Presented at:

Environmental Monitoring and Assessment Program
Great River Ecosystems
Biological Indicators Workshop
October 24-26, 2006
Holiday Inn - Duluth, Minnesota

Hows and whys of EMAP-GRE hydrology and habitat metrics

D. Taylor, October 2006

How do we ---

- use/reduce the field-collected habitat + hydrology data into useable metrics and then into assessment indicators?

- coordinate the use of field data with landscape-level data to assess the condition of the Great Rivers?

- coordinate with the biotic assessment groups?

land use/cover

geomorphology

soils

ground +
canopy cover

bank stability

hydrology

dams, dikes

woody debris

littoral slope,
substrate

→

metrics
and indices
of watershed,
riparian +
littoral habitat
quality

→

useable
information

condition

major stressors

data

metrics

indices

1. measure at several spatial scales
2. integrate conditions over time

“hydrology”

hy·drol·o·gy (hī-drŏl'ə-ē)
n.

The scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Why did I push to add
a close look
at historical and
recent surface water +
hydrologic data
to the habitat assessments
for EMAP-GRE?

Short answer:

Because the magnitude of discharge,
seasonal differences in the patterns of discharge,
timing and durations of droughts and floods,
and the hydroperiod/flashiness
of high-discharge events
can all affect if and how biota will use the
Great River mainstems as habitat

Hydrology –

magnitude,
timing
and duration of flow events ---

is greatly modified on the MO, MS, and OH Rivers
due to dams, channelization, levees, diversion

much of traditional "stream hydrology" will not work here

How can we adapt what we know about
hydrology/biota interactions to Great Rivers?

Will need to rely on USGS gauging data

+ ADCP data

Primary emphasis on conditions at/near time of sampling, but will also look at historical flow patterns

Five types of hydrology metrics:

- magnitude of discharge (Q) at any given time
- seasonal timing of high and low Q events
- frequency/magnitude of specific
  high and low Q conditions
  such as droughts and floods
- duration of specific Q conditions,
  such as droughts and floods
- rate of change of stage/Q
  = hydroperiod/flashiness

Keep in mind ---
some hydrologic variation is natural,
some is human-induced

is the biota selecting/not selecting
a given habitat
because of natural hydrology,
or because of human alterations
to that natural habitat ???

Also keep in mind ---

Hydrologic variation can be influencing biota indirectly by influencing water/sediment chemistry

This may be particularly true in relation to river/floodplain connectivity

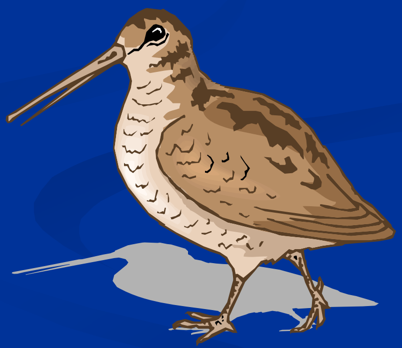
Five types of hydrology metrics:

- **magnitude of discharge (Q) at any given time**
- seasonal timing of high and low Q events
- frequency/magnitude of specific
  high and low Q conditions
  such as droughts and floods
- duration of specific Q conditions,
  such as droughts and floods
- rate of change of stage/Q
  = hydroperiod/flashiness

Magnitude of water at any given time ---

Why important?

- wetted area, habitat volume in littoral zone
- human uses: agriculture, power, recreation
- water table relative to river
- can terrestrial animals get to river?
- food/cover/hiding places
  for animals that nest/feed at river edge
- water temp, O2 levels, photosynthesis



Magnitude of water at any given time ---

Likely metrics:

- mean annual Q
- historical monthly mean Qs
- Q on day of and immediately before sampling date

Five types of hydrology metrics:

- magnitude of discharge (Q) at any given time
- **seasonal timing of high and low Q events**
- frequency/magnitude of specific
  high and low Q conditions
  such as droughts and floods
- duration of specific Q conditions,
  such as droughts and floods
- rate of change of stage/Q
  = hydroperiod/flashiness

seasonal timing of high and low Q events

Why important?

