Low-cost Stream Enhancement Using Hand-placed Log Structures: Lessons Learned

2019 Ohio Stormwater Conference

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Sustainable Streams LLC
Science · Service · Solutions

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Kentucky Dept. of Fish & Wildlife Resources

MILL CREEK ALLIANCE
A Groundwork USA Trust & Council of Communities

cuyahoga SOIL&WATER conservation district

Cleveland Metroparks

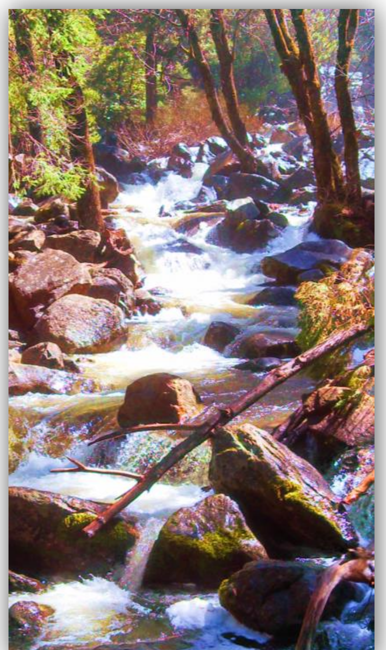
Franklin Soil and Water Conservation District
Creating Conservation Solutions for Over 70 Years

Stream Geomorphology 101: Tendency Toward Equilibrium

Resistance α Erosion

Sediment Supply in Balance with Water Supply and Slope

Lane's (1955) Balance



Resistance α **Erosion**

sediment supply (Qs)

sediment size (d_{50})

bankfull width (W)

floodplain width

grade control

bank strength

vegetation …

Large Woody Debris (LWD)

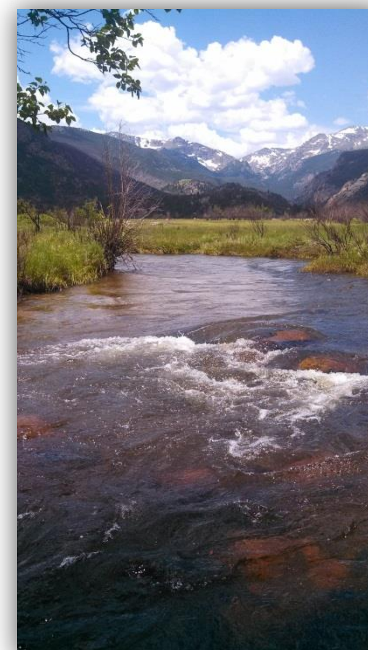
discharge (Q)

slope (S)

bankfull depth (y)

floodplain depth

valley slope …



Adapted from Hawley (2018) BioScience

Recent/Ongoing Impacts

Resistance << Erosion

sediment supply (Qs)

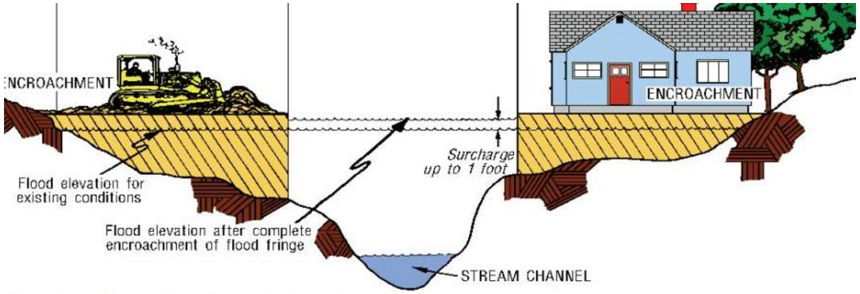
sediment size (d_{50})

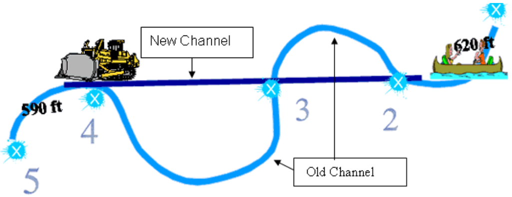
channelization	bankfull width (W) -
floodplain encroachment	floodplain width -
	grade control
riparian removal	bank strength -
	vegetation -...

discharge (Q) + urbanization

slope (S) +

	channelization
bankfull depth (y) +	
floodplain depth +	floodplain encroachment
valley slope ...	





Historic Deforestation

Historic Deforestation

Disney (1958)


