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The Stream Restoration Puzzle: Why Investment Projects Often Fail to Meet Expectations

Matthew J. Ehrhart
Director of Watershed Restoration

John K. Jackson, Ph.D.
Senior Research Scientist
&
Colleagues and Coworkers

PACD Section 319 Planning/Implementation May 2024



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Our Agenda Today

- A 2024 perspective on impairments and stressors
 - ❖ Reflects our experience primarily in PA, and EPA Regions 2 and 3
- Re-examine stressors, changes in stressors, and promised vs observed outcomes
- Address approaches to Stream & Watershed Restoration and Resilience
 - ❖ including Stroud's approach to stream and watershed protection and restoration, with a special emphasis on forested buffers

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Take Homes for Today

- The public does not understand impairments or stressors
 - ❖ Does not grasp our past successes, or future challenges
- Efforts to communicate or simplify messaging has complicated pollution-reduction efforts
 - ❖ Target single or a few pollutants, and hope for the best
- Failure to delist impairments, climate change, and emerging pollutants are changing this discussion
 - ❖ As the new "news" sinks in, we have to revisit "restoration" approaches from the last 10-20 years


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Clean Water Act 1972 Safe Drinking Water Act 1974

2024 is the
52nd anniversary
Clean Water Act


76th anniversary
Federal Water Pollution Control Act – 1948

87th anniversary
Pennsylvania Clean Streams Law – 1937




5

Protected Uses in the Clean Water Act




Swimmable




Drinkable

Also -
agricultural,
industrial,
navigational
uses

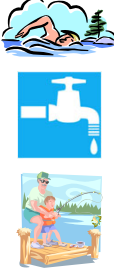


Fishable



6


Impaired = protected uses are not sustained



Swimmable


Drinkable

Fishable




7



Chemical



Physical




Biological





8


Aquatic Macroinvertebrates
Primarily aquatic insects, but non-insects too




Mayflies




Caddisflies




Stoneflies



Crayfish






Snails



Mussels

9




Pollution-Sensitive Species

Ephemeroptera
Plecoptera
Trichoptera

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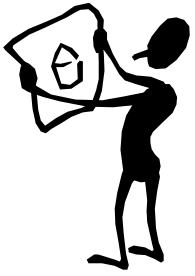

Pollution-Sensitive Species

Restoration = recovery of some (not all) indicator species

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What Have Stream Assessments Found?

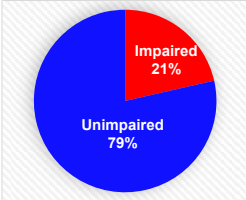



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2022 PA Integrative Report
<https://www.dep.pa.gov/Business/Water/CleanWater/WaterQuality/IntegratedWatersReport/Pages/2022-Integrated-Water-Quality-Report.aspx>

- 21% of Pennsylvania river and stream miles do not support healthy populations of aquatic life or other designated uses

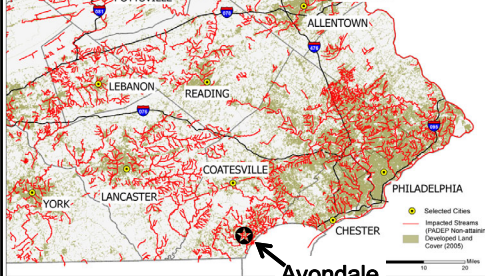
27,883 miles



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We have a lot of polluted and clean streams



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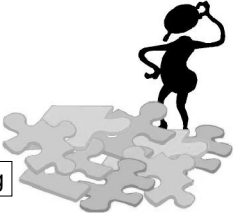
We have a lot of polluted and clean streams

Lancaster County, PA

1286 miles impaired (89%)

6,790,080 feet impaired
as of 2022

6,790 projects if 1000 feet long



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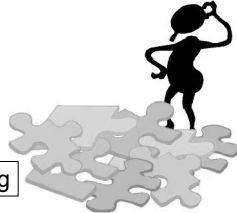
We have a lot of polluted and clean streams

Chester County, PA

1020 miles impaired (72%)

5,385,600 feet impaired
as of 2022

5,385 projects if 1000 feet long



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We have a lot of polluted and clean streams

Delaware County, PA

364 miles impaired (95%)

1,921,920 feet impaired
as of 2022

1,921 projects if 1000 feet long



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We have a lot of polluted and clean streams

Monroe County, PA

102 miles impaired (10%)

