

# **Fish Passage and Abundance around Grade Control Structures on Incised Streams in Western Iowa**

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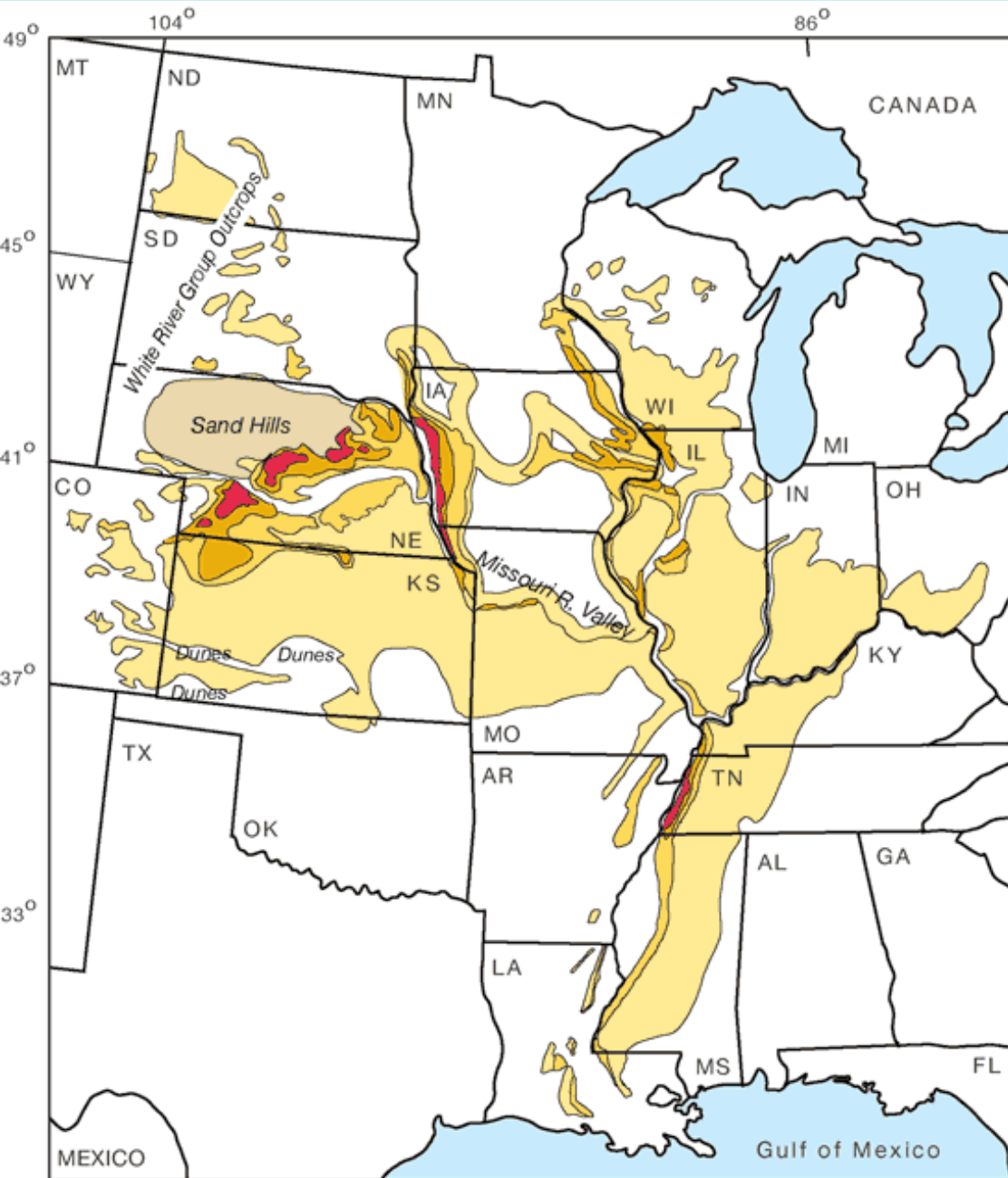
Clay Pierce – USGS and Iowa State University

