National Scale Assessment of Fish Habitat: Update on Data, Analytical Plan and Proposed Products for 2015

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Outline

- Brief review of 2010 National Inland Assessment- Infante
- New & Updated Data- Daniel
  - New dams and fragmentation metrics – Cooper
  - New landscape data
  - New fish community data
- Improvements to the Analytical Methods- Daniel
  - Variation between catchment sizes
  - Controlling for spatial autocorrelation
  - Correcting false fragmentation in NHDPlus V1
  - Plans for scoring methods for Habitat Condition index (HCI)
- Proposed Products- Daniel

2010 PROJECT OUTCOMES

1. Developed a spatial framework with standard spatial units, multiple scales
   - Wang et al. 2010. Fisheries.

2. Compiled and attributed data to the framework, created a nation-wide database
   - www.nbii.gov/far/nfhap

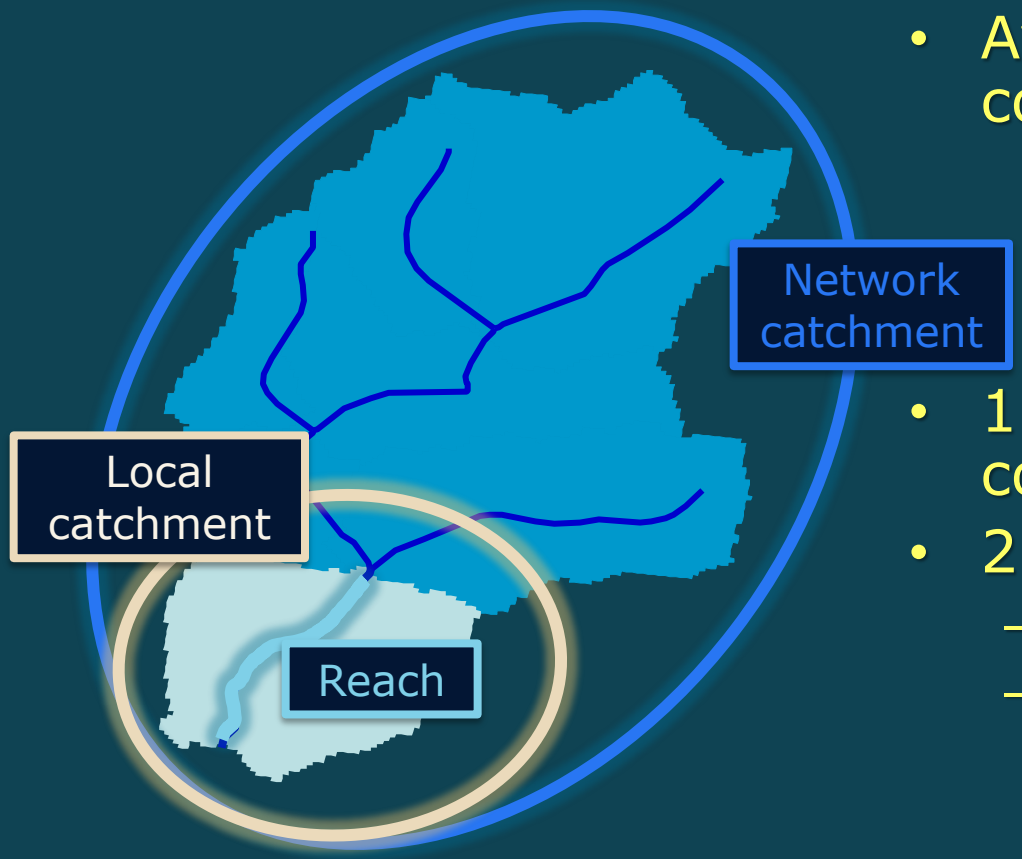
3. Completed assessments of habitats for rivers in:
   - Conterminous US
   - Alaska and Hawaii (initial efforts)
   - www.fishhabitat.org

NATIONAL FISH HABITAT ACTION PLAN

SPATIAL FRAMEWORK: KEY TO MANAGING, ANALYZING, SUMMARIZING DATA

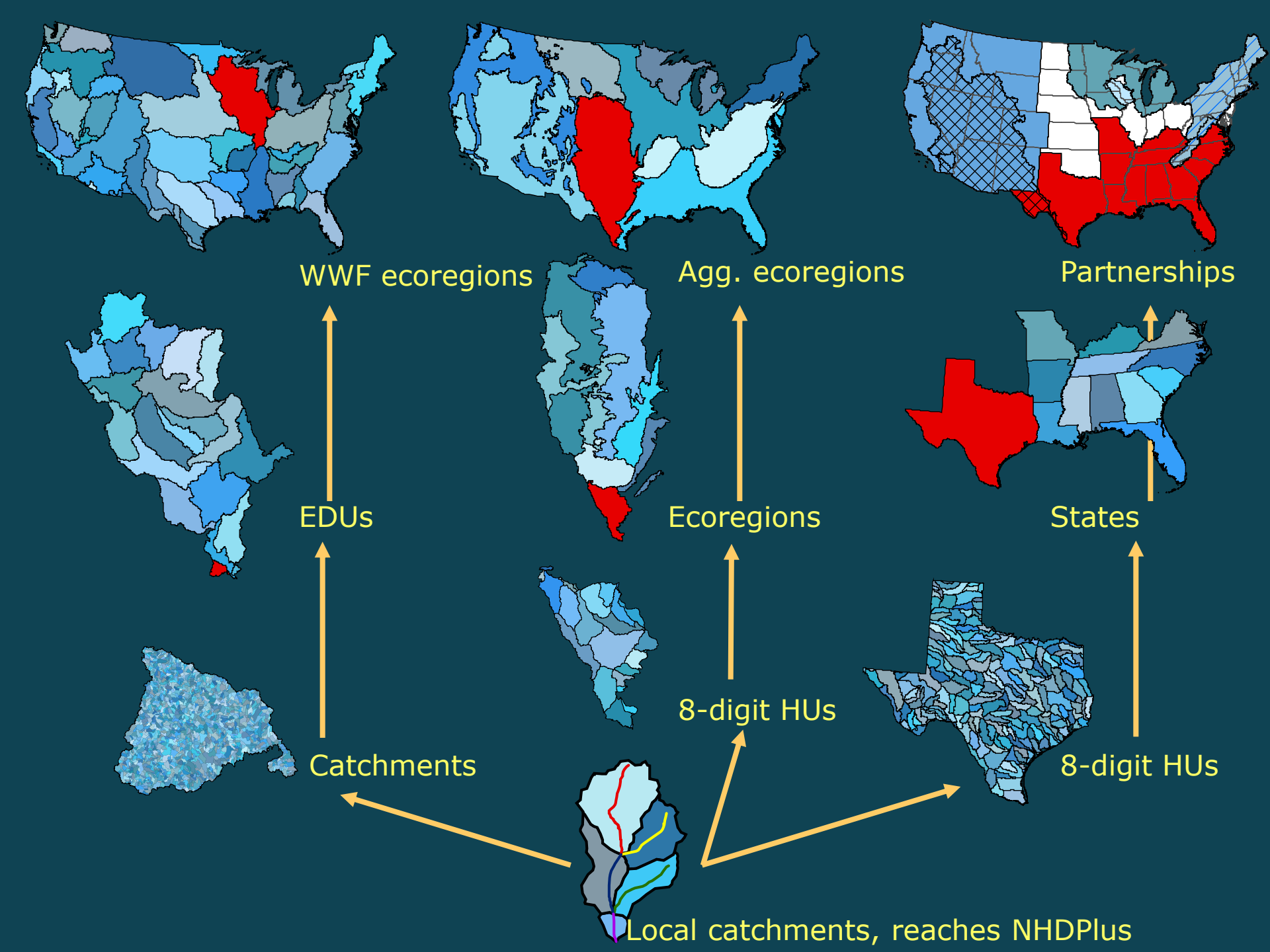
National Hydrography Dataset Plus (NHDPlus V1)

http://www.horizon-systems.com/nhdplus/

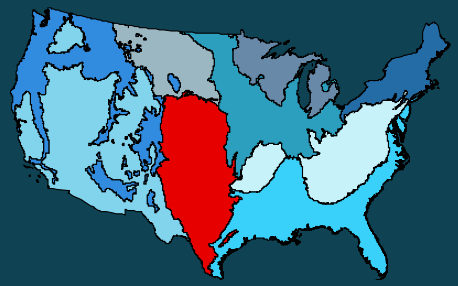


- Stream reach = basic unit
- Available throughout conterminous US

- 1:100,000 scale river coverage
- 2.6 million reaches
  - Local catchments defined
  - Includes network topology (network catchment summaries)


WWF ecoregions
Agg. ecoregions
Partnerships
EDUs
Ecoregions
States
8-digit HUs
Catchments
8-digit HUs
Local catchments, reaches NHDPlus

REGIONAL DETERMINATION OF ASSESSMENT SCORES



Network catchment

Local catchment

Human activities (anthropogenic land uses) limit fish by altering habitat

Natural landscape factors also influence habitat

Habitat

Influence in local and network catchments

Fishes

Natural landscape factors vary regionally…

IDENTIFYING FISH METRICS
TO INDICATE HABITAT CONDITION

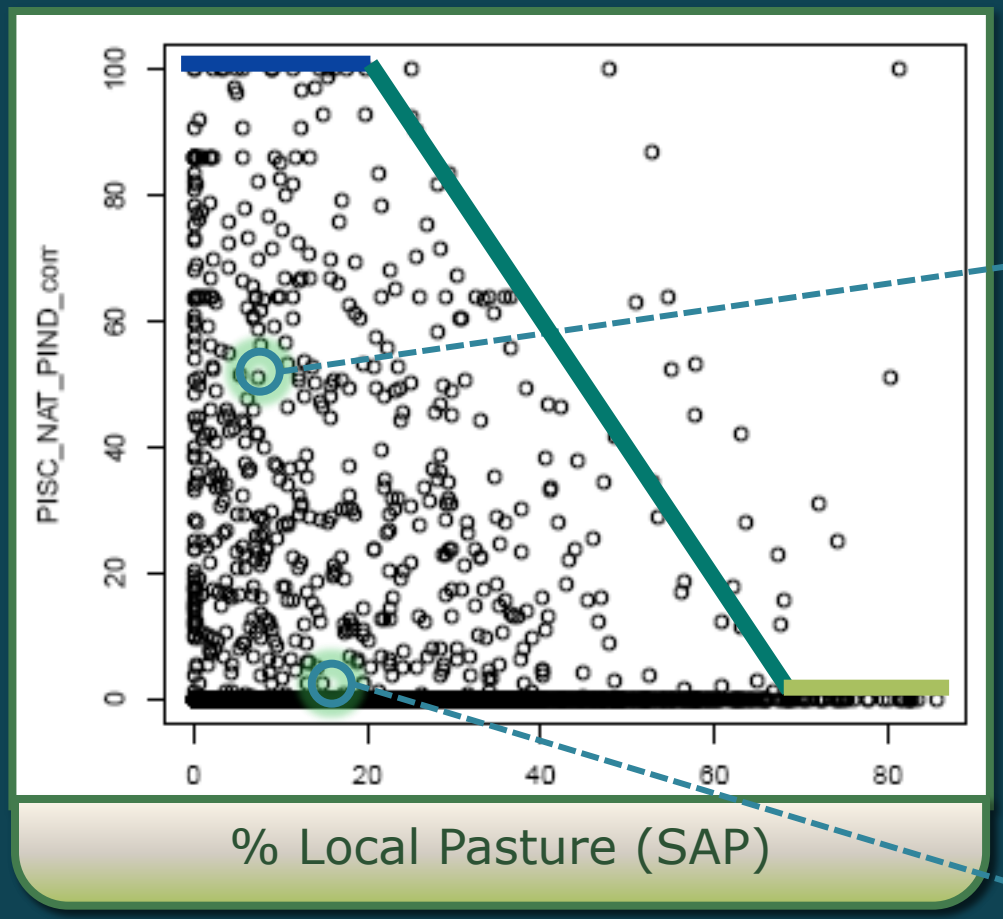
- Summarized fish by functional metrics suggesting fish response to habitat
- Followed Stoddard et al. (2008) to select **metrics most responsive to landscape anthropogenic landscape stresses** in 9 regions
- Classified most/least impaired reaches, using conservative estimates of landscape condition thresholds determined from literature

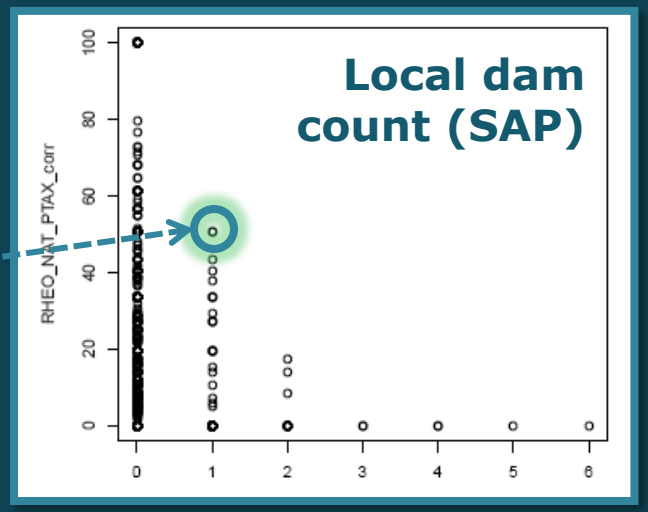
SCREENING APPROACH

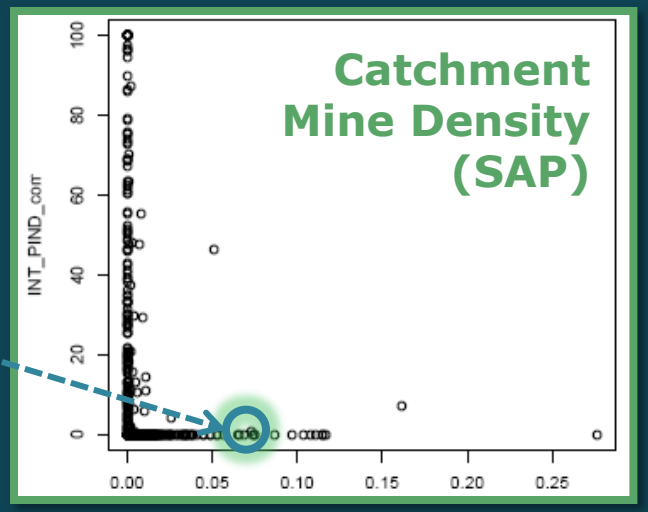
- **Calculated fish metrics**
- **Zero test**
- **Metric range**
- **Reproducibility**
- **Sensitivity test**
- **Redundancy check**

