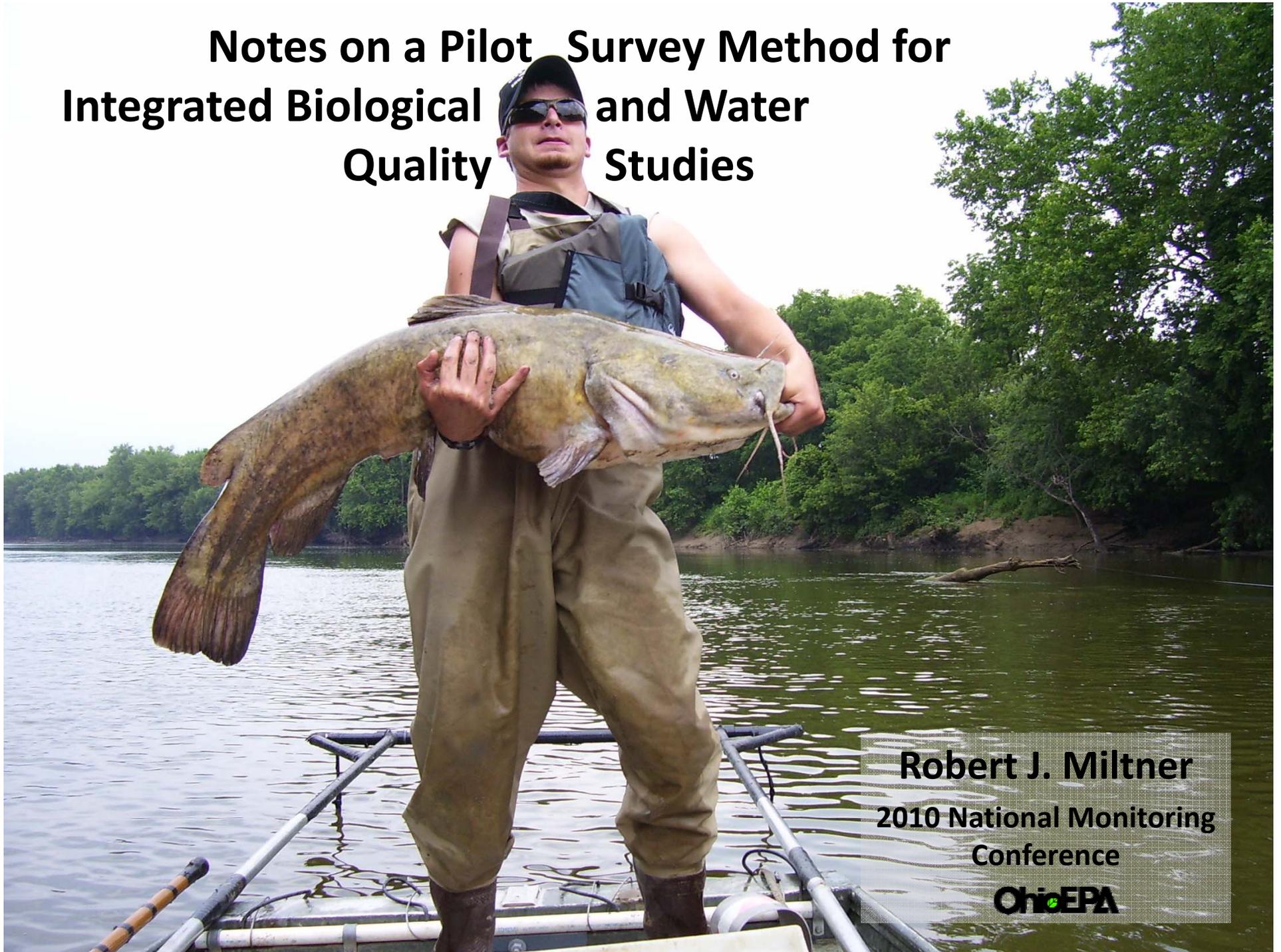


Notes on a Pilot Survey Method for Integrated Biological and Water Quality Studies



Robert J. Miltner
2010 National Monitoring
Conference

OhioEPA

Watershed Surveys

Large Scope - Limited Resources

- Program-specific needs
 - TMDL
 - Condition status
 - Identify causes and sources
 - NPDES
 - Beneficial Use Designations
 - Nonpoint/319
 - AFOs & Livestock
 - Channelization
 - On-site sewerage
 - Stormwater
- General needs
 - *Accrue data for retrospective analyses*

Advantages of Biological Indicators

- Direct Measure of CWA Goal
- Live Continuously in Water
 - integrate past events, short and long-term
- Response-Recovery
- Tethered to Reality



Survey Designs Past and Present

- Past

- longitudinal reach surveys focused on point sources
- NPDES, construction grants

