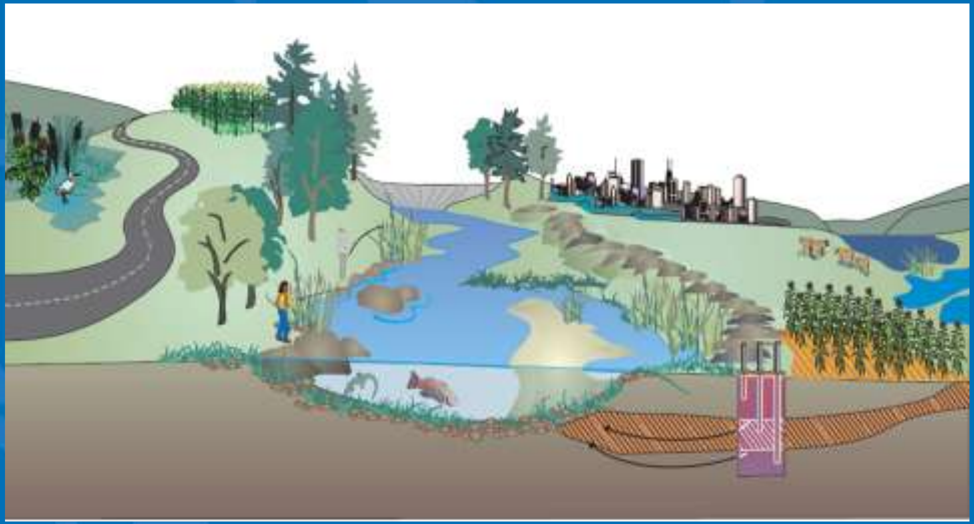
United States Environmental Protection Agency

Connecting water quality to ecosystem restoration and watershed management

Ken Forshay



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Office of Research and Development
NRMRL, Groundwater, Watershed, and Ecosystem Restoration Division, Watershed, Ecosystem, and Subsurface Research Branch

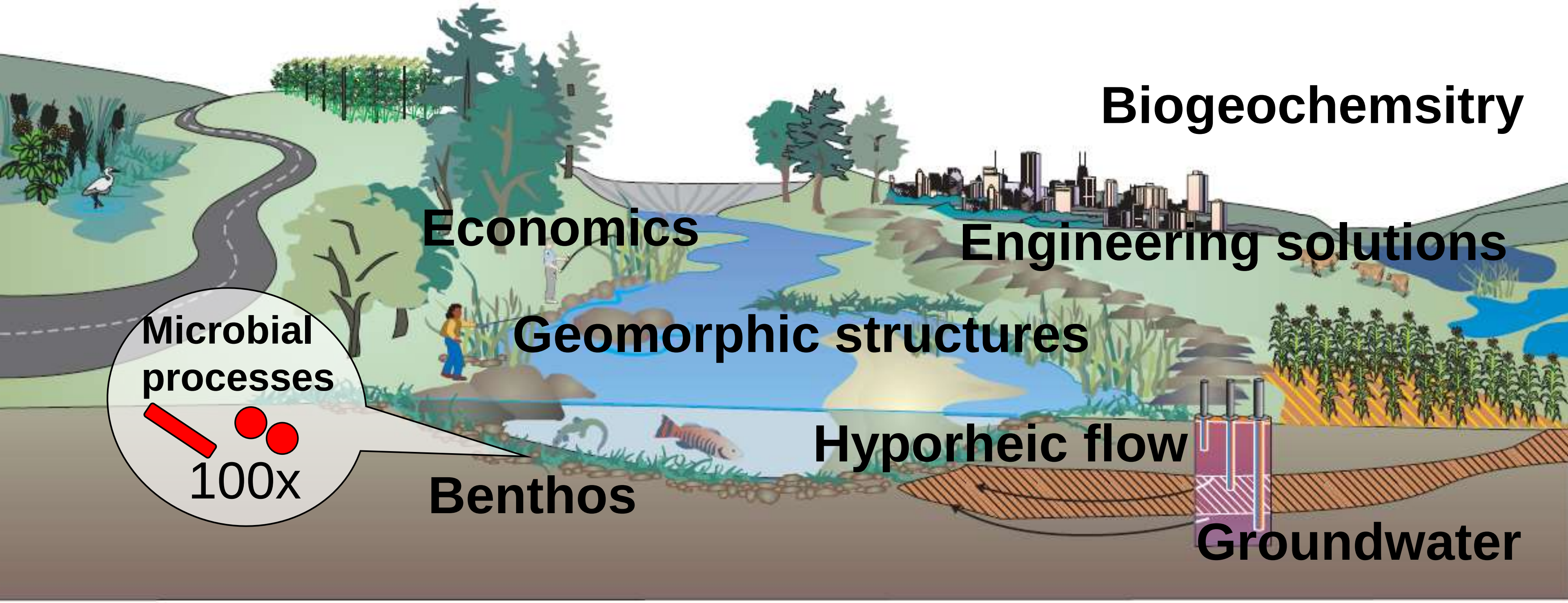
Problem and Approach

- How to meet nonpoint source pollution reduction goals through ecosystem restoration and watershed management?
  - Focus has been on nitrogen