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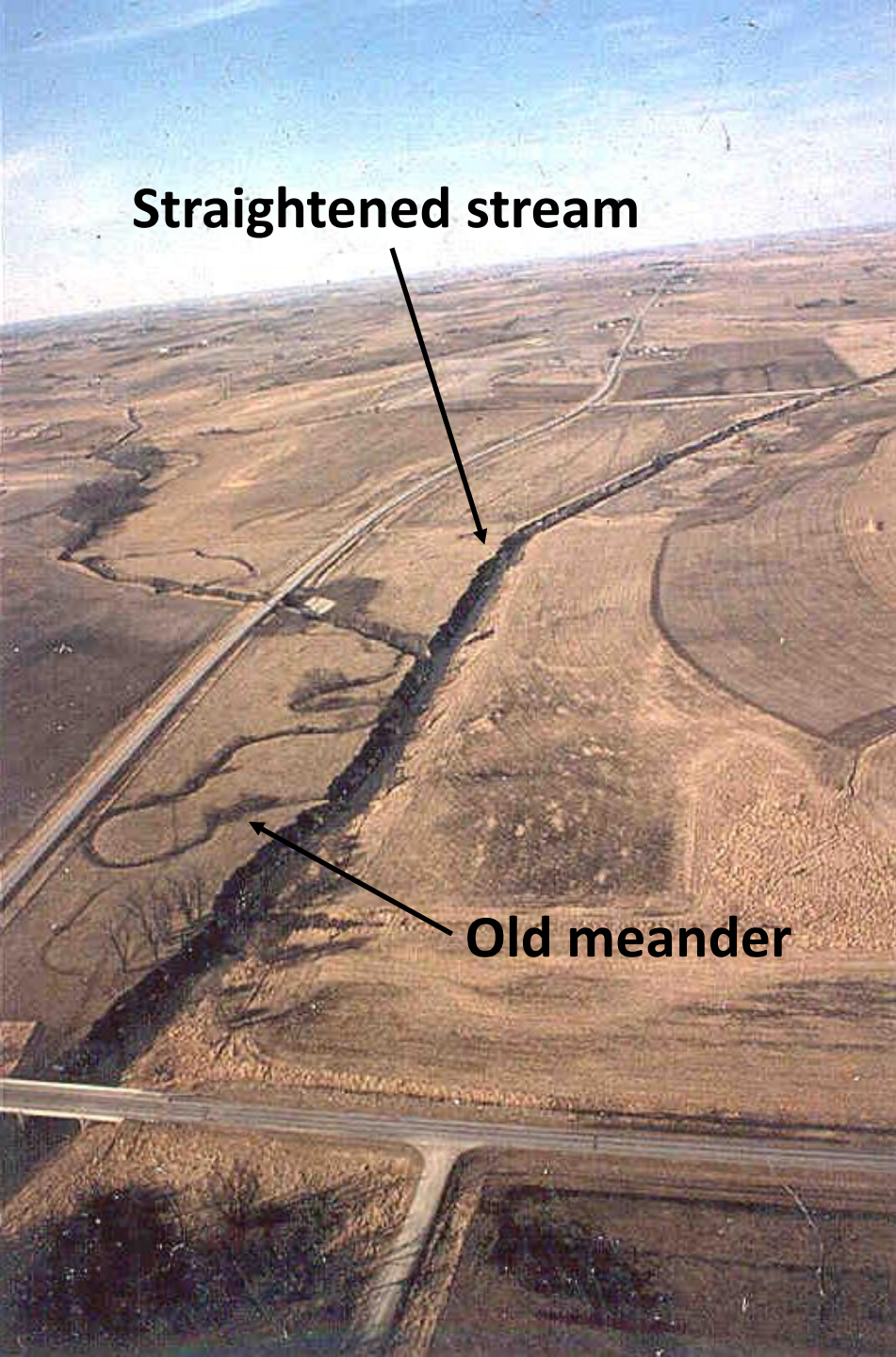
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4th Annual Upper Midwest Stream Restoration Symposium – February 2013



- Loess is a very erosive streambed material
- Thicker loess deposits = ↑ potential erosion
- MRV loess deposits reach great enough depth (> 5 m) to cause widespread stream channel downcutting and erosion



**Straightened stream**

**Old meander**

Highly erodible loess soils  
+  
Stream straightening and land  
use changes  
=  
Higher water velocities  
=  
Channel downcutting  
=  
Higher sediment loads  
Altered flow regimes  
Lost fish habitat  
No pool-riffle sequences  
Lost lateral connectivity w/  
floodplain  
=  
Decreased biodiversity



