DEVELOPMENT OF A HIERARCHICAL RIVERINE CLASSIFICATION SYSTEM AND ASSESSMENTS TO HELP DEFINE CONSERVATION TARGETS AND POTENTIAL REFERENCE SITES

Scott P. Sowa and David D. Diamond
Missouri Resource Assessment Partnership
(MoRAP)
www.cerc.usgs.gov/morap

Outline

- Conceptual underpinning
- Classification hierarchy
  - Ecological Drainage Units
  - Aquatic Ecological Systems
  - Valley Segment Types
- Conservation Assessments (look for the ‘best’)
  - Planning Areas
  - Assessment Units
  - Stressor Index
  - Targets
- Example: identification of focus areas (potential reference sites) for the Meramec Ecological Drainage Unit

Why do we need a hierarchical classification of riverine ecosystems?

- Organize data and thoughts and communicate information (all classifications)
- Ecosystems consist of their abiotic and biotic components
  - Account for natural abiotic variation to facilitate stratification (compare apples to apples)
  - Account for biological variation based on evolutionary processes due to
    - stream system connectivity
    - hard species dispersal barriers

Federal Water Pollution Control Act (as amended, Nov. 27, 2002)

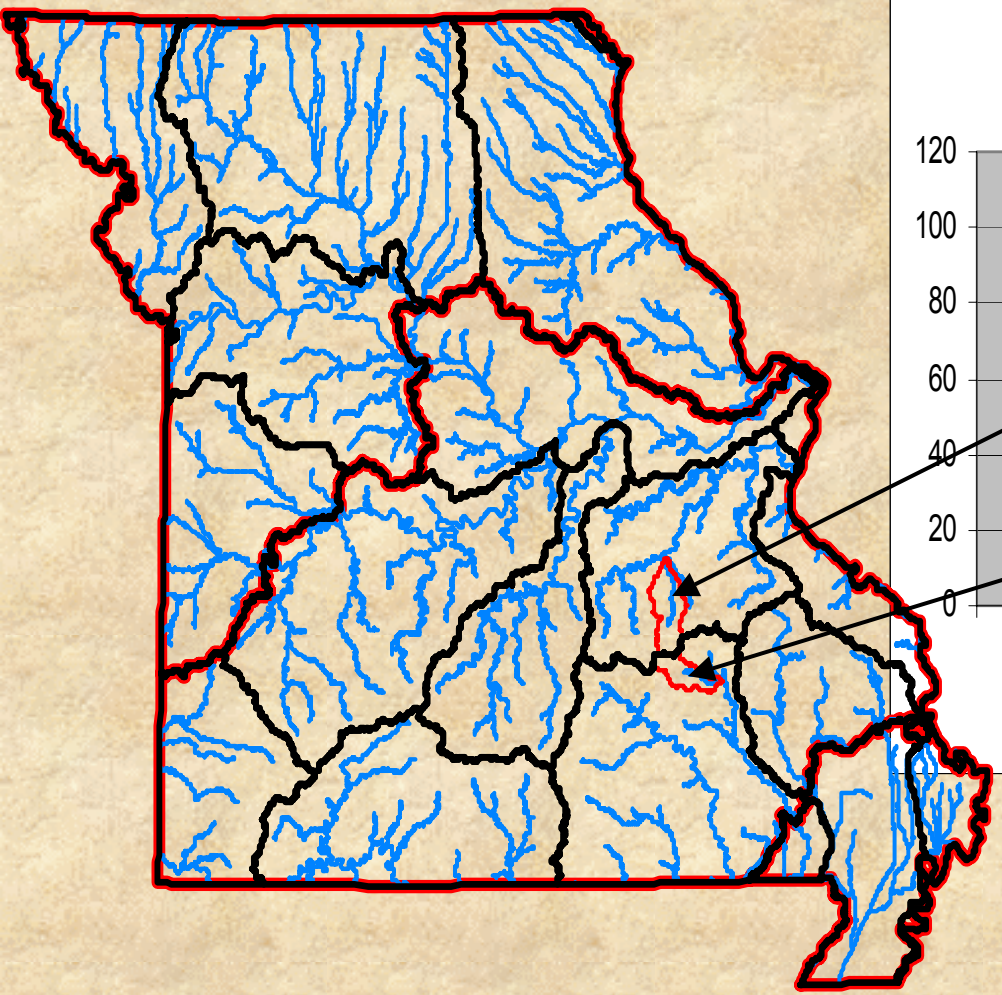
"Section 101: The objective of this act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

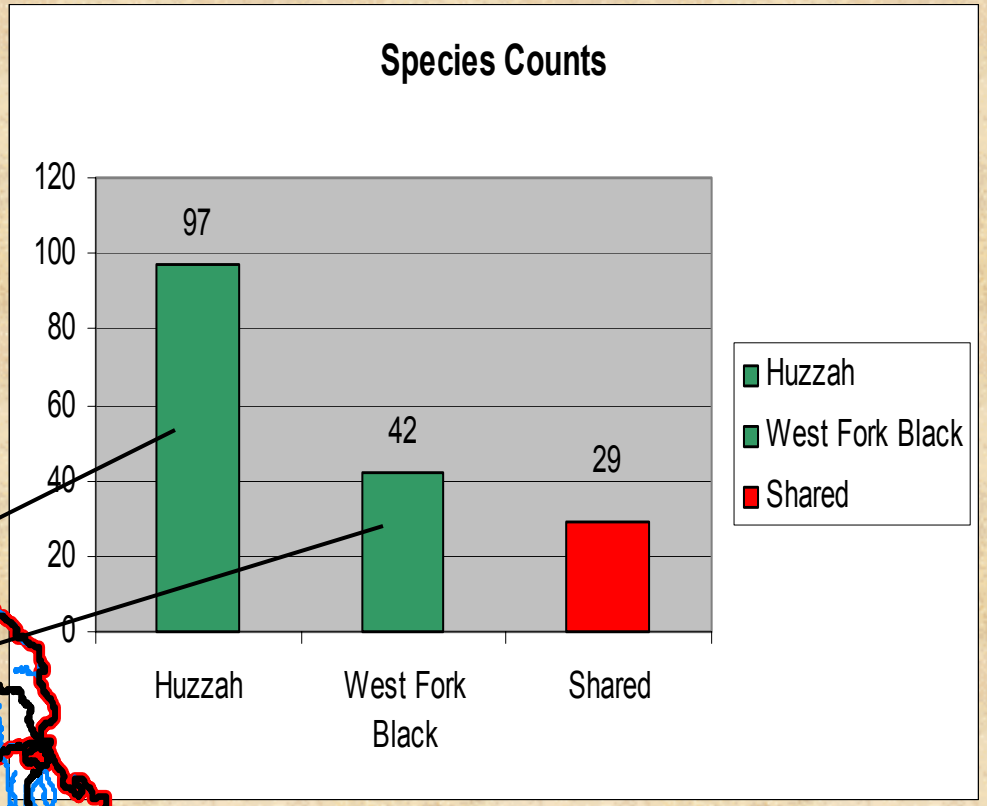
Need for Hierarchical Classification: Although Metrics Should Have Broad Application