CONSIDERING RELATIONSHIPS BETWEEN

FISH METRICS AND STRESSES







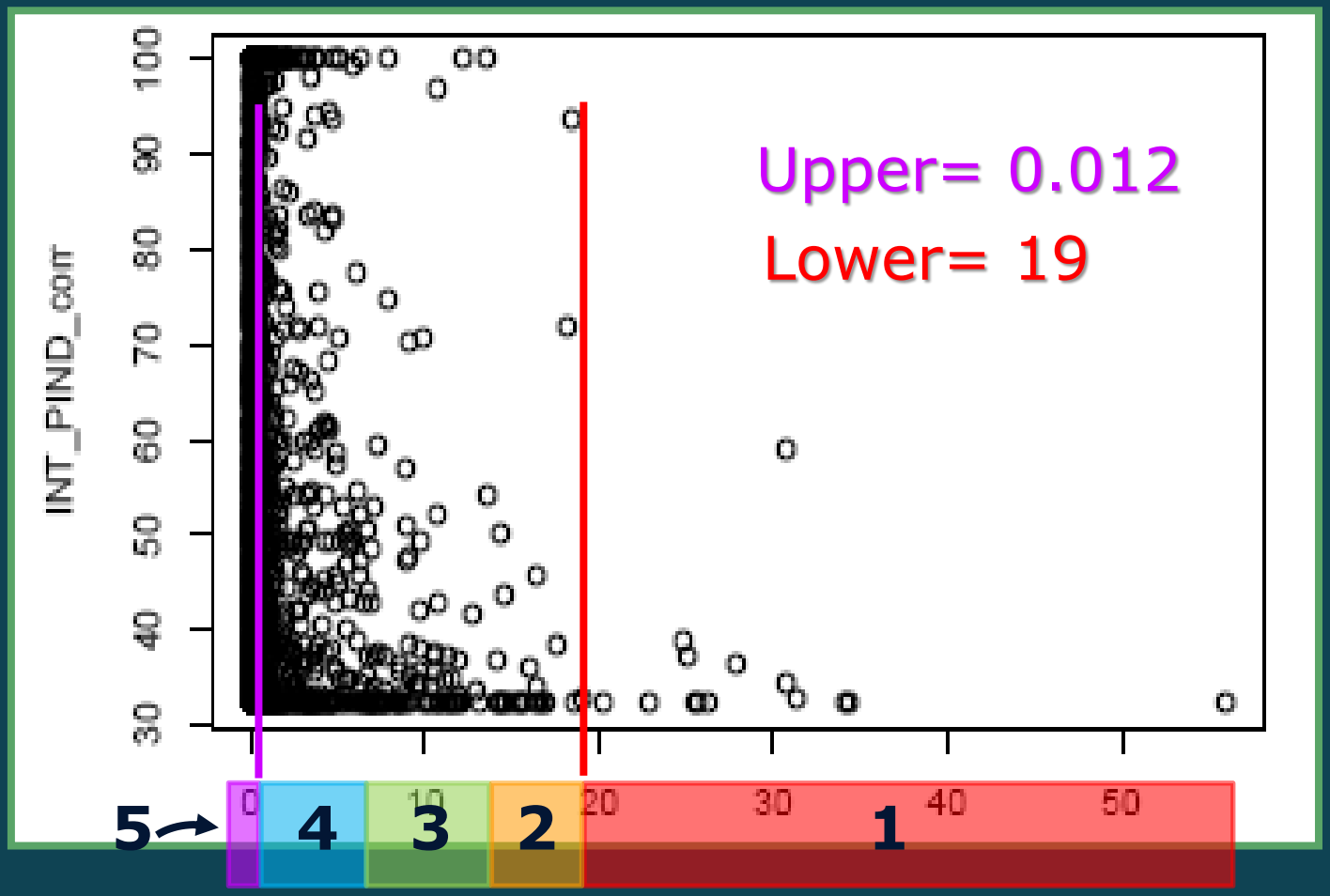
1. Repeating, characteristic response across metrics and stresses
2. Area under the curve = limited by other stresses

TO GENERATE SCORES FOR EACH REACH, WE

IDENTIFIED CONDITION CLASSES

FOR EACH BIOLOGICAL METRIC-STRESS PLOTS BY REGION

1. Threshold at which impairment begins, Baker and King (2010)
2. Maximum level of degradation, identified visually
3. Mid-range scores determined by equal breaks



% NETWORK MEDIUM DENSITY URBAN (NAP)

STRESS VALUES TO CONDITION SCORES FOR REACHES FOR INDIVIDUAL BIOLOGICAL METRICS

1. Biological condition can only be as good as its response to its most limiting influence

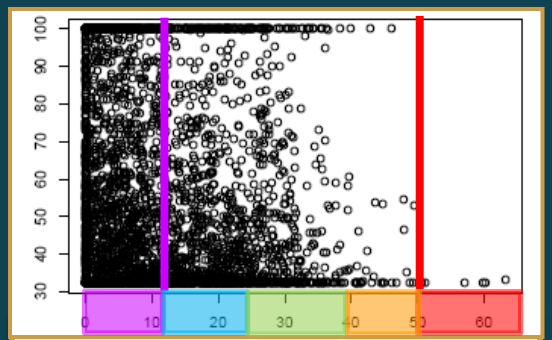
2. Habitat condition determined by most limiting stress to each reach

Actual Reach Stress Values

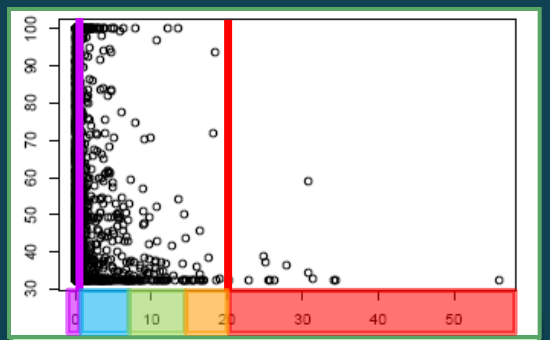
Reach	%Urb	%Past	#Dam
1	4	10	0
2	0	60	0
3	18	3	4

CONDITION SCORE FOR BIOLOGICAL METRIC

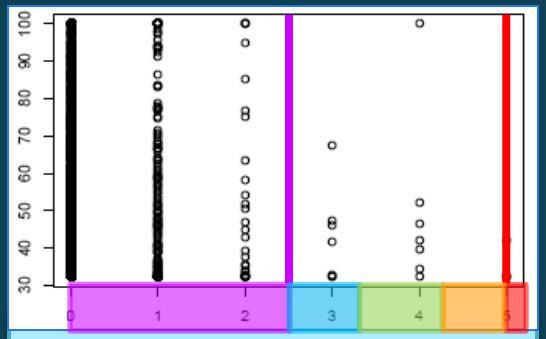
Reach	Urb	Past	Dam	HCI
1	4	5	5	4
2	5	1	5	1
3	2	5	3	2



% Network Urban



% Local Pasture



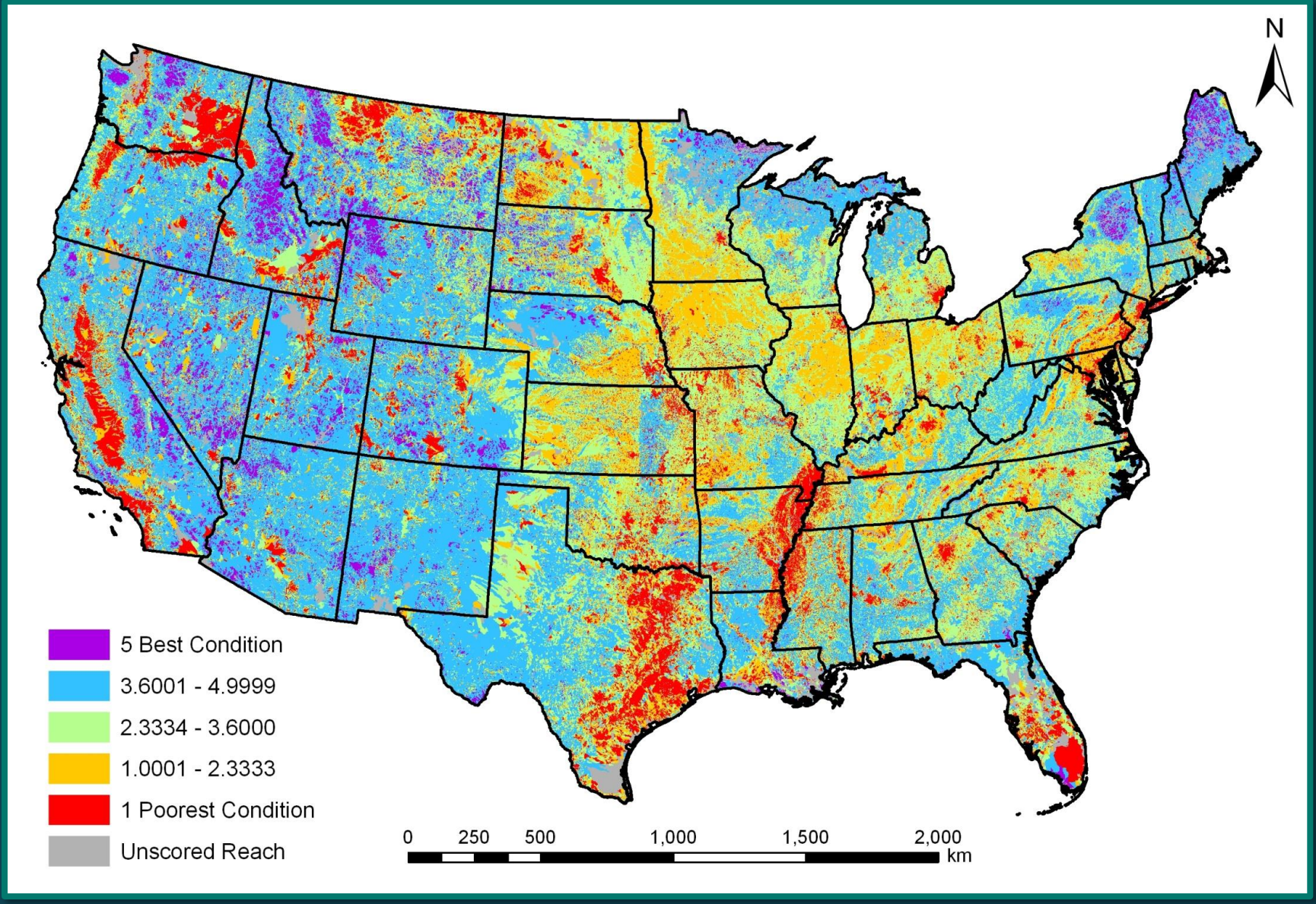
Network Dams

CUMULATIVE SCORE FOR STREAM REACH

BASED ON MULTI-METRIC RESPONSE OF FISH ASSEMBLAGES

- Previous step: created habitat condition index (HCI) for each biological metric for each reach in each region
- Next step: averaged individual biological metric scores for a reach to derive average habitat condition index (HCI)
- Mapped scores…

Reach	Biometric1	Biometric 2	Biometric 3	AvgHCI
1	4	5	5	4.66
2	5	1	5	3.66
3	2	5	3	3.33



RESULTS OF 2010 LANDSCAPE ASSESSMENT OF FISH HABITAT CONDITIONS IN UNITED STATES RIVERS AND THEIR WATERSHEDS

OPPORTUNITIES
FOR 2015 ASSESSMENT

- Fish data – add additional records
- Characterize dams and river fragmentation more accurately
- Summarize disturbances in stream buffers
- Characterize water withdrawals
- Test/enhance our scoring approach…

New & Updated Data

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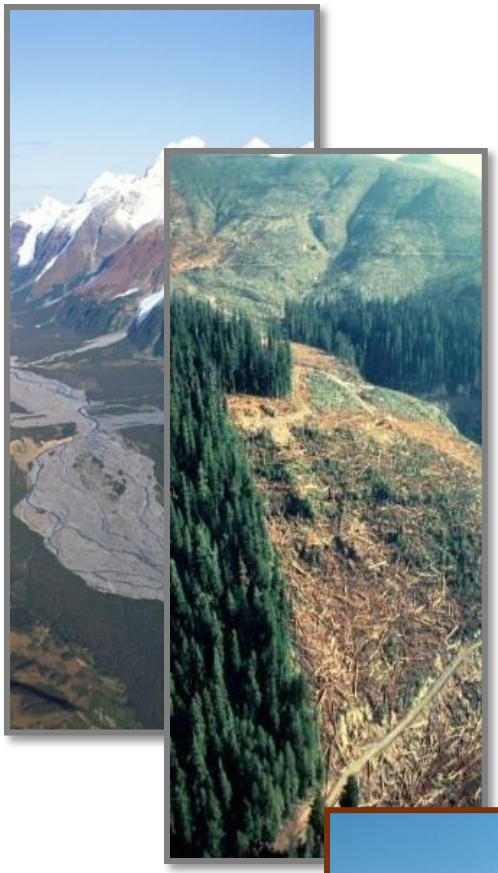
SELECTION OF LANDSCAPE VARIABLES



Identified GIS datasets summarizing disturbances that were:

1. Representative of conditions since 2000
2. Consistent across conterminous US
3. Meaningful for assessing fish habitat
4. * Of fine enough spatial resolution to discriminate between catchments

* Like to revisit this point

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Updated & New Landscape Data

- NHDPlus V1
- Updated
  - Land use 2006 NLCD
  - Road variables 2006 TIGER
  - Climate data 1990-2010
- New
  - 90m buffer for local and network catchments
  - NABD dams & fragmentation metrics
  - Mine variables (Coal and Uranium mines)
  - *Atmosphere deposition (Nitrate and Sulfate)
  - *Water withdrawals
  - *County-Level Estimates of Nutrients