## Streambed Degradation – Knickpoints and Headcuts



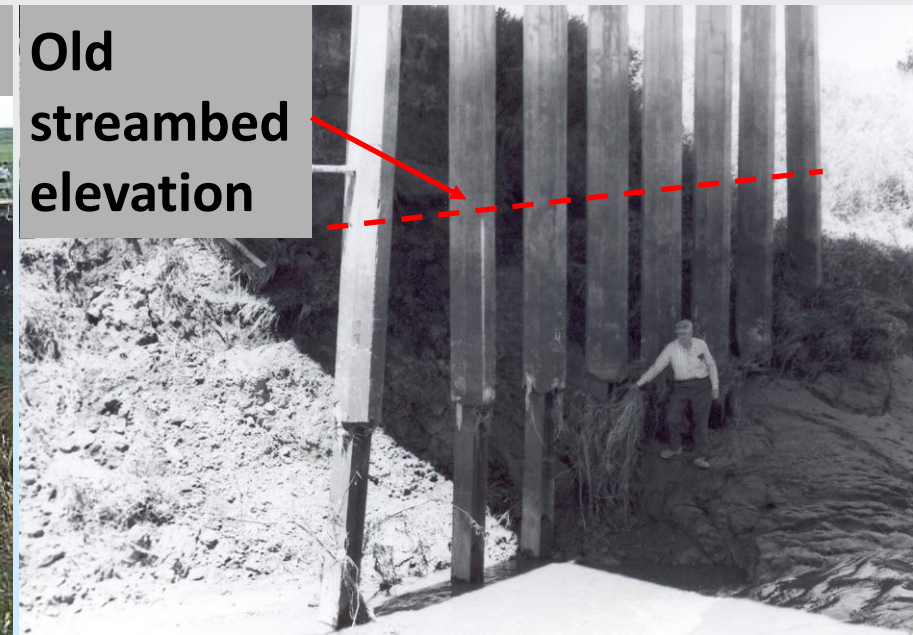


## Bank Failure, Stream Widening, and Bridge damage

Approximate old channel cross section



Old streambed elevation



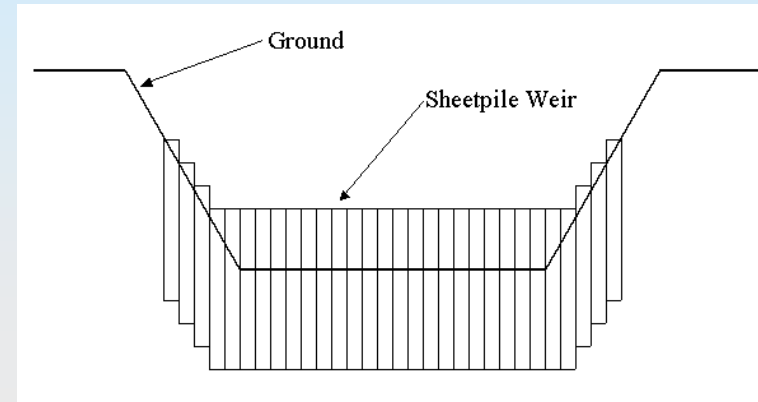
# Streambed Stabilization and Watershed Awareness



- Streambed stabilization key to preventing erosion & protecting infrastructure
- Knickpoints affect entire watershed as erode upstream
- Stream videos locate erosion
- Structures at regular intervals change stream profile from erosive steep incline to stable stair-step pattern

# Grade Control Structures

- Raised steel sheet pile weir
- Rip-rap, concrete grout slopes
  - Bedrock very poor quality
- Decreases slope of streambed
- Prevents further downcutting
- Creates an upstream backwater condition
  - Sediment settles out upstream
  - Reduces sediment loads
  - Protects bridge pilings
- For every \$1 invested in GCS:
  - > \$4.20 in property value (bridges, culverts, utility lines, farmland)
  - ≈ 910 kg of soil protected



**Known Streambed  
Grade Control  
Structures in  
Western Iowa  
and Construction  
Funding Sources:**

(followed by # of structures in parentheses)

- HCA (Hungry Canyons Alliance)  
& county road department (353)
- NRCS (Natural Resource  
Conservation Service) -  
EWP (Emergency Watershed  
Protection) program (278)
- HCA, NRCS & private landowner (114)
- county road department (136)
- city - electric, power, and water (12)
- Iowa Department of Transportation (30)
- Iowa Department of Natural Resources (1)
- railroad company (11)
- gas pipeline company (13)
- U.S. Army Corps of Engineers (13)
- stream — Missouri River