1:11 / 3:26


11:30 / 17:01


1:19 / 3:26


11:32 / 17:01


11:57 / 17:01


12:02 / 17:01

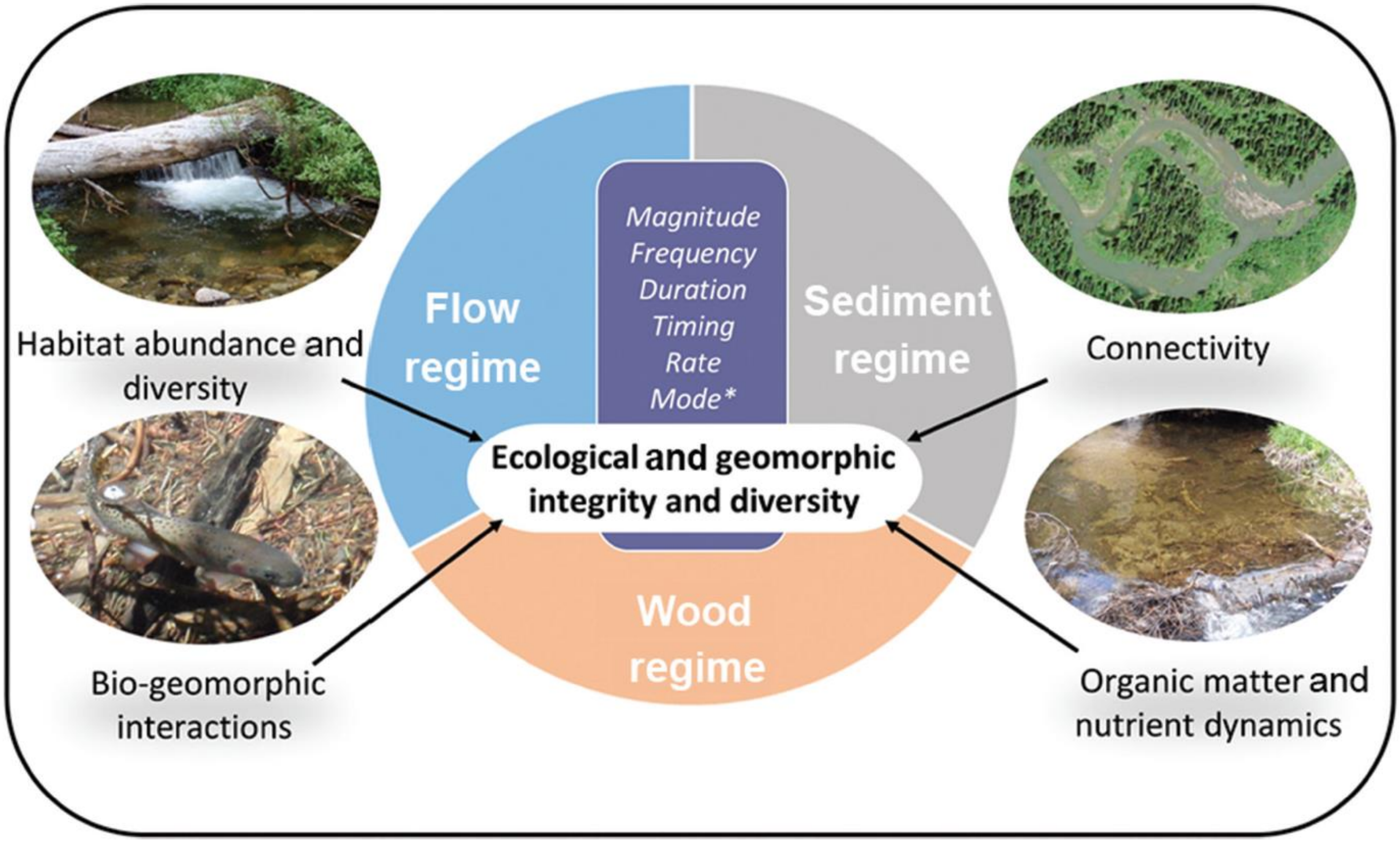

11:59 / 17:01


Play (k)
12:07 / 17:01

Riverine Wood Was Immensely Abundant

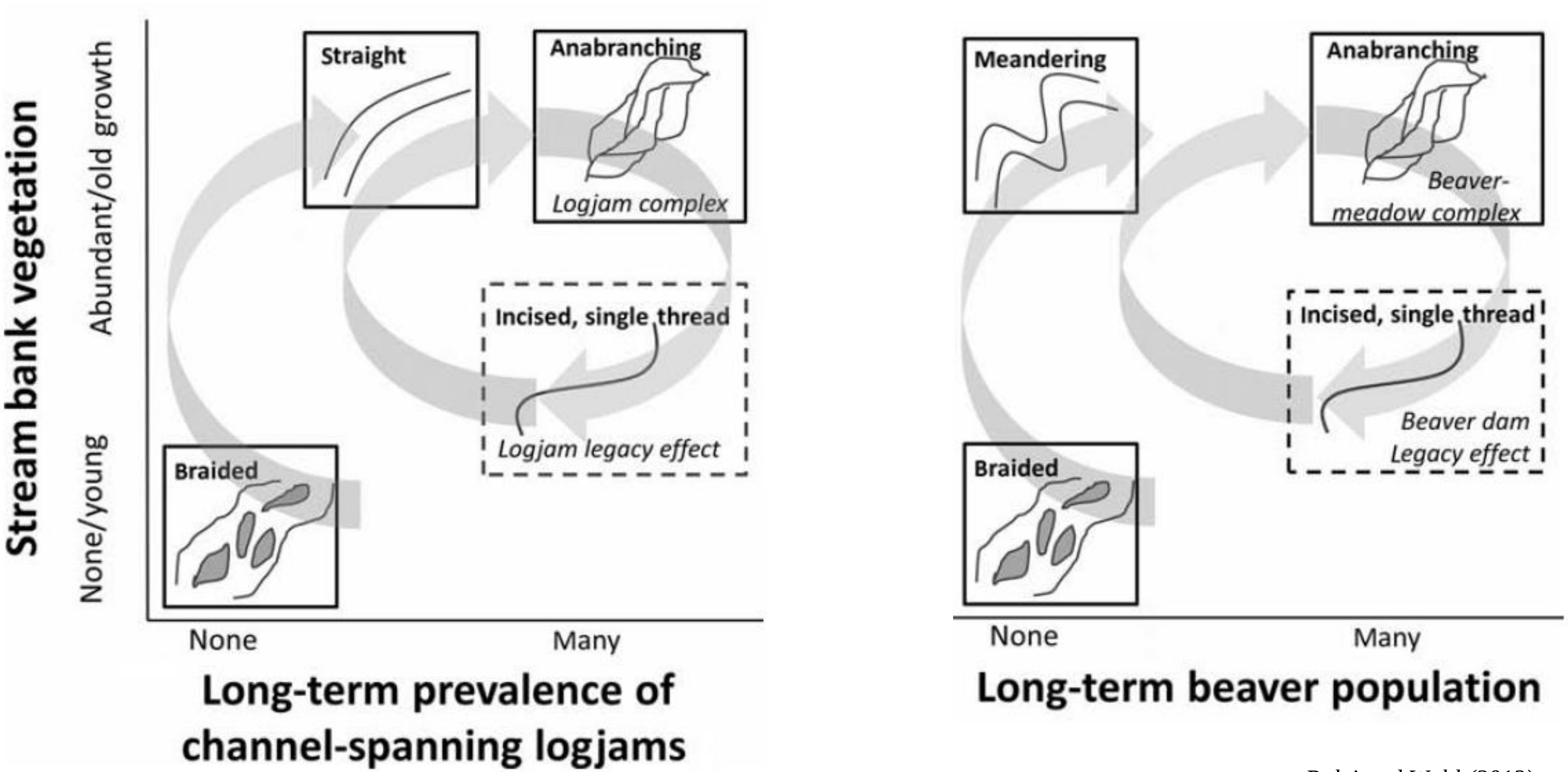
Polvi and Wohl (2013)
BioScience

In-stream Wood Contributes to Geomorphic & Ecologic Function



Wohl et al. (2019)
BioScience

Restoring the Natural Wood Regime Can Transform River Form



Polvi and Wohl (2013)
BioScience


0:59 / 4:33
HOW WOLVES CHANGE RIVERS
Play (k)
0:05 / 4:33


3:34 / 4:33


Play (k)
1:55 / 4:33


0:36 / 4:33


2:24 / 4:33


4:10 / 4:33

~25 Years of River Restoration

Abundant Riverine Wood Is <u>Good</u> for Ecosystems

- **Habitat Stability & Diversity**
  - Refugia during bed-mobilizing events
  - Diversifies velocity and depth regimes

- **Aquatic Foodwebs**
  - Stable benthic surface for primary production
  - Traps leaf litter and detritus (food sources for macroinvertebrates)

- **Water Quality**
  - Depositional zones for sediment
  - Carbon source for nutrient cycling

Old growth redwood forest, photo by RJ Hawley
Sonoma Coast State Park – Willow Creek Addition

Too Much/Mobile Wood Can Be Bad for Stakeholders

- **Flood Control**
  - Can reduce hydraulic capacity
  - Can increase flow roughness
- **Structure Stability**
  - Can increase local scour at piers/abutments
- **Recreational Safety**
  - Extremely dangerous boating risk

See Stack Exchange from The Great Outdoors:
"How do you survive getting towed under a log jam?"

You Don't!

Montgomery et al. (2003)
American Fisheries Society

Growing Potential for Wood Loads in Urban Streams

greentopeka.org

- **Riparian Buffers**
  - Recent incorporation into development codes/initiatives
- **Diseases/Pests**
  - Emerald ash borer

Geomorphology 337 (2019) 1–14

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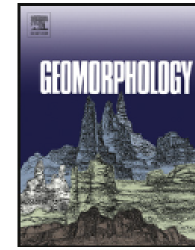

If a tree falls in an urban stream, does it stick around? Mobility, characteristics, and geomorphic influence of large wood in urban streams in northeastern Ohio, USA

No!

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Wood mobility
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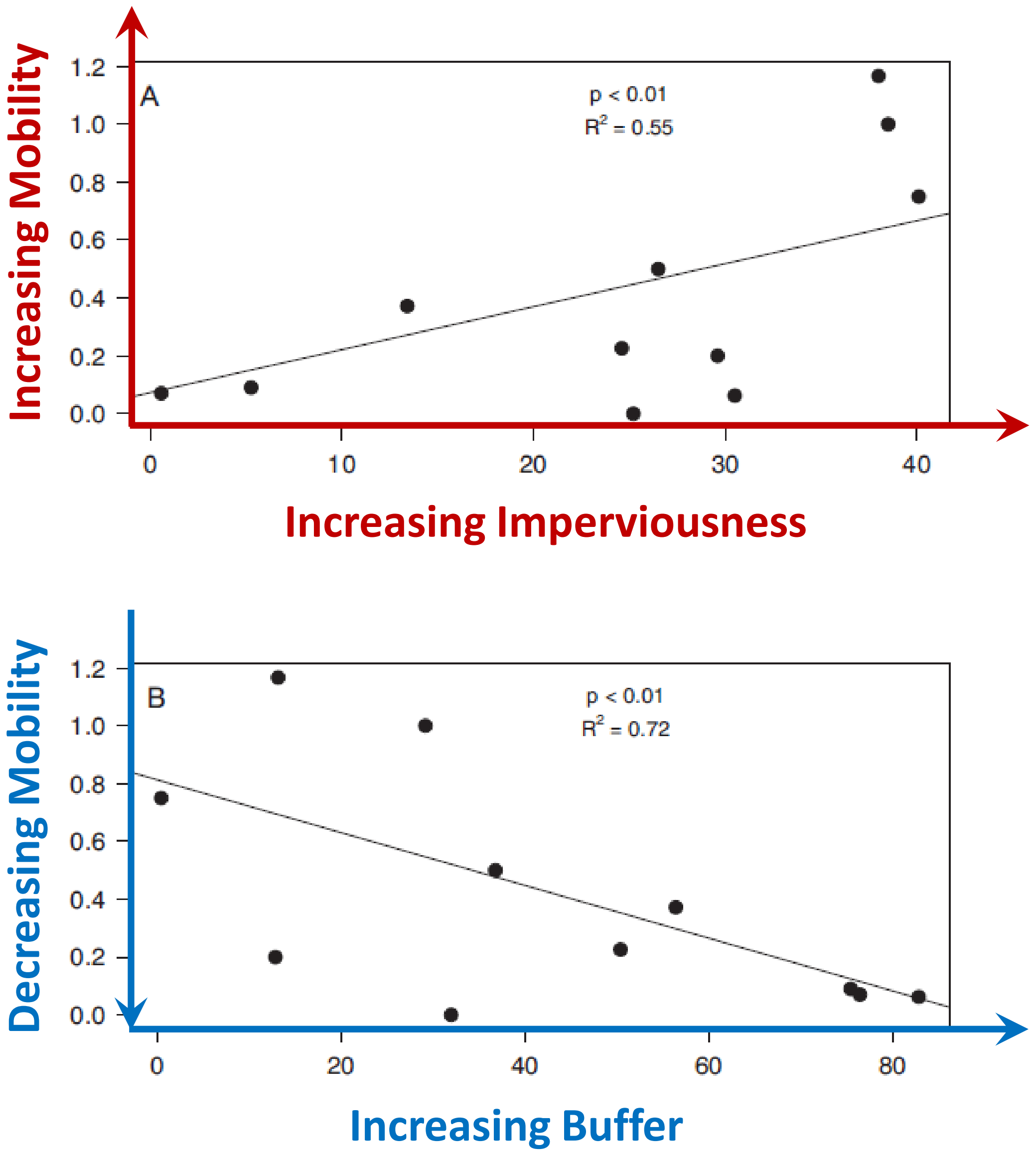
Impervious surface

ABSTRACT

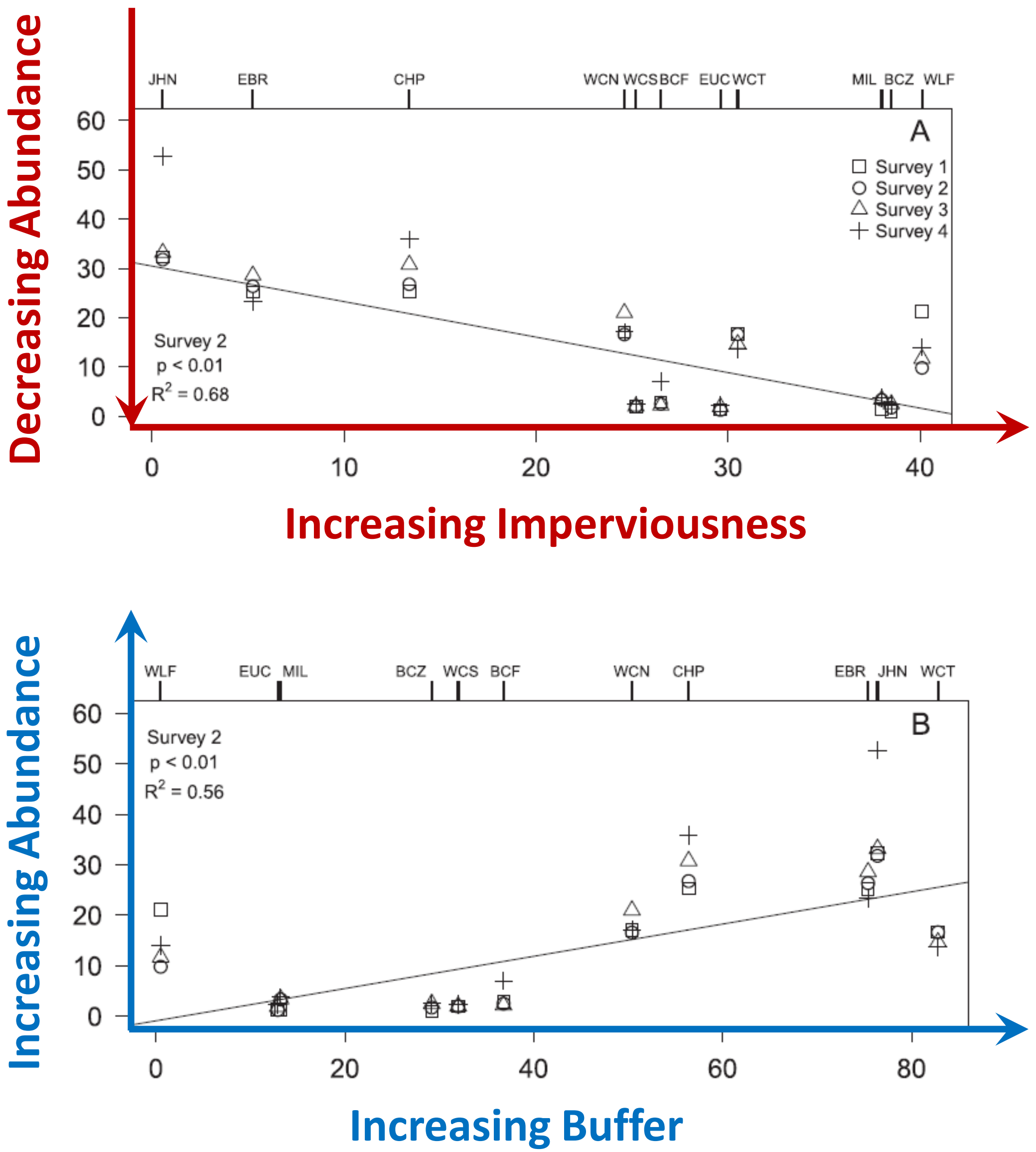
Large wood influences geomorphological, ecological, and biogeochemical functions of streams, but in urban areas it is also considered an unaesthetic hazard. Quantifying the abundance and mobility of in-stream wood along an urban intensity gradient, and understanding the relationship between wood dynamics and stream reach, network, and watershed characteristics allows for a stronger understanding of the potential benefits and hazards of wood in urban streams. Repeat wood surveys were conducted at 11 stream reaches in the Cleveland, Ohio area, where wood removal is not practiced and forested riparian zones exist. Study reaches span a gradient of impervious surface cover and extent of the stream network with a forest buffer. Channel morphology and sediment size were also measured. Stream hydrology does not change when imperviousness is 12–40% in this region, so quantification of impervious surfaces stands in for a broader suite of urban impacts.

