Presented at

Great Rivers Reference Condition Workshop

January 10-11, Cincinnati, OH

Sponsored by

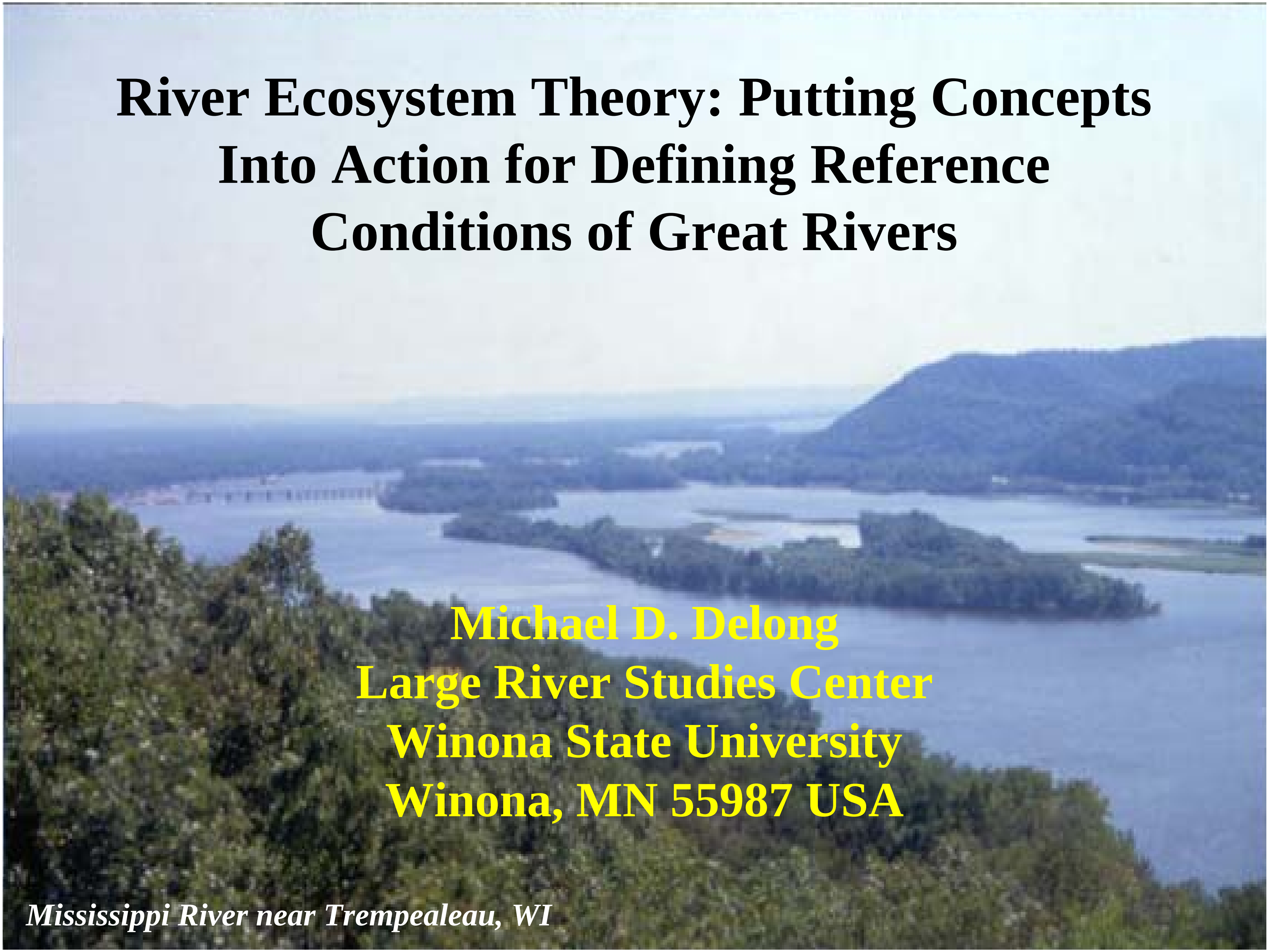
The U.S. Environmental Protection Agency and The Council of State Governments

U.S. EPA Office of Research and Development

Environmental Monitoring and Assessment Program

River Ecosystem Theory: Putting Concepts Into Action for Defining Reference Conditions of Great Rivers

Michael D. Delong
Large River Studies Center
Winona State University
Winona, MN 55987 USA



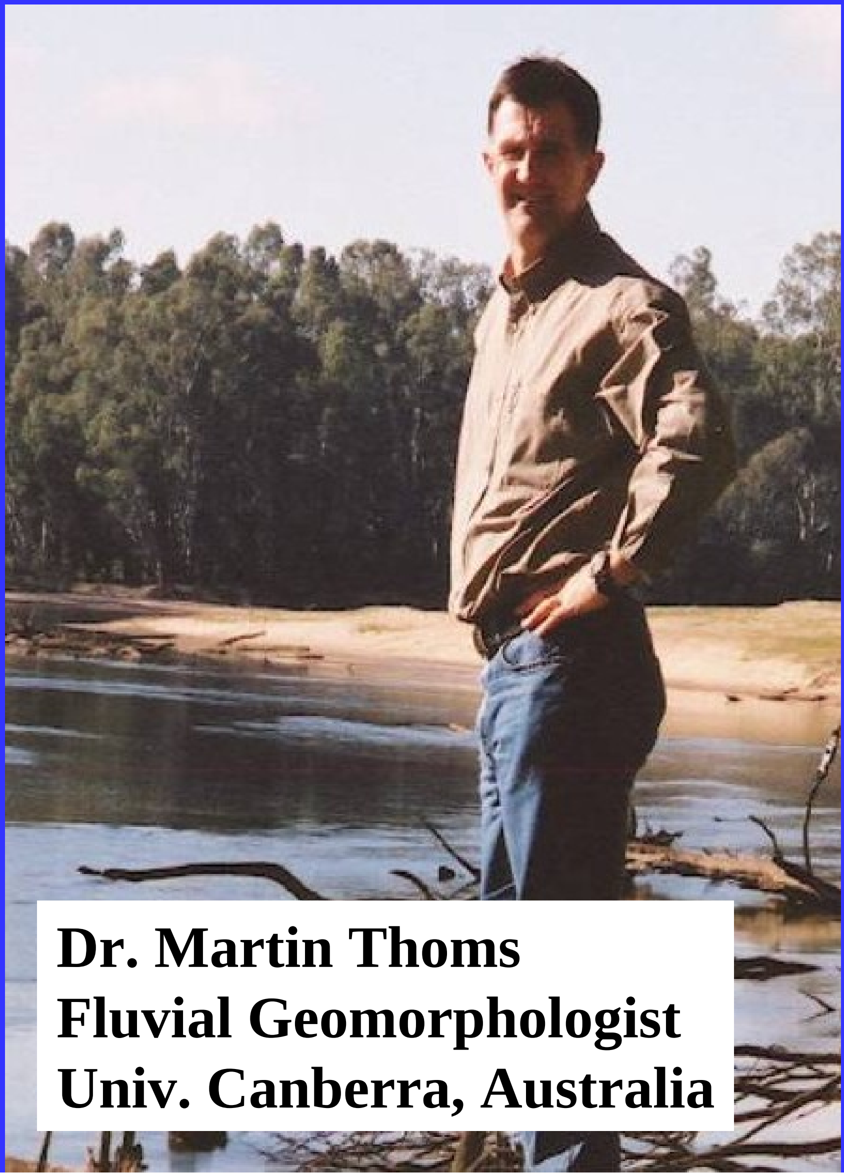
Mississippi River near Trempealeau, WI

Presentation based on:

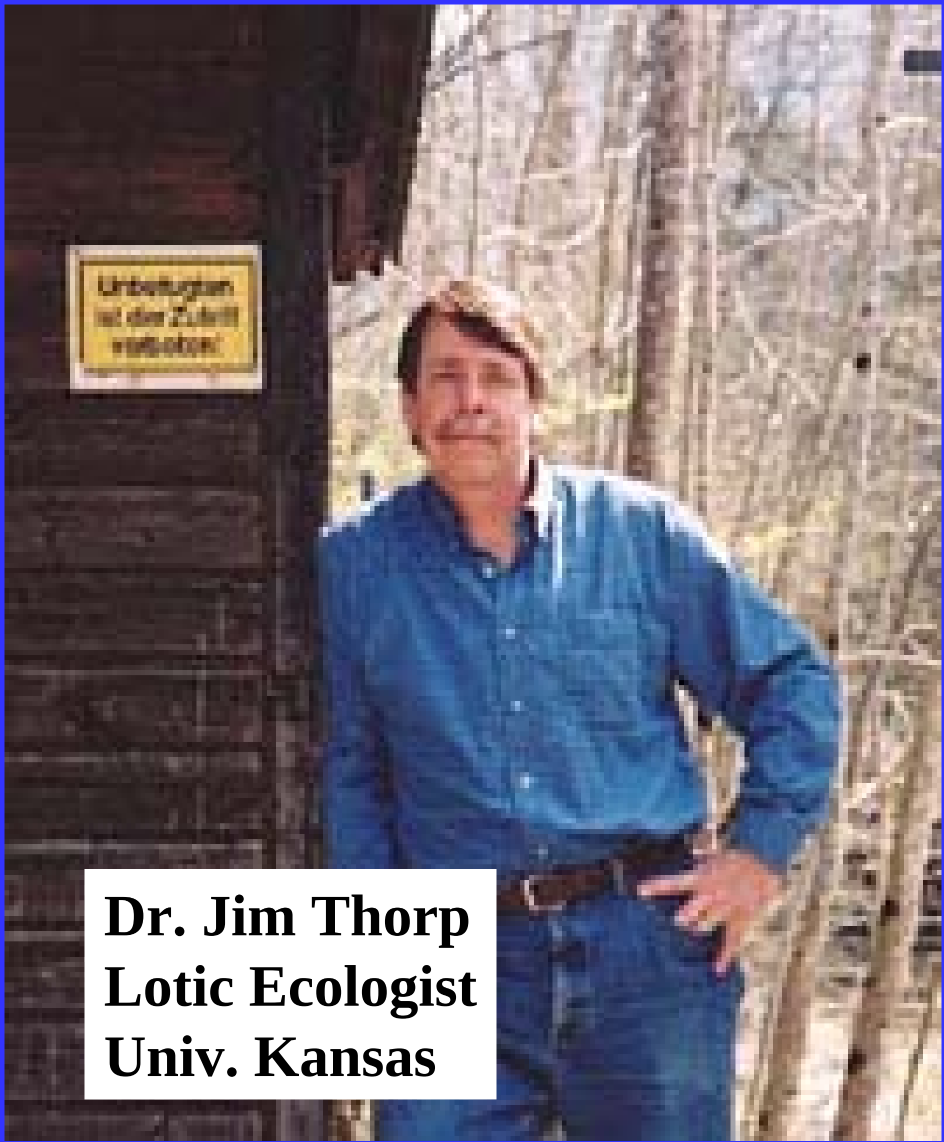
Thorp, J.H., M.C. Thoms, & M.D. Delong. The riverine ecosystem synthesis: biocomplexity in river networks across space and time. *River Research and Applications* (In Press).

