An Ecological Assessment of the Mississippi, Missouri, and Ohio Rivers

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U.S. EPA

Office of Research and Development

EMAP Symposium 2007

Environmental Monitoring and Assessment Program for Great River Ecosystems (EMAP-GRE)

Theme

Assessing condition is a prerequisite of protecting the health & services of Great Rivers.

EPA ORD NHEERL MED: **Ted Angradi, Brian Hill, Terri Jicha, Deb Taylor, Mark Pearson, Sharon Batterman, Mary Moffett, Al Batterman, Leroy Anderson, Colleen Elonen**

EPA Regions: Larry Shepard & Bill Franz
EPA ORD NERL: Jim Lazorchak, Brent Johnson

USGS Water Missouri Sciences Center
USGS Upper Midwest Environmental Sciences Research Center
WI, MN, IA Departments of Natural Resources
Illinois Natural History Survey
Missouri Department of Conservation
Ohio River Valley Water Sanitation Commission.
University of Kansas
University of Minnesota
University of Iowa
Stroud Water Institute

http://www.epa.gov/emap/greatriver

EPA Ecological Research Program Mission

Conduct innovative ecological research;
Provide information & methods needed;
Shape policy & management actions at multiple scales.

EMAP-GRE's Goals

<u>Research</u> assessment approach for Great Rivers.
<u>Demonstrate</u> the approach with states & managers.
<u>Transfer</u> the data & approach to managers.

The Problem

Water quality problems on Great Rivers might be real and ominous or they might just be water quality standards problems because assessment approaches are inconsistent.

Unmet needs for assessments of Great Rivers

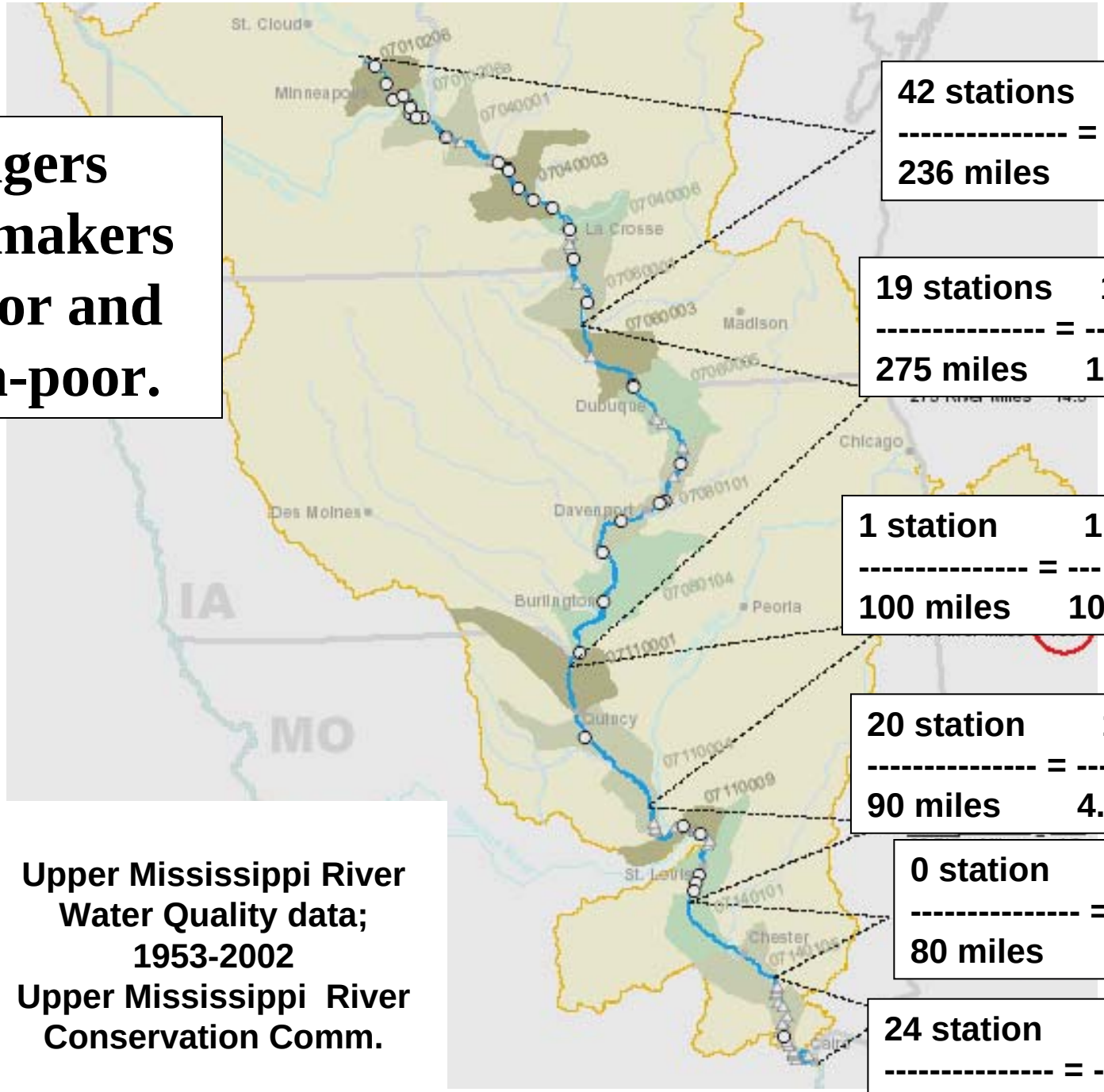
- Estimate extent of environmental condition.
- Estimate extent of stressors and disturbance.
- Condition assessment relative to a reference.
- Account for effectiveness of management actions.
- Estimate impact rivers have on receiving waters.
- Estimate impact of climate change on river ecology.

Drivers of Great River Monitoring and Assessment

- Major
  - Endangered Species Act
  - Restoration/rehabilitation
  - Adaptive management
  - designated uses (navigation, flood control, hydropower, habitat, irrigation)
  - Targeted problems, sites, chemicals, or conditions (hypoxia, NEPA, nutrient loading, non-point source pollution, sedimentation)
- Minor
  - Clean Water Act (CWA designated uses & use attainment , standards)

Currently, inventorying water quality and identifying impairments are deemed impractical because of the lack of consistent sampling designs, designated uses, water quality standards, and biological criteria.

River managers and policy-makers are data-poor and information-poor.



Upper Mississippi River Water Quality data; 1953-2002
Upper Mississippi River Conservation Comm.

42 stations	1	=	---
236 miles	6		

19 stations	1	=	---
275 miles	15		

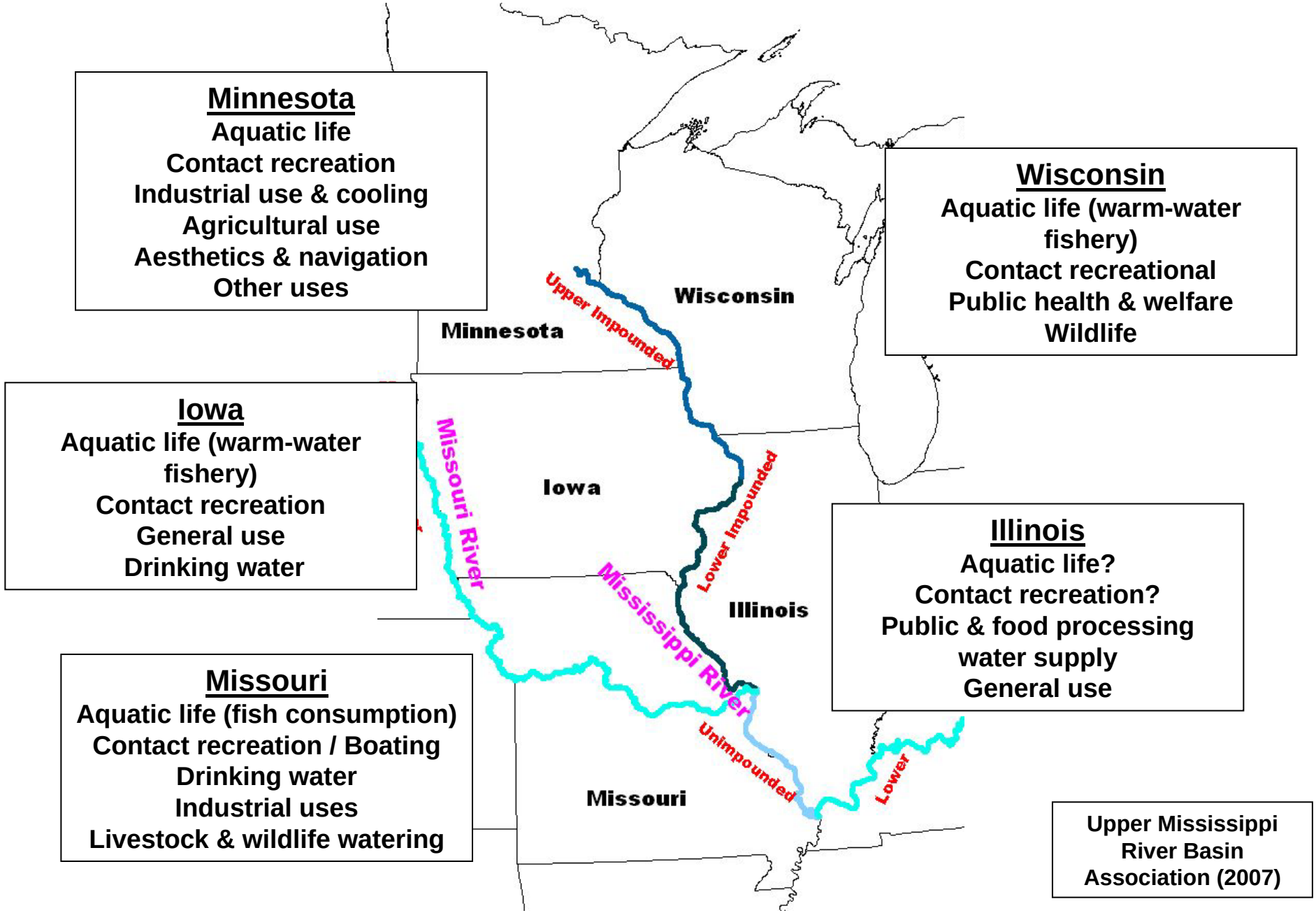
1 station	1	=	---
100 miles	100		

20 station	1	=	---
90 miles	4.5		

0 station	0	=	---
80 miles	80		

24 station	1	=	---
80 miles	3.3		

Designated Uses on the Upper Mississippi River



Listed impairments on the Upper Mississippi River
Most criteria are narratives.