- Present

- watershed surveys covering point and non-point sources
- TMDLs



The Paint Creek Basin

2006 Survey Year

Drainage Area = 1170 mi²

Stream Network ~ 1575 miles

Monitoring Needs



401s

NPDES Permits



Municipal



Industrial



Sludge Fields



AFOs

Land Cover



Water



Urban



Forest



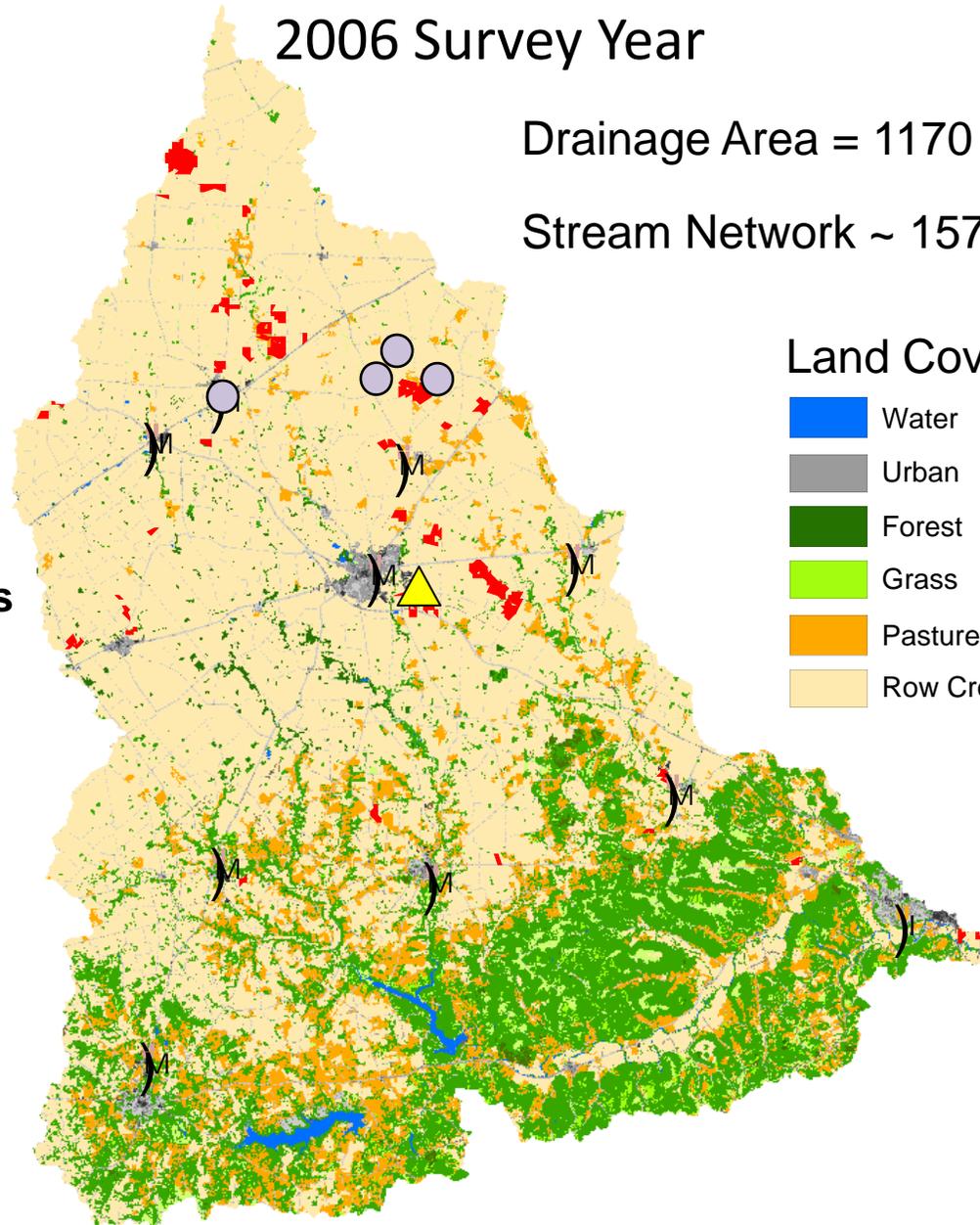
Grass



Pasture



Row Crop



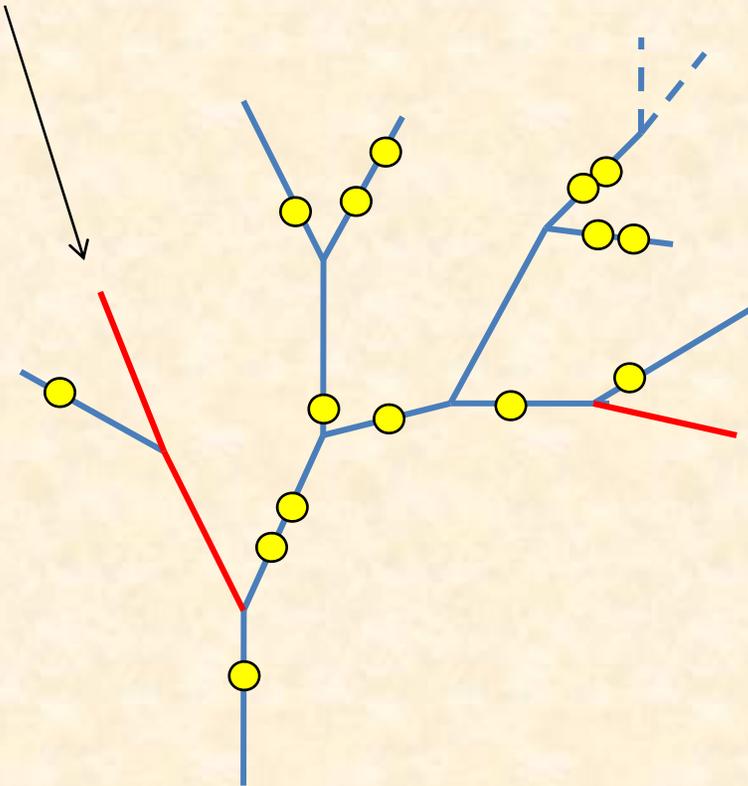
Survey Designs

- Complete census
 - population (sources, named streams, temporal) ?
 - costly, impractical
- Target only known or suspected sources
 - ignores vast swaths of the watershed
- Probability Sample
 - what is your population?
 - stratification
 - *stressors are not distributed randomly*
 - practical limitations
- Systematic Sample
 - ease of execution

Thumbnail Sketch of Probabilistic and Systematic Sampling

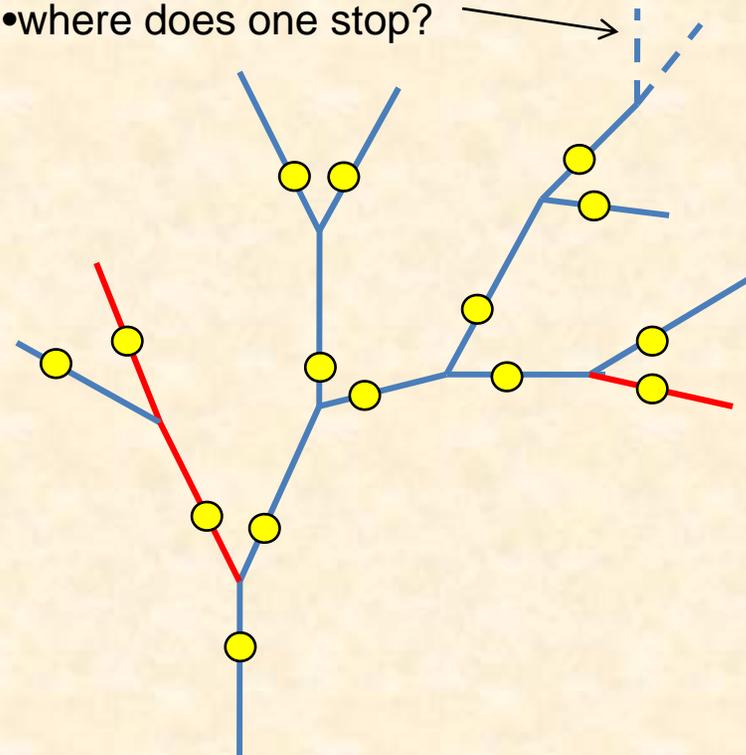
Simple Random Draw

- stream network ordered as continuous line
- can weight to avoid over-draw on small streams
- some segments will be missed