□ HCA county

Total # of known grade control structures: 961

**Do GCS affect  
fish passage,  
abundance, and  
longitudinal  
connectivity?**



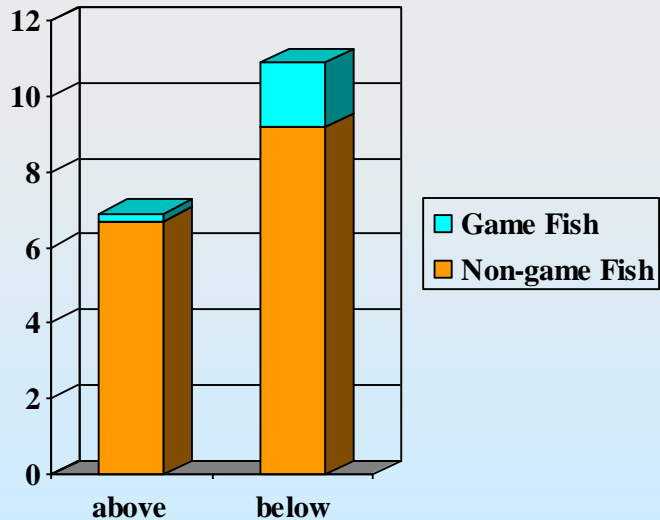
# Western Iowa Fish and GCS

- Warm-water streams – drainages > 400 km<sup>2</sup>
- Channel catfish game fish species; flathead and creek chubs non-game fish species
  - All not powerful swimmers
- Sampling efforts and angler reports indicated decline in channel catfish numbers, size and distribution, and species diversity
- Straight drop GCS or steeply sloped GCS
  - Restricted fish movement
  - Loss of longitudinal connectivity
- DNR sampled fish on streams controlled by GCS with 1:20 and 1:4 (rise/run) downstream slopes