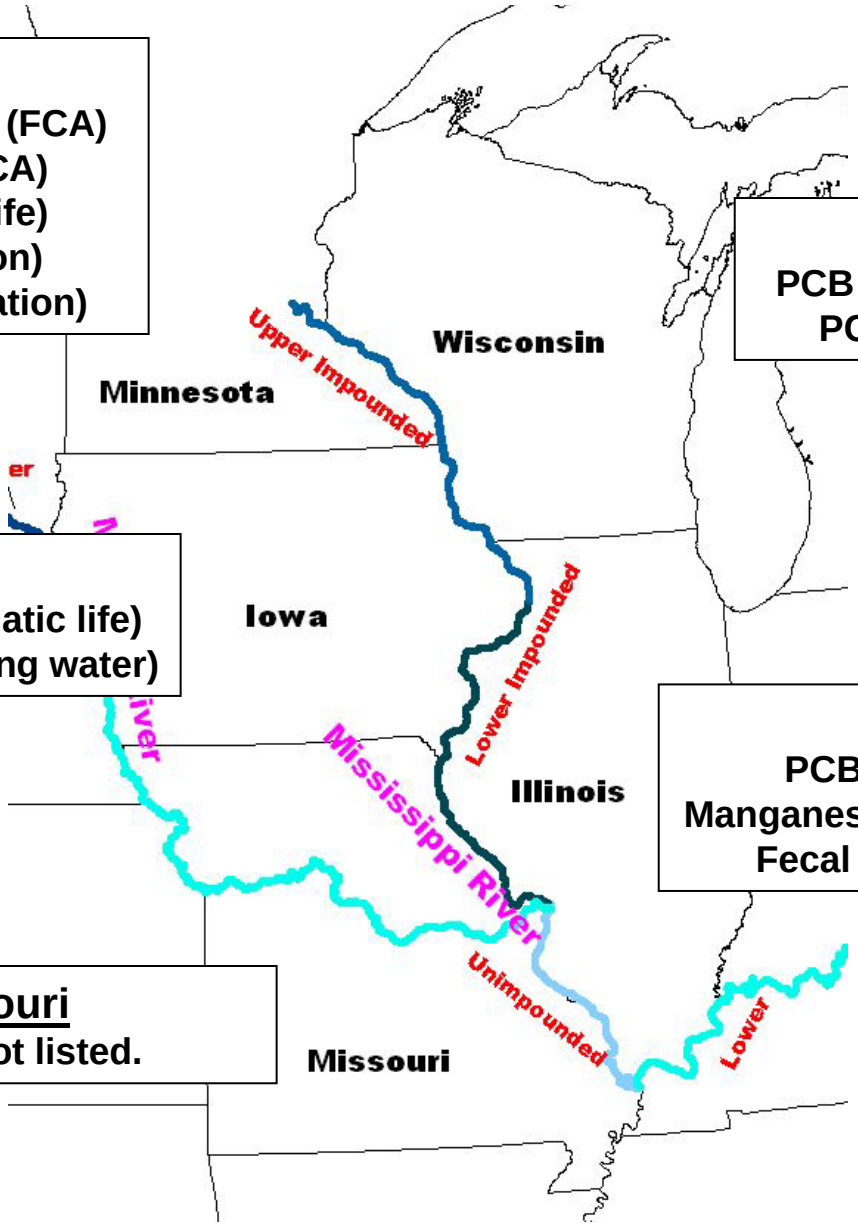
Minnesota
PCB & Hg (fish tissue) (FCA)
Mercury (water) (FCA)
Turbidity (aquatic life)
Nutrients (recreation)
Fecal coliform (recreation)

Wisconsin
PCB & Hg (fish tissue) (FCA)
PCB & Hg (water) (FCA)

Iowa
Nutrients (local) (aquatic life)
Arsenic (local) (drinking water)

Illinois
PCB (fish tissue) (FCA)
Manganese (local) (drinking water)
Fecal coliform (recreation)

Missouri
River is not listed.



Upper Mississippi River Basin Association (mostly 2006 reports)

Assessing condition is fundamental to improving water quality and water quality standards problems.

What % (+/- error) of [resource] in [unit] is in [condition] as indicated by [indicator] ?

Resource	*Assessment Unit*	*Condition*	*Indicator*
Main-channel	State River inter-state units	Good Fair Poor	Biotic integrity Water Quality Stressors Habitat integrity
Challenges			
Relevancy Data limits Representativness Context	State buy-in Sample size	Reference conditions Biocriteria WQ standards Designated uses	Variability & QA Metric selection & screening

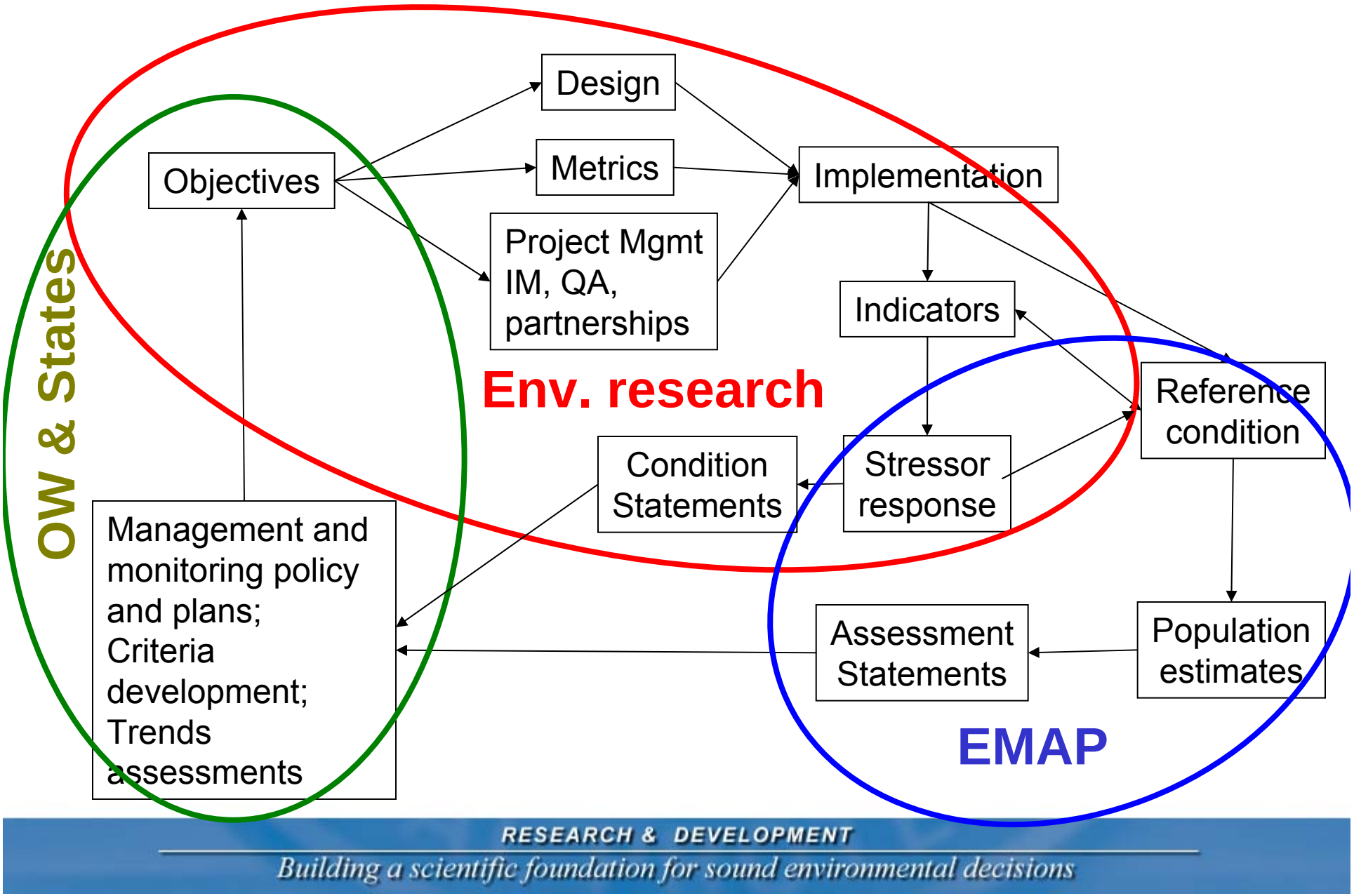
What % (+/- SE) of the Upper Mississippi River is in good condition as indicated by native fish species ?

EMAP-GRE Basics

Develop & **demonstrate** state-based assessment technology to assess ecological conditions in the Mississippi, Missouri, and Ohio Rivers.
Transfer assessment data and technology to managers.

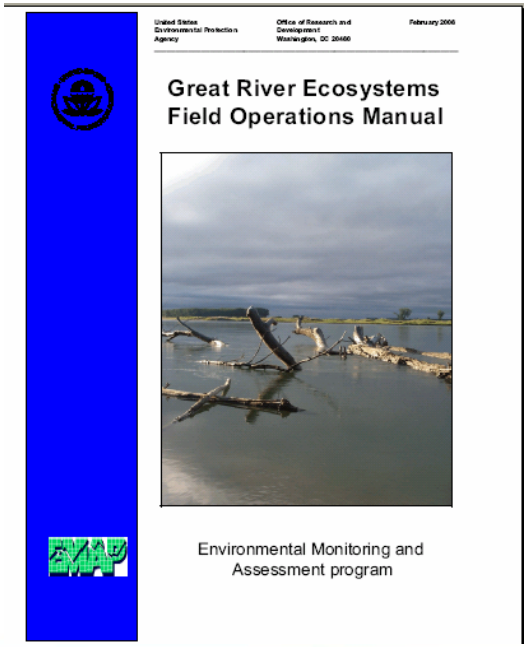
- **Sampled Upper Mississippi, Missouri, and Ohio Rivers in 2004-2006.**
- **About 475 unique sites; probability-based design**
- **10 crews; ≥100 people from about 15 agencies**
- **>8,000 samples processed**
- **Consistent methods for multiple indicators + training + QA**
- **Additional research includes aquatic vegetation as WQ indicator, mussels, impairment diagnostics, methods comparisons, and integration of water & biology assessment programs**