Thorp, J.H., M.C. Thoms, & M.D. Delong. Riverine ecosystem synthesis. Elsevier Publishing, anticipated publication – late 2006 to early 2007.

Co-Conspirators



Dr. Martin Thoms
Fluvial Geomorphologist
Univ. Canberra, Australia



Dr. Jim Thorp
Lotic Ecologist
Univ. Kansas

Objectives

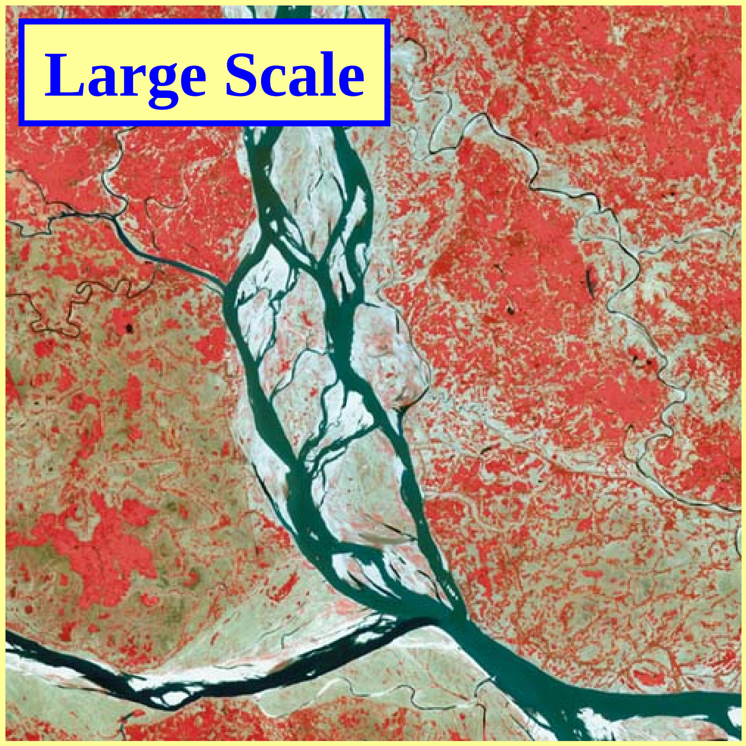
- Brief description of Riverine Ecosystem Synthesis (RES)
- Application of RES toward identification of reference and altered conditions
- Describe how RES fits within sampling methodologies of EMAP, including sample site identification

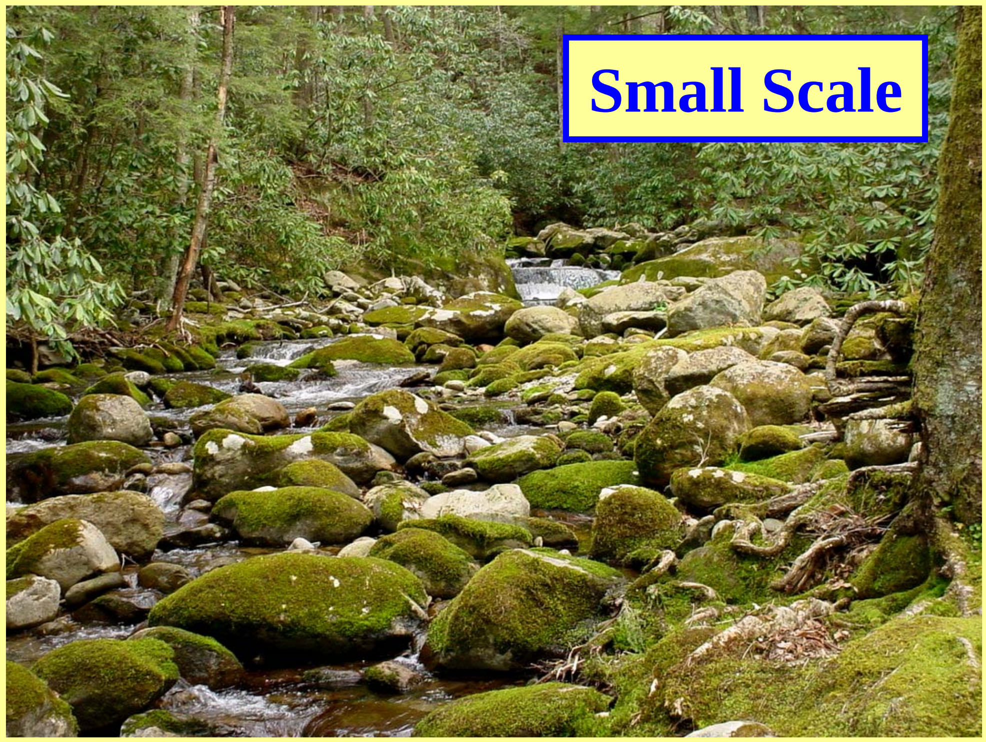
What is the Riverine Ecosystem Synthesis?

- Not a new model or theory
- Merging of
  - Hierarchical Patch Dynamics
  - Ecogeomorphology
  - Lotic Ecological Theory 1980 – 2004

Overall Goal of RES: Provide a <u>foundation</u> for understanding…

- broad, often discontinuous patterns along longitudinal and lateral dimensions; and,
- local patterns across temporal & smaller spatial scales.