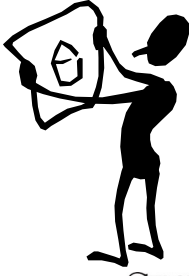

538,560 feet impaired
as of 2022

538 projects if 1000 feet long

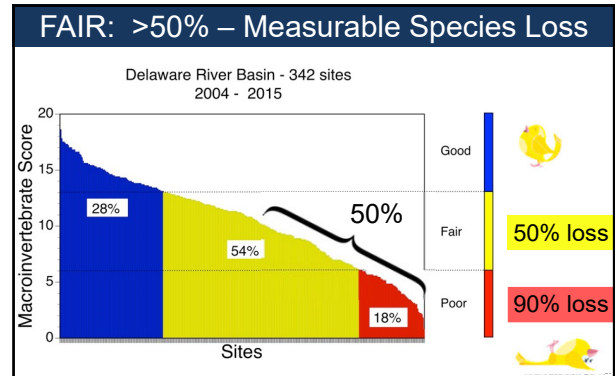


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What is the current condition of streams in the Delaware River Basin?

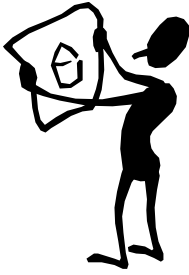




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What is the cause of current stream degradation in the Delaware River Basin?

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In the Delaware River Basin, polluted sites are often downstream of both agriculture & development






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People

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Is the Clean Water Act protecting our streams and rivers?

1. Have conditions improved or been maintained?

Yes!

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You Can See It, Smell It, Feel It:



Rivers are not burning

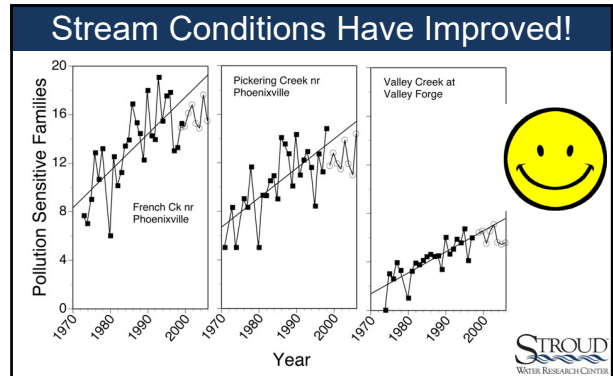


Pipe Discharges Are Not Filthy

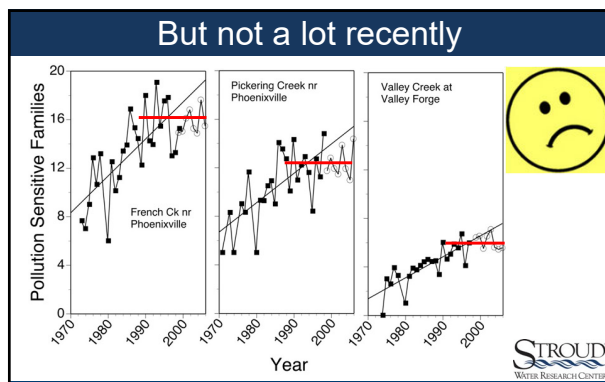


Dead Fish Are Not Common

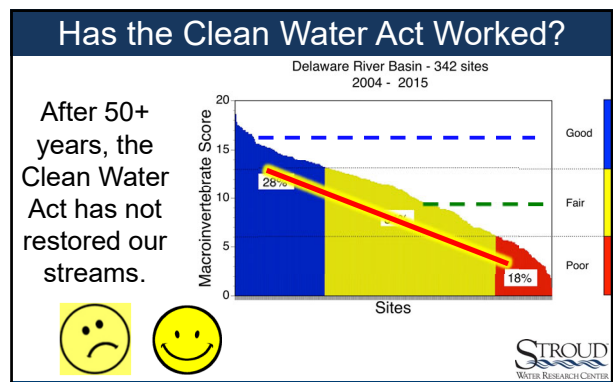
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Why are we not seeing streams delisted, or at least larger improvements?

1. Not Enough Time?
2. Not Enough Intensity?
3. Wrong Prescription?
4. Missed Something?



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Addressing 100 ft here and 1000 ft there, leaves us much more to do!

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(89%)

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Wrong Prescription?




Focus on excess sediment load from eroding stream banks.