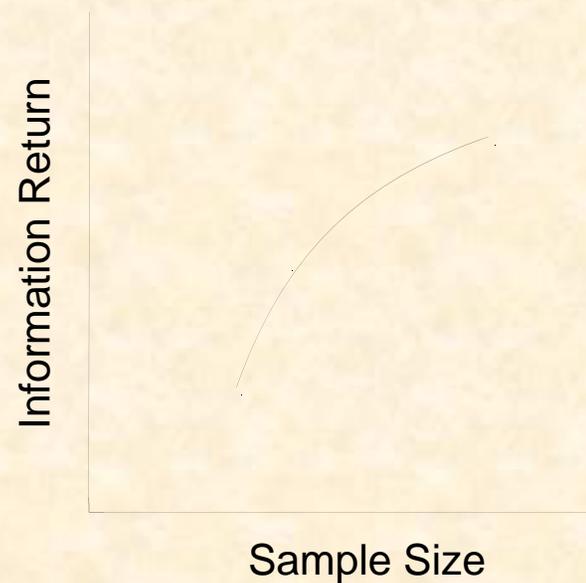
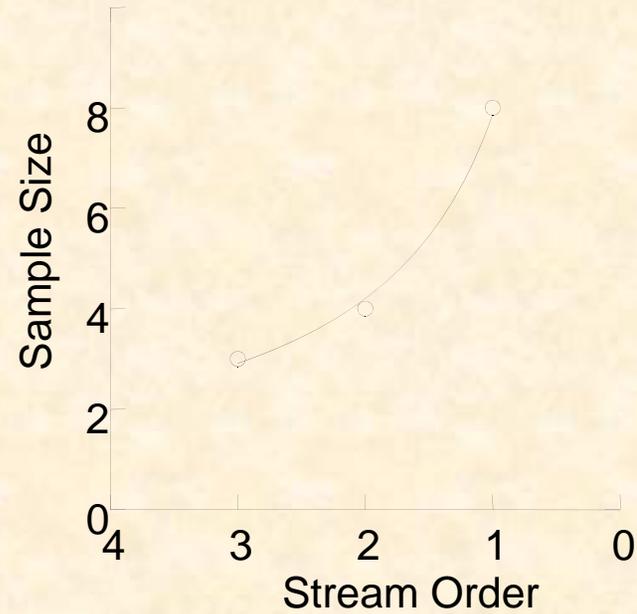
Systematic Draw

- follow bifurcation or drainage area
- provides info on each stream
- what's the information return on the i^{th} sample?
- where does one stop?



Information Return

The Everlasting Sameness* of the ECBP Ecoregion



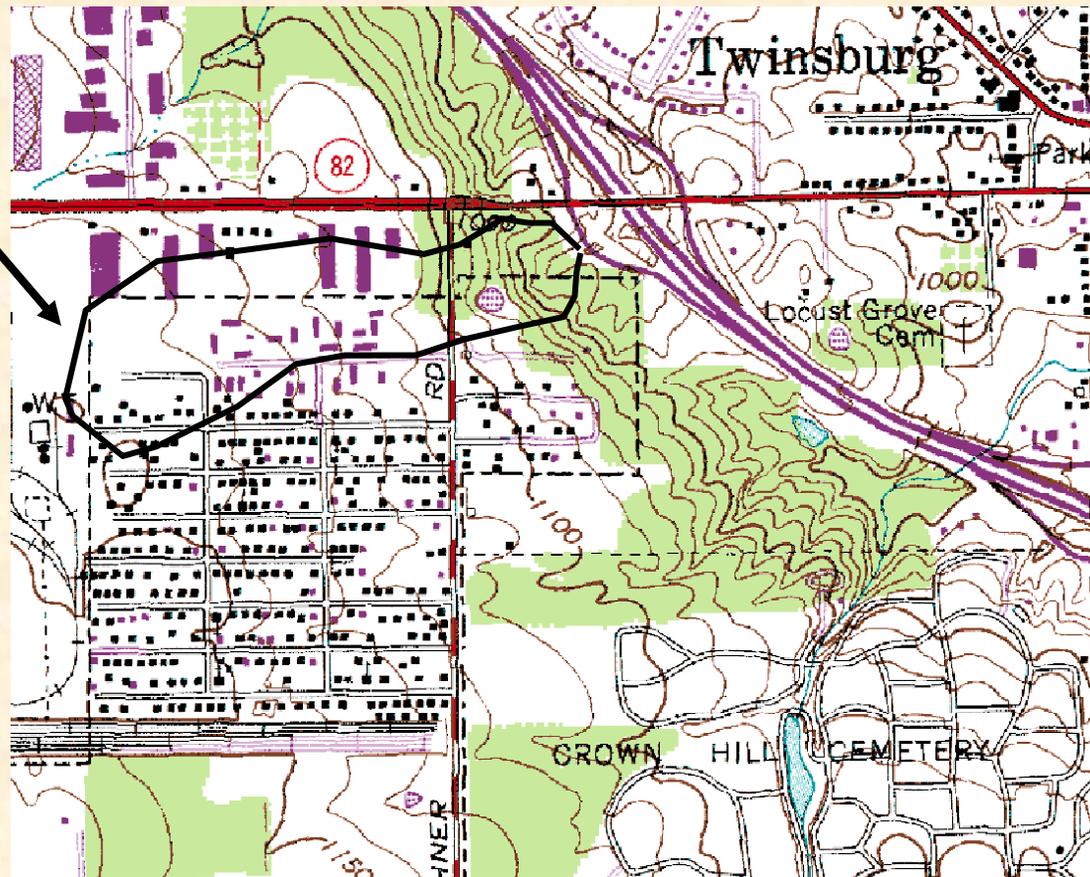
*Paul Colinvaux *Why Big Fierce Animals are Rare*

Where Does One Stop?

Is there a stream here?

0.68 sq. mi.

- USGS topo sheet 1: 24,000
- No “Blue line” depicted here



“Invisible” Stream...