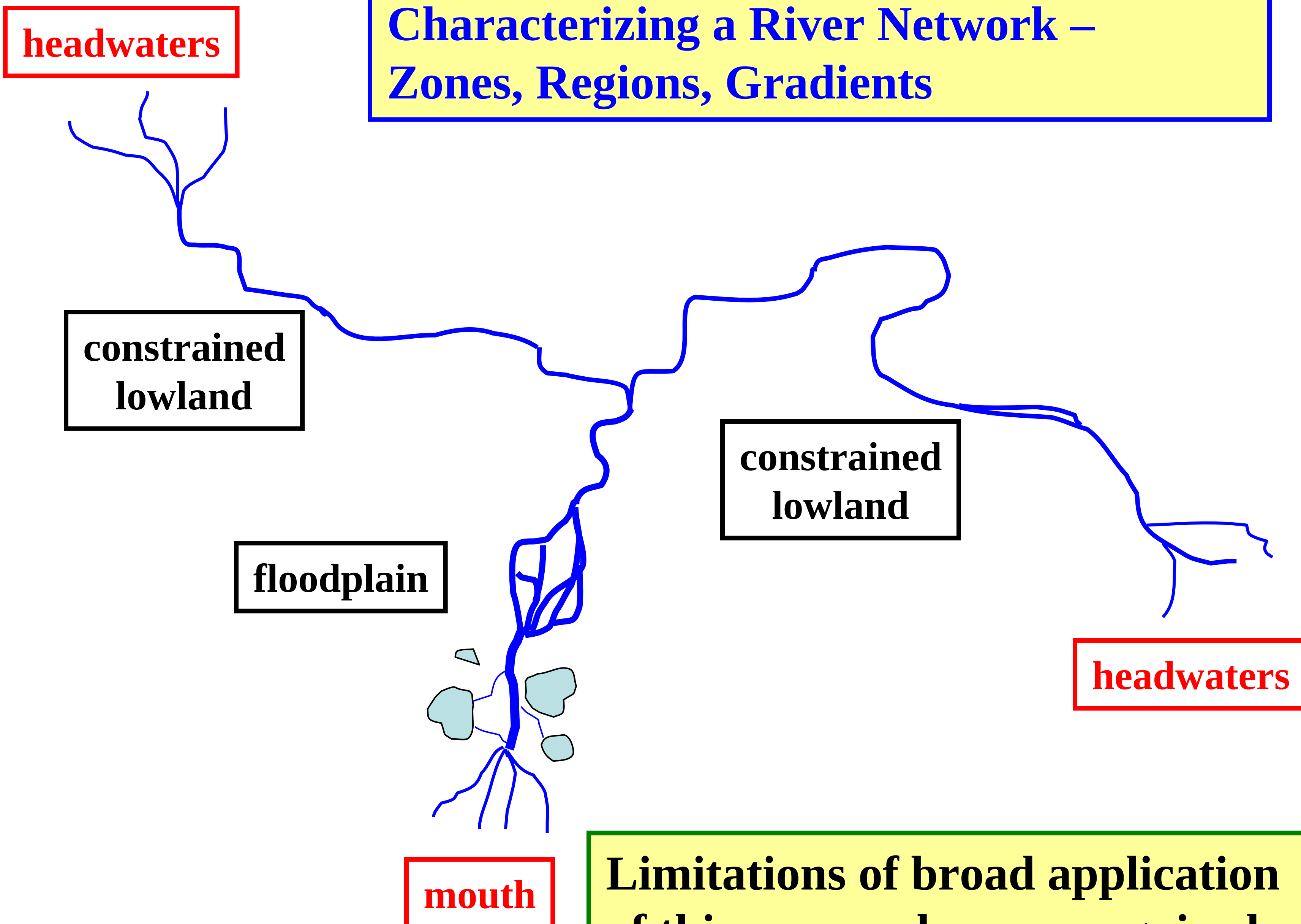




Ganges & Brahmaputra Rivers, Bangladesh

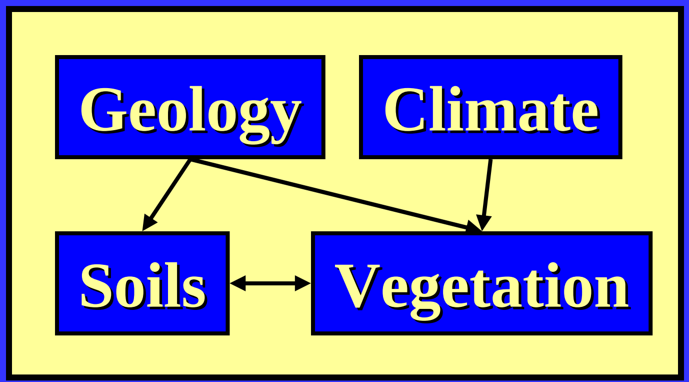
Rocky stream, Smoky Mountains, USA

Characterizing a River Network – Zones, Regions, Gradients

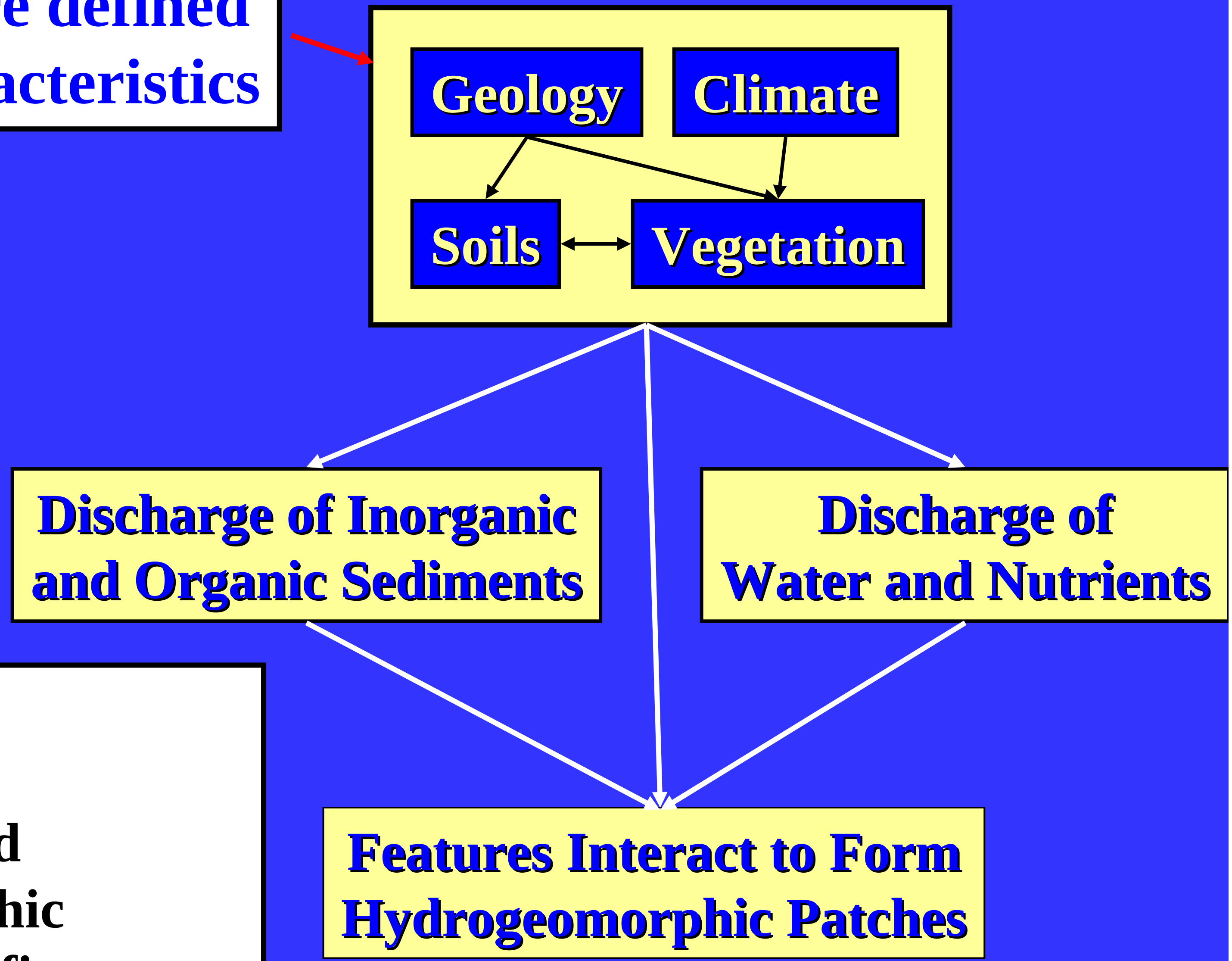


Limitations of broad application of this approach are recognized

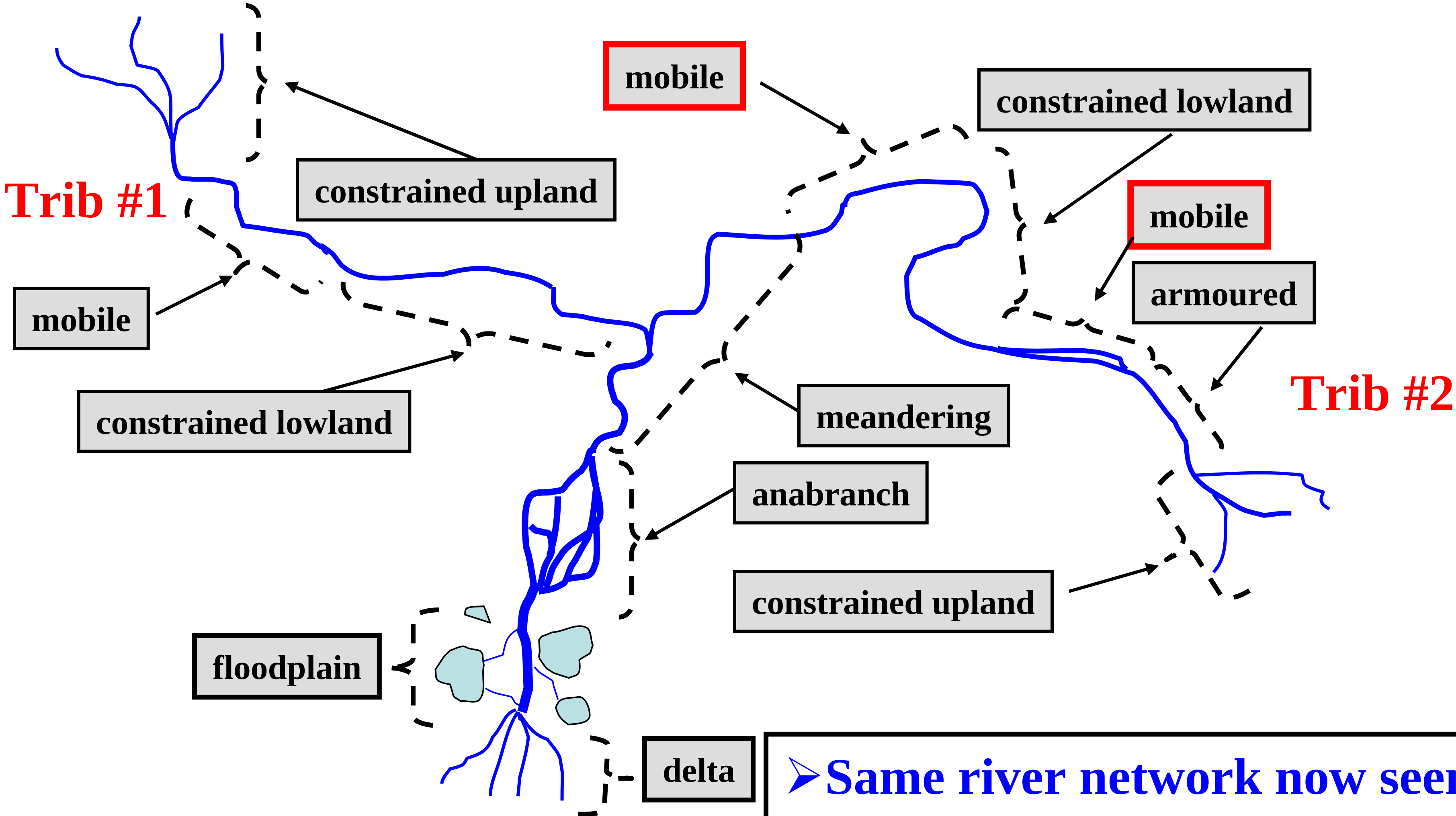
Ecoregions are defined by these characteristics