Wood abundance decreases – and mobility increases – as urban intensity in the watershed and along the stream network increases. Jams become smaller and less stable, but the size and orientation of individual wood pieces do not change along an urban gradient. Over the 6-month study period, wood mobility exceeded 100% in some of the most urbanized streams and transport distances are inferred to be on the order of 100s of meters. There

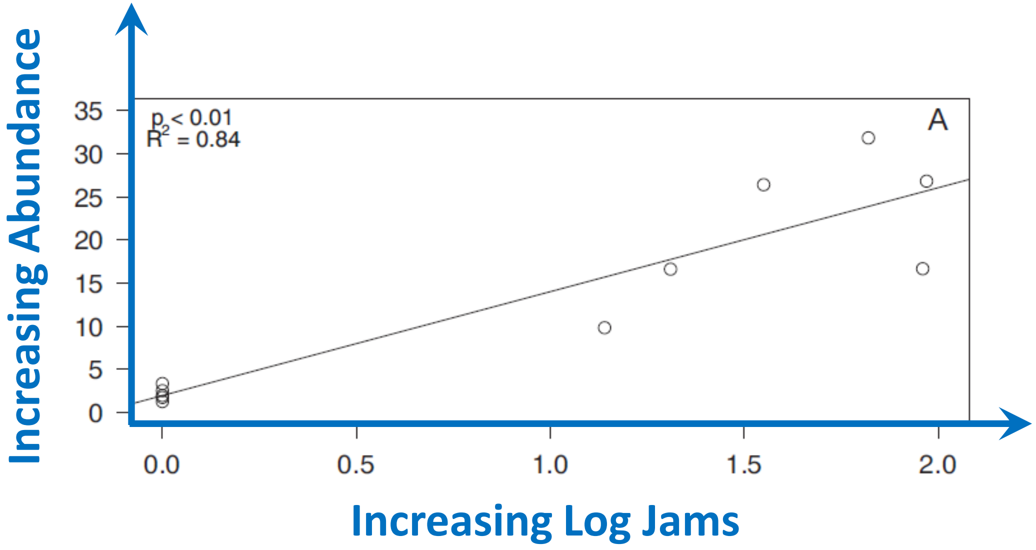
Urban Streams Have High Wood Mobility



Urban Streams Have <u>Low Wood Abundance</u>



Wood Mobility Tends to Decrease with More Frequent Log Jams



Literature Review Summary: Stable "Key Pieces" Can Serve as Anchors

- Length > 0.5 x Bankfull Width[(1)]
- Diameter > 0.5 x Bankfull Depth[(1)]
- Trunks with rootwads[(2)]/ branches
- Ramped up bank
- Anchored behind live trees
- Partially buried[(2)]

[(1)]Can require large equipment depending on size of stream

[(2)]Likely requires heavy equipment and/or grading

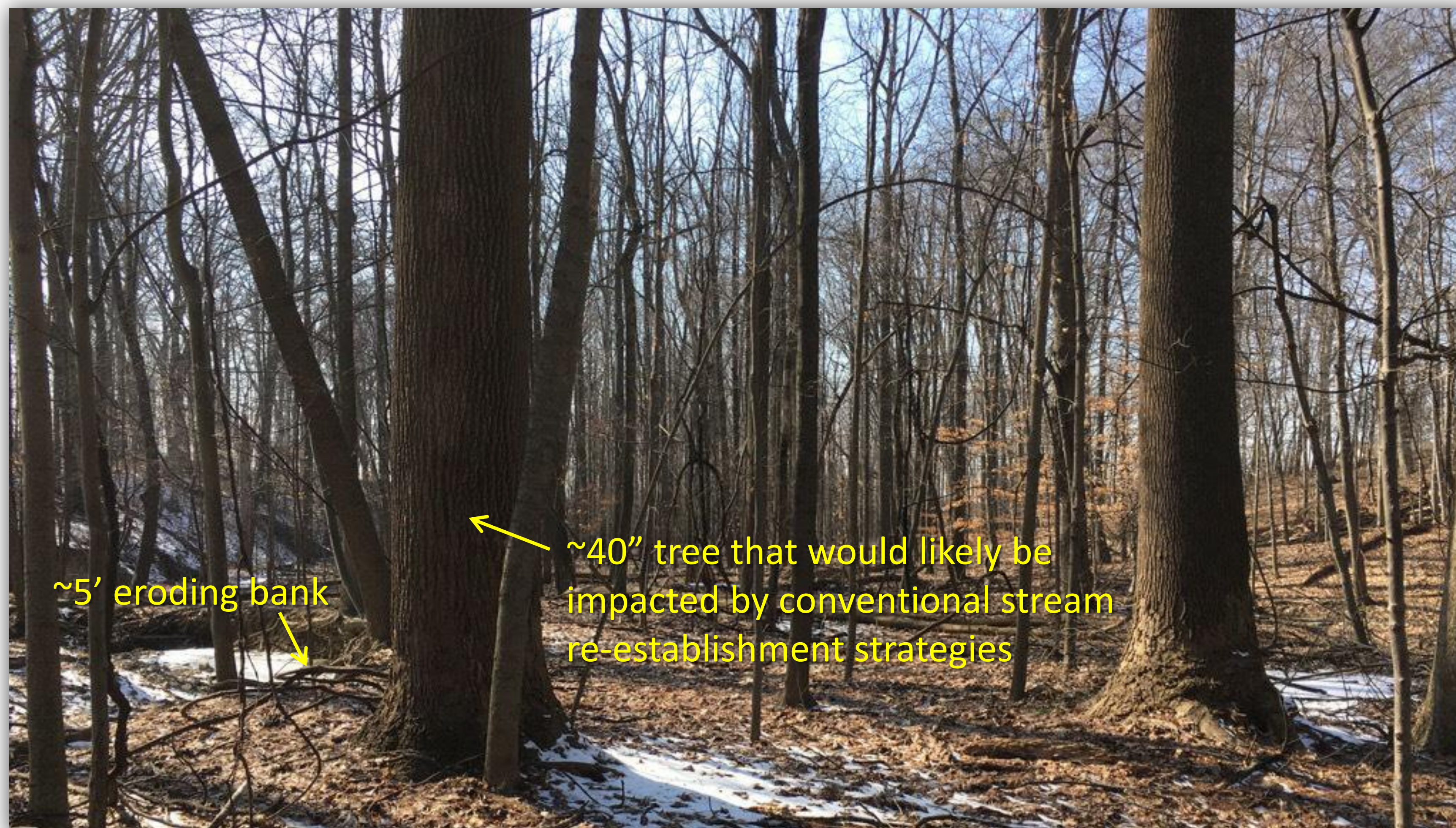
Equipment-placed

More Site Disturbance
Greater Stability
Higher Cost

Hand-placed

Nominal Site Disturbance
Higher Floating Risk
Lower Cost

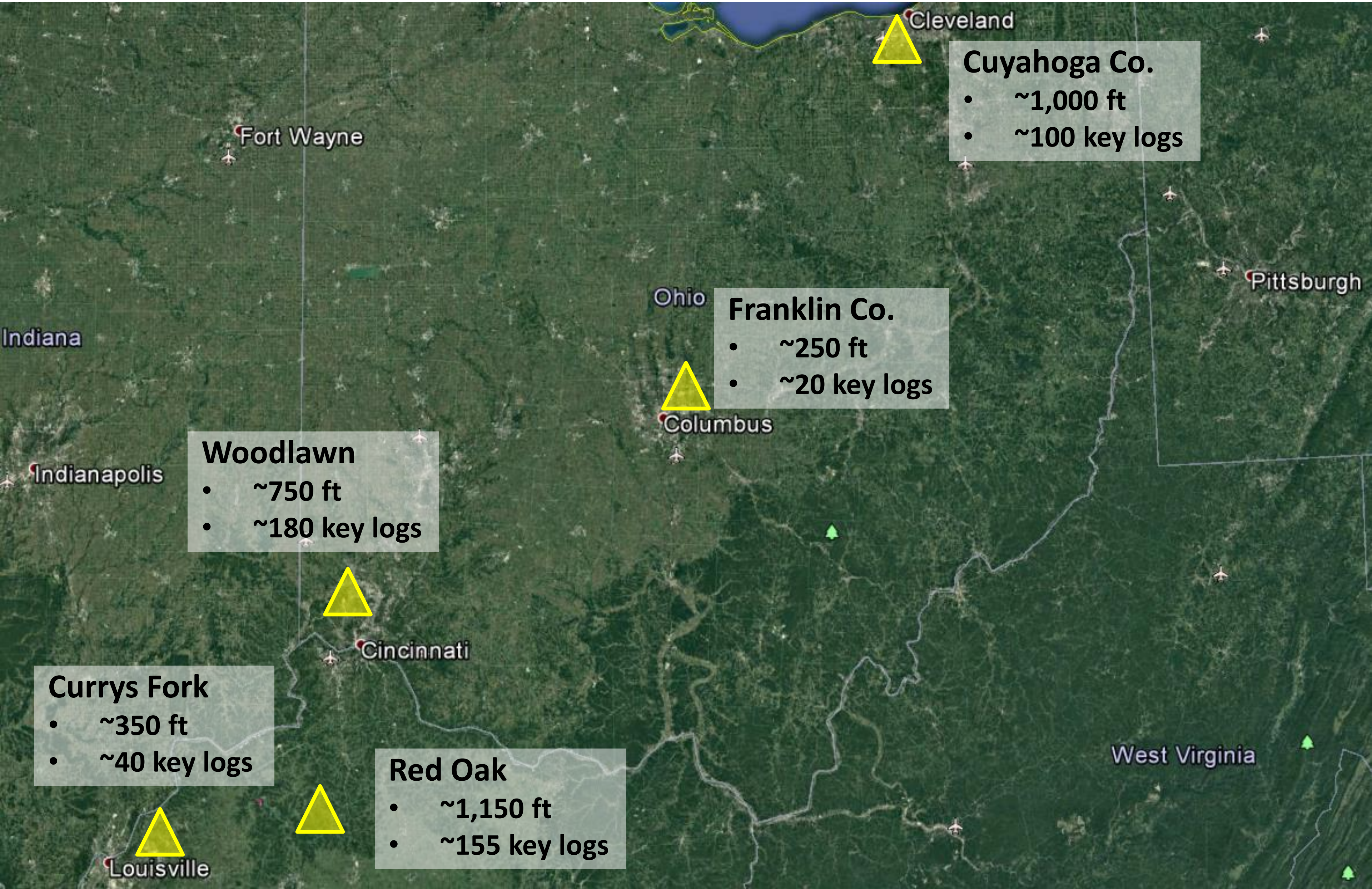
Hand-placed Log Structures Are Ideal for Small Streams with Nice Canopy and/or Low Budgets