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Wrong Prescription?



Channel Modifications ←

"Fixing" 1% of the watershed cannot clean up the problems from the other 99%



Field Challenges Unaddressed →

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Wrong Prescription - Hydrology:

We are not learning from our failures


Emerson, C.H., C. Welty, and R.G. Traver. (2005)
Watershed-scale evaluation of a system of storm water detention basins.
Journal of Hydrologic Engineering 10:237-242.

little evidence for hydrologic improvements due to stormwater infrastructure

Detailed study >100 BMPs 17 years ago

Miller, A.J., C. Welty, J.M. Duncan, M.L. Baeck, J.A. Smith. (2021)
Assessing urban rainfall-runoff response to stormwater management extent.
Hydrological Processes 35: e14287.

Same result 2021



35

Wrong Prescription - geomorphology:

We are not learning from our failures

Bernhardt, E.S. and M.A. Palmer (2011).
River restoration: the fuzzy logic of repairing reaches to reverse catchment scale degradation.
Ecological Applications 21:1926-1931.

little evidence for ecological uplift after a stream's geomorphic attributes have been repaired

Literature Review 12 years ago

Hilderbrand, R.H., J. Acord, T.J. Nuttle and R. Ewing (2020)
Quantifying the ecological uplift and effectiveness of differing stream restoration approaches in Maryland
Final Report - Chesapeake Bay Trust for Grant #13141

40 Streams 2020

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Wrong Prescription - geomorphology: We are not learning from our failures

Stowe, Petersen, Rao, Walther, Freeman, Wenger (2023)

Stream restoration produces transitory, not permanent, changes to fish assemblages at compensatory mitigation sites

Restoration Ecology Vol. 31 (5): e13903,

23 "Natural Channel Design" projects, 53 sites in Georgia

Early "benefits" were not observed by the 7th year

little evidence for ecological uplift after a stream's geomorphic attributes have been repaired

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Wrong Prescription - geomorphology: We are not learning from our failures

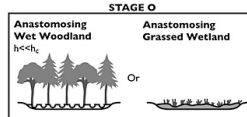
Smith, Neideigh, Rittle, Wallace (2020)

Assessing macroinvertebrate community response to restoration of Big Spring Run: Expanded analysis of before-after-control-impact sampling designs.

River Research and Applications 36:79-90

After 3 years: "restoration had no effect on the macroinvertebrate community due to poor in-stream conditions"

little evidence for ecological uplift after a stream's geomorphic attributes have been repaired



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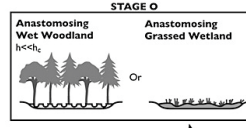
Wrong Prescription - geomorphology: We are not learning from our failures

Pizzuto, Huffman, Symes. (2023)

Pre- and postsettlement depositional processes and environments of the 3rd-to 5th-order White Clay Creek watershed, Piedmont Province, Pennsylvania and Delaware, USA.

Geological Society of America Bulletin.

Based on 10 sites in 3rd – 5th order watersheds: "Instead of being dominated by wetlands, presettlement river corridors are better described as a complex mosaic of riparian environments including ... older colluvial landforms ... floodplains ..., primary (and possibly secondary) channels, ... either localized or valley-spanning wetlands ..."



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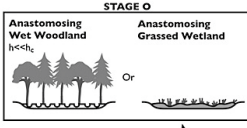
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Based on 10 sites in 3rd – 5th order watersheds: "millponds were important locally, but their deposits represent a minor component of the stratigraphic record."



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There are new pollutants of concern today – some are roadway and parking lot pollutants tied to all of us ...

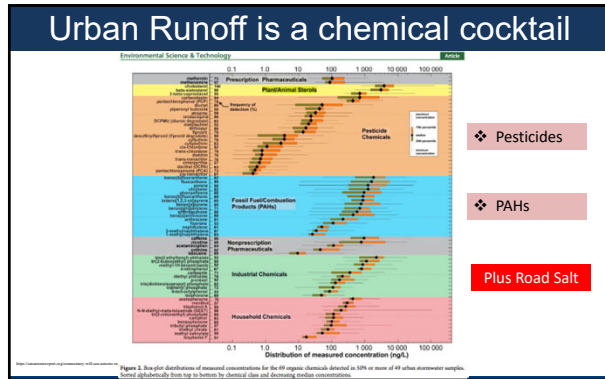


Winter deicing salts (2003)