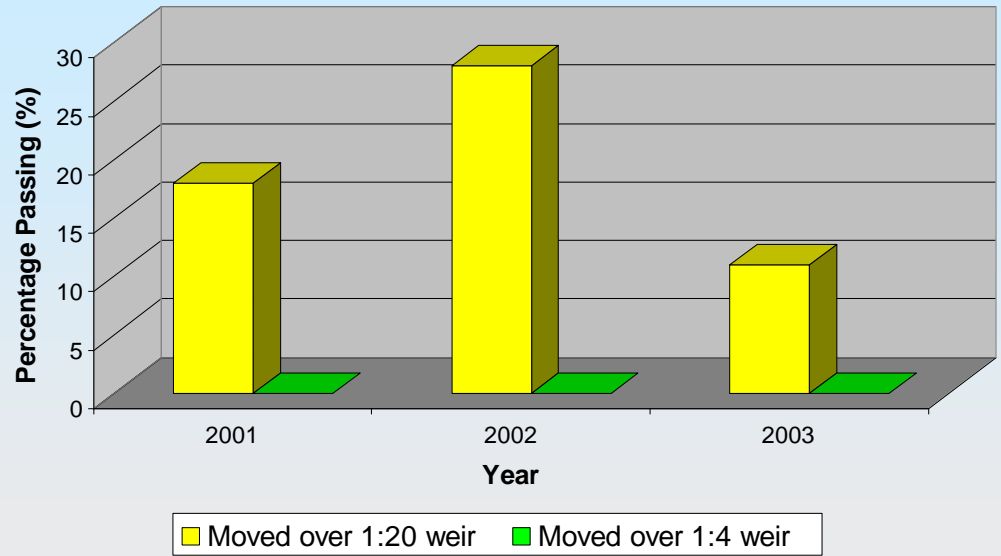
# Results of First Sampling Study

## Species diversity and 1:4 GCS

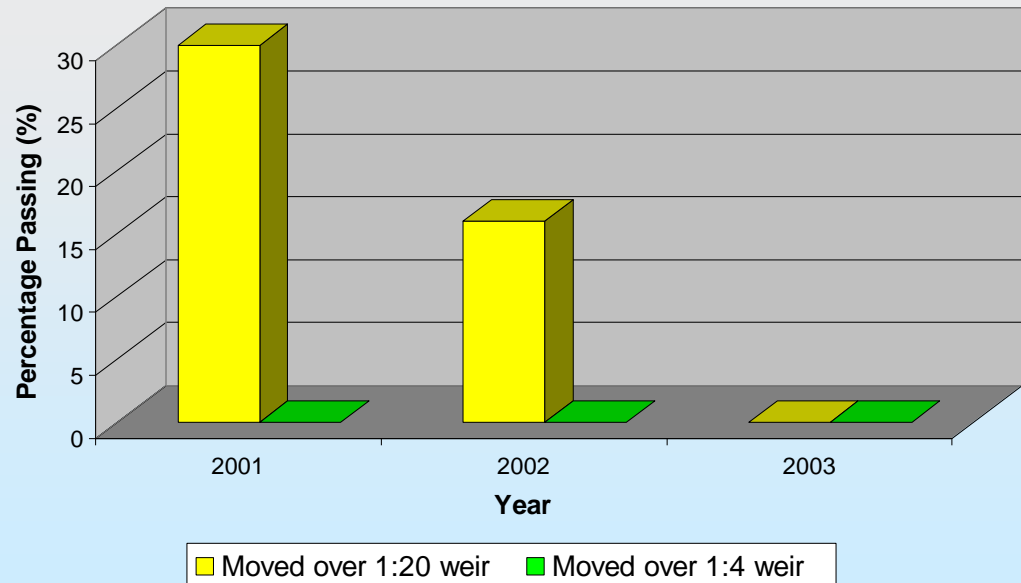
# Species



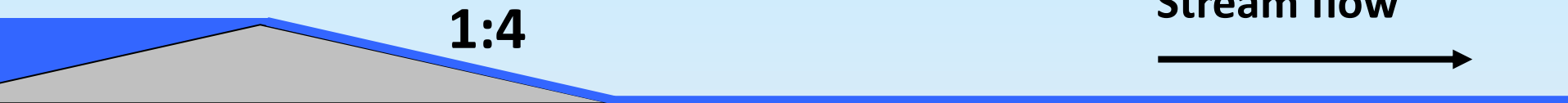
Percentage of Channel Catfish Passing Over Weir



Percentage of Flathead/Creek Chub Passing Over Weir

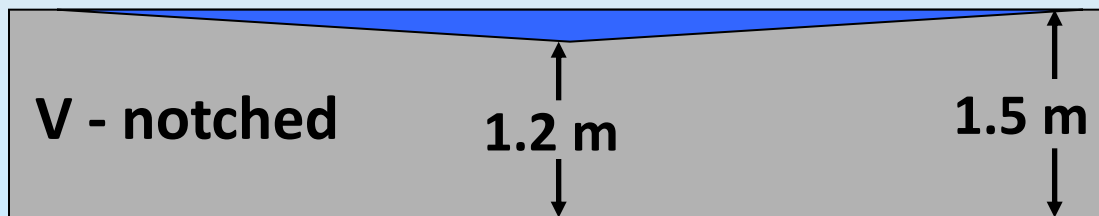
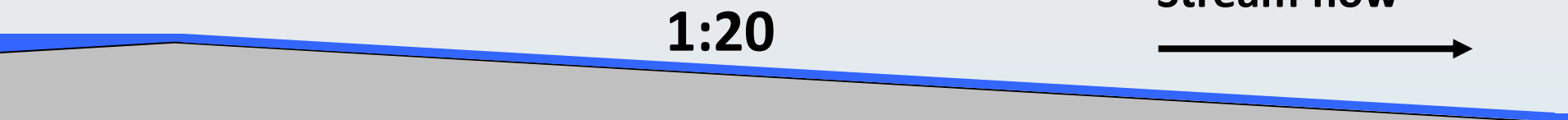


## Old Design



**\$80,000**

## Modified Design



**\$150,000**



## GCS designed for fish passage





## GCS designed for fish passage





**GCS designed for fish passage**



# What is the steepest weir slope that will allow fish passage?

- Steepest weir slope = least expensive
- Second study to determine optimal slope
  - Sampled fish at 5 GCS with downstream slopes between vertical and 1:20 (rise/run)
    - 3 sites modified during study
  - Macroinvertebrate communities on GCS and at reference sites
    - Sampled 20 sites
      - 5 at GCS
      - 5 upstream GCS
      - 5 downstream GCS
      - 5 reference sites > 1km from any GCS

# Results of Second Sampling Study

1. Fish species found tolerant of degradation
2. Fish passage over weir slopes  $< 1:12.7$ 
  - 1% recaptured
3. Increased fish passage after modification to  $\leq 1:15$ 
  - 16% recaptured
4. Several fish species detected further upstream after modification including channel catfish
5. Significant IBI score increase after modification (4.6 points)





## 12 metrics of IBI (Index of Biotic Integrity):

- |                                   |                                     |
|-----------------------------------|-------------------------------------|
| 1. # native species               | 7. % fish as omnivores              |
| 2. # sucker species               | 8. % fish as top carnivores         |
| 3. # sensitive species            | 9. % fish as lithophilous spawners  |
| 4. # benthic invertivores         | 10. Fish assemblage tolerance index |
| 5. % abundance top 3 species      | 11. Adjusted catch per unit effort  |
| 6. % fish as benthic invertivores | 12. Adjustment for high delt %      |