Glen Canyon Dam on the Colorado River, AZ
www.cliffdwellerslodge.com

Largest mine in US
Bingham Canyon Mine, UT
Google Earth

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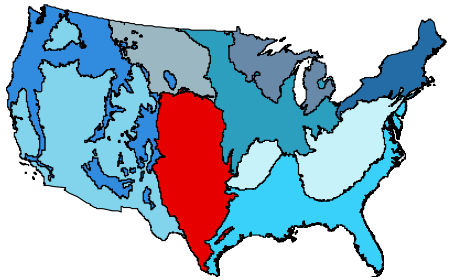
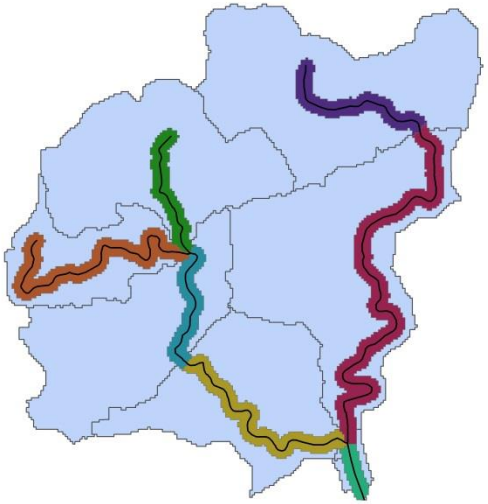
REGIONAL DETERMINATION OF ASSESSMENT SCORES



Network catchment & 90m buffer

Local catchment & 90m buffer

Habitat



Fishes

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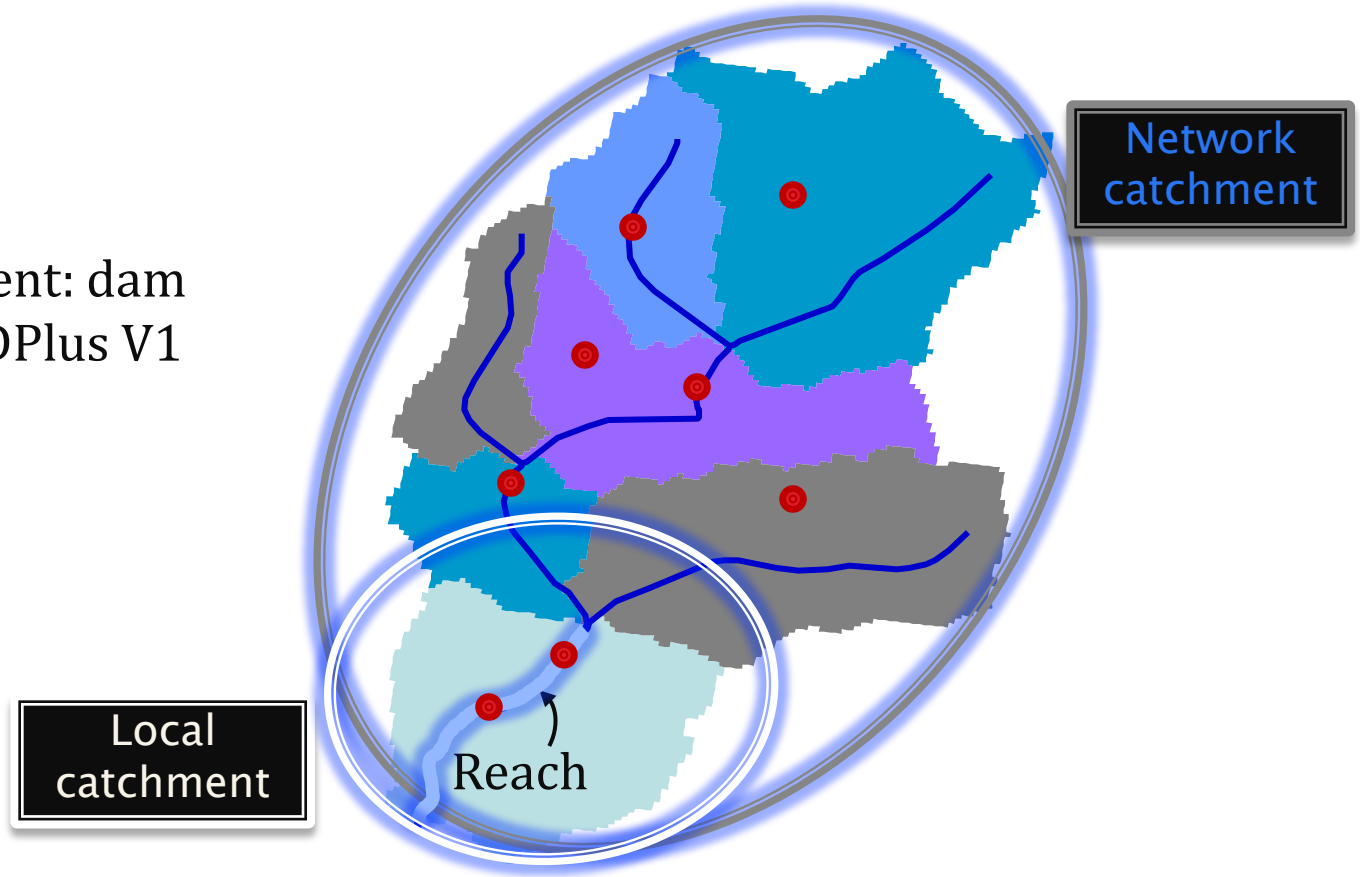
Improved Landscape Data: Dams

2010 assessment: dam density in NHDPlus V1 catchments



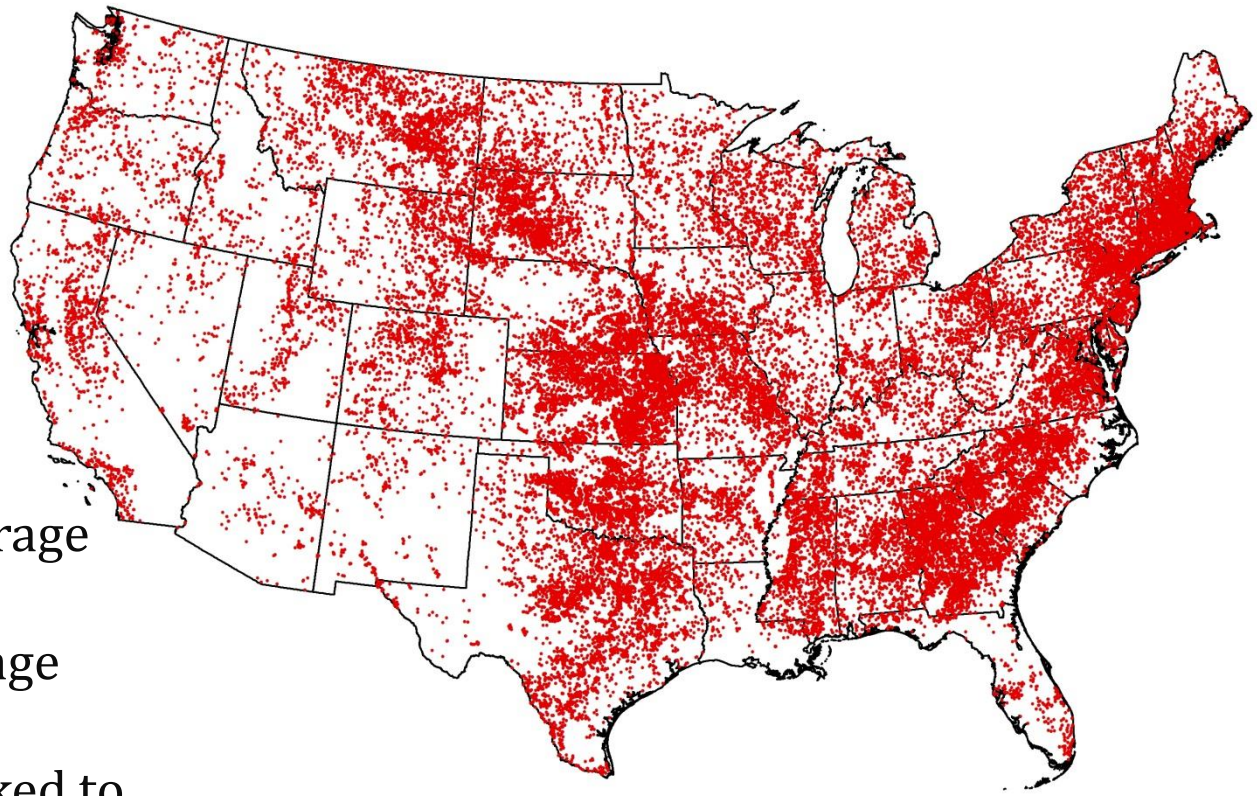
2012 National Anthropogenic Barrier Dataset (NABD)

- ~80,000 total dams

- Original dataset: National Inventory of Dams (NID) 2009

- Size Criteria:
>25ft height & 15ac ft storage
Or
>6ft height & 50ac ft storage

- Spatially verified and linked to NHDPlus V1



Cooper et al. In Prep
Dam fragmentation metrics

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Fragmentation Metrics

Selected four fragmentation metrics:

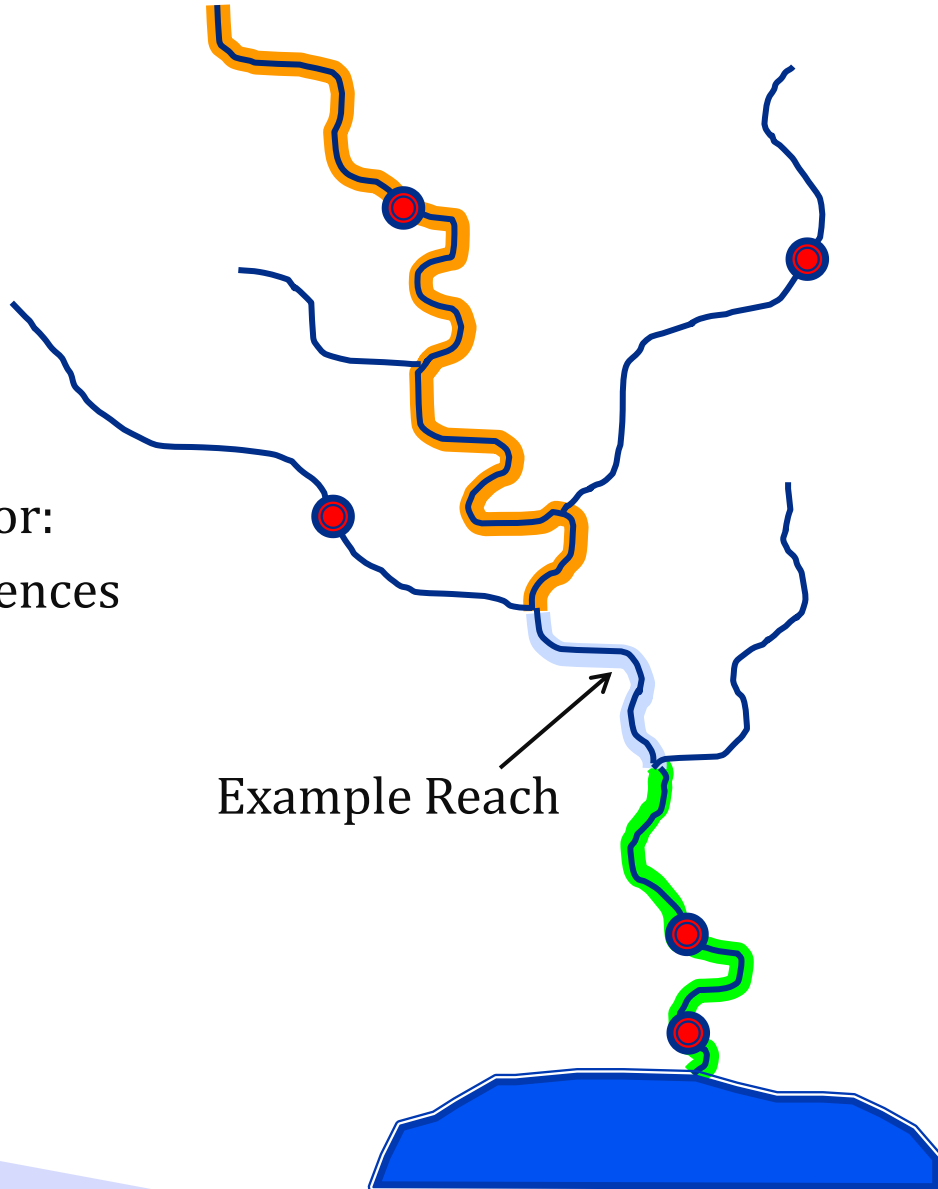
1. Upstream network density
2. Downstream mainstem density
3. Upstream mainstem openness
4. Downstream mainstem openness

Combined, this set of metrics accounts for:

Upstream and downstream dam influences

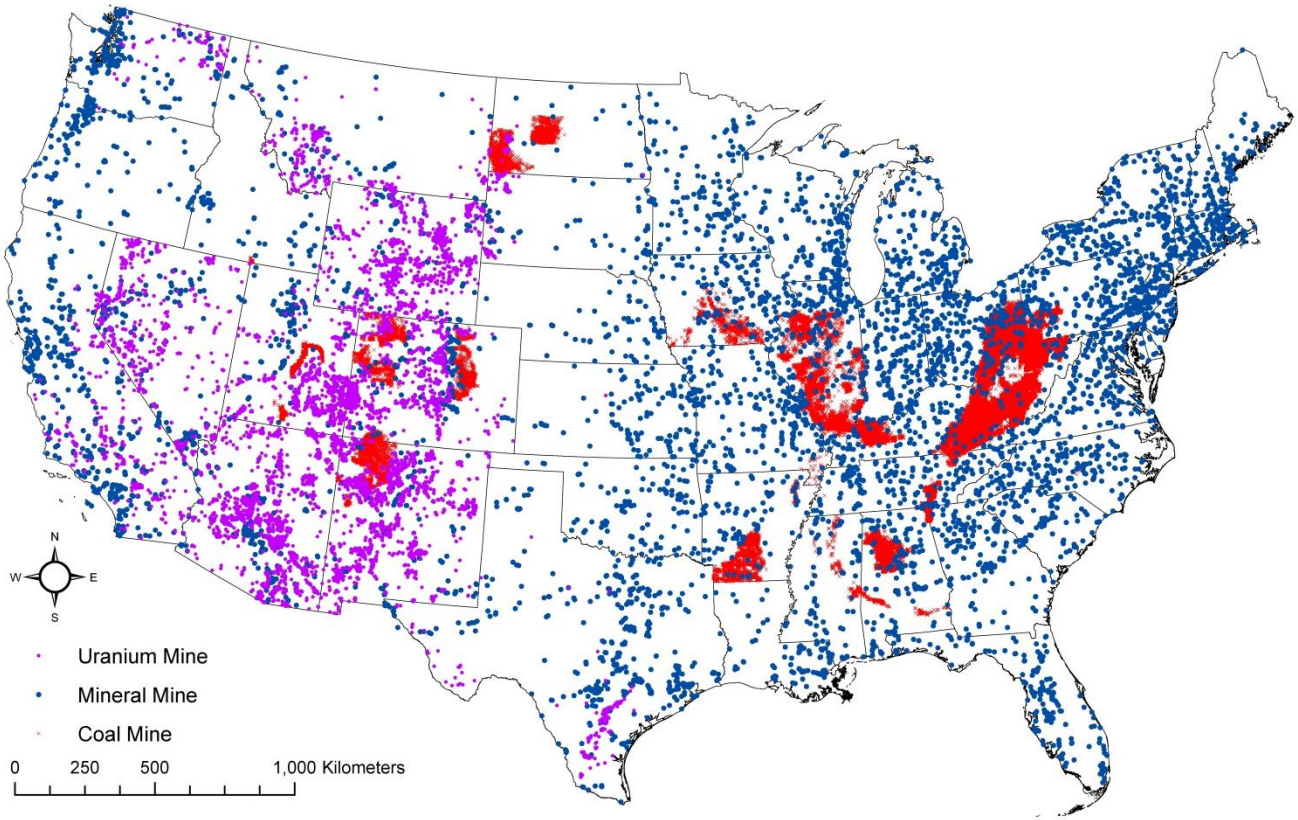
Connectivity loss

Cumulative dam effects



Coal and Uranium Mines Datasets

Conterminous US only



- ~70,000 coal mines
- ~92,000 minor coal mine support activities
- ~22,000 Uranium mines
- Spatially linked to NHDPlus V1

Daniel et al. *In review* Ecological Applications

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LANDSCAPE VARIABLES TO BE USED IN 2015 ASSESSMENT

Anthropogenic

- Open/low intensity urban land use (%)
- Medium intensity urban land use (%)
- High intensity urban land use (%)
- Impervious surface (%)
- Pasture/hay land use (%)
- Cultivated crops land use (%)

} 2006 NLCD

- Population density (#/km^2) — 2000 Census
- Road length (m/km^2)
- Road crossings (#/km^2)

} 2006 TIGER

- *Dams and fragmentation metrics (#/km^2) — 2012 NABD
- Mines (Mineral, *Coal, *Uranium) (#/km^2) — 2003 USGS, 2012 USGS, 2003 EPA
- Toxics release inventory sites (#/km^2)
- National pollution discharge elimination system sites (#/km^2)
- EPA superfund national priorities sites (#/km^2)

} 2007 EPA

- *Atmosphere deposition (Nitrate and Sulfate) (ug/ha) — 1994-2010 NADP
- *Water withdraw (Surface and Ground) (MGD/Km^2*100) — 2005 USGS
- *County-Level Estimates of Nutrient Inputs to the Land(kg/km^2) — 1982-2001 USGS

*= new variables

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LANDSCAPE VARIABLES TO BE USED IN 2015 ASSESSMENT

Anthropogenic

Open/low intensity urban land use (%)
Medium intensity urban land use (%)
High intensity urban land use (%)
Impervious surface (%)
Pasture/hay land use (%)
Cultivated crops land use (%)
Population density (#/km^2)
Road length (m/km^2)

Summarized at:
Network, Local catchment, and 90m Buffer

Road crossings (#/km^2)
*Dams and fragmentation metrics (#/km^2)
Mines (Mineral, *Coal, *Uranium) (#/km^2)
Toxics release inventory sites (#/km^2)
National pollution discharge elimination system sites (#/km^2)
EPA superfund national priorities sites (#/km^2)

Summarized at:
Network, Local catchment

*Atmosphere deposition (Nitrate and Sulfate) (ug/ha)
*Water withdraw (Surface and Ground) (MGD/km^2*100)
*County-Level Estimates of Nutrient Inputs to the Land (kg/km^2)

Summarized at:
Network catchment

*= new variables

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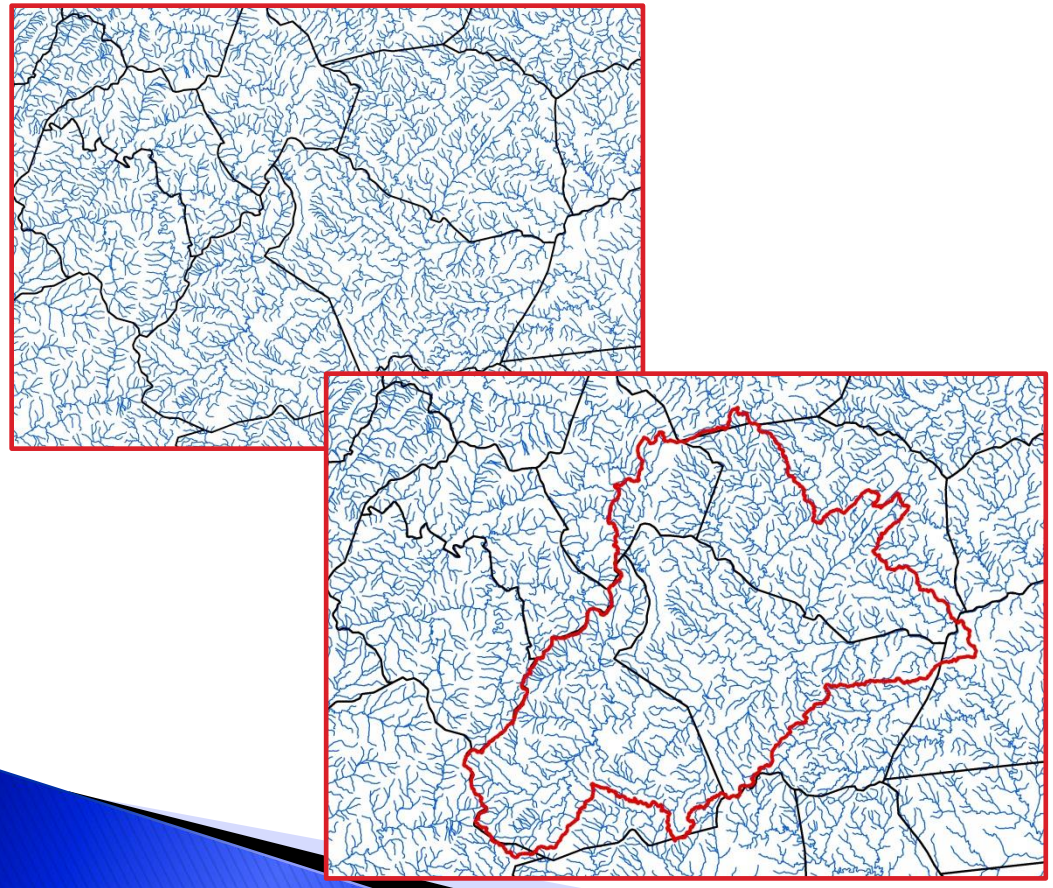
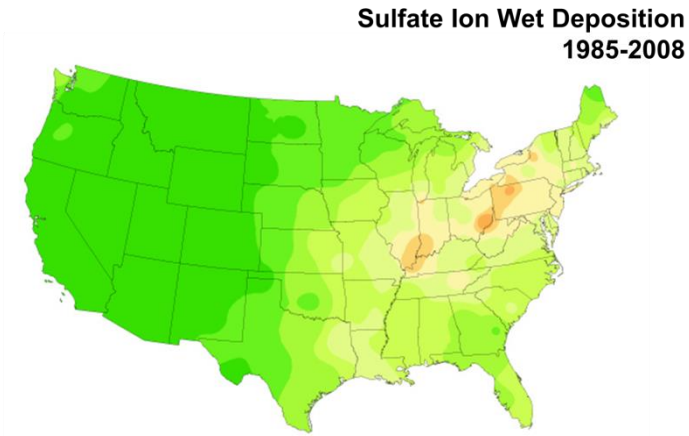
LANDSCAPE VARIABLES TO BE USED IN 2015 ASSESSMENT

Atmosphere deposition (Nitrate and Sulfate) (ug/ha)- NADP
Water withdraw (Surface and Ground) (MGD/km^2*100)-USGS
County-Level Estimates of Nutrient Inputs to the Land(kg/km^2)-USGS





Question:
Should we incorporate variables that do not discriminate among arcs in the assessment?

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LANDSCAPE VARIABLES TO BE USED IN 2015 ASSESSMENT

Natural

(Used in establishing best available condition)

Mean elevation of local catchment (m)
Mean slope of local catchment (degrees)
} 2005 USGS

Mean annual air temperature (degrees C)
Mean annual precipitation (mm/year)
} 1990-2010 PRISM

Network catchment area (km^2) — NHDPlus V1

Baseflow index (base flow/total flow * 100) — 2003 USGS

Additional natural variables:

TNC easement layer — 2012

Stewardship layer — 1993-2007 GAP Land Stewardship USGS

Surficial Lithology — 2004 USGS

STATSGO soil hydrology — 1995 USGS

SELECTION OF FISH SAMPLES

Photos Credit: Kyle Herreman & Daniel Wieferich

Identified fish community samples from state, federal, university, and museum sources:

1. Fish samples since 1990
2. Collected by single pass electrofishing techniques
3. Whole community samples (not target species sampling)
4. Relative abundance/counts for species (not presence/absence)
5. Site location data

New Fish Community Data

- Number of fish records in fish database
  - **2010: 633,200**
  - **2015: 855,039**
- Updated data from previous state providers
- Number species represented in 2015 database
  - 702 species (excludes hybrids and subspecies)
- *Fish abundance data for Alaska
- *Fish presence/absence for Hawaii

* Will be discussed in a future call

Fishes of Northern Kentucky

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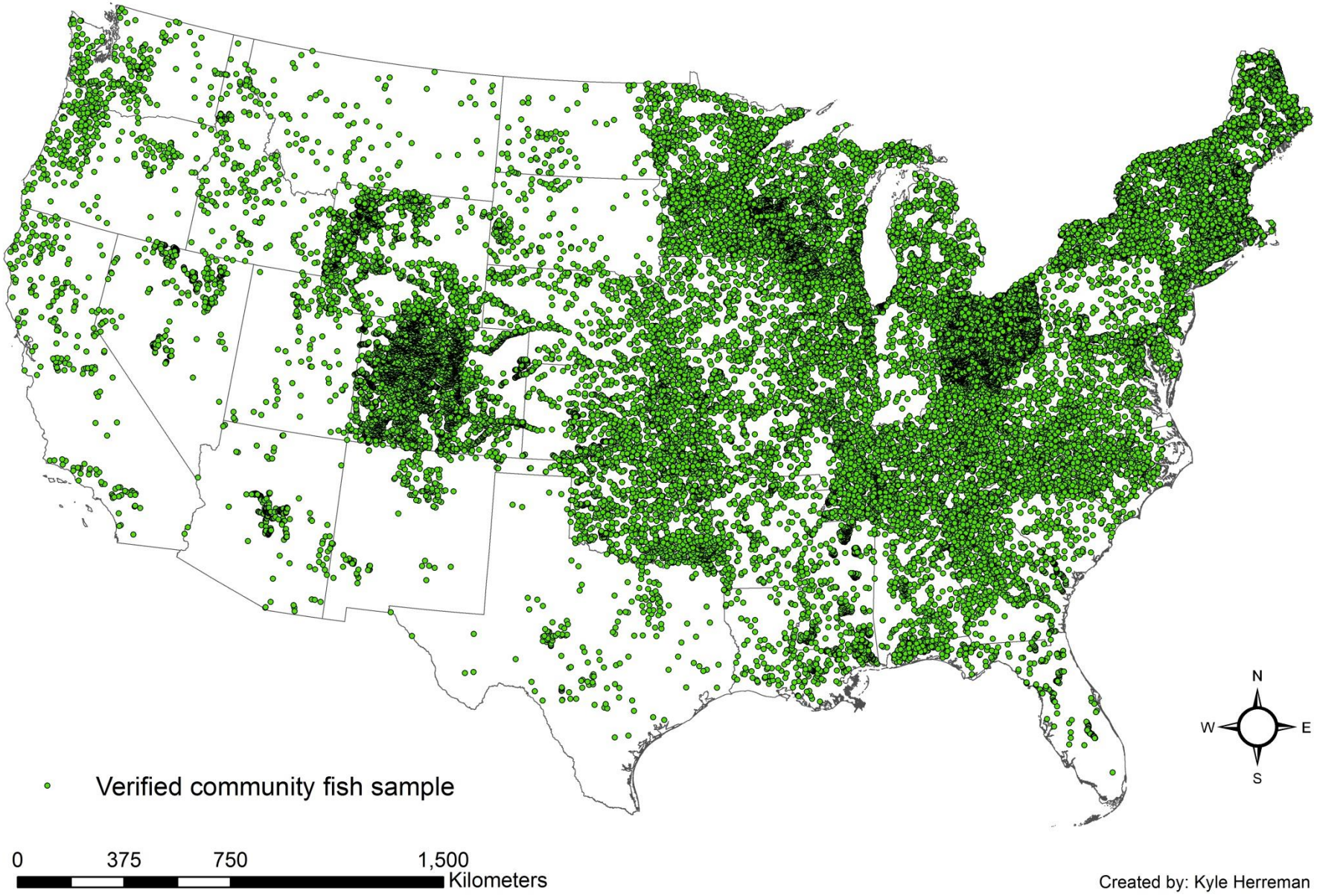
N
W
E
S
Verified community fish sample
0
375
750
1,500
Kilometers
Created by: Kyle Herreman