EMAP-GRE Program Plan



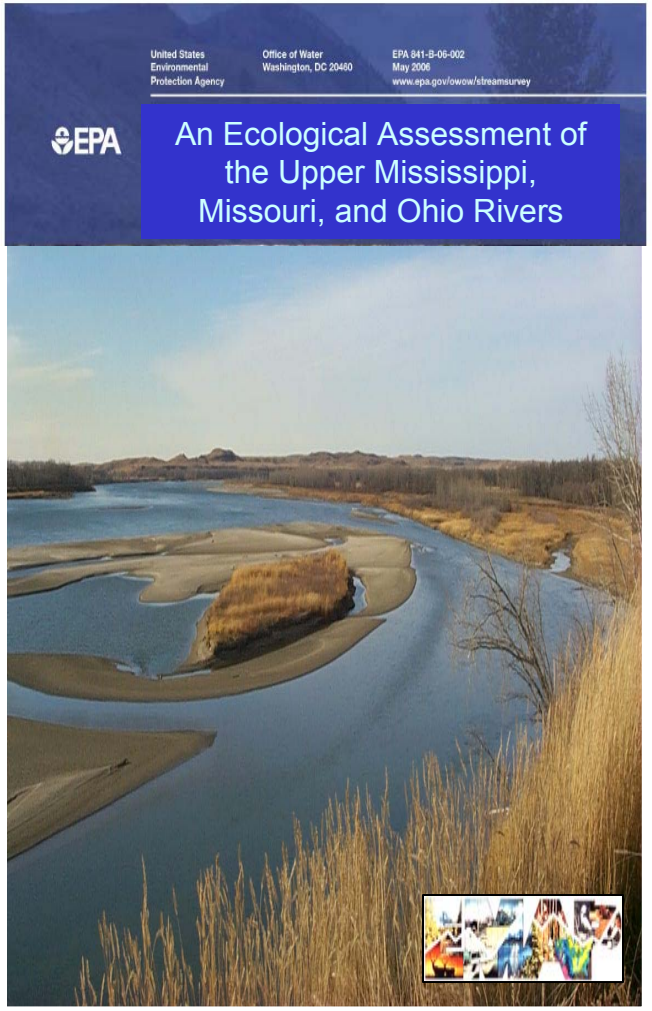
The EMAP-GRE road map

starts here,

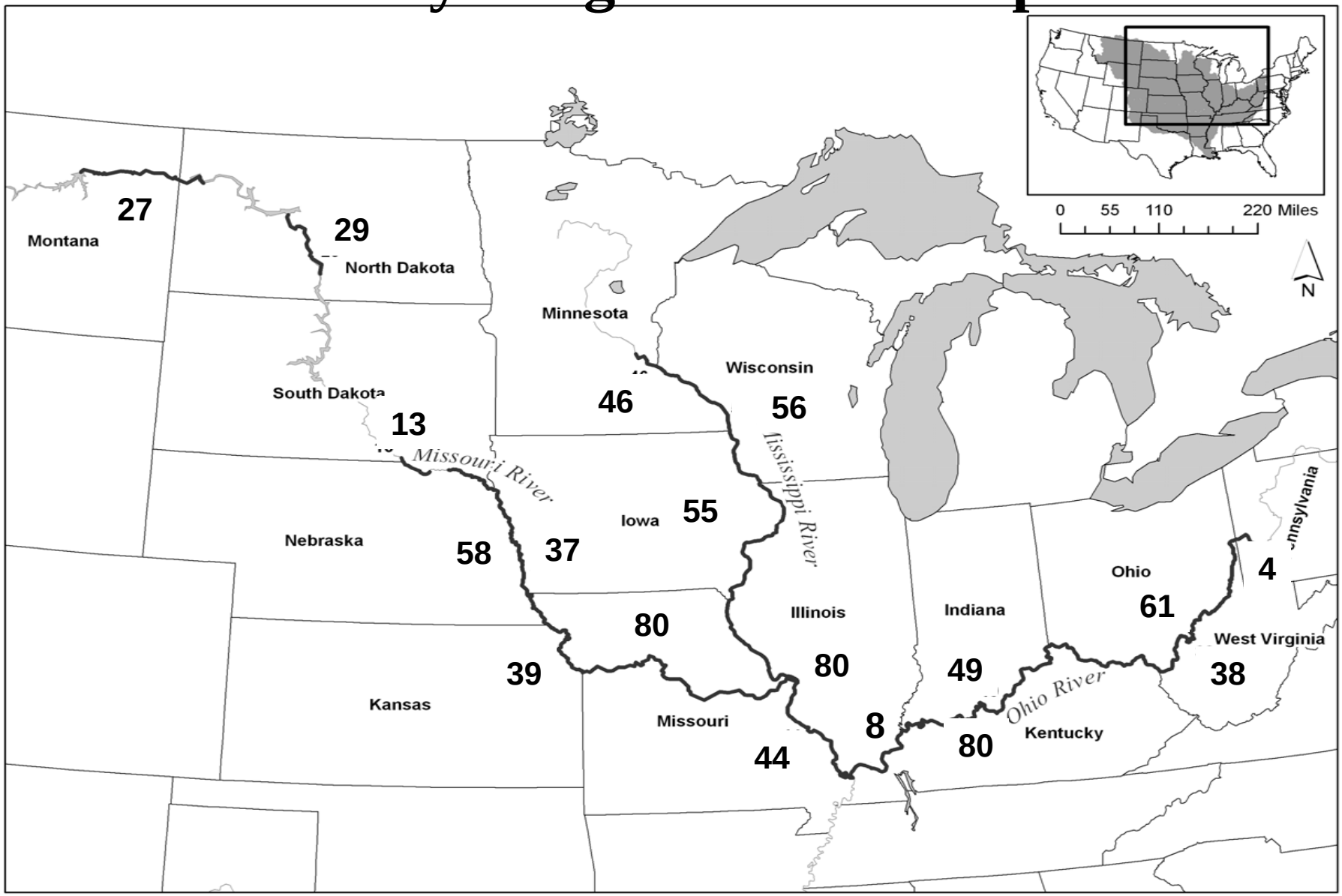


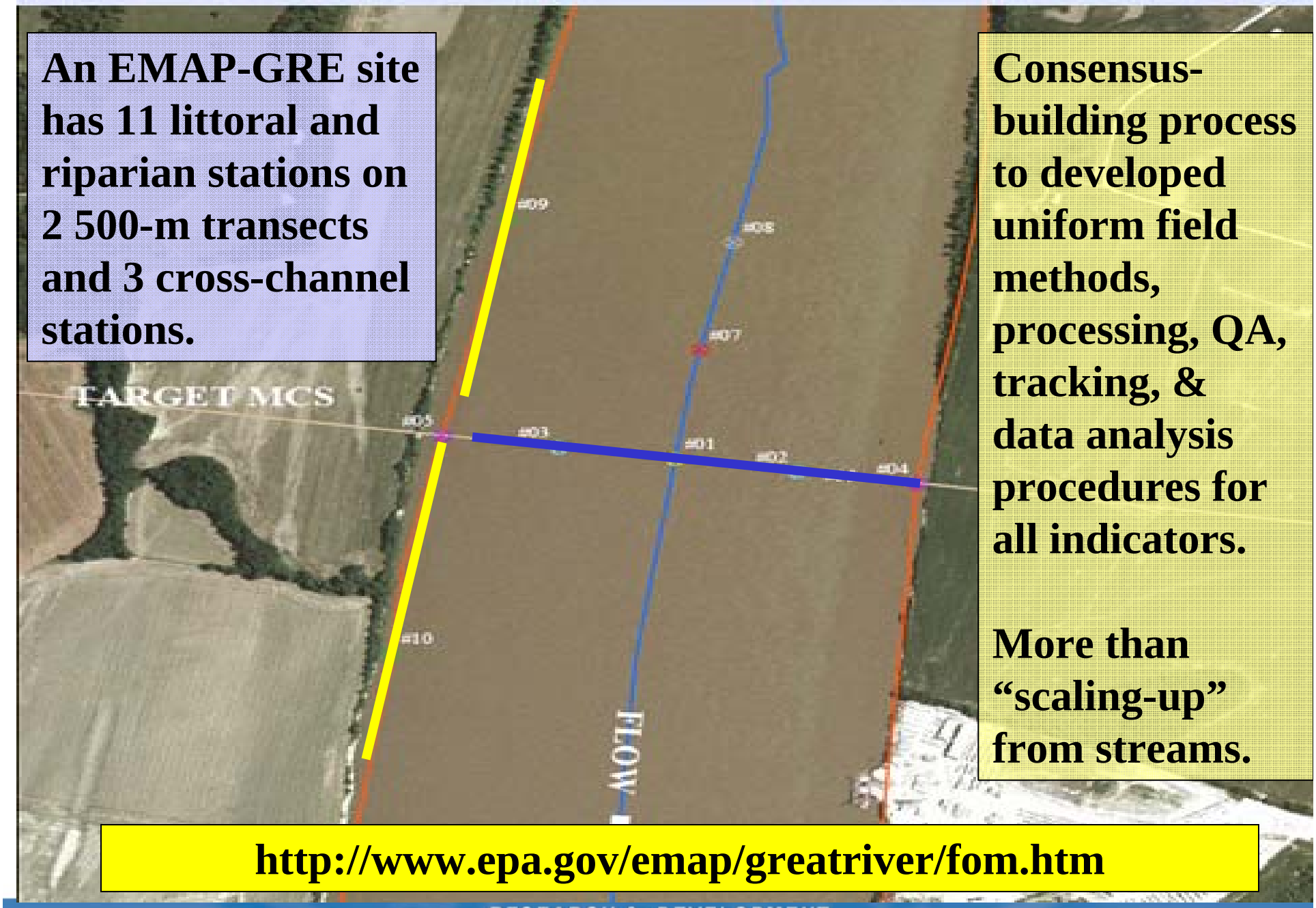
goes through here,

& ends here.



Probability design & State Sample Sizes





An EMAP-GRE site has 11 littoral and riparian stations on 2 500-m transects and 3 cross-channel stations.

Consensus-building process to developed uniform field methods, processing, QA, tracking, & data analysis procedures for all indicators.

More than "scaling-up" from streams.

http://www.epa.gov/emap/greatriver/fom.htm

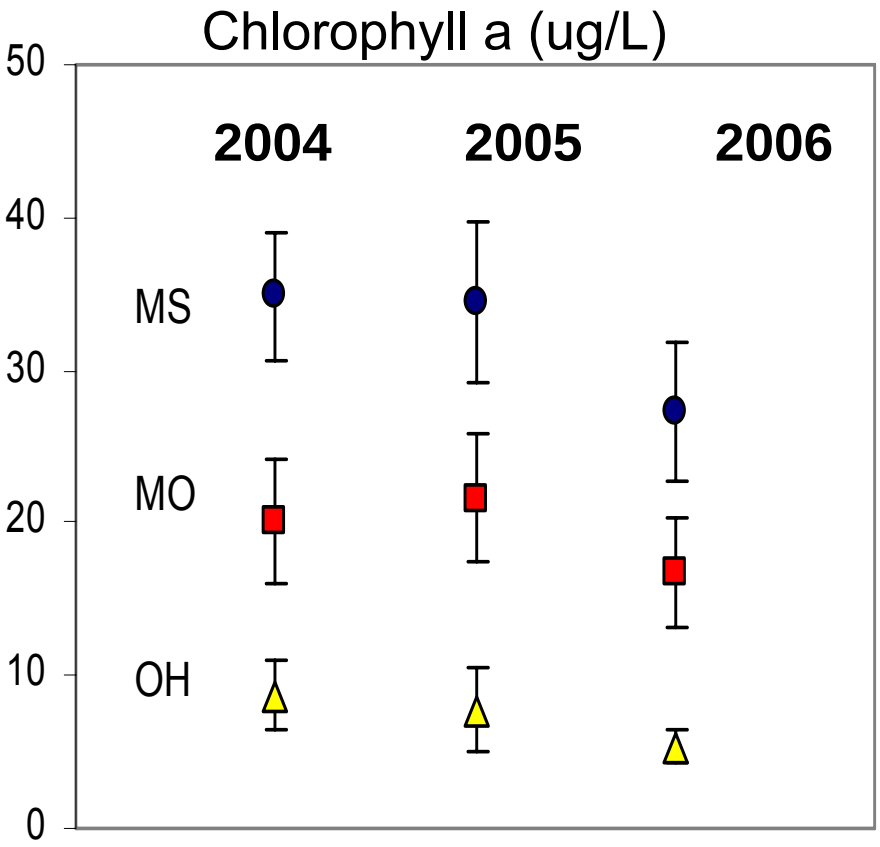
Selected metrics and indicators balance assessment & research.

- **Water Quality**
  - Dissolved oxygen
  - Conductivity
  - pH
  - Metals (As, Pb, Se, CU, Fe, Ni, Zn)
  - Temperature
  - Anions & Cations
  - Turbidity, Suspended matter
  - **Chlorophyll**
  - Alkalinity
  - **Total & Dissolved P, N, & C**
  - Particulate organic N
  - Silica
  - Elemental particle analysis
  - Particulate stable isotopes
- **Sediment**
  - Enzyme activity
  - Toxicity
  - Grain size
  - Total and volatile matter
  - Chemistry (organics, inorganics)
- **Biotic Assemblages**
  - **Fish**
    - **Tissue contaminants**
    - **Genetic diversity**
  - Invertebrates
    - Littoral
    - Snags
  - **Zooplankton**
  - Phytoplankton
  - Periphyton
  - Submersed aquatic vegetation
- **Habitat & Landscape**
  - Littoral
    - Vegetation cover
    - Substrate
    - Depth
    - Velocity
    - Woody debris
  - Riparian
    - Development/disturbance

Water Quality Indicators

Paul Bukaveckas (Virginia Commonwealth University)