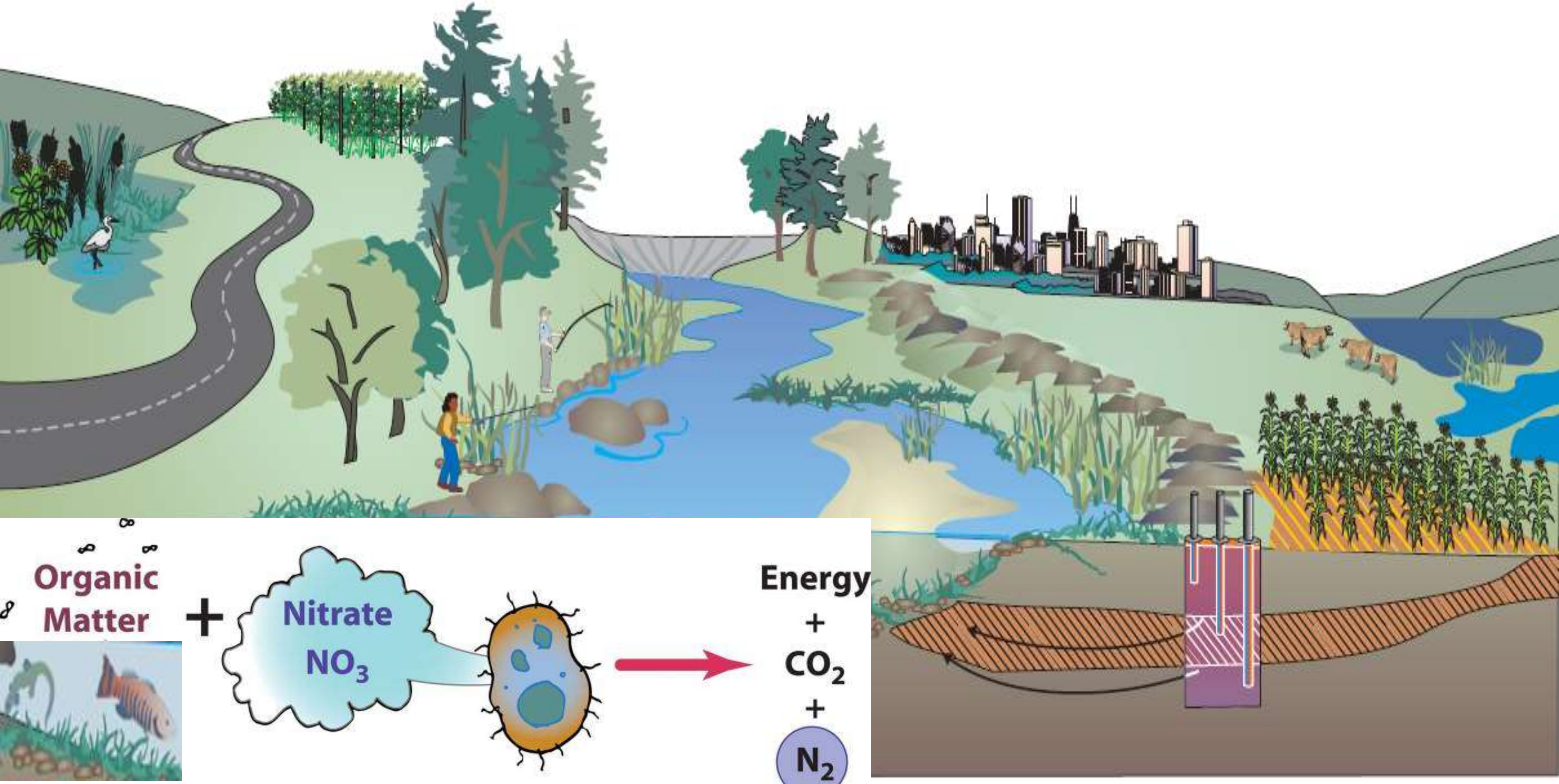
- Watershed restoration to solve nutrient pollution problems requires reducing sources and increasing removal options.
  - Understand and model the pollution sources and removal options
  - Enhance biological removal
  - Increase retention time and connectiveness

- Opportunities for multiple benefits can lead to better outcomes.
  - Integrate ecosystem restoration with infrastructure improvements
  - Understand costs, benefits, and payback times for ecosystem restoration

Field, laboratory, and modeling research can support water quality improvement in watersheds with excess nutrient pollution problems.