Improvements to the Analytical Methods

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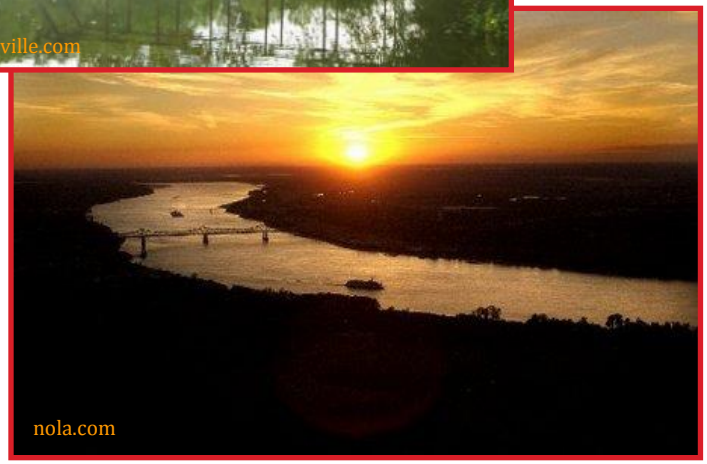
Site Variation

- 2010 assessment accounted for variation between sites in WSA ecoregions
- We propose to also use stream size classes in ecoregions
  - When enough data is available
- Stream size classes based on Goldstein and Meador 2004, Wang et al. 2011
- Headwater <100 km^2
- Medium rivers 100<10,000 km^2
- Large rivers >10,000 km^2

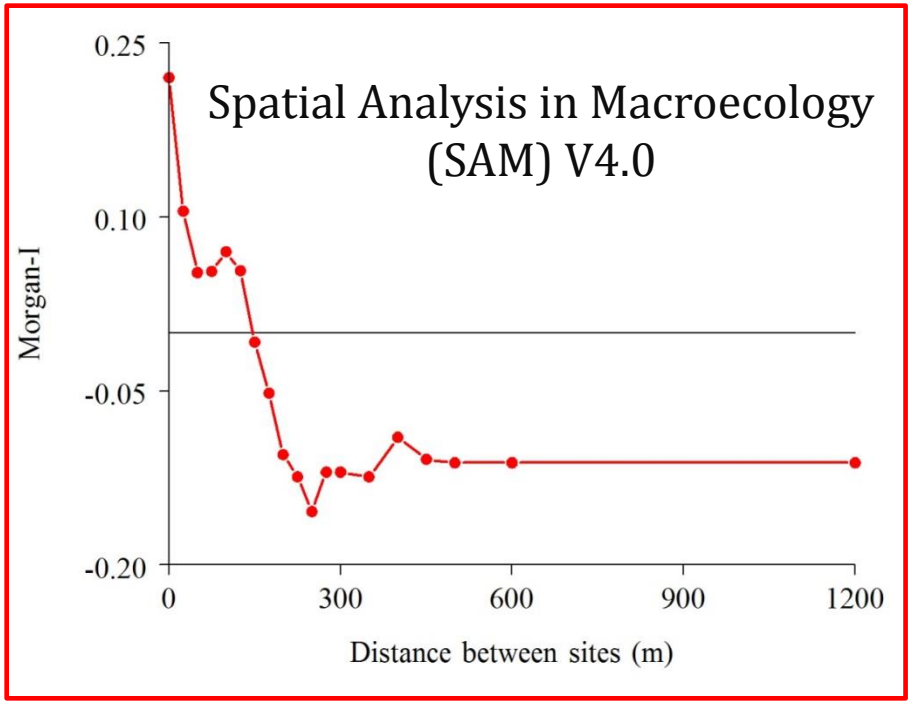
Stream in Ohio

Green River, KY



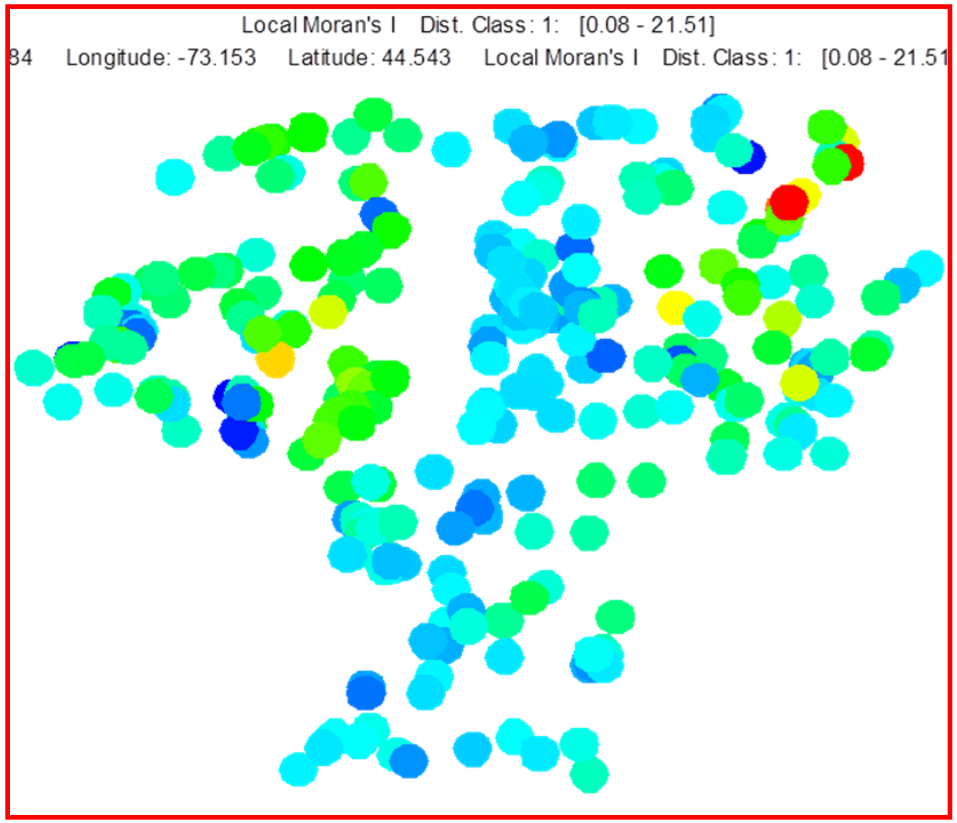
Mississippi River near New Orleans, LA

Controlling for Spatial Autocorrelation



Controlling spatial autocorrelation in fish sample sites

- Conterminous US in HUC 6s



Example:
HUC 6: 20100
Highest Moran I: 0.21
In states :
Vermont and
New York

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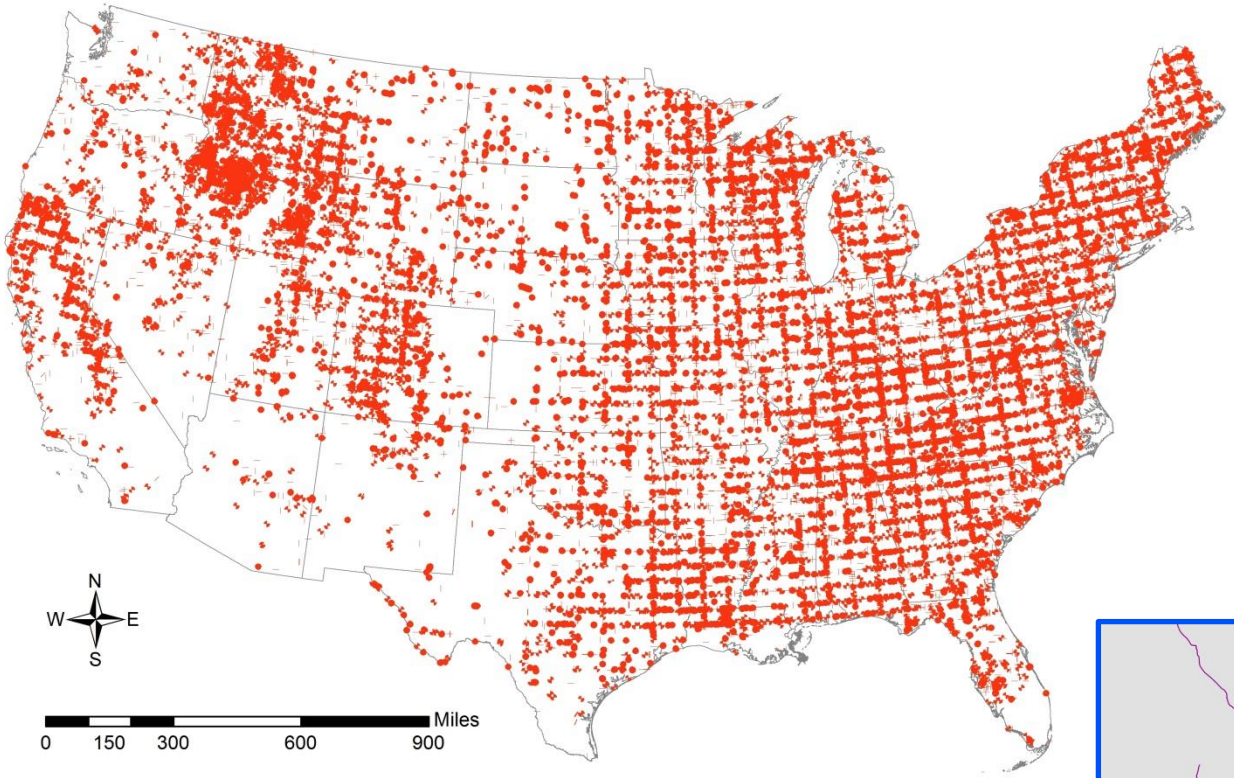
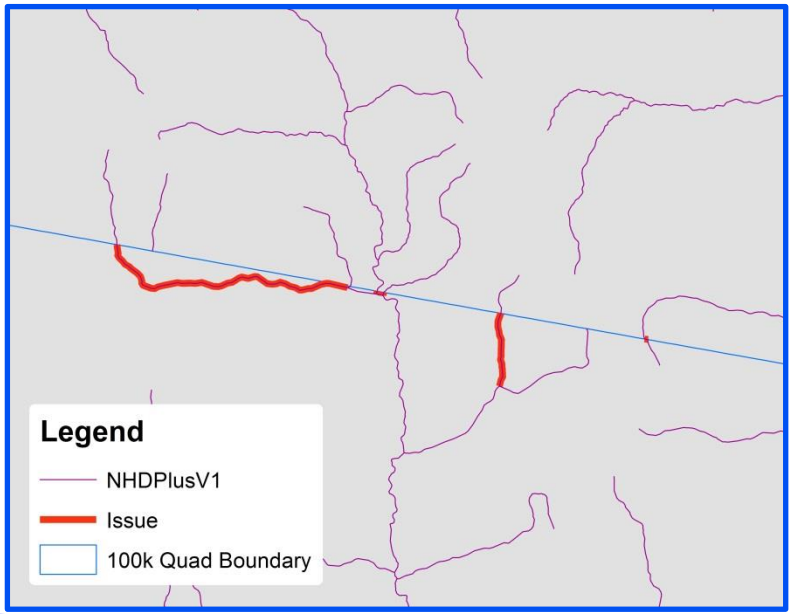
Artificial Reaches



- ~1% of Arcs
- We did not alter NHDplus V1
- Arcs found to be artificially broken at quad boundaries were linked together in the database



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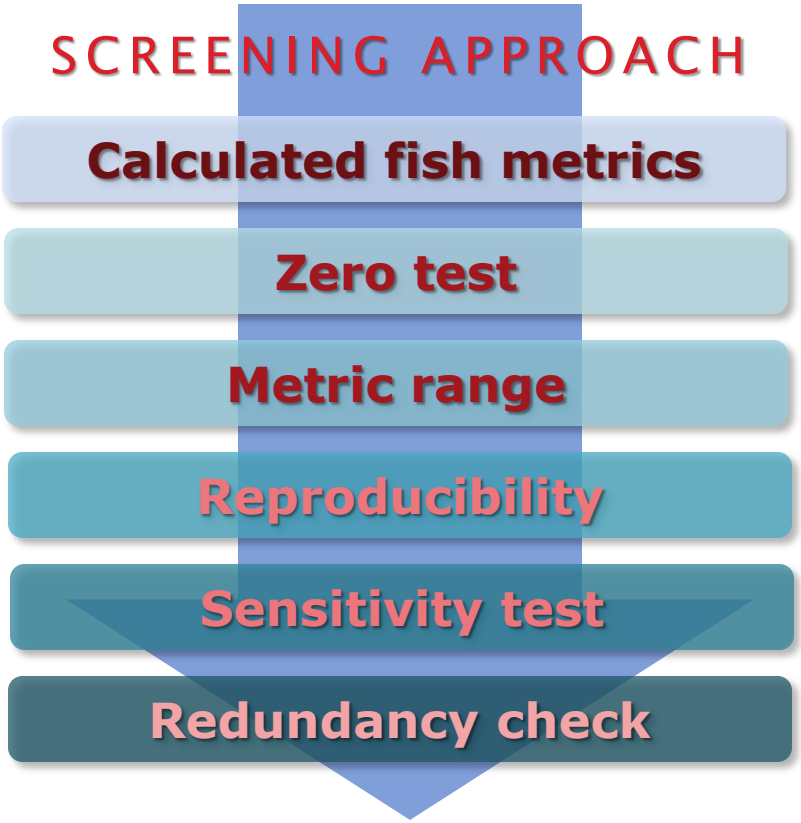
IDENTIFYING FISH METRICS
TO INDICATE HABITAT CONDITION

- Select new set of fish metrics following the Stoddard et al. (2008) approach for each WSA ecoregion
  - Emmanuel A. Frimpong's (Virginia Tech) newest fish trait matrix
  - New EPA intolerant and tolerant metrics developed from literature*
- Also use the previously selected metrics from the 2010 assessment
- New game fishes metric*



