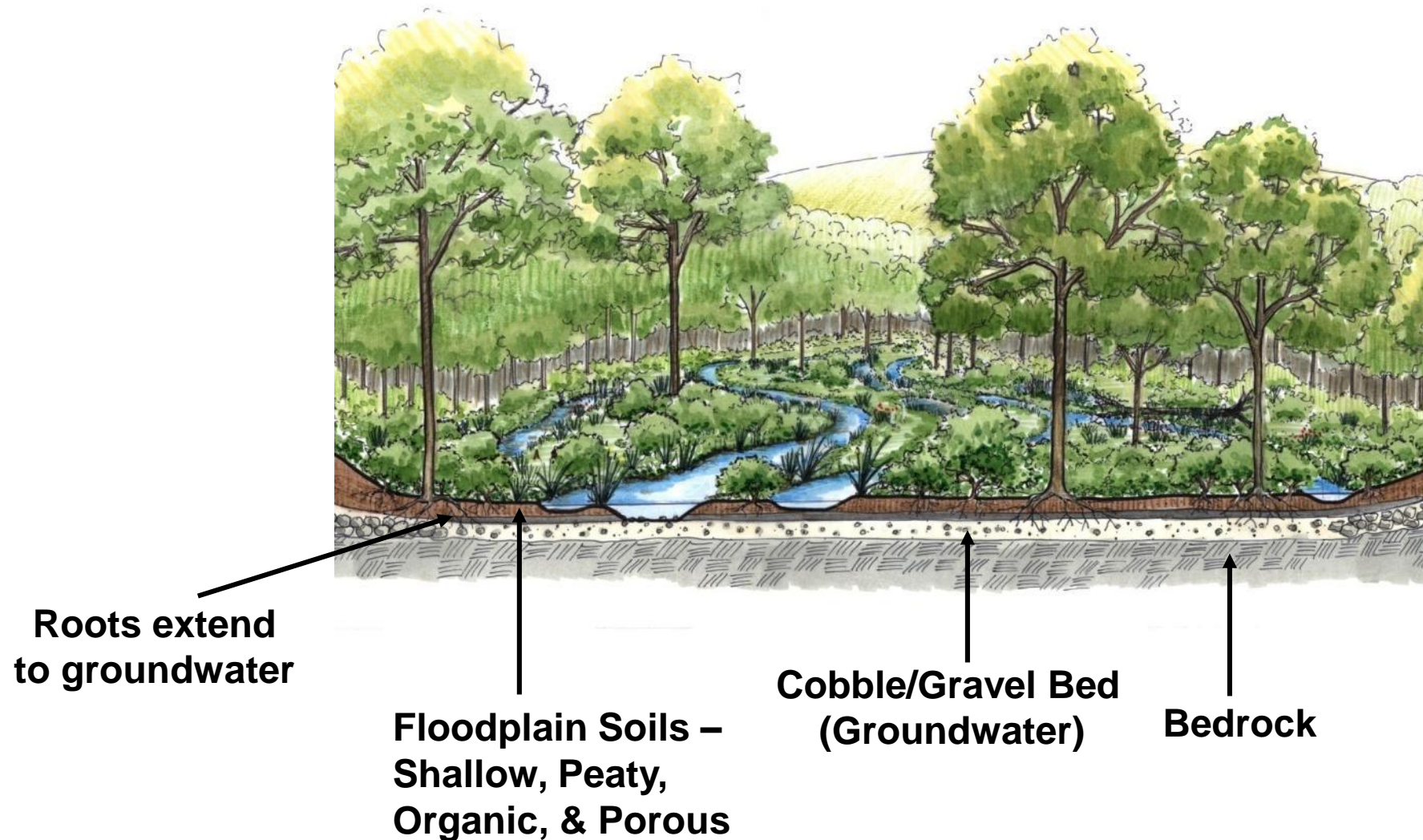
Short & Long Term Benefit

- Removal of impairment
- Restored function of aquatic resource



Natural Piedmont Stream Valley

Connectivity between rooting zone, groundwater, and stream flow



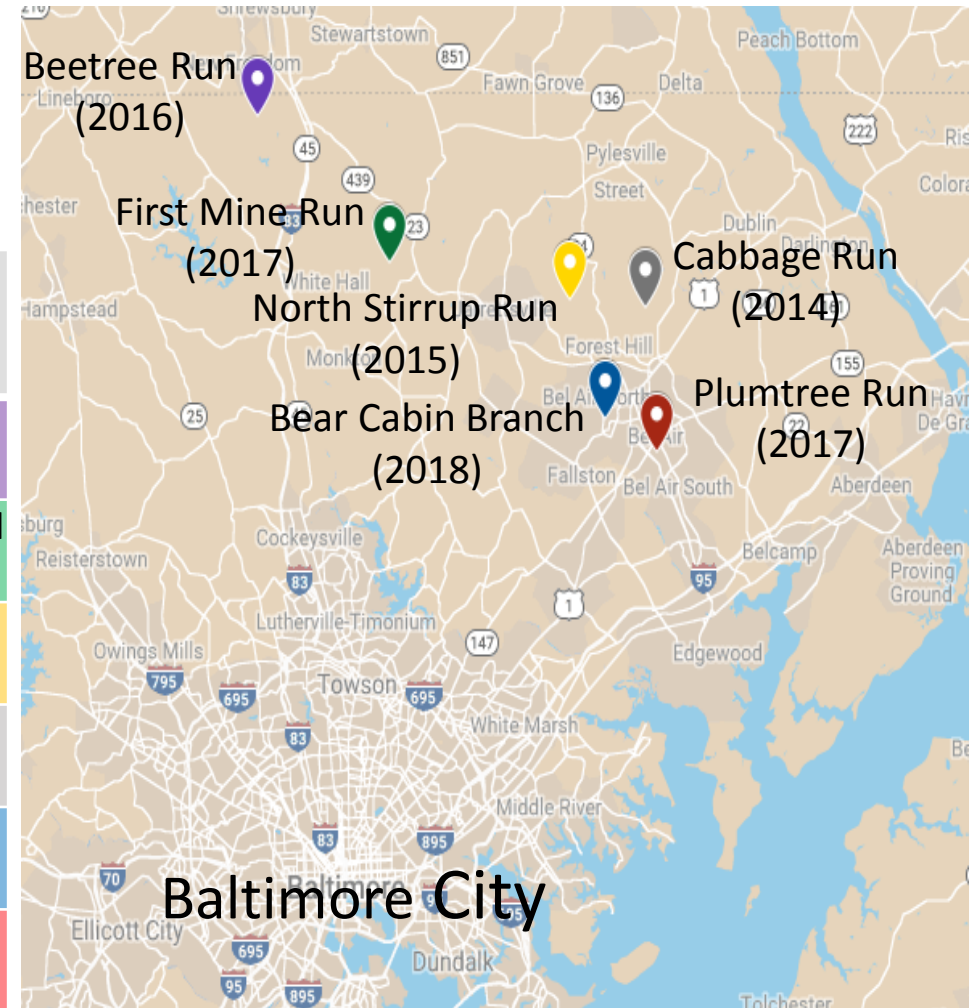


Evaluation of Legacy Sediment Removal and Floodplain Reconnection as a Restoration Technique

- Vegetation
 - Increased dominance of hydric vegetation
 - Response to disturbance? Invasives?
 - Change in community composition
- Water chemistry
 - Relationship with drainage area? Impervious cover? Project length?
 - Decrease in N, P and TSS due to increased overbank events and longer residence time.

Study sites

Site	Drainage Area (km ²)	Forest (%)	Impervious surface cover (%)	Restoration length (linear ft)	Usage
BTRD	6.55	14.5	1.26	5320	Reforested / Retired Agricultural
BTRU	6.03	13.3	1.03		
FMRD	3.88	26.4	1.26	2400	Row crop with (former) forested buffer
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PTRD	0.96	5.01	56.4	1240	Dense urban
PTRU	0.88	3.29	54.9		





Bear Cabin Branch





Bear Cabin Branch

A photograph of a forest stream. The foreground is dominated by a dense, vibrant green field of low-lying plants, possibly water hyacinths, which appear to be growing in or along the stream. To the right, a small, shallow stream flows, its water a murky brown color. The banks are heavily wooded with a variety of trees and thick bushes. Some trees have green leaves, while others show hints of yellow, suggesting an early autumn setting. A fallen log lies horizontally across the middle ground, partially submerged in the stream. The background is a dense canopy of trees, with some light filtering through the leaves. The overall scene is a lush, natural landscape.

First Mine Run



First Mine Run



First Mine Run



Plum Tree Run



Plum Tree Run

Plum Tree Run





Plum Tree Run

Vegetation Methods

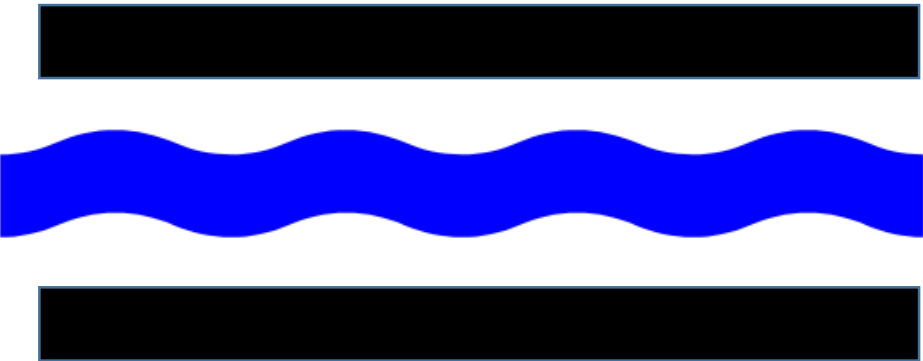
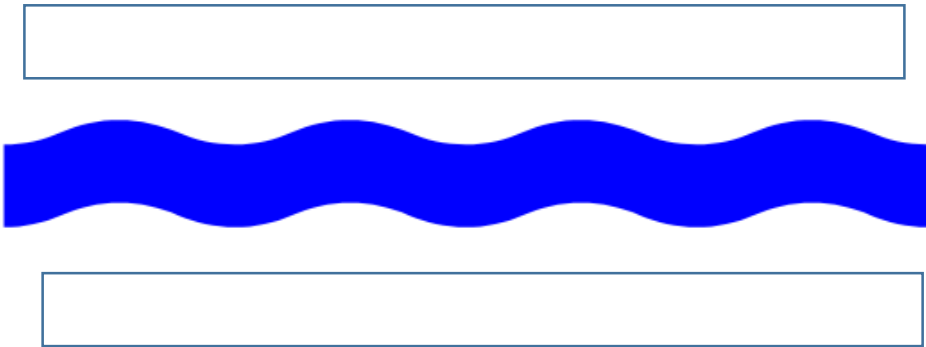


Sampled in spring and fall for two years

Reference

Restored

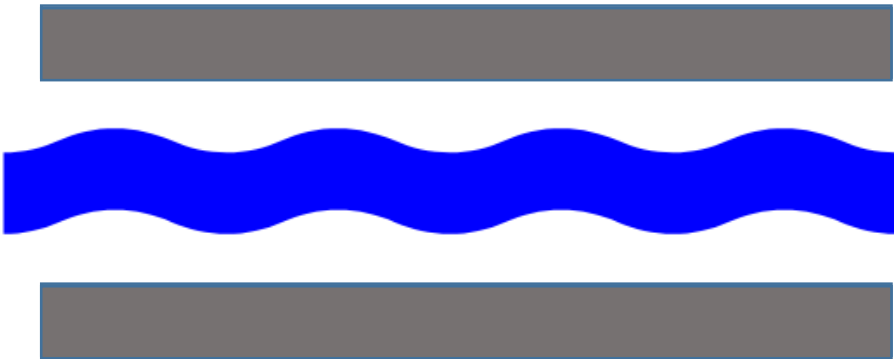
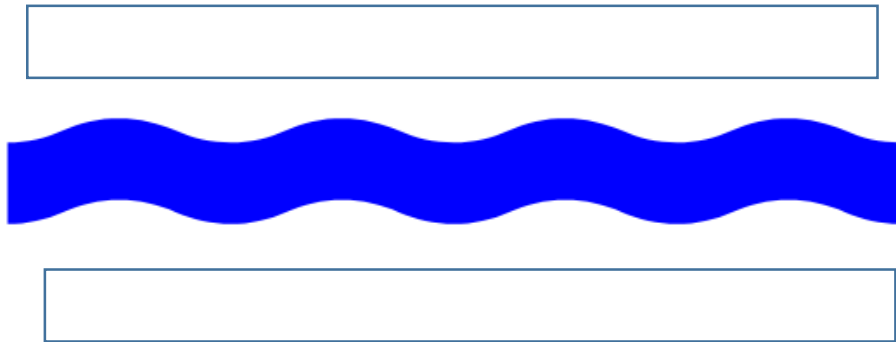
Three sites



Reference

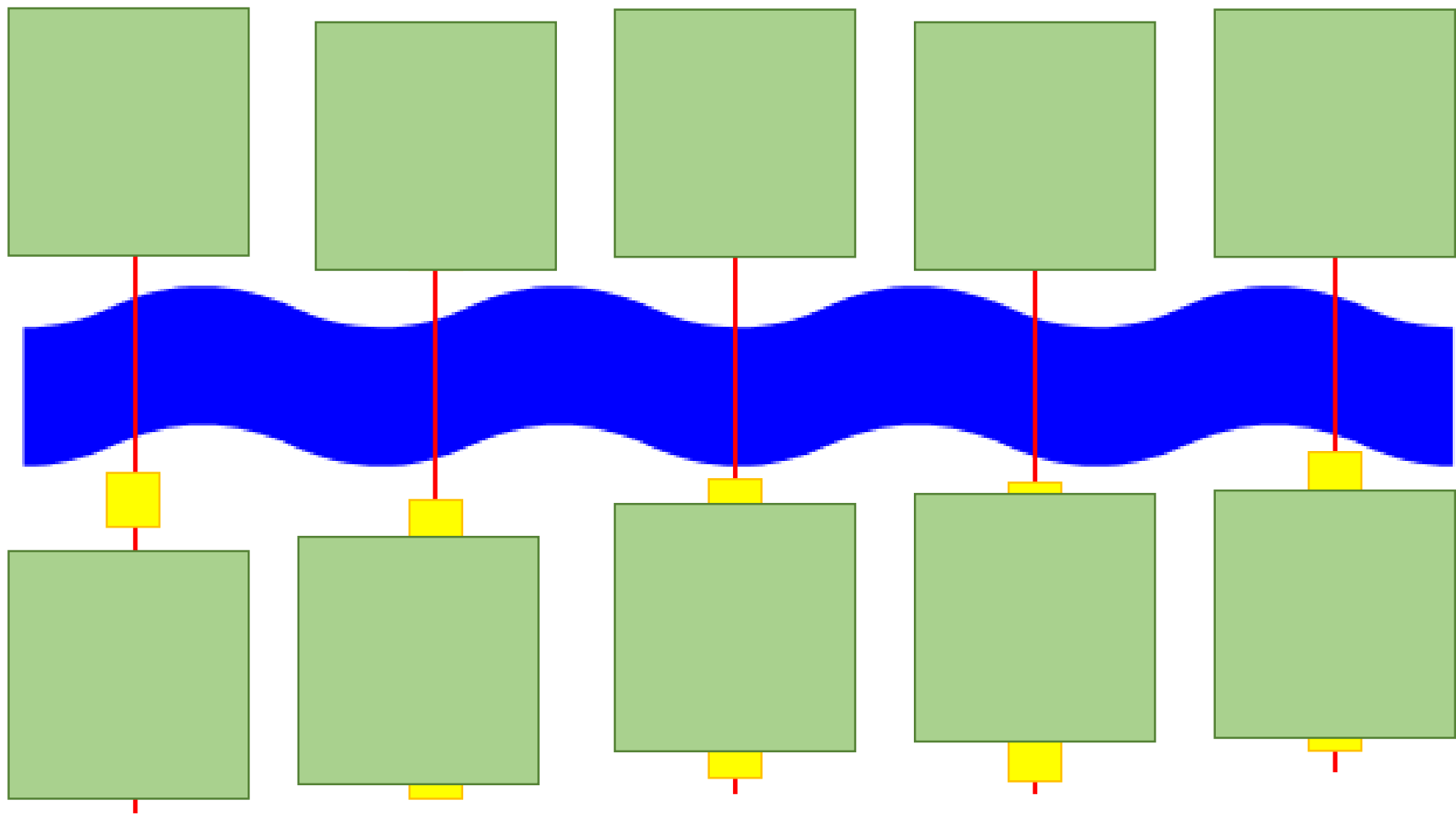
Post Restoration

Three sites



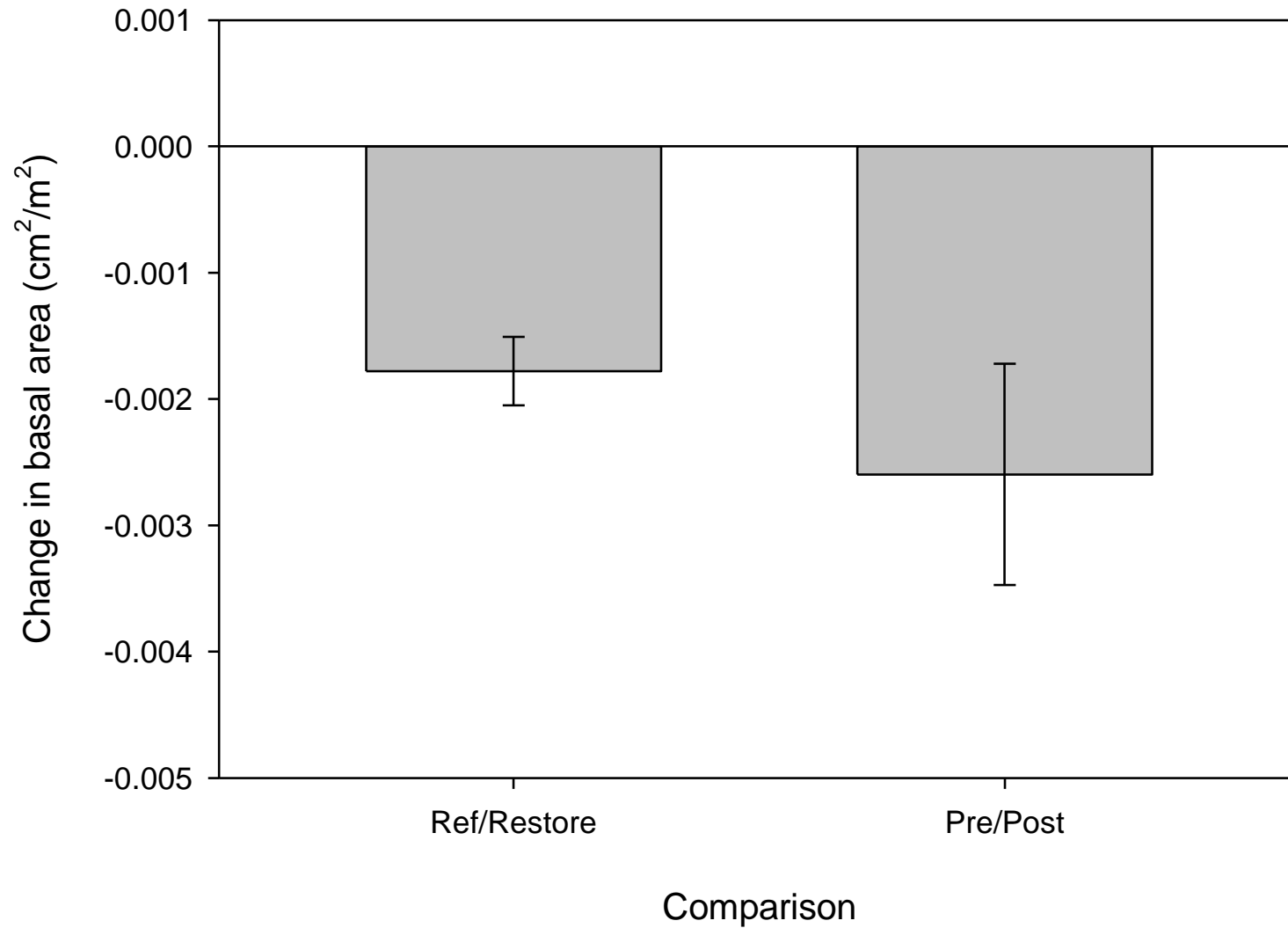
Sampled in spring and fall for two years