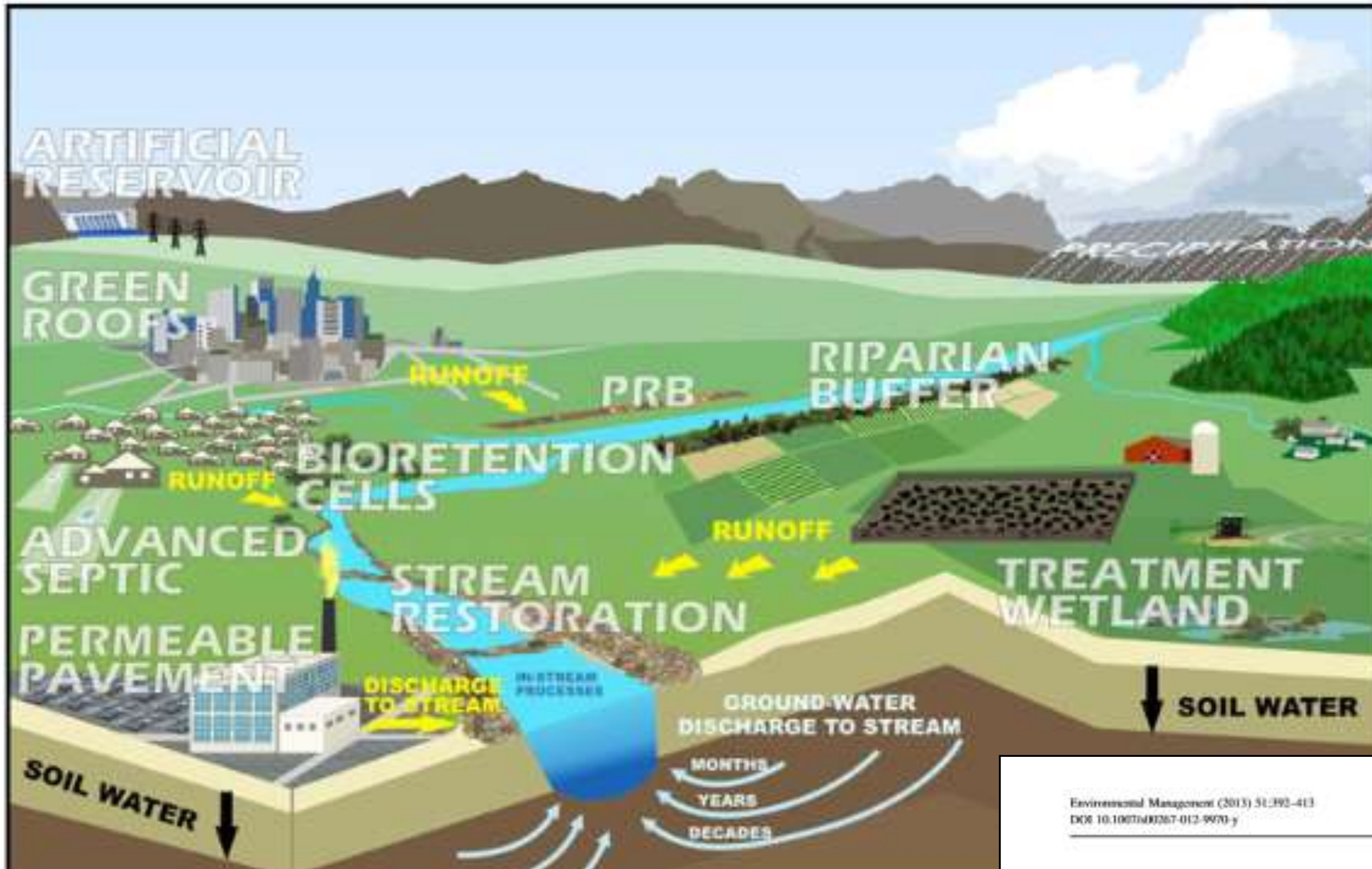


Biogeochemical processing is the driver of nitrogen attenuation, but where and how?



Biological denitrification removes nitrate

Engineered infrastructure and ecosystem management practices can help reduce nitrogen pollution in watersheds