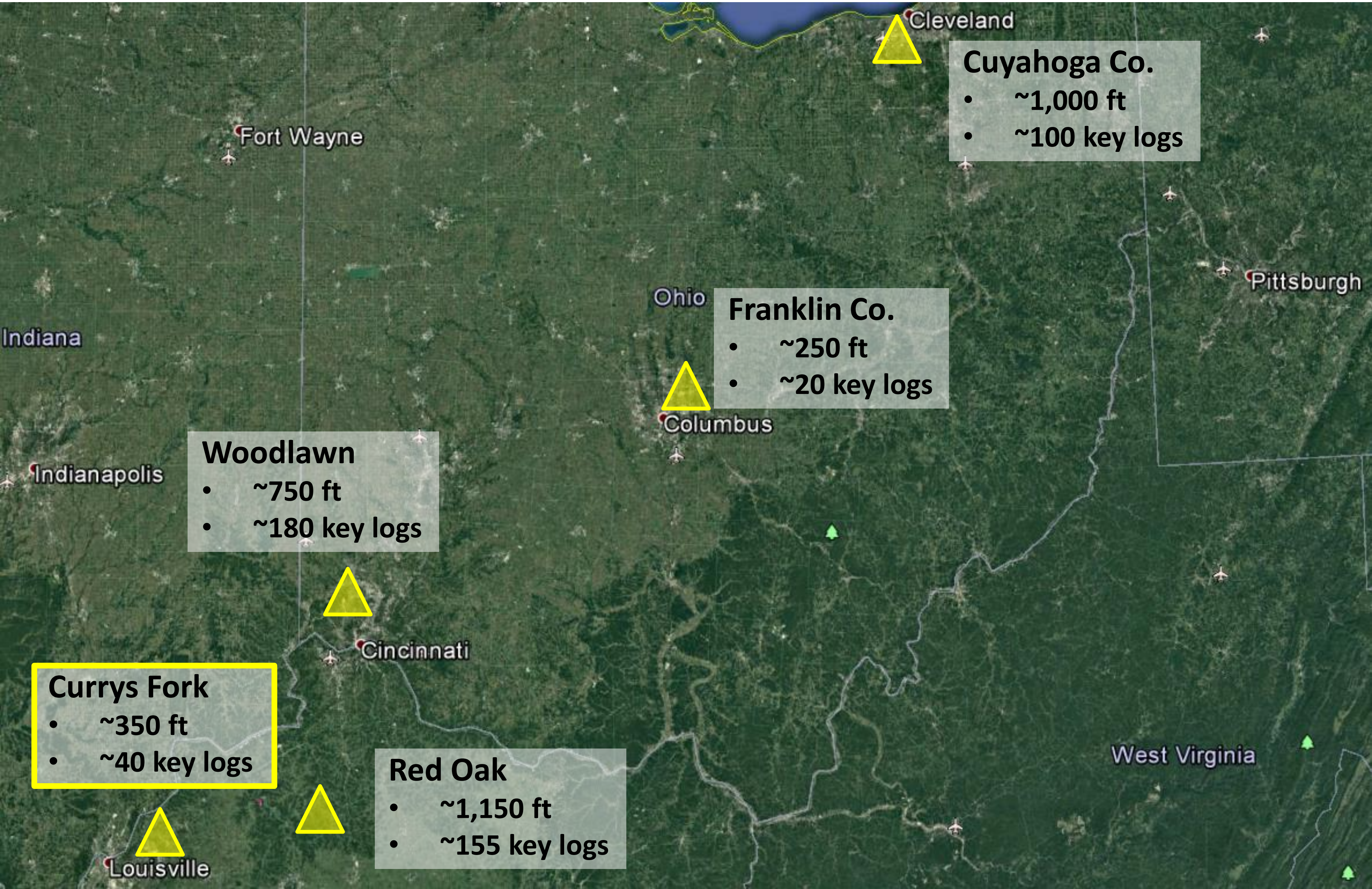
Pilot Installation Mimicked Naturally-Occurring Wood

Must Incorporate Strategies to Prevent Floating

Lessons Learned from Five Installations



Lessons Learned from Five Installations



Unnamed Tributary to Currys Fork

- Drainage Area ~0.09 mi^2
- BF Width ~ 10 ft

Hand work along tributary saved a lot of $

Majority of the grant funding was needed to rehab the "tire wall"

Installed July 2016

~350 Feet ~40 Key Logs

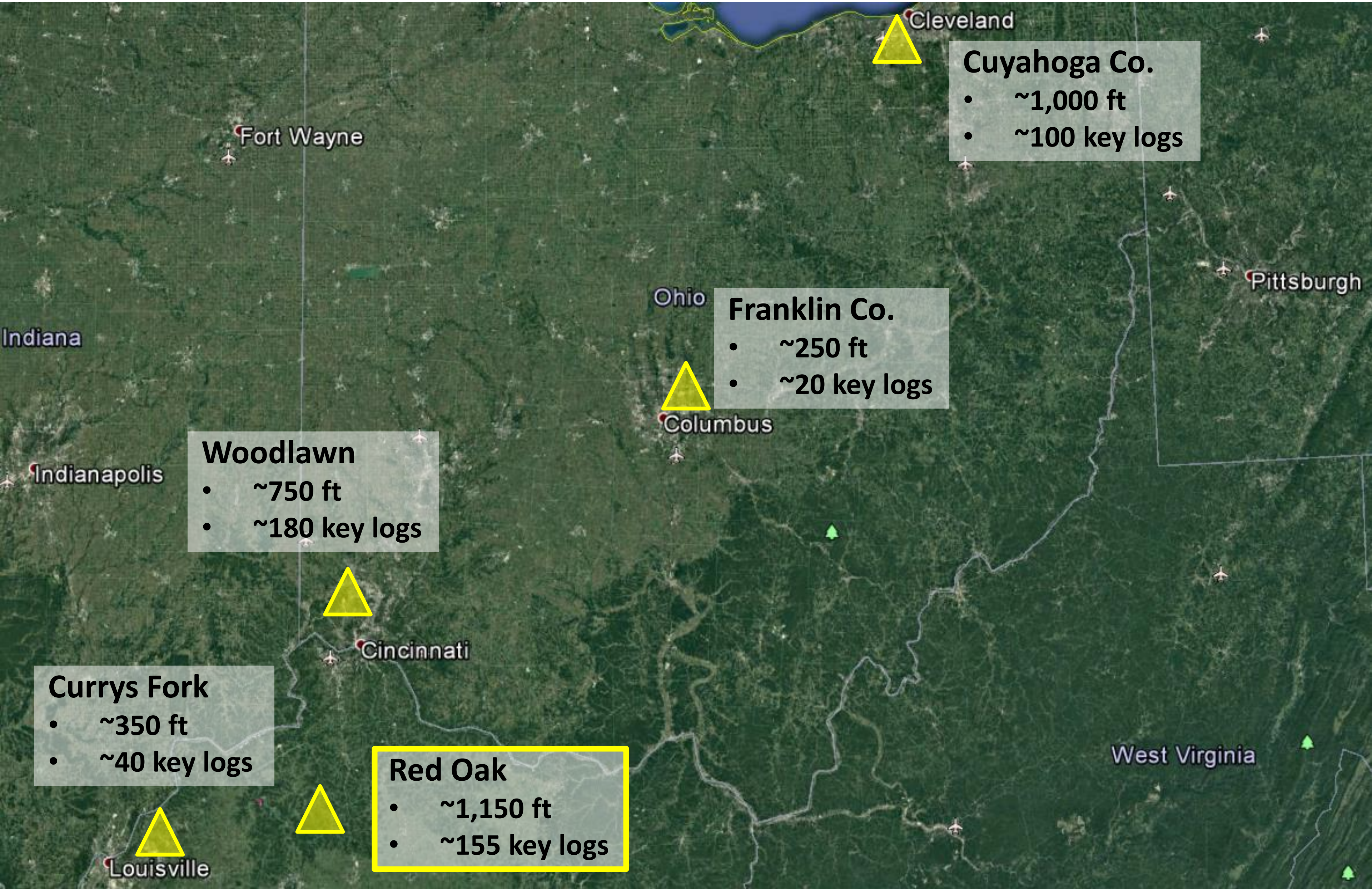
Bank Protection and Bar Building ~ 1 Year Later