Sampled in spring and fall for one year before and one year after restoration





Average 81% DECREASE in basal area



Reference/Restored Reaches

Cabbage Run

North Stirrup Run

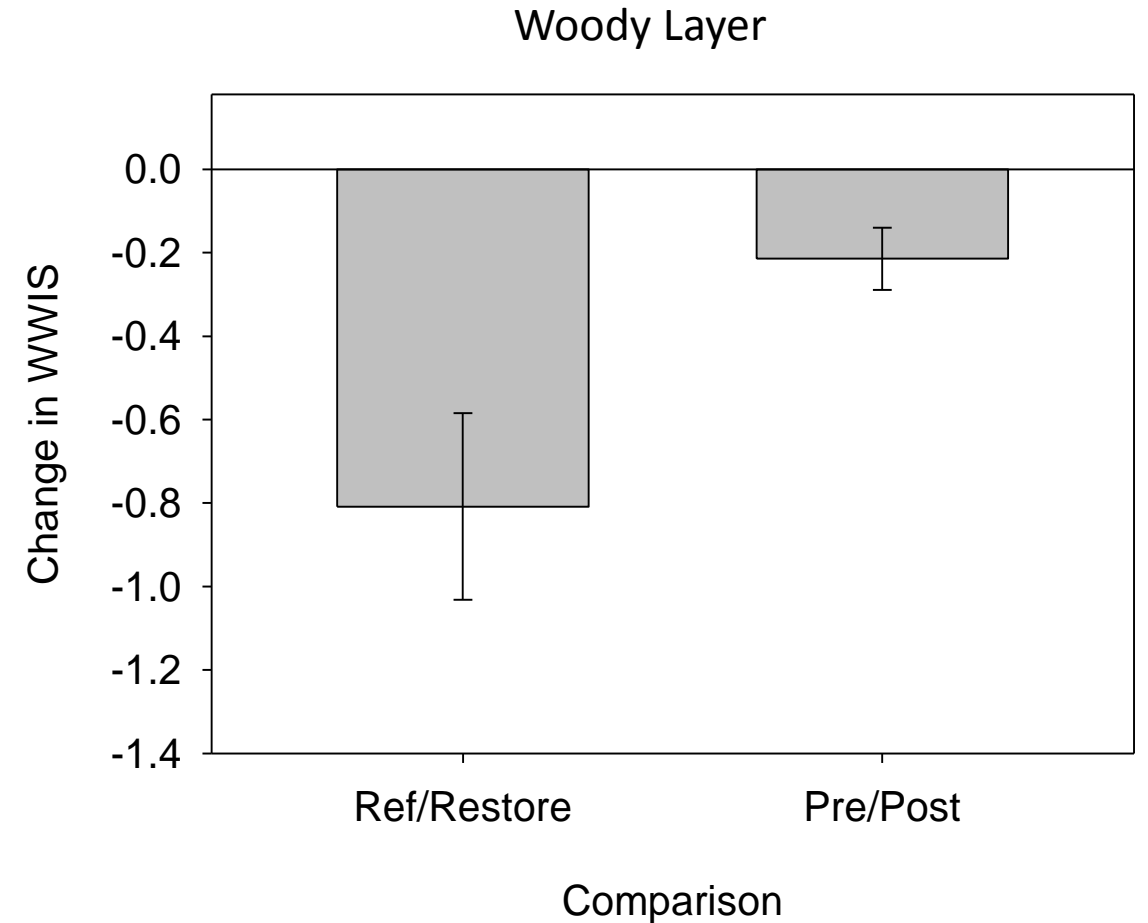
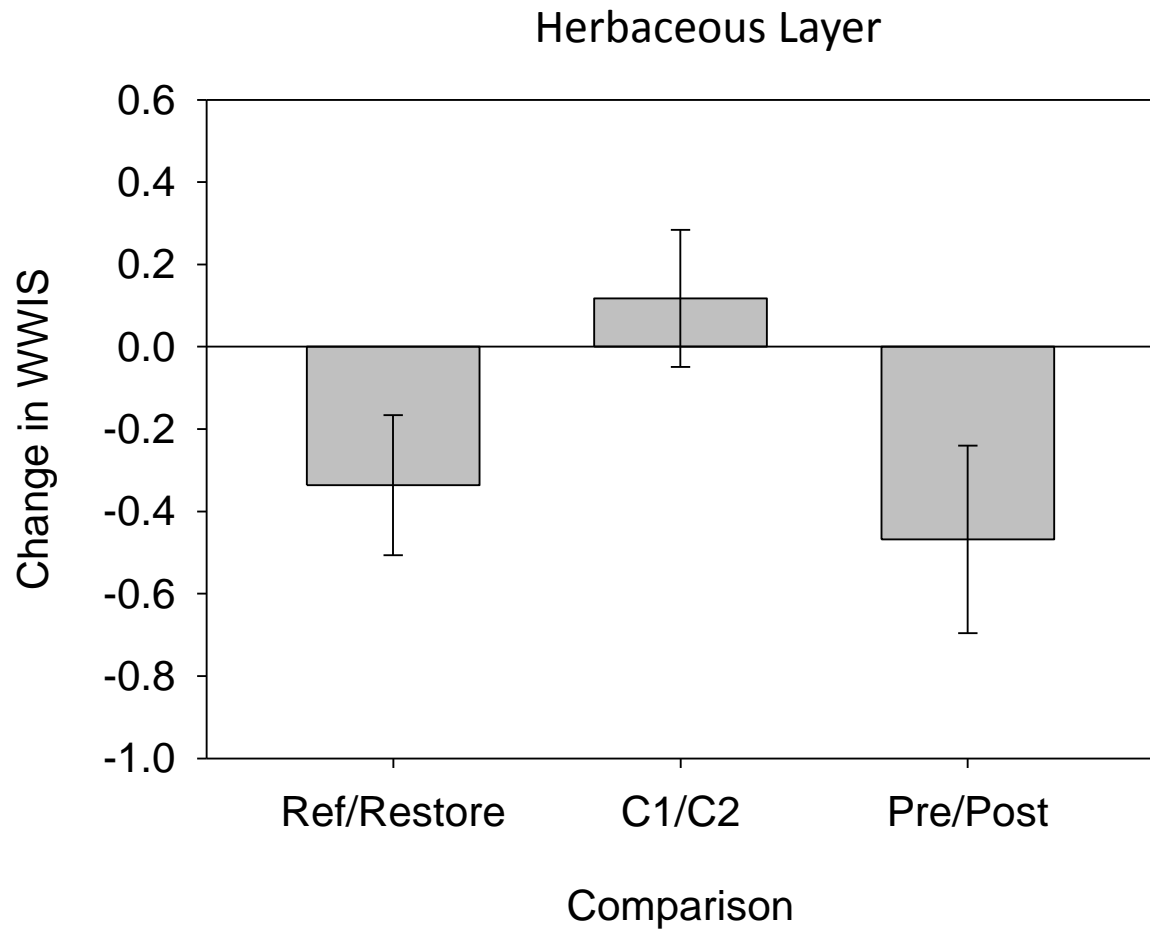
Bee Tree Run

Pre/Post Restoration Reaches

Bear Cabin Branch

First Mine Run

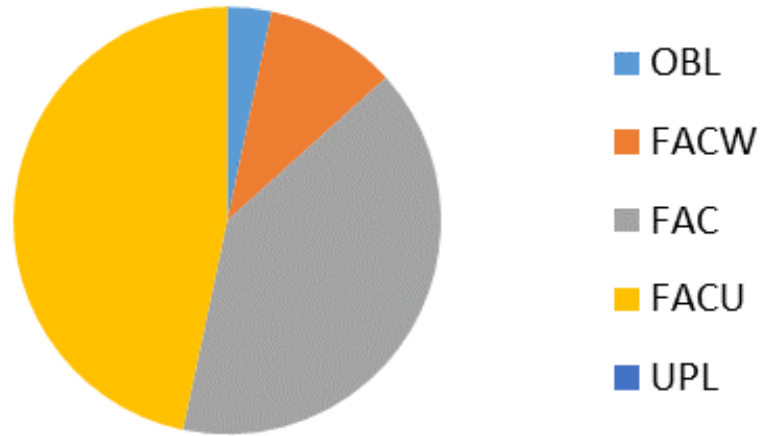
Plum Tree Run



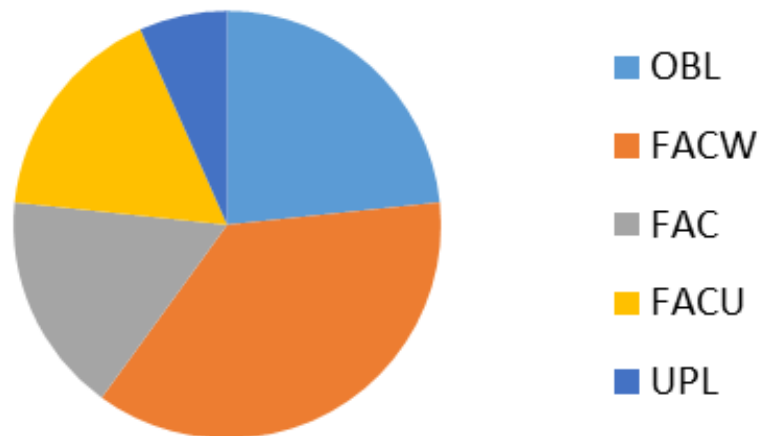
Significant increase in hydrophytic vegetation in both the herbaceous and woody layers (Herb $p = 0.028$; Woody $p = 0.028$)

Herbaceous Layer

Reference/Unrestored



Restored



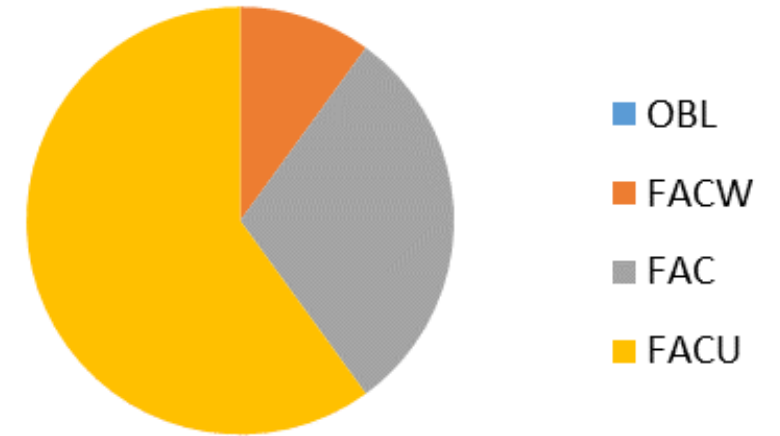
Top 30
herbaceous
and top 10
woody species
by Importance
Value

Increase in
OBL and FACW

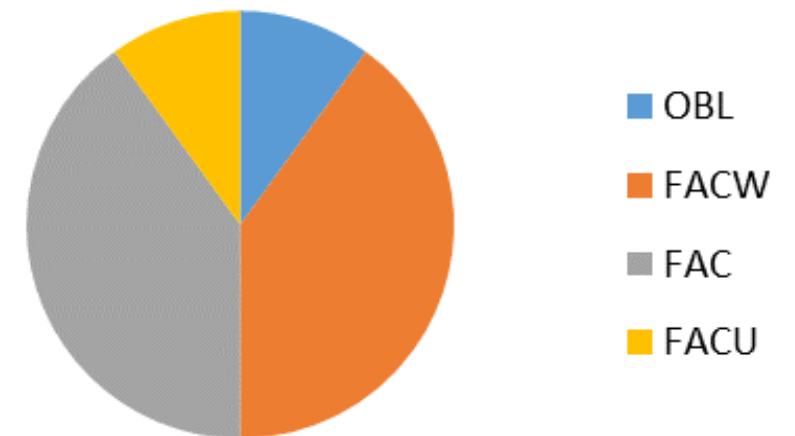
Decrease in
FACU

Woody Layer

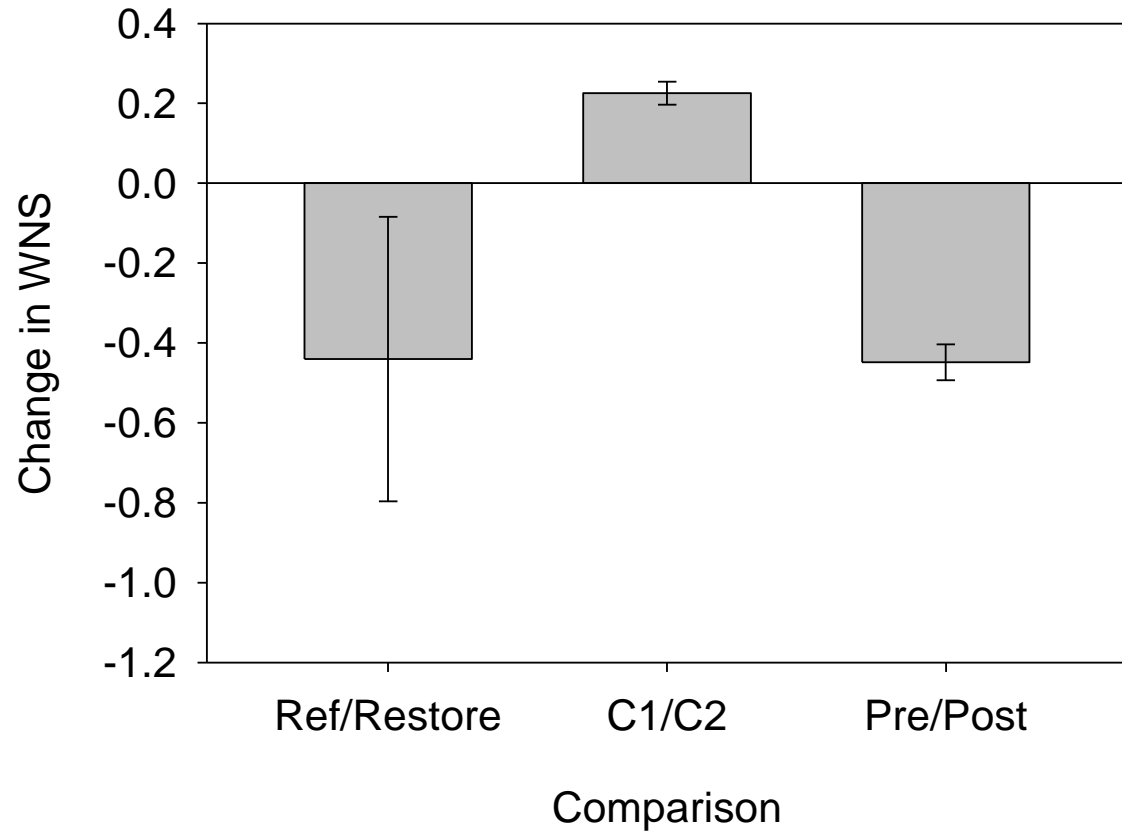
Reference/Unrestored



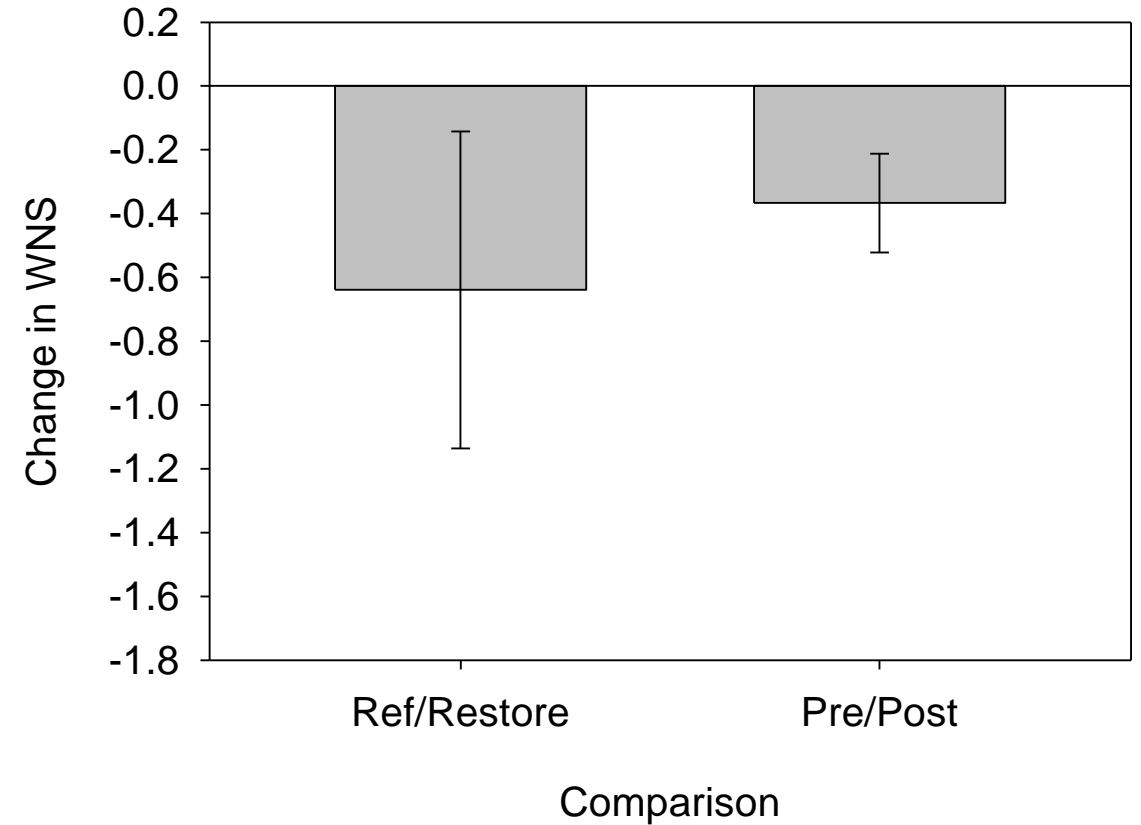
Restored



Herbaceous Layer



Woody Layer

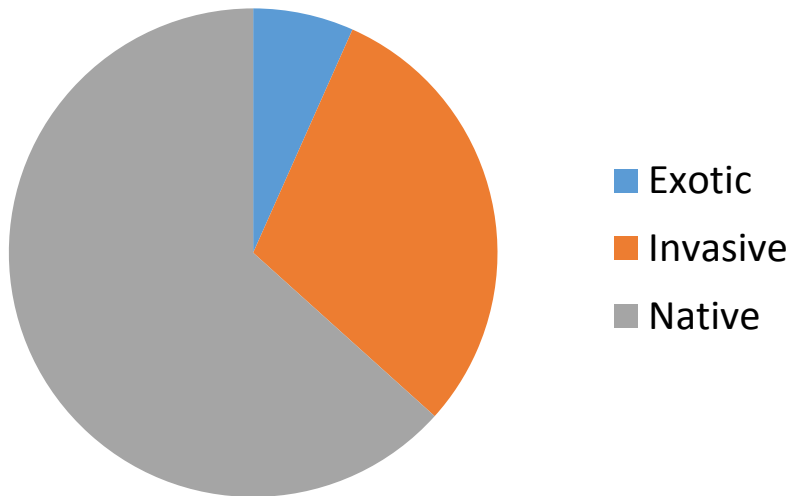


Significant increase in native vegetation in herbaceous layer.

