Can Re-introducing Bugs Help Restore Biodiversity in Urban Streams?

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Wildlife overpass in Banff National Park. Credit: Canadian Geographic

INVITED FEATURE

Ecological Applications
Vol. 21, No. 6

Ecological Applications, 21(6), 2011, pp. 1962–1971

River restoration success depends on the species pool of the immediate surroundings

ANDREA SUNDERMANN, STEFAN STOLL,[1] AND PETER HAASE

SPECIAL ISSUE

WILEY Freshwater Biology

Metacommunities in river networks: The importance of network structure and connectivity on patterns and processes

Jonathan D. Tonkin[1] | Jani Heino[2] | Florian Altermatt[3,4]

Freshwater Biology

Freshwater Biology (2014) doi:10.1111/fwb.12387

Dispersal distance and the pool of taxa, but not barriers, determine the colonisation of restored river reaches by benthic invertebrates

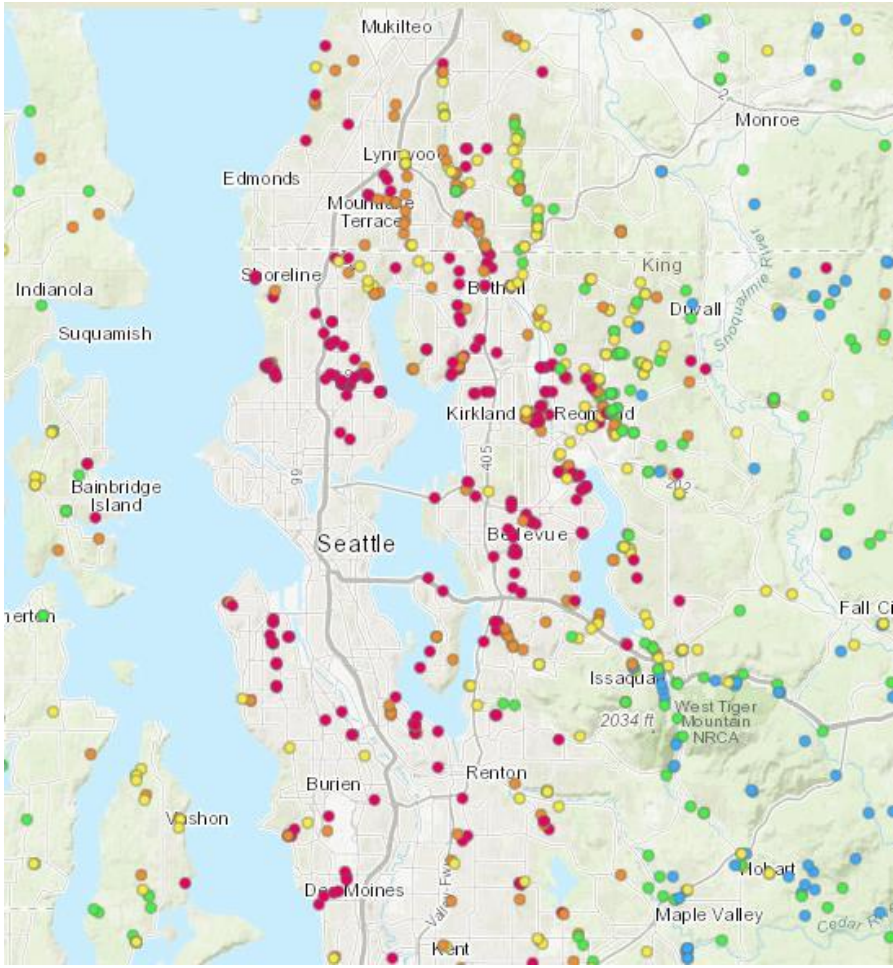
JONATHAN D. TONKIN, STEFAN STOLL, ANDREA SUNDERMANN AND PETER HAASE
Department of River Ecology and Conservation, Senckenberg Research Institute and Natural History Museum Frankfurt, Gelnhausen, Germany

Bug Seeding:
Intentional re-introduction of macroinvertebrates to streams

- *Why re-introduce bugs?*
- *Where, when, and how did we do this?*
- *What did we find?*

Why re-introduce bugs?

- Urban stream restored but community not recovered, or little hope that it could recover
- Can stream support a more diverse community?
- Taxa richness key indictor of stream health
- Tested the isolation hypothesis and jump start recovery in several streams



B-IBI sites indicated by score (red = very poor)

BUT WAIT!

- Don’t we have tons of data to show this might be a terrible idea?

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Minnesota DNR stocking trout

Asian giant “murder” hornet, WSDA

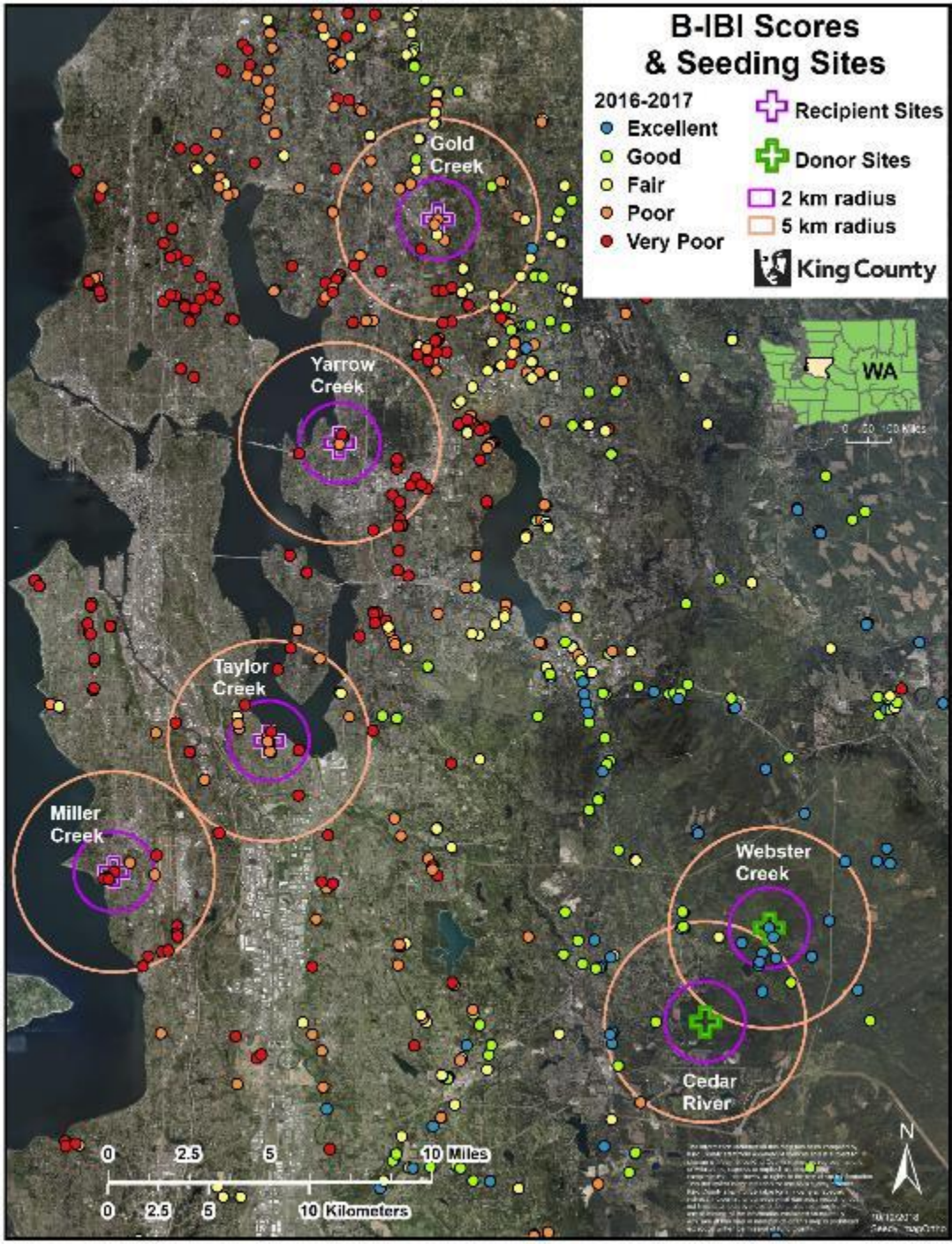
BUT WAIT!