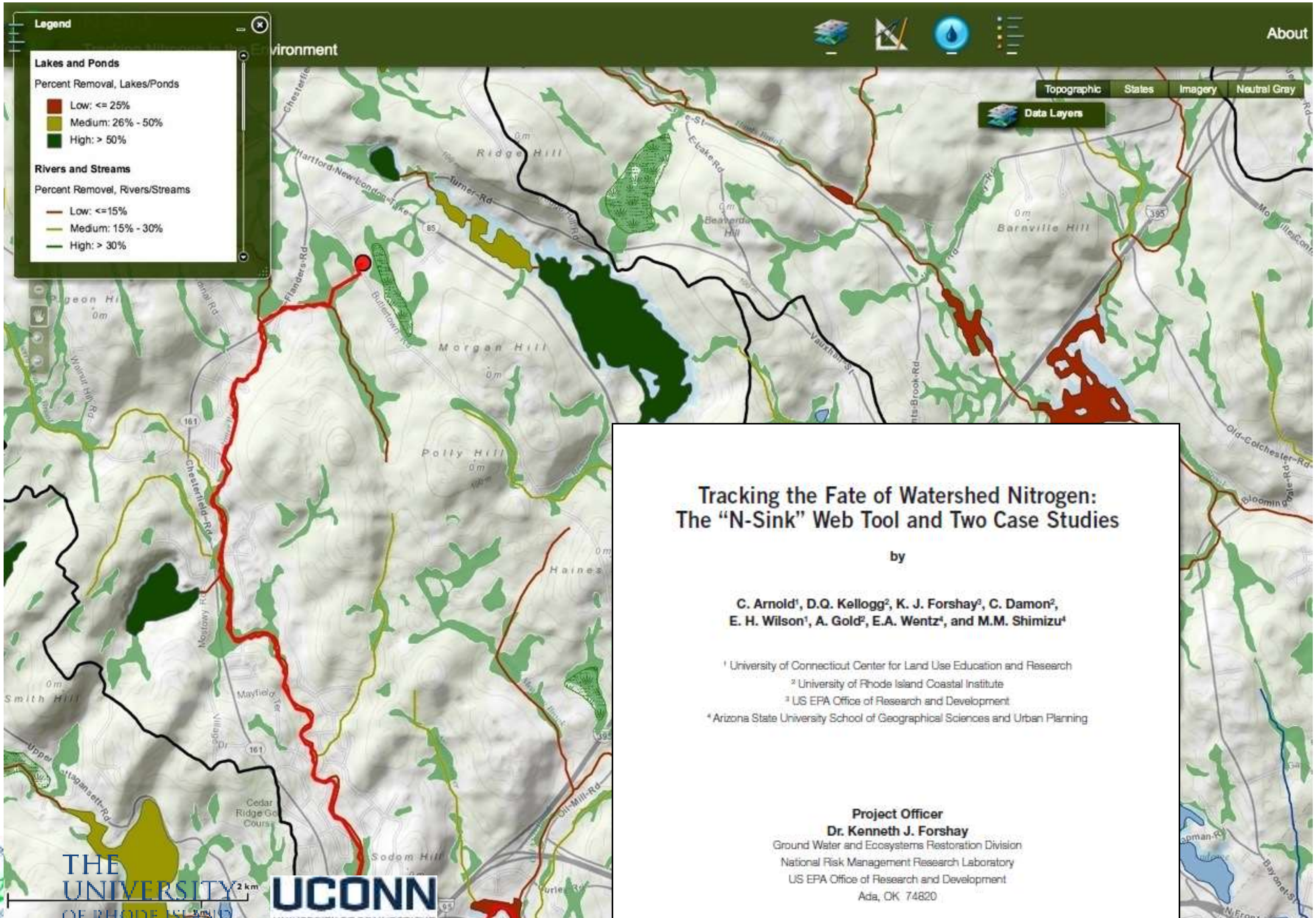


Environmental Management (2013) 51:392–413
DOI 10.1007/s00267-012-9970-y

Ecological Engineering Practices for the Reduction of Excess Nitrogen in Human-Influenced Landscapes: A Guide for Watershed Managers

Elodie Passeport · Philippe Vidon · Kenneth J. Forshay · Lora Harris · Sujay S. Kaushal · Dorothy Q. Kellogg · Julia Lazar · Paul Mayer · Emilie K. Stander

N-Sink is a web based decision support tool for land use planners and managers that shows locations sensitive to nitrogen pollution within a watershed.



Tracking the Fate of Watershed Nitrogen:
The "N-Sink" Web Tool and Two Case Studies

by

C. Arnold[1], D.Q. Kellogg[2], K. J. Forshay[3], C. Damon[2], E. H. Wilson[1], A. Gold[2], E.A. Wentz[4], and M.M. Shimizu[4]

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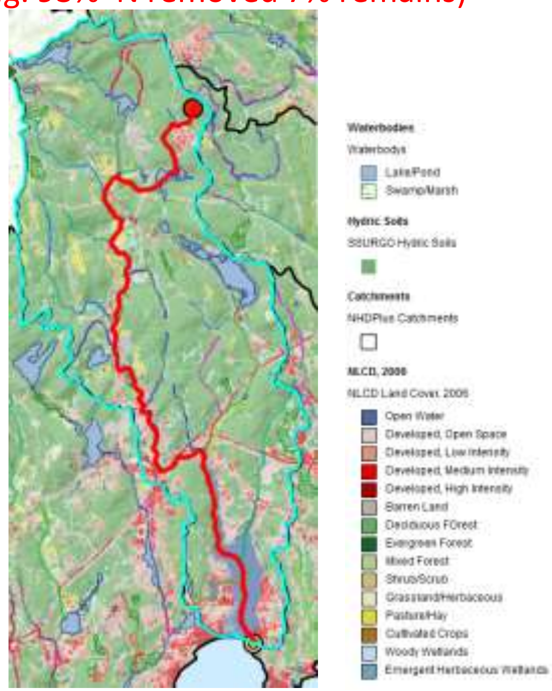
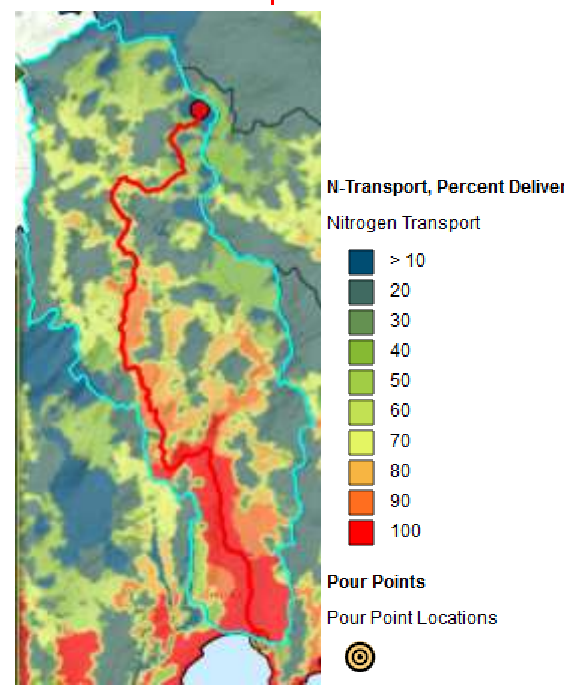
N-Sink uses hydrology, land cover, and best available biogeochemistry data to estimate nitrogen retention along the flowpath.