Typical IBI Metrics

Category	Metric
Species richness and composition	Total number of fish species
	Number of darter species
	Number of sunfish species
	Number of cyprinid species
	Number of intolerant species
	Proportion of individuals as green sunfish
Trophic composition	Proportion of individuals as omnivores
	Proportion of individuals as insectivores
	Proportion of individuals as piscivores
Fish abundance and condition	Number of individuals in sample
	Proportion of individuals as hybrids
	Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies

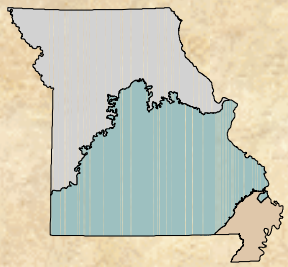
For Biodiversity Conservation Species Composition and Population Isolation are of Critical Importance



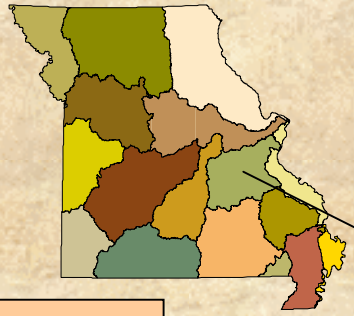


Classification Hierarchy

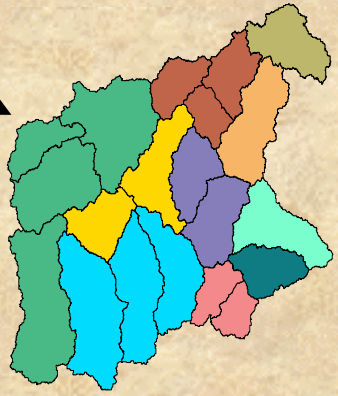
Level 4
Subregions



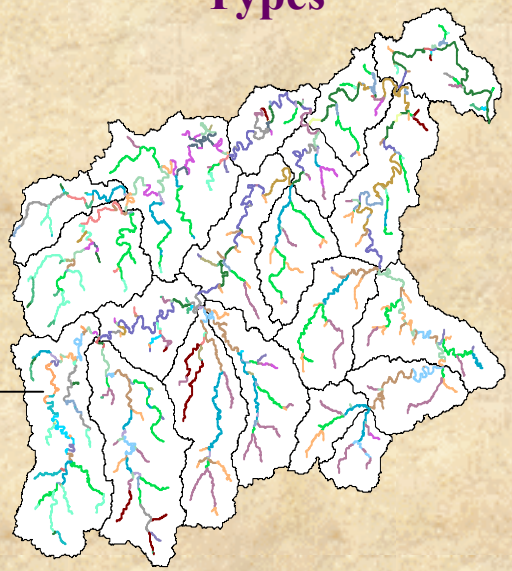
Level 5
Ecological Drainage Units