- Don’t we have tons of data to show this might be a terrible idea?
- Yes, and therefore we:
  - Considered risks to donor and recipient streams.
  - Minimized risks of introducing diseases and non-native species.
  - Selected recipient streams carefully; spoke with co-managers.
  - Evaluated how to best measure effectiveness.
  - Got permits.

Where, when, and how?

- Evaluated recipient streams
  - Do they lack sensitive taxa?
  - Are they isolated?
  - Co-managers OK with this?
  - Are there good donor streams?

Sundermann et al. 2011 and Tonkin et al. 2014



Where, when, and how?

- Set out colonization baskets for 6+ weeks in 2 donor streams, July 2018

Where, when, and how?

- Sampled recipient streams pre-seeding
- Transported 34 baskets to each recipient stream, Sept 2018
- Sacrificed and identified all bugs in 10 baskets

Where, when, and how?

- Moved ~46,000 inverts to each recipient stream (+1000 lbs of cobble)
- 15 new mayfly taxa
- 9 new stonefly taxa
- 13 new caddisfly taxa

What did we find?

- In 4 years post-seeding

- Gold Creek:
  - *Pteronarcys princeps* (stonefly)
  - *Soyedina* (stonefly)
  - *Drunella doddsii* (mayfly)

- Taylor Creek:
  - *Cinygmula* (mayfly)
  - *Acneus* (beetle)
  - *Pacifastacus leniusculus* (crayfish)

- Yarrow Creek:
  - *Pteronarcys princeps* (stonefly)
  - *Psychoglypha* (caddisfly)

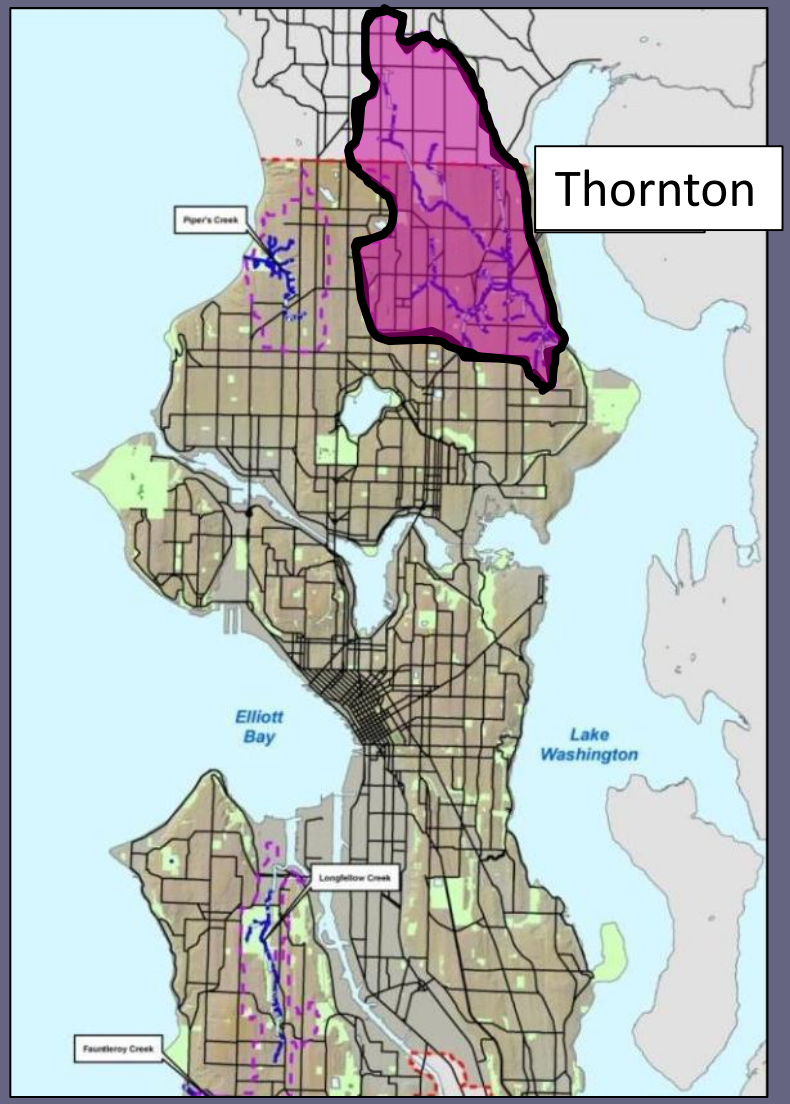
- Miller Creek:
  - *Diphetor hageni* (mayfly)

What did we find?

- 9 new taxa found at least once after seeding
- New taxa rare
- Diversity increased but not by a lot and not necessarily sustained

Urban Floodplain Restoration

Q: Can we “jump start” the recovery process by seeding?