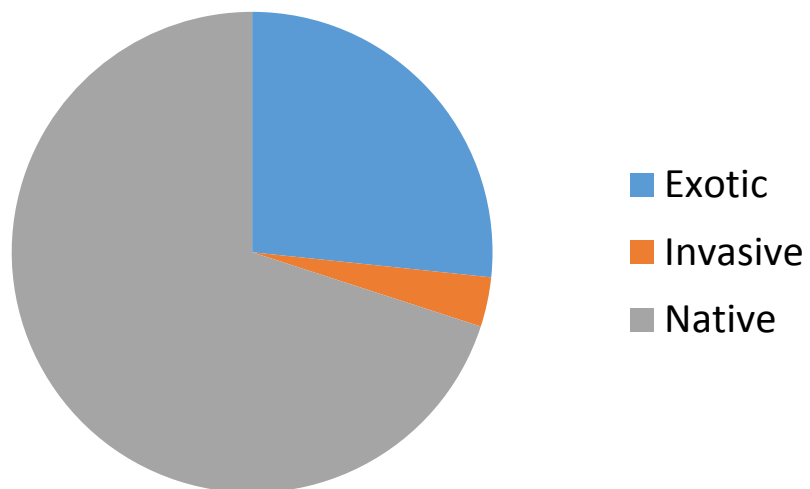
Trend toward increase in woody layer. (Herb $p = 0.046$; woody $p = 0.075$)

Herbaceous Layer

Reference/Unrestored



Restored

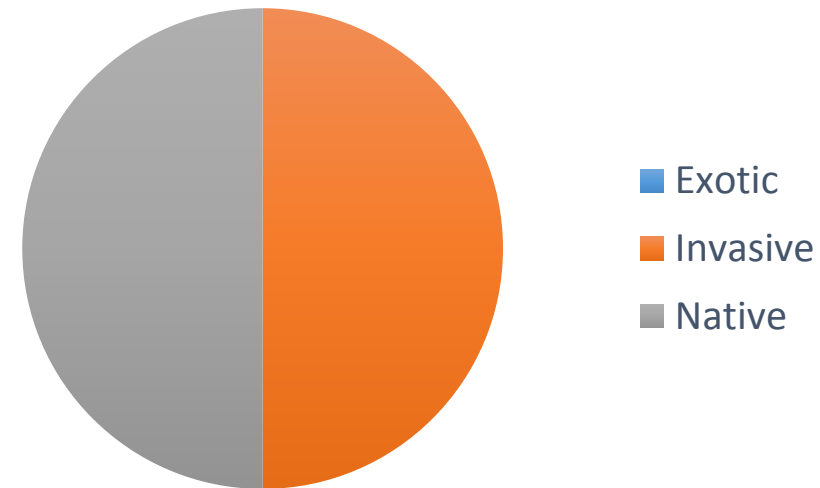


Top 30
herbaceous
and top 10
woody species
by Importance
Value

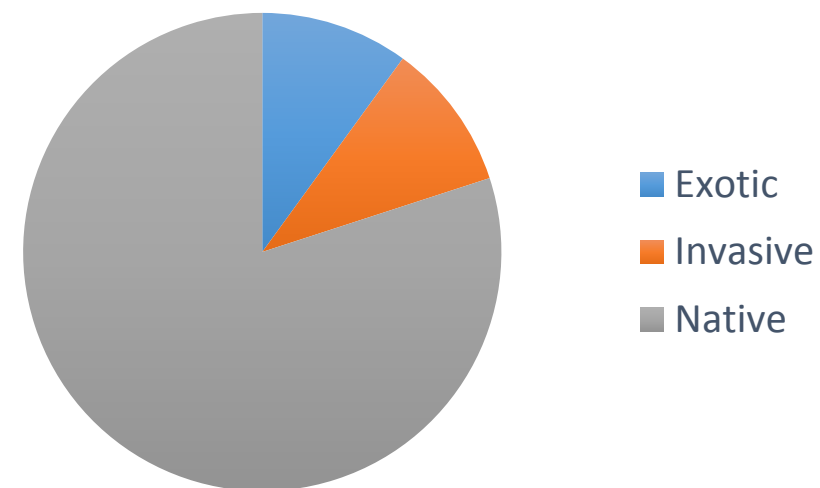
Decrease
in invasive
species

Woody Layer

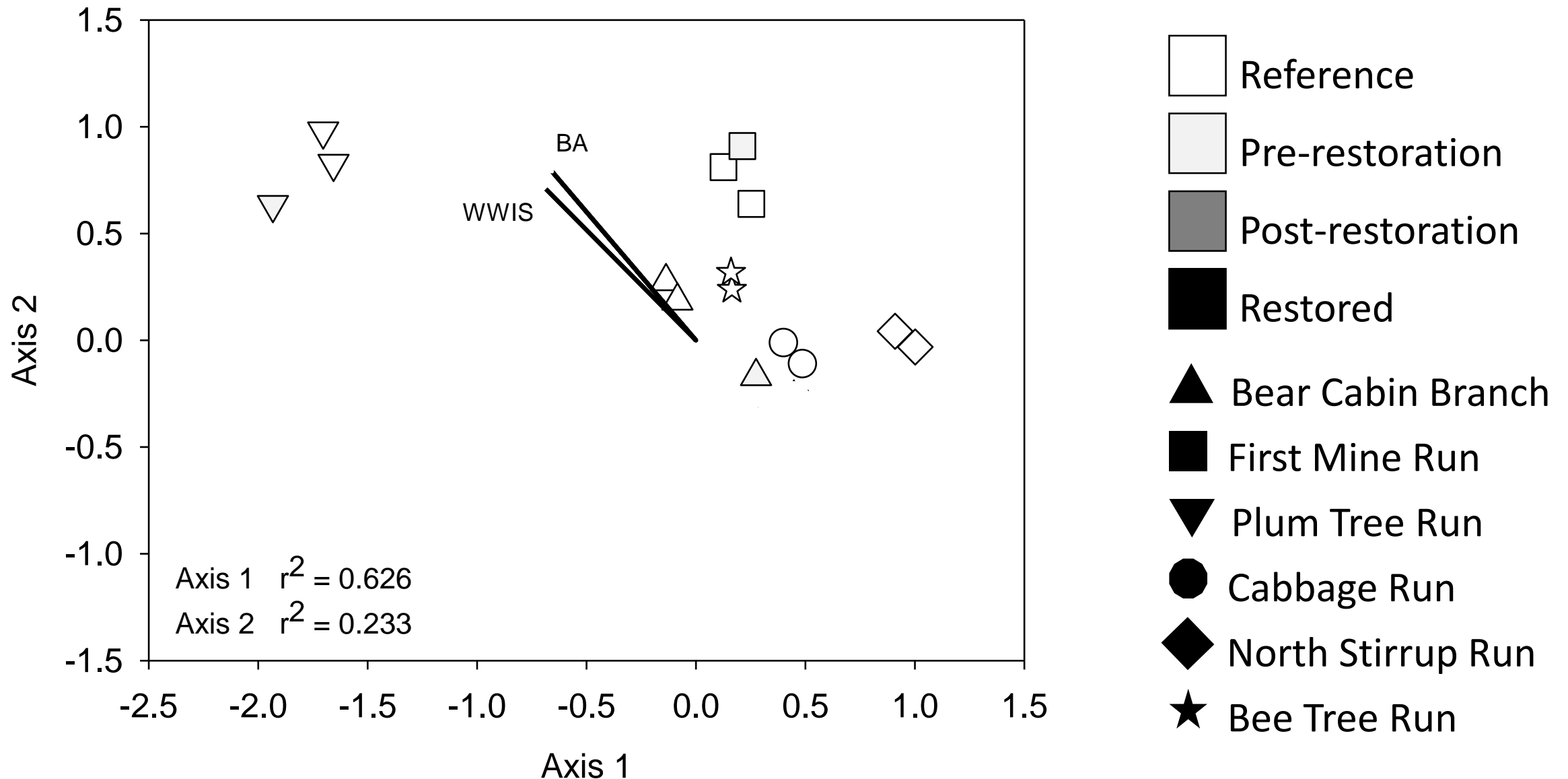
Reference/Unrestored



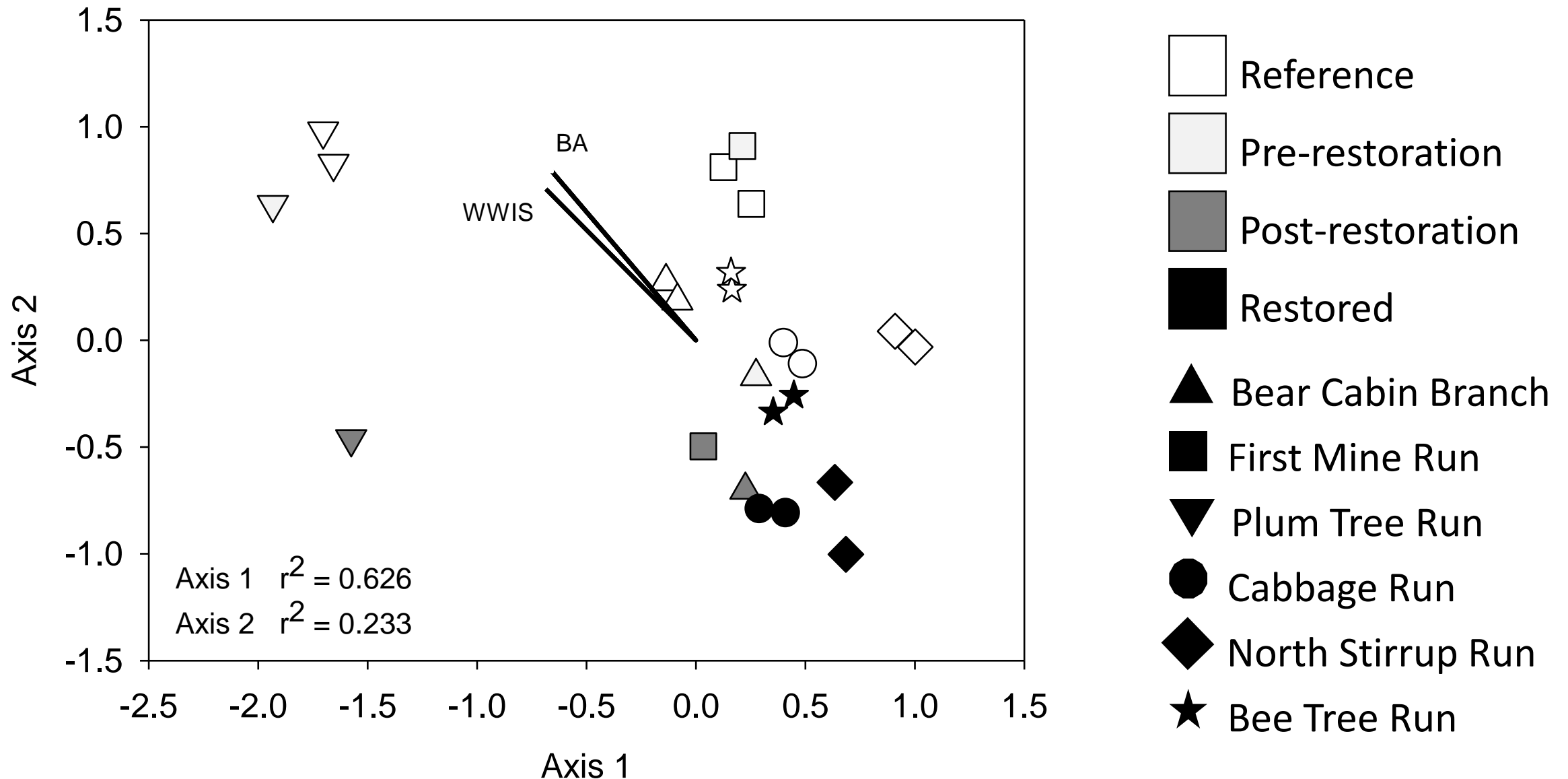
Restored



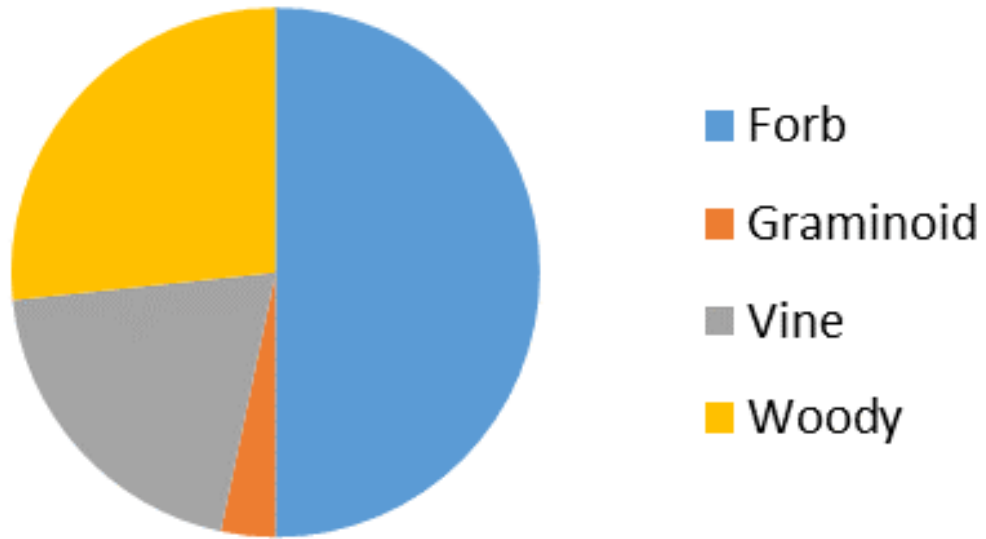
Herbaceous vegetation – Change in composition, sites maintain identity



Herbaceous vegetation – Change in composition, sites maintain identity

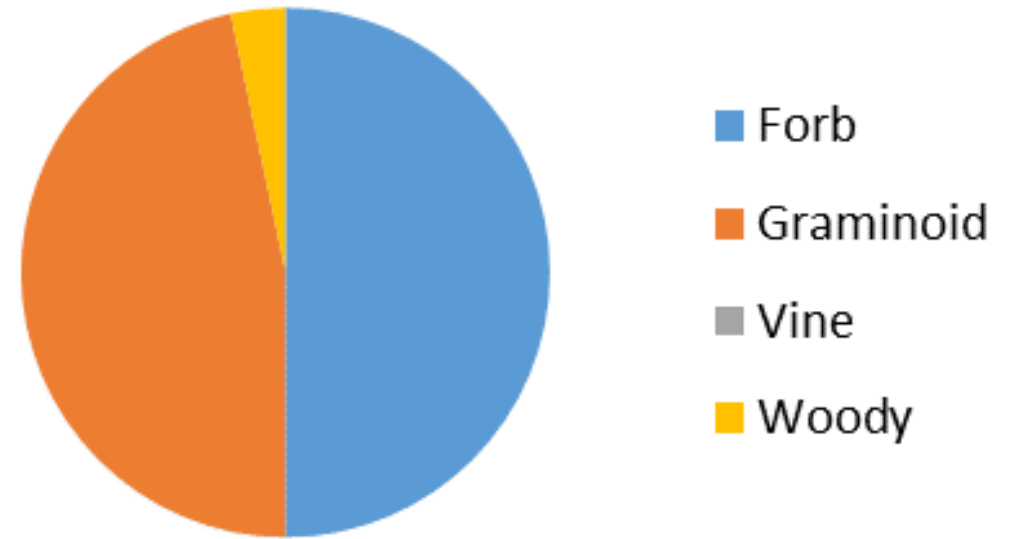


Reference/Unrestored



Top 30 herbaceous species
by Importance Value

Restored

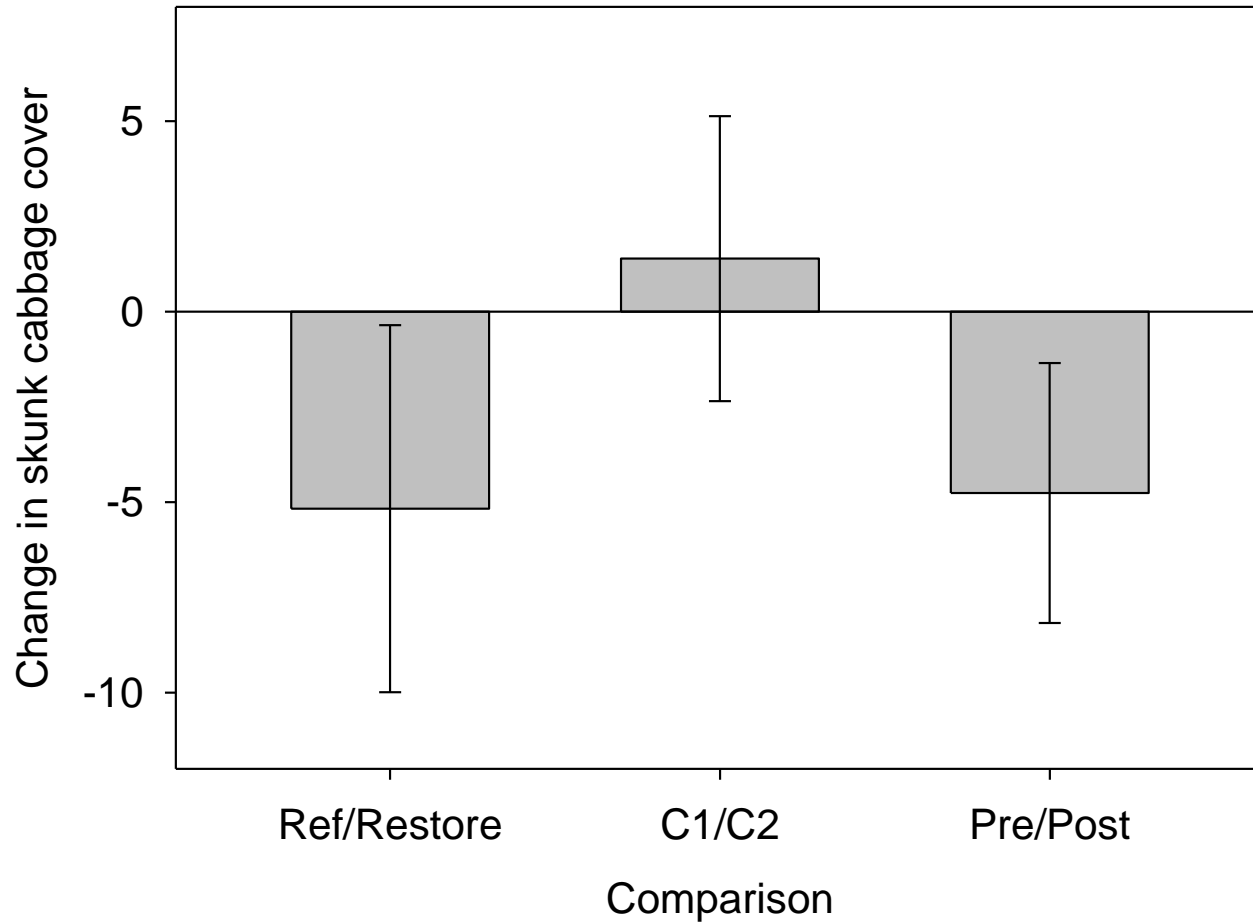


Decrease in vines and woody,
increase in graminoids

Indicators of unrestored reaches
<i>Alliaria petiolata</i> – garlic mustard
<i>Rosa multiflora</i> – multiflora rose
<i>Lindera benzoin</i> - spicebush
<i>Viola sororia</i> – blue violet
<i>Circaea lutetiana</i> - enchanter's nightshade
<i>Geum canadense</i> – white avens
<i>Symplocarpus foetidus</i> – skunk cabbage