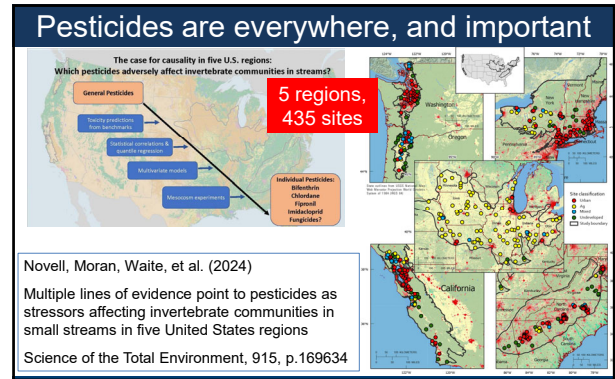
PAHs in coal tar seal coats (2003)

6PPD-quinone from tires (2020)

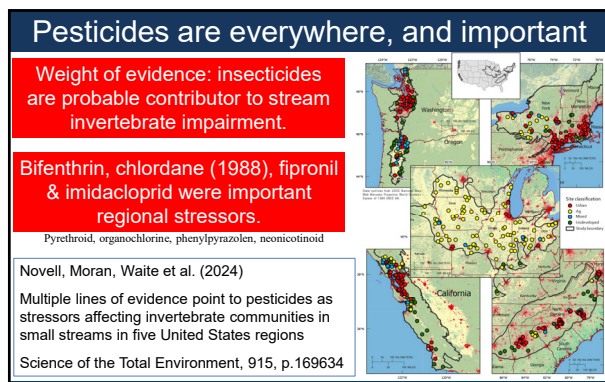
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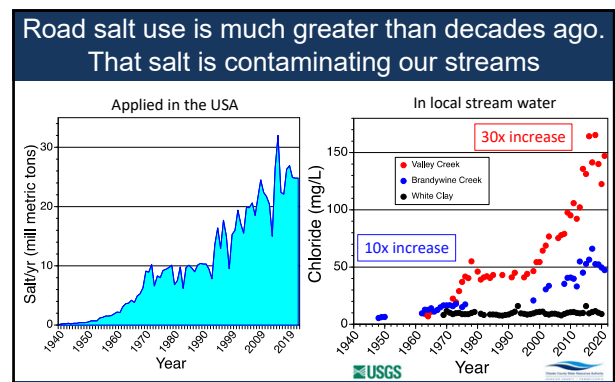
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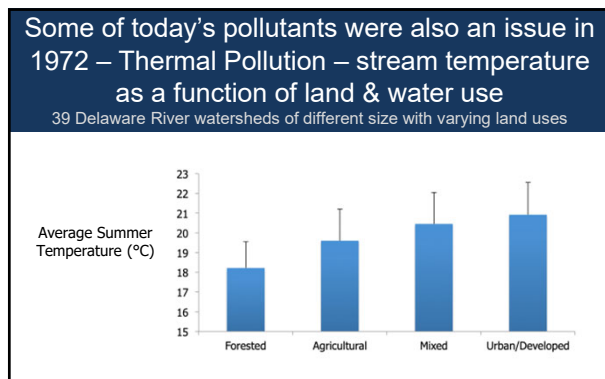
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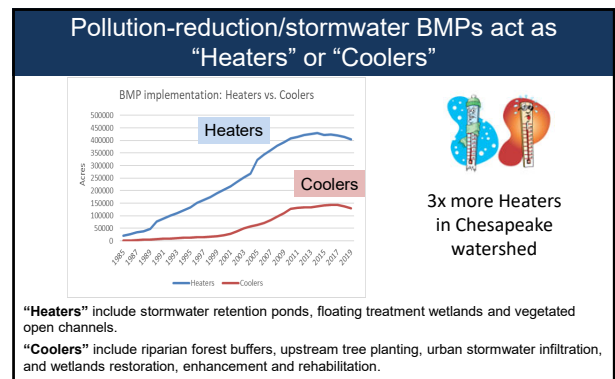
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Unhealthy Stream = Unhealthy Watershed

– generally with many concurrent stressors –
Vary spatially and temporally, with cumulative/additive effects

Unhealthy Streams:
Land-based activities can increase nutrients, toxicants, and sediments entering streams.

Healthy Streams:
Well-managed land-based activities will reduce the amount of nutrients, toxicants, and sediments entering streams.