1) Start with hydrology in a watershed (e.g. Niantic R.)

2) Move water and N where landscapes remove N along path. (e.g. 93% N removed 7% remains)



3) Repeat every grid cell to see where N is and is not retained to generate a “heat map”.



Ecosystem restoration can help improve nutrient retention.

Big Spring Run in Lancaster, PA

Yakima River in Washington State

Disconnected floodplains have low denitrification, so remove the sediments and reconnect the floodplain.

Big Spring Run in Lancaster, PA is a unique example.

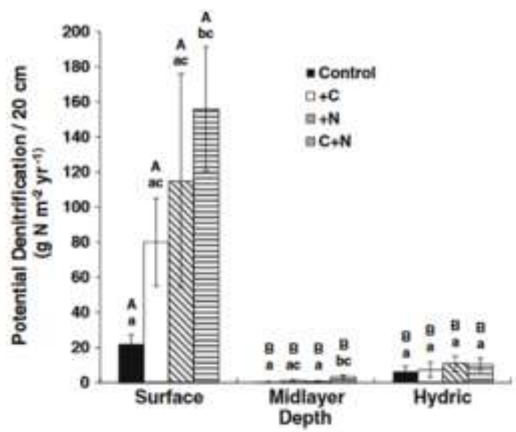


Fig. 3 Potential denitrification rates (g m^{-2} year^{-1}) of 20 cm stream bank sample segments expressed as averages of all three sampling dates across three depths and four nutrient amendment treatments. *Vertical bars* denote one standard error of the mean (n = 18). For a given depth, bars with different *lowercase letters* represent statistically significant ($P < 0.05$) differences between nutrient amendments. For a given nutrient amendment, *bars* with *different uppercase letters* represent statistically significant ($P < 0.05$) differences with depth

Excess legacy sediments deposited in former impounded streams often bury Holocene pre-settlement wetlands.


Biogeochemistry

Potential nitrogen and carbon processing in a landscape rich in milldam legacy sediments

Julie N. Weitzman · Kenneth J. Forshay · Jason P. Kaye · Paul M. Mayer · Jason C. Koval · Robert C. Walter

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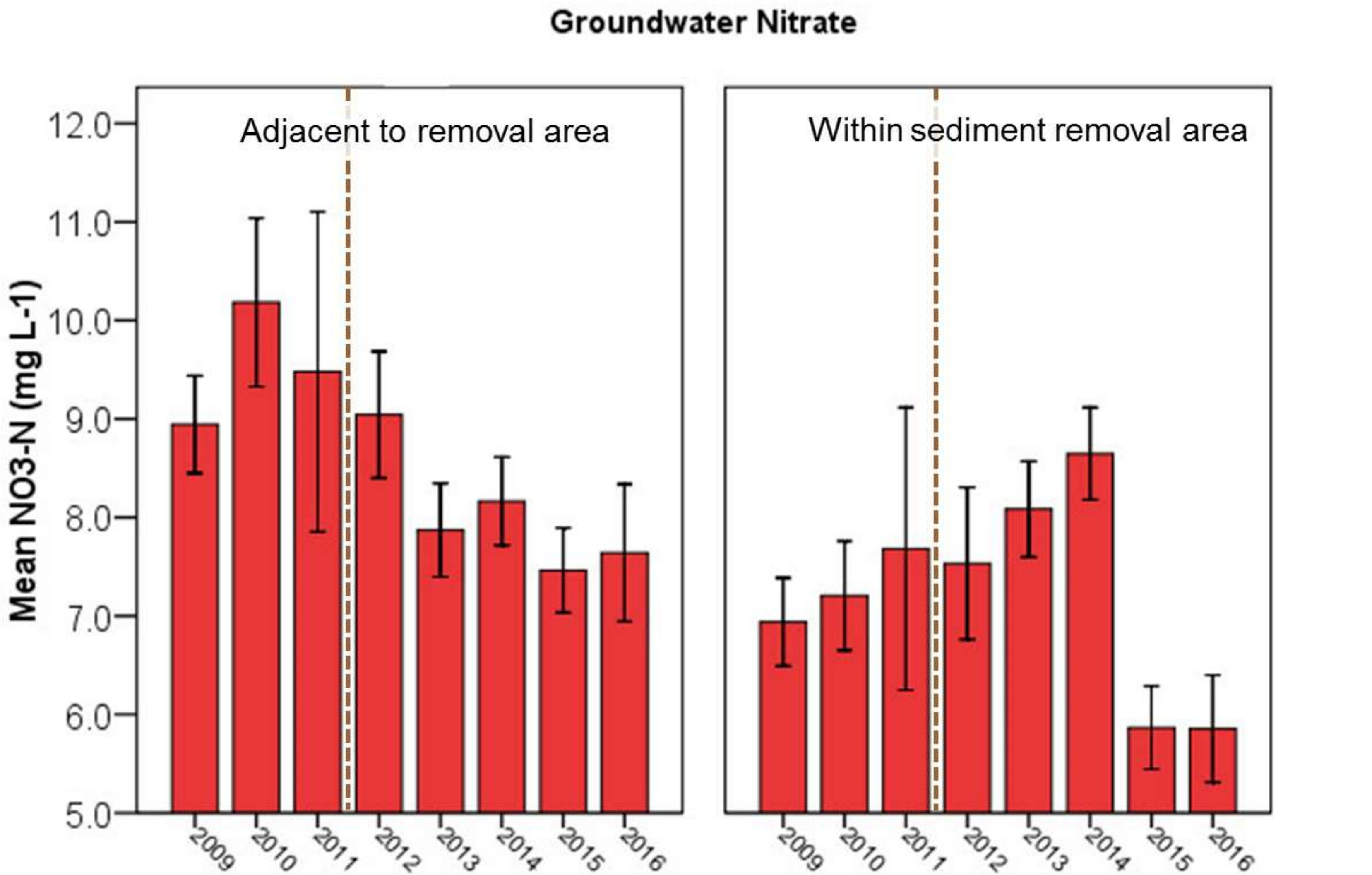
Big Spring Run - Groundwater nitrate decreased four years after restoration.