1999



... Lost...
to the Great Real Estate Bubble

2001

The same headwater stream after a nationwide permit



Paint Creek 2006 Biological & Water Quality Survey

52 Geometric Sites (Drain Area ≥ 8 mi²) = 76 Samples

89 Geometric Sites (Drain Area 2-8 mi²) = 89 Samples

52 Targeted Sites = 100 Samples

Total Field Effort = 265 Samples
(~3 field crews worth of effort)

2 crews to do the work



Random Sample of Smallest Geometric Strata

Population of Terminal Node Headwaters

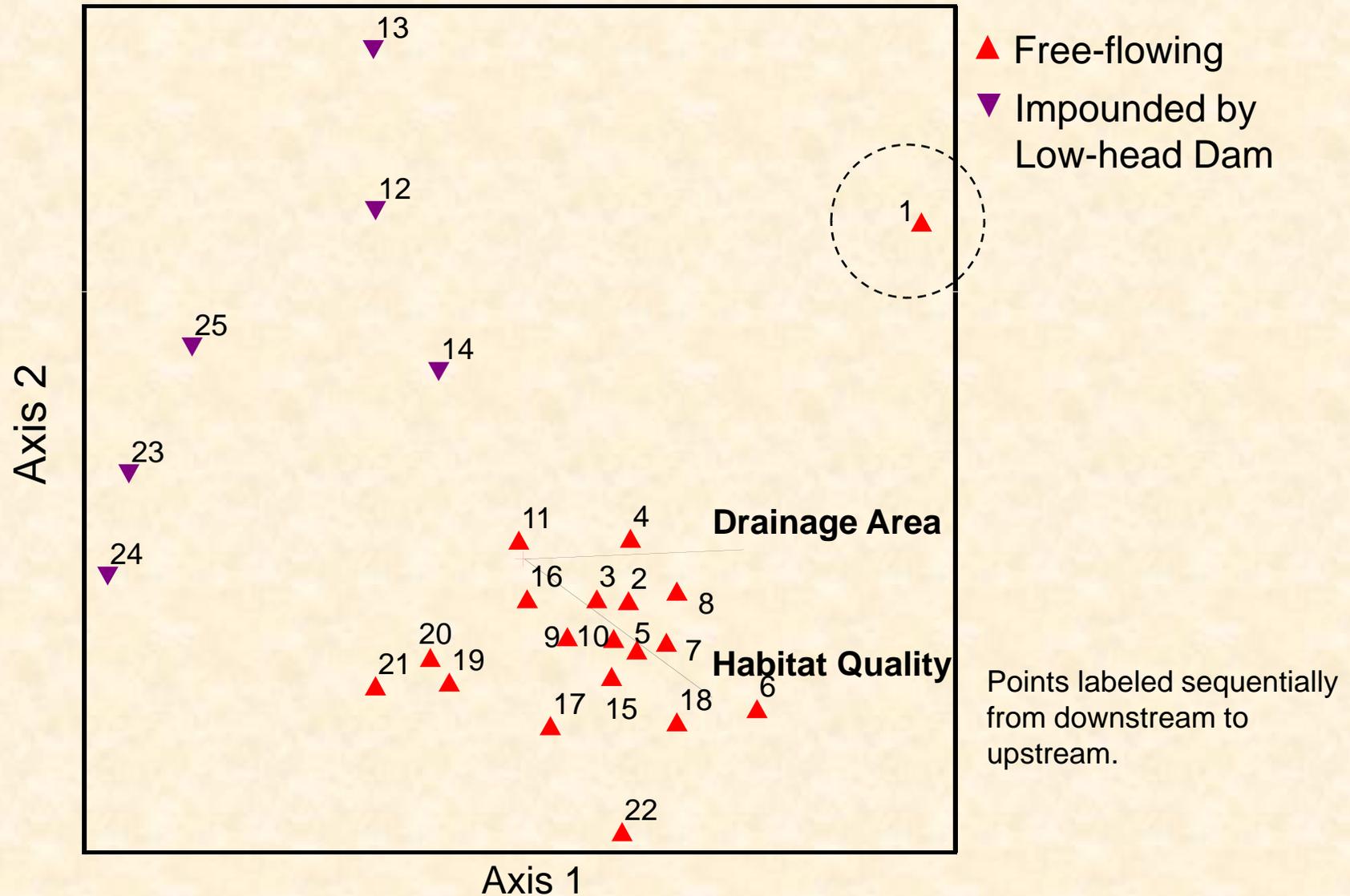
- The upstream most ends of tributaries that abut watershed or subwatershed boundaries
- Have drainage areas $\sim 2 - 8 \text{ mi}^2$ (lower limit of index calibration)
- Paint Creek N = 89 (roughly one field survey worth of effort)
- Must be accessible
 - assumes that community structure is persistent at the reach level

Objectives

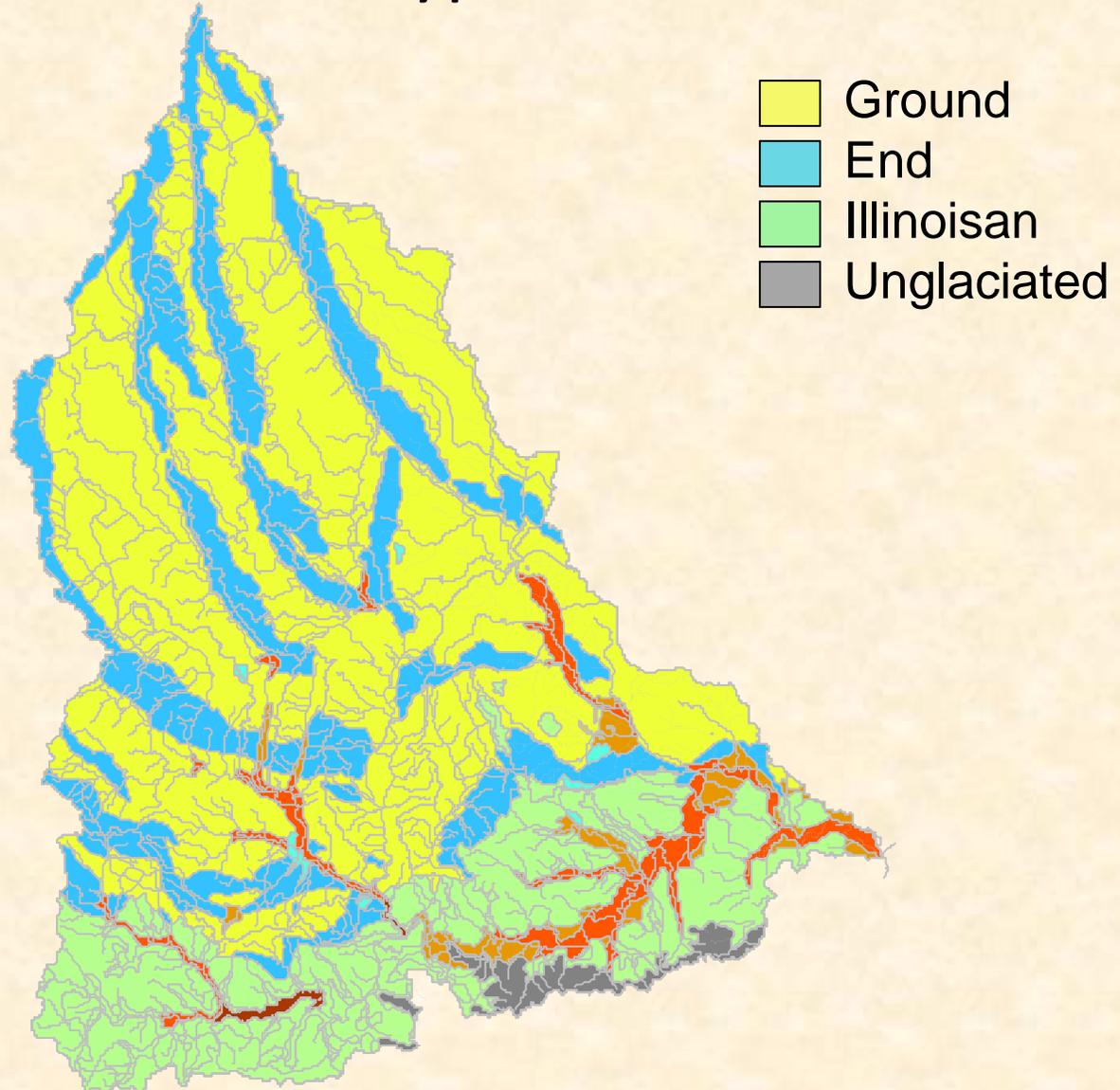
- Condition status of small headwaters
- Identify stressors acting on population