Revegetation of Bars

~3 Years Later
~90% of Structures Still Present

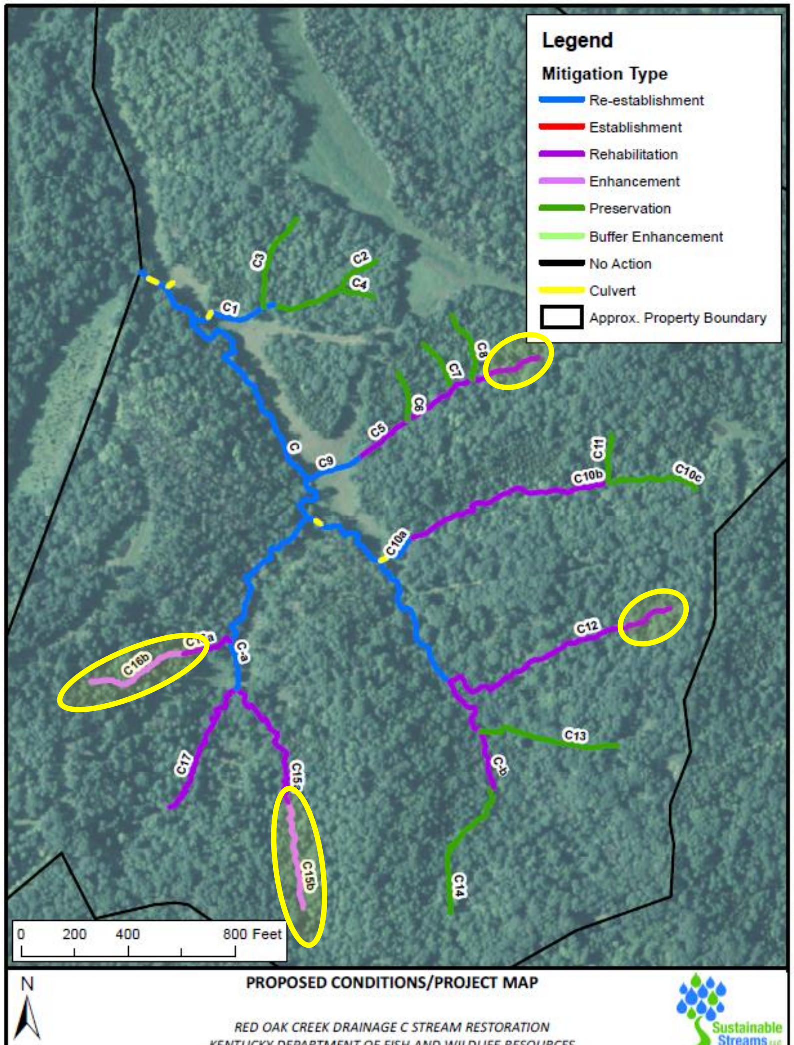
Logs More Embedded
Signs of Early Spring Vegetation

Lessons Learned from Five Installations



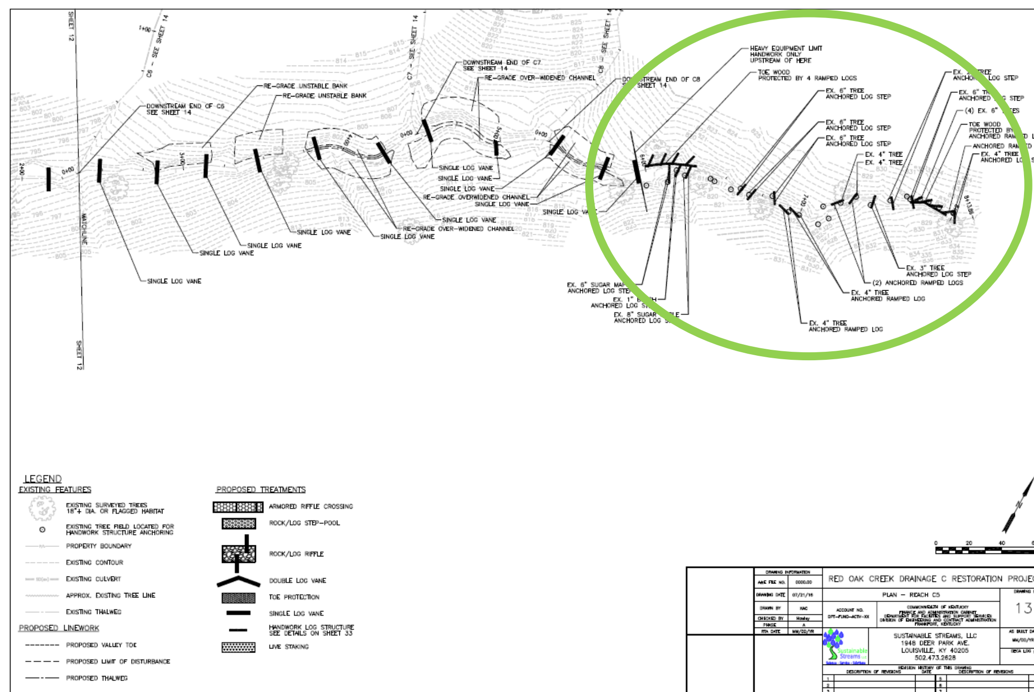
Red Oak
First Reach Installed July 2016

- Drainage Area ~ 0.006 to 0.012 mi^2
- BF Width ~ 3 to 6 ft

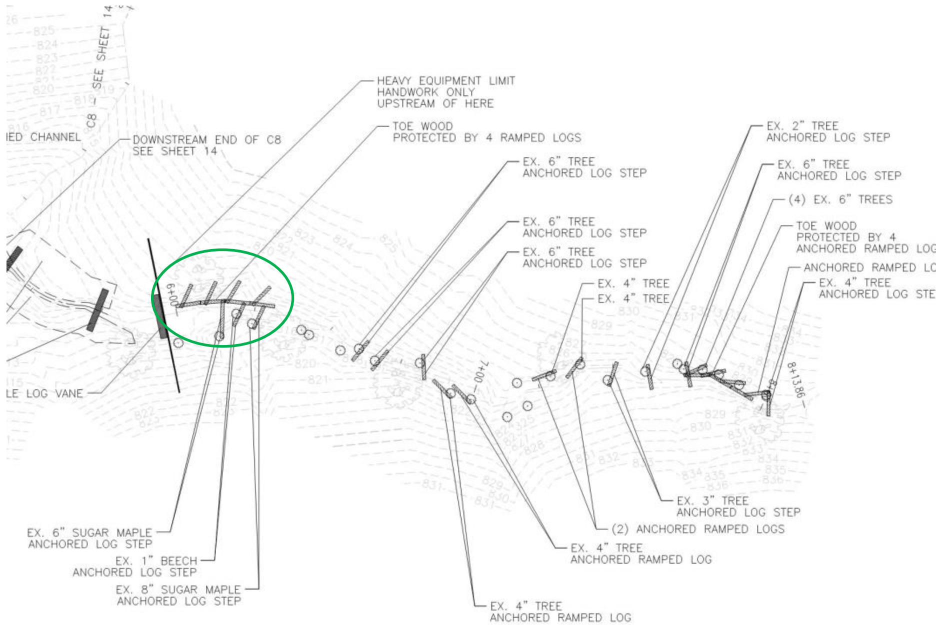


Last Updated On: Thursday, May 19, 2016
Appendix D: Project Mapping
D.4

Upstream of Equipment Limits on a Stream Mitigation Project



Appendix J: Design Drawings
J.14


HEAVY EQUIPMENT LIMIT
HANDWORK ONLY
UPSTREAM OF HERE
TOE WOOD
PROTECTED BY 4 RAMPED LOGS
DOWNSTREAM END OF C8
SEE SHEET 14
C8 - SEE SHEET 14
IED CHANNEL
LE LOG VANE
EX. 6" TREE
ANCHORED LOG STEP
EX. 6" TREE
ANCHORED LOG STEP
EX. 6" TREE
ANCHORED LOG STEP
EX. 4" TREE
EX. 4" TREE
EX. 2" TREE
ANCHORED LOG STEP
EX. 6" TREE
ANCHORED LOG STEP
(4) EX. 6" TREES
TOE WOOD
PROTECTED BY 4
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EX. 4" TREE
ANCHORED LOG STE
6+00
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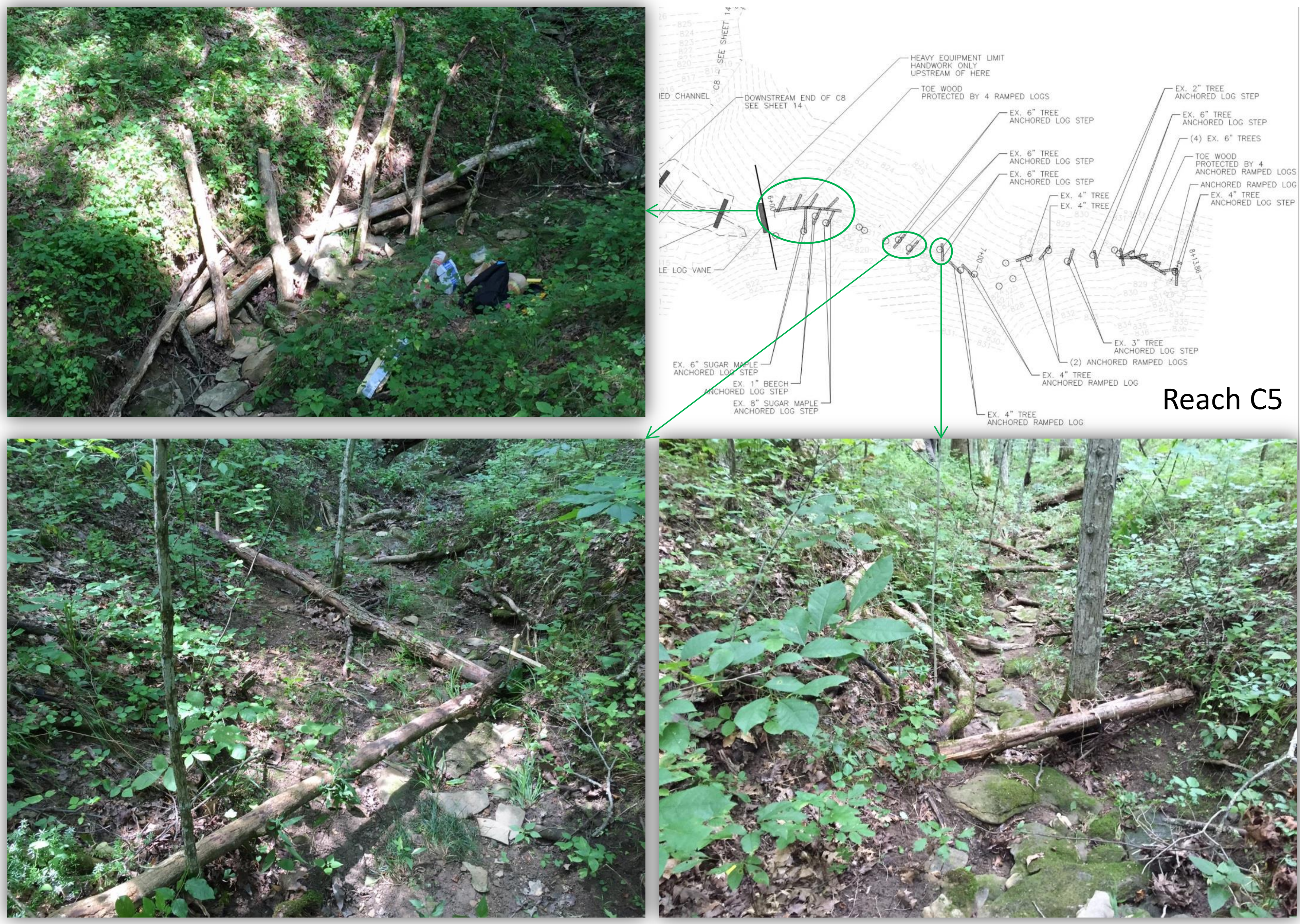
8+13.86
EX. 6" SUGAR MAPLE
ANCHORED LOG STEP
EX. 1" BEECH
ANCHORED LOG STEP
EX. 8" SUGAR MAPLE
ANCHORED LOG STEP
EX. 4" TREE
ANCHORED RAMPED LOG
EX. 4" TREE
ANCHORED RAMPED LOG
(2) ANCHORED RAMPED LOGS
EX. 3" TREE
ANCHORED LOG STEP