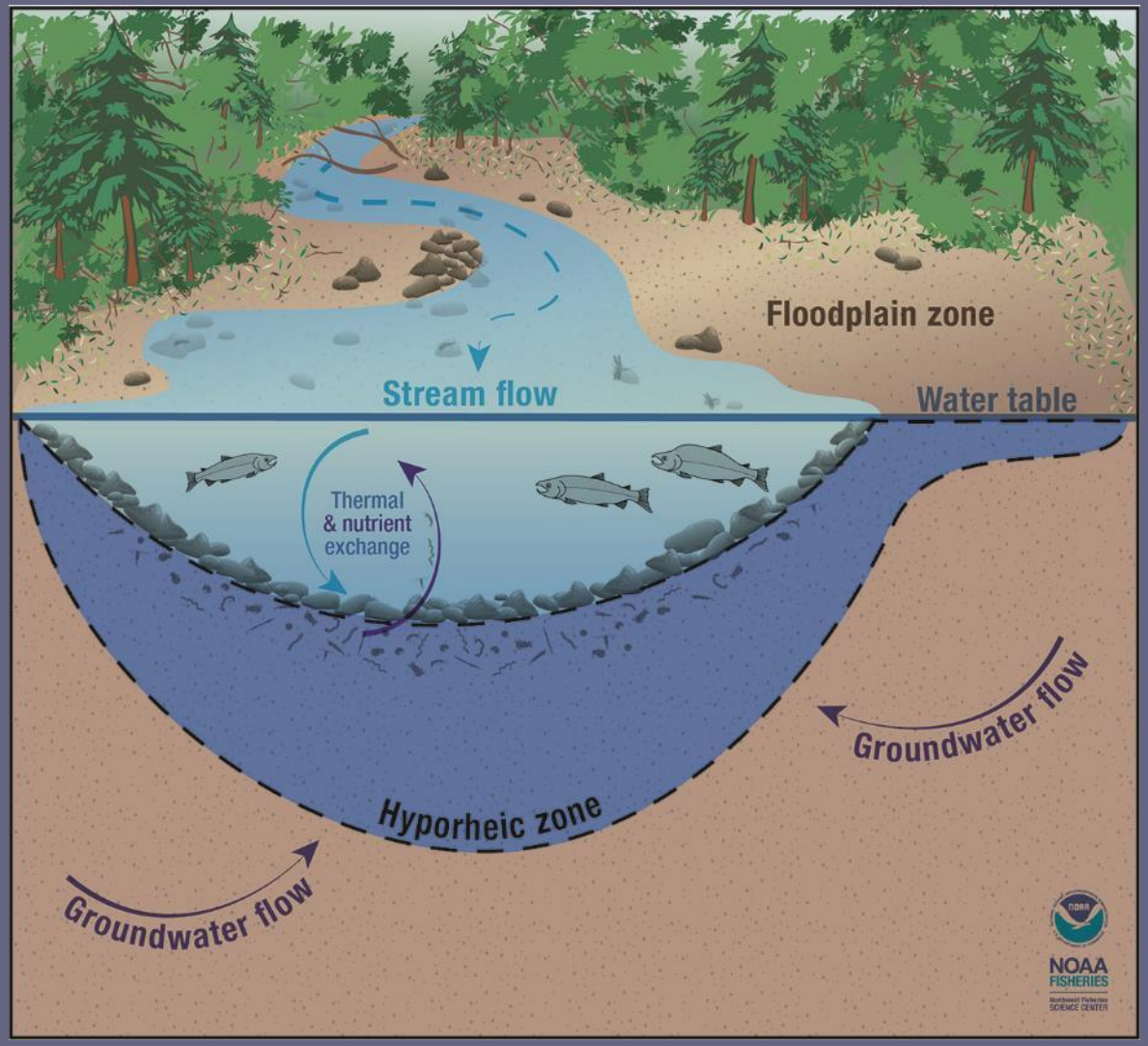


NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

City of Seattle

Projects Included Hyporheic Zone

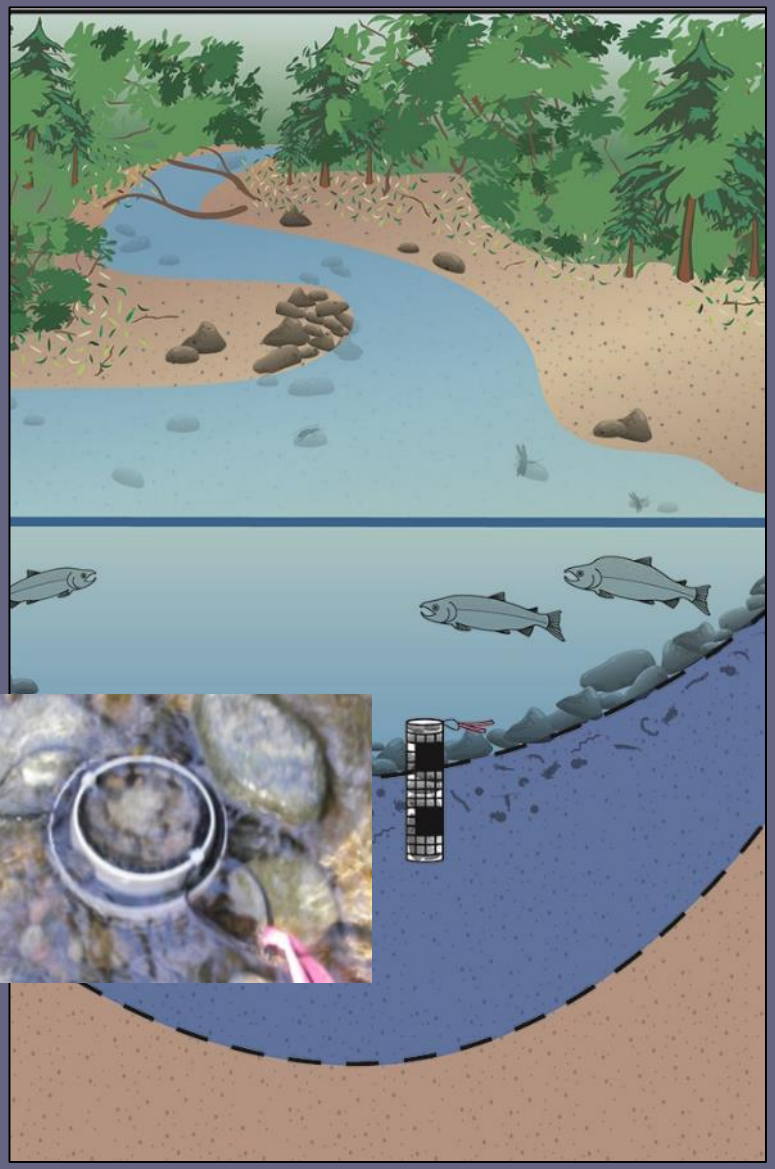
Mixing of surface and groundwater below and alongside channel

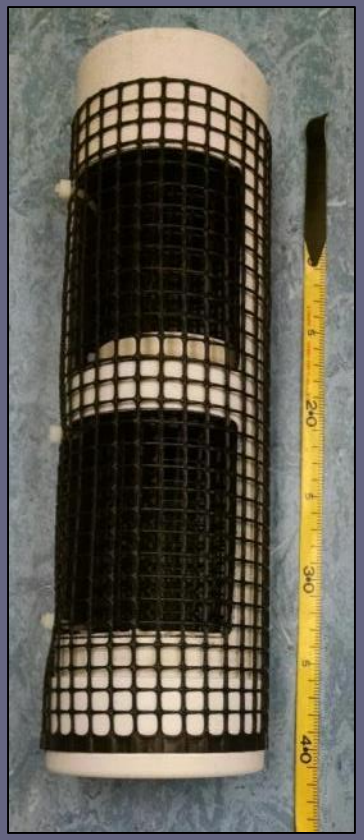


- Flood dampening
- Groundwater recharge
- Temperature regulation
- Biological production
- Nutrient cycling

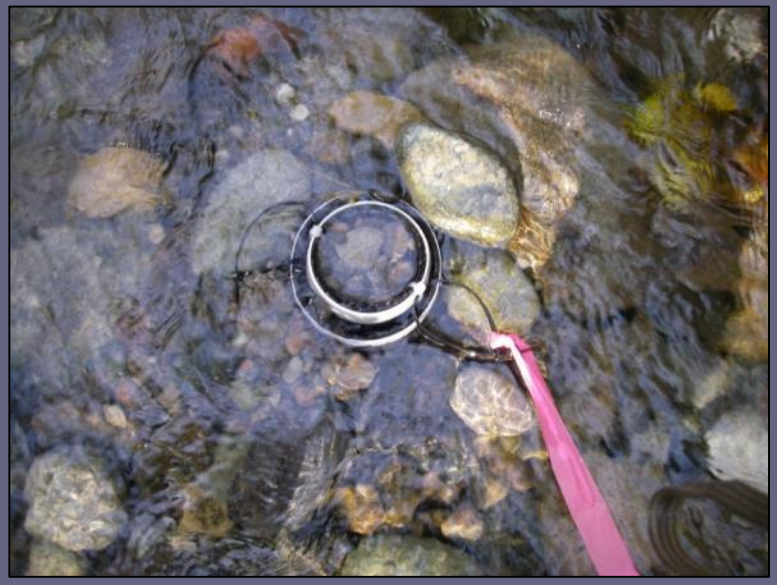
We Seeded Invertebrates and Microbes

We Used Vertical Colonization Baskets





Where, When, and How?