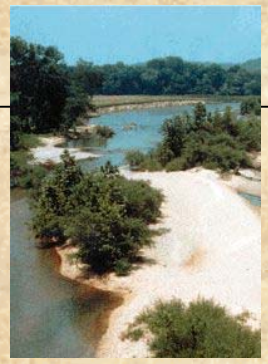
Level 6
Aquatic Ecological System Types



Level 7
Valley Segment Types



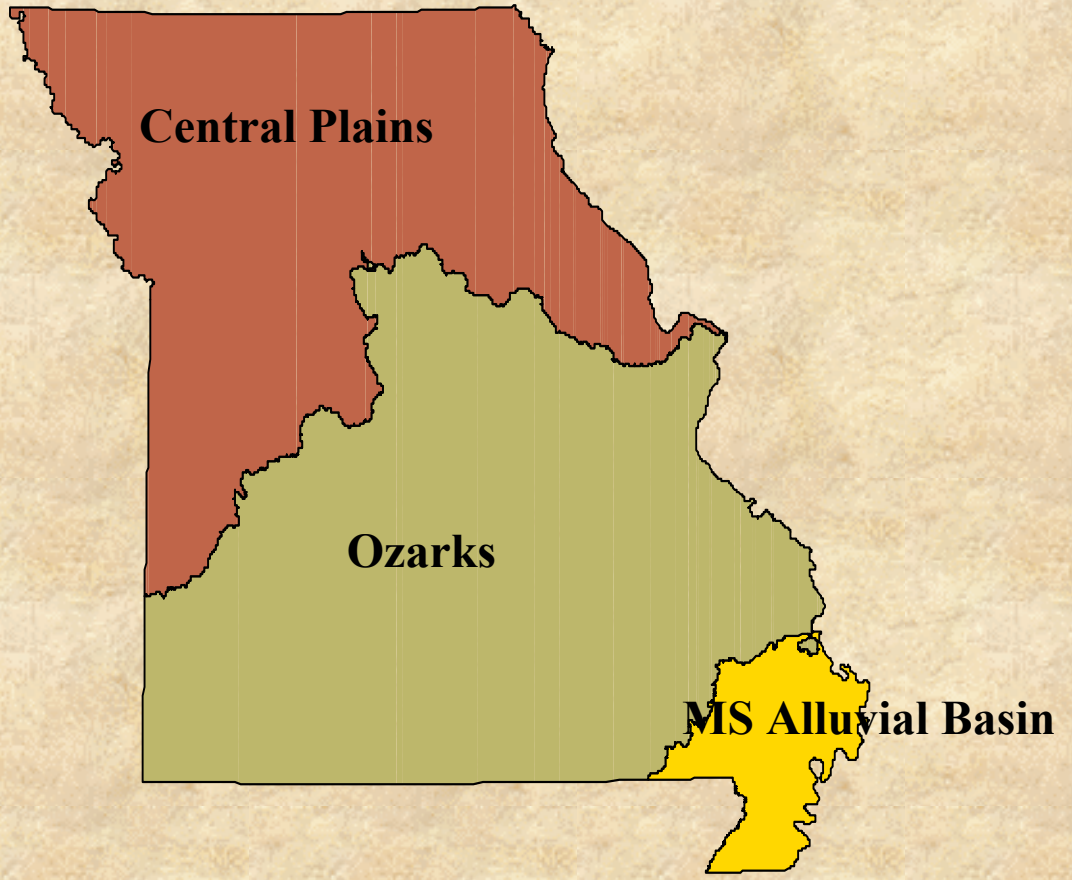
Zone:
Nearctic zoogeographic zone
Subzone:
Arctic/Atlantic Drainages
Region:
Mississippi Drainage
Subregion:
Ozark Plateau
Ecological Drainage Unit:
Ozark Plateau/Meramec Drainage
Aquatic Ecological System:
Upper Meramec/Dry Fork, Oak/Woodland Plain, sandstone dominated, low gradient and spring density stream complex
Valley Segment Type:
Warm, perennial, creek with a relatively high gradient, flowing through sandstone, and connecting to another creek



“A little inaccuracy sometimes saves a ton of explanation.”

~H. H. Munro~

Level 4: Aquatic Subregions

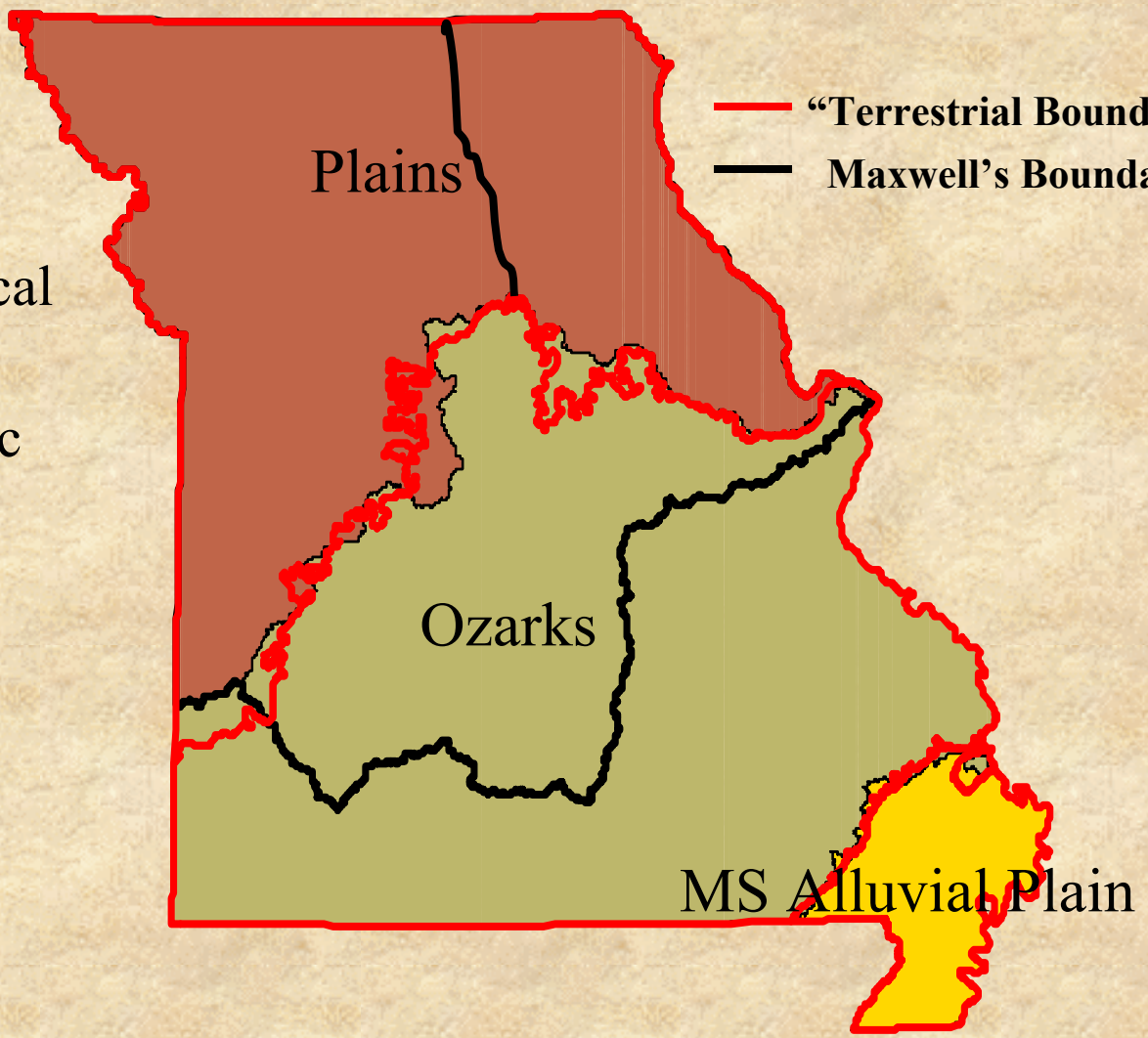


- Largely correspond to ecoregions, which account for differences in aquatic assemblages resulting from geographic abiotic variation in ecosystem structure/function (e.g., flow, habitat)