Reach C5


BEFORE


AFTER



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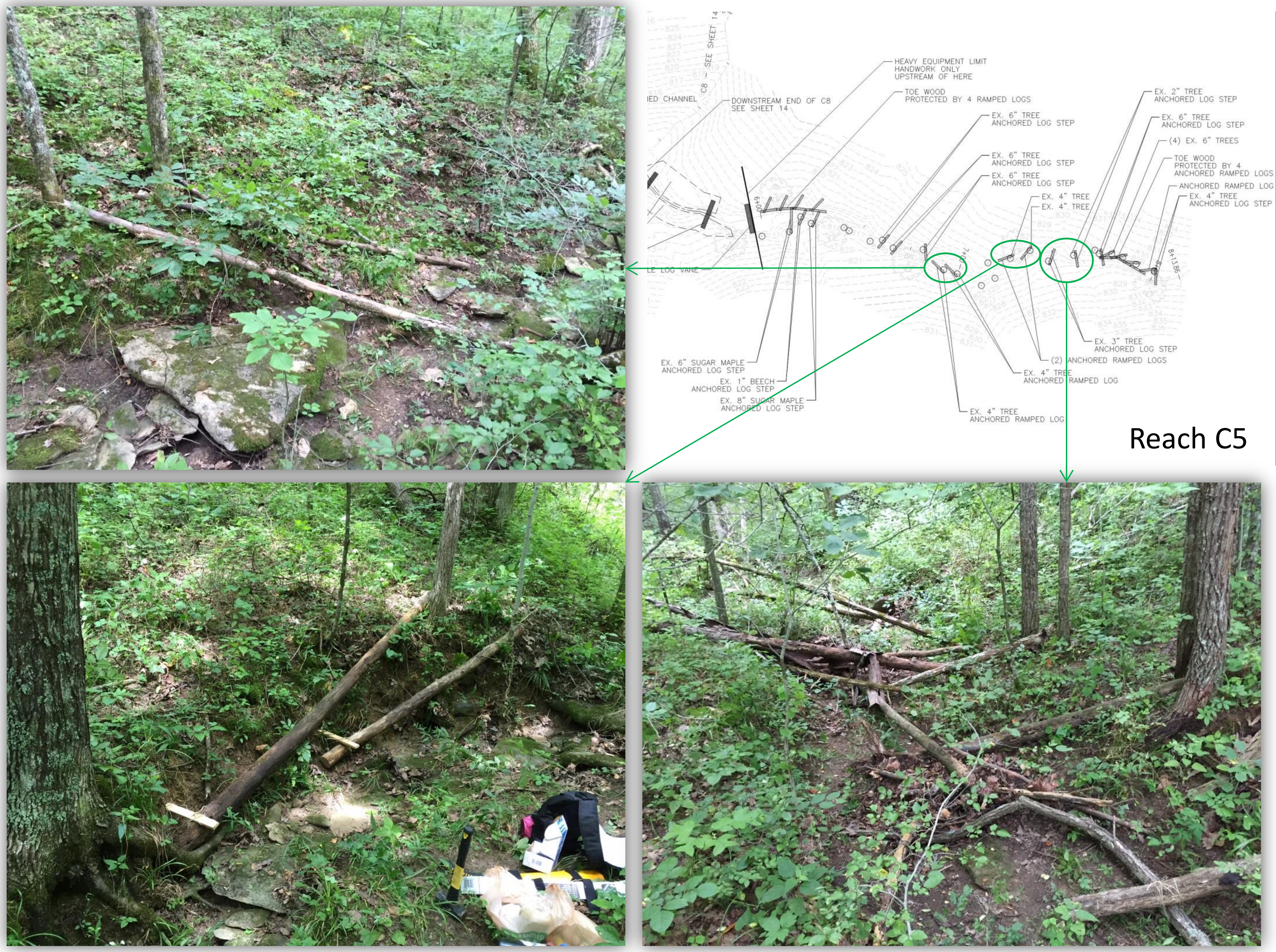
Reach C5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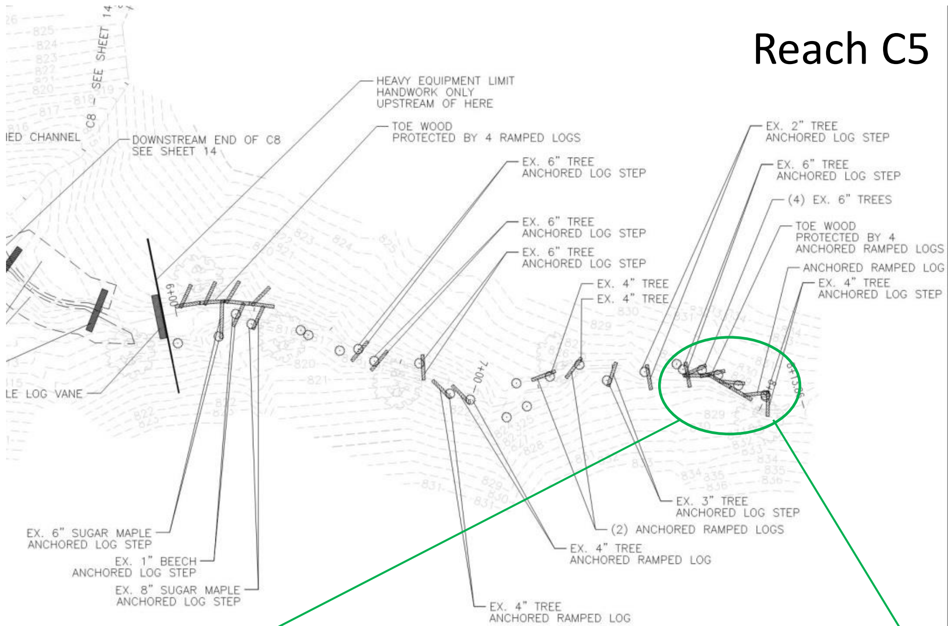
Reach C5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EX. 4" TREE ANCHORED RAMPED LOG
(2) ANCHORED RAMPED LOGS
EX. 3" TREE ANCHORED LOG STEP