Sample Timeline

2014 2015

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov

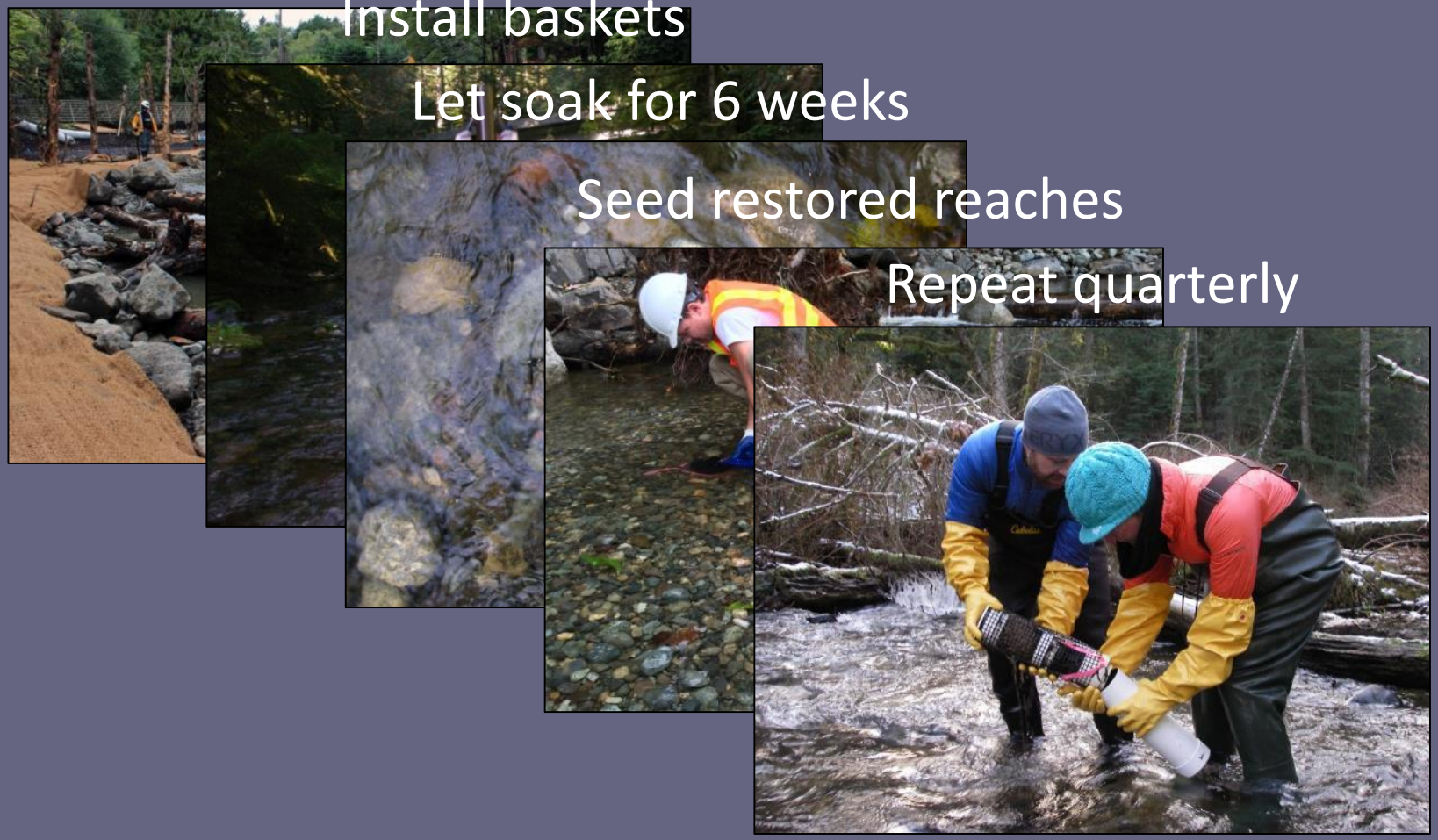
Construction completed

Install baskets

Let soak for 6 weeks

Seed restored reaches

Repeat quarterly



Inoculation Response – Invertebrates

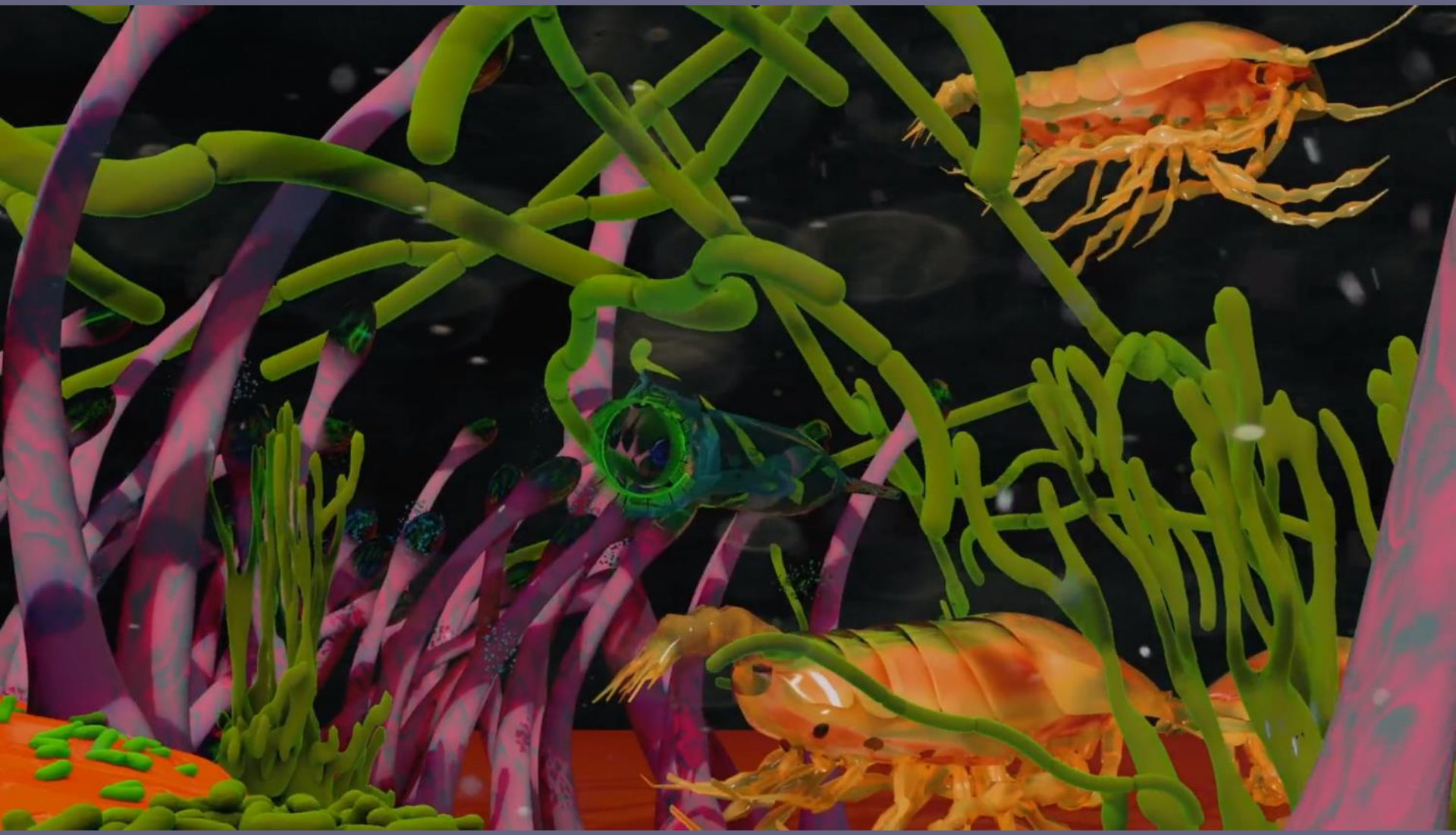
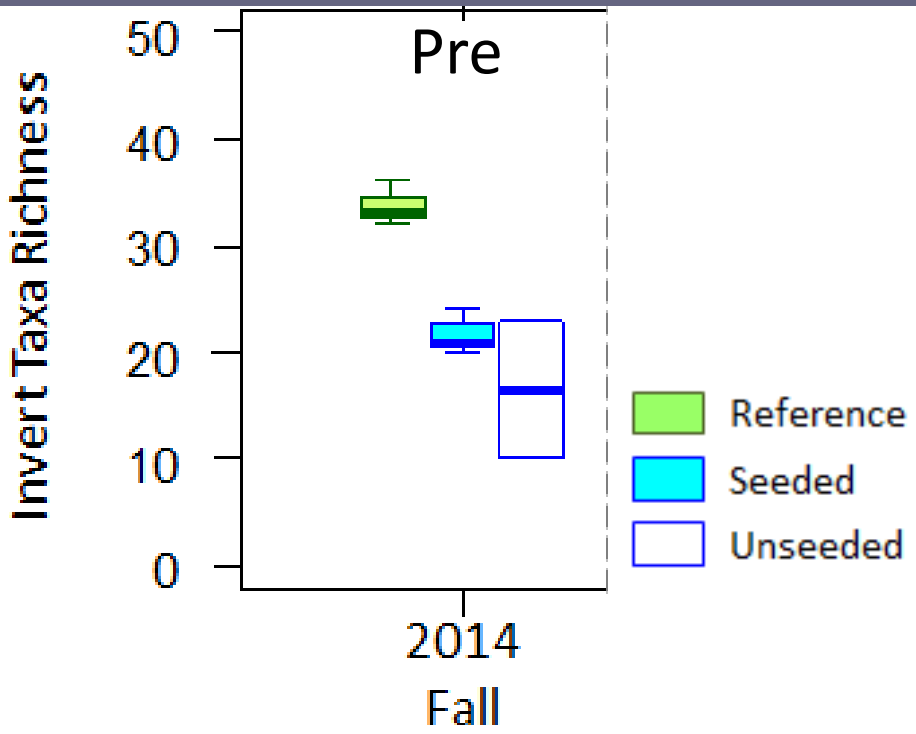