Factors that degrade streams:

- Storm water runoff from parking lots, roofs, and paved lots
- Storm water runoff from lawns, gardens, and other landscaped areas
- Storm water runoff from roads, parking lots, and other paved areas
- Storm water runoff from roofs, parking lots, and other paved areas
- Storm water runoff from roofs, parking lots, and other paved areas
- Storm water runoff from roofs, parking lots, and other paved areas

Factors that protect streams:

- Storm water runoff from roofs, parking lots, and other paved areas
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- Storm water runoff from roofs, parking lots, and other paved areas
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- Storm water runoff from roofs, parking lots, and other paved areas

Healthy streams include:

- Stream water
- Stream banks
- Stream bed
- Stream flow
- Stream temperature
- Stream velocity
- Stream width
- Stream depth
- Stream length
- Stream area
- Stream volume
- Stream discharge
- Stream infiltration
- Stream evaporation
- Stream transpiration
- Stream precipitation
- Stream runoff
- Stream recharge
- Stream storage
- Stream release
- Stream transport
- Stream transformation
- Stream degradation
- Stream restoration
- Stream management
- Stream protection
- Stream conservation
- Stream preservation
- Stream maintenance
- Stream improvement
- Stream enhancement
- Stream rehabilitation
- Stream remediation
- Stream restoration
- Stream management
- Stream protection
- Stream conservation
- Stream preservation
- Stream maintenance
- Stream improvement
- Stream enhancement
- Stream rehabilitation
- Stream remediation

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How do we see more improvement?

We may need to reset the goal posts

- 1) **Do more, try new things.**
 - Same efforts = same results
 - Research
- 2) **Be vigilant.**
 - Monitor to assess success
 - Confirm and learn
- 3) **Change regulations or incentives.**
 - Demand for clean water/clean streams will increase

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Restoration Approach: Mimic or Restore Natural Function

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Watershed Scope and Scale

Beiler Run

- Approximately 1500 acres
- 13 Parcels (11 farms) stream adjacent
- 19 total farms in the watershed

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Inconvenient Resiliency

Streams are dynamic systems.
Streams are not static in place, time, hydrology or ecosystem function

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Wrong Prescription




- "Restoration"?
- Reduced resiliency
- The modeled load reduction numbers may support this approach. The science does not.



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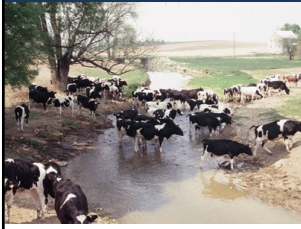
Where Do We Start?

- ❖ Accept that restoration efforts will have to scale with the problem and the watershed size
- ❖ Consider and address multiple stressors
- ❖ Recognize and plan for the human dimension aspect of the work
- ❖ Be prepared to critically evaluate the work and adapt
- ❖ Use Models as planning tools and for perspective, but don't let them limit your efforts



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We know wide, setback fences help



Before & after cows removed



Photo courtesy of Lancaster Co. Conservation District

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We know managed barnyards help



Before & After



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We know wide, forested buffers help




Before & After



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We know wide, forested buffers help



Stream functions we are changing:

- Flow
- Runoff
- Erosion
- Temperature
- Geomorphology
- Food Resources
- Nutrient Processing
- Organic Matter Processing

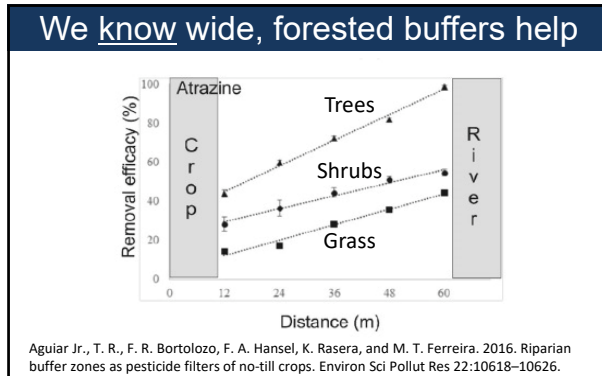
All without channel & floodplain "restoration" projects



60



61



62

We know wide, forested buffers help

Streamside forest buffer width needed to protect stream water quality, habitat, and organisms: a literature review.
Sweeney, BW and JD Newbold. 2014. Journal of the American Water Resources Association 50:560-584.

