Functional measures of biotic recovery in an acid mine impacted stream remediated by alkaline addition

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Structural measures (biological community)

Number of organisms
Number/diversity of taxa
% sensitive taxa (EPT)
% tolerant taxa present
Trophic structure
Habit (clingers, sprawlers)

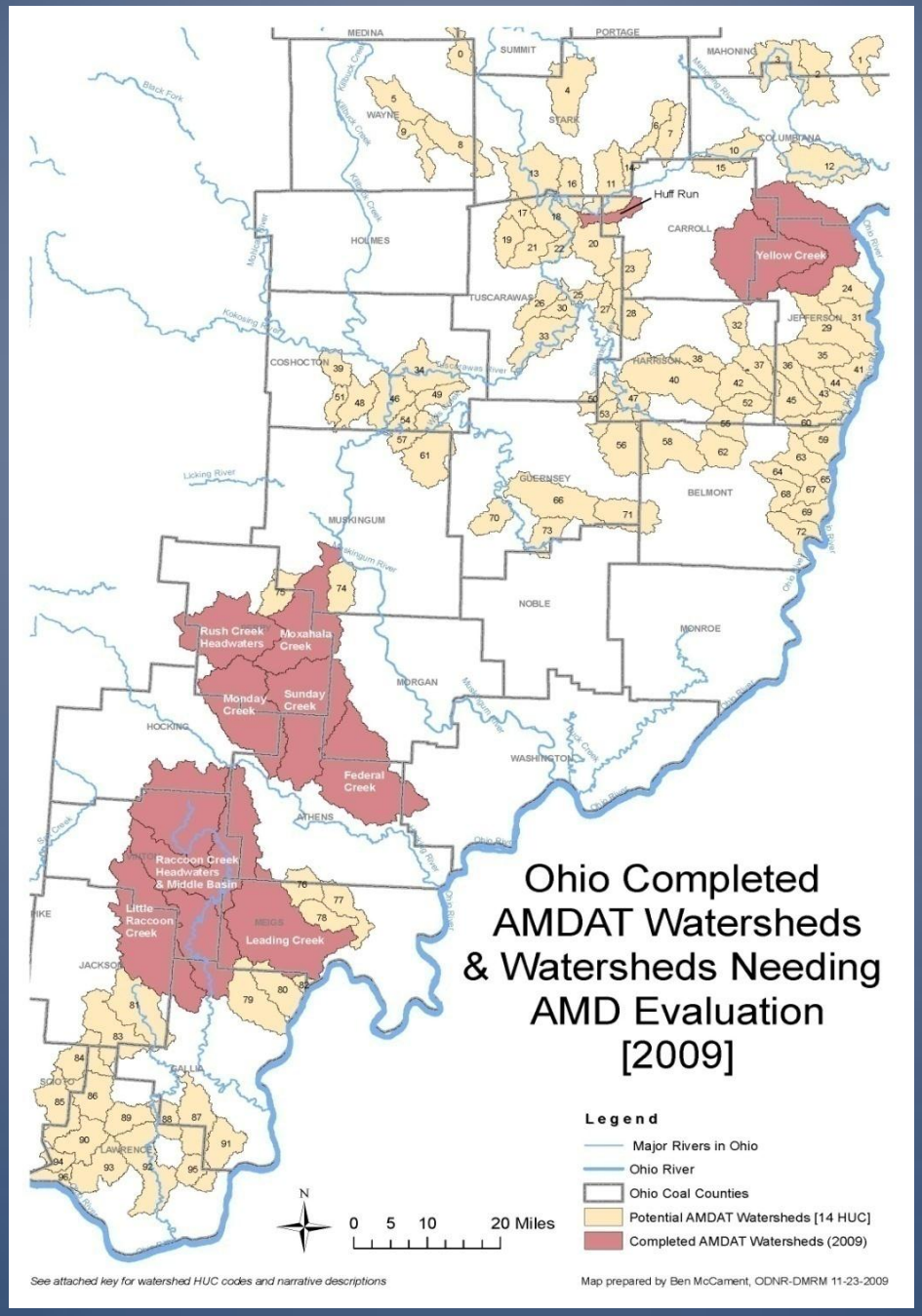
Functional measures (ecosystem processes)

primary production
stream respiration
Benthic, microbial respiration
Leaf litter degradation
Nutrient cycling, transport

Legacy of abandoned mines

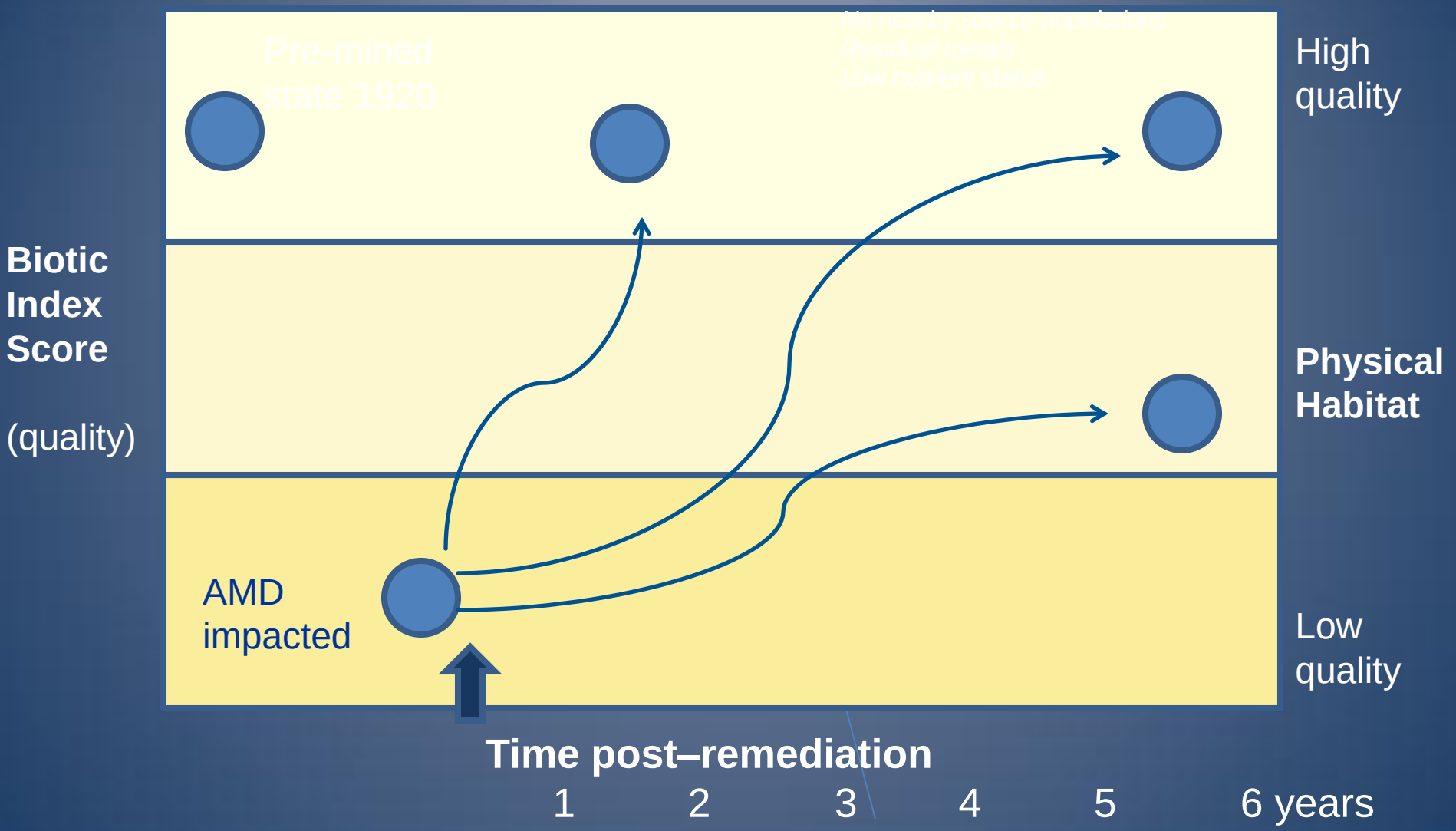
Acid mine drainage impacts over 1500 miles of streams in southeastern Ohio