Infrastructure within the watershed requires management and repair.

This provides opportunity for more sustainable decision making, protection of resources, and restoration of ecosystem services like nutrient retention.

Quantifying the water quality and ecosystem service benefits of floodplain restoration

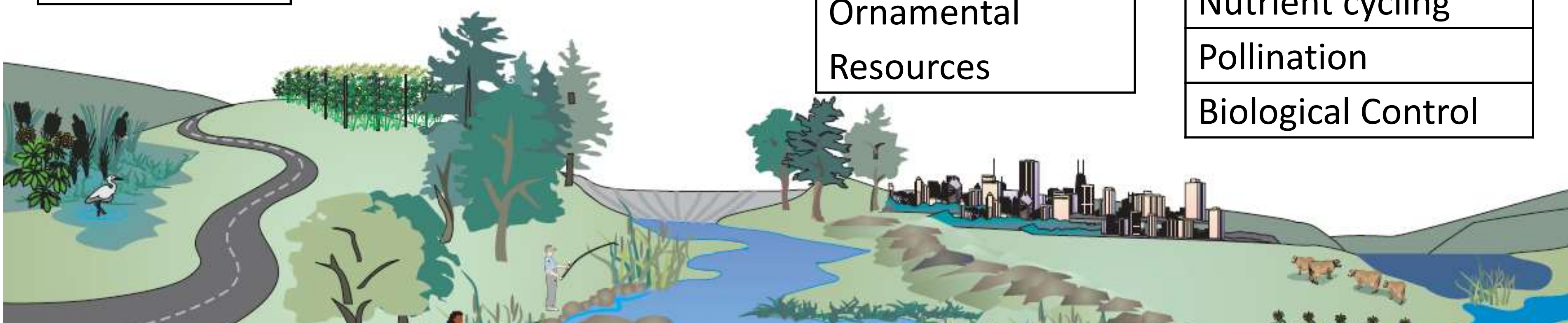
We can classify the ecosystem services and look at their value in a floodplain.