Wider buffers (>30 m) on small streams have positive impacts on these functions:

- Subsurface nitrate removal
- Sediment trapping
- Stream channel width
- Channel meandering and bank erosion
- Temperature
- Large woody debris
- Macroinvertebrates and fish

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Riparian Forest Buffers – habitat – aquatic and terrestrial

Complex instream habitat

- ❖ Channel geomorphology
- ❖ Stream bank stabilization
- ❖ Coarse sediment
- ❖ Stream is dynamic

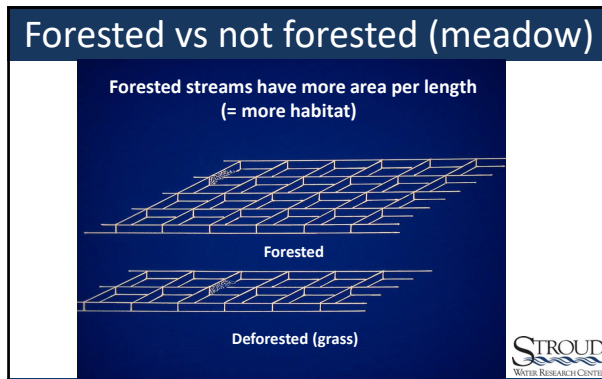
64

Sweeney et al. 2004. PNAS

Riparian deforestation, stream narrowing, and loss of stream ecosystem services.

Riparian deforestation, stream narrowing, and loss of stream ecosystem services
Sweeney, B. W., J. D. Newbold, and A. R. Meyer. 2004. Proceedings of the National Academy of Sciences 101:15173-15178.

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Forested vs not forested (meadow)

- ❖ 1.5 to 3x wider
- ❖ Up to 2.5 slower (longer residence time)
- ❖ Up to 5x more biological activity

Leading to:

- ❖ Up to 9x more N uptake (4x typical)
- ❖ Often 2-5x more P uptake (highly variable)
- ❖ Up to 3x atrazine degradation



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Riparian Forest Buffers

– cannot be the only BMP, stop all pollutants



Concentrated overland flow through a wide, grass buffer


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Whole Farm Approach at Watershed Scale

1. Get farm animals and farm practices out of stream/floodplain (replant a wide riparian forest)
2. Control pollution from barnyards, manure management, private and public roads
3. Improve croplands and pastures (soil health, nutrient management)
4. Aggregate projects to improve watershed & stream

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What can we change? Whole-farm Approach




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We know improved soil health helps



- MAXIMIZE CONTINUOUS LIVING ROOTS**
 - Crop Rotation
 - Relay Crops
 - Forage and Biomass Planting
 - Perennial Crops
 - Cover Crops
- MINIMIZE DISTURBANCE**
 - No-till
 - Reduced Tillage
 - Controlled Traffic
 - Avoid Tillage When Wet
 - IPM
- MAXIMIZE BIODIVERSITY**
 - Crop Rotation
 - Rotational Grazing
 - IPM
 - Pollinator Plantings
 - Organic Fertilizers
 - Legumes in Mix
 - Agroforestry
 - Cover Crops
 - Crop/Livestock Integration
- MAXIMIZE SOIL COVER**
 - Mulching
 - Reduced Tillage
 - Forage and Biomass Planting
 - Residue Retention
 - Cover Crops
 - Green Manures



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Whole Farm Approach at Watershed Scale

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Whole Farm Approach = Passive Stream & Watershed Restoration

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Cost Effectiveness of Passive Restoration

6 Lancaster County, PA farms: Stream miles = 2.38, buffer acres = 26.3, crop acres = 295	Nitrogen (\$/lb • yr)	Phosphorus (\$/lb • yr)	Sediment (\$/lb • yr)
Riparian Forest Buffer (\$6260 per acre) cost effectiveness (\$/lb per yr)	\$39.62	\$2790.47	\$1.37
RFB w/ Livestock Exclusion cost effectiveness (\$/lb per yr)	\$55.89	\$251.48	\$0.32
Cover crop / No-Till on Crop Acres cost effectiveness (\$/lb per yr)	\$4.95	\$202.98	\$0.12
"Stream Restoration" \$500,000/mile cost effectiveness (\$/lb per yr)	\$1322.08	\$1324.43	\$0.38
"Stream Restoration" \$5,000,000/mile cost effectiveness (\$/lb per yr)	\$13,220.75	\$13,244.30	\$3.81

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Urban watersheds present additional challenges

We have strengthened the connection between our lives and the stream.