*Daniel et al. *In review* Ecological Applications

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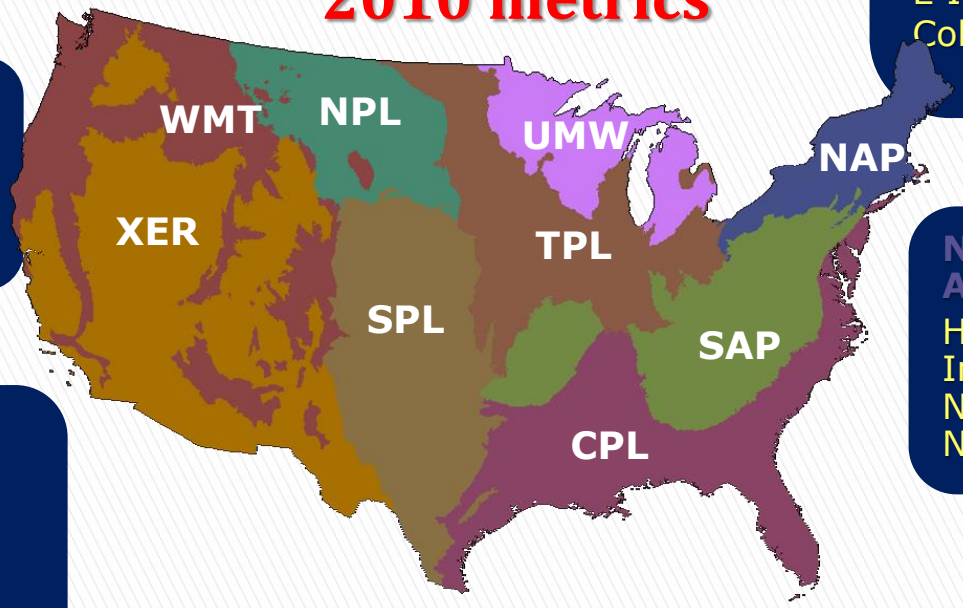
2010 metrics

Western Mountain (WMT)
% Native Water Col Individuals, Native Lithophilic Individuals, Native Herbivore Taxa, Native Lotic Individuals, Omnivore Taxa

Northern Plains (NPL)
Herbivore Individuals, Lithophilic Taxa, T & E Individuals

Upper Midwest (UMW)
Native Herbivore Taxa, Native Hider Taxa, Intolerant Individuals, Lithophilic Individual, Omnivore Individuals, Piscivore Individuals, T & E Individuals, Water Column Taxa

Xeric Region (XER)
Herbivore Individuals, Lithophilic Taxa, T & E Individuals



Northern Appalachians (NAP)
Herbivore Individuals, Intolerant Individuals, Native Lithophil Taxa, Native Piscivore Taxa

Southern Plains (SPL)
Omnivore Taxa, Native Herbivore Taxa, Native Lithophilic Individuals, Native Lotic Individuals, Native Water Column Ind.

Tallgrass Prairie (TPL)
Herbivore Taxa, Invertivore Individuals, Native Lithophil Taxa, Native Lotic Individuals, Native Piscivores, Nesting Taxa, Water Column Taxa

Southern Appalachians (SAP)
Lithophilic Individuals, Intolerant Individuals, Native Piscivore Individual, Native Rheophilic Taxa, Native Water Column Ind.

Coastal Plains (CPL)
Herbivore Taxa, Native Invertivore Taxa, Nesting Individuals, Omnivore Individuals

EPA Intolerant and Tolerant metrics

- Intolerant and tolerant species metrics were developed from the USEPA's published list of fish indicator species (Grabarkiewicz and Davis 2008).

- Ohio EPA 1987
- Jester et al. 1992
- Lyons 1992
- Whittier and Hughes 1998
- Barbour et al. 1999
- Halliwell et al. 1999
- Pirhalla 2004
- *Whittier et al. 2007

*= Added to the EPA List

- We chose the most conservative species from the list that had the majority of their designations as either tolerant or intolerant, but not both.

Daniel et al. *In review* Ecological Applications

EPA Intolerant and Tolerant metrics

Tolerant Fishes

Scientific name	Common name
Ameiurus melas	Black bullhead
Ameiurus natalis	Yellow bullhead
Ameiurus nebulosus	Brown bullhead
Carpiodes carpio	River carpsucker
Catostomus commersonii	White sucker
Ctenopharyngodon idella	Grass carp
Cyprinus carpio	Common carp
Fundulus diaphanus	Banded killifish
Fundulus heteroclitus	Mummichog
Lepomis cyanellus	Green sunfish
Lepomis macrochirus	Bluegill
Perca flavescens	Yellow perch
Pimephales notatus	Bluntnose minnow
Pimephales promelas	Fathead minnow
Rhinichthys atratulus	Eastern blacknose dace
Semotilus atromaculatus	Creek chub

Intolerant Fishes

Scientific name	Common name
Acipenser brevirostrum	Shortnose sturgeon
Acipenser medirostris	Green sturgeon
Acipenser oxyrinchus	Atlantic sturgeon
Acipenser transmontanus	White Sturgeon
Ammocrypta pellucida	Eastern sand darter
Catostomus insignis	Sonora sucker
Catostomus occidentalis	Sacramento sucker
Centrarchus macropterus	Flier
Clinostomus elongatus	Redside dace
Cottus aleuticus	Coastrange sculpin
Cottus bairdii	Mottled sculpin
Cottus beldingi	Paivte Sculpin
Cottus carolinae	Banded sculpin
Cottus confusus	Shorthead Sculpin
Cottus klamathensis	Marbled Sculpin
Cottus leiopomus	Wood River Sculpin
Elassoma zonatum	Banded pygmy sunfish
Enneacanthus chaetodon	Blackbanded sunfish
Erimystax dissimilis	Streamline chub
Erimystax x-punctatus	Gravel chub
Etheostoma camurum	Bluebreast darter
Etheostoma histrio	Harlequin darter
Etheostoma maculatum	Spotted darter
Etheostoma zonale	Banded darter
Fundulus catenatus	Northern studfish
Hypentilium nigricans	Northern hog sucker
Hybopsis amblops	Bigeye chub
Ichthyomyzon fossor	Northern brook lamprey
Ichthyomyzon gagei	Southern brook lamprey
Ichthyomyzon greeleyi	Mountain brook lamprey
Lampetra appendix	American brook Lamprey
Lampetra richardsoni	Western Brook Lamprey
Lampetra similis	Klamoth River Lamprey
Lampetra tridentata	Pacific lamprey
Lota lota	Burbot
Moxostoma carinatum	River redhorse
Moxostoma cervinum	Black redhorse
Moxostoma lachneri	Greater jumprock
Moxostoma valenciennesi	Greater redhorse
Nocomis biguttatus	Hornyhead chub
Nocomis micropogon	River chub
Notropis rubellus	Rosyface shiner

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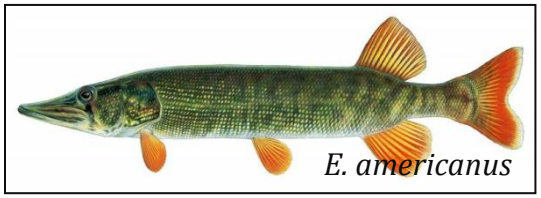
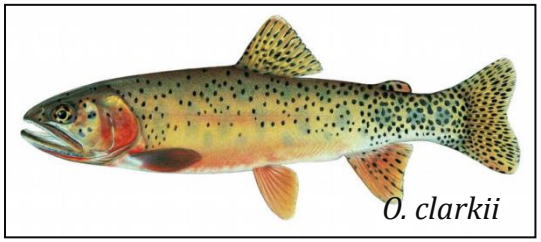
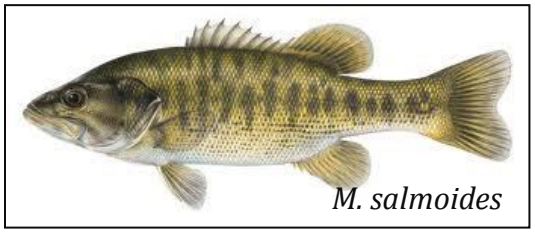
Game Fishes Metric

NFHP Science and Data Board reviewed in Spring 2013

- Game fishes are defined in this study as species (or in some cases, groups of fishes) that are recognized by individual states as potentially being targeted by anglers and that have regulations limiting their harvest for recreational use as described in publically-available fishing guide books specific to each state.
- The purpose for generating this metric is to test responsiveness of game fishes to anthropogenic landscape disturbances.
- This metric was specific to each state and reflects only that state's recognized game species.







Daniel et al. *In review* Ecological Applications

Images from Fishes of Texas

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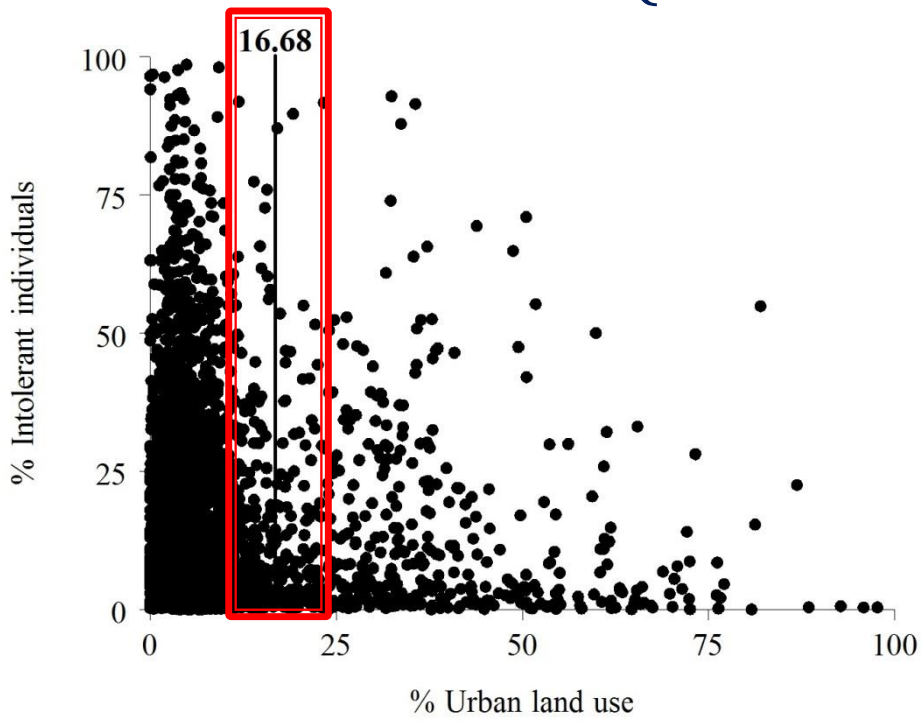
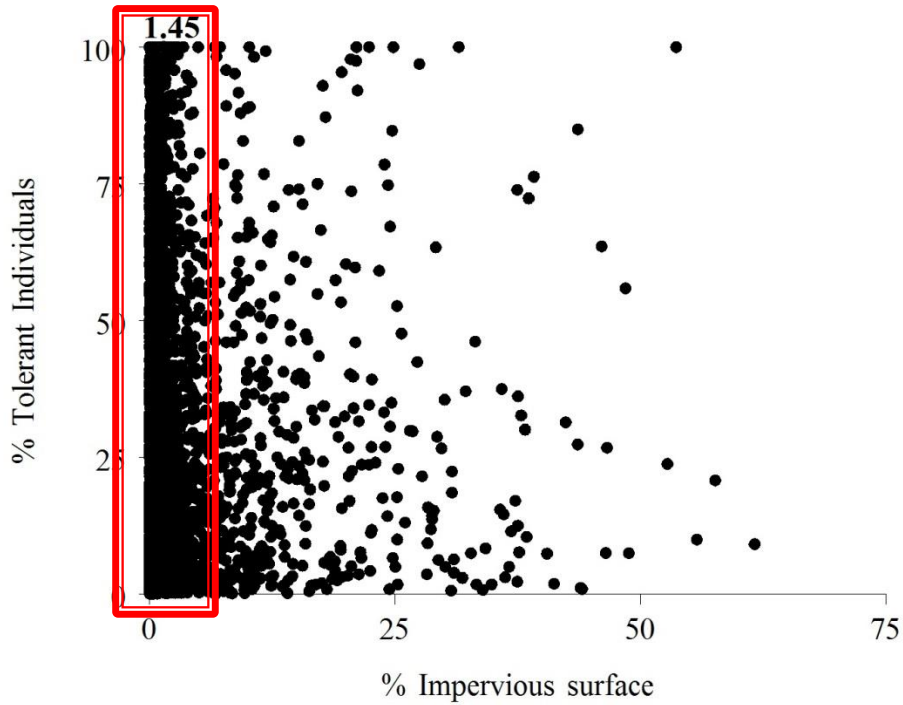
Threshold Detection

TITAN (Baker and King 2010)



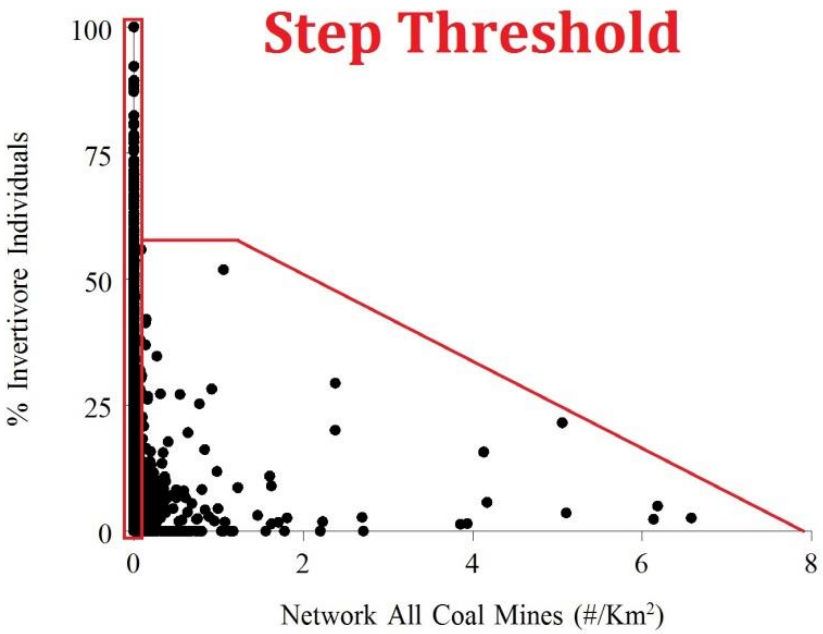


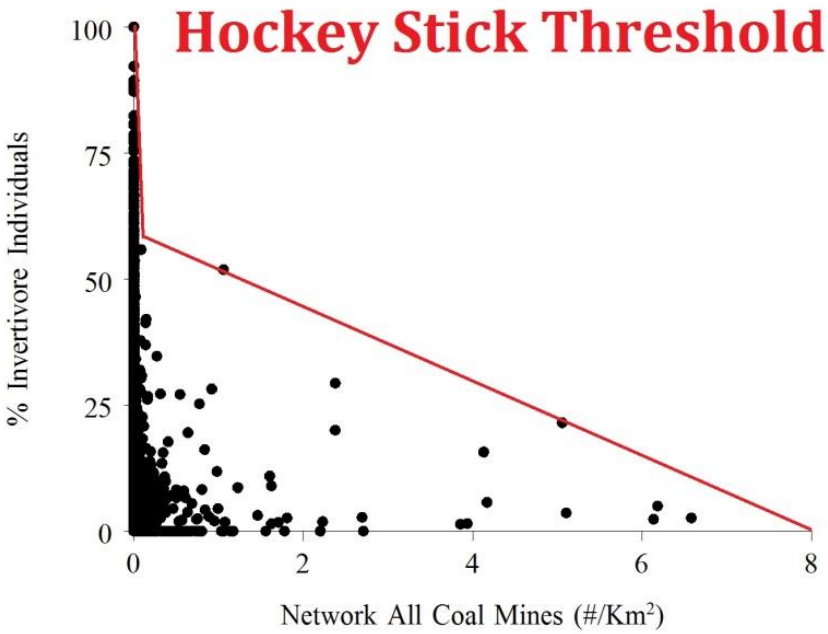
Recent Freshwater Science Articles

Cuffney and Qian 2013

Baker and King 2013

Threshold Detection





TITAN (Baker and King 2010)
(change-point analysis with indicator analysis)