Habitat Services
Nursery Service
Genetic Diversity

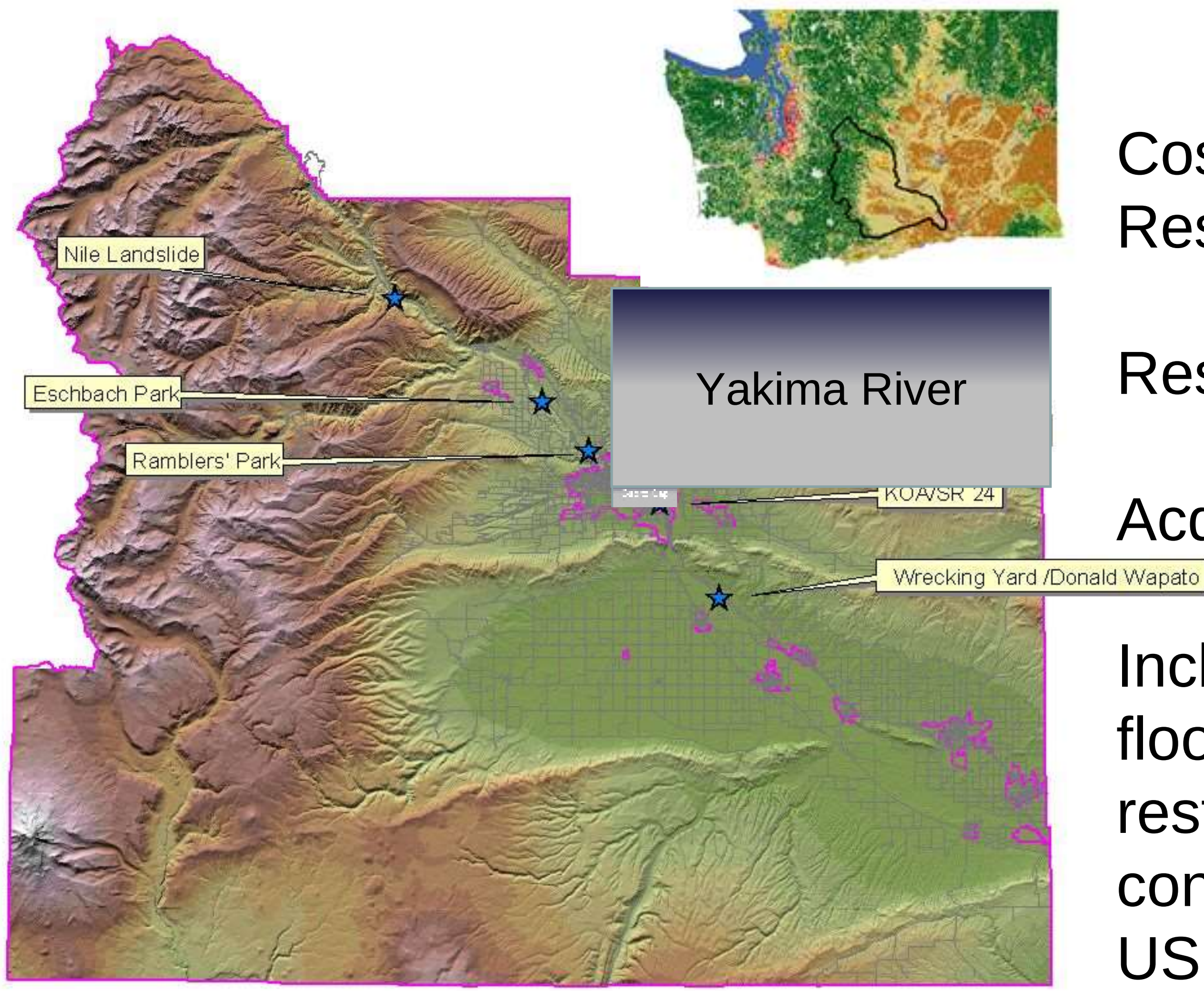
Cultural Services
Aesthetic information
Recreation
Inspiration
Spiritual experience
Cognitive Development

Provisioning Services
Food
Water
Raw Materials
Genetic Resources
Medicinal Resources
Ornamental Resources

Regulating services
Air Quality Regulation
Climate regulation
Moderation of Disturbance
Water flow regulation
Waste treatment
Erosion prevention
Nutrient cycling
Pollination
Biological Control



Used data from 5 floodplain restoration projects from Yakima County, WA and 151 projects from a national database to determine value and payback period