Ecoregions are defined by these characteristics

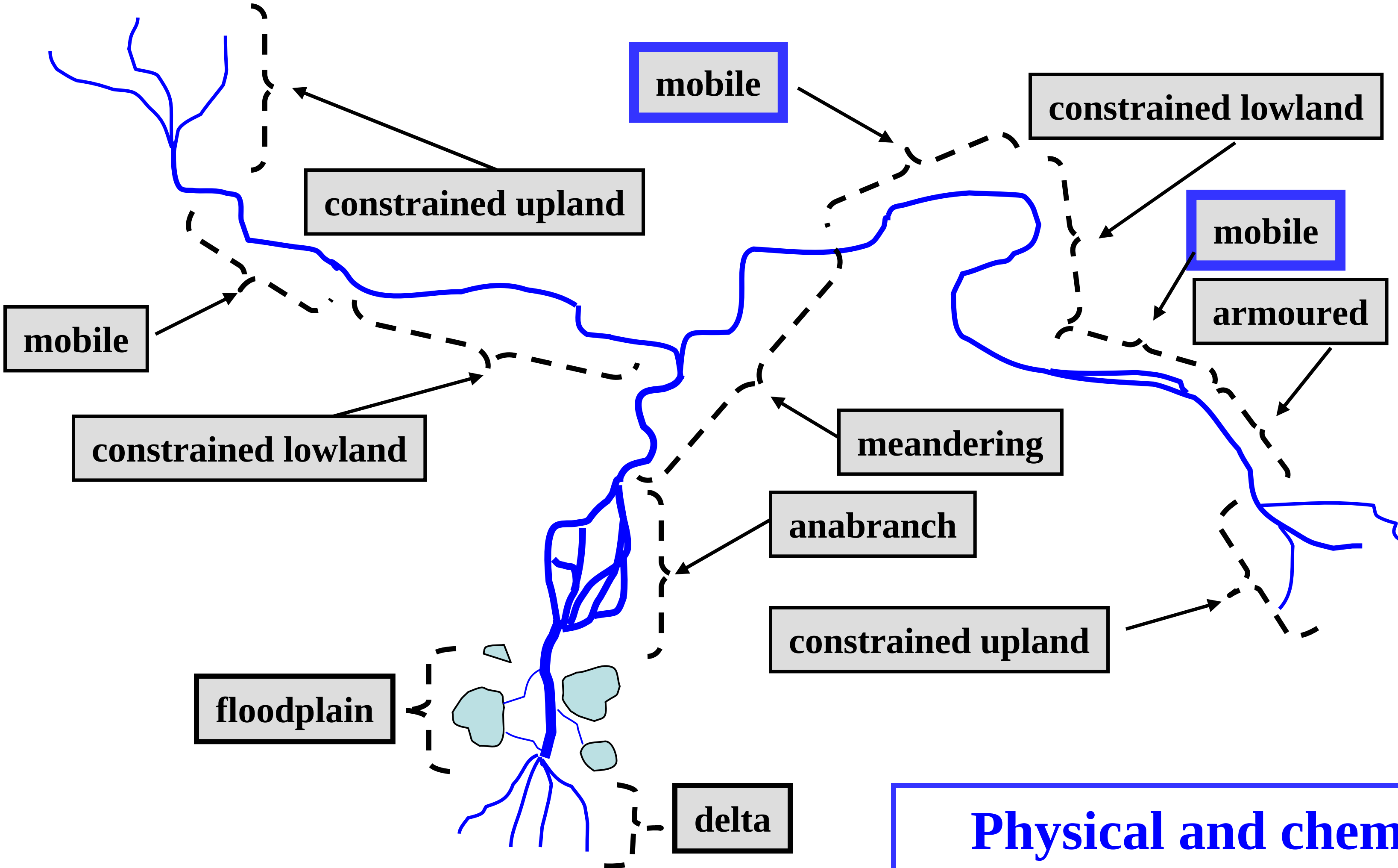


Ecoregional characteristics + hydrologic and fluvial geomorphic features then define hydrogeomorphic patches

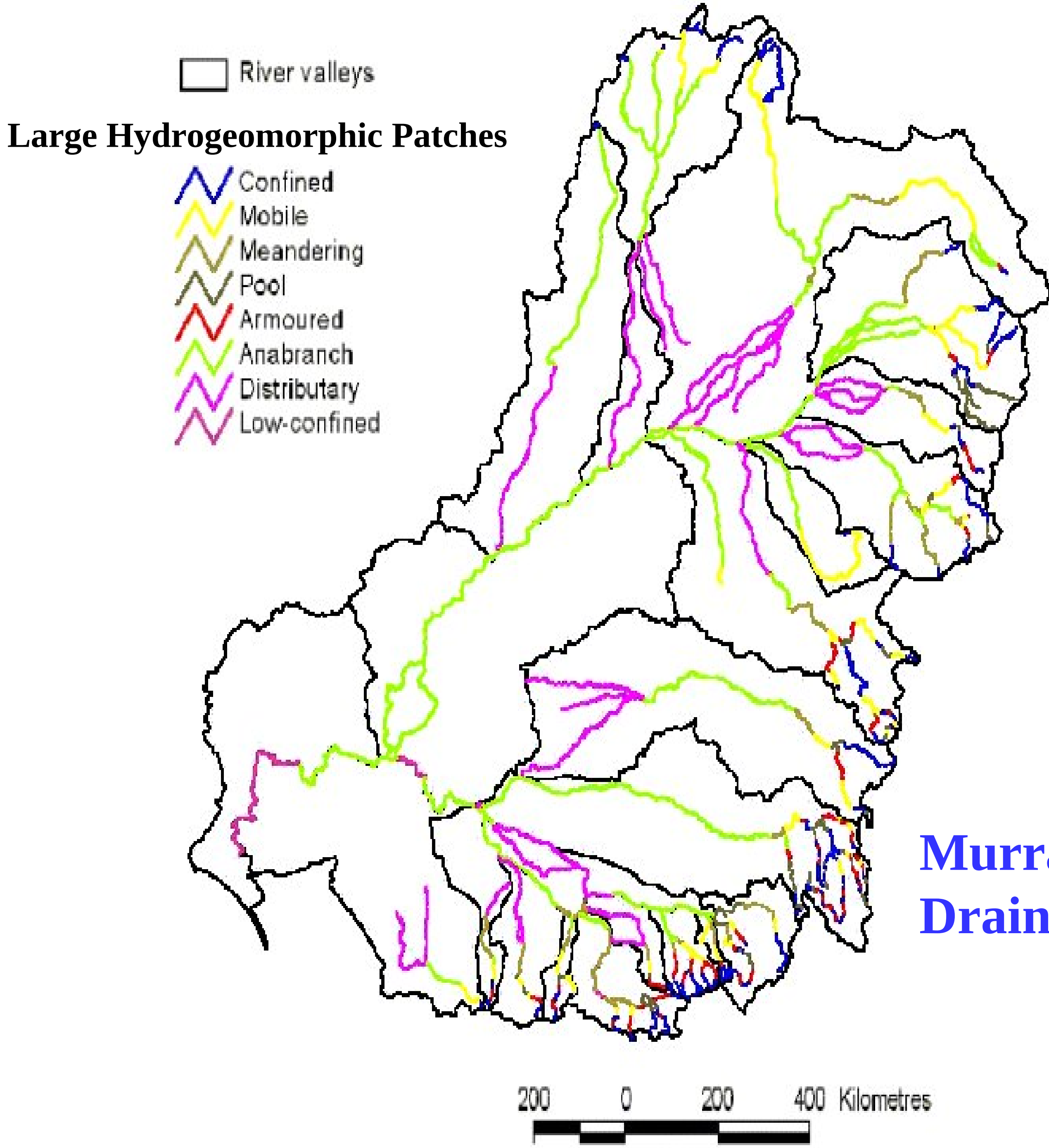


➢Same river network now seen in context of hydrogeomorphic patches

➢Unlike continuum, HG patches can repeat longitudinally

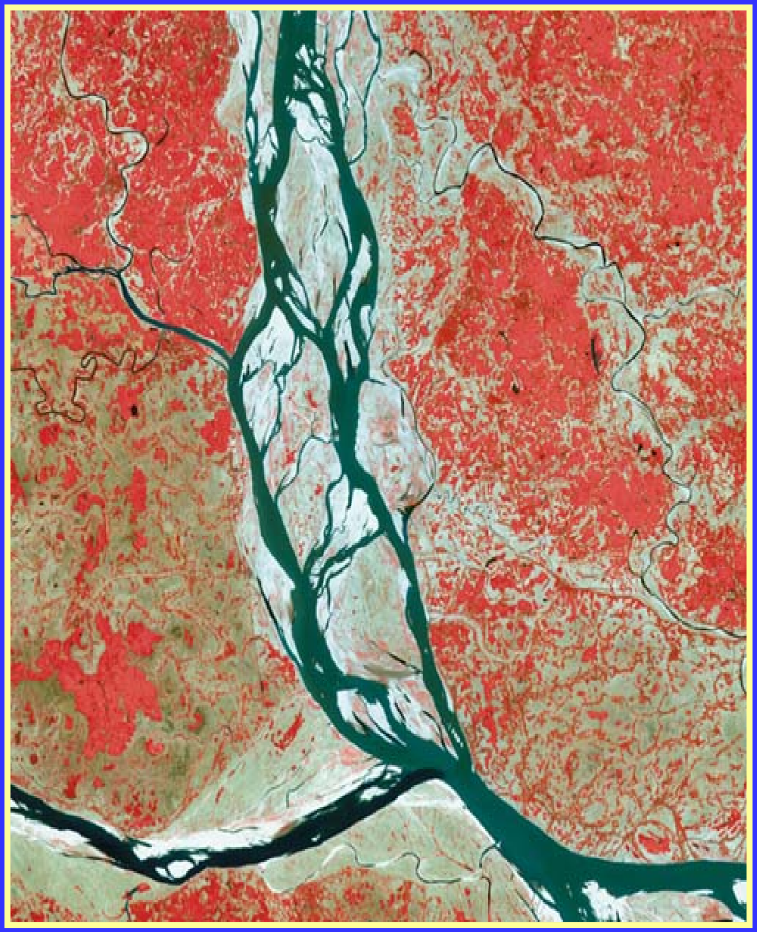


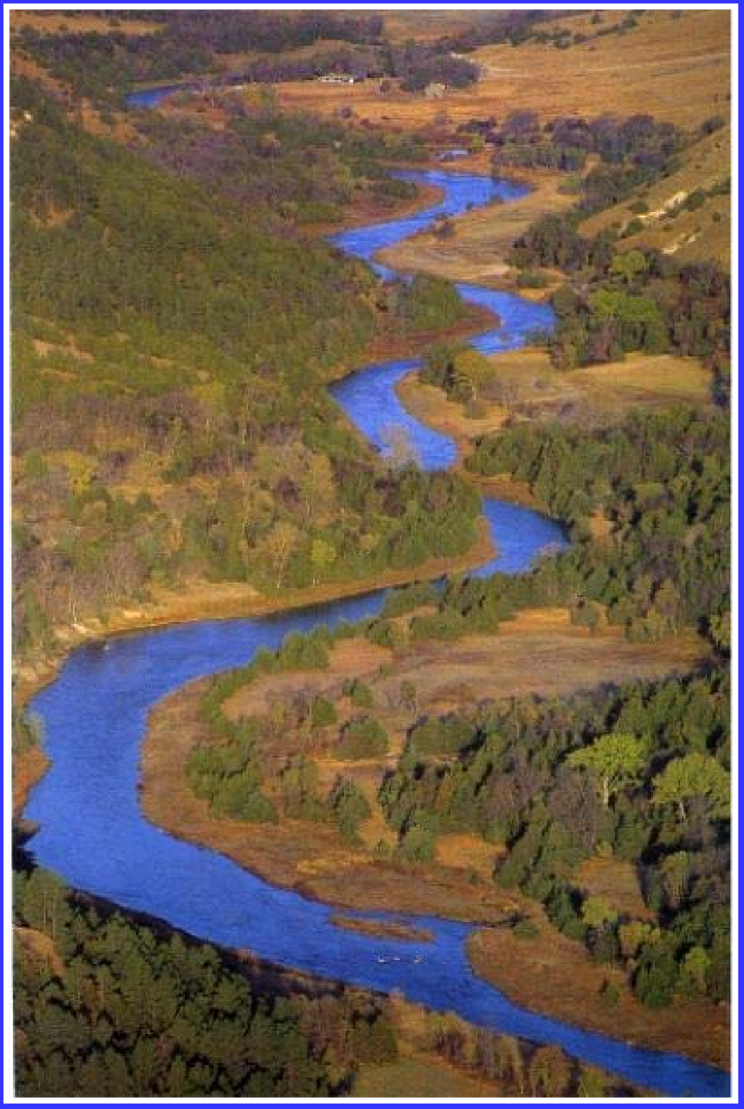
Physical and chemical characteristics of each hydrogeomorphic patch define unique ecological structure and function