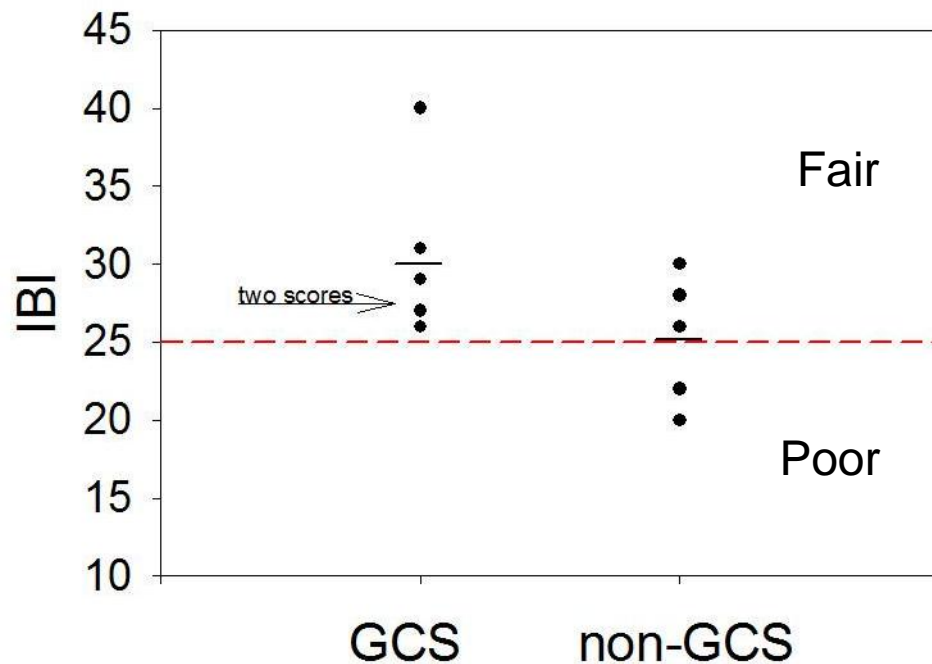
### IBI Scores

Excellent: 76-100

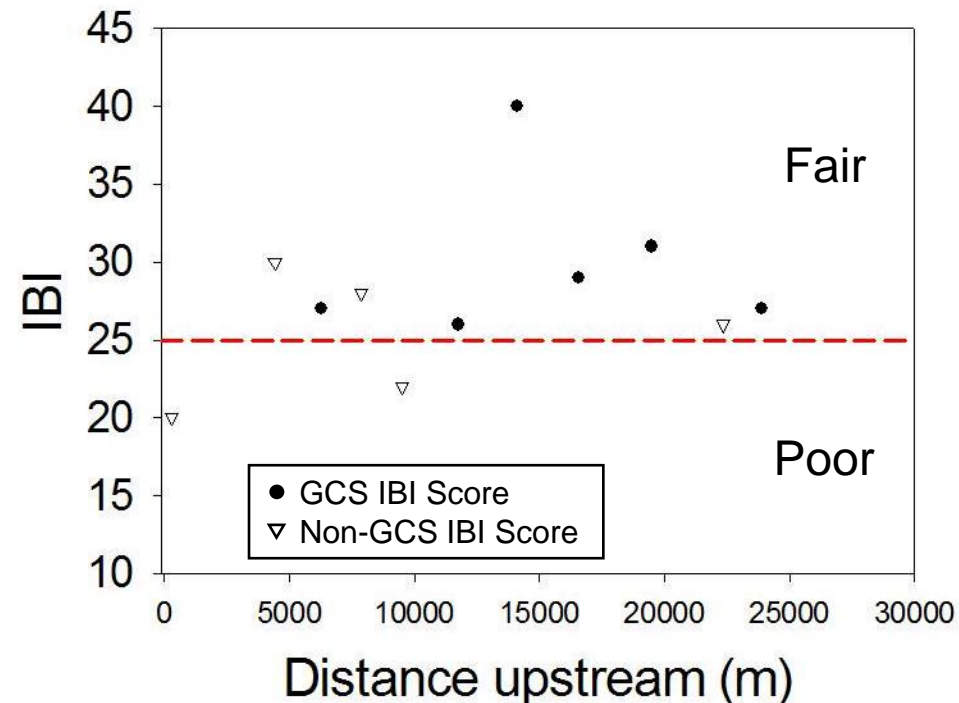
Good: 51-75

Fair: 26-50

Poor: 1-25

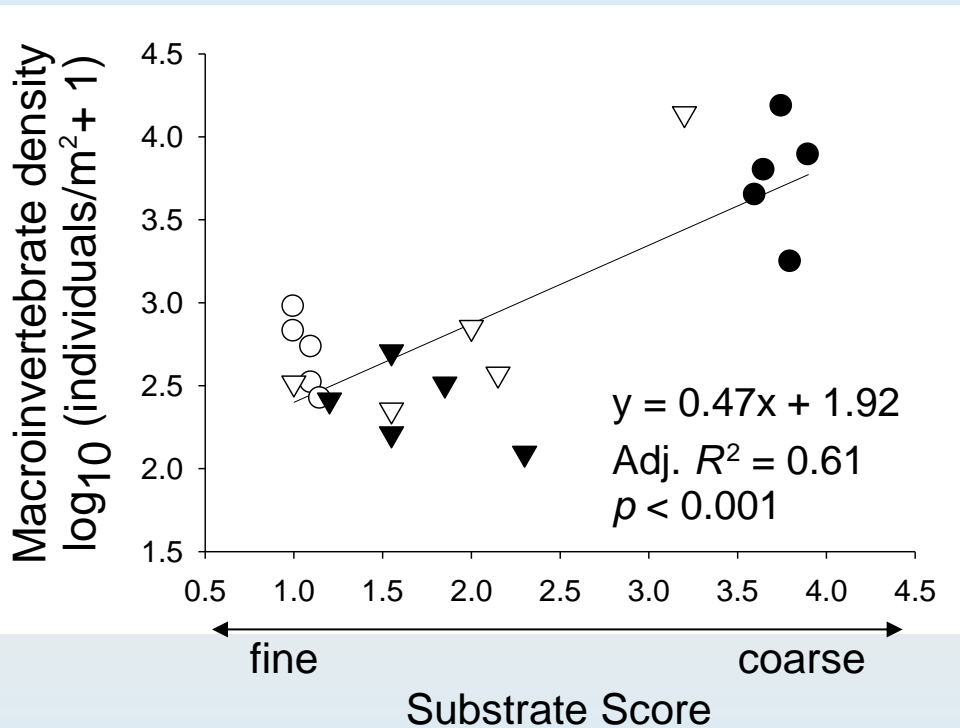


Slightly higher (5%) fish community scores at GCS vs. reaches without GCS

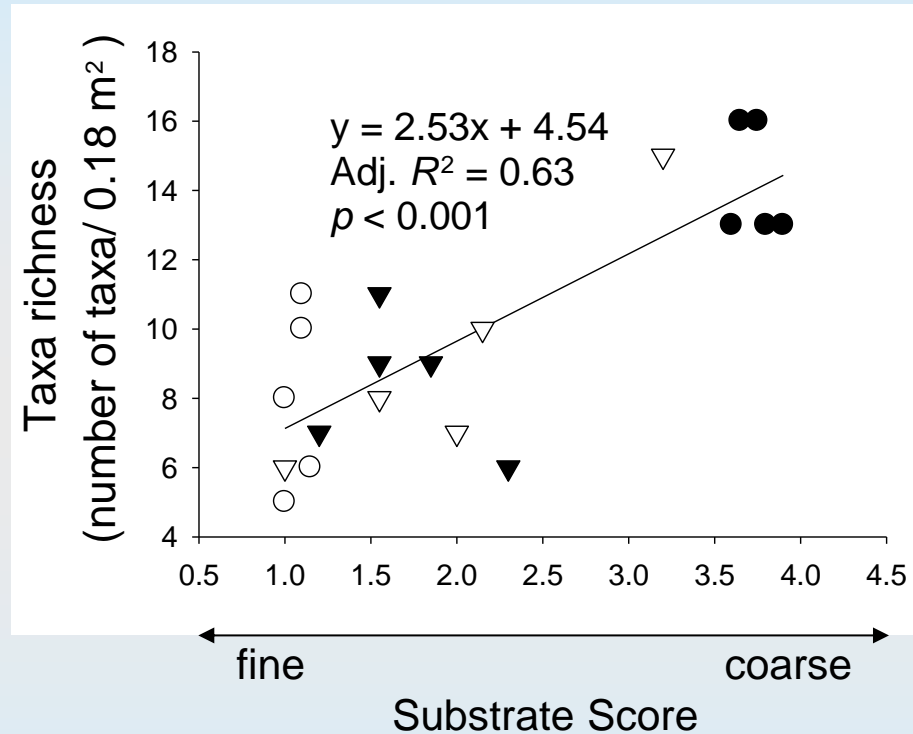


No significant decrease in fish community scores from downstream to upstream

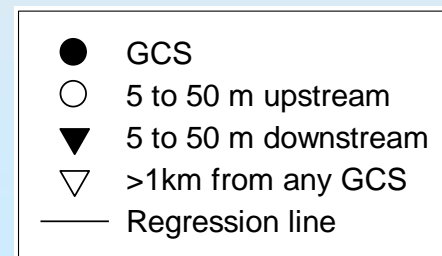
## Total macroinvertebrate abundance



## Macroinvertebrate taxa richness



Macroinvertebrate abundance and diversity 60% greater at GCS vs. reaches without GCS



# Weir Hydraulics Study

- Verification of steepest weir slope allowing fish passage
- Minimum requirements for catfish passage determined by Iowa DNR
  - minimum flow depth of  $\geq 0.31$  m (1ft)
  - maximum flow velocity of  $\leq 1.22$  m/s (4ft/s)
- Sampled 22 GCS
  - 8 riprap weirs
  - 10 grouted riprap weirs
  - 4 fish baffle weirs
  - Ground survey
  - ADV (Acoustic Doppler Velocimetry) measurements
  - LSPIV (Large Particle Image Velocimetry) Measurements

# Results of Hydraulic Study

- GCS slope Y (depth) and V (velocity) requirements rarely met
  - minimum depth often violated
  - relatively low flows during the fall of 2004 measuring period
  - mean point flow velocities averaged for each GCS did not violate max. velocity