- Acidified water (pH 3.0-5.0)
- Elevated sulfate, iron
- Elevated metals (Al, Zn)
- Metal hydroxide precipitates ‘yellow boy’

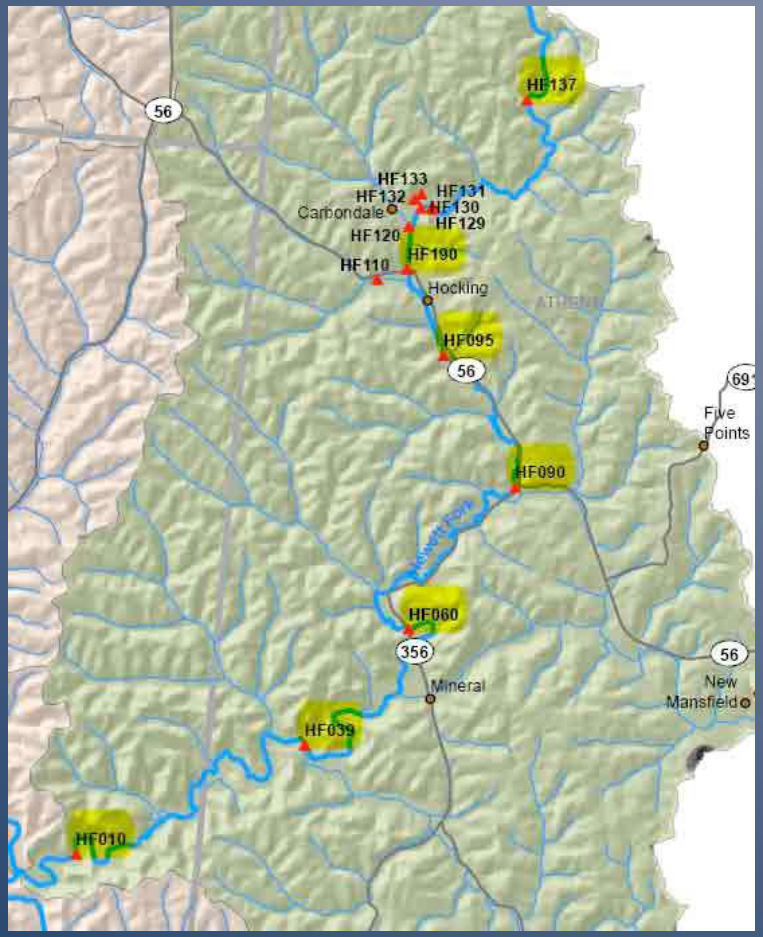

Ohio Completed AMDAT Watersheds & Watersheds Needing AMD Evaluation [2009]
Legend
Major Rivers in Ohio
Ohio River
Ohio Coal Counties
Potential AMDAT Watersheds [14 HUC]
Completed AMDAT Watersheds (2009)
N
0 5 10 20 Miles
Rush Creek Headwaters
Moxahala Creek
Monday Creek
Sunday Creek
Federal Creek
Raccoon Creek Headwaters & Middle Basin
Little Raccoon Creek
Leading Creek
Huff Run
Yellow Creek
MEDINA
SUMMIT
PORTAGE
MAHONING
WAYNE
STARK
COLUMBIANA
HOLMES
CARROLL
TUSCARAWAS
JEFFERSON
COSHOCTON
HARRISON
GUERNSEY
BELMONT
MUSKINGUM
NOBLE
MONROE
MORGAN
HOCKING
WASHINGTON
ATHENS
MEIGS
JACKSON
PIKE
SCIOTO
GALLIA
LAWRENCE
Black Fork
Licking River
Kokosing River
Muskingum River
Ohio River
See attached key for watershed HUC codes and narrative descriptions
Map prepared by Ben McCament, ODNR-DMRM 11-23-2009

Remediation treatments

PREDICTING RECOVERY TRAJECTORIES



Hewett Fork Doser (2004 to present) treats 11 miles of stream



Case Example: Hewett Fork doser

- Characterize changes in water chemistry downstream the doser
- Characterize the spatial and temporal variation in biological recovery of the macroinvertebrate assemblage
- Compare diagnostic value of multimetric biotic index (*structural measures*) with a *functional measures* of ecosystem processes (leaf litter degradation)