Average 79% DECREASE in skunk cabbage cover



<https://www.nps.gov/miss/learn/nature/skunkcabbage.htm>

<https://urbanecologycenter.org/blog/native-plant-eastern-skunk-cabbage.html>

Indicators of restored reaches



24 species identified

Herb/Graminoid = 92%

Obligate/FACW = 63%

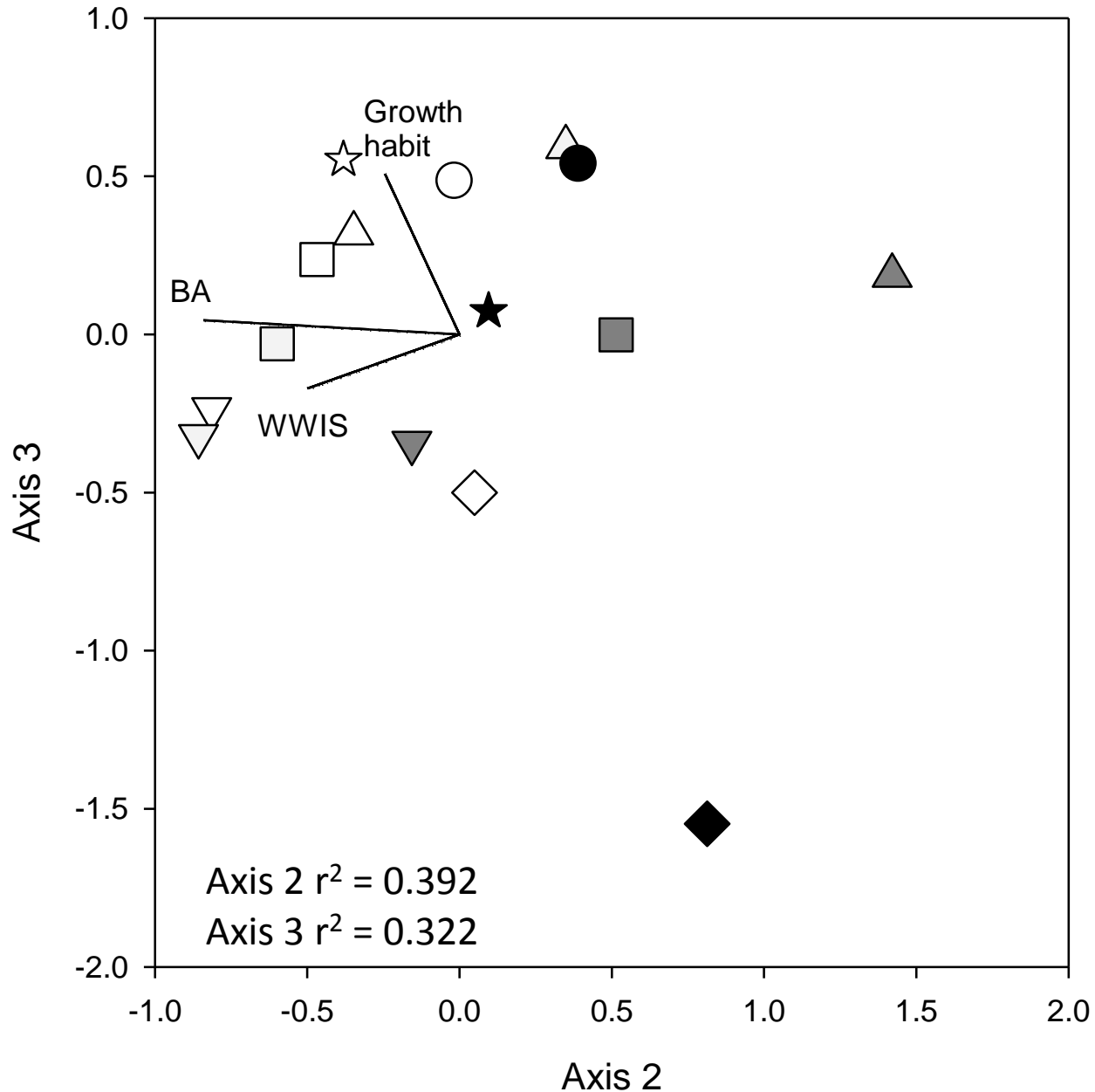
Native = 67%

Planted = 25%

Majority of
dominant/indicator
species were NOT
PLANTED

Evidence for seed bank?

Woody vegetation Change in composition, sites maintain identity

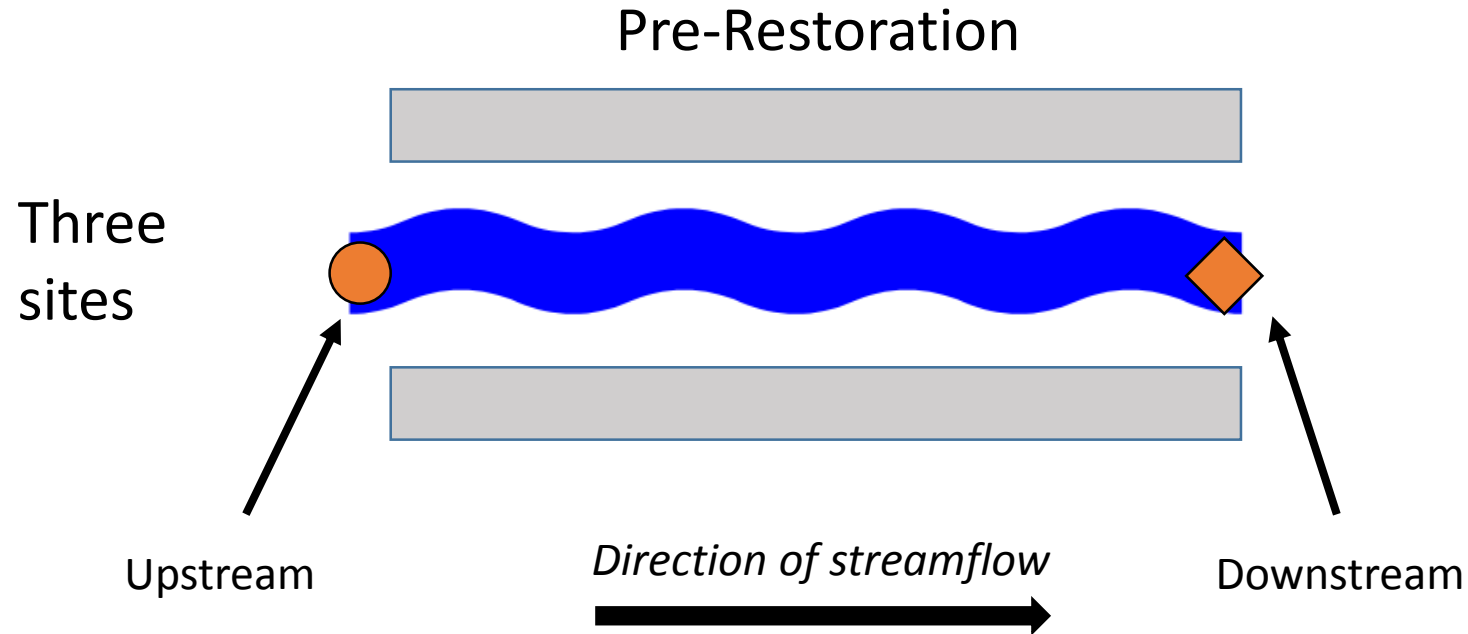


Woody Indicator Species

Unrestored Reaches	Restored Reaches
<i>Celastrus orbiculatus</i> – bittersweet	<i>Salix purpurea</i> – basket willow
<i>Rosa multiflora</i> – multiflora rose	<i>Platanus occidentalis</i> - sycamore
<i>Rubus phoenicolasius</i> - wineberry	<i>Salix nigra</i> – black willow
<i>Lonicera japonica</i> – J. honeysuckle	
<i>Lindera benzoin</i> - spicebush	

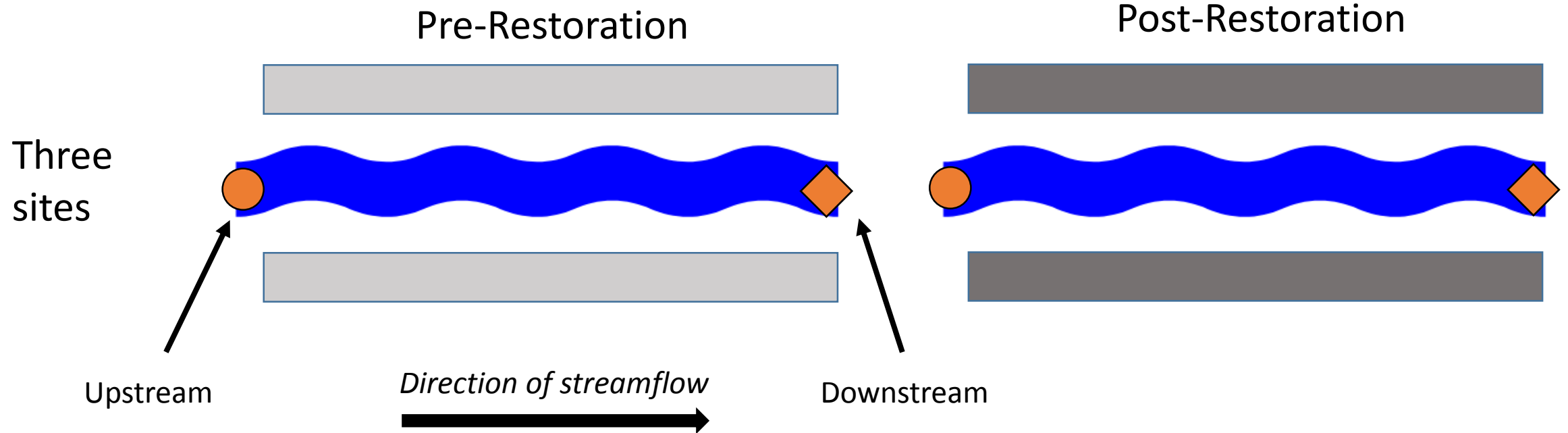
All indicators of restored reaches were planted at three to five of the six study sites.