Image: Leaping Frog Films

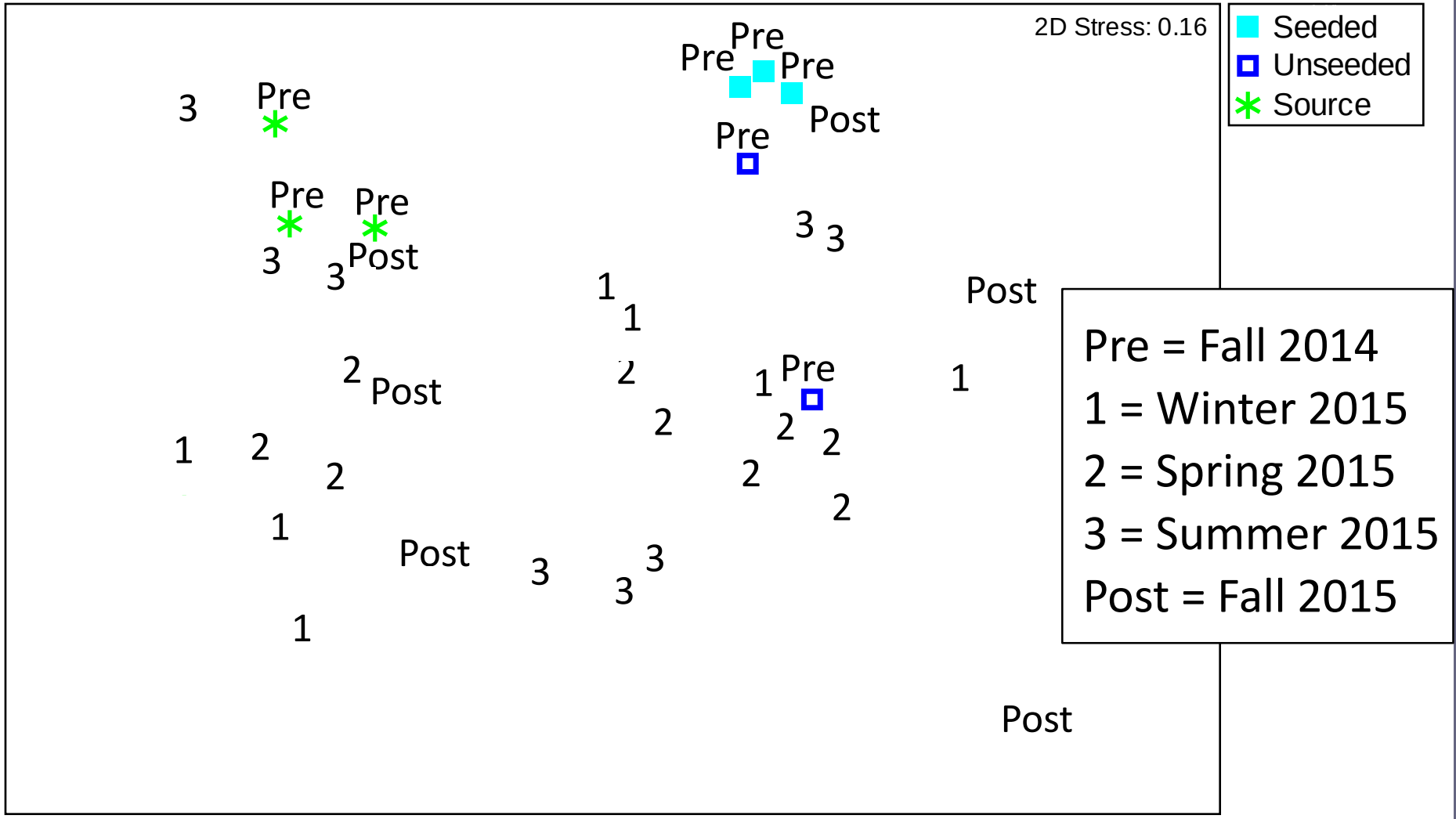
Inoculation Response – Invertebrates



Inoculation Response – Microbes

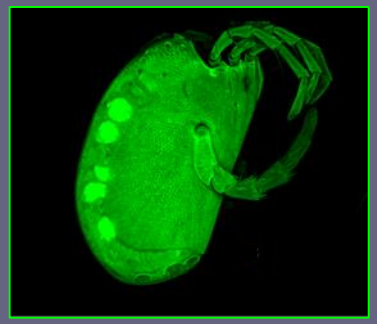
Image: Leaping Frog Films

Inoculation Response – Microbes



Summary of Seeding Response to Date

- Small transient changes in microbial taxonomic structure
- No significant changes in invertebrate density or structure
- Detection of four “new” invertebrate taxa at seeded reach



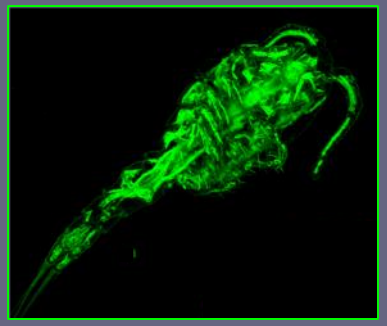


Image Source: S. Iepure

What's the Take Home?

- Bug seeding is not a silver bullet – proceed with caution
- More studies needed to determine long-term potential
- Scale and context of projects likely critical to outcome

Thank you!

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- **King County Stream Teams**
- **Katherine Lynch, Seattle Public Utilities (SPU)**
- **Kit Paulsen, City of Bellevue**
- **Dave Beedle and Amy LaBarge, SPU**
- **Linda Rhodes, NOAA Fisheries NWFSC**
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  - **WA Department of Ecology**

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Challenges and Uncertainties

- Bug seeding is not a silver bullet
- Hard to know if restoration was sufficient and conditions are adequate
- Hard to know which taxa are present pre-seeding; therefore, challenging to measure effect
- Can be hard to find good donor streams
- Can be hard to move enough bugs

Stream Restoration Toolbox

- If done appropriately…
  - ✓ Lower taxa richness than expected
  - ✓ Conditions have improved
  - ✓ Stream is isolated
  - ✓ Safe source of colonists
  - ✓ Permits
  - ✓ Monitoring plan in place

  …. bug seeding can be a useful tool.

  - Effectiveness studies
  - Accelerate recovery in urban streams
  - Better understand sensitivities of specific taxa

Proceed with Caution

- CRITICAL: Don’t introduce non-native species or pathogens to donor or recipient streams
- Carefully select recipient and donor streams
- Have a plan for measuring effectiveness
- Get permits
- Collect and transport bugs carefully
- Monitor annually for at least five years

Additional Resources

Proceed with Caution

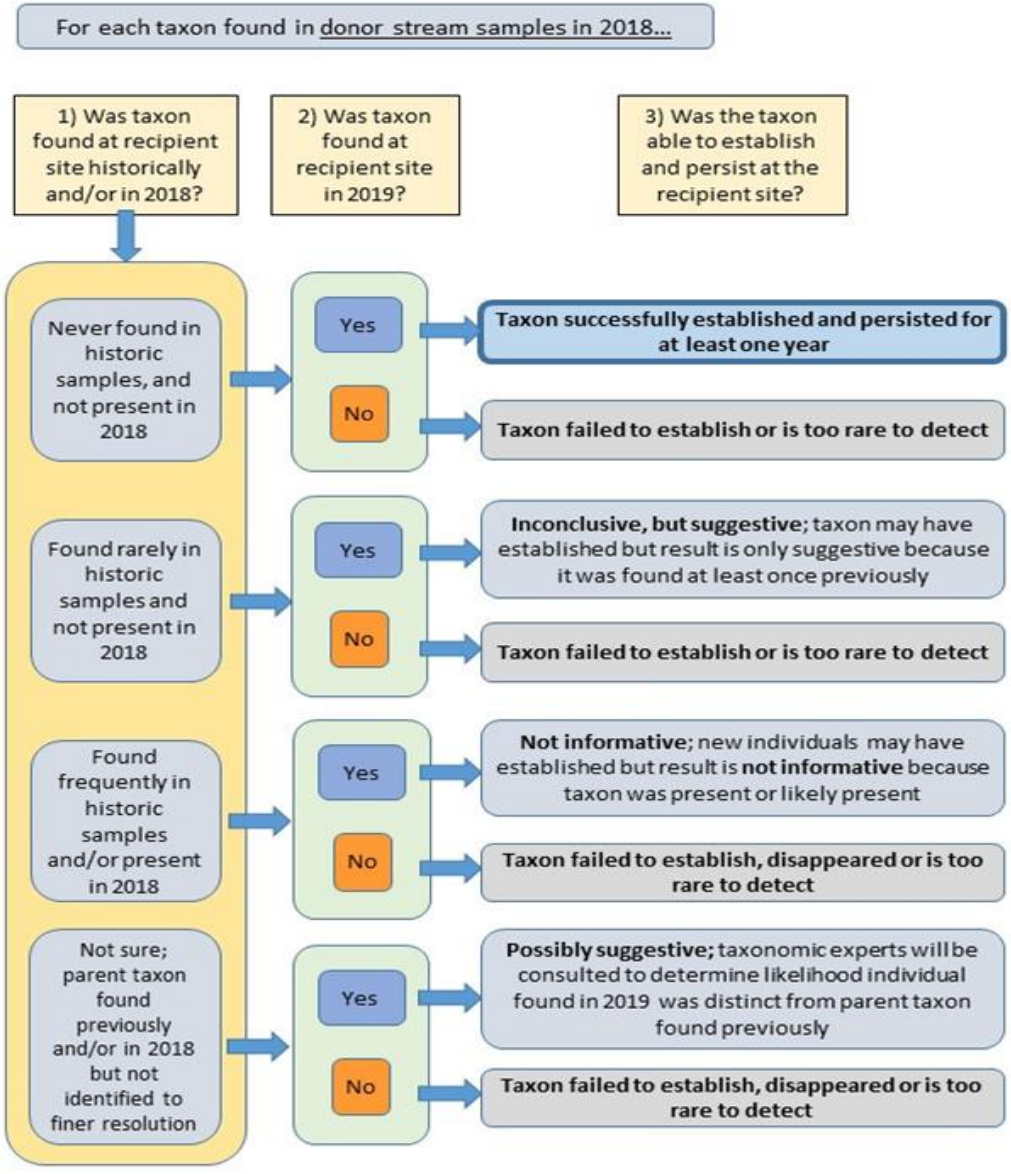
Many of these recommendations included in Freshwater Science paper:

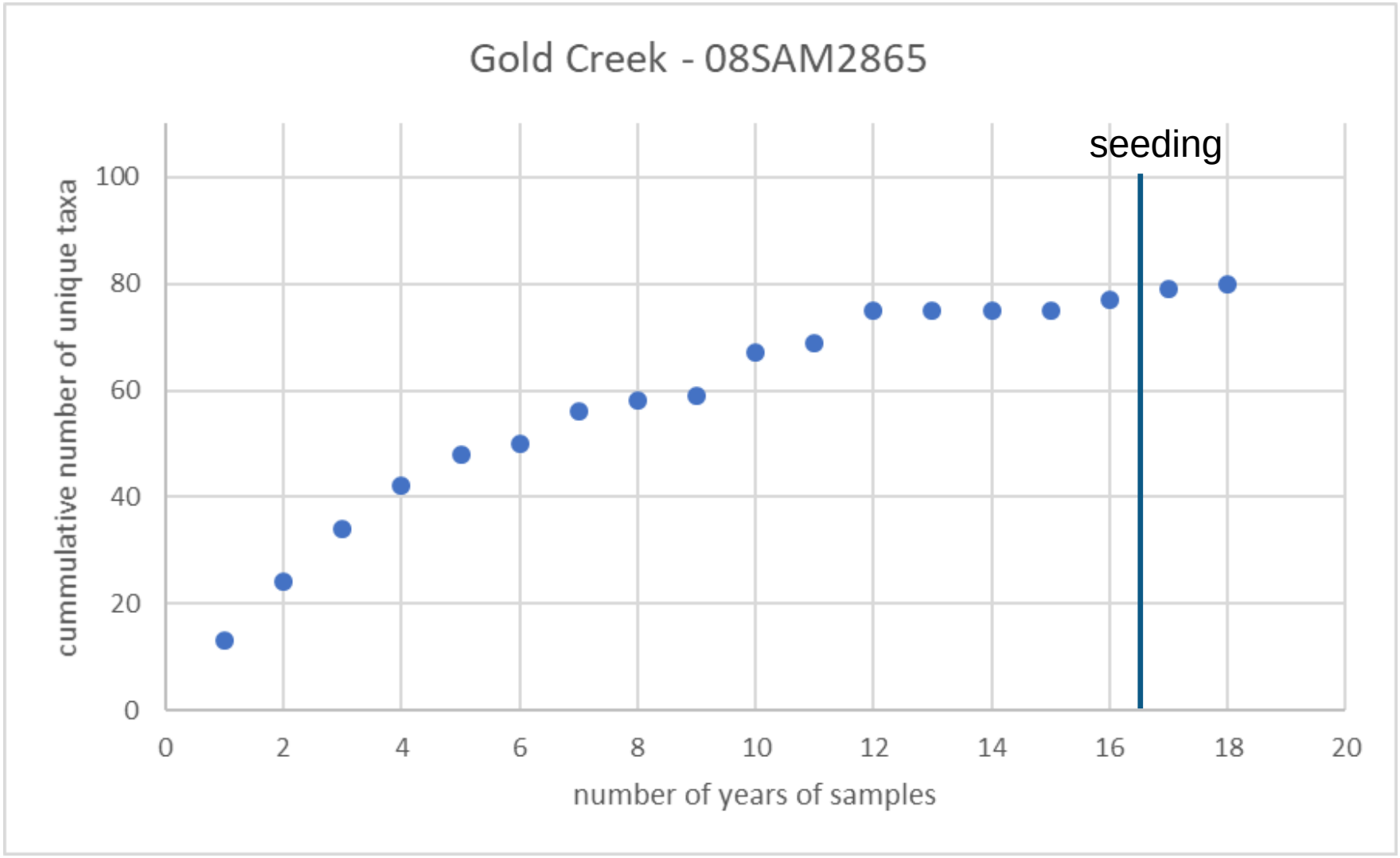
Stream macroinvertebrate reintroductions: A cautionary approach for restored urban streams

Sandra M. Clinton[1,4], Jacqueline Hartman[1,5], Kate H. Macneale[2,6], and Allison H. Roy[3,7]

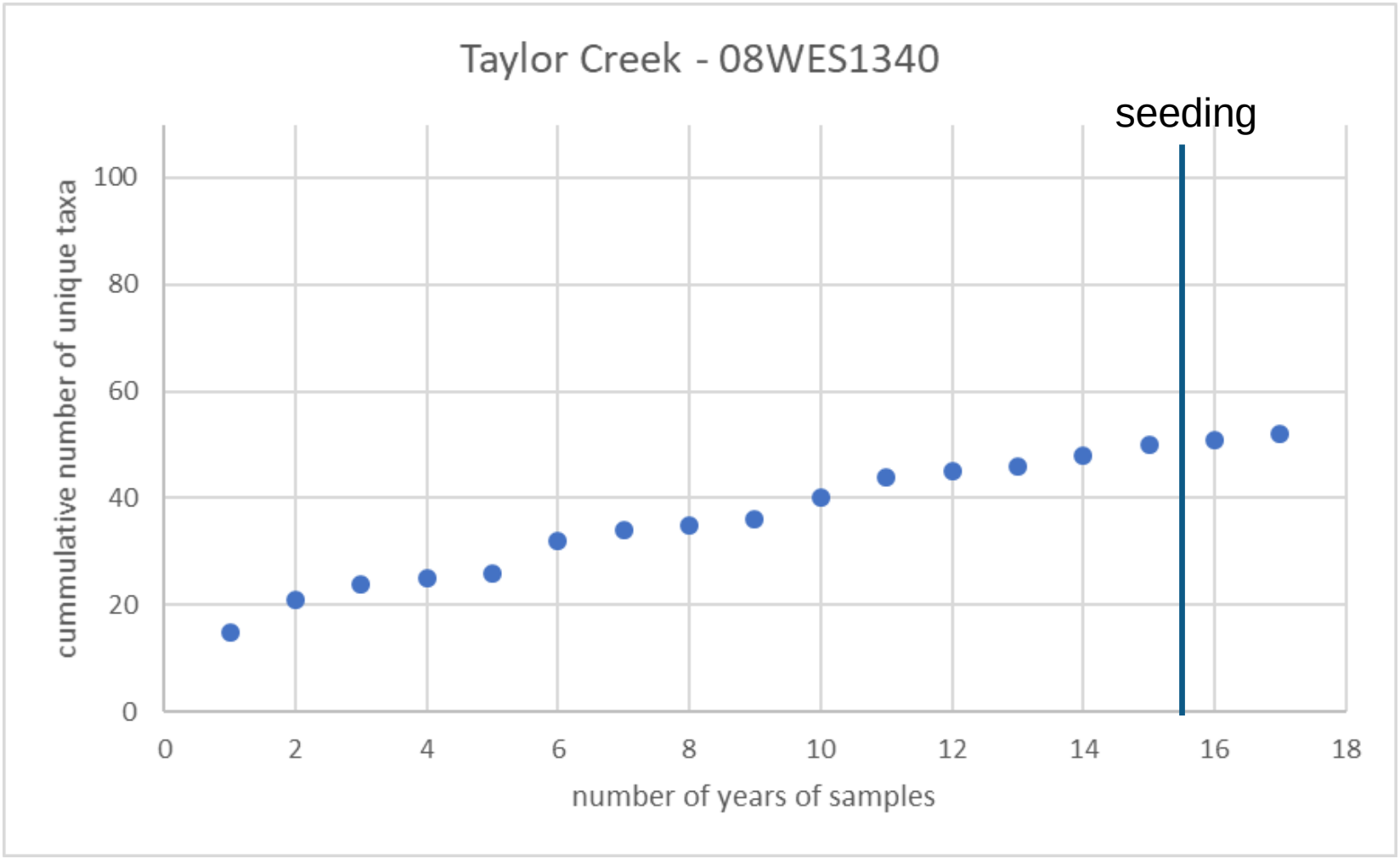
Freshwater Science, volume 41, number 3, September 2022