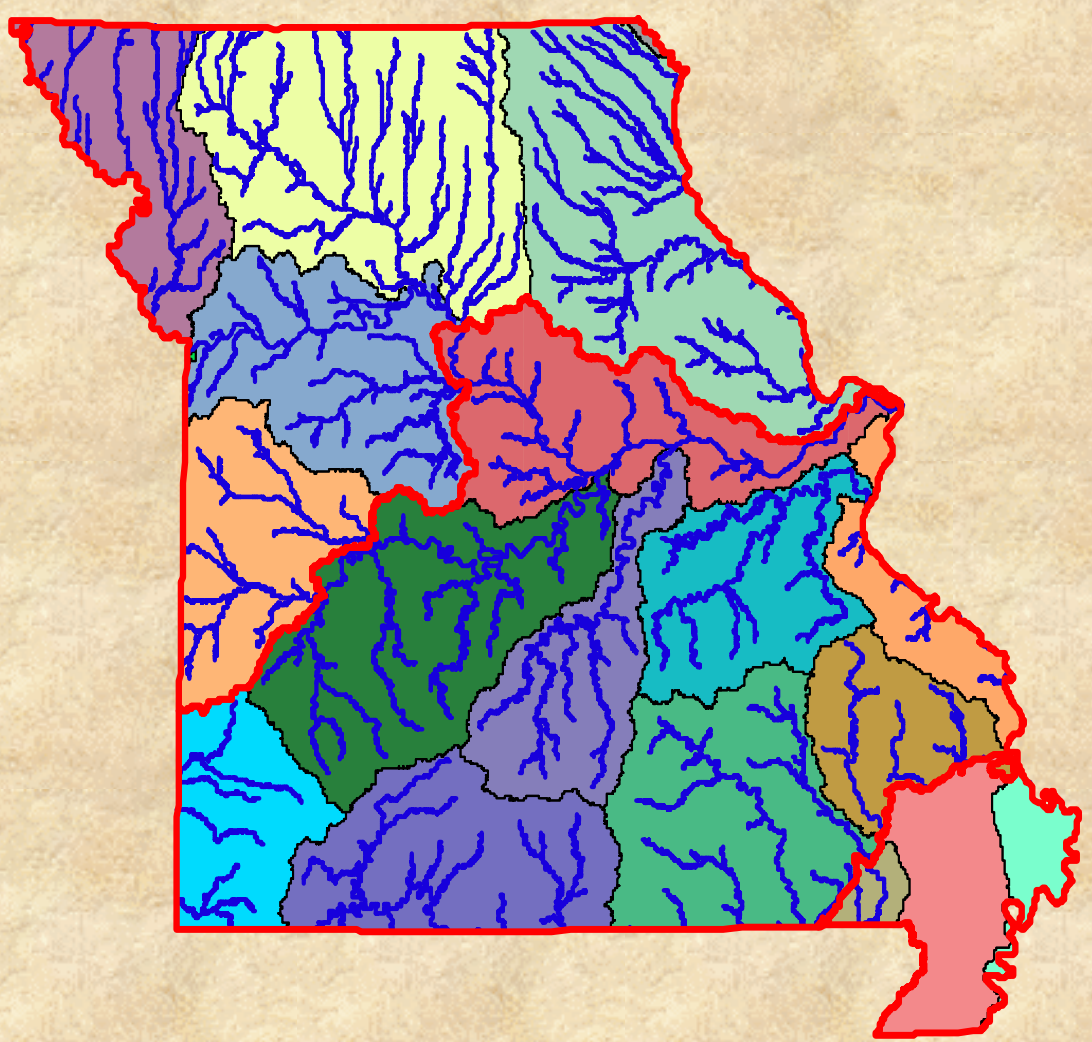
Level 4:
Aquatic Subregions
(Showing Drainage Enforcement)

Largely Correspond to:

- Omernik Level 2
- Bailey's Ecological Provinces
- Pflieger's Aquatic Faunal Regions