Sampling approach

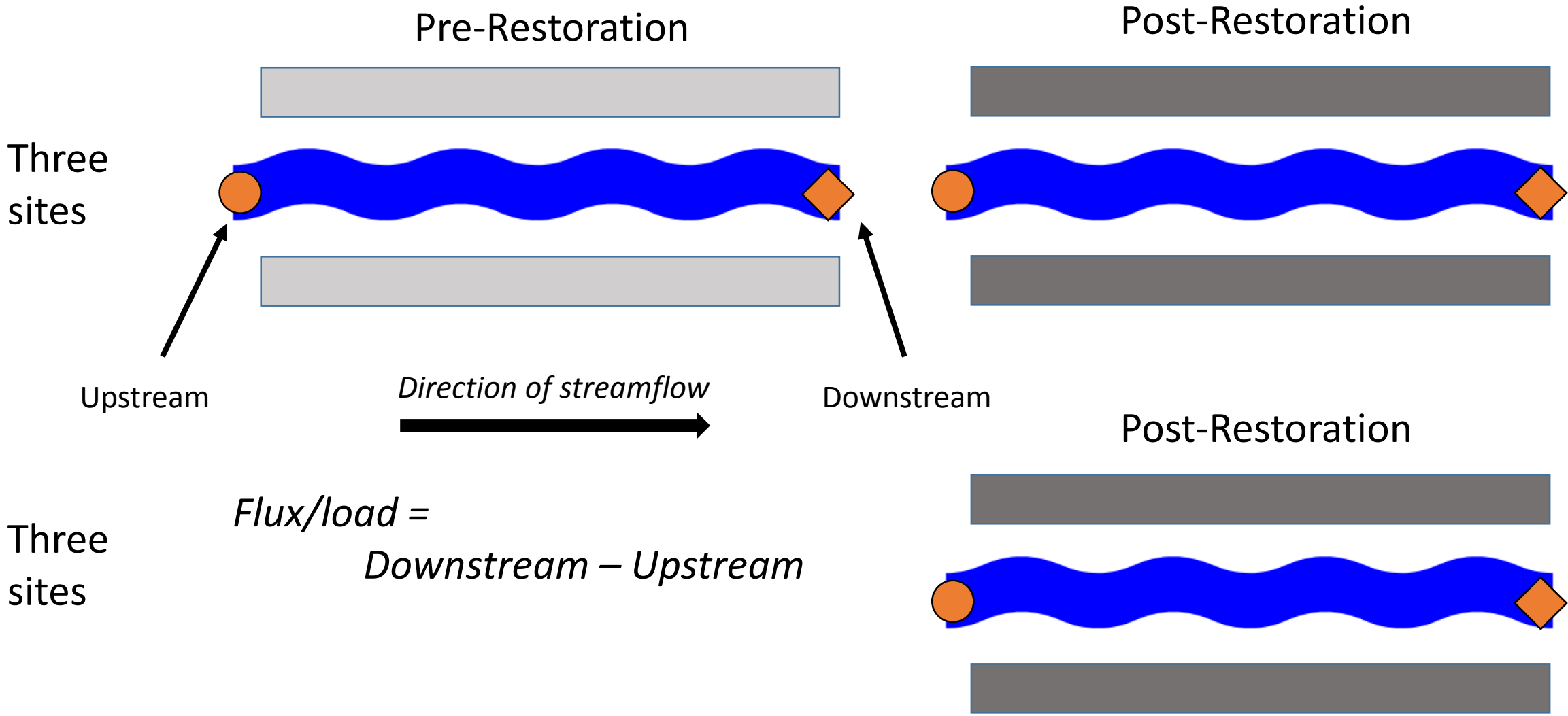


$$\text{Flux/load} = \text{Downstream} - \text{Upstream}$$

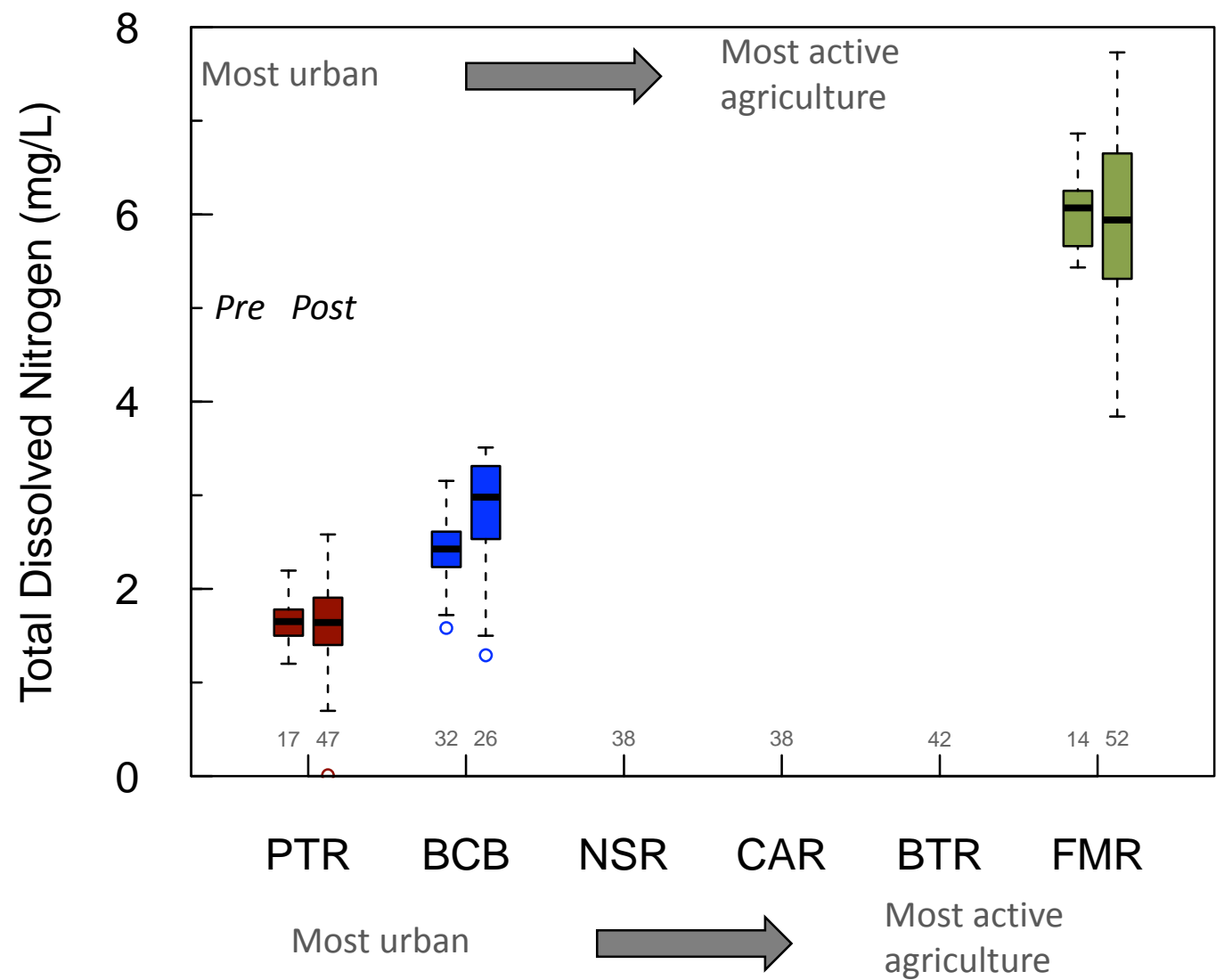
Sampling approach



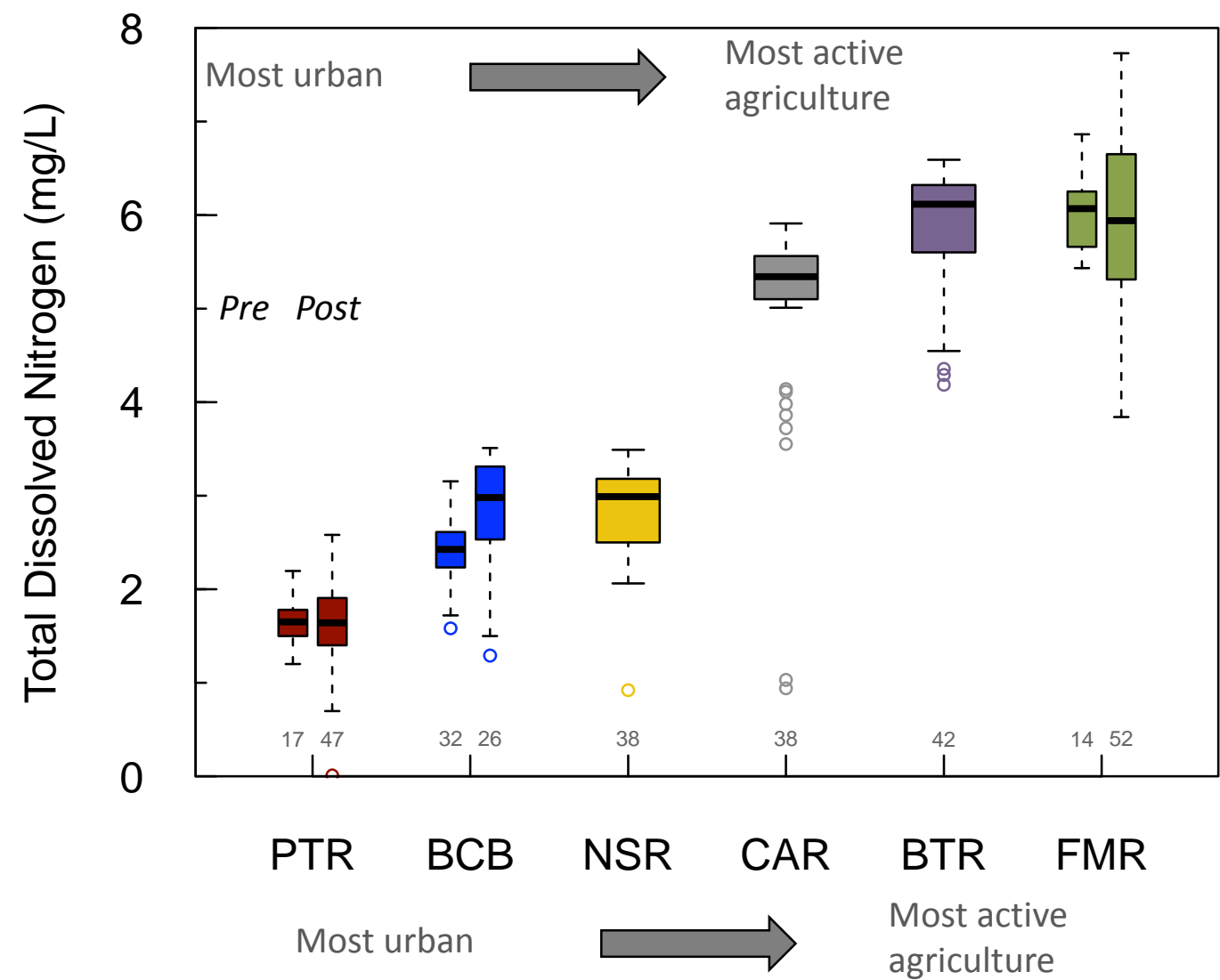
Sampling approach



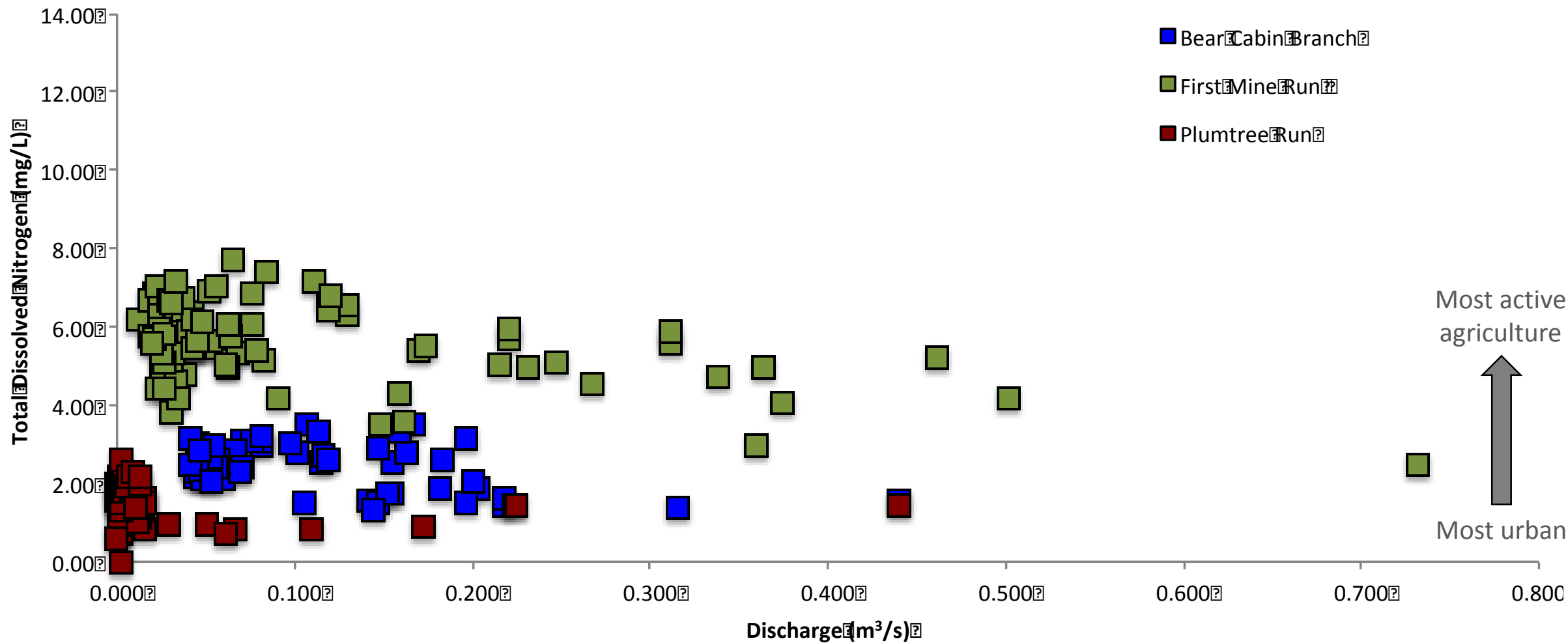
Biggest control for N: land use
Pre-/Post-restoration: no significant difference (yet)



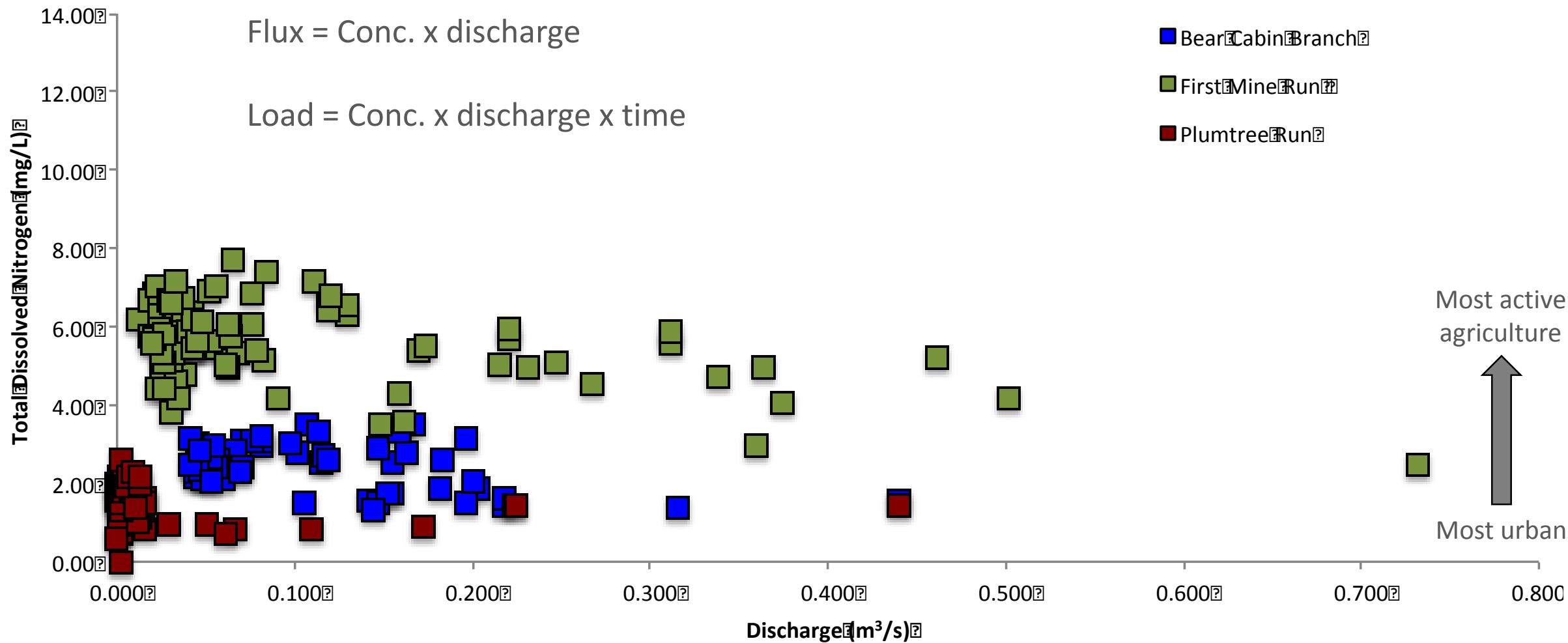
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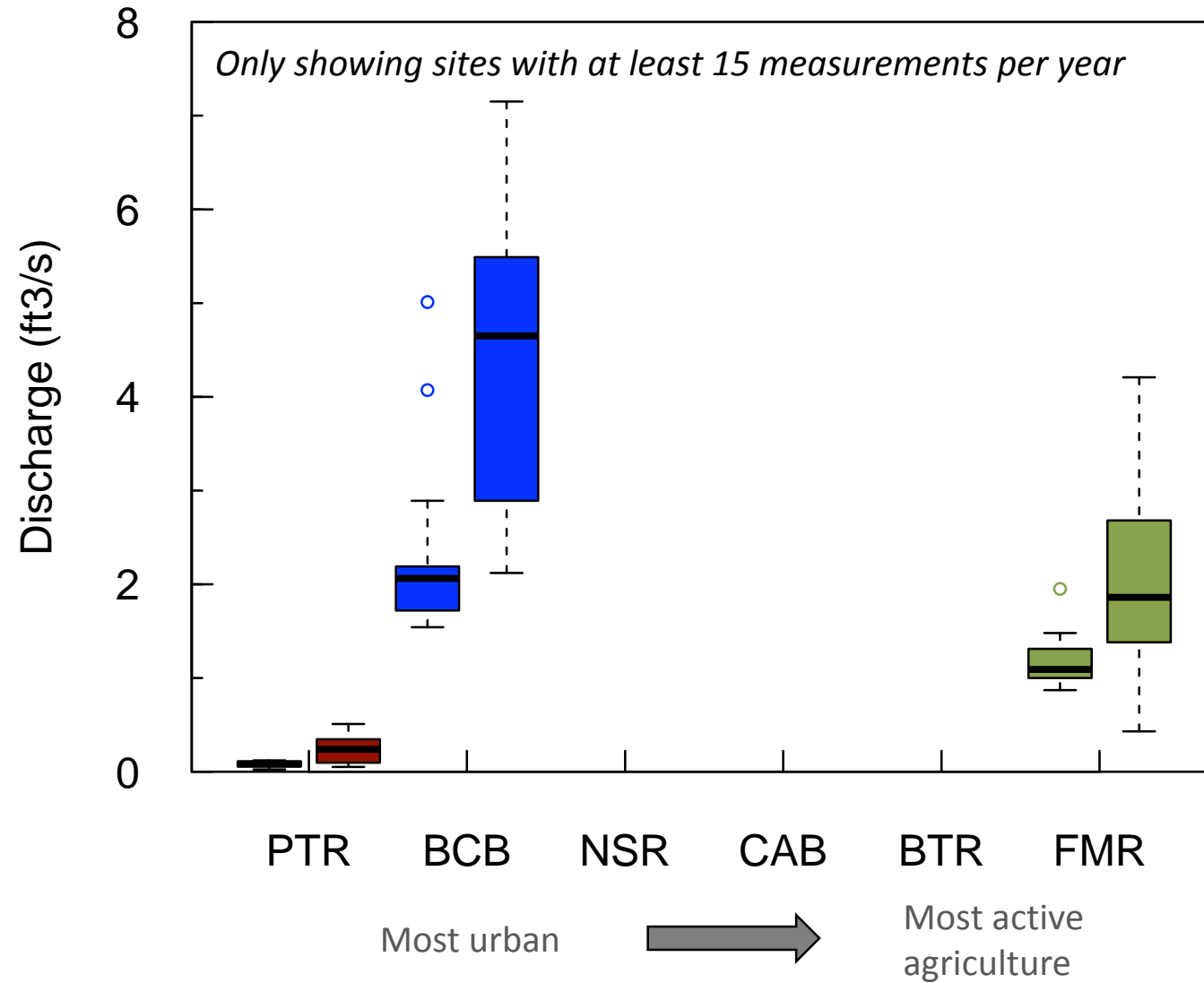
Little dilution of N with increased discharge. Result is substantial loads