Water chemistry sampled 3 times per year

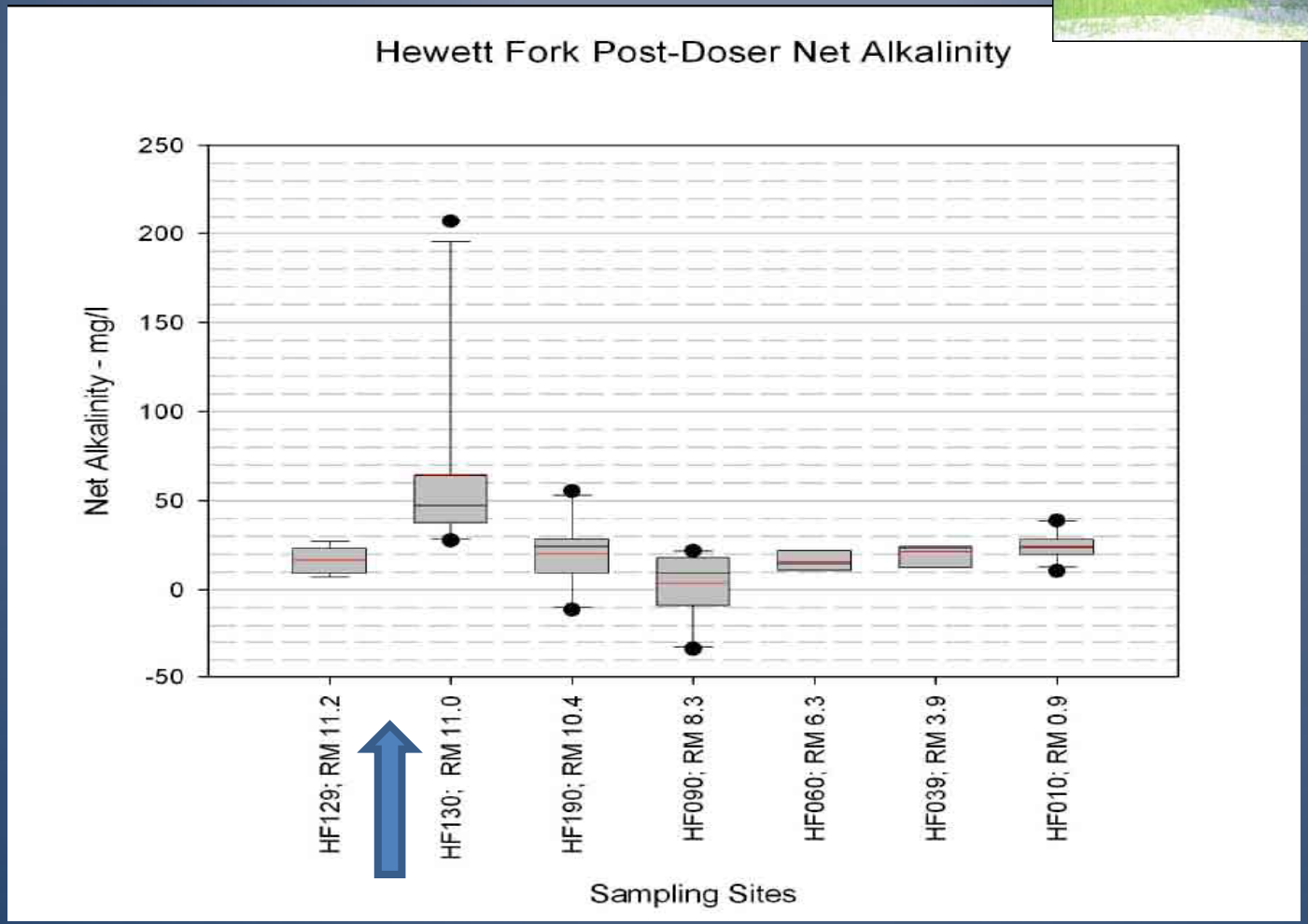
Macroinvertebrates each year (July)

- kicknet + D-ring dip net
- family-level taxonomy

Macroinvertebrate Multimetric (MAIS)

- Number of EPT families
- Number of mayfly families
- % abundance mayflies
- % 5 dominant taxa
- Simpson Diversity Index
- Modified Hilsenhoff Biotic Index
- Number of intolerant taxa
- % scrapers
- % haptobenthos