R code Segmented (Muggeo 2013)
(piecewise regression)

- To be considered a significant threshold
  - Both techniques had to be significant
  - Threshold point has to overlap within the ≤ 5% error rate

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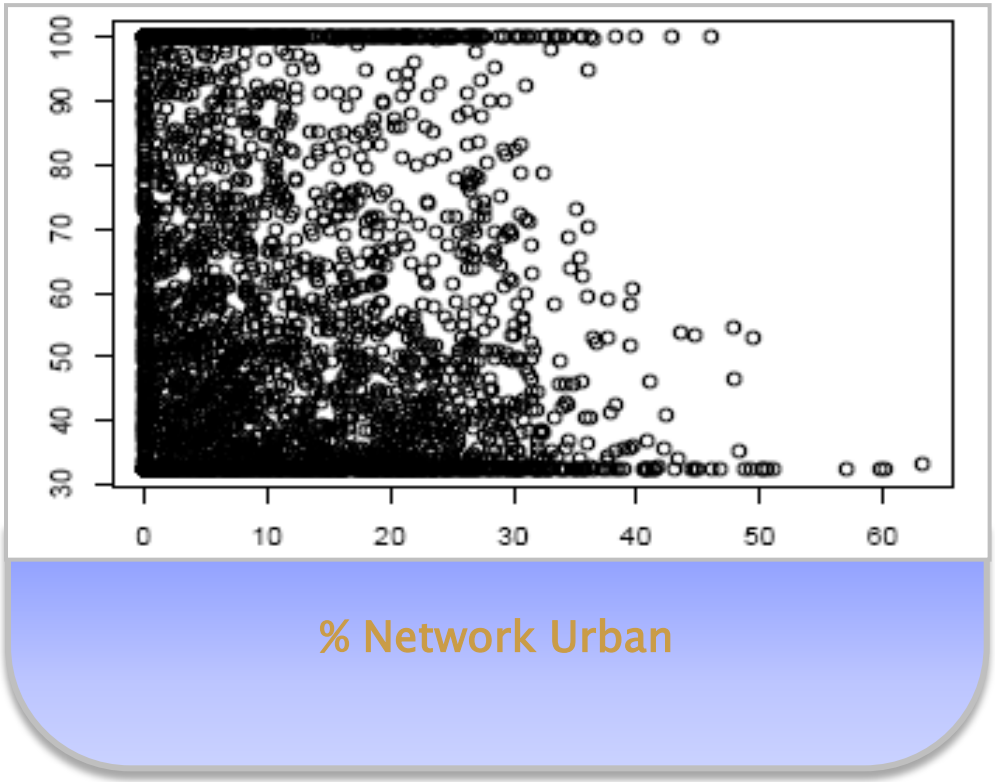
Daniel et al. *In review* Ecological Applications

IDENTIFIED CONDITION CLASSES

- 2010 assessment used 5 classes to represent habitat condition based on the community response to most limiting disturbance variable.
- Maintain that number of condition classes
- Test the development of breaks in the intermediate classes
- Incorporate multiple disturbances



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IDENTIFIED CONDITION CLASSES

- Continue with 5 score groups
- An assessment with 5 categories allows multiple categories with an intermediate condition and allow detection of small changes in habitat quality
- Follows EPA Biological condition gradient

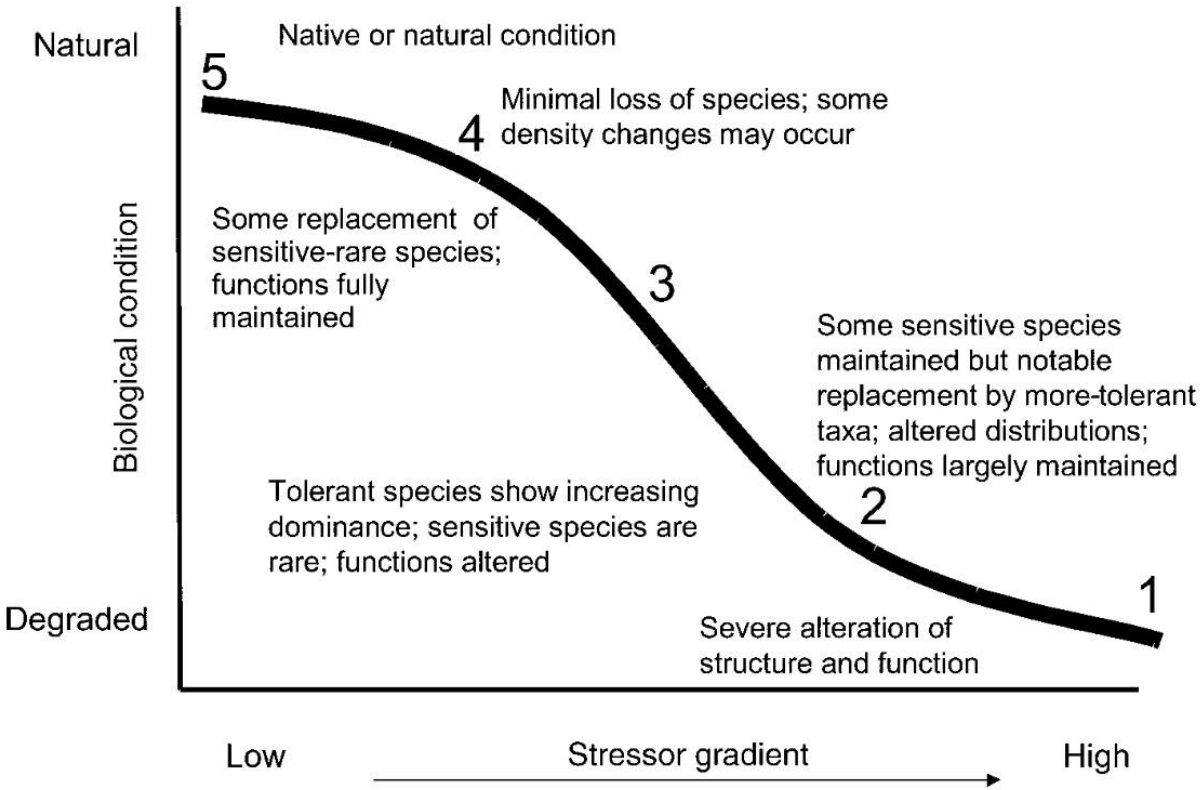

Figure based on :
Davies and Jackson 2006

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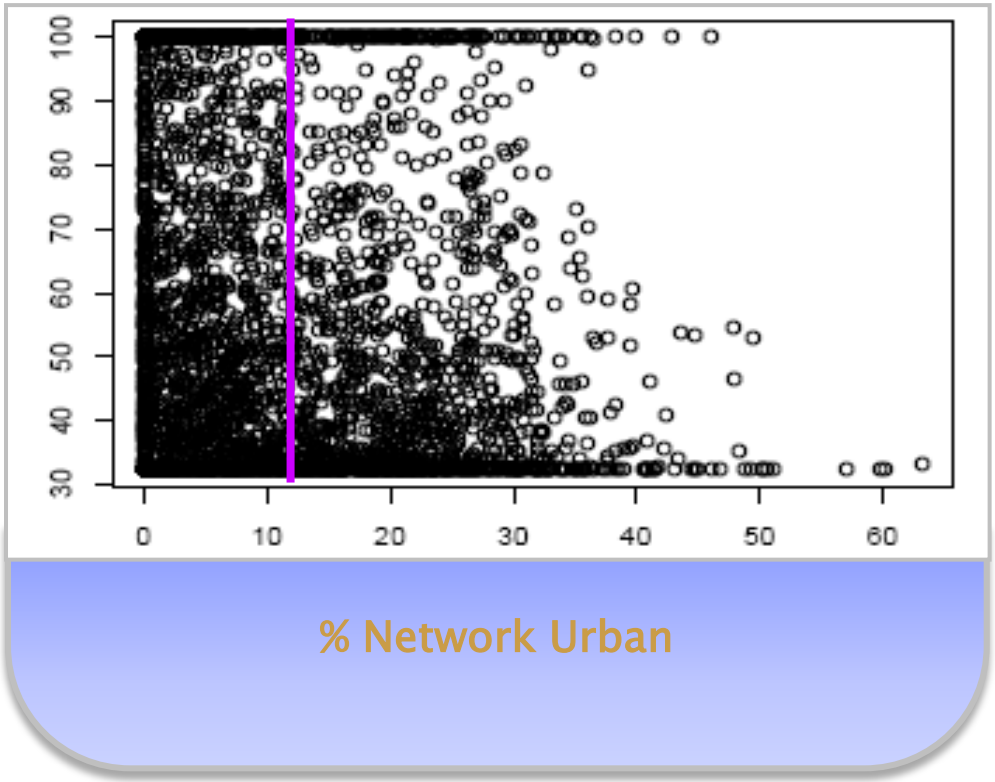
EPA United States Environmental Protection Agency

Condition classes scoring

Threshold point



Condition classes scoring: breaks in intermediate classes

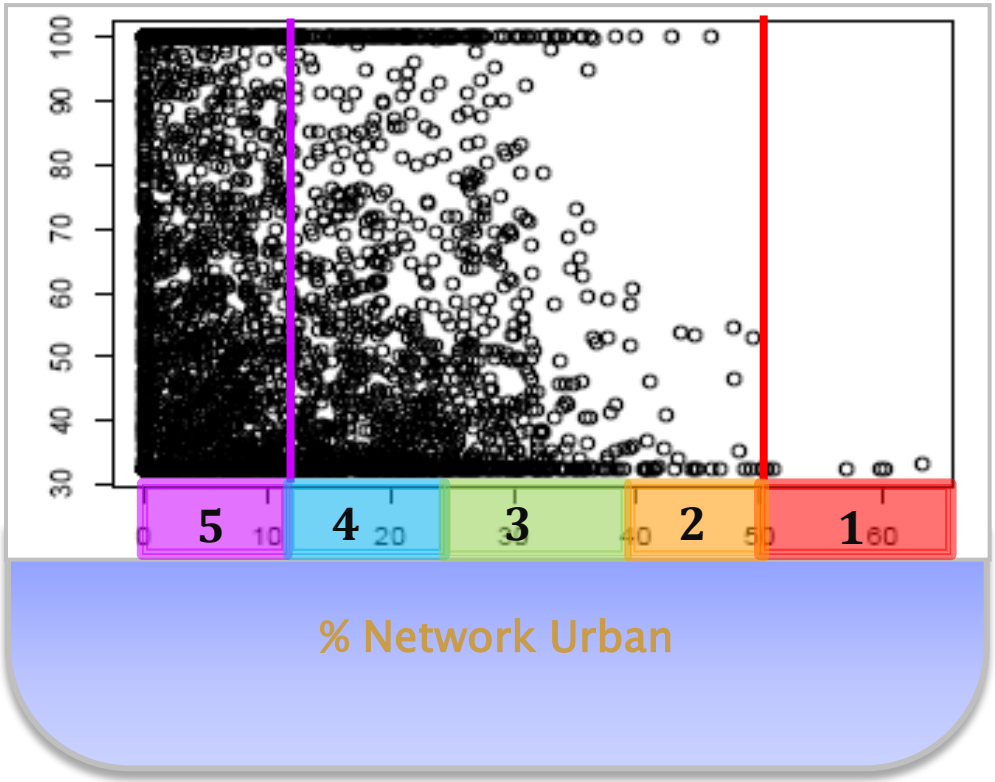
Testing new methods:
Natural breaks
Standard deviations

Threshold point

Group 5: best available
From zero on X axis to threshold point

Group 1: most disturbed
Visually assessed at maximum biological potential ceases to decline and persists at a very low value

Groups 4-2: intermediate groups
Divide the range of stress values between the 5 and 1 by three



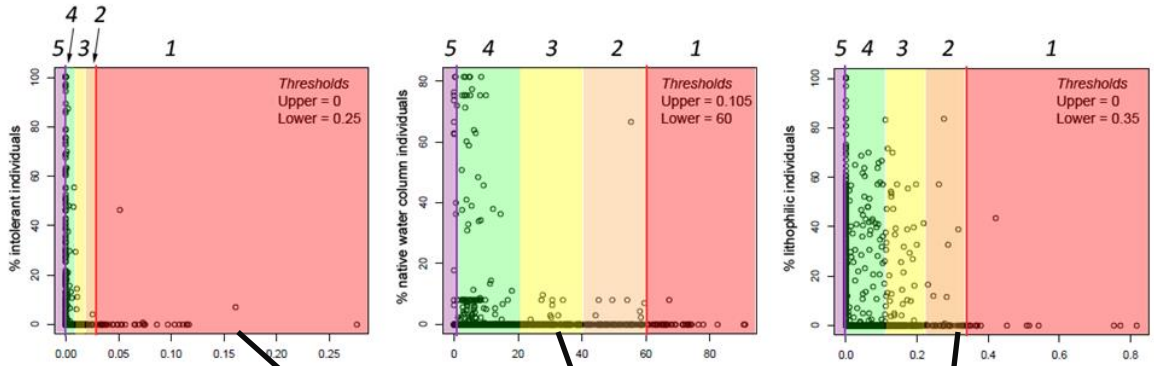
Note: These are the same steps taken in 2010 assessment