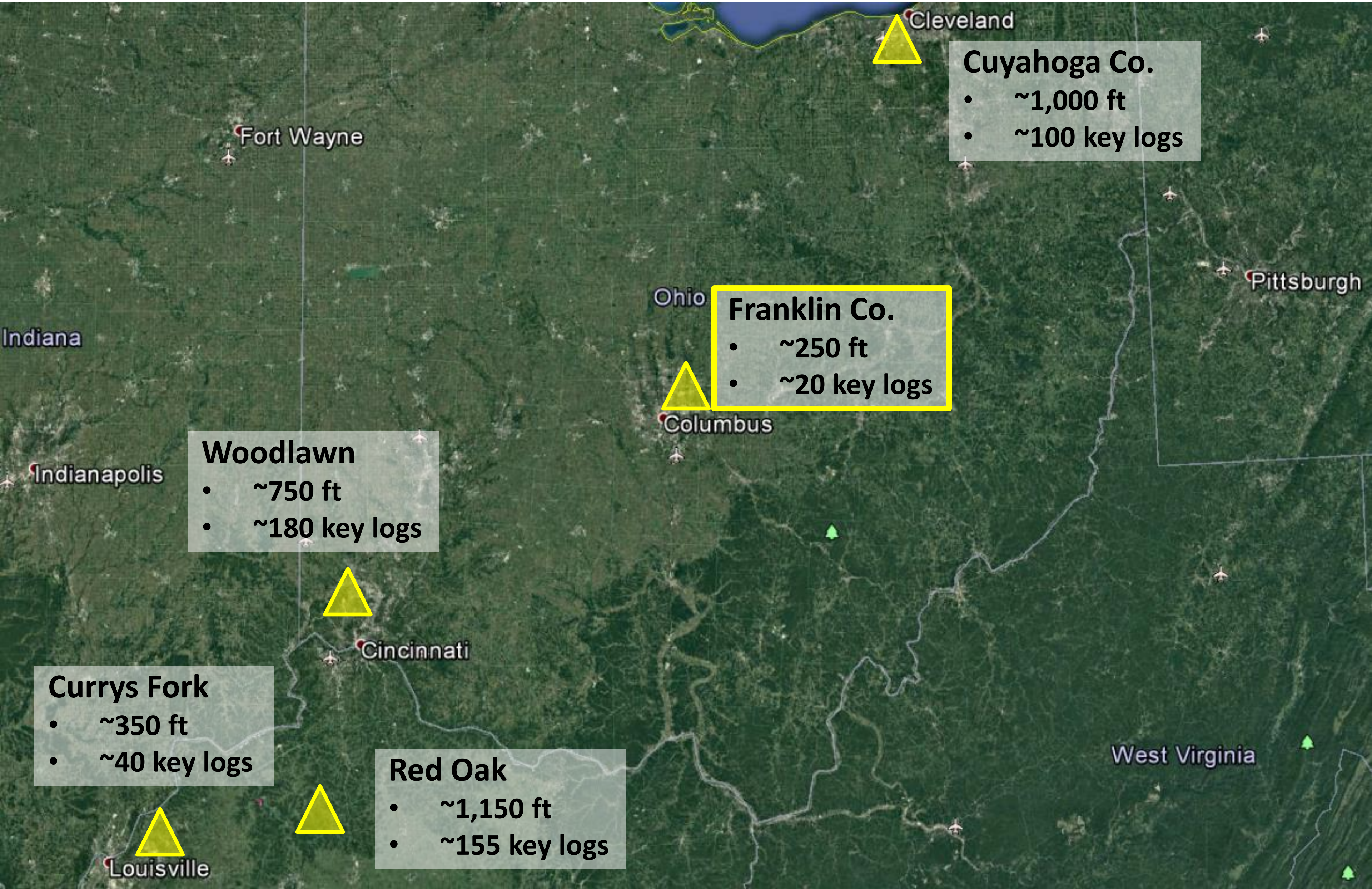
All Structures Present ~2 Years Later

Contractor Installed Remaining Reaches Fall 2018

Frequent Jams & Very High Wood Abundance

All Structures Survived Really Wet Fall/Winter/Spring

Lessons Learned from Five Installations



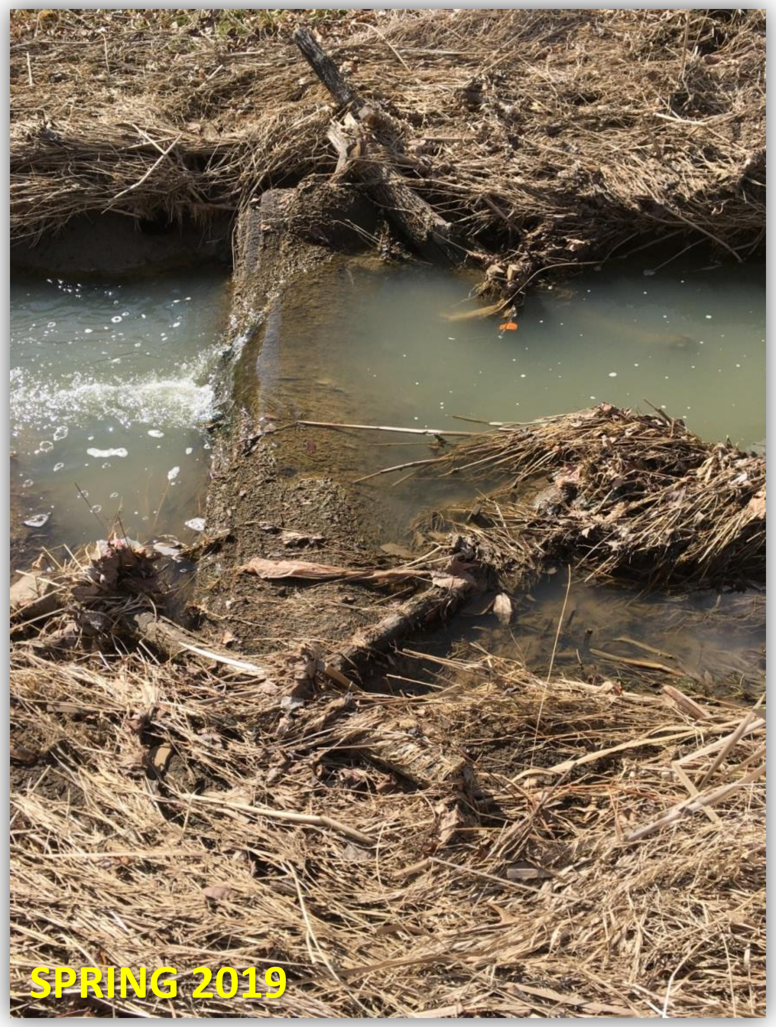
Unnamed Tributaries to Dysart Run

Installations along channelized ditch between houses

- Drainage Area ~1.46 mi^2
- BF Width ~ 5 ft

Installed in Combination with Riffle Inserts
(see Kurt Keljo & Team, Franklin Co. Soil & Water)

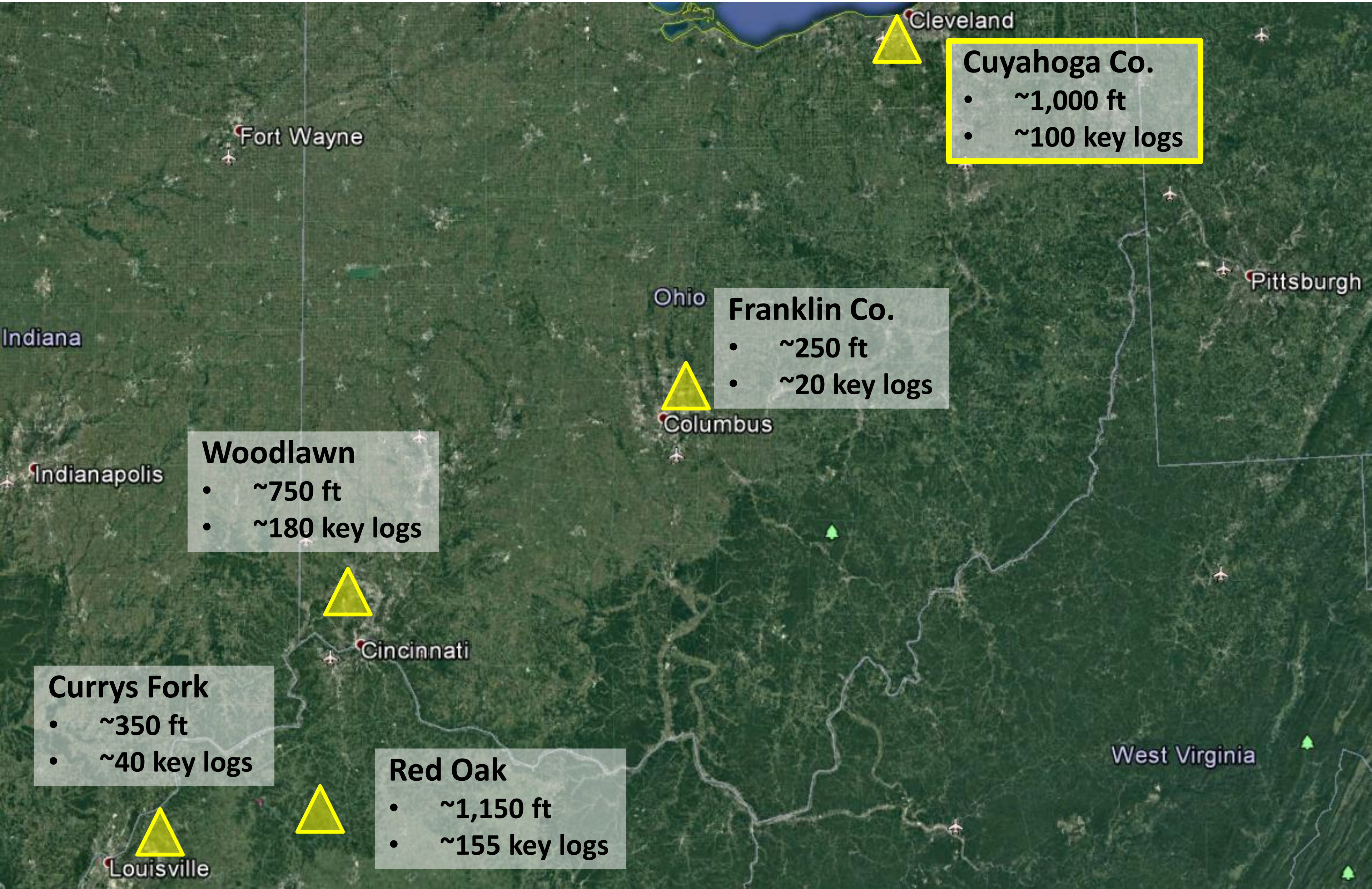
Preventing Flanking Around Riffle Inserts



Low Cost Bank Protection, Trapping Organic Debris & Urban Trash!

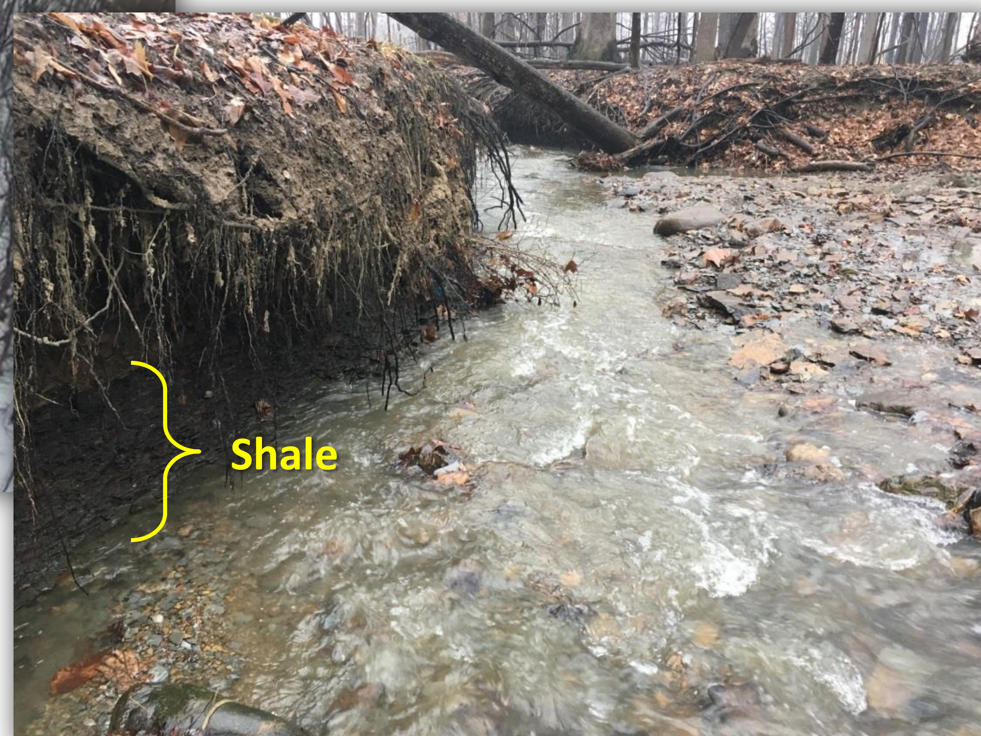
Low-Cost Habitat Variability and Water Quality Enhancement