Doser increases net alkalinity



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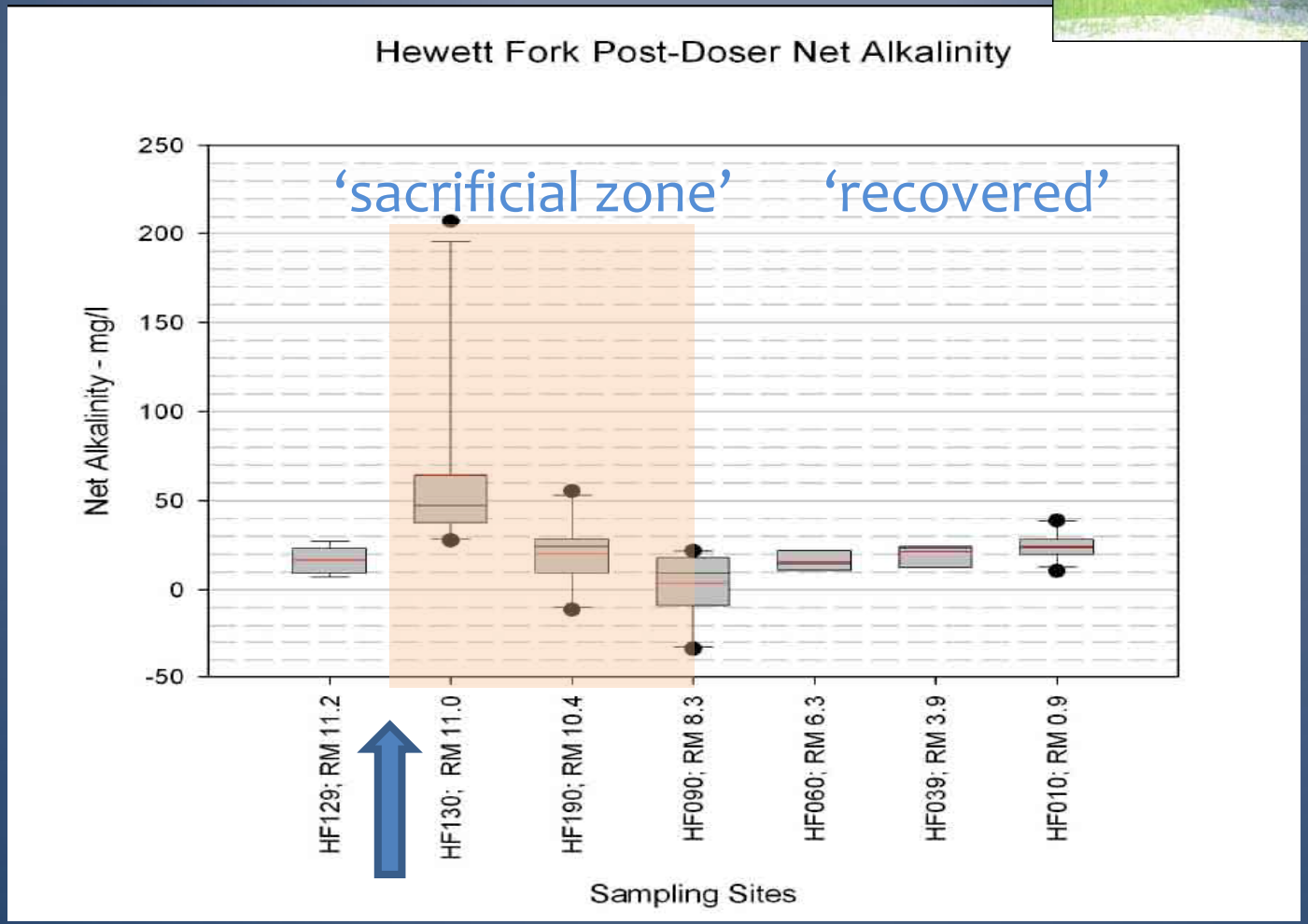
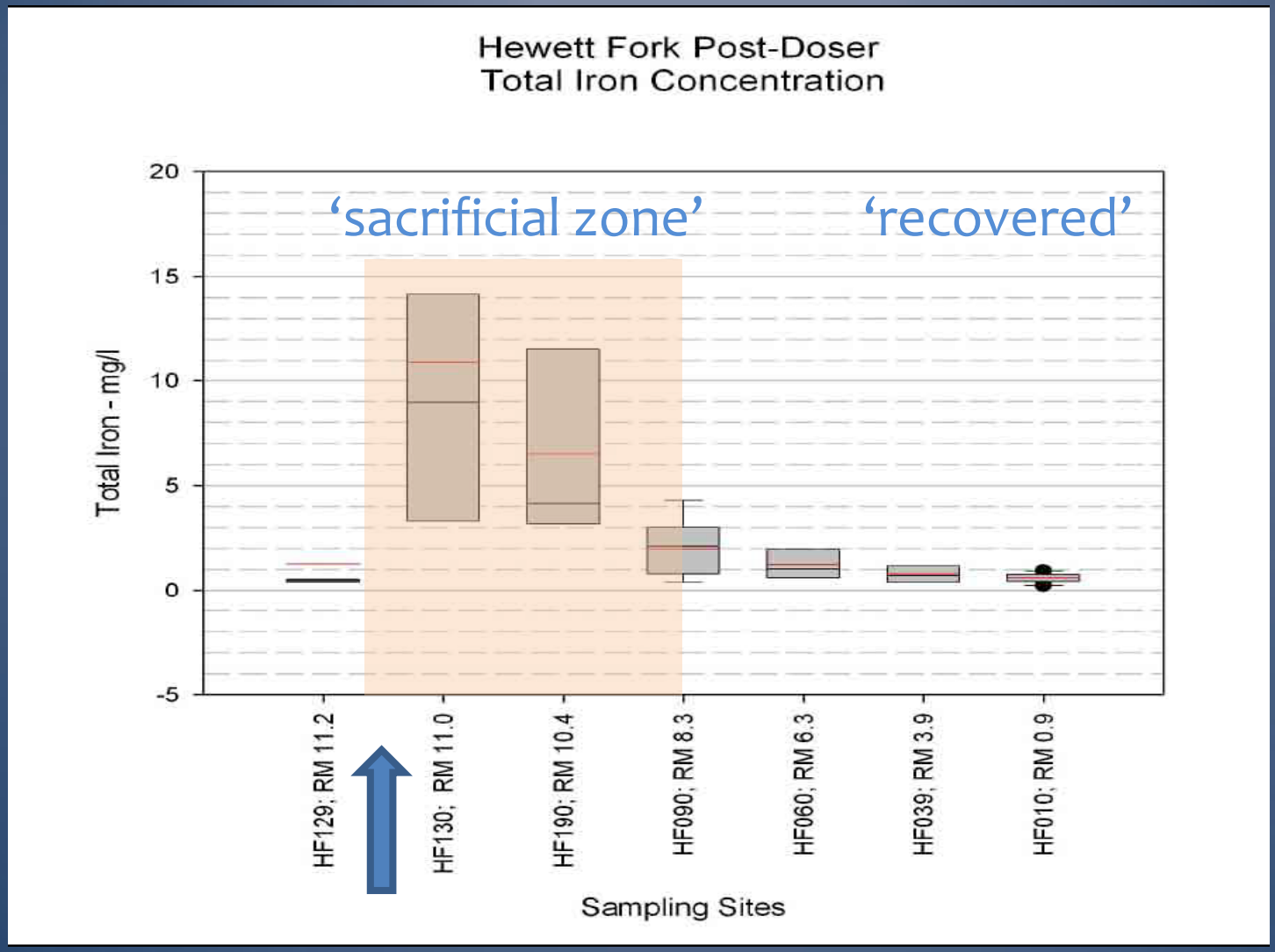
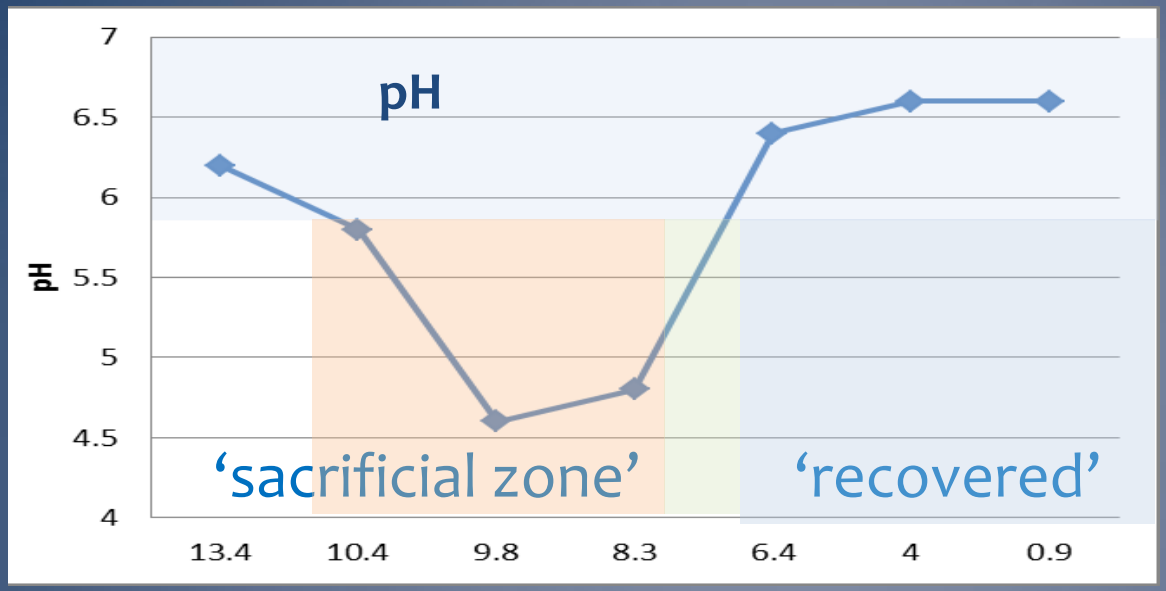