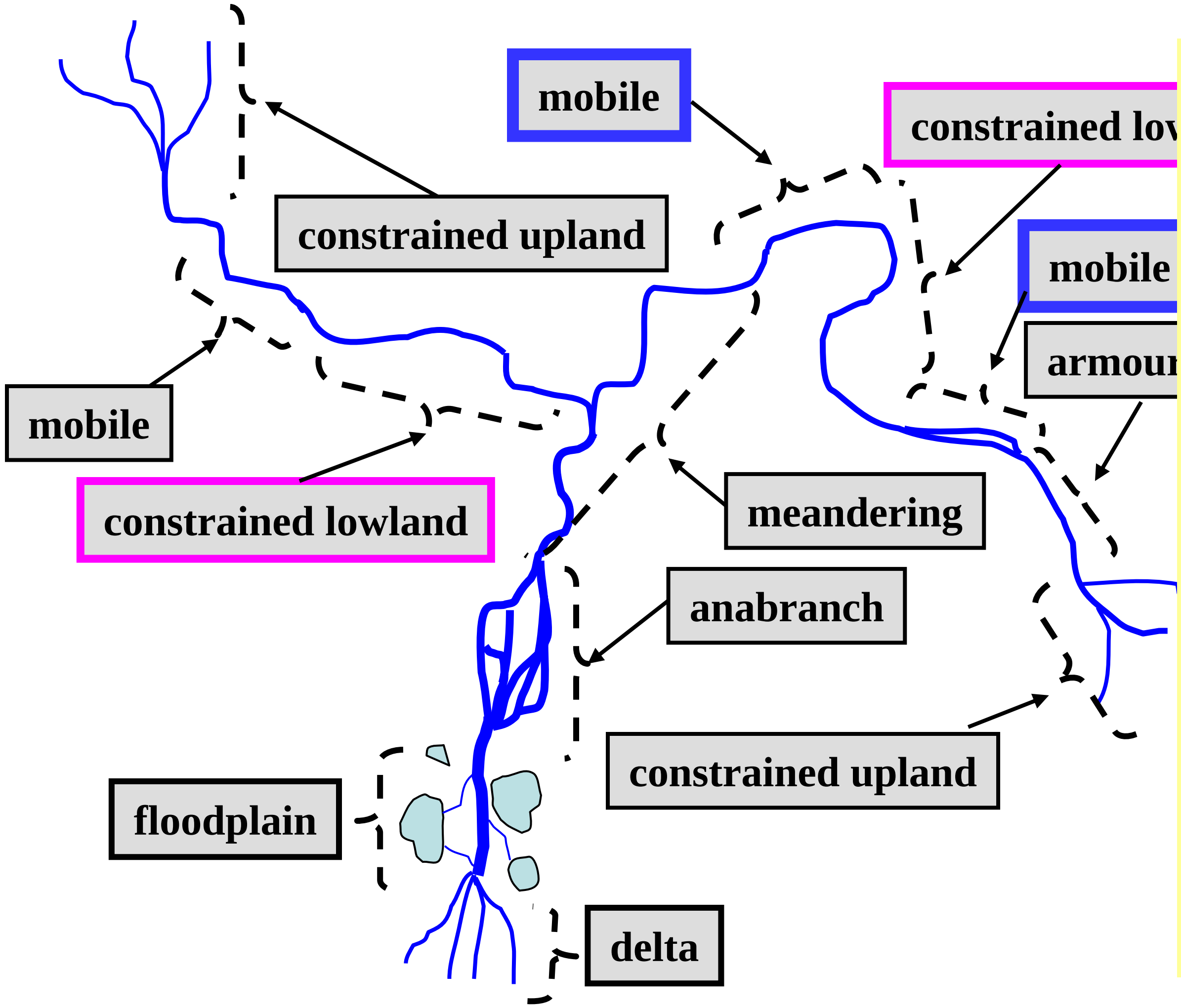


Murray-Darling Drainage Basin

Application of Hydrogeomorphic Patches in Ecological Assessment







- Similar biocomplexity within identical patches
- Minimize sample effort within and between identical patches
- Prevents application of one patch as representative of a different patch

Hydrogeomorphic patches identify unique and common areas of a river, with each HG patch have a characteristic biocomplexity

Very rough approximation **of hydrogeomorphic patches in Upper Mississippi River.**

-based on geomorphology and does not consider hydrology, tributaries, etc., fully

Assume represent patches based on historical data…..

What is nature of HG patches today?

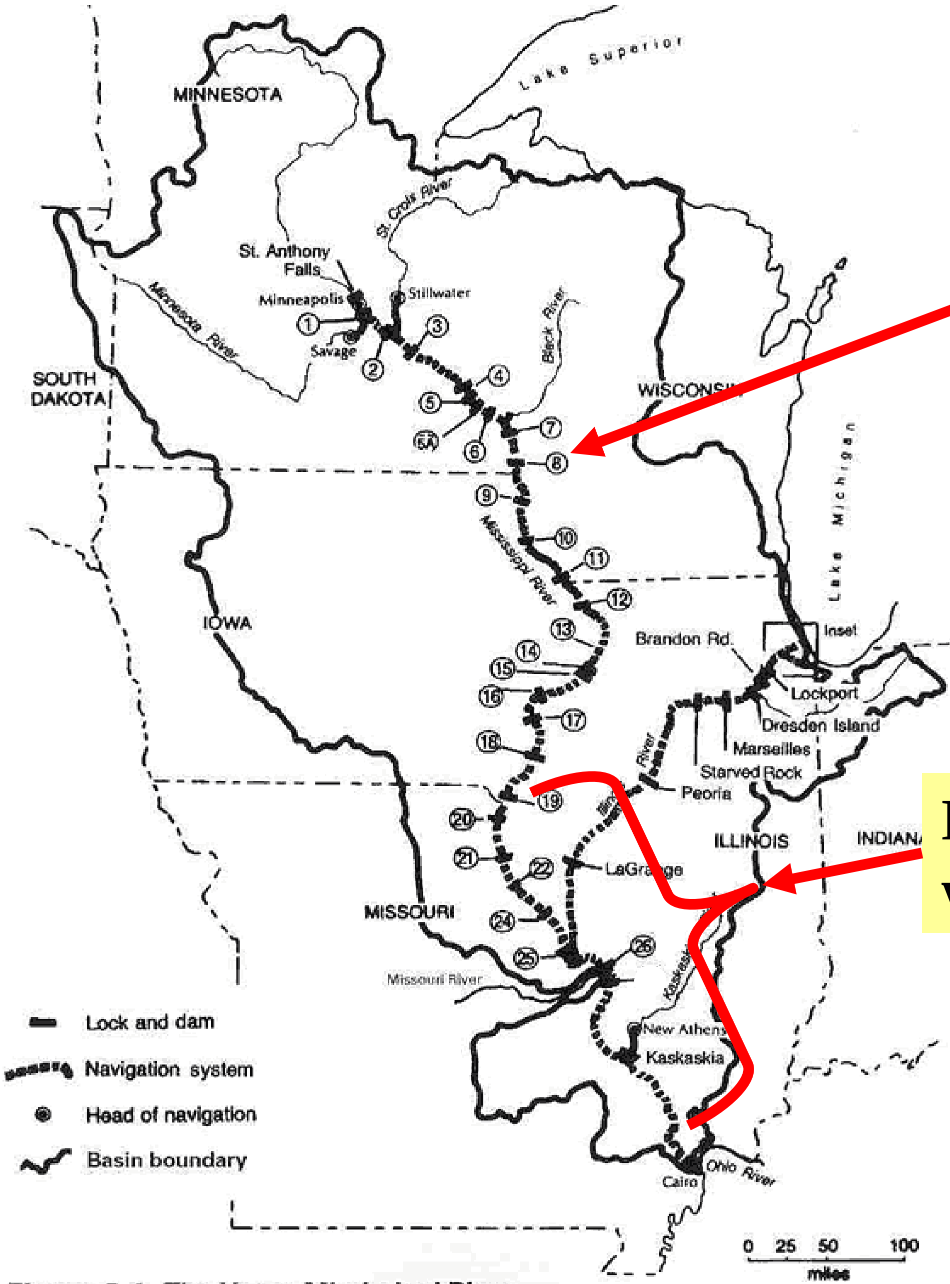
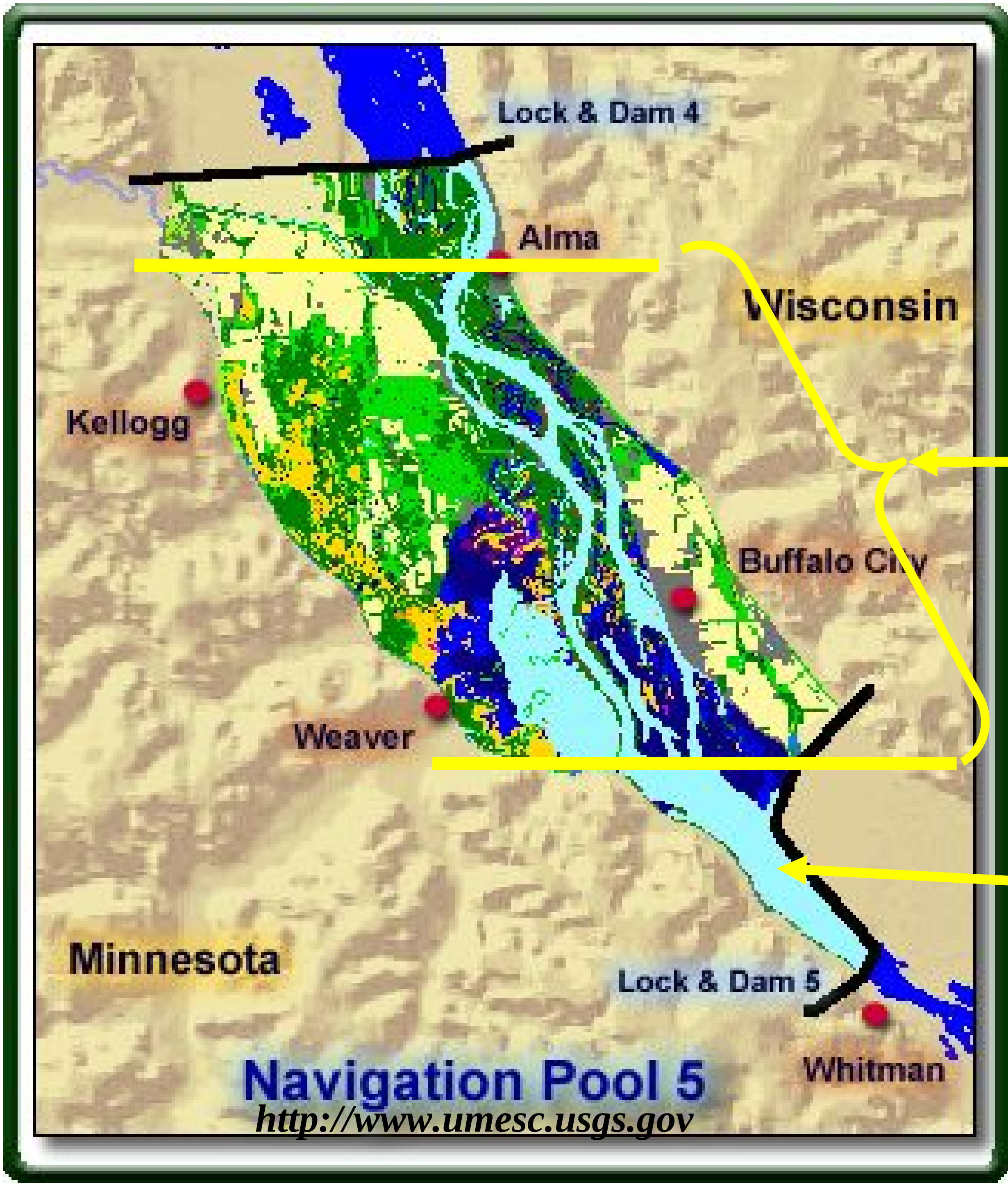