Goats were sedated and blindfolded Thursday in Olympic National Park before being put into harnesses as part of the goat relocation project.(Ramon Dompor / The Seattle Times)

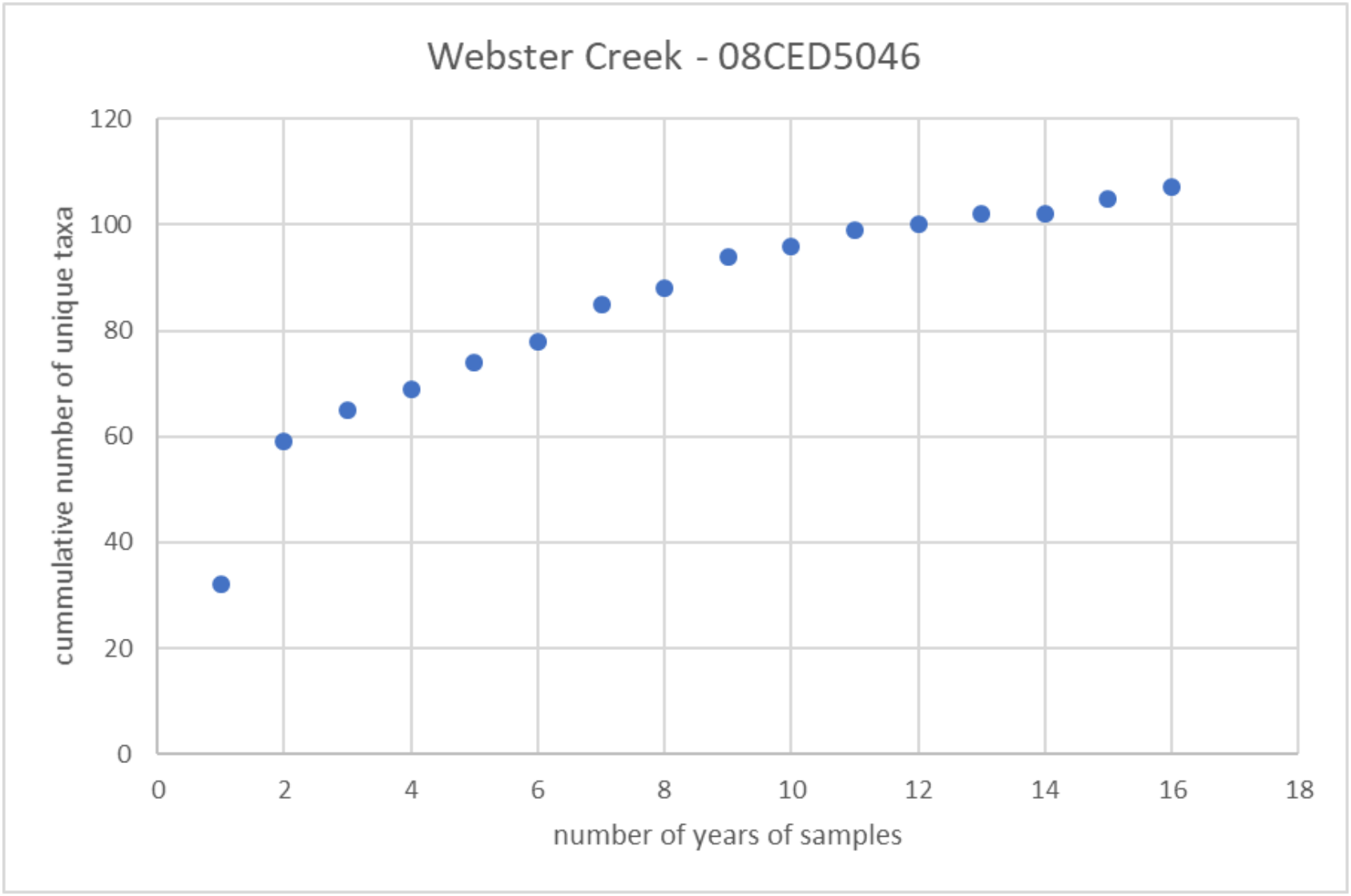

For each taxon found in donor stream samples in 2018...
1) Was taxon found at recipient site historically and/or in 2018?
2) Was taxon found at recipient site in 2019?
3) Was the taxon able to establish and persist at the recipient site?
Never found in historic samples, and not present in 2018
Found rarely in historic samples and not present in 2018
Found frequently in historic samples and/or present in 2018
Not sure; parent taxon found previously and/or in 2018 but not identified to finer resolution
Yes
No
Taxon successfully established and persisted for at least one year
Taxon failed to establish or is too rare to detect
Inconclusive, but suggestive; taxon may have established but result is only suggestive because it was found at least once previously
Taxon failed to establish or is too rare to detect
Not informative; new individuals may have established but result is not informative because taxon was present or likely present
Taxon failed to establish, disappeared or is too rare to detect
Possibly suggestive; taxonomic experts will be consulted to determine likelihood individual found in 2019 was distinct from parent taxon found previously
Taxon failed to establish, disappeared or is too rare to detect