Little dilution of N with increased discharge. Result is substantial loads

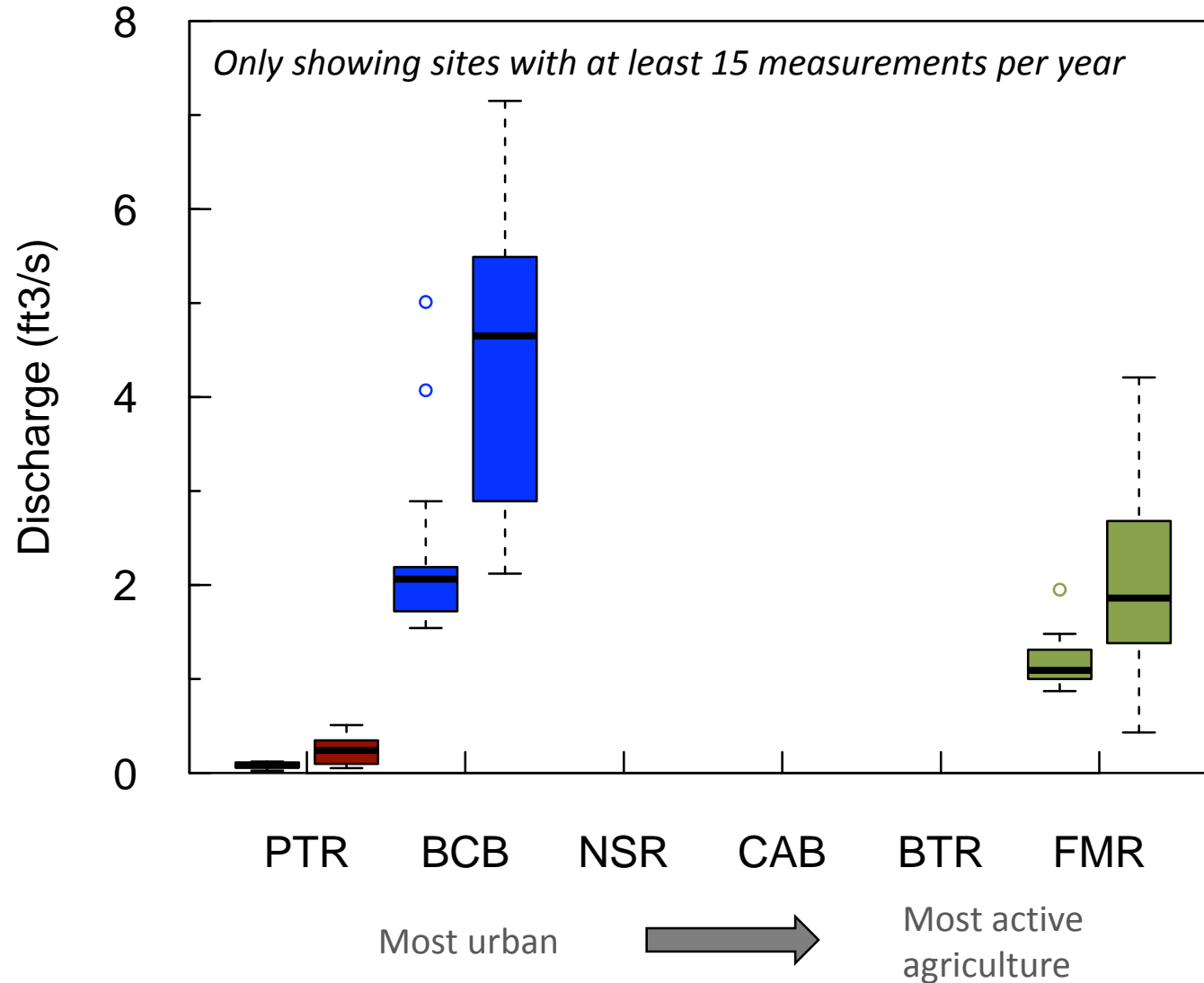


2017 vs 2018 baseflow discharge

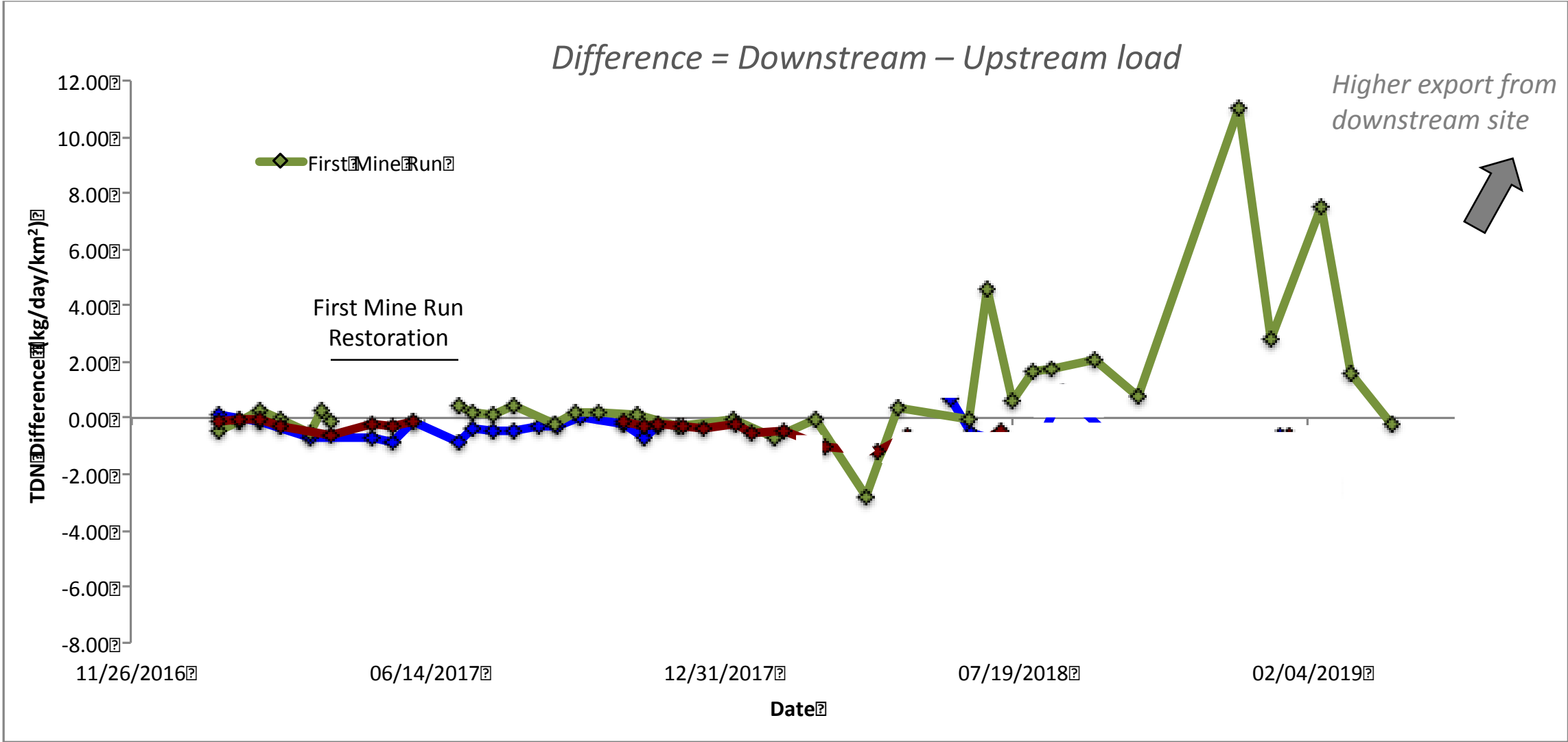


2017 vs 2018 baseflow discharge

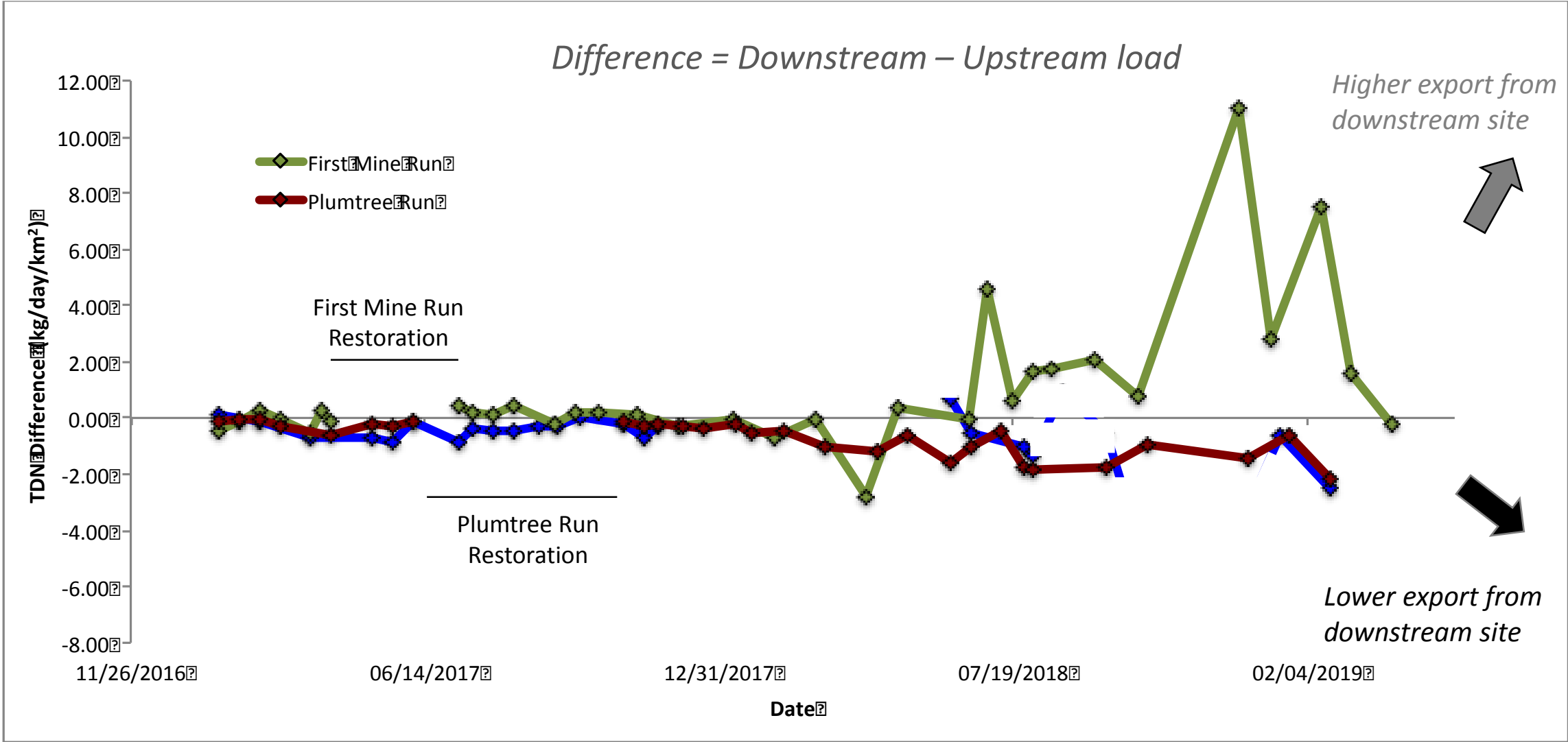
2018 was high precipitation & discharge year – so higher fluxes/loads quite likely



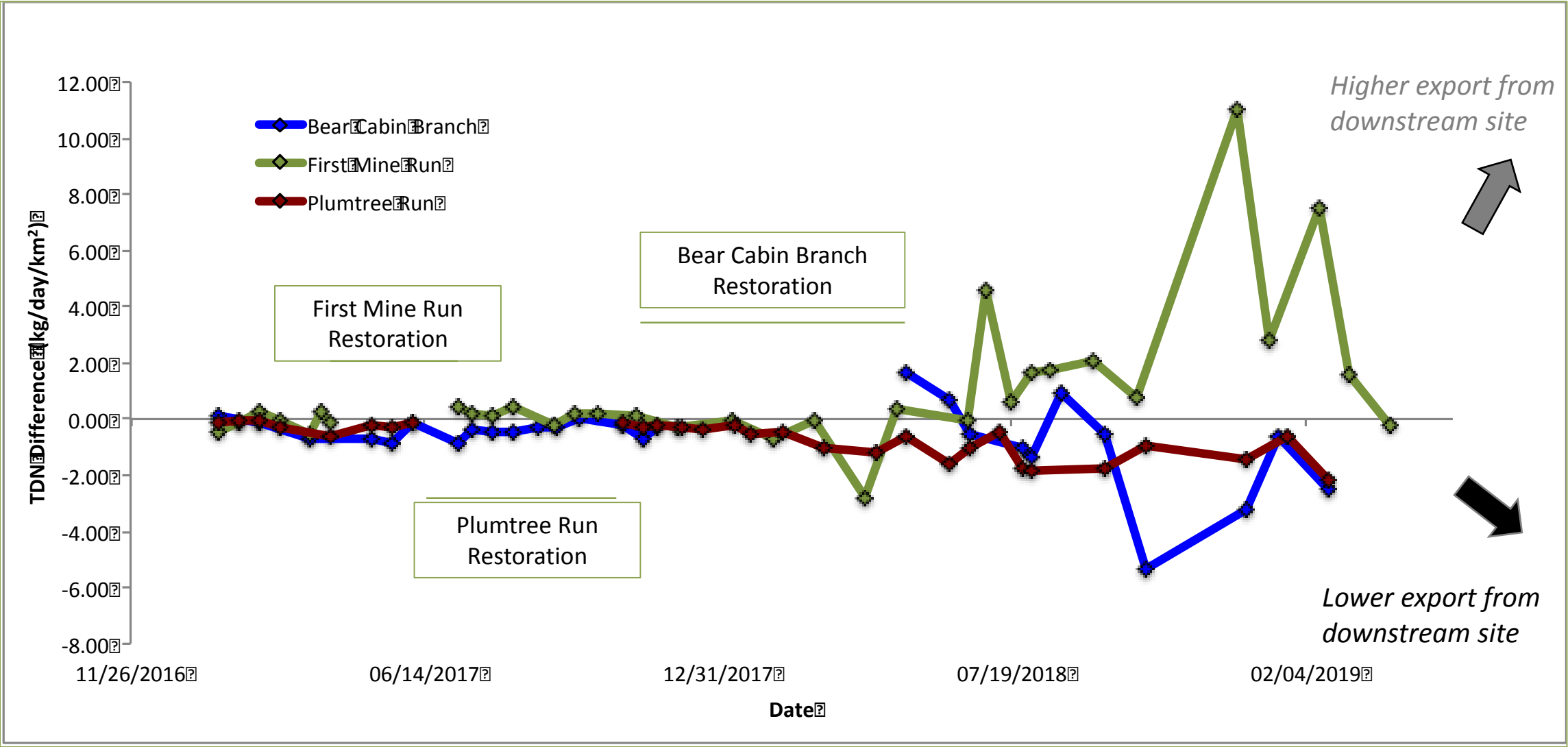
Baseflow fluxes seem to have changed post-restoration



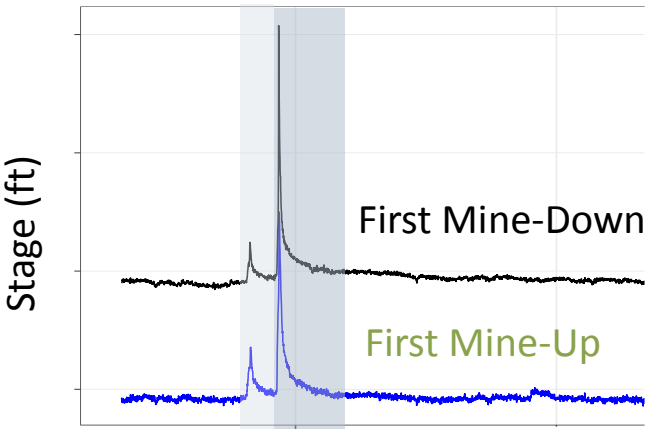
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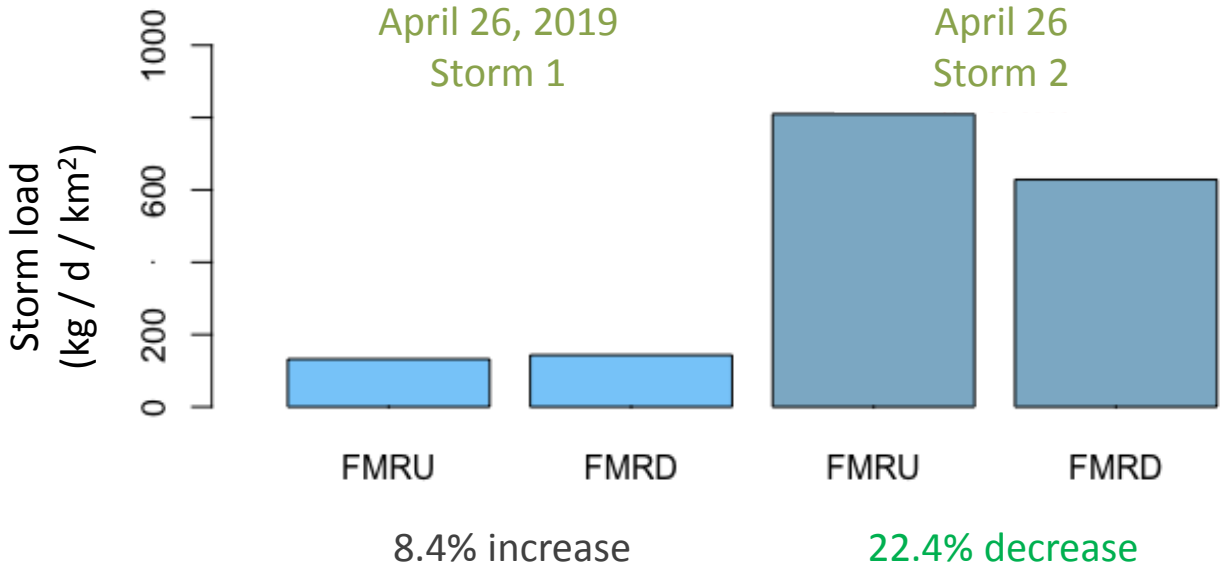


Suspended sediment load shows a decrease in bigger storms

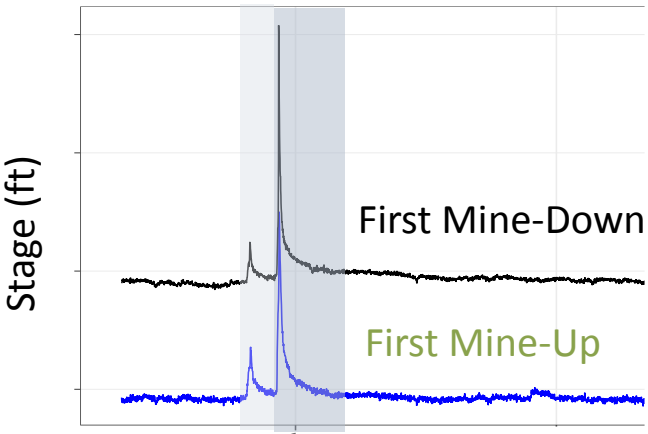


FMR: Site with highest agricultural intensity

April 24, 2019



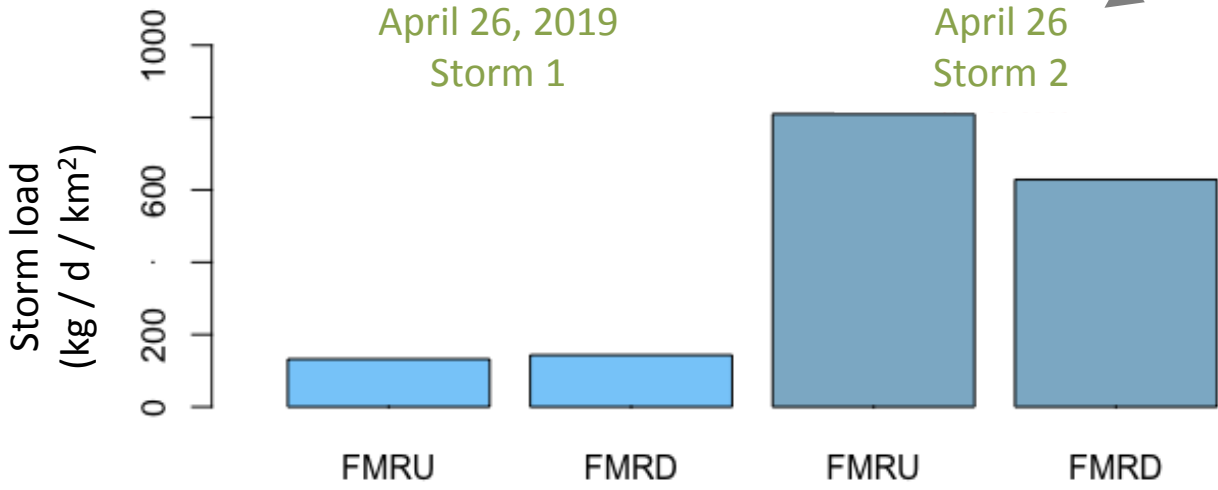
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April 24, 2019

FMR: Site with highest agricultural intensity

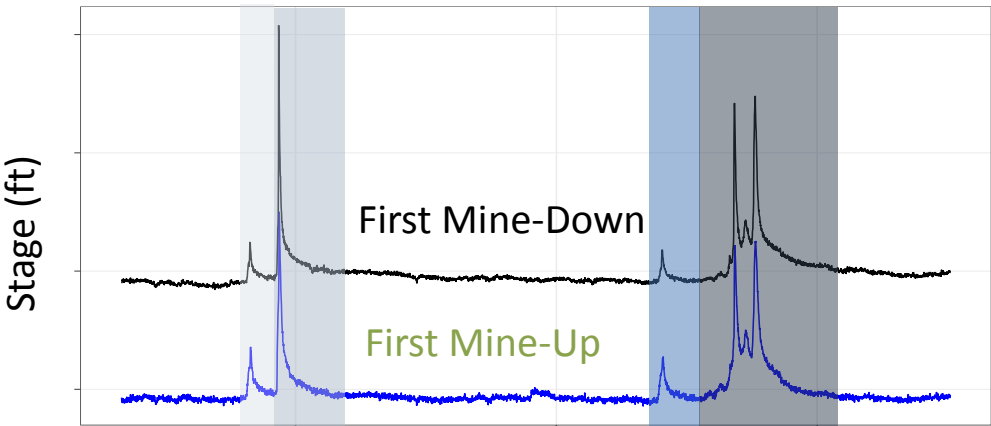
Perhaps overtopping banks & reaching floodplain