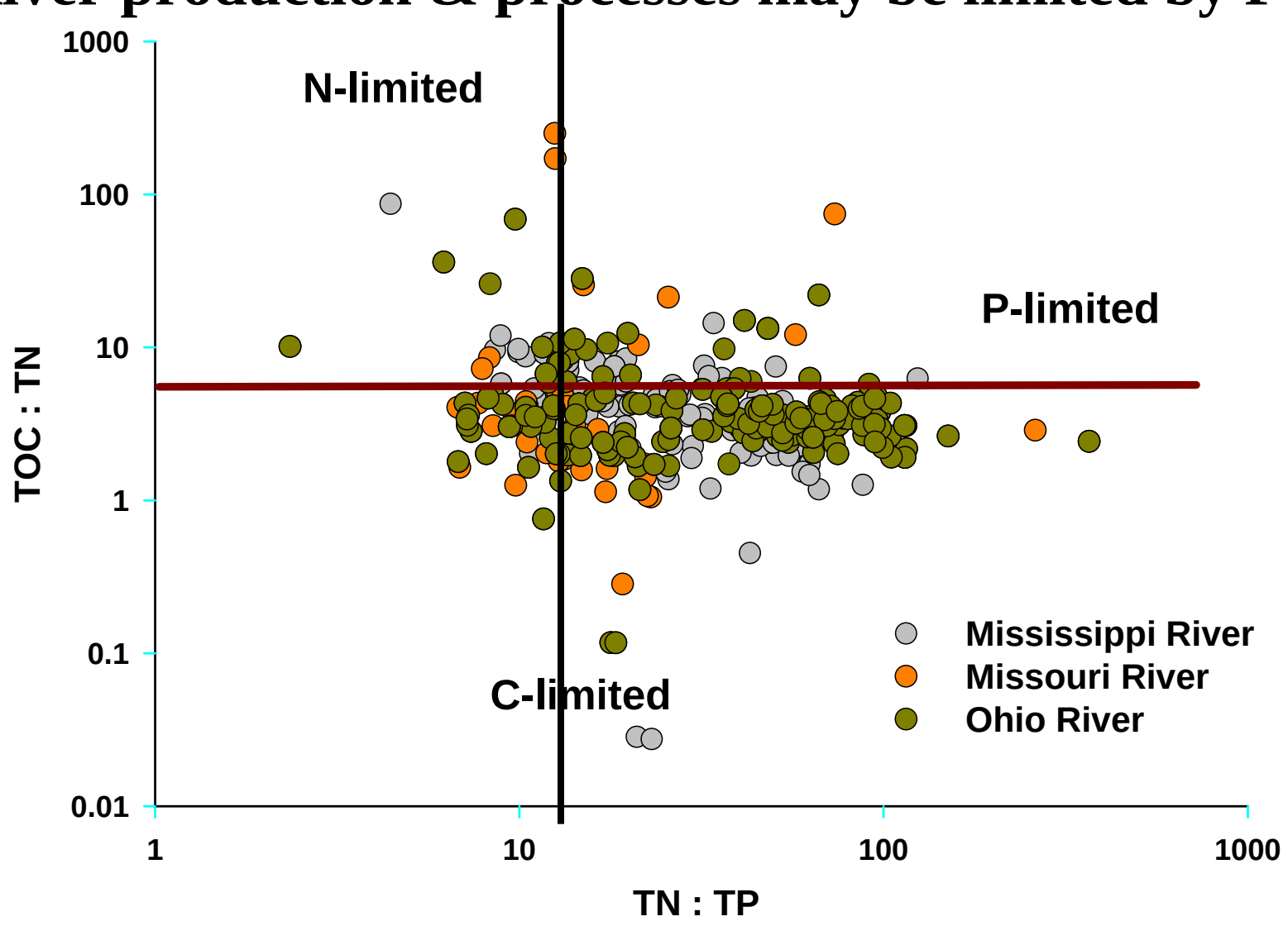
Anthony Aufdenkampe (Stroud Water Research Center) (see poster)



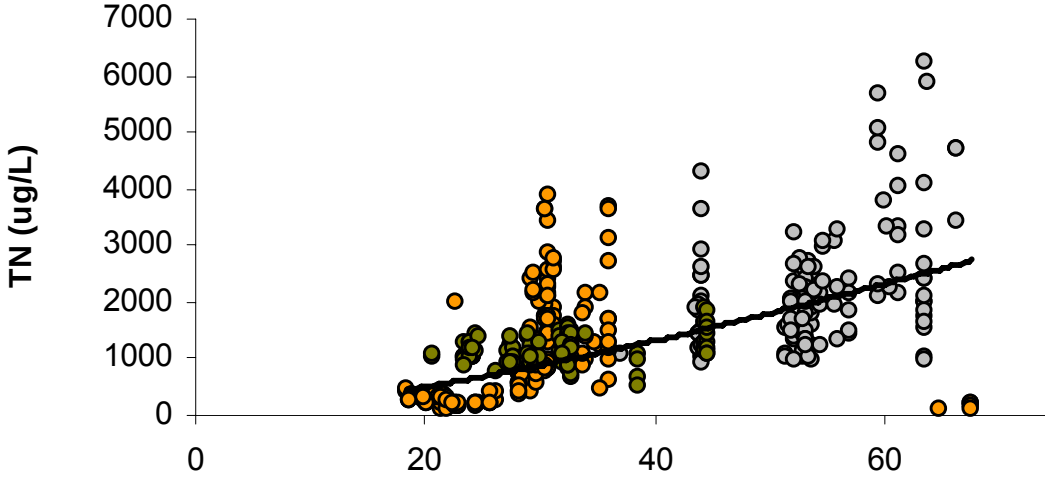
River water quality is distinct within years and coherent between years.

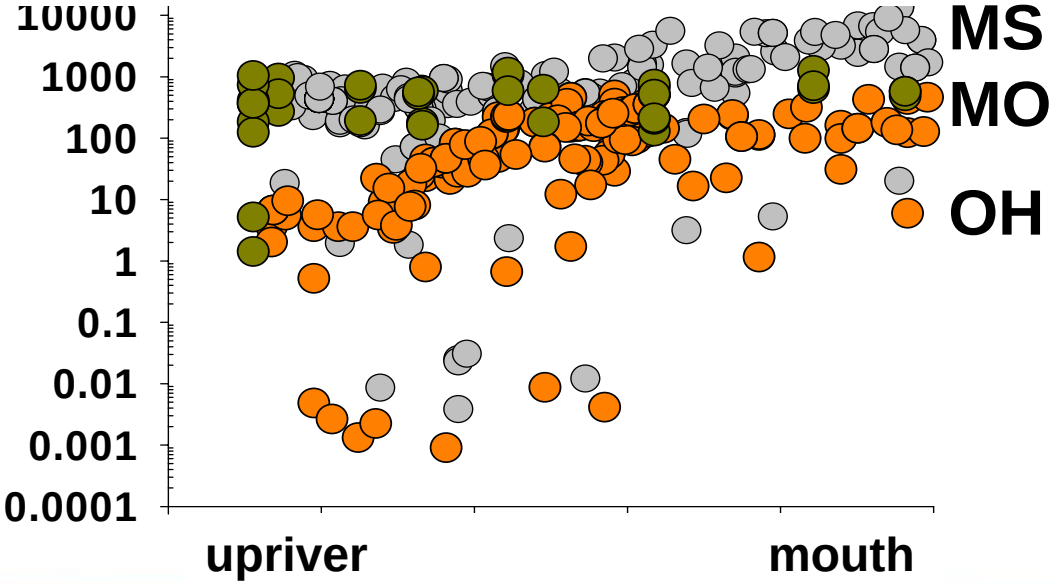
	OH	MO	MS
Depth (m)	6.1	2.7	3.9
Light extinction (m^{-1})	2.07	5.39	3.40
Velocity (m/s)	0.62	1.16	0.68

Water chemistry reflects nutrient inputs and processes. River production & processes may be limited by P and C.



Downstream trends in nutrient loads





N concentrations (ug/L) and % agriculture

+

Estimated mean annual flow from National hydrologic data

↓

N Loading (T/yr)

Biological Results

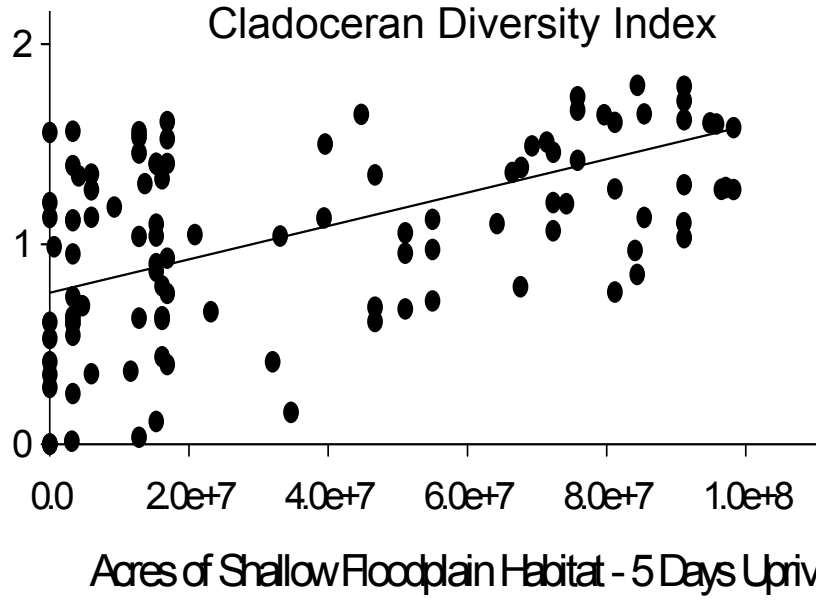
John Chick & Alex Luvcek Illinois Natural History Survey
John Havel Missouri State University
Jeff Jack University of Louisville

Zooplankton habitat needs

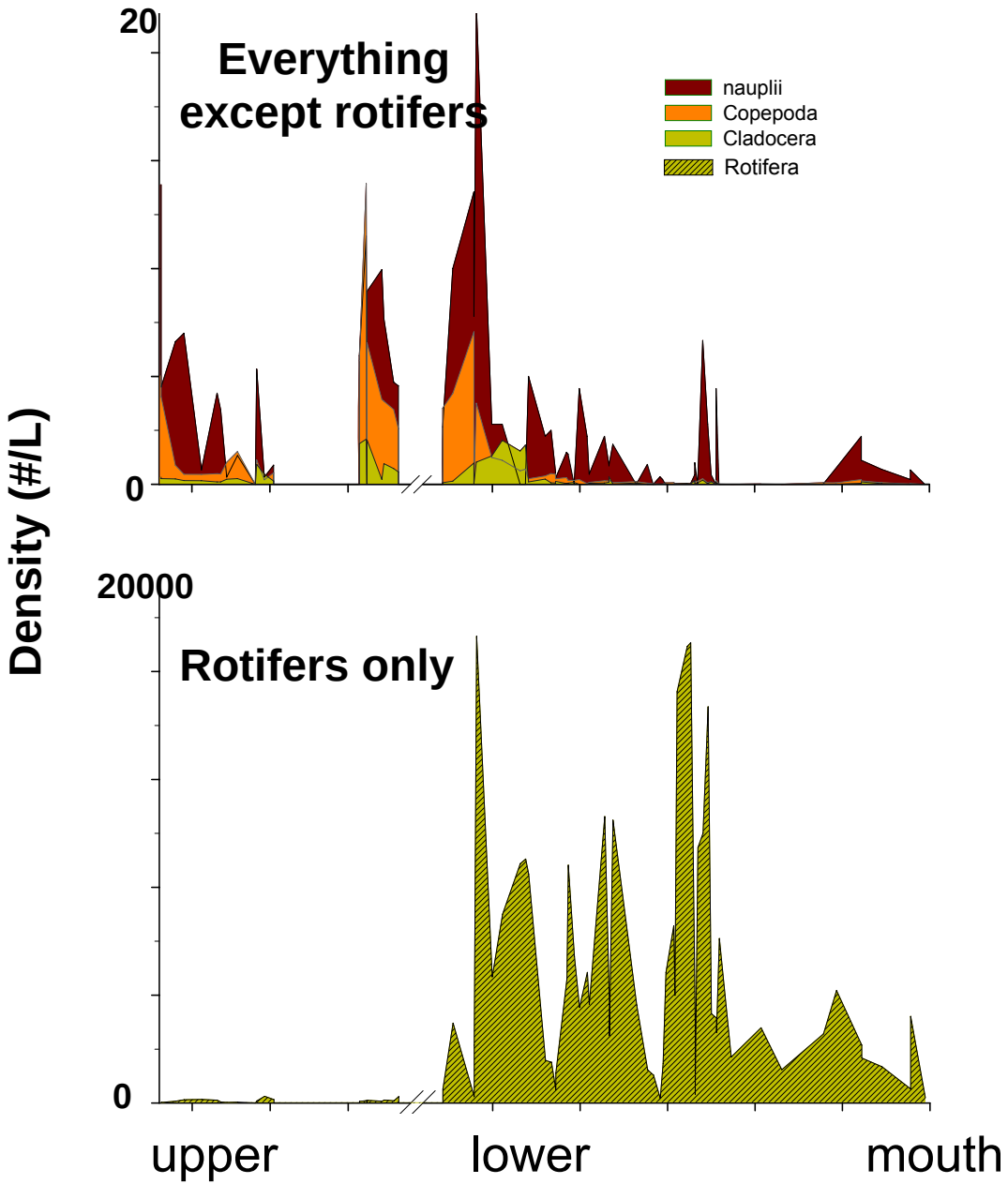
Rotifers secondary channels, temperature, chl-a, turbidity

Cladocerans secondary channels & contiguous shallow floodplain aquatic areas, temperature, conductivity, chl-a

Copepods backwater lakes & contiguous shallow floodplain aquatic areas, conductivity, temperature, pH



Upper Mississippi River zooplankton diversity increases with more upriver shallow floodplain area.