Persistence of Community Structure

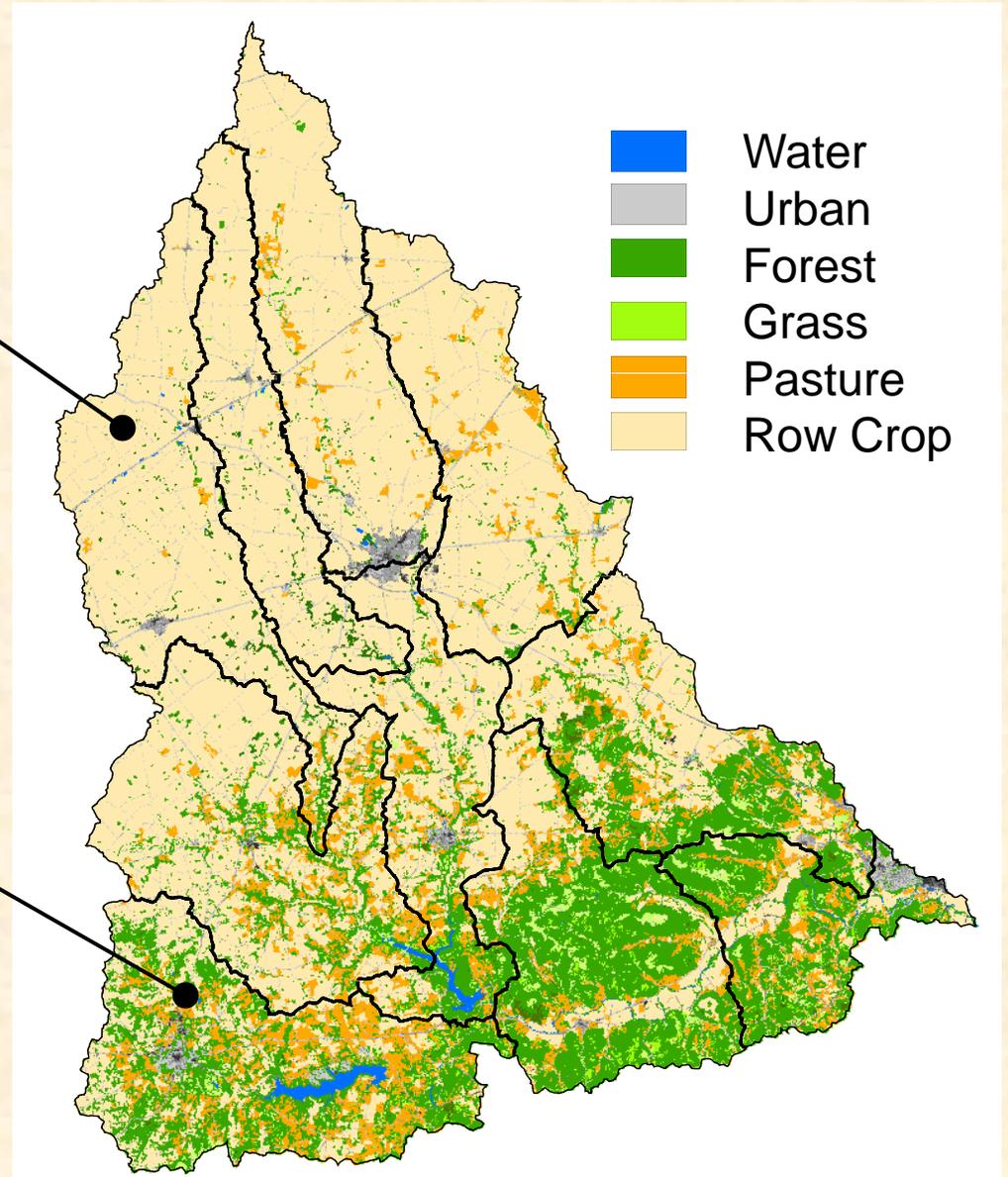
Similarity Along a 40 Mile Mainstem Reach