8.4% increase

22.4% decrease

Suspended sediment load shows a decrease in bigger storms

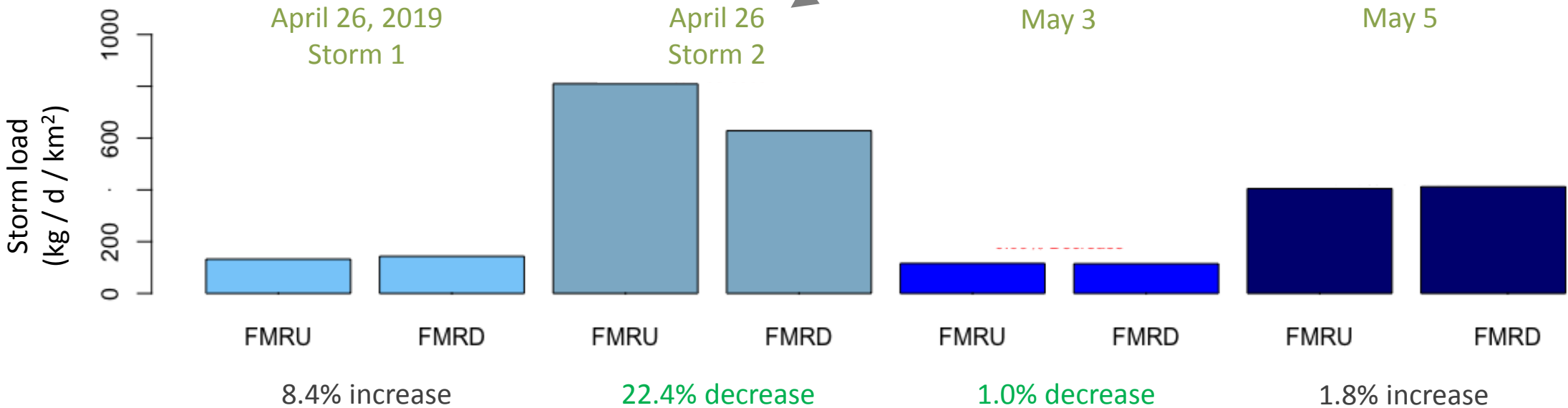


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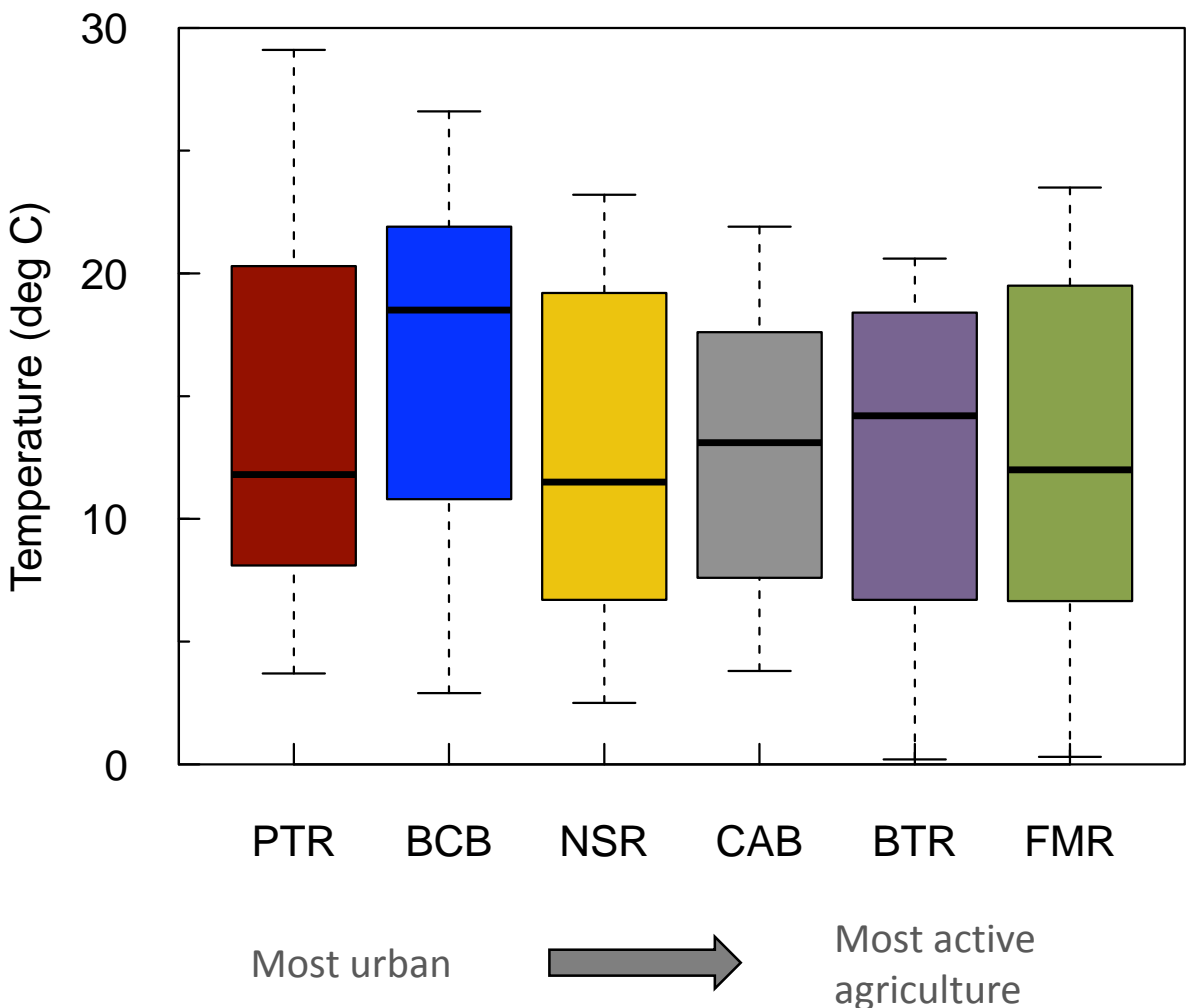
Perhaps overtopping banks
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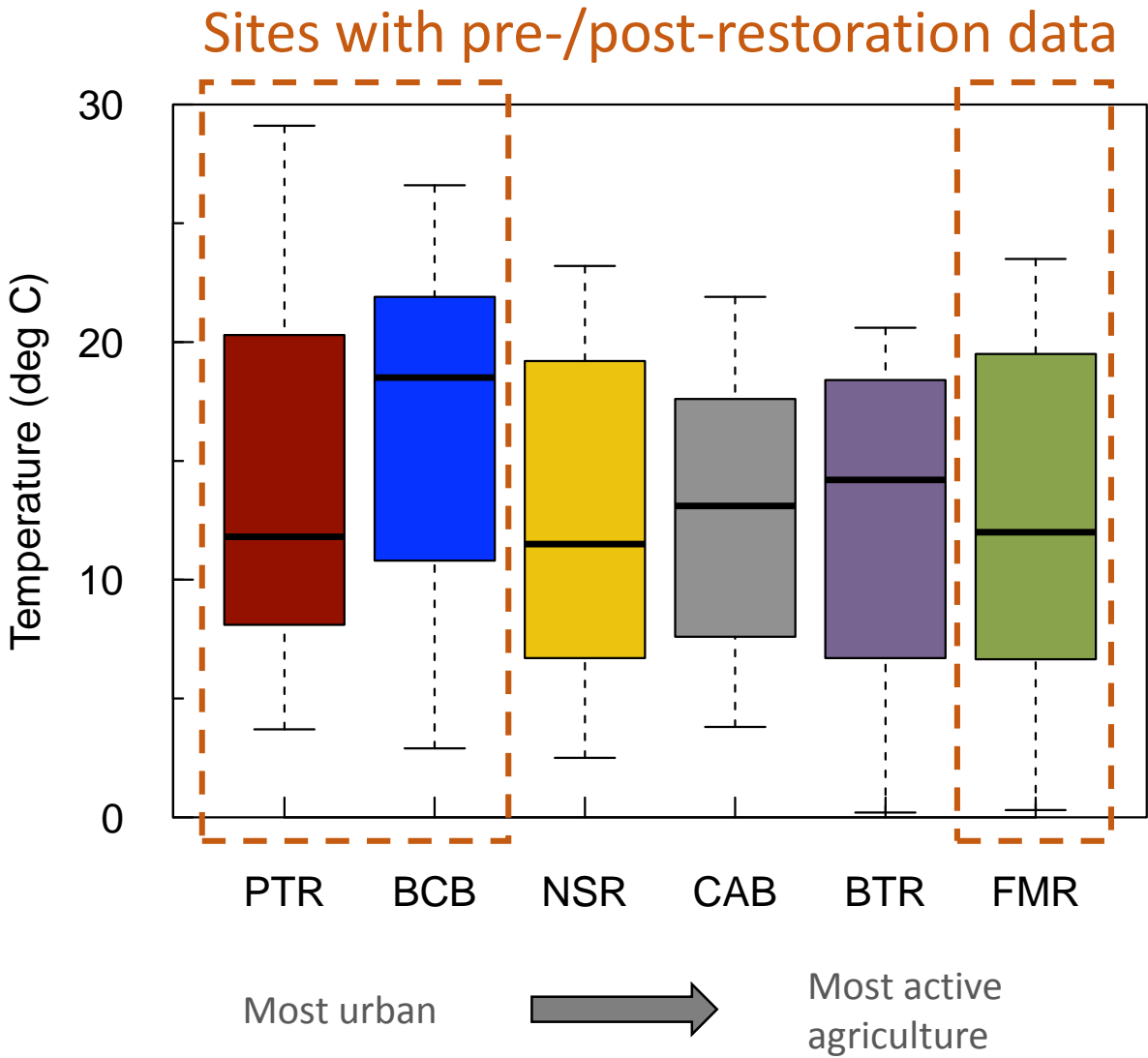
May 9



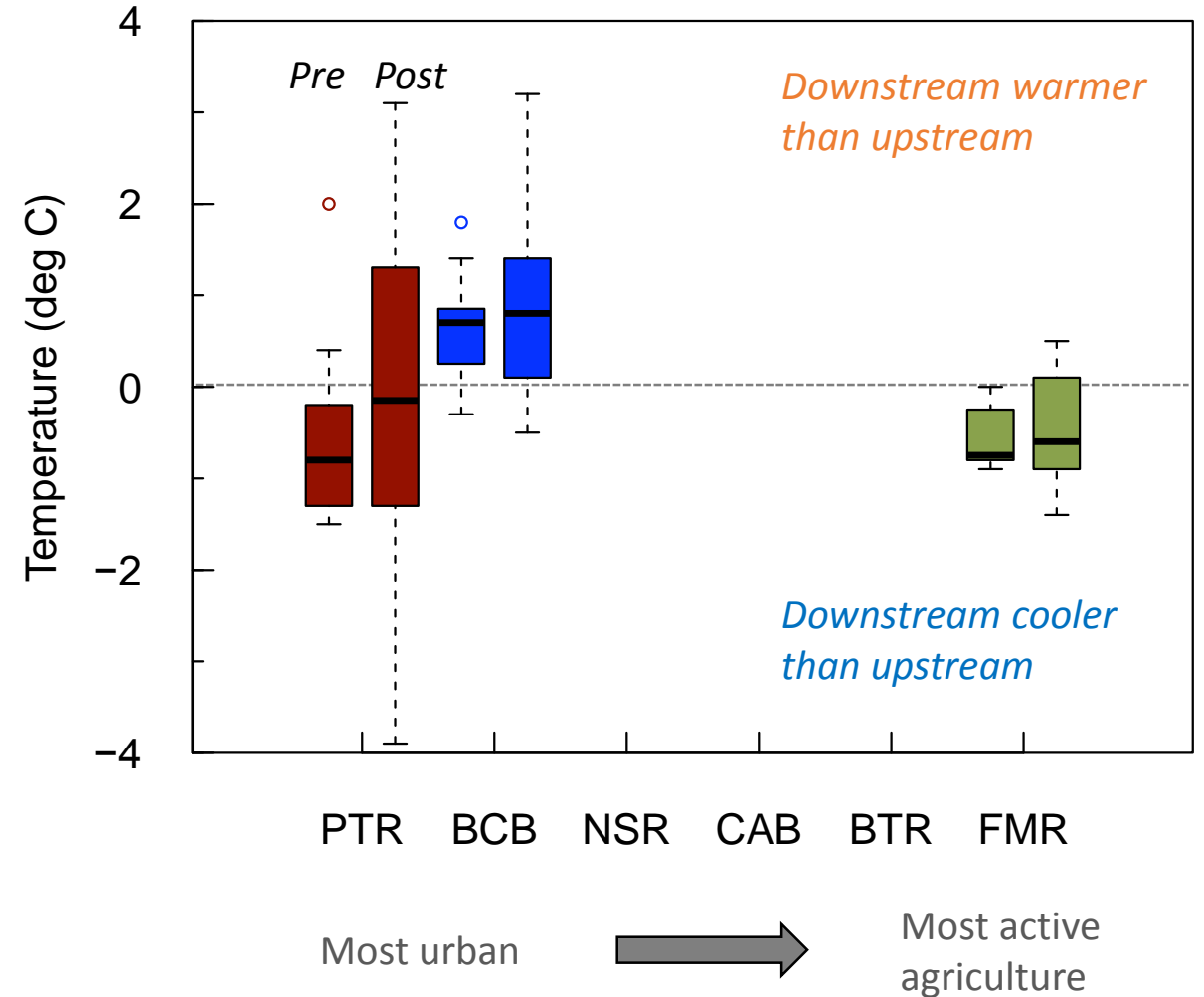
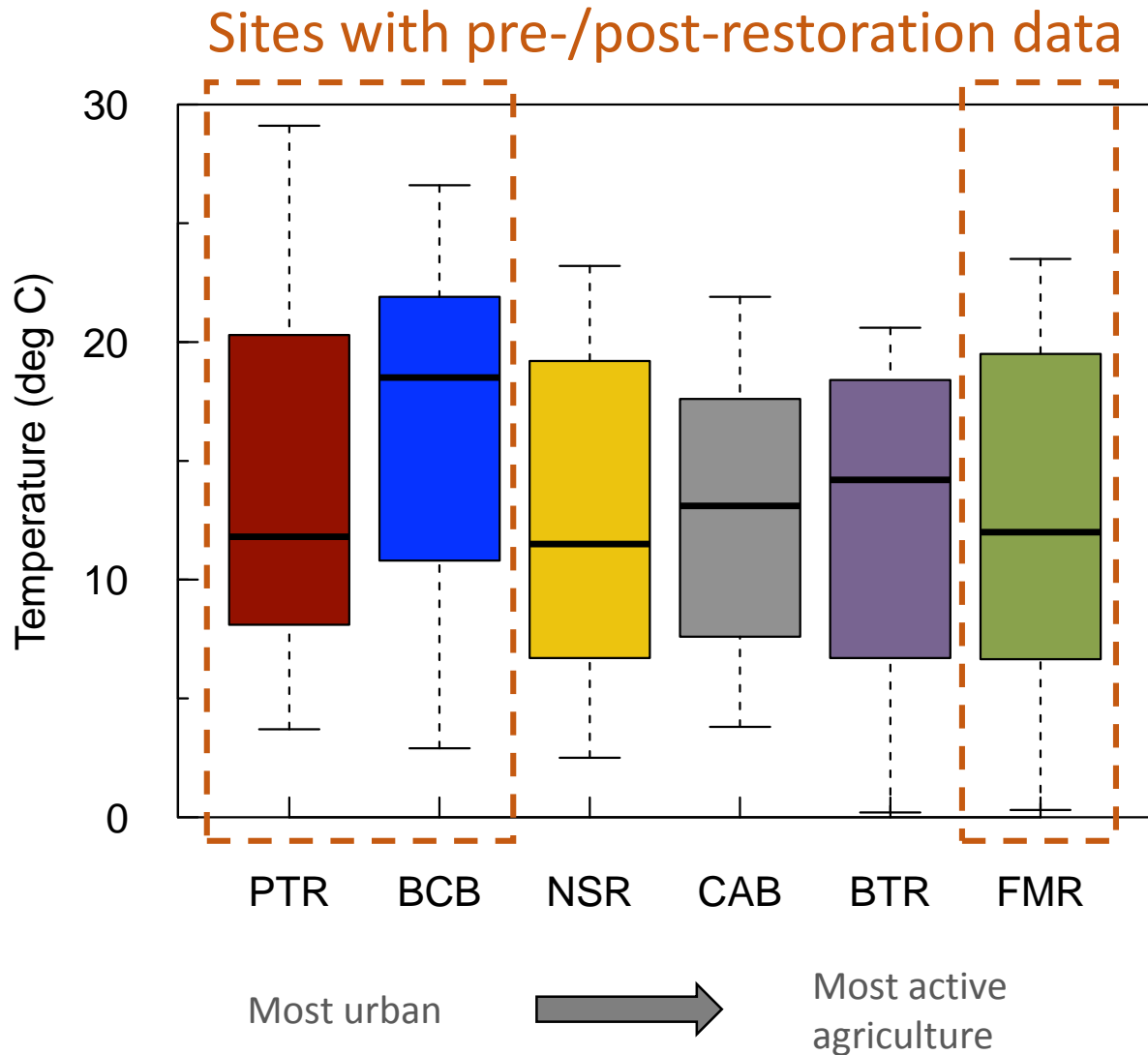
Temperature



Temperature



Temperature: no statistically significant post-restoration change



Caveats: as few as 9 points & no summer for FMR; ongoing high-frequency temperature

Summary - Vegetation

- Decrease in woody vegetation
 - Removal of trees
 - Near-complete elimination of vines
- Increase in hydrophytic, native vegetation
 - Loss of species (like skunk cabbage) that don't disperse/regenerate well from seed
 - Loss of forest understory species
 - Increase in graminoid species (grasses, rushes, sedges)
 - Response to hydrology and light



Summary - Water

- No significant difference in N (yet)
 - Surrounding land use controls N levels
- Little dilution of N with increased discharge. Result is substantial loads.
- Record rainfall year obscures any changes in N fluxes
- Suspended sediment load shows a decrease in bigger storms
- No significant effect of restoration on water temperature

Acknowledgements

- Funding
 - Chesapeake Bay Trust, Towson University,
- Logistical support – Ecotone, Inc.
- Landowners – Henry and David Pitts, Rigdon Family, Edwards Family, Harford County, City of Bel Air
- Students – Patrick McMahon, Patrick Baltzer, Ginny Jeppi



Vanessa B. Beauchamp
and Joel Moore
Towson University

Translation Slides by Scott Lowe

What does this mean for me?

- The wet year of 2018 obscured some results in research
 - Nutrients, Sediment, and Temperature inconclusive
 - Why no dilution in higher discharges?
- Land Use of Watershed has dominant impacts
 - Are urban loads correlating with Bay Model?
- Legacy Sediment Removal increases hydrophytic vegetation establishment and decreases invasives at these sites
- Majority of herbaceous vegetation established was not planted, majority of woody vegetation was planted

What does this mean for me?