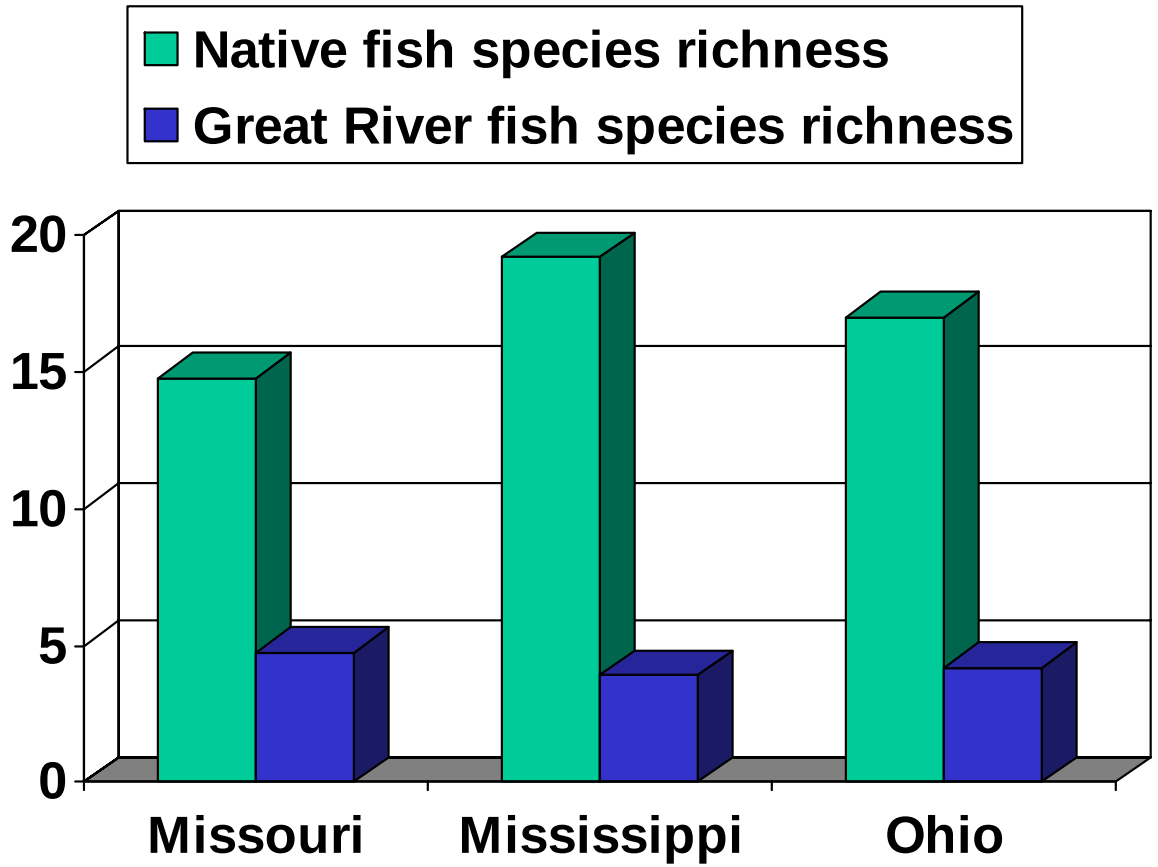
The zooplankton in the inter-reservoir Missouri were diverse but densities were very low relative to densities in the channalized river.

Rotifers dominated the assemblage in the lower river.

Fish abundance and assemblage diversity

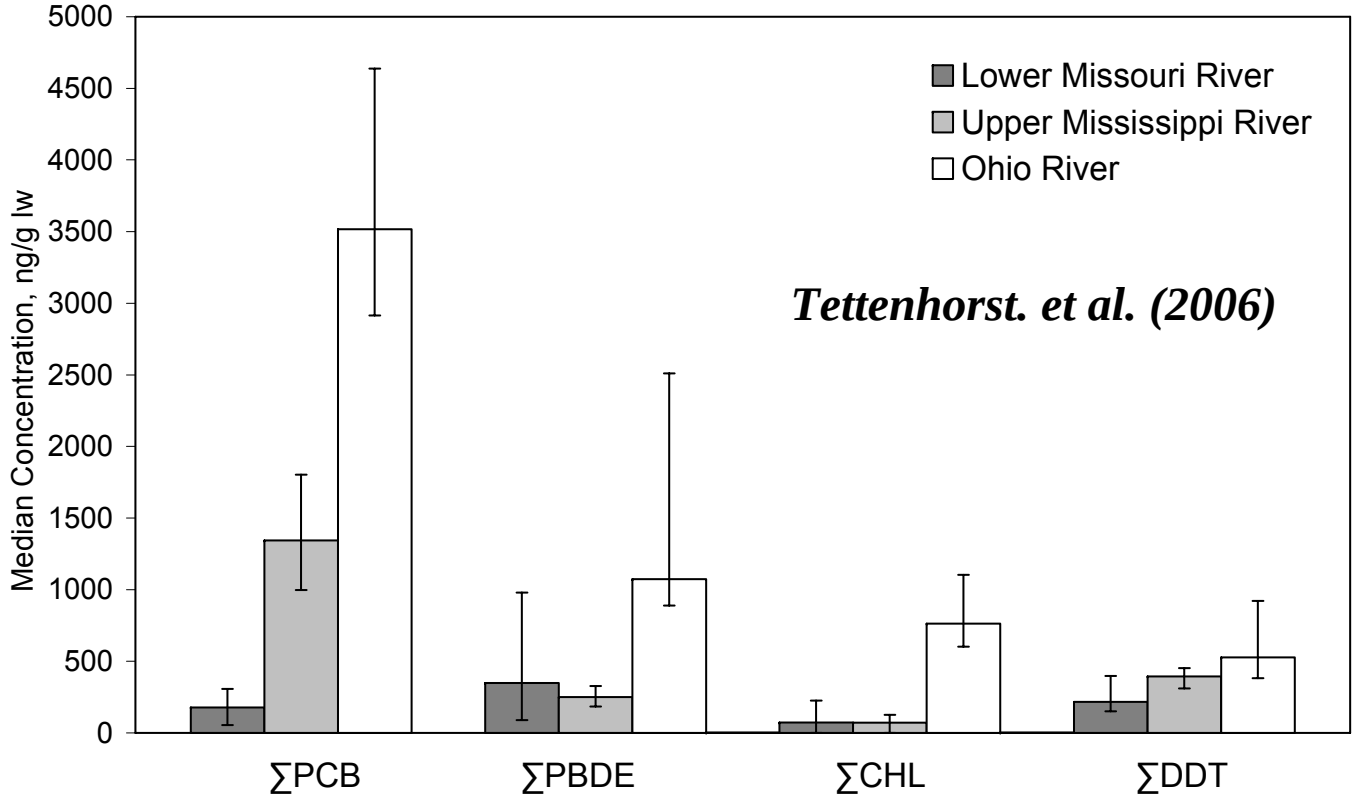
Higher diversity of native fishes in the Upper MS River could reflect higher habitat diversity.

Higher diversity of "Great Rivers" fishes in Missouri River could reflect retention of Great River character despite modifications.



Poster: Ted Wallace and Val Barko

Survey of organochlorine pesticides, PCBs, 10 PFCs, PBDEs, PFOAs, musks, and Hg in selected fish species.



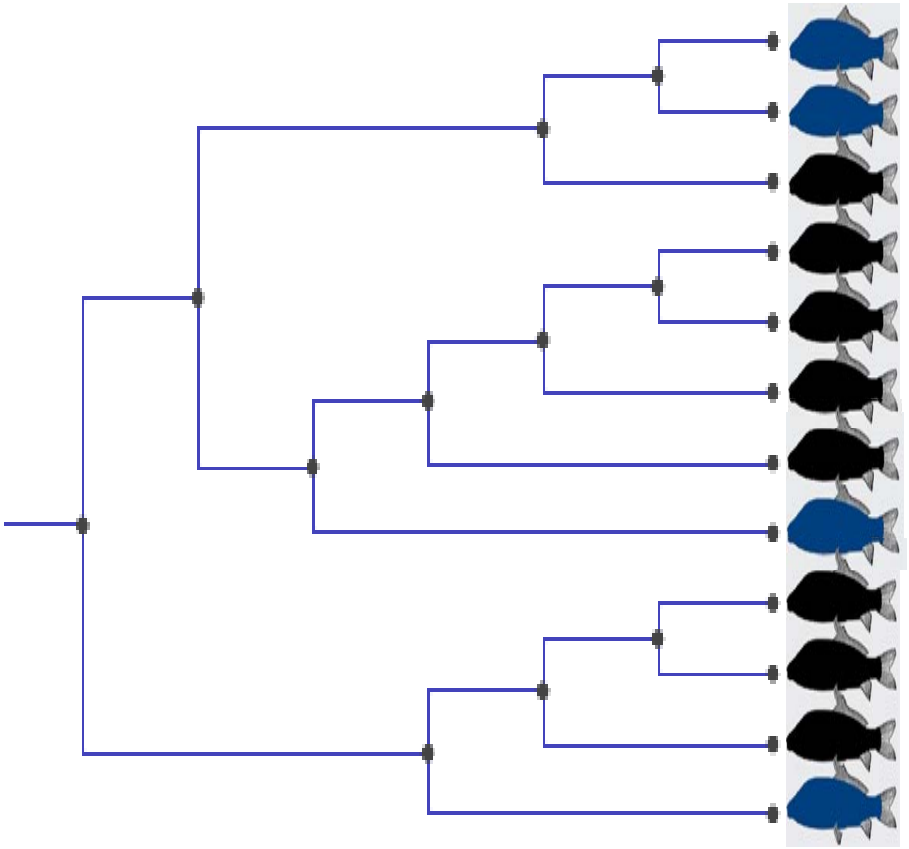
PFCs (mostly PFOS) were widely distributed (beyond currently known areas); Ohio R. > Mississippi = Missouri

EMAP-GRE is using genetics to research stressor response and biogeography.

Do fish hybridization rates differ in stressed systems?

Is genetic diversity an indicator of community or population health?

Is genetic diversity an indicator of biogeographical boundaries within river ecosystems or between basins?



Phylogenetic tree for select Catostomids: Black Buffalo and Smallmouth Buffalo

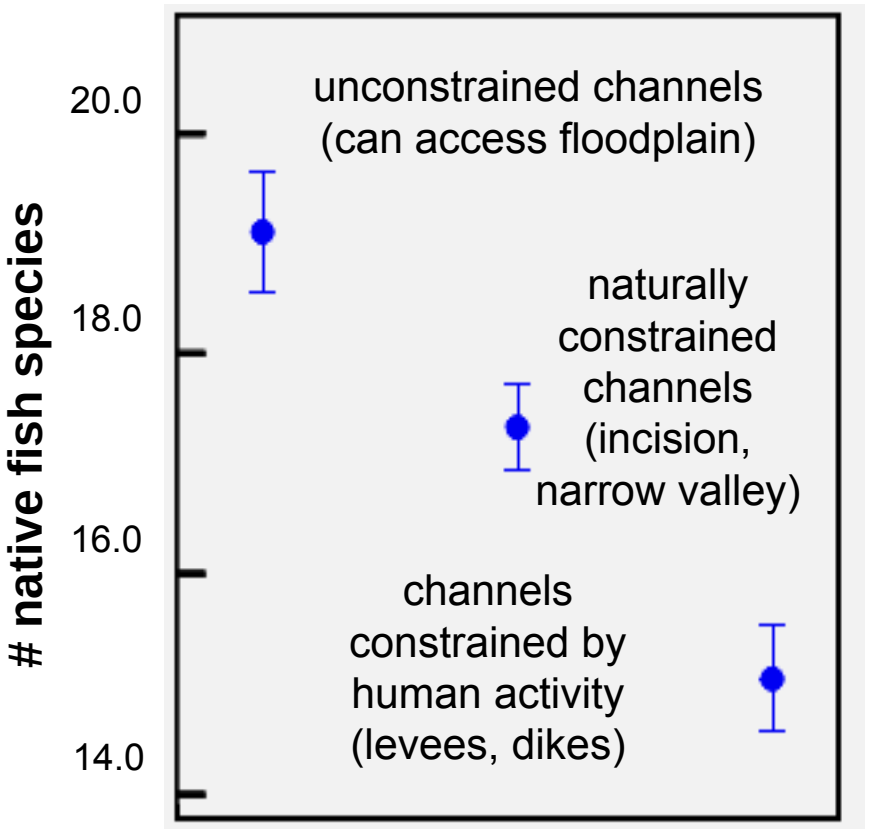
EMAP-GRE is contributing to methods development for ecologically relevant pharmaceuticals and metabolites in water, fish tissue, and sediment.