Figure 2-1. The Upper Mississippi River Navigation System with locks and dams numbered

Locks and Dams – maintain sufficient depth during low flows for navigation; natural hydrograph mostly intact

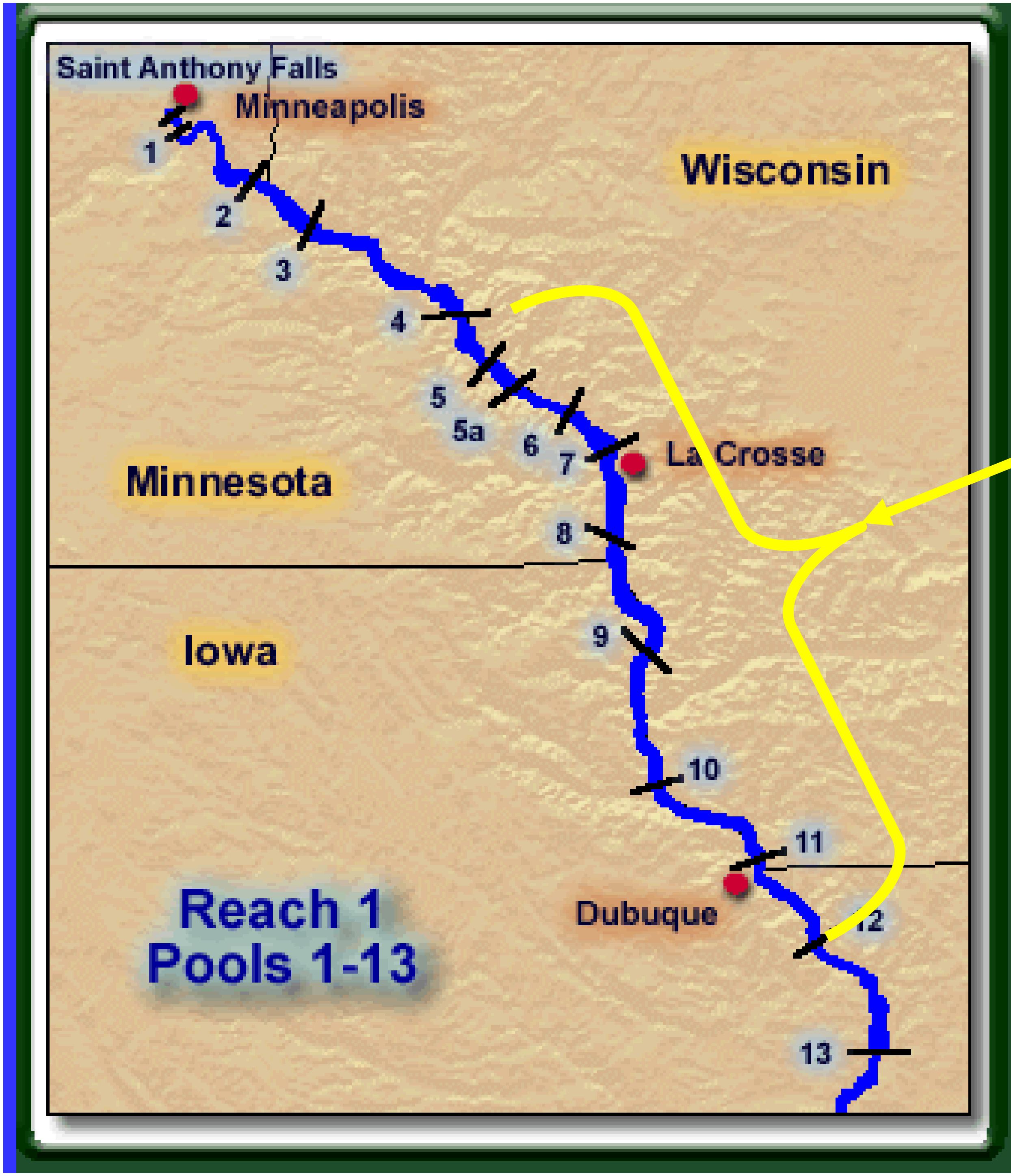
Levees – disrupt lateral surface water connectivity **problematic??