Reach Scores Based on Multiple Disturbances

- Move away from single most limiting disturbance scores/ base scores on multiple disturbances
  - Excludes information
  - Accounts for more disturbance to system
  - Multiple disturbances can:
    - Indicate accumulative or indirect influences
    - Better approximate mechanistic impacts
- Use significant disturbances (threshold responses) in a reach to derive average habitat condition index (HCI)

Reach Scores: Multiple Disturbances

<u>Hypothetical example</u>
NAP region has
- 5 fish metrics
- 4 significant disturbances



Reach 1 NAP	Network Dams	Buffer Urban	Local Mines	Network Road Crossings
Intolerant	3	1	4	2
Water column	3	1	4	2
Herbivore	3	3	4	3
Omnivore	2	2	4	2
Lithophilic	3	3	3	2
HCI Score	2.8	2	3.8	2.2

Reach Scores: Multiple Disturbances

The four most important disturbances in the reach based on average HCI scores

Hypothetical example
NAP region has
- 5 fish metrics
- 4 significant disturbances

5= best available 1= most disturbed

Reach 1 NAP	Network Dams	Buffer Urban	Local Mines	Network Road Crossings
Intolerant	3	1	4	2
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Lithophilic	3	3	3	2
HCI Score	2.8	2	3.8	2.2

Reach Scores: Multiple Disturbances

Hypothetical example
NAP region has
- 5 fish metrics
- 4 significant disturbances

Most Limiting from 2010

5= best available 1= most disturbed

Reach 1 NAP	Network Dams	Buffer Urban	Local Mines	Network Road Crossings
Intolerant	3	1	4	2
Water column	3	1	4	2
Herbivore	3	3	4	3
Omnivore	2	2	4	2
Lithophilic	3	3	3	2
HCI Score	2.8	2	3.8	2.2

Important information that is excluded with most limiting approach. Suggests altered connectivity in the network catchment.

Reach Scores: Multiple Disturbances

Weighting limiting disturbances

Hypothetical example

NAP region has

- 5 fish metrics
- 4 significant disturbances

5= best available 1= most disturbed

Reach 1 NAP	Network Dams	Buffer Urban	Local Mines	Network Road Crossings
Intolerant	3	1	4	2
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Herbivore	3	3	4	3
Omnivore	2	2	4	2
Lithophilic	3	3	3	2
HCI Score	2.8	2	3.8	2.2

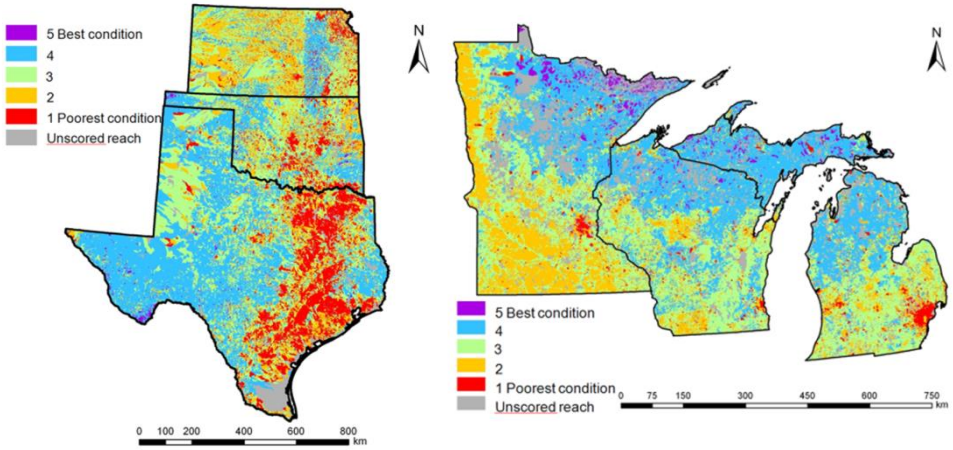
Possible weighting scale based on average HCI score:

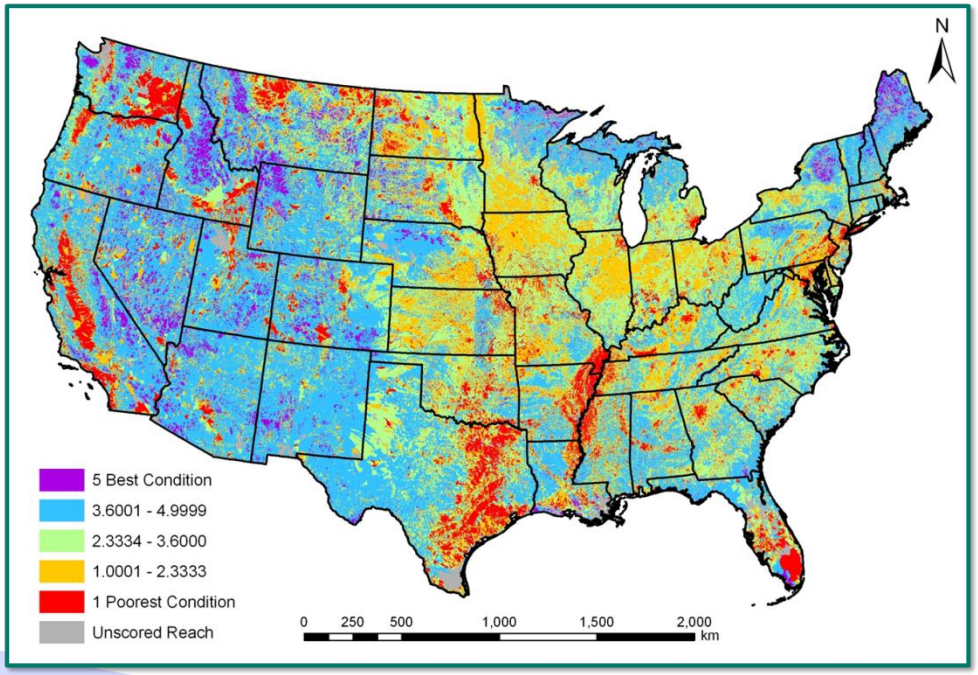
Most limiting:	50%
2nd	30%
3rd	20%
4th	10%

Weighted score for the reach : **2.6**

Cumulative score for stream reach

- **Cumulative scores** would represent ecoregion variation based off best and poorest condition sites.
- Uniqueness of ecoregions are better represented by a multiple disturbance score index
- Narrative classification maybe updated
- 5=Excellent
- 4= Good
- 3= Fair
- 2= Poor
- 1= Very poor
- Still comparable to 2010 results



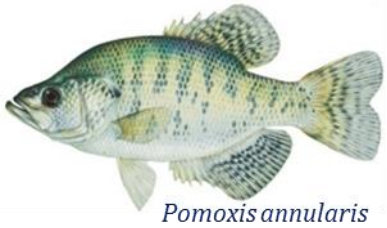


NATIONAL FISH HABITAT PARTNERSHIP

Accomplishments to date

- ✓ Acquired new fish community data sets
- ✓ Acquired additional landscape information
- ✓ Improved characterization of stream fragmentation
- ✓ Created buffer summaries
- ✓ Screened records and link site coordinates to NHDPlus V1 stream arcs
- ✓ Improved our threshold-response approach
- ✓ Accounted for spatial-biases
- ✓ Accounted for false fragmentations in NHDPlus V1 layer
- ✓ Development of new response metrics

Products from the 2015 Assessment



- Updated scores and maps of fish habitat condition for the conterminous US, Alaska, and Hawaii
  - Fish community
  - Game fishes (for each WSA & state)
- Comparison to 2010 results to see areas of alteration
- List of the most significant disturbances for each WSA region
  - Including the most limiting
- List of the most responsive fish metrics for each WSA region

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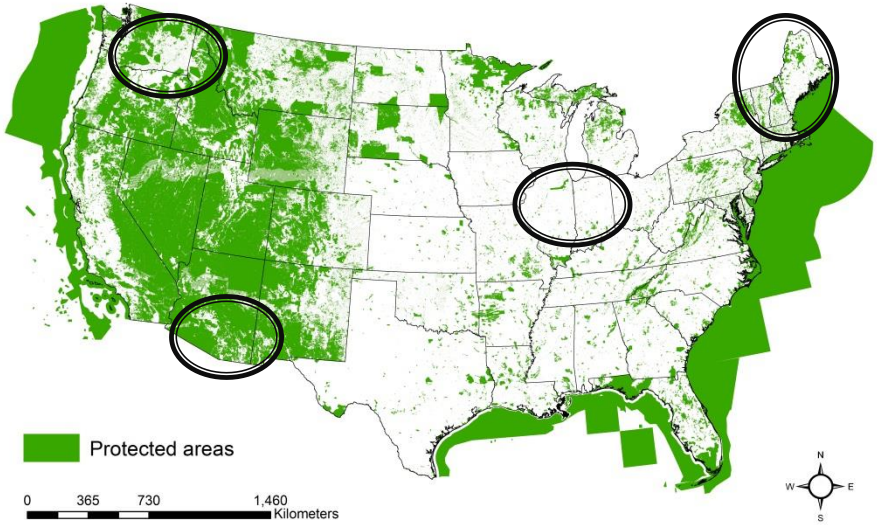
Images from Fishes of Texas

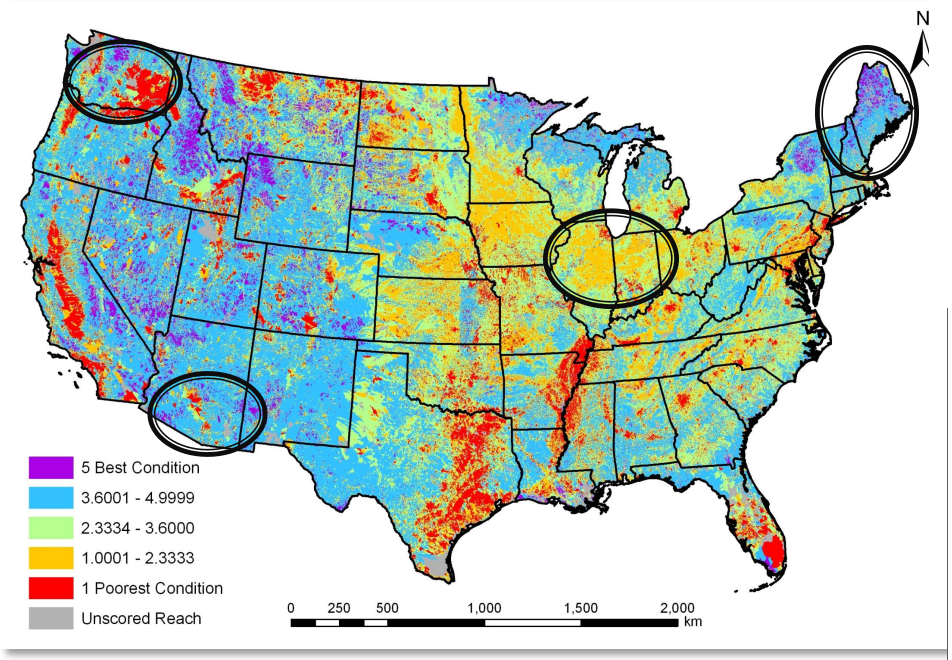
Additional Products
that could be produced from the 2015 results

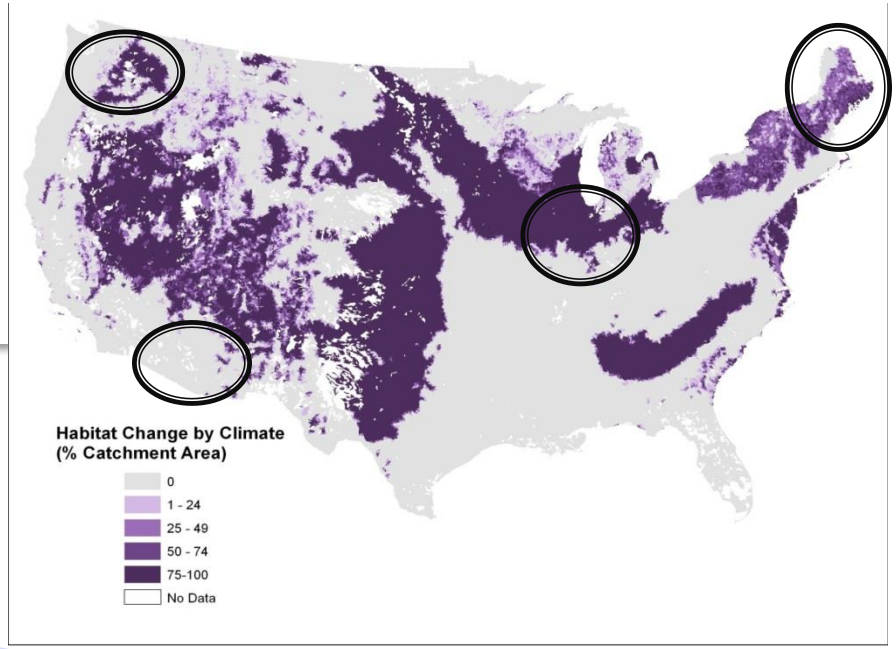
- Decision support information for selecting restoration, enhancement and conservation sites in each ecoregion
  - Use of optimization methods and additional landscape variables to make "informed" decisions
    - Protected lands
    - EPA 303d variables
    - Invasive species
    - Climate change models
    - Possible integration of social economic information
- Ecoregion, State, FHP specific (maps & GIS layers)products with additional data not used in the assessment

Additional Products

Current condition + future condition







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Time frame

Spring 2014
- Threshold analysis
- Proposal for scoring approach for review
- NFHP Science and Data board call

Summer 2014
- Hawaii assessment review

Fall 2014
- Alaska assessment review
- NFHP Science and Data board call

Winter 2015
- Plan for the inland lake assessment
- Draft 2015 National Inland Assessment

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