- No GCS with slopes  $>1:12$  met both fish passage requirements
- 27% of GCS with slopes  $< 1:12$  met depth requirement
  - Of those GCS meeting depth requirement:
    - 60% of  $1:12-1:16$  met velocity requirement
    - 100% of  $< 1:16$  met velocity requirement
- Fish ladders with baffles formed eddies 30% larger than average catfish fork length of 0.3 m, enough to disorient fish
- Fish ladders observed to catch debris

# Now Improving Fish Passage

- Considering studies and economics
  - HCA and DNR agreed – 1:15 grouted weir slopes standard
- Streams classified by fisheries potential
  - Class 0, 1, 2
- Find structure locations on class 2 streams that may not allow fish migration
  - vertical or steep slopes
- Prioritize weirs inhibiting fish passage for modification
  - HCA, US FWS, Iowa DNR funds
  - ≈ 93 structures currently blocking fish passage
  - 37 modified so far

# Summary

## 1. Incised channels

- Altered flow regime
- Lateral connectivity loss
- Biodiversity loss

## 2. Grade Control Structures (GCS)

- Prevent further erosion
- Protect infrastructure
- Reduce sediment loads
- Can impact fish passage

## 3. GCS, fish passage, and biodiversity

- $\leq 1:15$  weir slopes best met minimum requirements to allow catfish passage ( $\geq 0.31$  m flow depth &  $\leq 1.22$  m/s flow velocity)
- Higher fish biomass and IBI scores at weirs vs. no weirs
- Macroinvertebrate abundance and diversity greater at weirs vs. no weirs

# Federal Grade Control Funding

- Void in federal programs/funding for grade-control mitigation projects
  - Small to medium sized streams
    - Army COE – large rivers
    - NRCS – very small drainages
- Proposed by HCA
  - New initiative/program in NRCS
    - Need involvement of other states so not an earmark
    - Provide funding for grade-control projects in deep loess areas where streams are actively downcutting
    - Funds directed to public entities for mitigation projects

# Research Partners and Main Reference

- Iowa Department of Natural Resources - Fisheries Bureau
- Iowa Department of Transportation - Highway Research Board
- US Geological Survey
- US Fish and Wildlife Service
- Natural Resource Ecology and Management at Iowa State University
- IIHR—Hydroscience and Engineering Department at the University of Iowa

Thomas JT, Culler ME, Dermisis DC, Pierce CL, Papanicolaou AN, Stewart TW, Larson CJ. 2011. Effects of grade control structures on fish passage, biological assemblages, and hydraulic environments in western Iowa streams: a multidisciplinary review. *River Research and Applications* **27**:1-10.





Thank You

Any  
Questions?



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