- Hydrogeomorphic attributes of "larger scale" HG patch intact

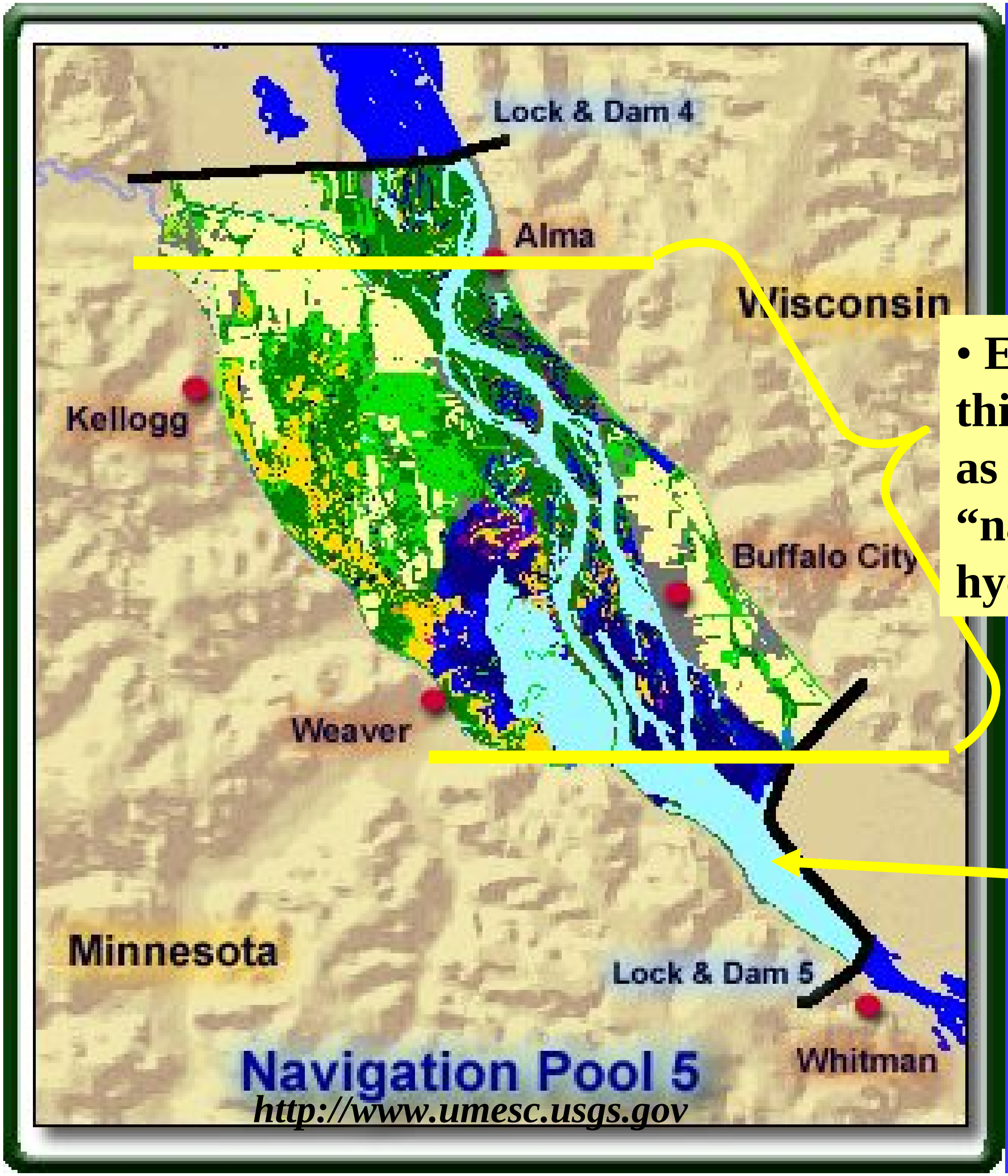
- Spatial and temporal scales intact

- Hydrology altered
- Lateral linkages diminished
- Distinct HG patch



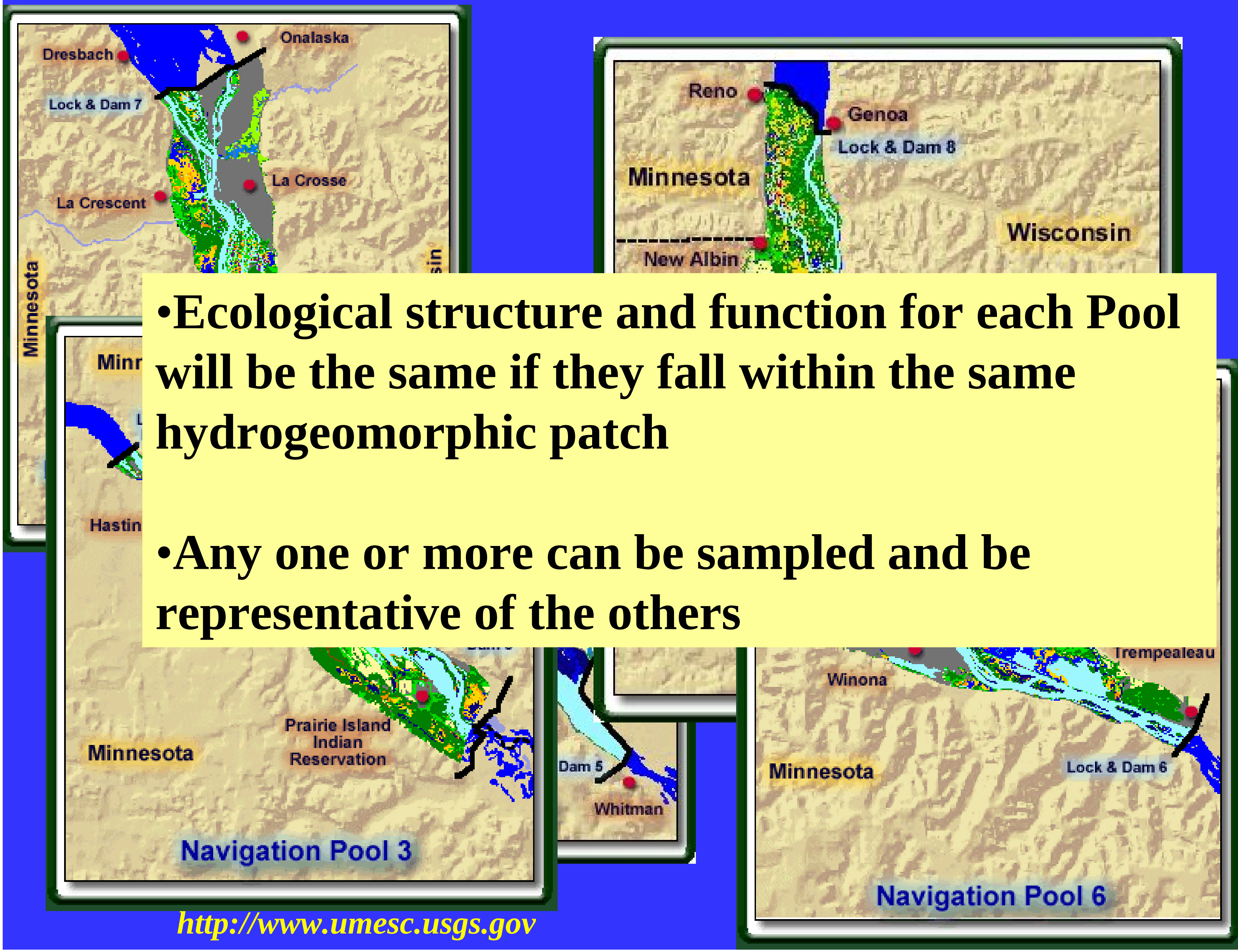
- **Assume this section represents a single hydrogeomorphic patch**

- **If this is true, then**



• Ecological conditions in this area can be sampled as indicative of the "natural" hydrogeomorphic patch

•Whereas this area is a distinct hydrogeomorphic patch created by disruption by dams



- **Ecological structure and function for each Pool will be the same if they fall within the same hydrogeomorphic patch**

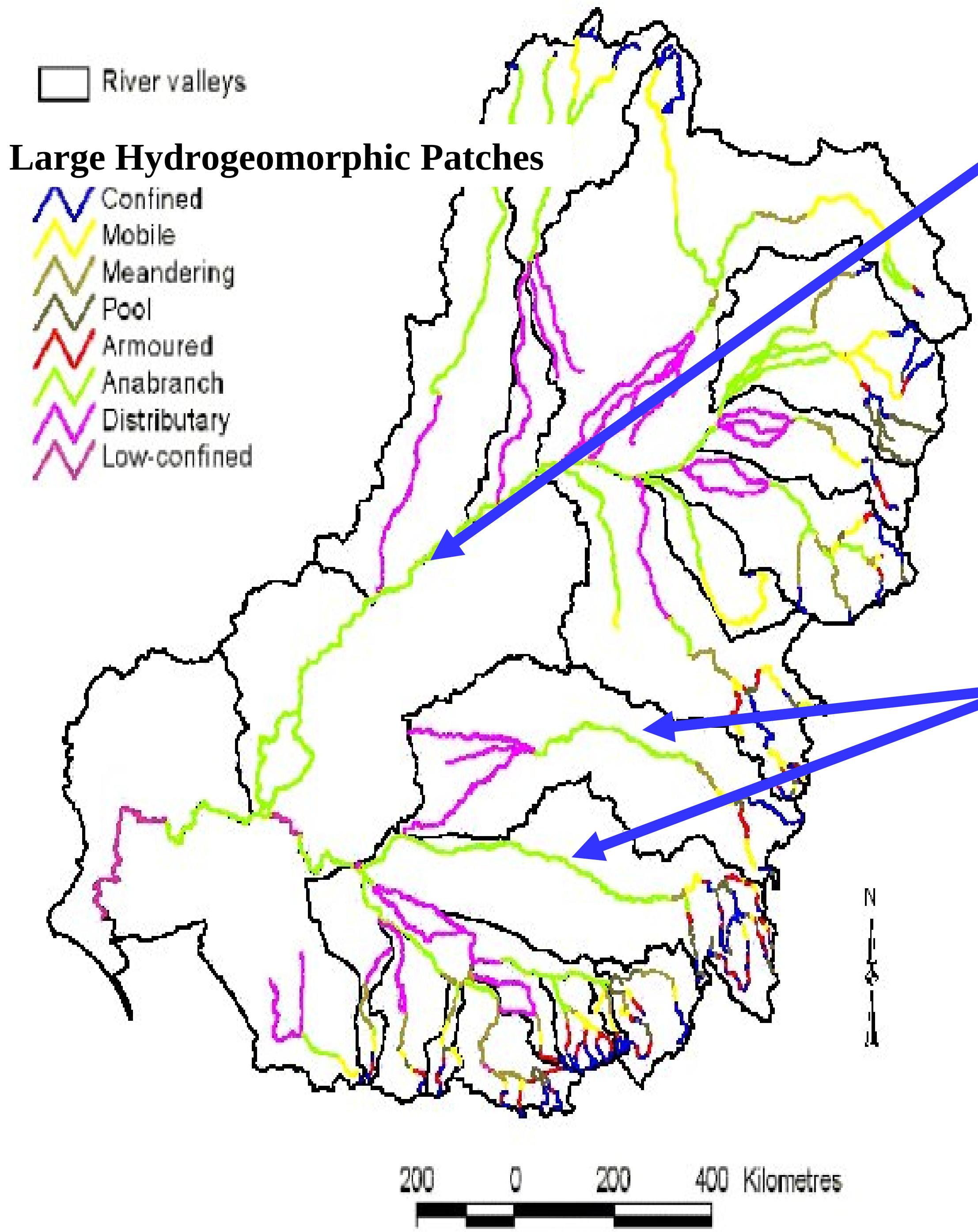
- **Any one or more can be sampled and be representative of the others**

http://www.umesc.usgs.gov

Not every Pool may be fully "natural"

- -Overriding effects
  - -Land use
  - -Tributaries
  - -Connectivity Loss
- -Will be evident in characterization of HG patch

• Urbanization; urban levees (if present)