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Urban Watershed Challenges

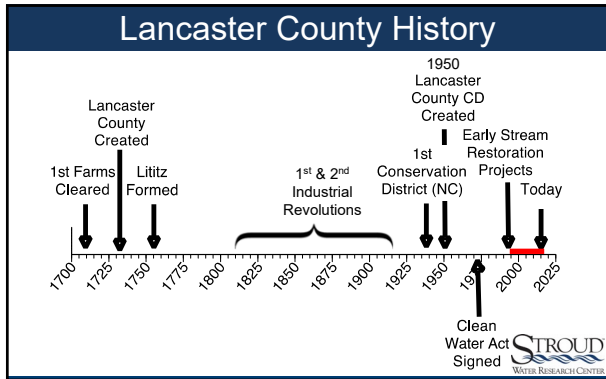
- Increased Impervious Area
- Increased & More Complex Chemical Inputs
- Increased Thermal Stress
- Decreased Habitat

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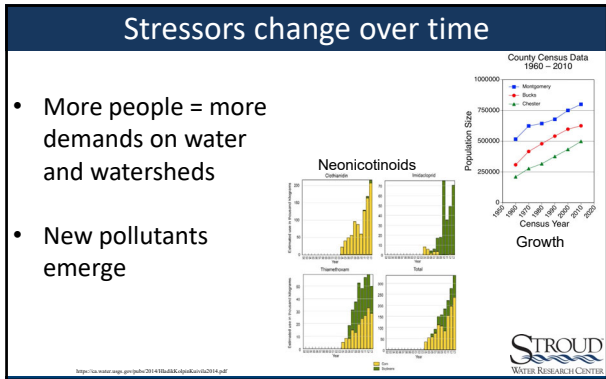
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1. Not Enough Time?
2. Not Enough Intensity?
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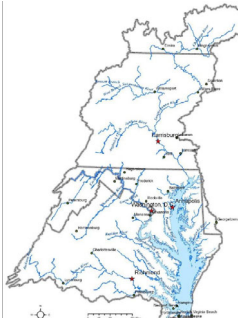


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System Response Time?

- Groundwater residence time
- Occurrence of significant storm events
- Annual weather variability

BUT ... We can't use this as a crutch or excuse for not critically evaluating our progress.



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Take Homes for Today

- The public does not understand impairments or stressors
 - ❖ Does not grasp our past successes, or future challenges
- Efforts to communicate or simplify messaging has complicated pollution-reduction efforts
 - ❖ Target single or a few pollutants, and hope for the best
- Failure to delist impairments, climate change, and emerging pollutants changing this discussion
 - ❖ As the new "news" sinks in, we have to revisit approach from the last 10-20 years

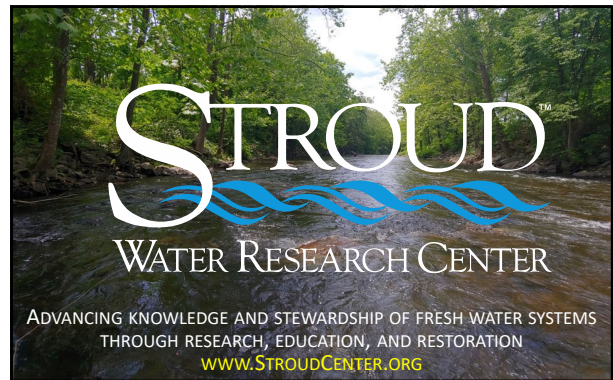
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Questions?



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THROUGH RESEARCH, EDUCATION, AND RESTORATION

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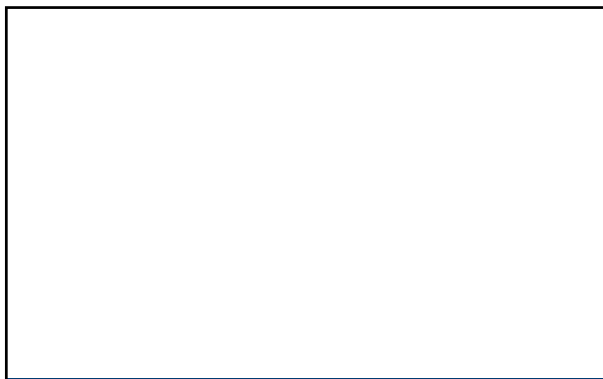
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