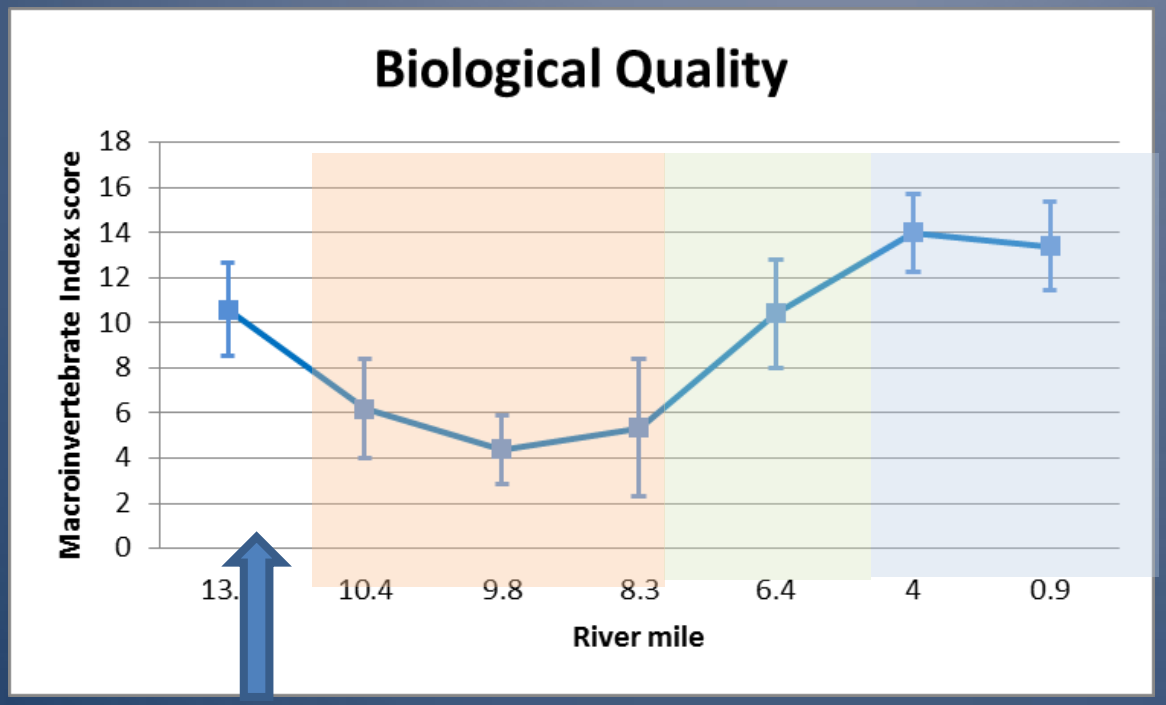
Doser reduces total iron, sulfate and other metals





Water chemistry suggests more river miles restored

(RM 6.4 to 0.9)
= 5.5 miles



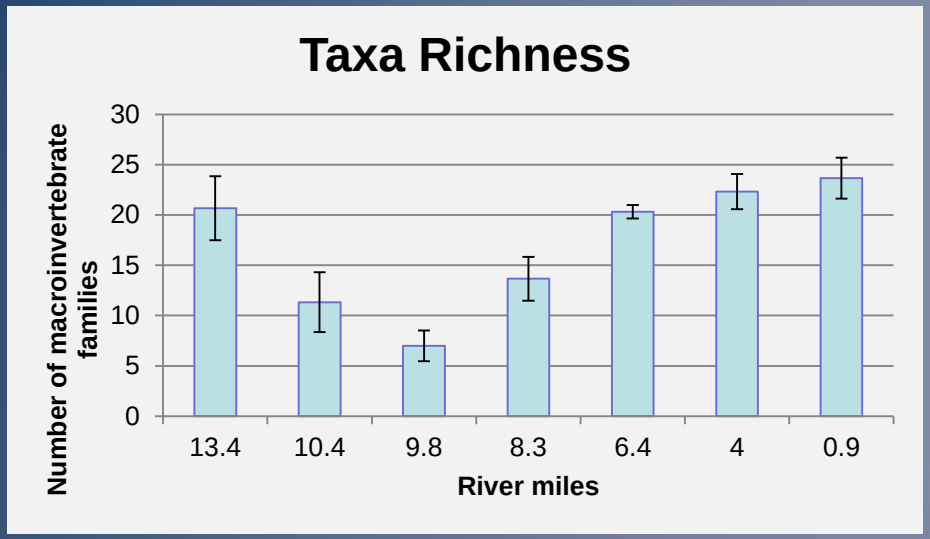
Macroinvertebrate Index indicates fewer river miles restored