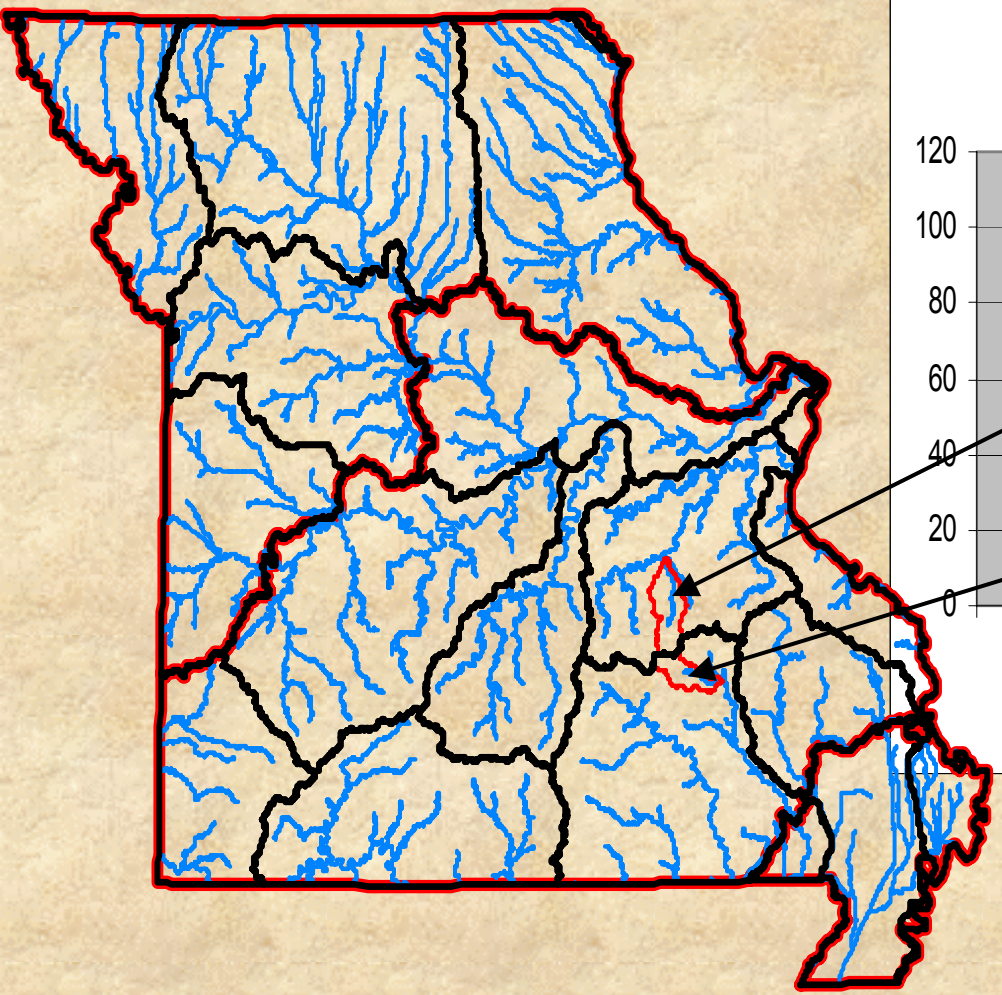


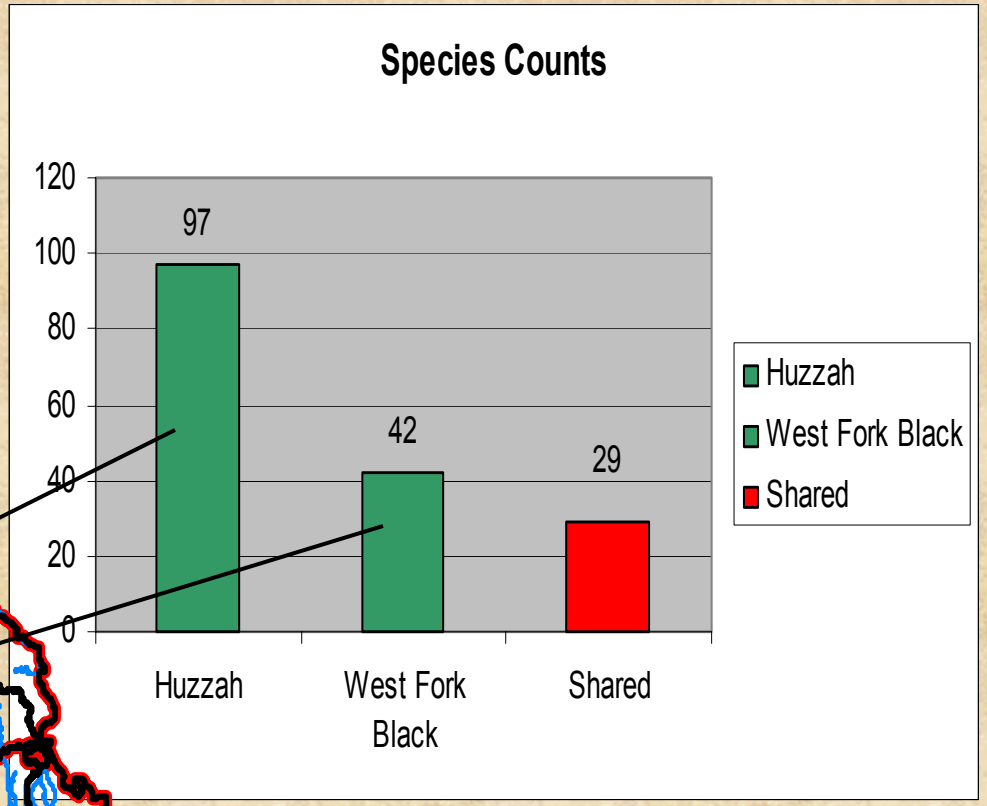
Level 5: Ecological Drainage Units (EDU)



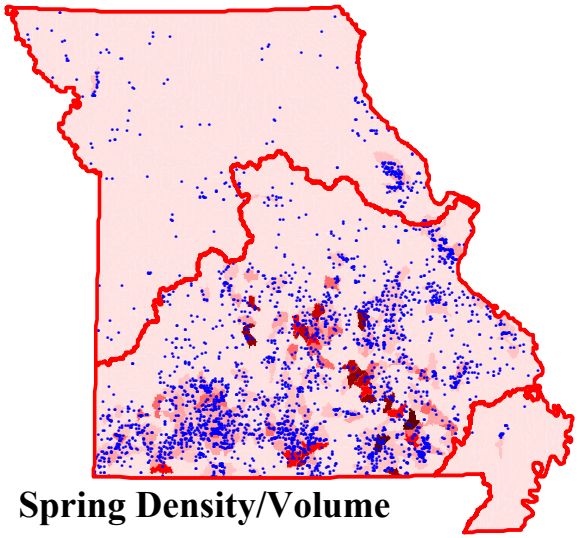
- Largely account for compositional differences in aquatic assemblages resulting from distinct evolutionary histories

For Biodiversity Conservation Species Composition and Population Isolation are of Critical Importance