What do I take from this if I am a practitioner:

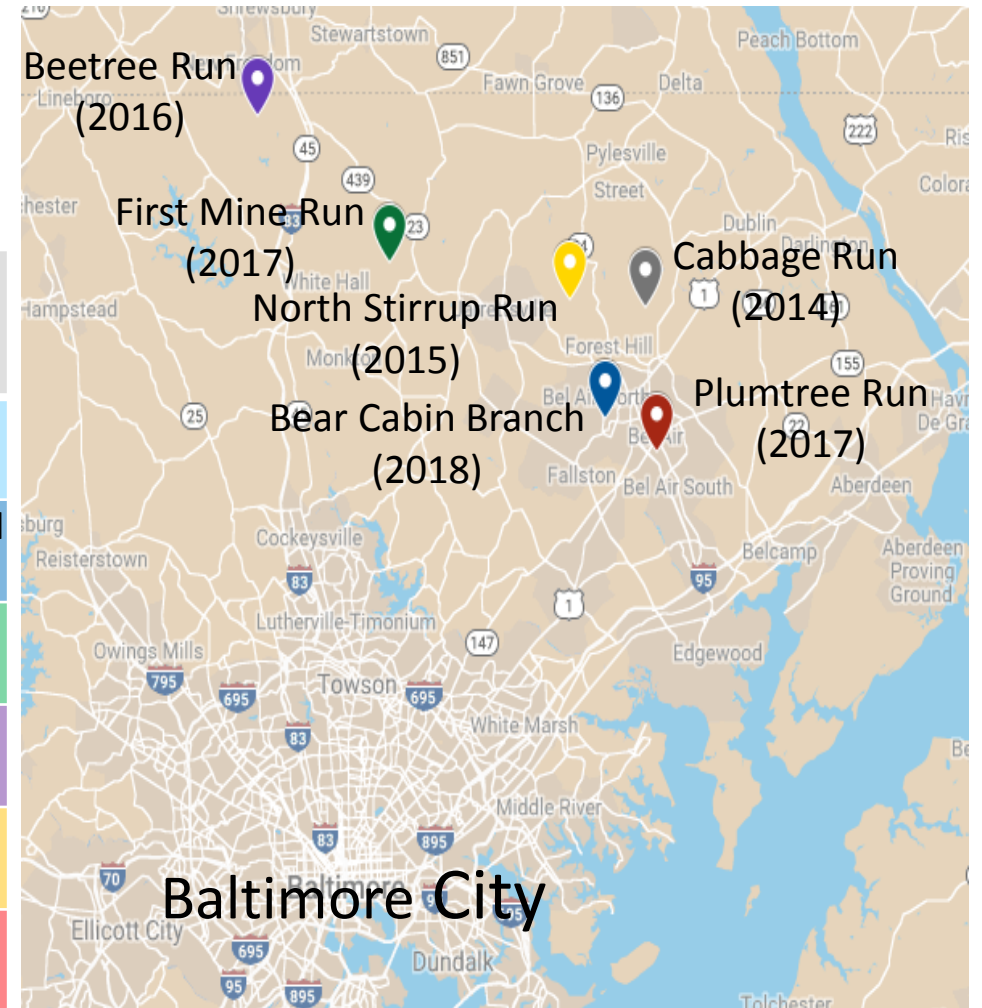
- What is optimal selection of floodplain access elevation?
Significance of baseflow versus flood flow nutrient and sediment fluxes?
- Siting of projects relative to land use
- Planting plan strategies, less overall but trees and skunk cabbage
- Look for ways to increase retention time for storm flows

What do I take from this if I am a regulator:

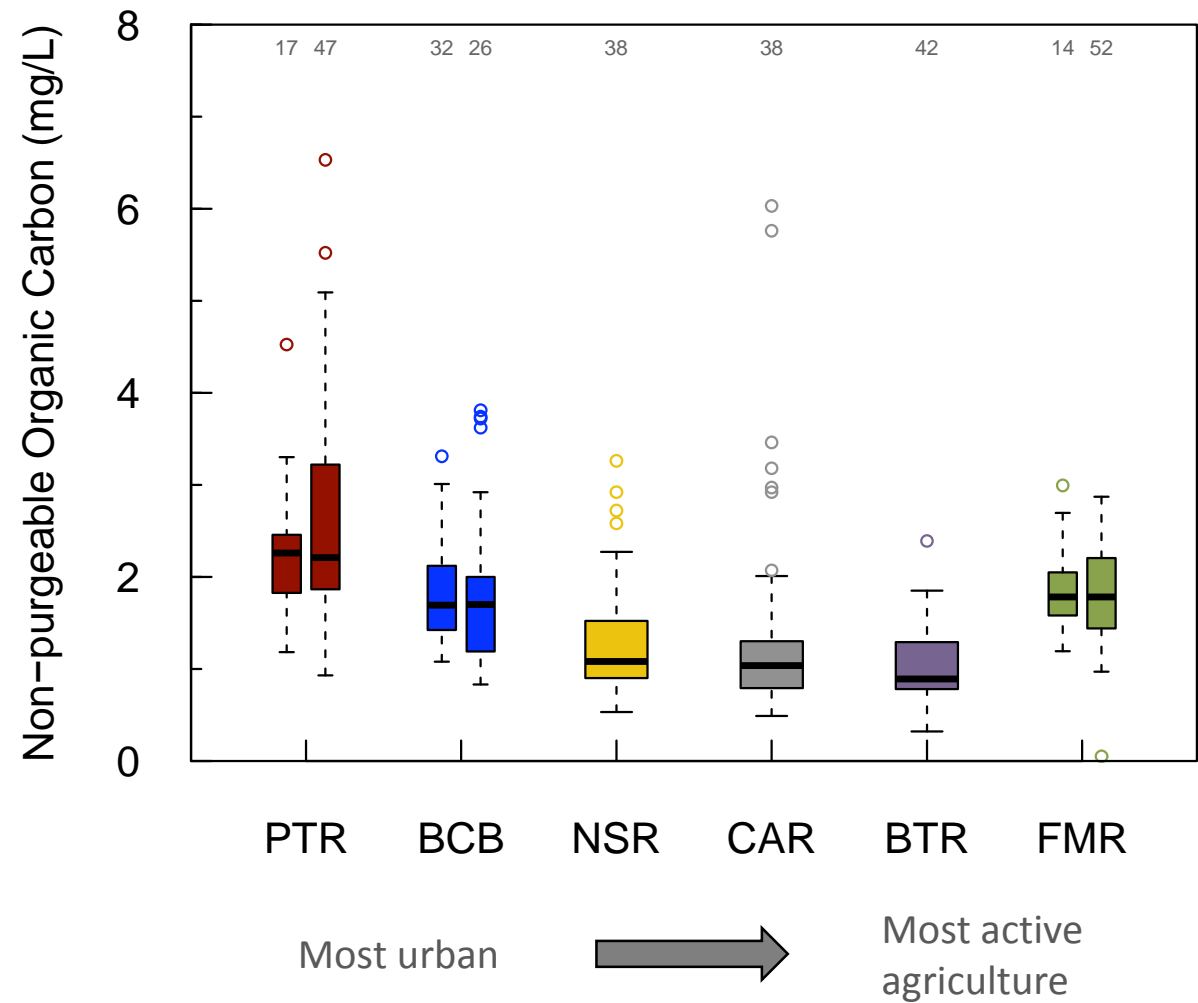
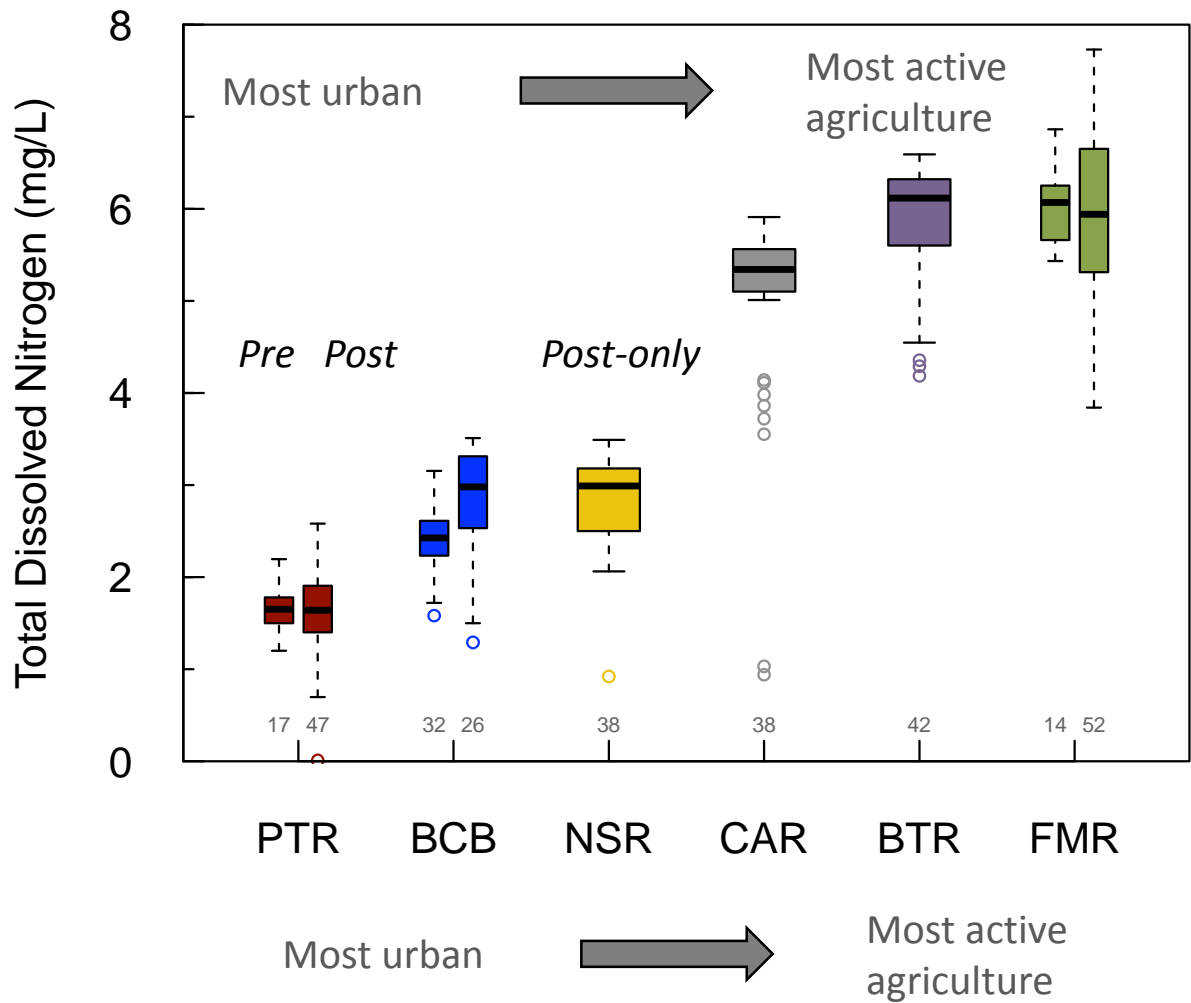
- Temperature fluctuations may be small but additional data in normal year and summer needed
- Lower risk of invasives
- Higher likelihood of self mitigating wetland impacts with hydrophytic vegetation quickly established?

Study sites – *for questions*

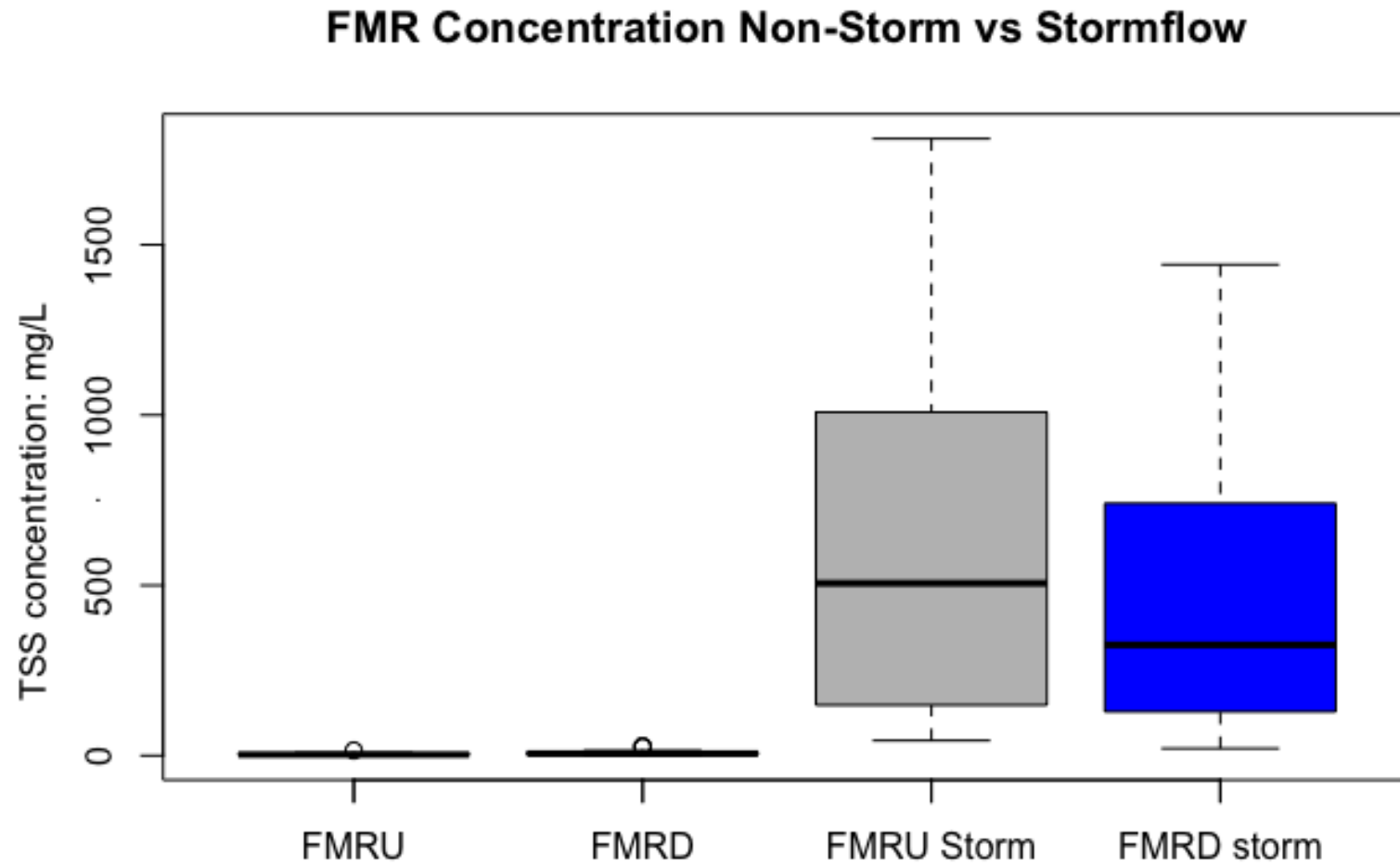
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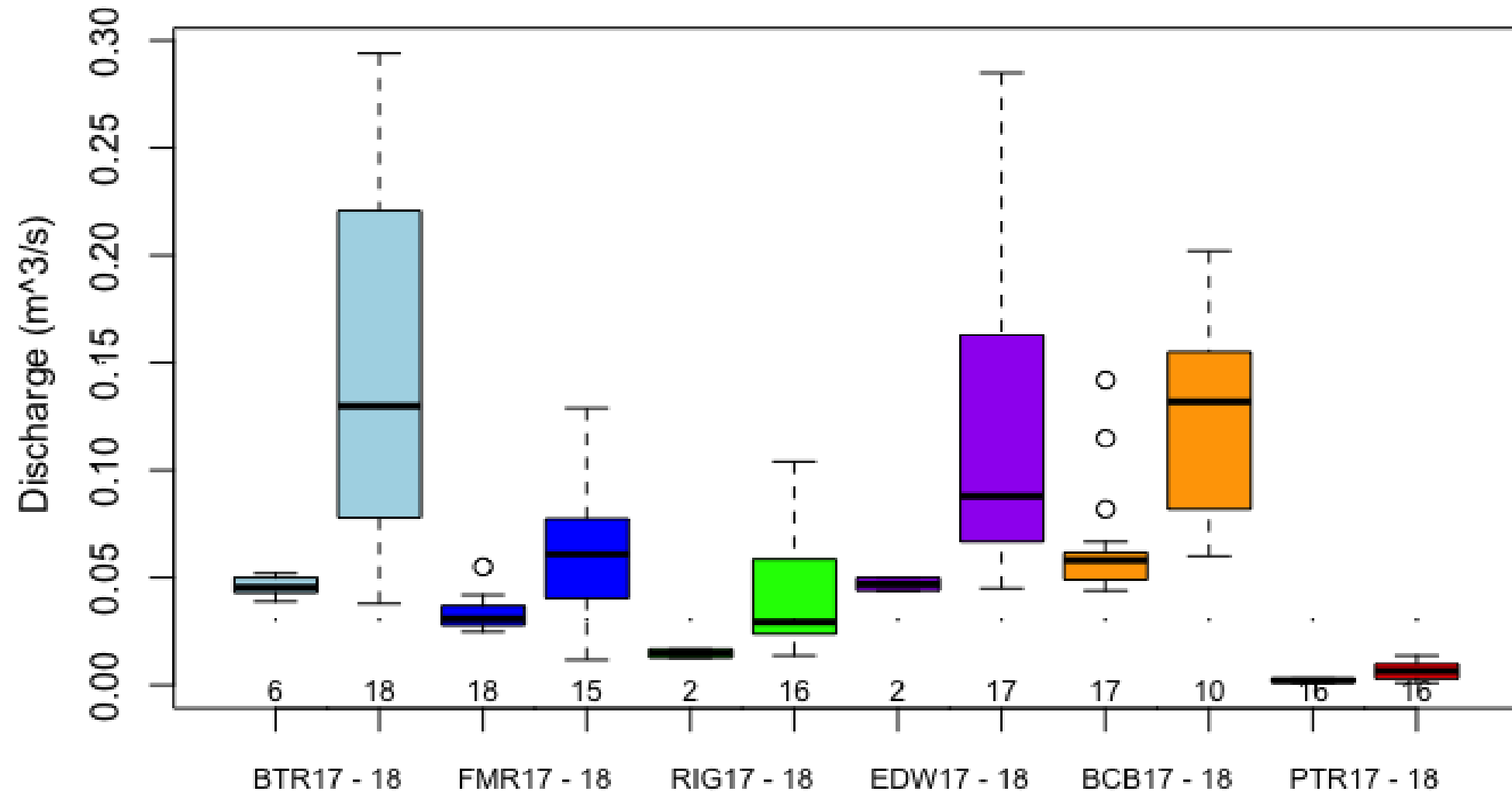
Biggest control for N: land use – *C* also but generally opposite
Pre-/Post-restoration: no significant difference (yet)



TSS – questions



2018 was high precipitation & discharge year – for questions



Vanessa B. Beauchamp
and Joel Moore
Towson University

Translation Slides by Scott Lowe

What does this mean for me?

- The wet year of 2018 obscured some results in research
 - Nutrients, Sediment, and Temperature inconclusive
 - Why no dilution in higher discharges?
- Land Use of Watershed has dominant impacts
 - Are urban loads correlating with Bay Model?
- Legacy Sediment Removal increases hydrophytic vegetation establishment and decreases invasives at these sites
- Majority of herbaceous vegetation established was not planted, majority of woody vegetation was planted

What does this mean for me?

What do I take from this if I am a practitioner:

- What is optimal selection of floodplain access elevation?
Significance of baseflow versus flood flow nutrient and sediment fluxes?
- Siting of projects relative to land use
- Planting plan strategies, less overall but trees and skunk cabbage
- Look for ways to increase retention time for storm flows

What do I take from this if I am a regulator:

- Temperature fluctuations may be small but additional data in normal year and summer needed
- Lower risk of invasives
- Higher likelihood of self mitigating wetland impacts with hydrophytic vegetation quickly established?