Curve had plateaued at ~77 taxa



Curve had not yet plateaued at ~50 taxa

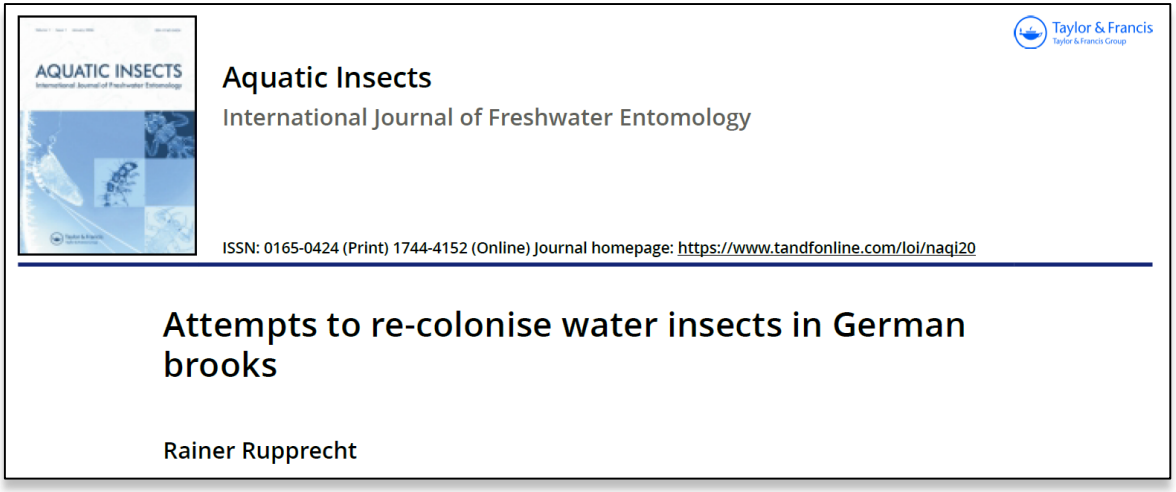


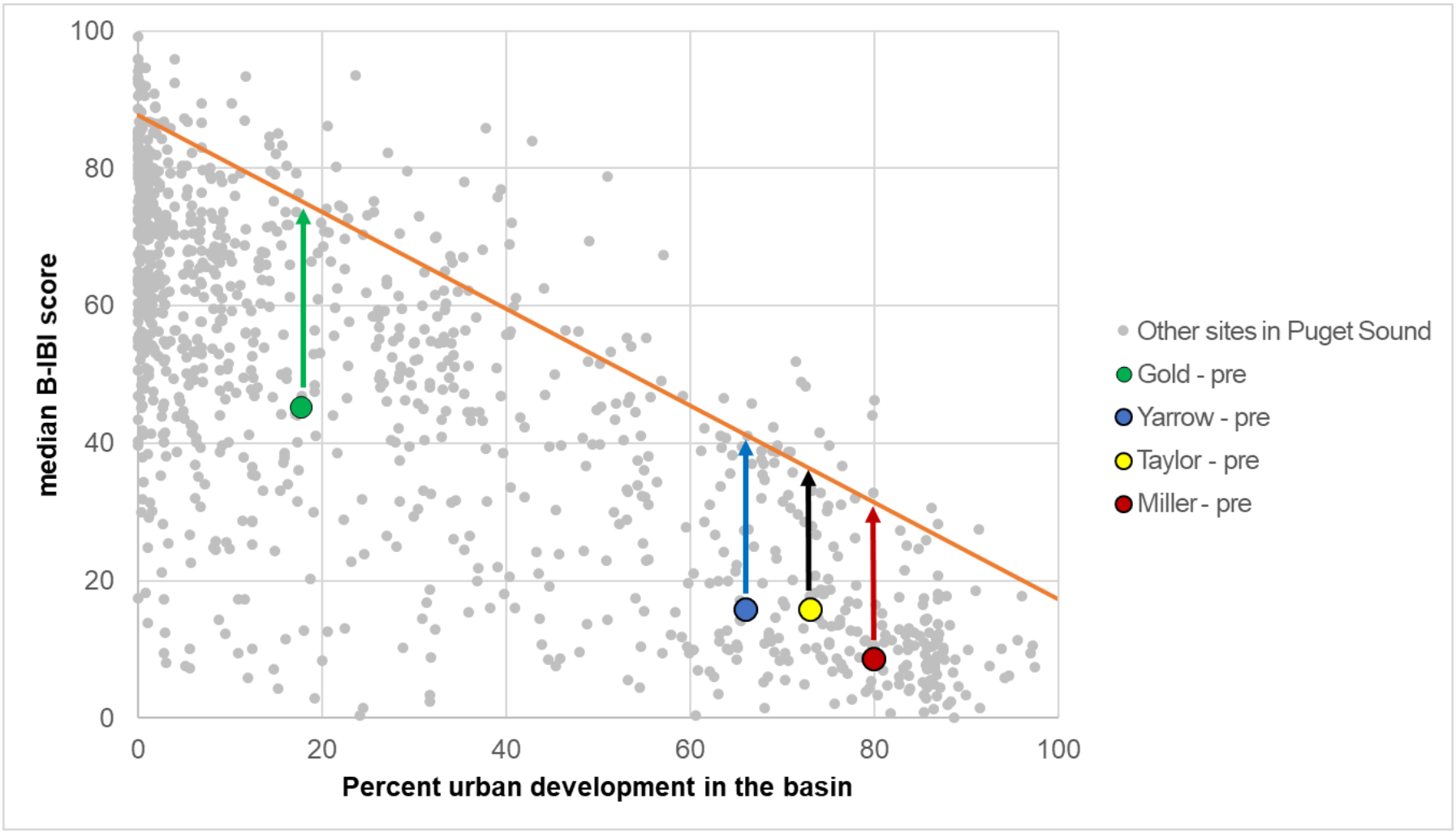
One of the donor streams; as of 2019, 107 unique taxa

Variable	Gold Creek	Taylor Creek	Yarrow Tributary	Miller Creek
Number of sites sampled in stream or subbasin	2	9	3	8
Years of record	2002 - 2018	1994 - 2018	2001, 2013, 2016, 2018	2003 - 2018
Number of samples reviewed to generate pre-seeding taxa list	26	77	4	92
Total number of unique taxa found in stream or subbasin	150	149	72	176

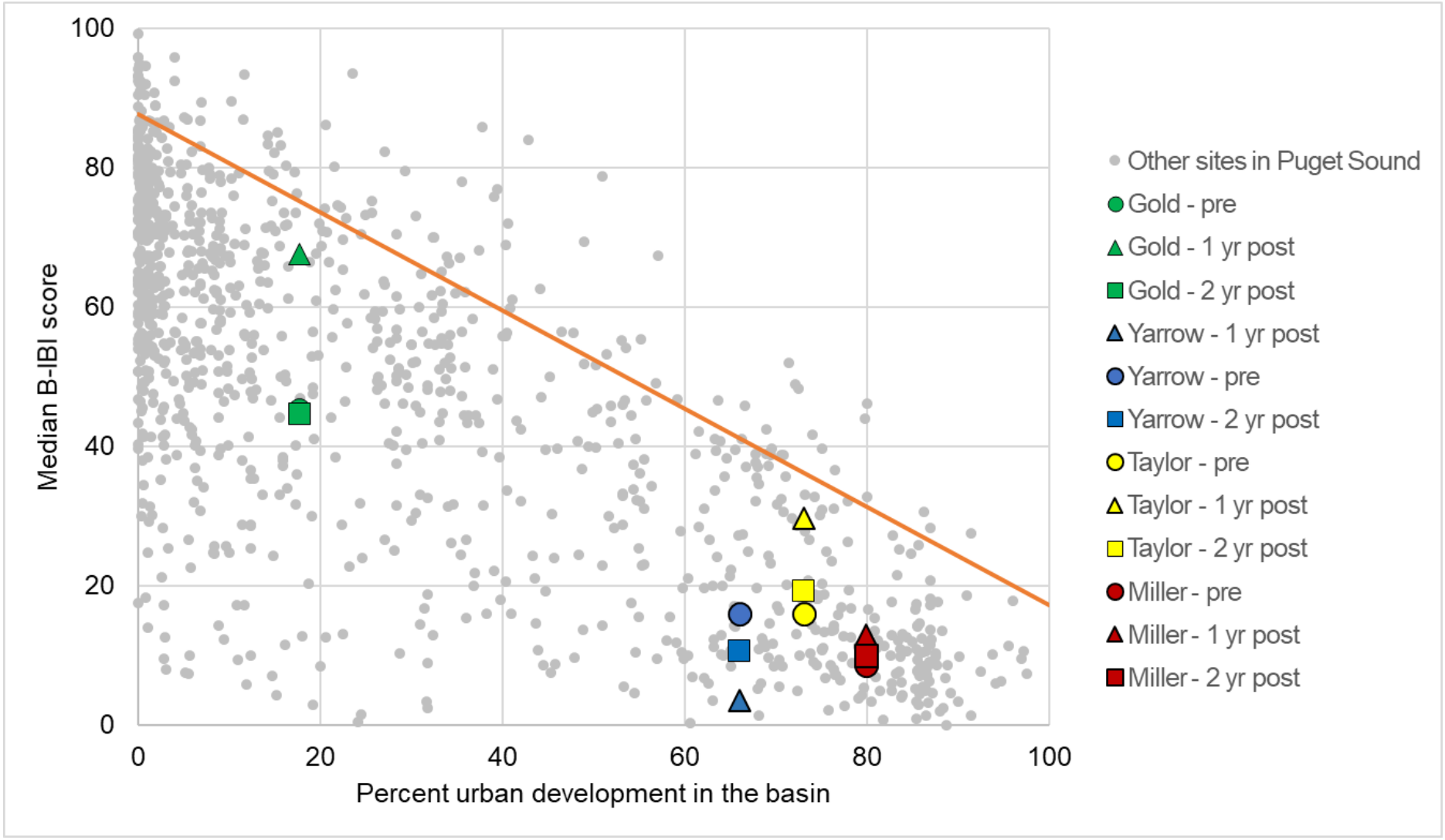
Note these unique taxa include Chironomids, Oligochaetes, and mites to genus/species; the graphs in the previous slides do not

San Francisco Forktail credit: Alan Wight





Paul et al. 2009


100
80
60
40
20
0
Median B-IBI score
0
20
40
60
80
100
Percent urban development in the basin
Other sites in Puget Sound
Gold - pre
Gold - 1 yr post
Gold - 2 yr post
Yarrow - 1 yr post
Yarrow - pre
Yarrow - 2 yr post
Taylor - pre
Taylor - 1 yr post
Taylor - 2 yr post
Miller - pre
Miller - 1 yr post
Miller - 2 yr post