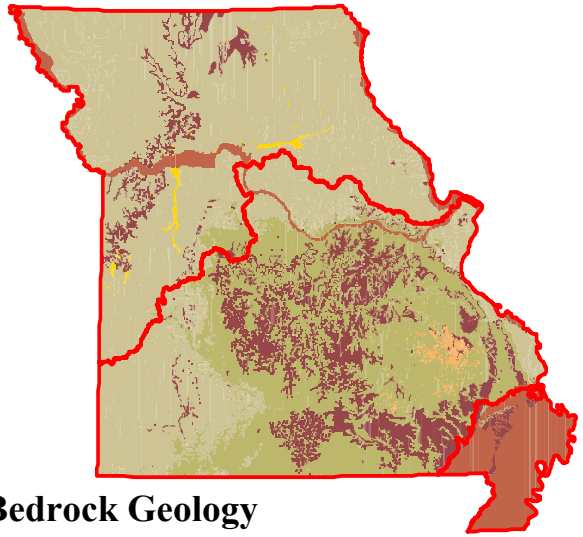




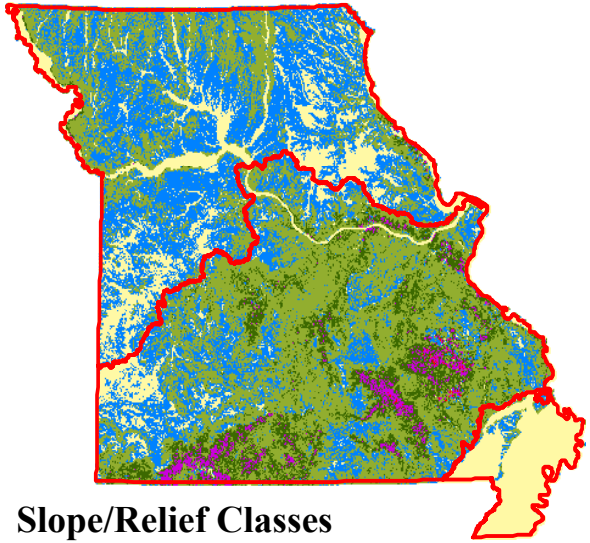
Aquatic Subregions & EDUs are NOT Homogenous