Cost of Restoration

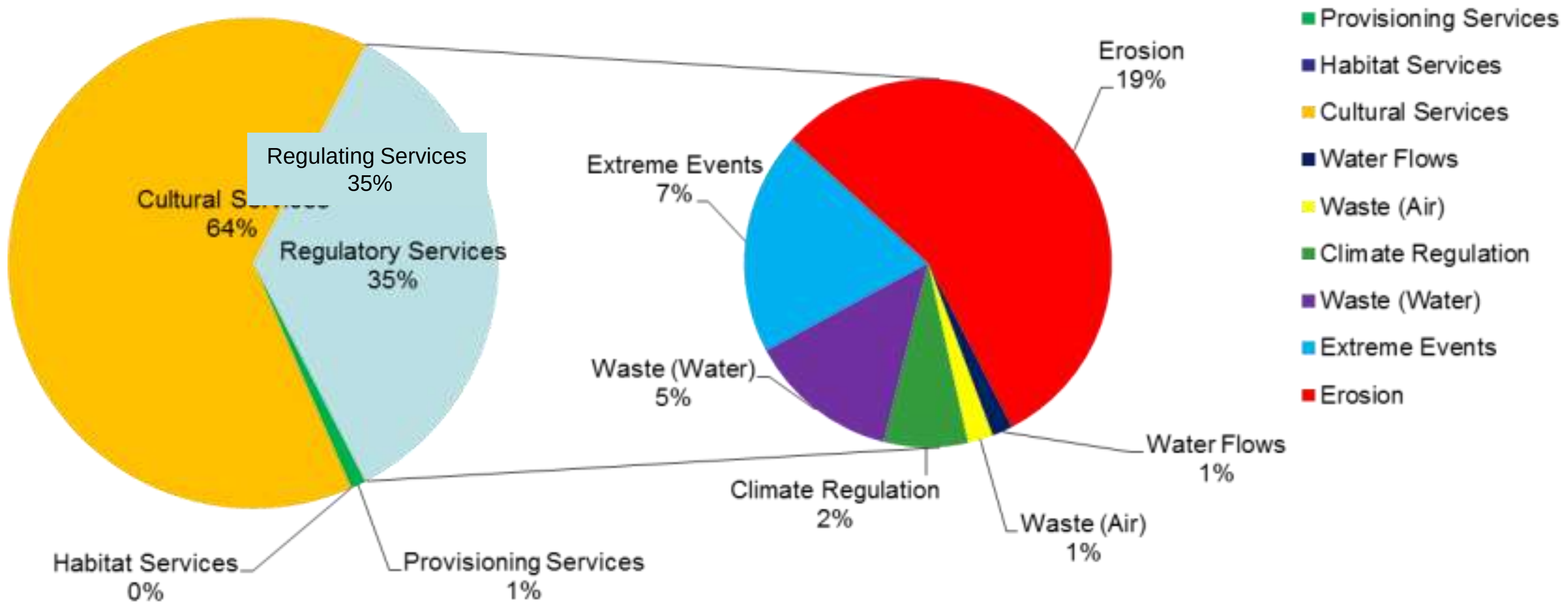
Restored area

Acquisition Cost

Included only floodplain restoration and connectivity in the US

Floodplain Ecosystem Service value is derived primarily from Cultural and Regulating Services

~$28k ($11k-$43k) per acre per year



Shrestha et al. 2017, in review

The cost can be very high and variable, but payback period is rapid

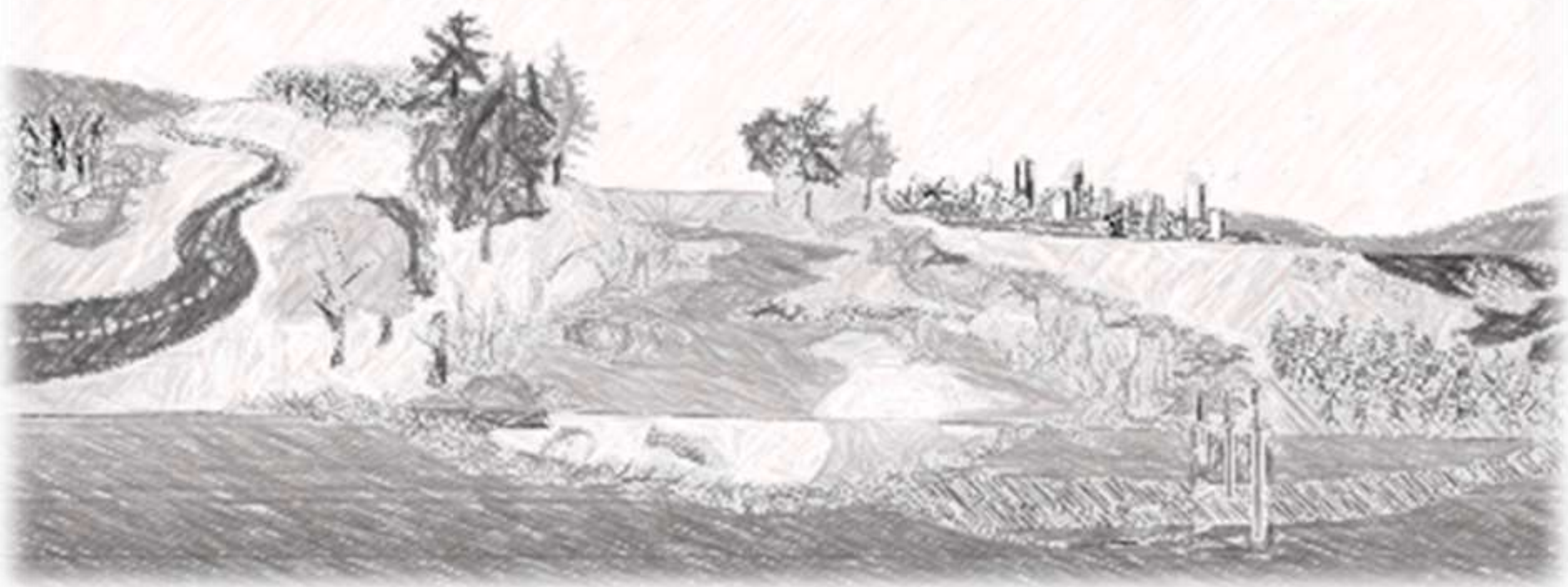
	National[1] Restoration Cost per acre per project ($)	National[1] Payback period per project (years)	Washington State[2] Restoration Cost per project per acre ($)	Washington State[2] Payback period per project (years)
No. of projects	n = 151		n = 5	
Mean	28,388	1.01	100,884	3.58
Std. Dev	89,841	3.19	90,7[illegible]	3.22
Max	[illegible]17	26.24	[illegible],000	7.64
Min	0	0	1,282	0.05
Median	1,651	0.06	66,667	2.37

Table 5: Cost of floodplain reconnection and payback period based on NRRSS database (modified from Shrestha et al. *in review*)

[1] Based on the National River Restoration Science Synthesis database

[2] Based on the Yakima County floodplain restoration data

Thank you.



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United States
Environmental Protection
Agency

Managing Risks to Watershed Water Quality

Integration Time

Years
Weeks
Hours

Watersheds
Nutrient management
tools and BMP evaluation

Rivers and Floodplains
Groundwater surface interactions
Restoration ecology and economics

Microhabitats
Biological
nutrient processing

Meters | 10's of Meters | Kilometers | 10's of Kilometers

Space

Kenneth J. Forshay

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