Lessons Learned from Five Installations



Cuyahoga County Demonstration Project

- Forested floodplain with pocket wetlands
- Tall/undercut shale banks



- Drainage Area ~0.29 mi^2
- BF Width ~ 15 ft

Limited Anchoring Opportunities on Some Banks

8 of 23 Structures (35%) Mobilized

Very long (>20') solo anchor logs with small diameters

8 of 23 Structures (35%) Mobilized

Exclusively anchored with stakes and twine (no nearby trees)

15 of 23 Structures (65%) Functioning

Anchored by live trees

15 of 23 Structures (65%) Functioning

Large diameters & trunks with branches

15 of 23 Structures (65%) Functioning

Jams with interlocking logs (the larger/longer the better)

15 of 23 Structures (65%) Functioning

Interlocking ramped logs, anchored by trees and roots

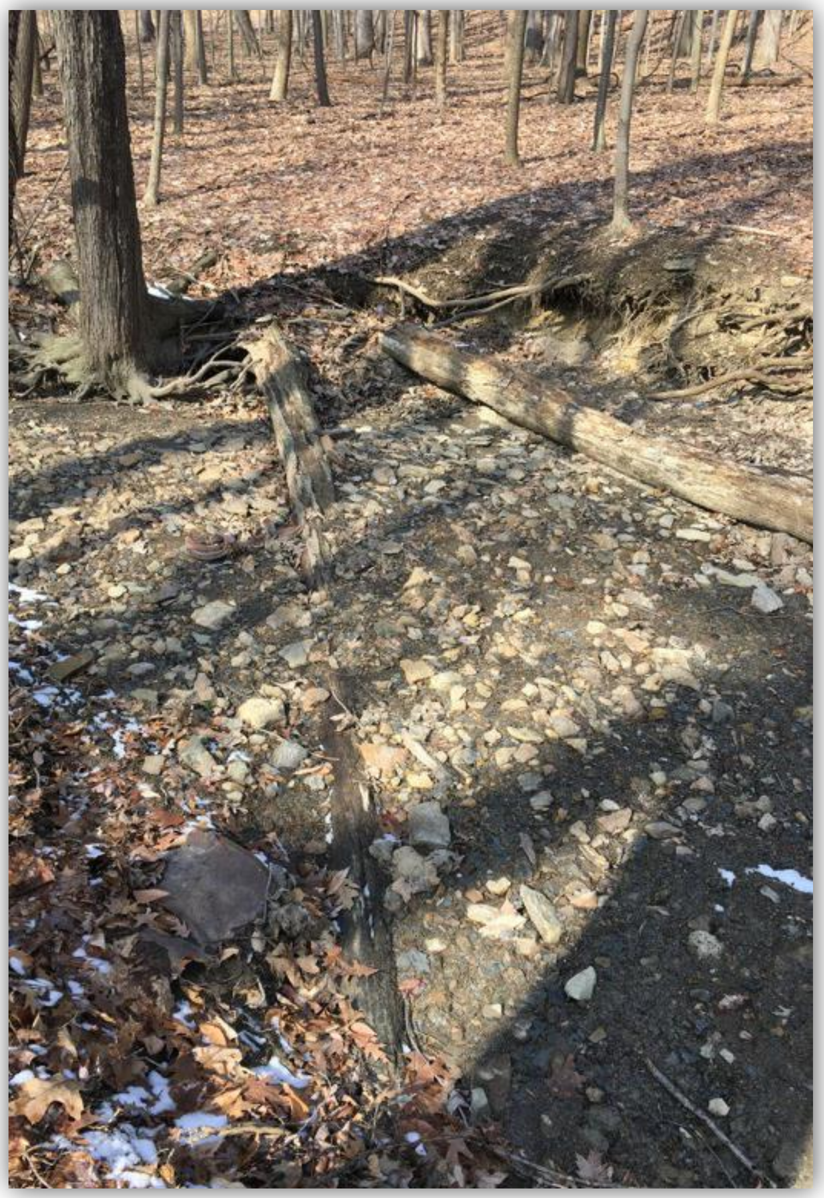
15 of 23 Structures (65%) Functioning

Anchored to existing features (fallen trees, aerial logs, boulders…)

Channel Is Retaining More LWD and Organic Matter

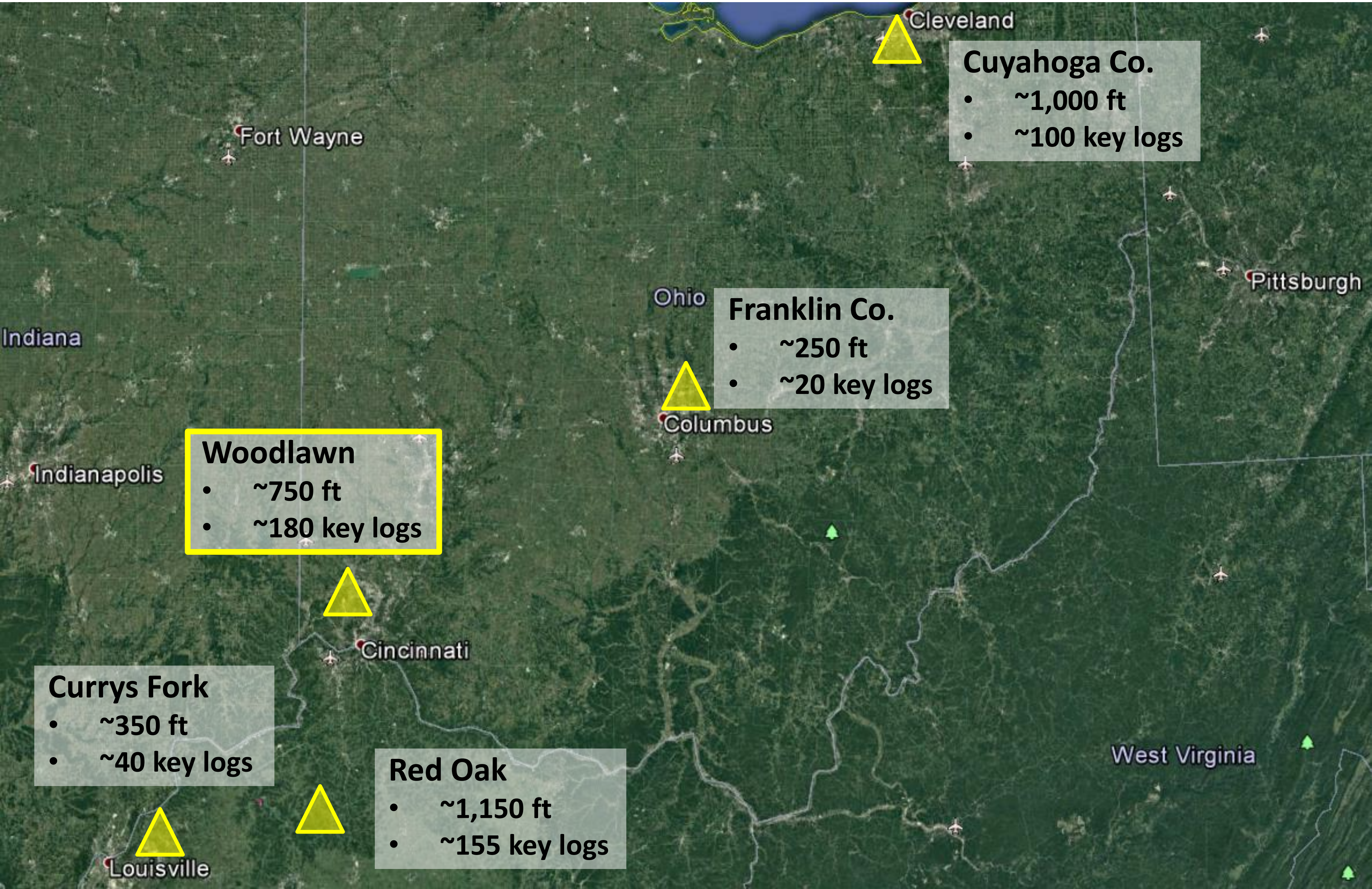
Channel-spanning Jams Trap A LOT of LWD/Organics

Large Diameter, Channel-spanning Logs Perform Well



Falling Trees Make Great Anchors & Can Facilitate Increased Trapping

Lessons Learned from Five Installations



Woodlawn Woods Stream Enhancement & Forest Restoration

Ephemeral Stream with Poor Habitat Dominated by Honeysuckle

- Drainage Area ~0.05 mi^2
- BF Width ~ 4 ft
- Pre-project HHEI = 51
  - ~80% silt
  - nominal LWD

A Silty Channel with Little Habitat Structure

Chronic Stream Downcutting and Bank Erosion

Headcuts Checked by Roots


PRE-PROJECT


FALL 2018

Trapping Leaf Litter & Brush


FALL 2018

Restoring Pool Habitat


FALL 2018

Becoming More Embedded


FALL 2018

Restoring a Low-Flow Channel with Benches

Restoration of Herbaceous Ground Cover

Adding Channel Roughness

Prolonging Base Flows

Improving Bank Stability

No Grading Necessary

“Messy” Channels = Lots of Habitat Niches

Tons of Carbon for Nutrient Cycling

Channel-Spanning Log Jams Catch Lots of Wood & Debris

V-Structures Trap Lots of Debris

Higher Abundance of Instream Wood

Increased Trapping of Wood & Debris

Reduced Wood Export to Downstream Culverts

Reduced Wood Export to Downstream Culverts

Reduced Wood Export to Downstream Culverts

Woodlawn Has Their Park Back ☺

A Woods You Can See Through Again

A Stream That Holds Water ☺

Inviting Trails

Stream Habitat Recovery In Progress

- Wet pools
- Meandering low-flow channel
- Improving substrate
- Bench development and colonization by vegetation
- Abundant wood & organic matter

Wet Pools

Meandering Low-Flow Channel

Habitat Variability

Improving Substrate

Bench Development and Vegetation Colonization

Bench Development and Vegetation Colonization

Bench Development and Vegetation Colonization

Lessons Learned & Recommendations

- **Go Big Or Go Home**
  - Abundant key logs
  - Frequent jams catch floaters, new wood, & organic debris
- **Key Logs Proportional to Channel**
  - Length > 0.5 x BF Width
  - Diameter > 0.5 x BF Depth
- **Ramping/Anchoring**
  - Up banks, behind live trees, etc.
  - Stakes & twine to prevent floating
- **Couple with Revegetation**
  - Honeysuckle removal / forest restoration
  - Live stakes

Sustainable Streams LLC

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Thank You!