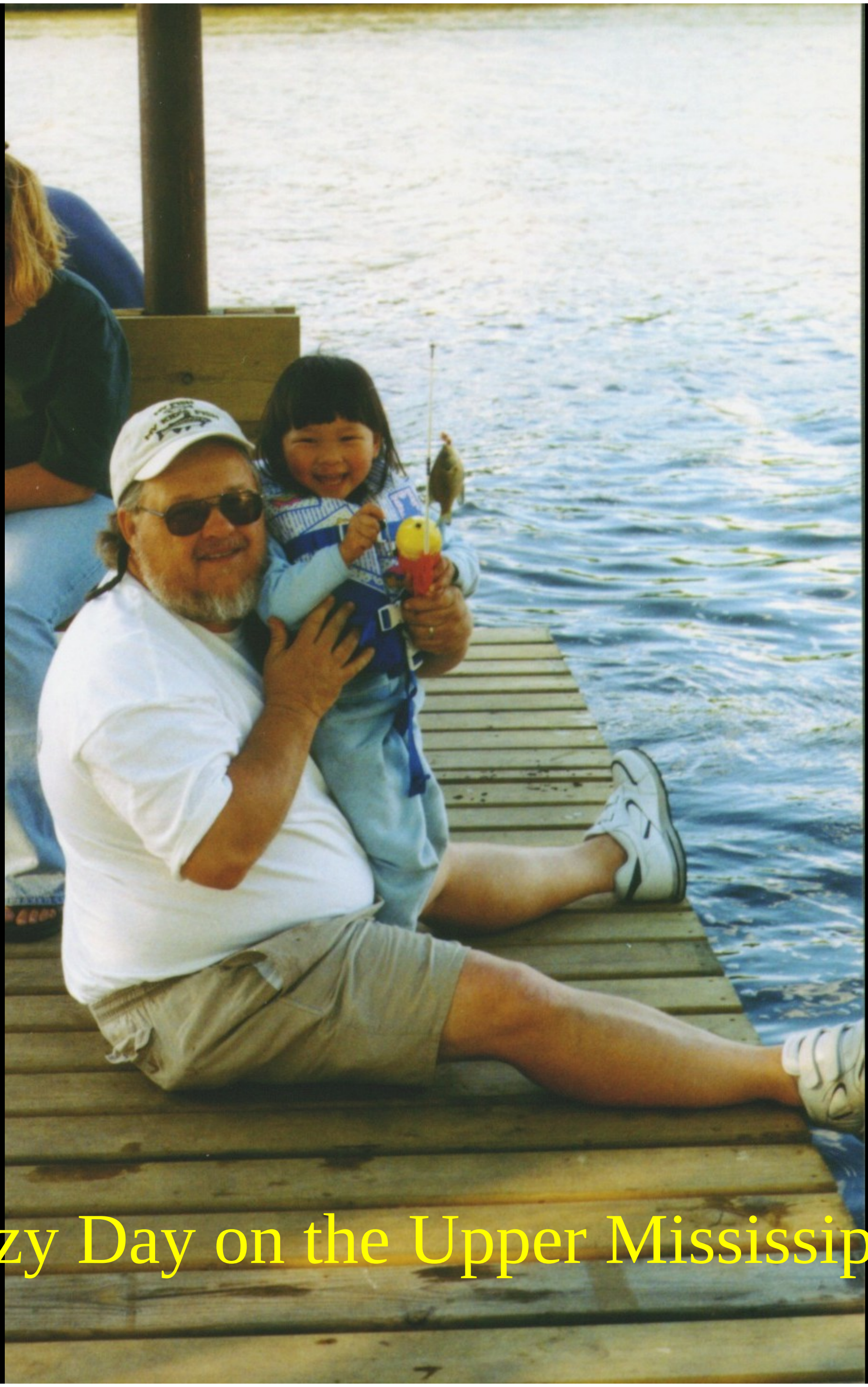
Situations where an impact may be pervasive (e.g., levees)

Other rivers can serve as reference if have same hydrogeomorphic patch

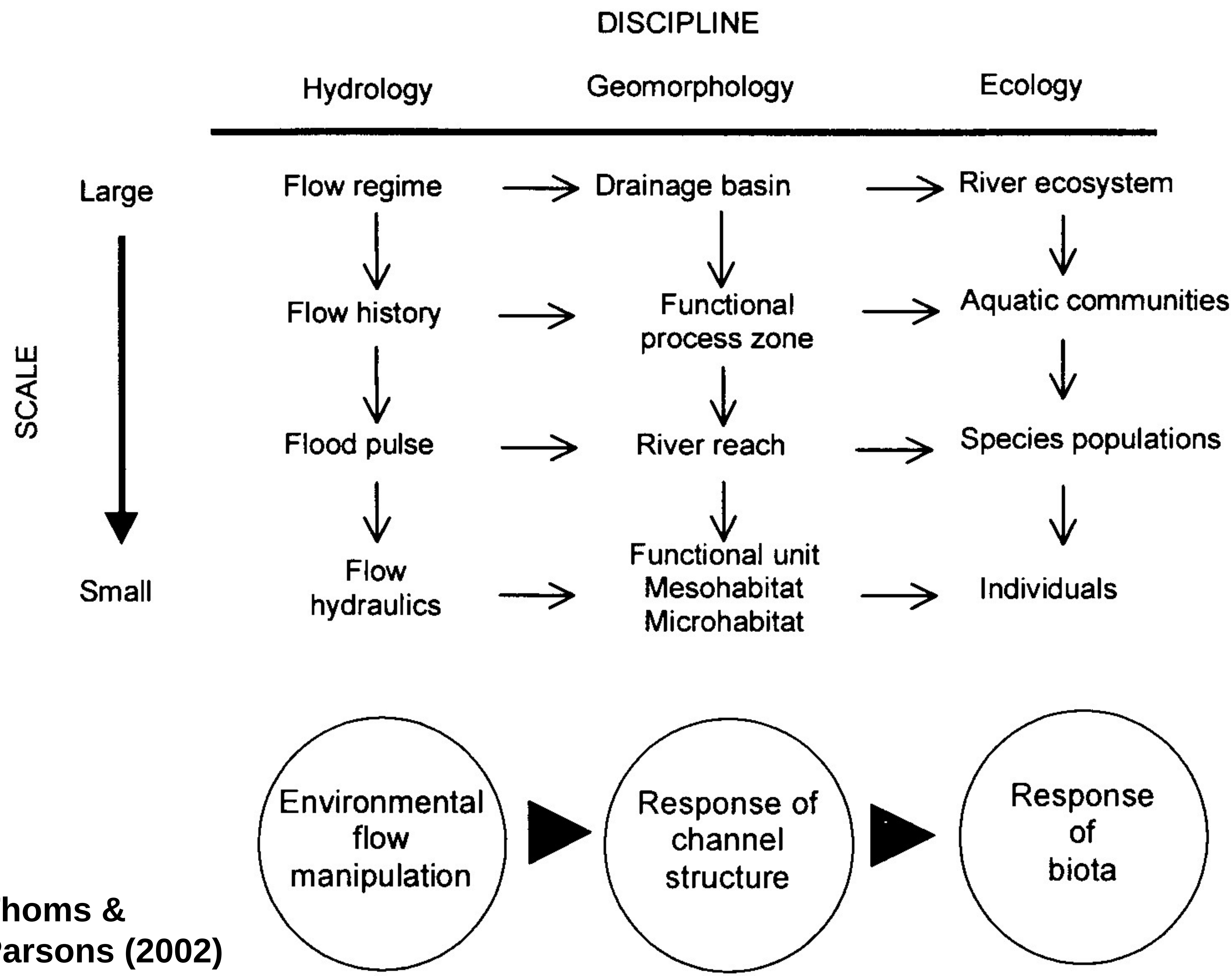
- **Applicable to other rivers**
- **Hydrogeomorphic patches identified on Missouri River (Pegg & Pierce 2002)**

Conclusions

- Hydrogeomorphic patches allow greater flexibility in defining references
- Approach fits within the strata framework of EMAP
- More natural units – greater ease of use for discrete sampling



Lazy Day on the Upper Mississippi



Thoms & Parsons (2002)

Table I. Flow variables used in multivariate analyses of the reference and current water-resource development scenarios. Seven main types of variables (labelled 1 to 7) were included, containing various categories of variables. Acronyms correspond to each category, but are also numbered sequentially within a category. For example, within the 'long-term values' category (LT) there were 18 individual flow variables. Growns and Marsh (2000) give a full list of the 340 flow variables. The number of flow variables from each category that were used in the reference and current water-resource development data sets is also given

Variable type and variable category	Scale	Acronym (and number of variables in each category)	Number of variables included in each scenario	
			Ref.	Current
(1) Daily flow summary				
Long-term values	Regime	LT (1–18)	15	15
(2) High flow spell analysis				
Number of 'above-threshold' flows	History	HSN (1–22)	17	17
Peak magnitude of 'above-threshold' flows	Pulse	HSP (1–22)	17	17
Duration of 'above-threshold' flows	Pulse	HSD (1–22)	17	17
Seasonal variation of 'above-threshold' flows	History	HSSV (1–36)	30	28
(3) Low flow spell analysis				
Number of 'below-threshold' flows	History	LSN (1–14)	8	8
Trough magnitude of 'below-threshold' flows	Pulse	LST (1–14)	2	2
Duration of 'below-threshold' flows	Pulse	LSD (1–14)	8	8
Seasonal variation of 'below-threshold' flows	History	LSSV (1–36)	18	18
(4) Moving average				
Maximum annual moving average	Regime	AMAX (1–12)	9	9
Minimum annual moving average	Regime	AMIN (1–12)	4	3
(5) Cessation of flow analysis				
Zero flows	History	ZF (1–6)	5	5
Number of rises and falls of the hydrograph	History	RFN (1–8)	8	8
Duration of rises and falls of the hydrograph	Pulse	RFD (1–8)	8	8
Magnitude of daily change in flow	Pulse	RFM (1–32)	26	26
(6) Monthly flow analysis				
Monthly flows	Regime	MF (1–50)	26	26
Inter-monthly variability	History	MFMV (1–4)	2	2
Inter-annual, monthly variability	Regime	MFAV (1–4)	4	4
(7) Additional variables				
Number of days between spells of zero flow	History	NDAY0 (1)	1	1
Maximum number of days between spells of 1/2 mean daily flow	History	NDAY5 (1)	1	1
Maximum number of days between spells of 1/3 mean daily flow	History	NDAY3 (1)	1	1
Maximum number of days between spells of 1/9 mean daily flow	History	NDAY9 (1)	1	1
Mean annual flow	Regime	MAFL (1)	1	1
CV mean annual flow	Regime	CVMAF (1)	1	15

Thoms & Parsons (2003)