Glacial Moraine Type as a Stratum



Land Cover as a Stratum



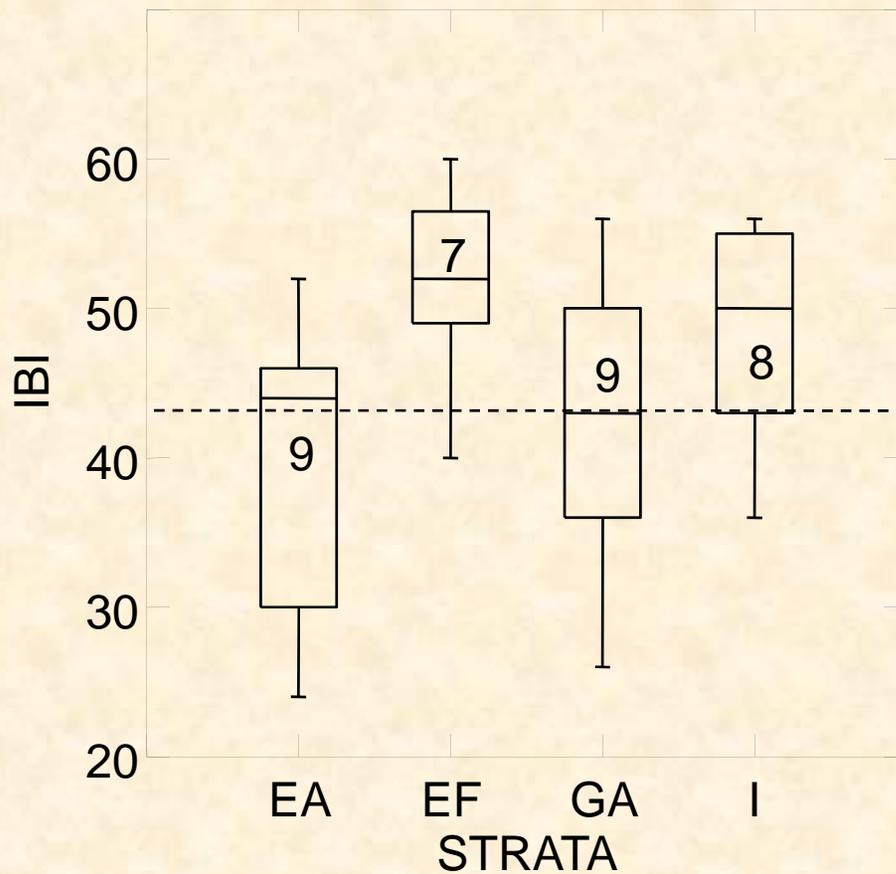
Paint Creek Sample Design

- Stratified Random Sample
 - Number of sites by moraine type and land cover
 - End with > 90% agricultural land use N = 13
 - Ground with > 90% agricultural land use N = 49
 - End with > 10% forest cover N = 7
 - Illinoisan (all > 10% forest cover) N = 20
 - Allocation
 - All 7 of the end-forested
 - 10 from the other three strata

Results



Distributions of Fish IBI Scores Within Strata



End-forested and Illinoisan strata between 4 and 17 points higher when contrasted to agricultural-end or ground strata

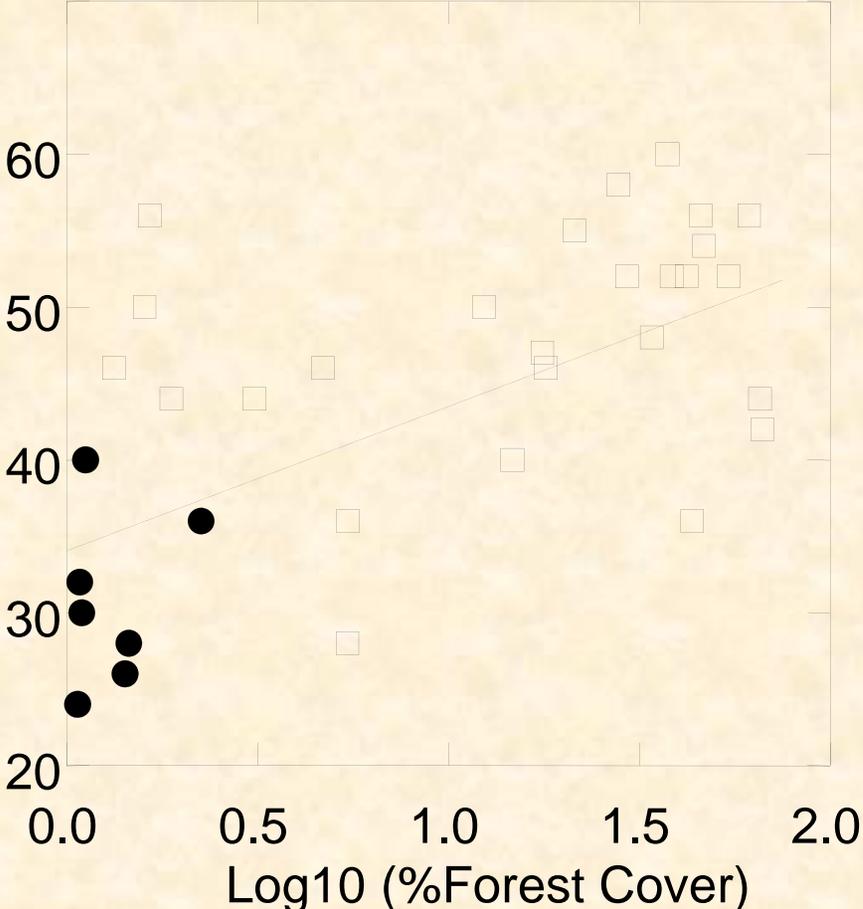
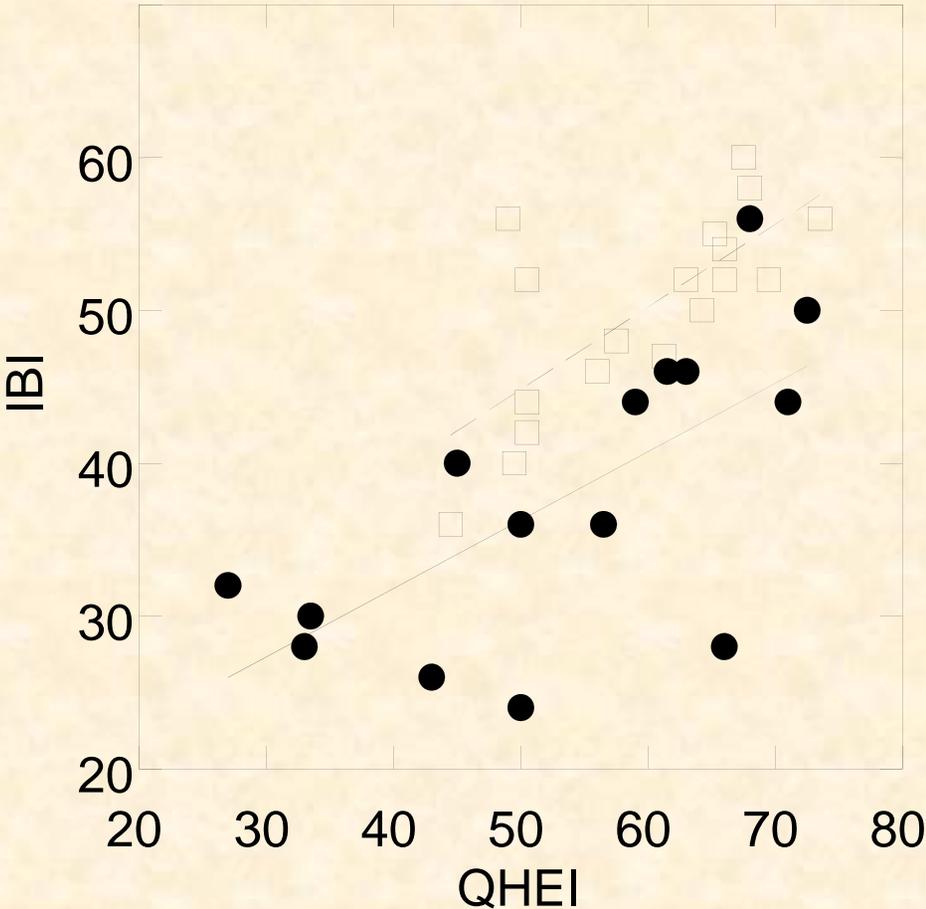
Moraine type apparently not significant

Does Forest Cover Explain Variance?