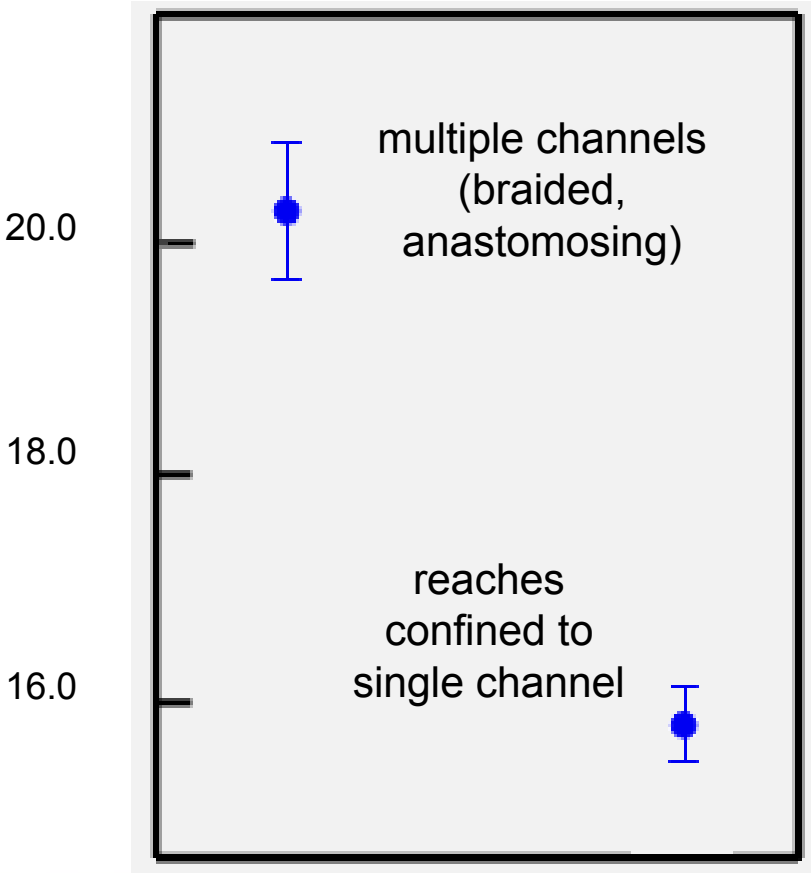
Angela Batt, Mitch Kostich, Jim Lazorchak, Dan Bender
EPA NERL

- **Corticosteroids**
- **Anti-diabetes drugs**
- **Beta-blockers**
- **Calcium channel blockers**
- **Estrogens**
- **CNS monoamine agonists**
- **Diuretics**
- **Angiotensin antagonists**
- **Statins**
- **Thyroid hormones**
- **Opioids**
- **Non-steroidal anti-inflammatory drugs (ibuprofen, aspirin, acetaminophen)**

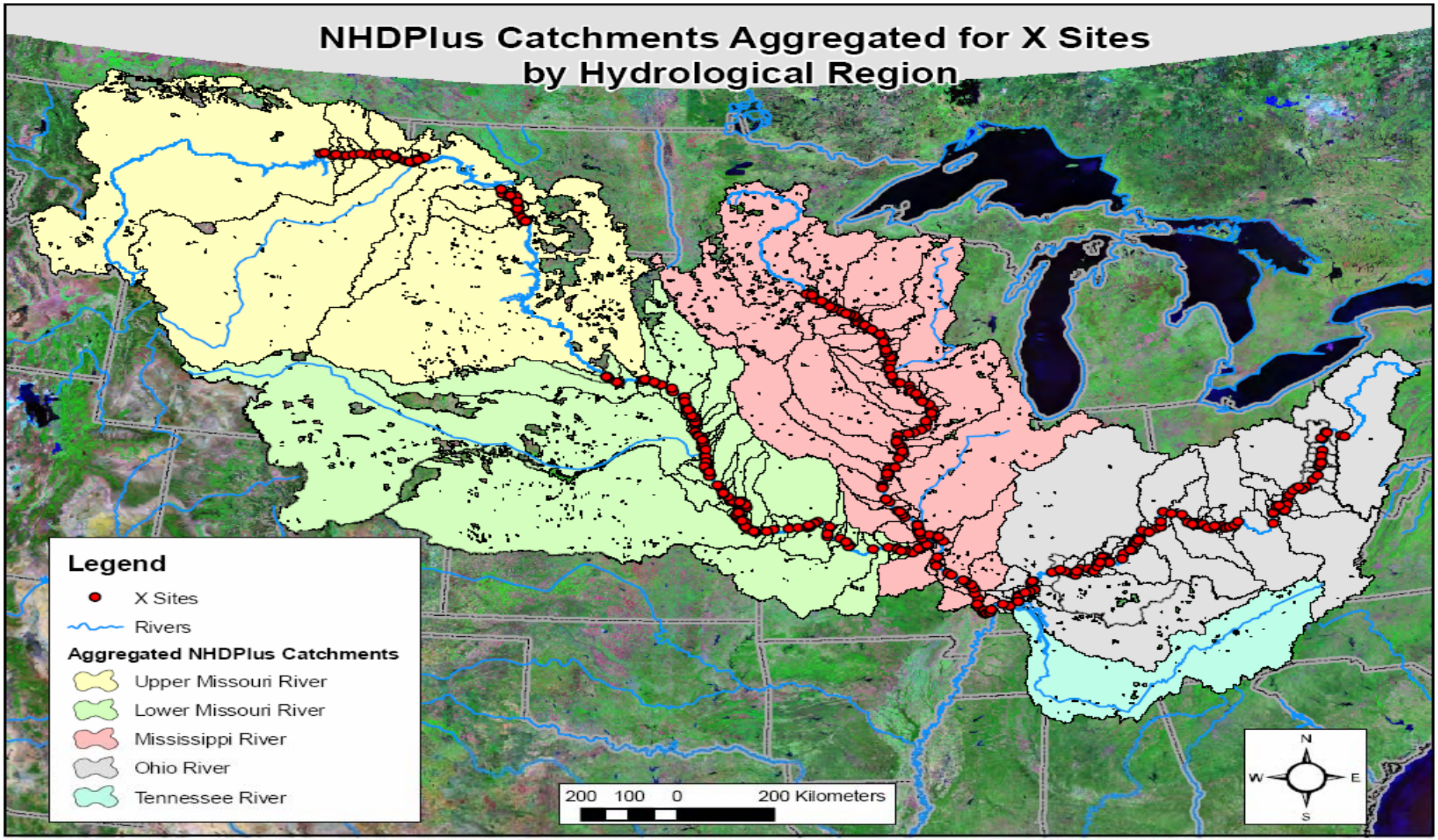
Physical Habitat & Fish Species Richness

Results from all rivers show that native fish species richness is highest in more complex and less constrained channels.

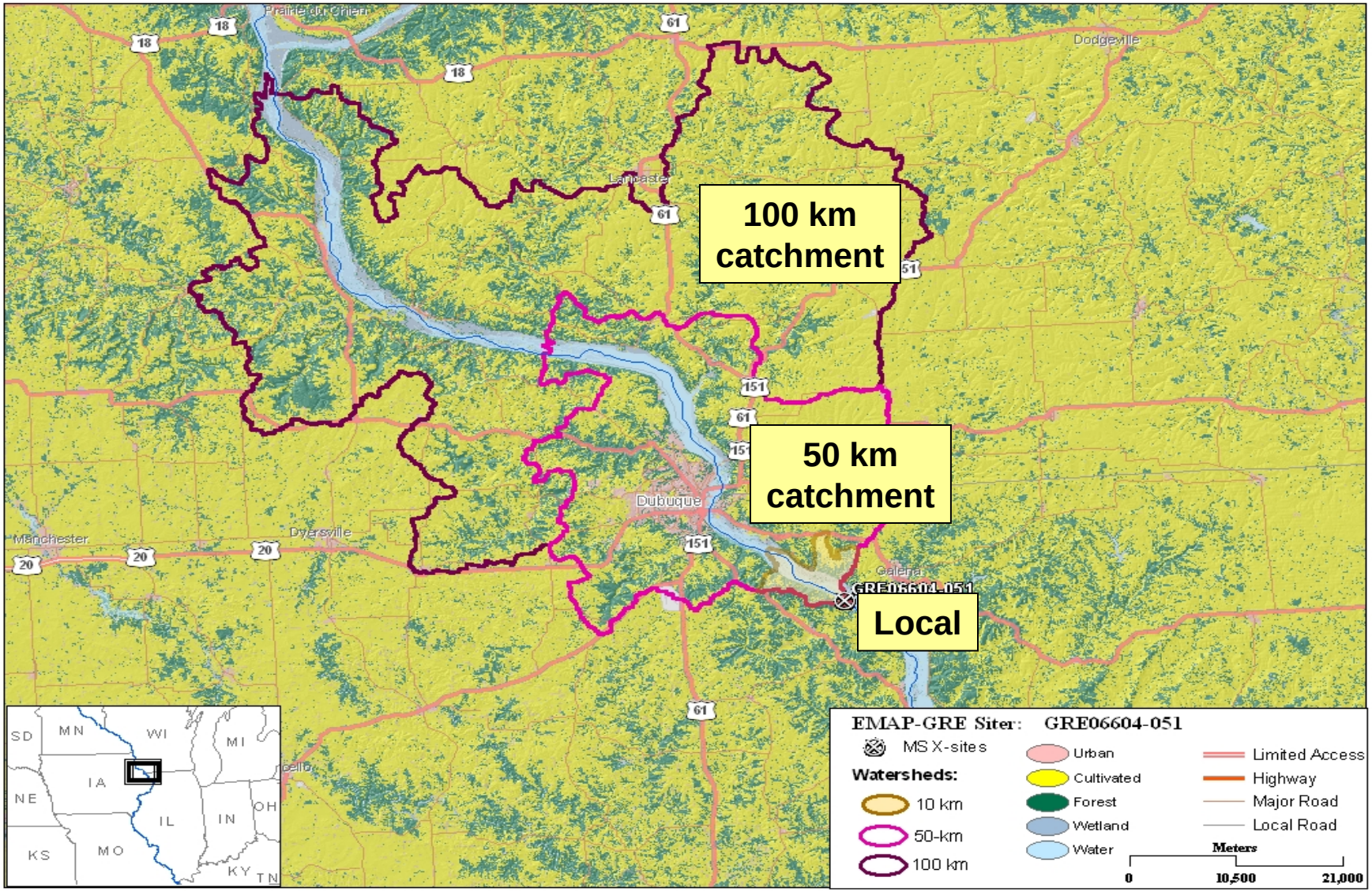




Spatial scales of landscape analyses range from continental basin (29% of contiguous U.S.) to local catchments.