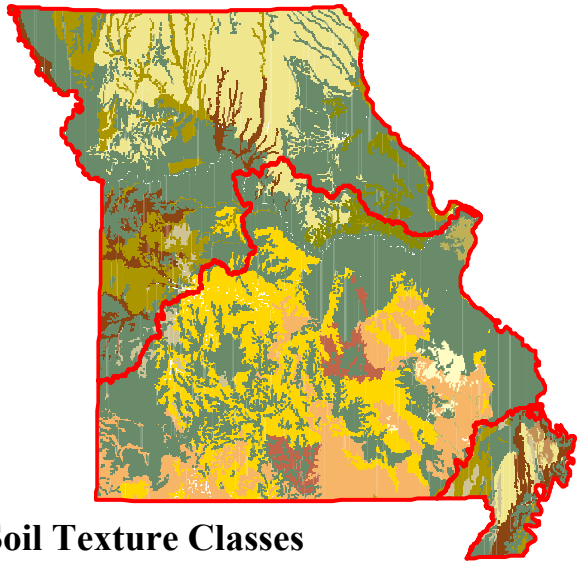
Spring Density/Volume



Bedrock Geology

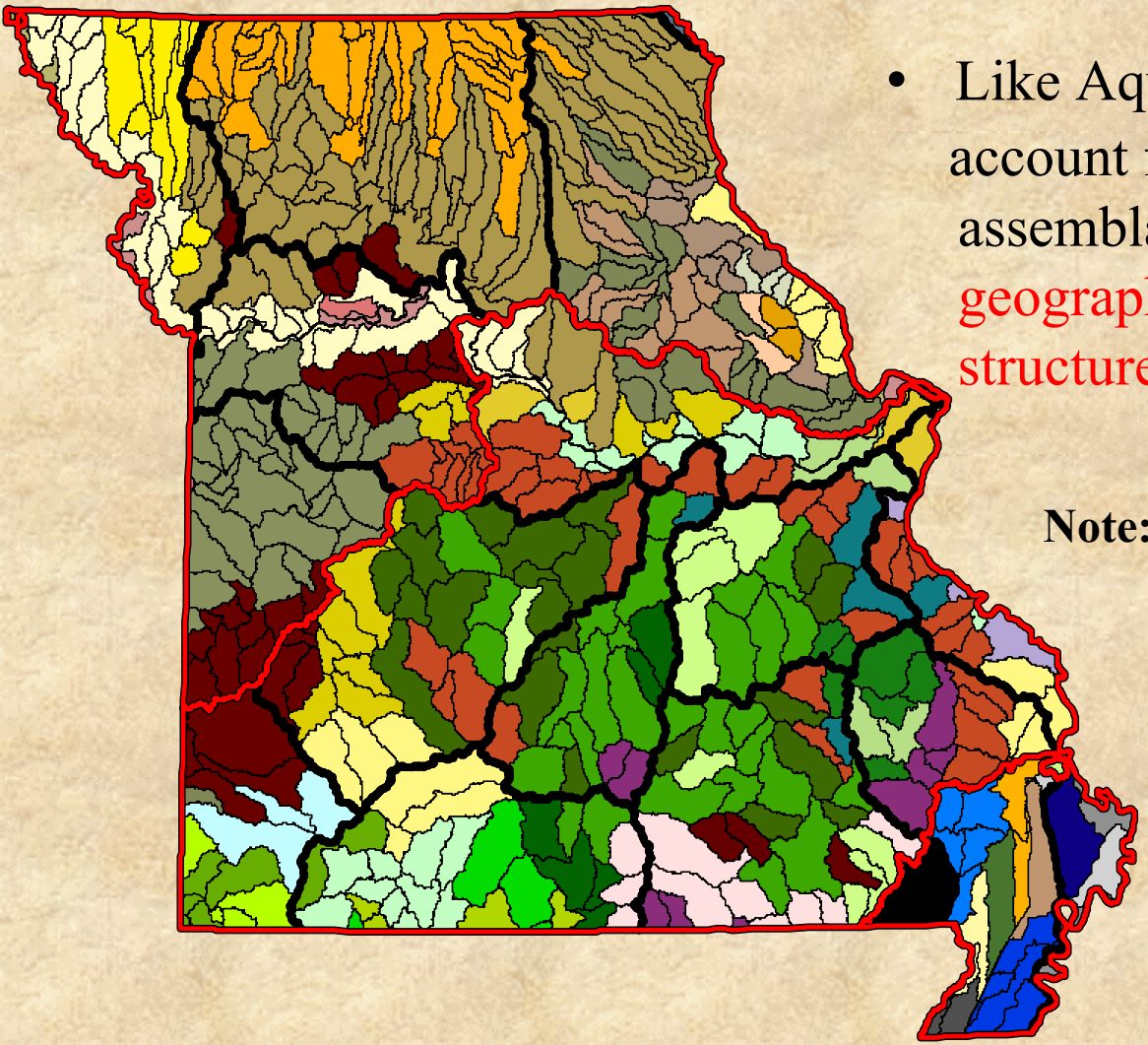


Slope/Relief Classes



Soil Texture Classes

Level 6: Aquatic Ecological System Types

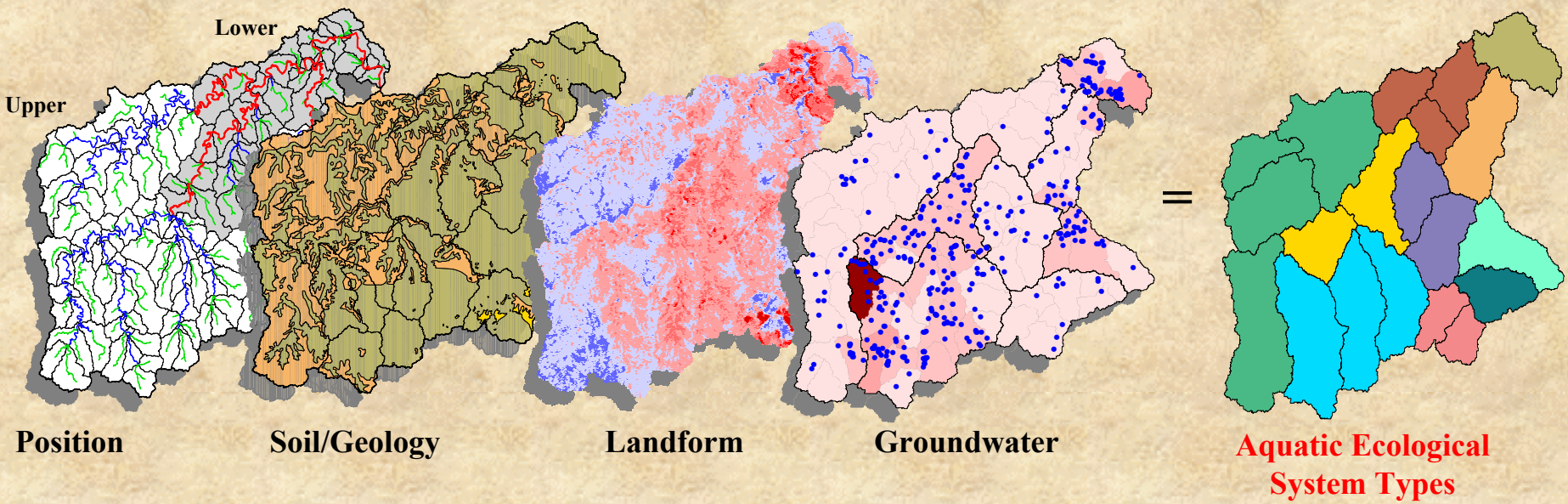


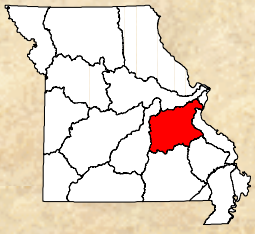
- Like Aquatic Subregions, AES-Types account for differences in aquatic assemblages resulting from geographic abiotic variation in structure/function (e.g., flow, habitat)

Note: **No 2 EDU's have the same combination or spatial arrangement of AES-types**

Like colors represent ecosystem units having similar structure and function (AES-Types)

Aquatic Ecological Systems and Types For the Ozark/Meramec EDU





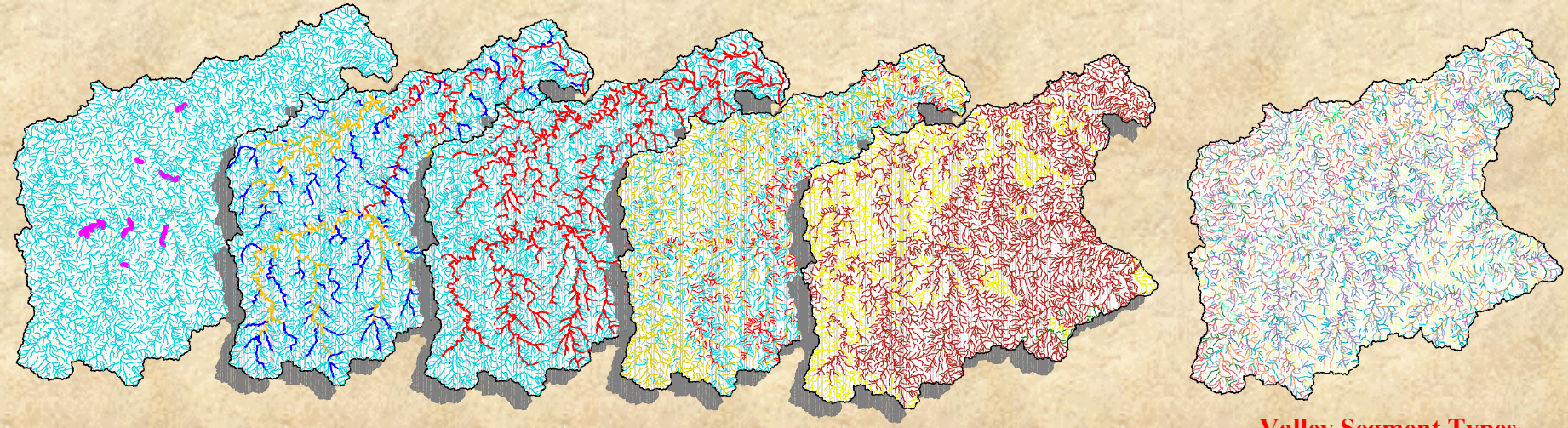
- Defined by multivariate cluster analysis of geology, soil, landform, and groundwater variables