- life cycle conditions met
  (access to special habitats during reproduction)?
- predictability/stress avoidance
  – can animals "plan ahead"?
- spawning cues for migratory fish?
- can humans count on given water levels
  at a given time of year?

seasonal timing of high and low Q events ---

Likely metrics:

- Julian Day for ave annual max and min Qs
- median Julian Day that floods occur
- max proportion of floods that fall
  into the same 60-day
  time period each year,
  actual time period + variation

Five types of hydrology metrics:

- magnitude of discharge (Q) at any given time
- seasonal timing of high and low Q events
- **frequency/magnitude of specific high and low Q conditions such as droughts and floods**
- duration of specific Q conditions, such as droughts and floods
- rate of change of stage/Q = hydroperiod/flashiness

frequency/magnitude of specific high and low Q conditions such as droughts and floods

Why important?

availability of floodplain habitats

- nutrient/organic matter exchange between river and floodplain
- frequency periphyton/macrophytes scraped in high velocities or forced to tolerate drought
- bedload transport – mainstem and tribs
- human uses – building in floodplain, ag, transportation

frequency/magnitude of specific high and low Q conditions such as droughts and floods

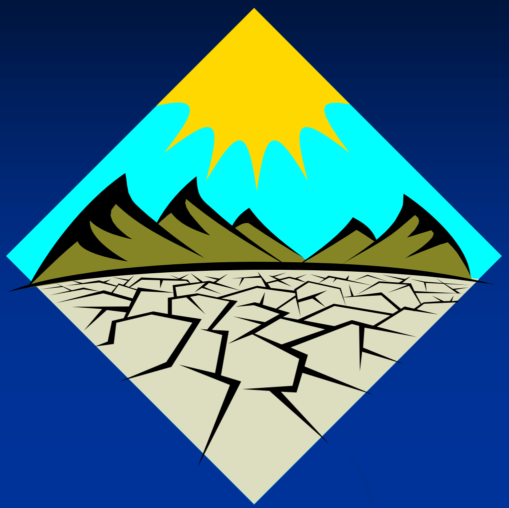
Likely metrics:

- Julian Day of, volume of,
  variation in max and min Qs
- baseflow (Richter et al. 1998)
- ave flood frequency (Poff and Ward 1989)
- ave days between floods

Five types of hydrology metrics:

- magnitude of discharge (Q) at any given time
- seasonal timing of high and low Q events
- frequency/magnitude of specific
  high and low Q conditions
  such as droughts and floods
- **duration of specific Q conditions,**
  such as droughts and floods
- rate of change of stage/Q
  = hydroperiod/flashiness

duration of specific Q conditions, such as droughts and floods



Why important?
(most of frequency/magnitude reasons, plus --)

- can a particular life-cycle stage be completed before water levels change?
- are flood or low-water pulses so long that mobile animals must leave to survive?
- can human activities (ag, tourism) adapt to floods/droughts?

duration of specific Q conditions,
such as droughts and floods

Likely metrics, again,
many frequency/magnitude apply, plus:

- average flood duration (Poff and Ward 1989)

Five types of hydrology metrics:

- magnitude of discharge (Q) at any given time
- seasonal timing of high and low Q events
- frequency/magnitude of specific
  high and low Q conditions
  such as droughts and floods
- duration of specific Q conditions,
  such as droughts and floods
- rate of change of stage/Q
  = hydroperiod/flashiness

rate of change of stage/Q
= hydroperiod/flashiness

Why important?

- stranded land animals on islands/floodplains when water rising?

- stranded aquatic animals on floodplains/islands when water falling?

- can plant roots maintain contact w/pore water?

- desiccation rates on low-mobility river-edge organisms, such as periphyton?

- humans – economic and duration of relief situations

rate of change of stage/Q
= hydroperiod/flashiness

Likely metrics:

- rate of rising hydrograph
- rate of falling hydrograph
- number of "reversals" (Richter et al. 1998)
- Richards-Baker flashiness index (Baker et al. 2004)

Summary (hydrology metrics):

- the MO, MS, and OH Rivers are not only large,
  they are modified hydrologically.
  this changes both the science and the techniques.