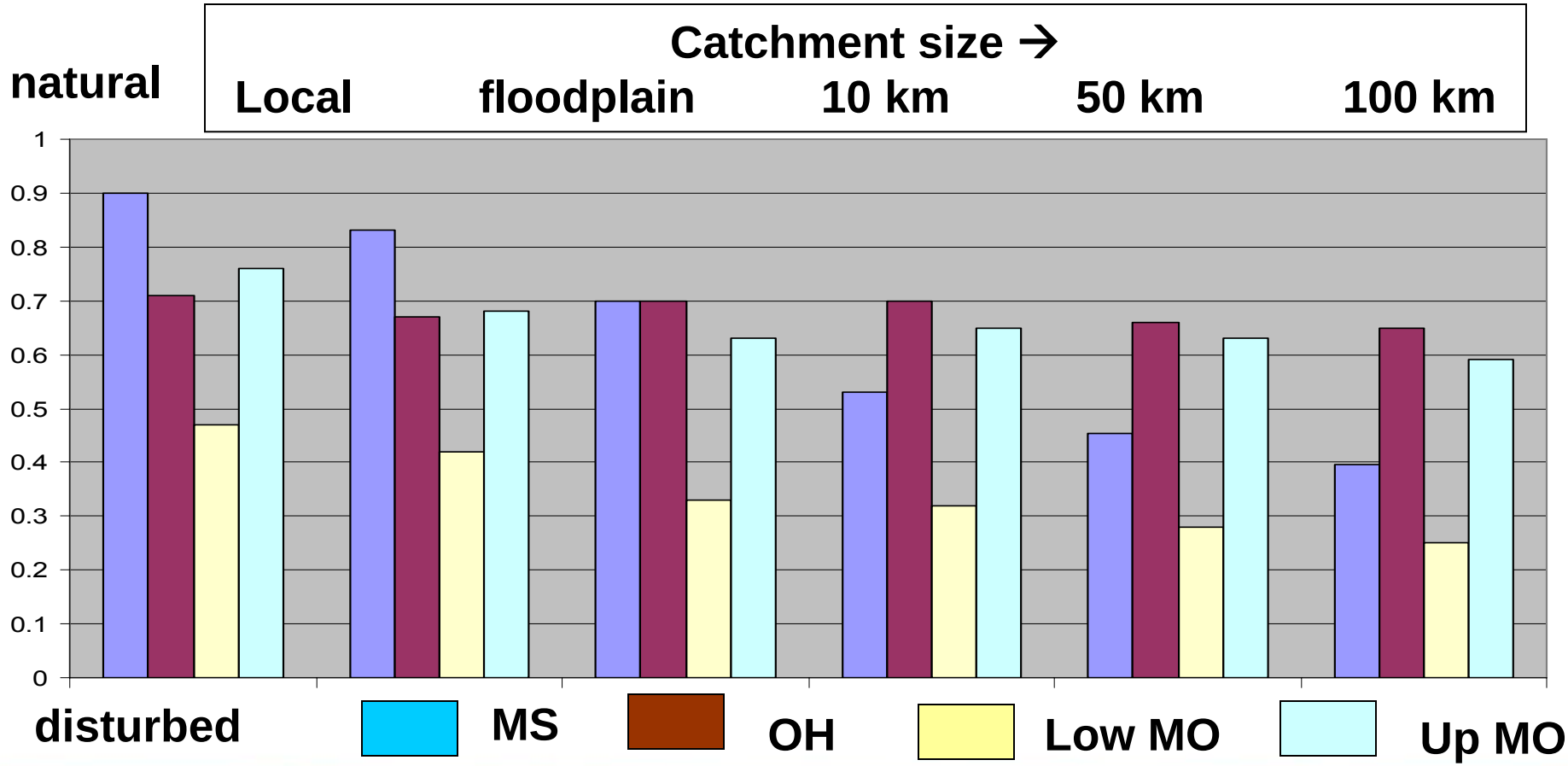


Characterizing spatially-nested site-specific catchments

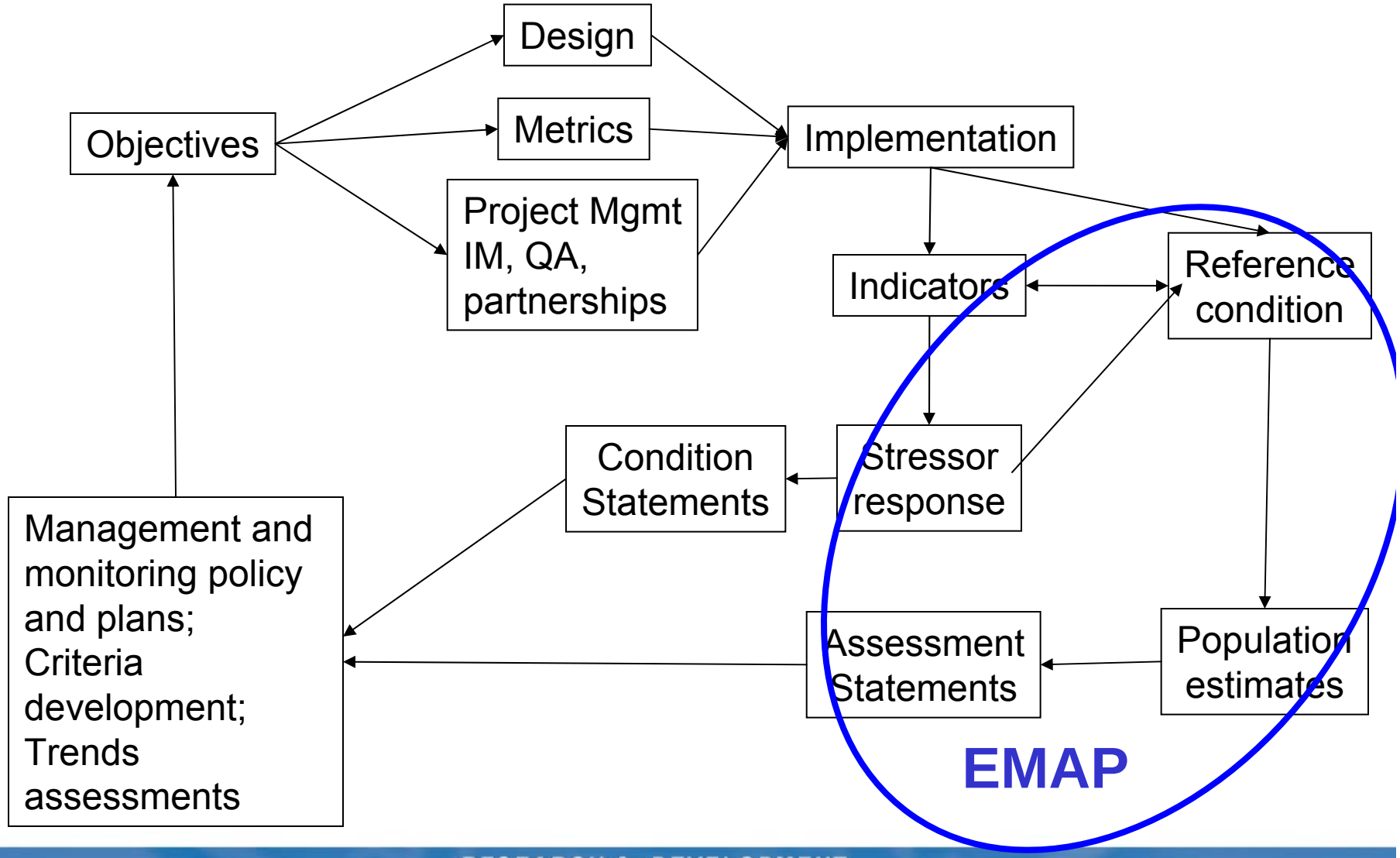


Landscape Results

On MS & Lower MO, local and floodplain catchments are relatively less disturbed than catchments upriver, off-channel, and up tributaries. Little change with scale on OH or Upper MO.



EMAP-GRE Program Plan



Characterizing Reference Conditions

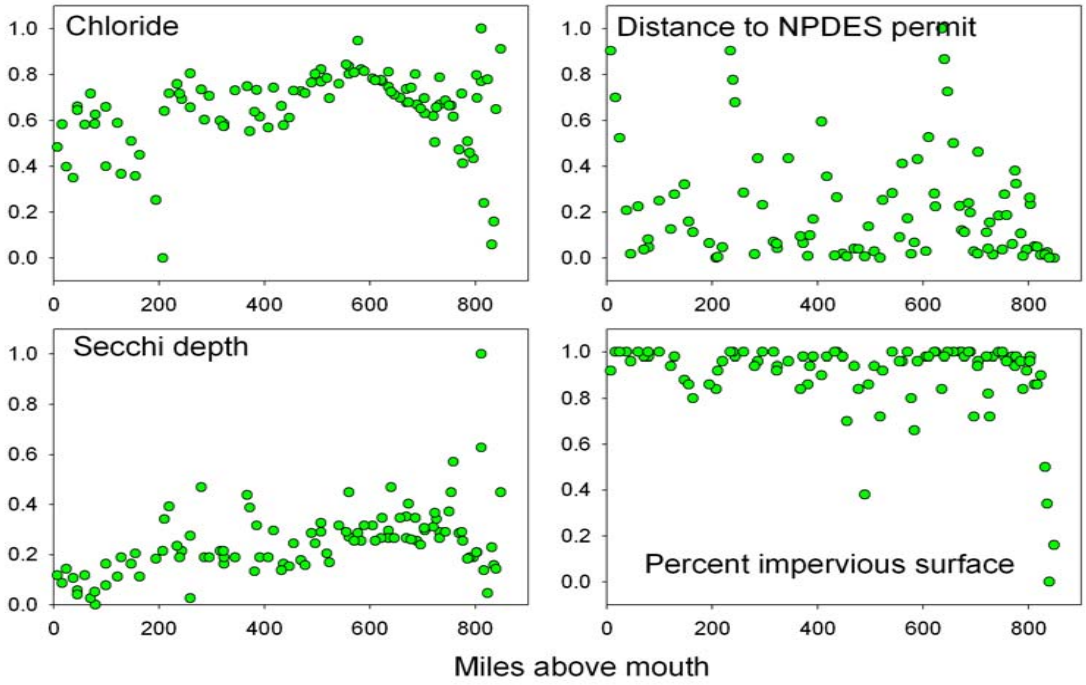
- Reference conditions are relative, empirical, and extant. They are the “best of what is left”.

- Multiple abiotic metrics define reference conditions.

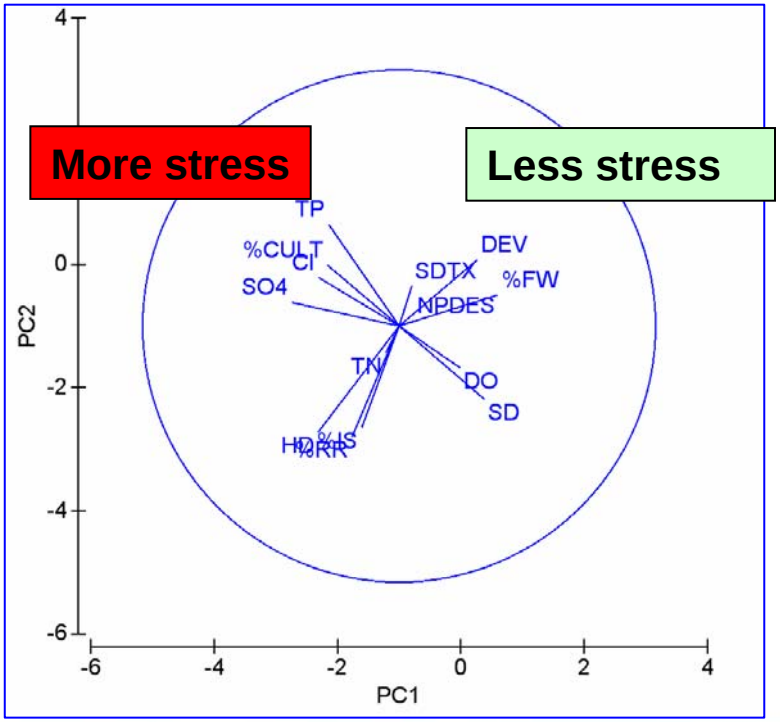
Metric Type	Filtering metric	Expected response
Water quality	Total N	+
	Total P	+
	Chloride*	+
	Sulfate	+
	Secchi depth*	-
	DO	-
Physical habitat	Human disturbance index	+
	Human development score	-
	Percent of rip-rap shore	+
Exposure	Sediment toxicity index	-
Local landscape	Distance NPDES discharge*	-
	Percent forest + wetland	-
	Percent cultivated	+
	Percent impervious surface*	+

Results: Upper Mississippi River

Metrics vary along river.
(examples from table)