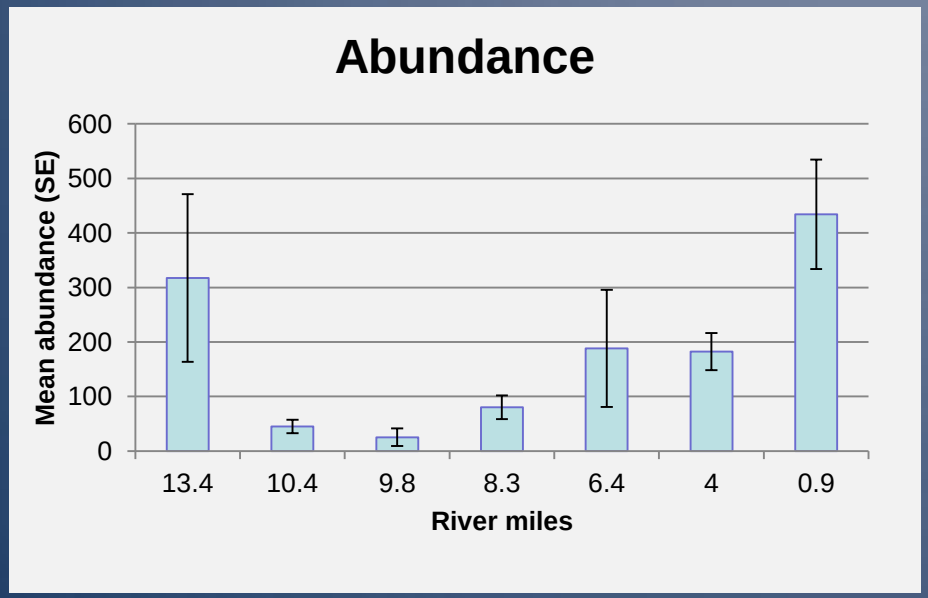
(RM 4.0 to 0.9)
= 3.1 miles

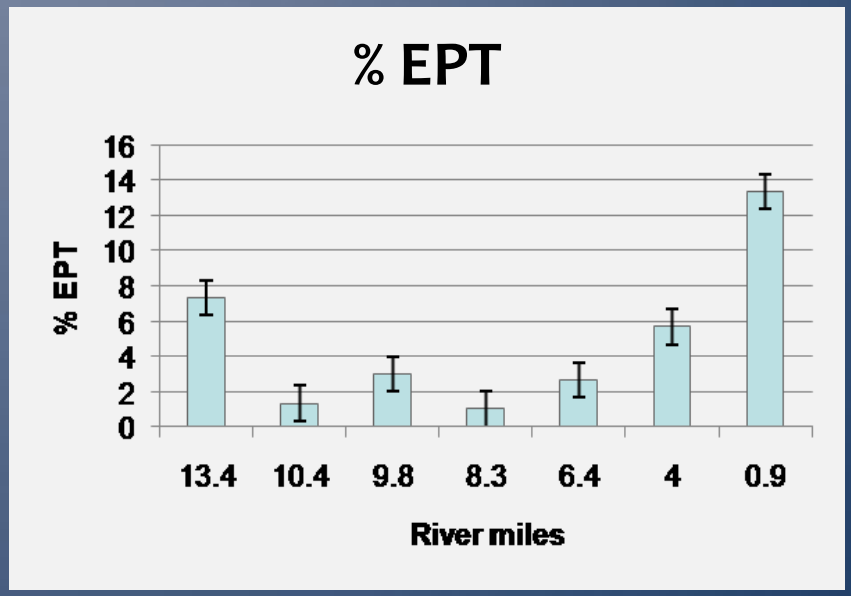
Taxa richness is high, but abundances and EPT taxa indicate poor recovery

Is recovery hampered by:

- low habitat availability?
- metals ?
- acid pulses?





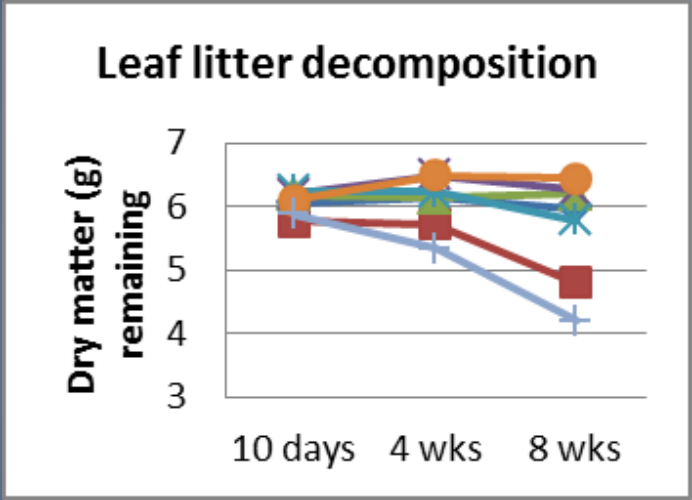


2008 Litter bag study

- leaf litter degradation rates
- abundance, diversity of shredders
- microbial respiration of leaf matter

Seven sites along remediated gradient
Five sets of silver maple leaf packs at each site
Bags collected at 10 d, 3 weeks, 8 weeks
Macroinvertebrates removed
Leaves ashed at 500 °C to obtain AFDM

Litter degradation rates



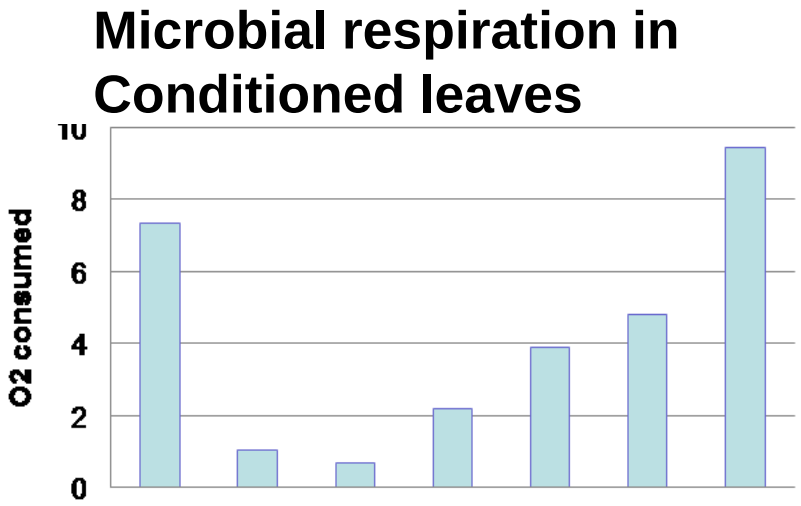
Pycnopsyche, Limnephilidae
Photo from University of Georgia