- discharge magnitude + seasonal variations,
  frequency, magnitude + duration of
  floods/droughts, and flashiness of hydrologic
  regime may all affect biota and human use

- some hydrologic variation is natural, some human-caused.
  which is more important in a *given* place
  and in a *given* organism's choice of habitat?

--- on to habitat data (EMAP “physical habitat”)

“the set of conditions that support and control species distribution and abundance” – Phil K.

habitat data types (landscape-level to come later):

Littoral/in-river habitat:

- woody debris
- littoral substrate
- fish habitat
- aquatic vegetation
- littoral morphology

Riparian/channel-scale habitat:

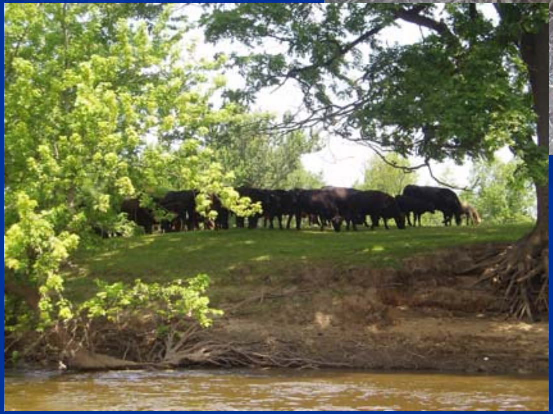
- bank morphology
- riparian vegetation
- channel morphology
- shoreline/macrohabitat
- human impacts
- invasive plant species

Why collect data on littoral morphology?

- water temp
- light penetration
- unevenness = cover
- drop-off v. gradual
- wave action/velocity

Why collect data on the river's riparian zone?

- **interface/buffer between watershed and river --- filter, sink and source**
- **reference ⟶ trashed**



- **economic pressure**
- **recreational pressure**
- **habitat (esp. for "terrestrial" species that are water-dependent)**

No shortage of habitat indices ---

EMAP wadeable and nonwadeable (Kaufmann)
Army Corps physical assessment review for CWA 404
USGS Water-Resources Investigations Report 98-4052
Pfankuch (USFS) Channel Stability Evaluation

Idaho's wadeable stream habitat index
Iowa DNR TMDL + Water Quality Section
Oregon riparian management policy
Wisconsin streams (fish habitat, Simonson)
Ohio – biological response indicators, QHEI
Maryland physical habitat index

BUT ---

“% fines accumulated in riffles”

WHAT RIFFLE?

“sinuosity”

“IN A SHIPPING CANAL?

‘bank stability”

“HOW DO WE FACTOR IN THE RIP-RAP?”

Habitat differences, wadeable stream v. Great River

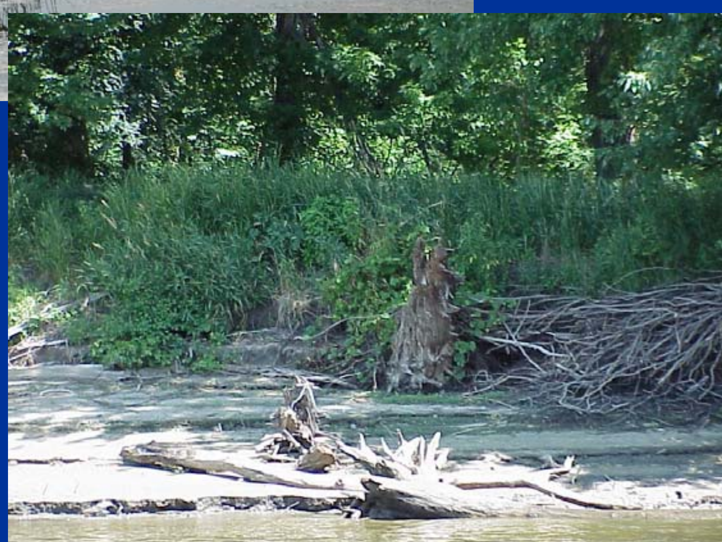
In a large river, probably less important:

- riffle-pool structure
- % fines in substrate
- gradient

Probably more important:

- backwaters, islands
- woody debris
- interaction (or lack thereof) w/floodplain
- tributary (+ or -) inputs
- regulated hydrologic regime

reinventing the habitat quality index for Great Rivers



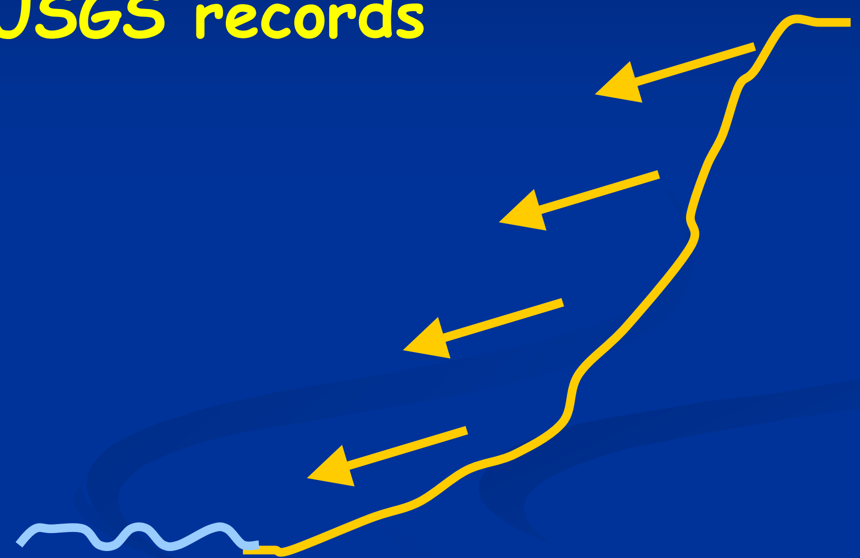
Three possible habitat/hydrology indices:

- channel erosion potential
- riparian inundation/runoff retention
- human/site disturbance

(plus a littoral fish habitat index)

channel erosion potential index:

EMAP-GRE field data,
GIS landscape coverages, USGS records



hydrologic regime
bank height, bank angle
observed bank erosion
riparian soil types
revetments, rip-rap
extent/type/root structure of riparian veg
distance veg to bank
slope, substrate in littoral region

riparian inundation/runoff potential index:

EMAP-GRE field data,
GIS landscape coverages, USGS records
plus climatological records

riparian buffer width
incision/entrenchment
presence, height of levees
channel morphology --- W:D ratio
vegetation types and densities ---
ground cover, understory, herbs v. woody
riparian litter pack
impervious surface, lawns
riparian soil types
WATER QUALITY

human/site disturbance index:

primarily EMAP-GRE field data,
some landscape-level data

based on both type of disturbance
and distance to disturbance
(in river, in riparian plot, other side of river)

extent and age structure of
riparian woody vegetation, esp. near shore

presence and extent of invasive vegetation

Some interesting preliminary data:

<u>May</u> be major "separators" between groups of sites:

- presence/absence of riprap/revetment
- degree of channel constraint (multiple v. single channel?)
- sites with shallow/low gradient littoral zones v. sites with "drop-off" littoral zones
- humid ⟶ arid

May be correlated with "good" littoral fish habitat:

- latitude (N is better than S) on MS
- naturally stable river banks

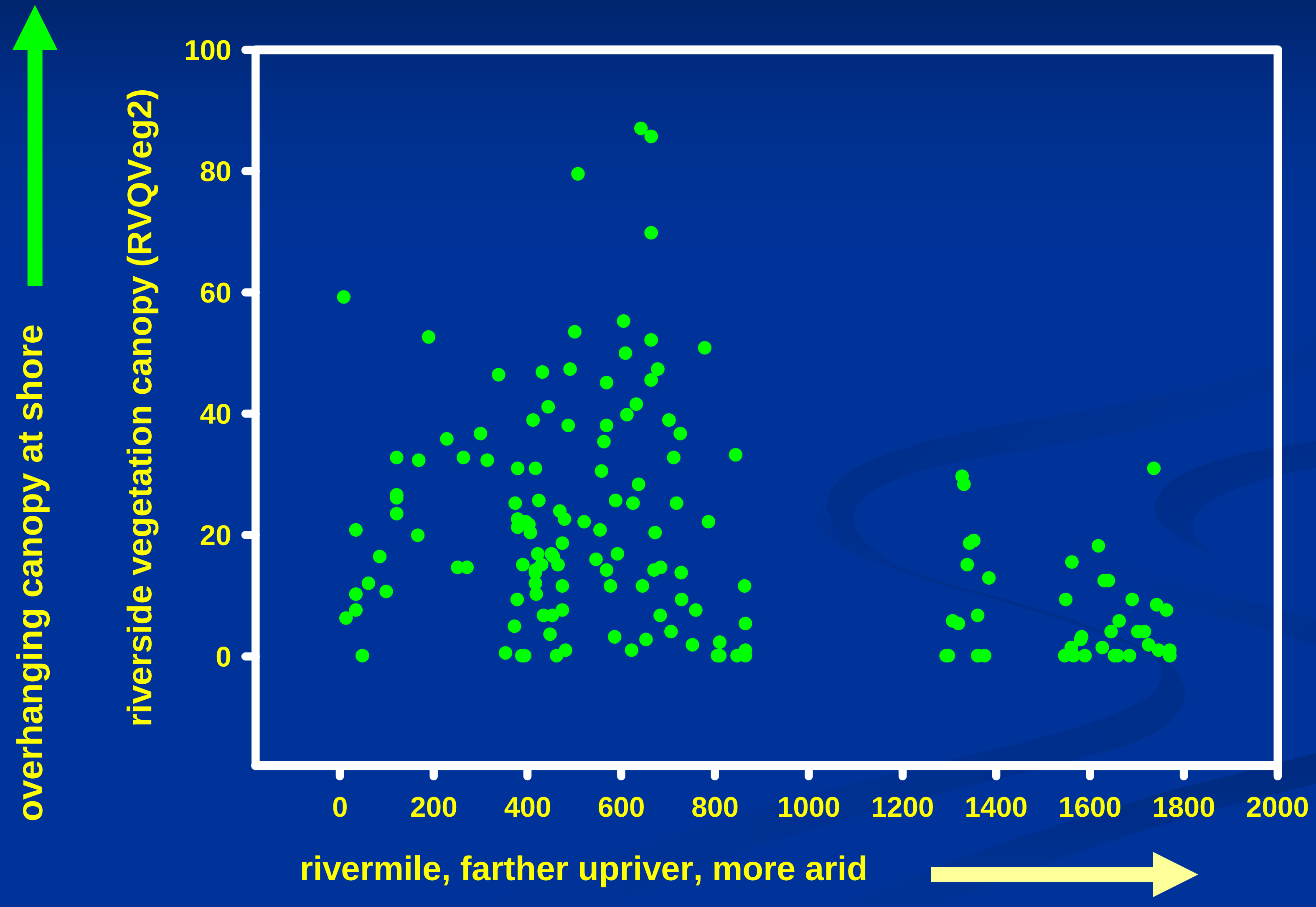
- less channel constraint
- healthier riparian zone w/less agriculture
- deeper (?!), more sloping,
  more varied littoral morphology (OH)