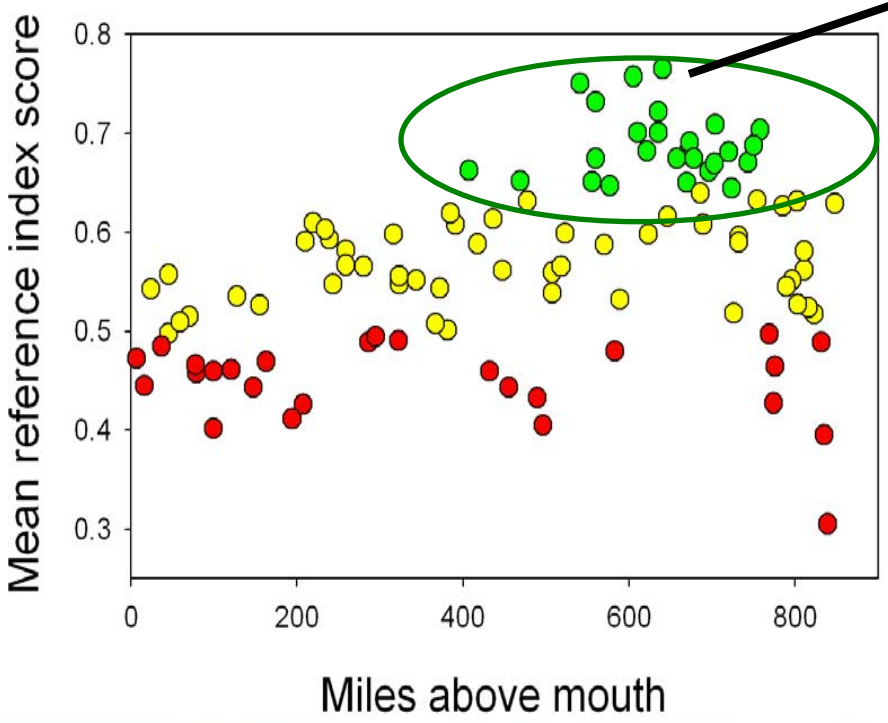


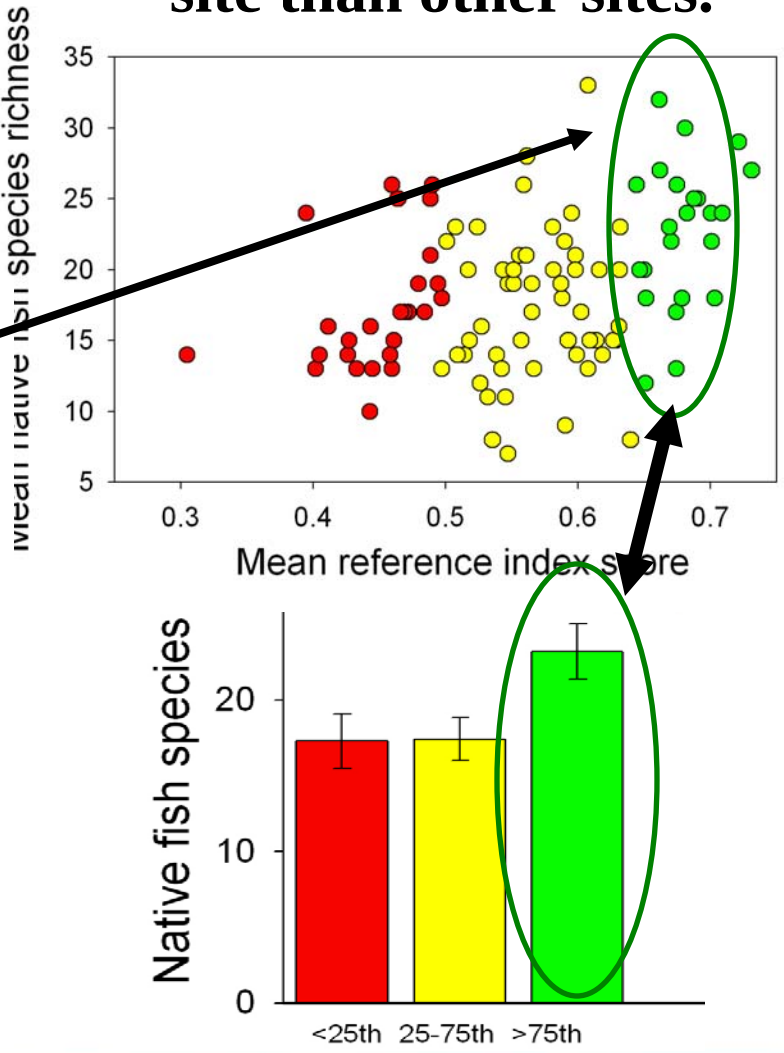
Combining metrics into a stressor gradient.



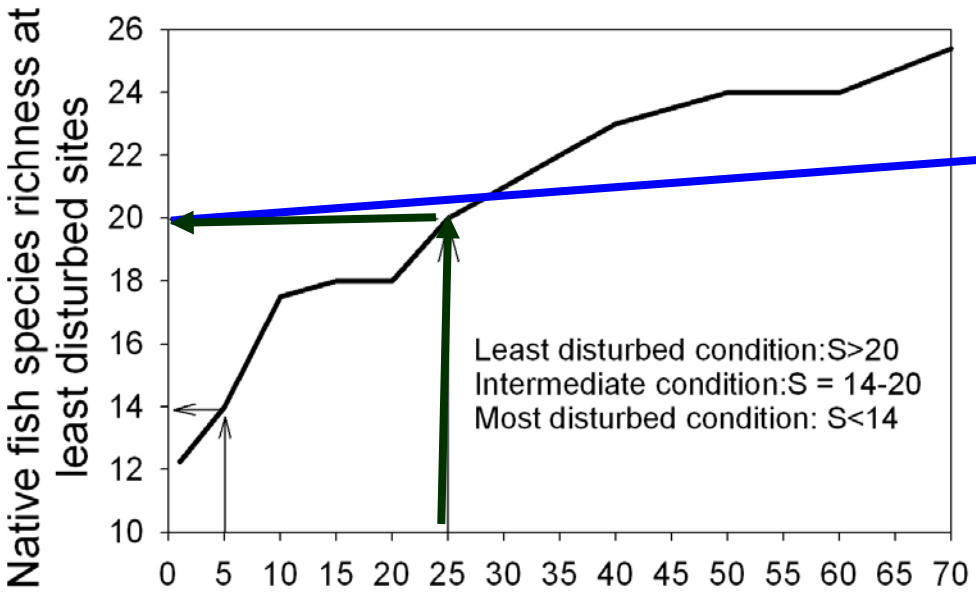
Sites scoring in top 25th percentile of index are "least-disturbed" sites. Least disturbed sites only found in some pools. Gradients or classification of reference condition is important issue.

There are more native fish species at least-disturbed site than other sites.



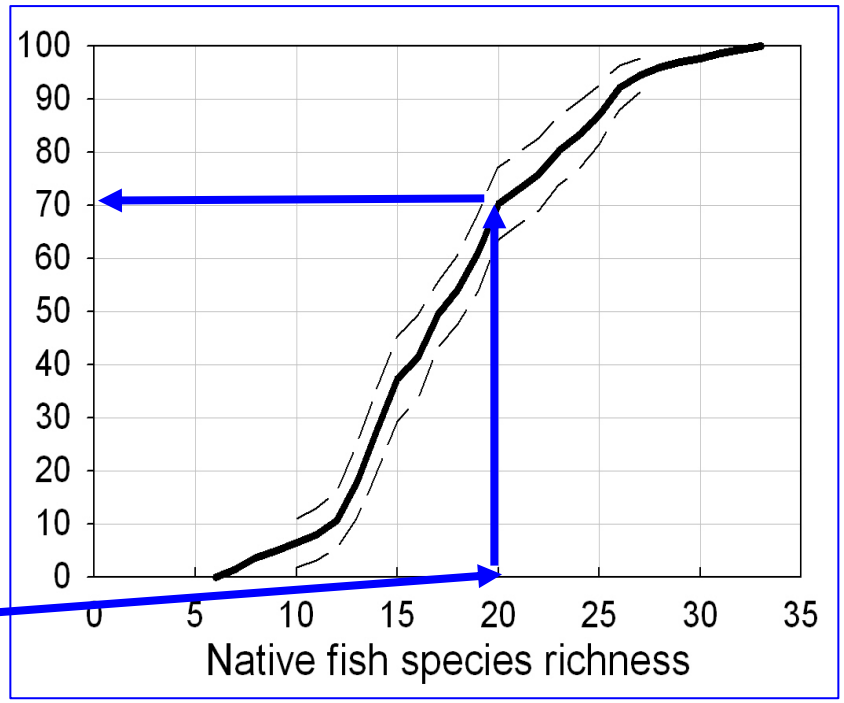


The top 75 percentile of the least-disturbed *sites* define least-disturbed *conditions*.
Least-disturbed conditions, as defined with abiotic metrics, have > 20 species of native fish.



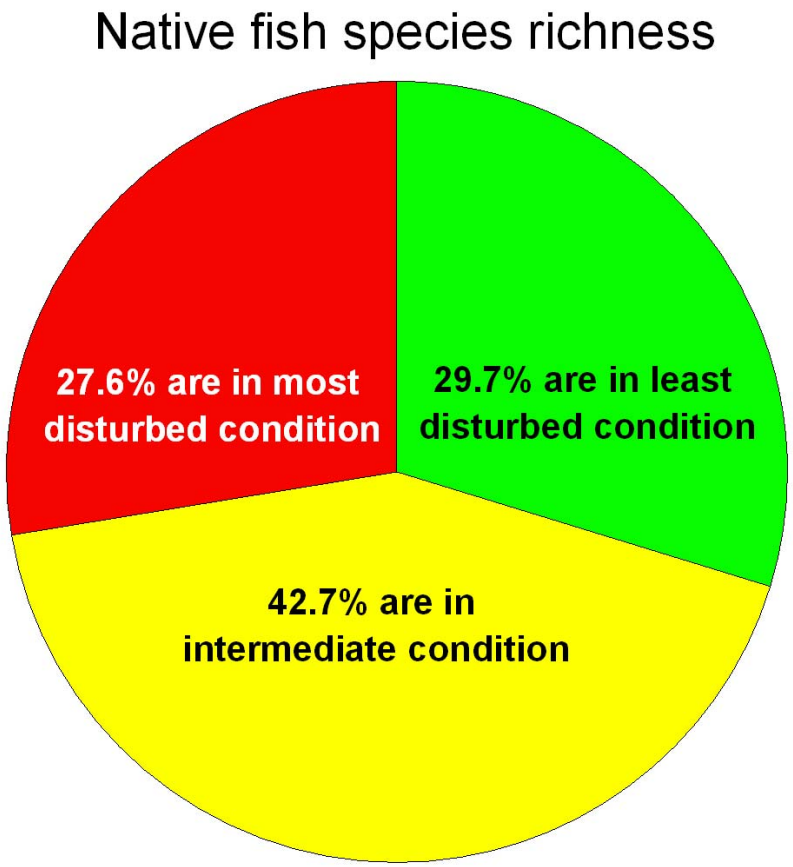
Percentile of least-disturbed sites

% of length of Upper MS River (population estimates)



Biology should respond to reference conditions.
Reference conditions do not respond to biology.

From preliminary data, we estimate that 27.6 (+/- 3.4)% or 384 km of the Upper Mississippi River are in good condition as indicated by native fish species.



Future Directions for EMAP-GRE

"In FY2008, EMAP will transition to become a data analysis program that focuses on analyzing (accumulated) data"

(EPA's Budget Justification to Congress March 2007)

- **Assessment of the Upper Mississippi, Missouri, and Ohio Rivers.**
  - Analyses of core indicators and reference conditions for assessment
  - Novel analyses
    - Fish genetics (biogeography, non-indigenous species, cryptic species, response to stressors, including climate change)
    - Biotic integrity indices for "other than fish" assemblages (zooplankton, algae)
    - Integrated multi-scalar landscape & physical habitat indicators
    - Extent of novel contaminants in fish tissue
  - Outreach to managers (states & programs)
- **Contribute to National River Assessments**
  - 2007 Partnerships & Development
  - 2008-2009 Field campaigns: Rivers (including Great Rivers) and Streams
  - 2010-2011 Data analyses and reporting

Researching, demonstrating, & transferring assessment methods are prerequisites of protecting ecosystem health & services of Great Rivers.