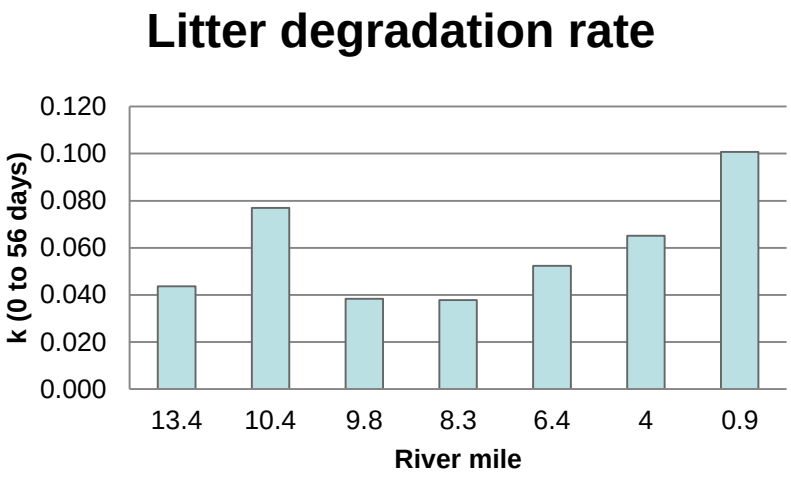
Shredder biomass estimated from body length-mass regressions

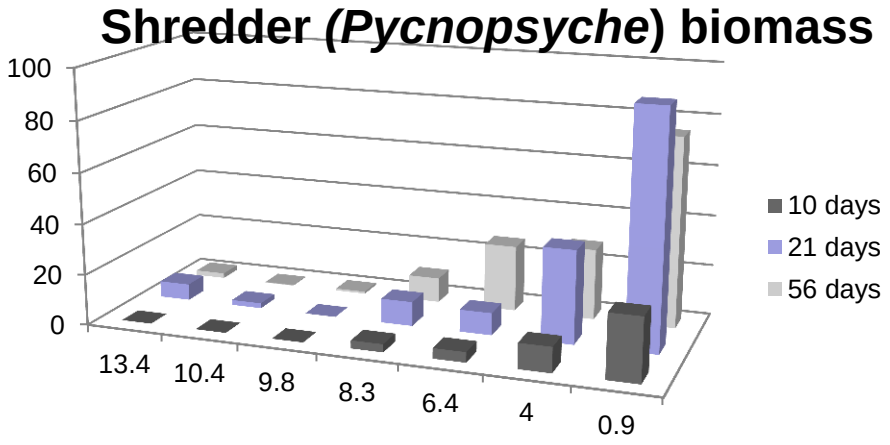
Microbial respiration

- 1 cm leaf discs in vials
- 24 h in dark
- O_2 microelectrode

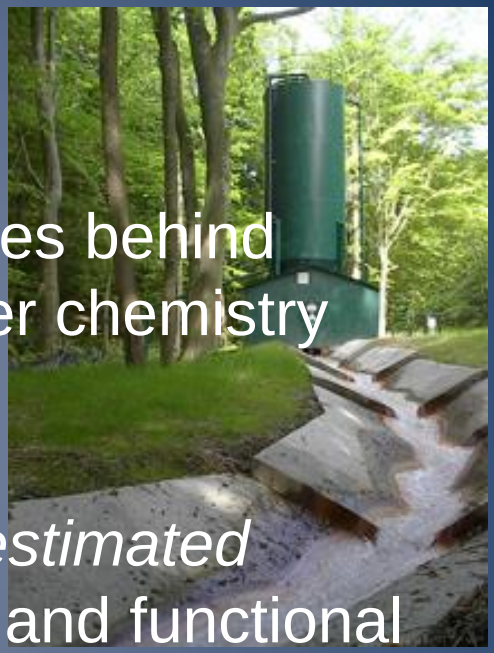
Functional measures implicate water chemistry, not habitat as limiting factor