Poststratification

- Forested
- Agricultural

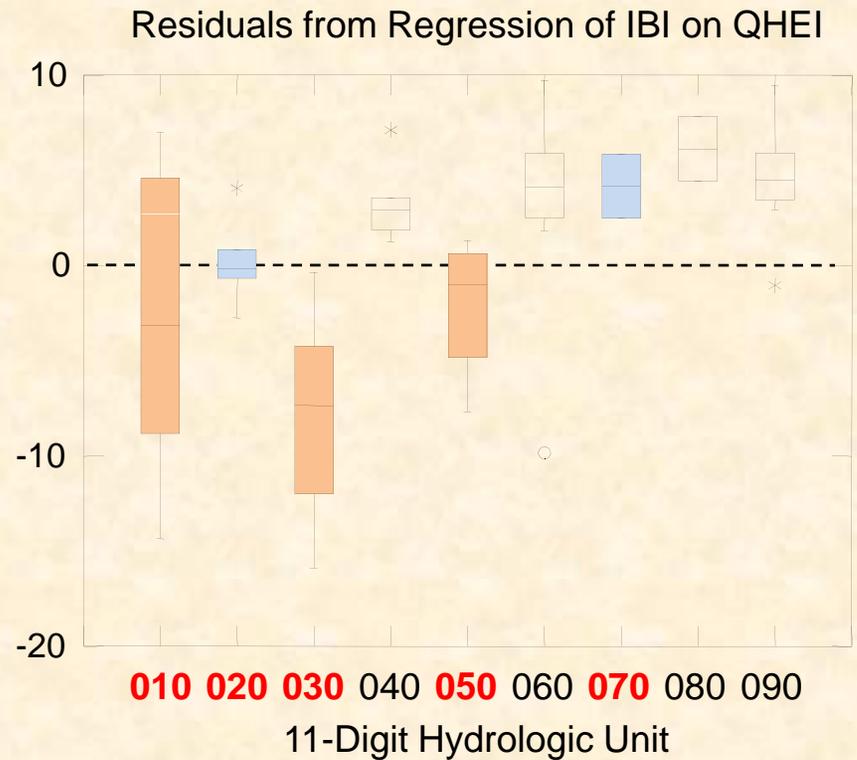
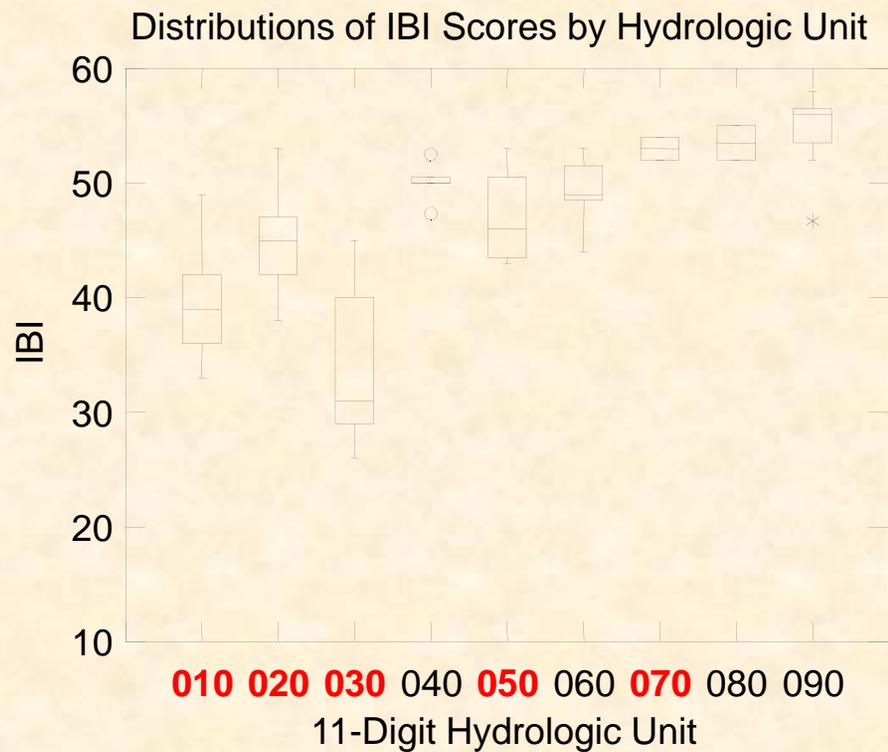
- Downstream Channel Natural
- Downstream Segment Channelized



Distributions of IBI Scores by Hydrologic Unit

Scale Effect of Habitat Degradation

Wadeable Streams



*Red font denotes extensive channelization of headwaters

Causes* of Impairment Noted at Headwater Sites

(drainage area < 20 square miles)

Random Sites (n=34)

- Hydromodification (habitat destruction)
 - 8 sites (channelized for drainage)
- Organic Enrichment
 - 3 sites (2 on-site sewerage, 1 livestock)
- Toxicity
 - 1 site (urban stormwater)