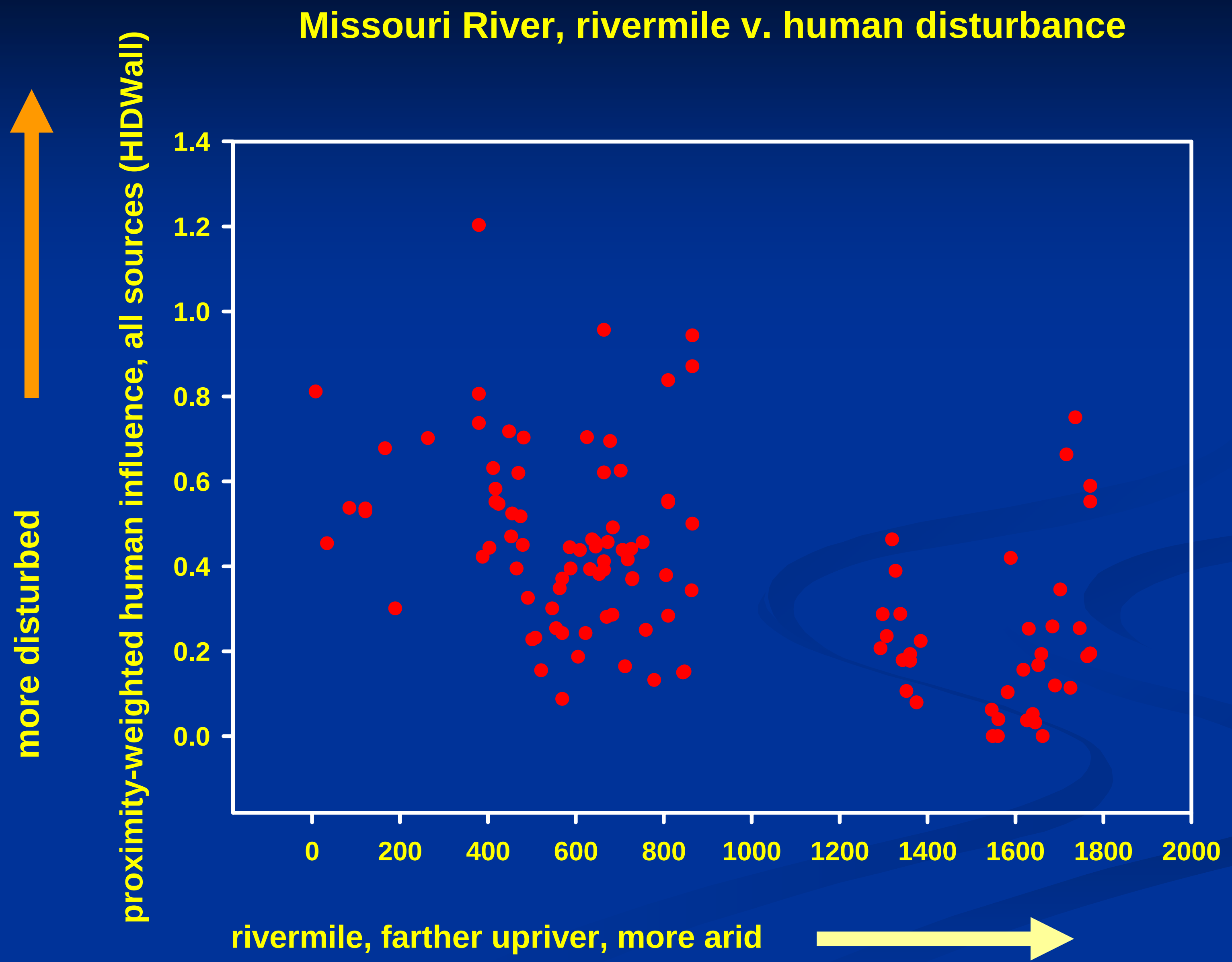
“Aridity” issue with MO River
+ EMAP riparian veg and disturbance indices –

Healthy, unimpacted veg community
may not be woody west of 100^{th} parallel

How do we consider climate differences
and still work with EMAPs gone by?

Missouri River, river mile v. woody riveredge veg cover




Missouri River, rivermile v. human disturbance
more disturbed
proximity-weighted human influence, all sources (HIDWall)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
rivermile, farther upriver, more arid

SO, does

(RVQVeg1*RVQVeg2*HIQDist) ^ (1/3) still = HIQVeg on the arid portions of the MO River ?????

OR, in non-EMAP lingo,

How do we modify existing EMAP indices of overall riparian/site health to accommodate non-woody stable/climax vegetation communities?

OR do we start over?

VISIT the HABITAT + HYDROLOGY GROUP !!!