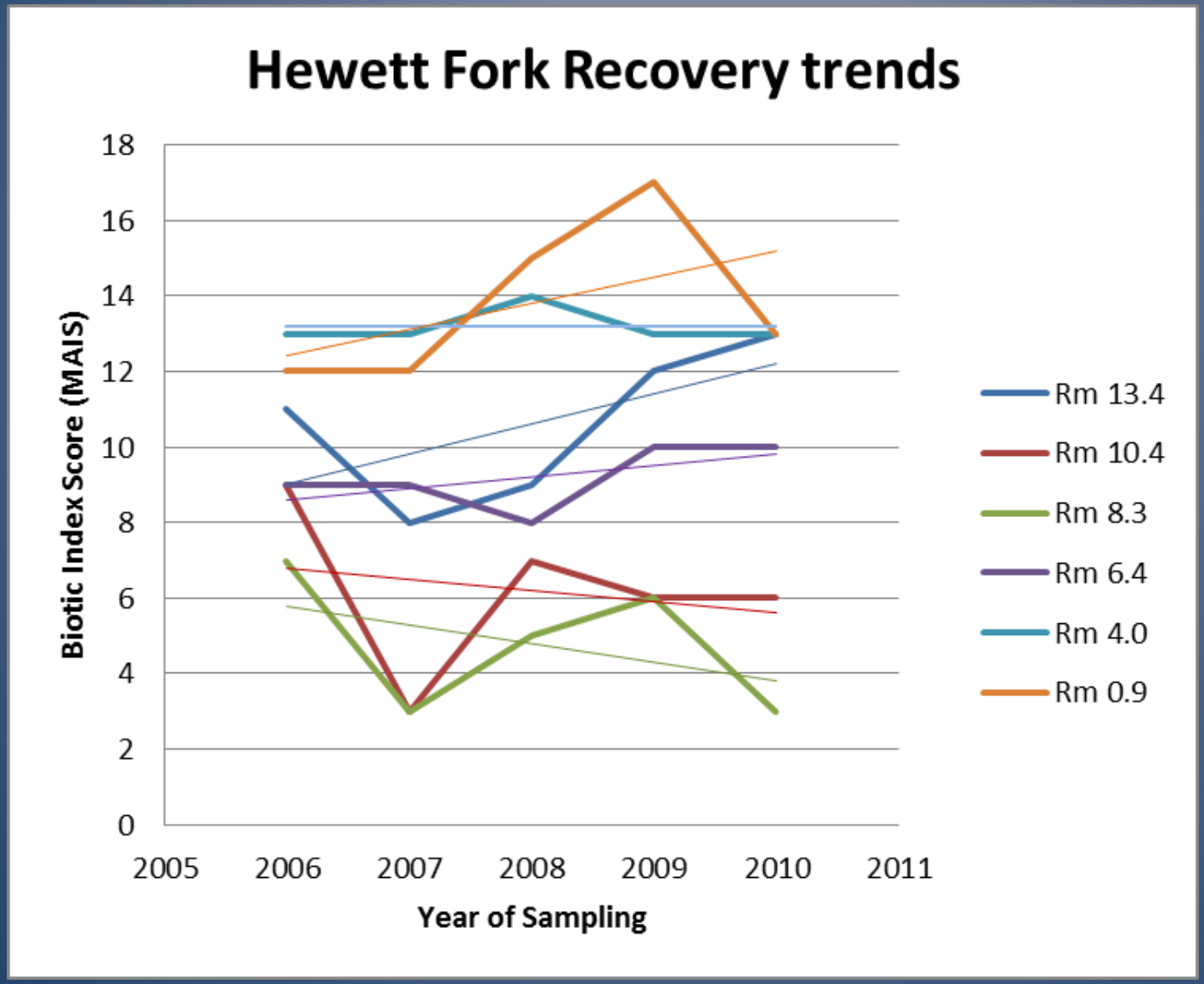
Conclusions



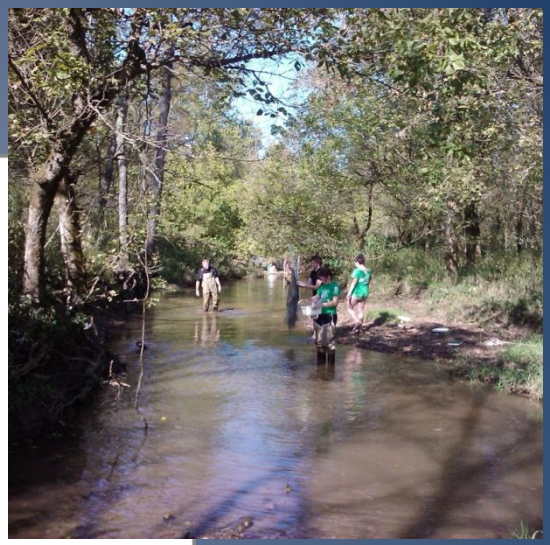
- Biological recovery lagged several river miles behind predictions based on water chemistry (water chemistry *overestimated* recovery potential)
- Macroinvertebrate taxa richness also *overestimated* recovery (compared to abundance, %EPT, and functional measures of microbial respiration and litter breakdown)
- Functional measures (respiration, litter breakdown) implicated water column chemistry over habitat in limiting biological recovery
- New focus now on metals (Fe, Al, Mn) and episoidic acid pulses

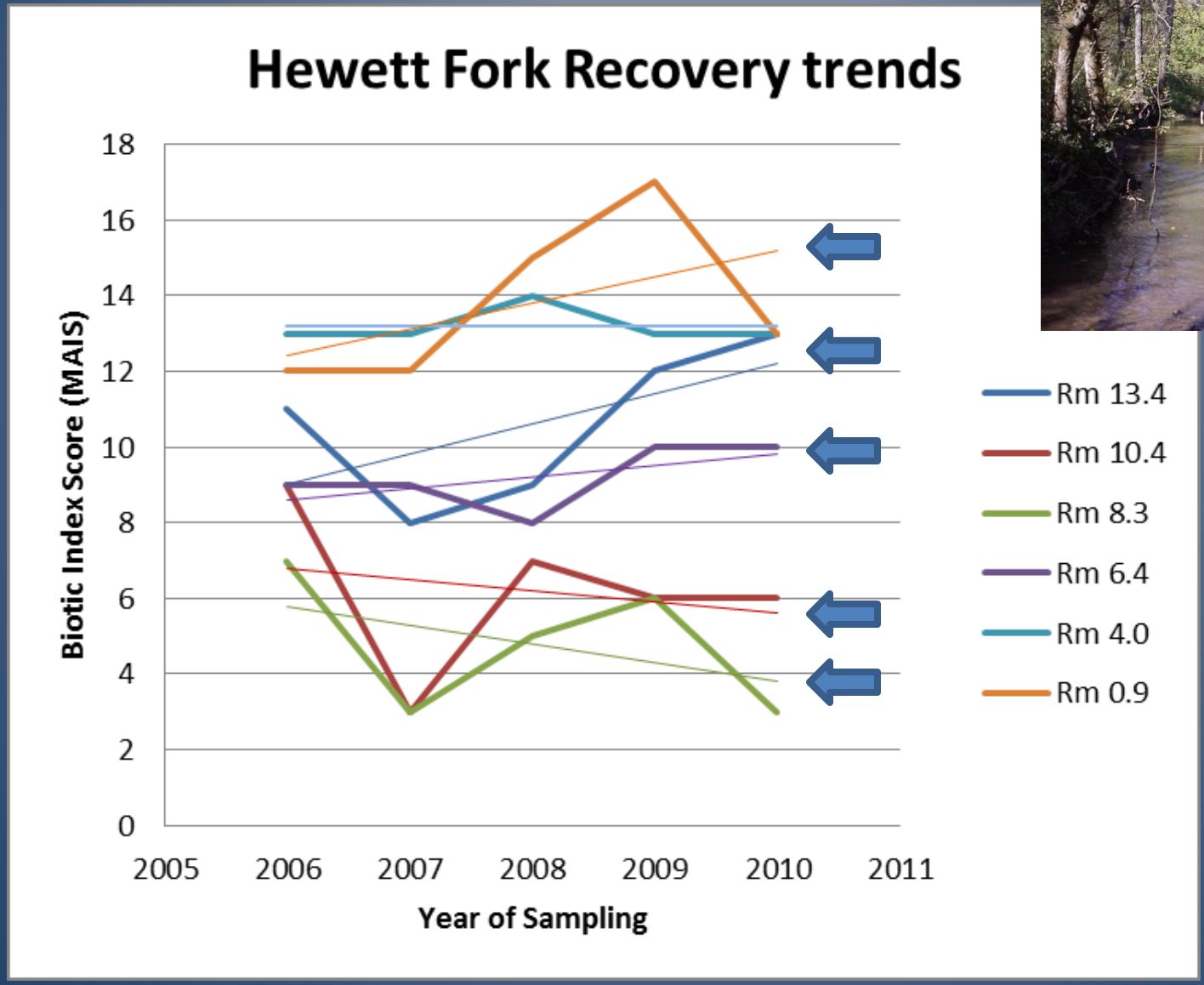

Thank you!

Annual monitoring



Annual monitoring





Biological improvement at RM 8.3 (approx. 2 miles downstream the doser)