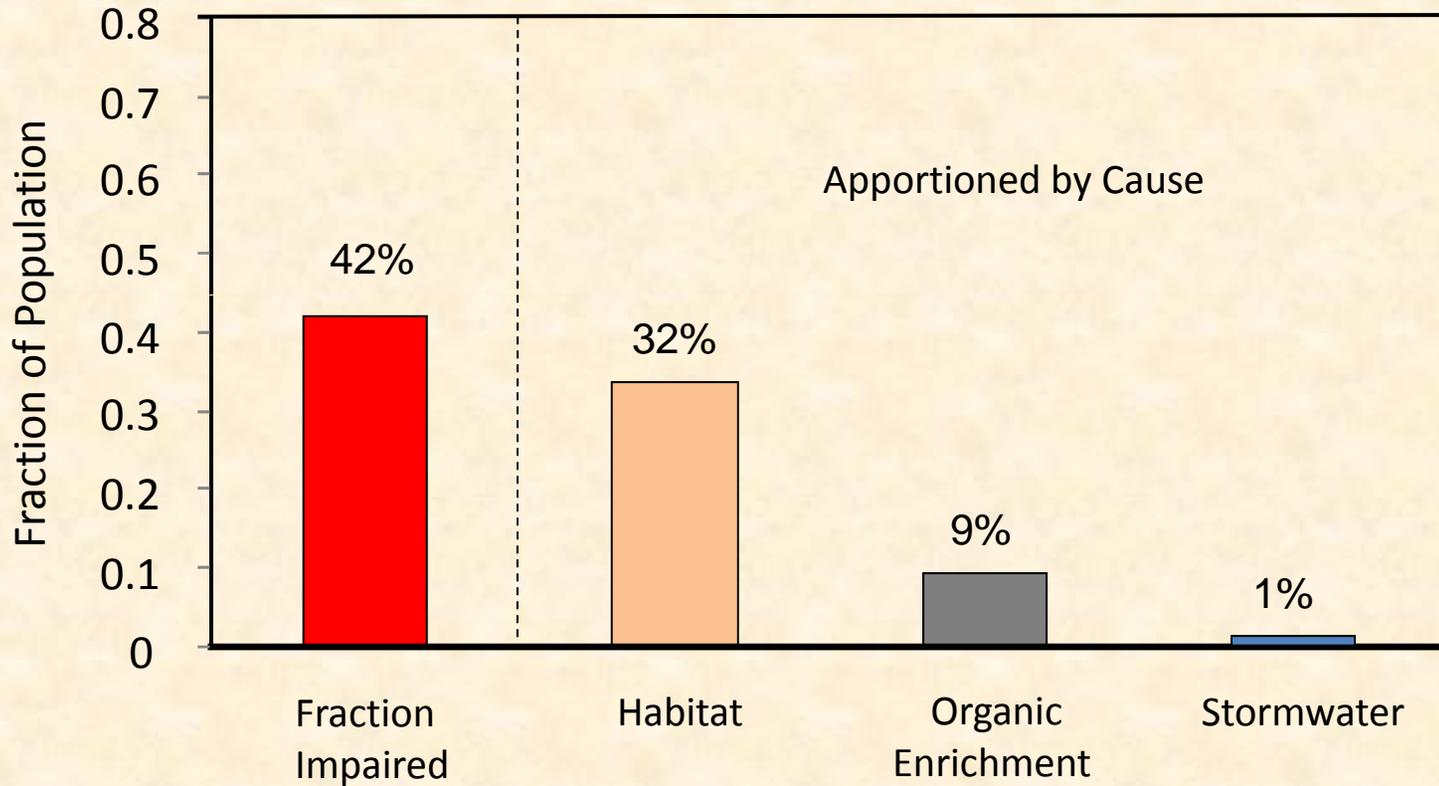
Targeted & Systematic Sites (n=38)

- Hydromodification (habitat destruction)
 - 6 sites (channelized for drainage)
- Organic Enrichment
 - 2 sites (1 on-site sewerage, 1 livestock)
- Toxicity
 - 2 sites (urban stormwater)
- Nutrient Enrichment
 - 1 site

*Primary or highest magnitude cause listed.

Impairment and Causes

Extrapolated to the Population of Terminal Node Headwaters



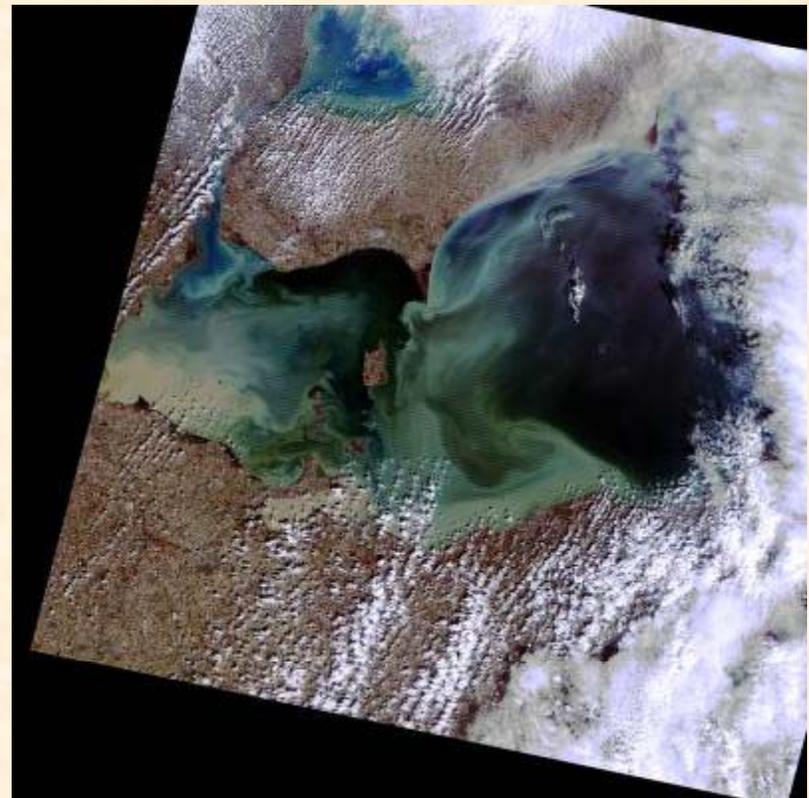
Conclusions

- Random sampling :
 - estimated the general condition of headwaters
 - identified major causes of impairment to Paint Creek headwaters
 - prospective design and retrospective analyses informed knowledge of system
 - scale effect of channelization
- Random sampling does not:
 - assign beneficial uses
 - allow for listing individual segments
 - capture all causes
 - provide a substitute for dense spatial coverage
 - conundrum of disproving the negative

Recommendations

- Deal with very small headwaters at the population level
 - Policies and regulations directed towards habitat, water quality & quantity protection
 - Drainage, urbanization, nutrients/manure, prescriptive BMPs

Lake Erie, Western Basin, 31 March 2007



Unresolved Questions

- Disjunct between regulatory structure and information returned from probability designs
 - we don't manage at the population level
- Sampling density and survey objectives
 - Paint Creek 1 site/31 mi² (random); 1site/10 mi² (all)
 - fish, bugs, chemistry ($\geq 4x$), sediment/tissue ($< 0.25x$), habitat
 - REMAP 1site/73 mi² (ECBP)
 - fish, habitat
 - NWSA 1 site/2748 mi²
 - bugs, chemistry (1x), habitat
- Mix of targeted and systematic samples to effectively yield a census
 - given the persistence of community structure



THE END