Level 7: Valley Segment Types

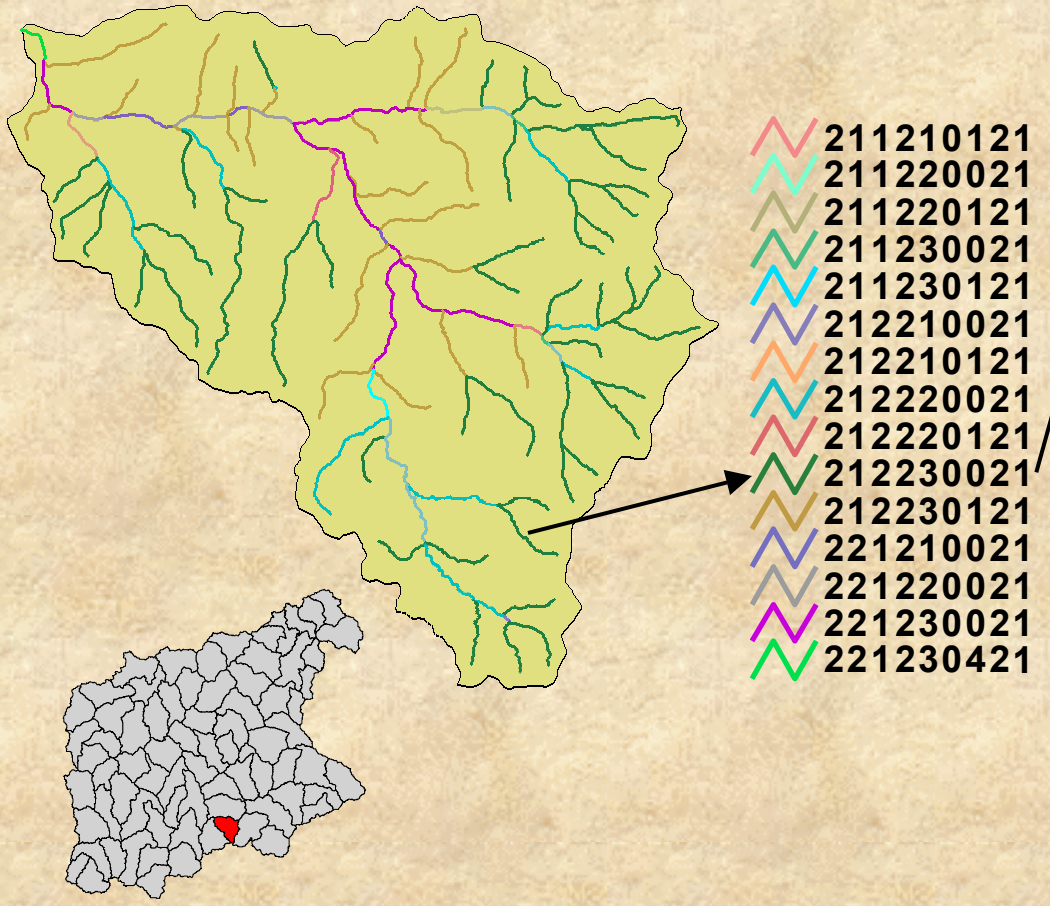
- Valley segments stratify a continuous stream network into distinct hydrogeomorphic patches
- Also account for differences in aquatic assemblages resulting from geographic abiotic variation in structure and function

Individual Variables

Unique Valley Segment Types



Deciphering VST Codes



Valley Segment Type Codes and Descriptions

212230021 = Valley Segment Type Code

2 = Warm

1 = Headwaters

2 = Intermittent flow

2 = Flowing through dolomite/limestone

3 = Relatively high gradient

0 = Valley wall interaction (N/A)

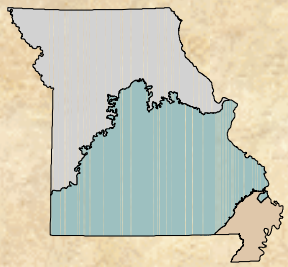
0 = Flows into another headwater

2 = Flowing within own valley

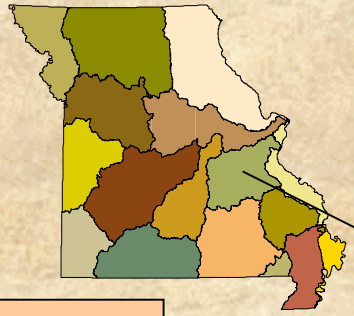
1 = Primary channel

Classification Hierarchy Provides Landscape Ecological Context

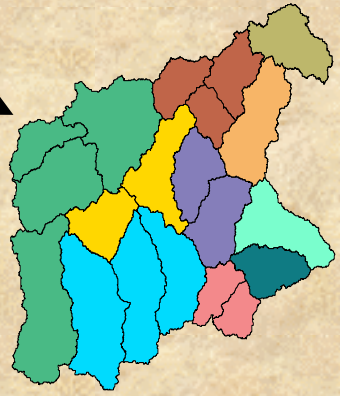
Level 4
Subregions



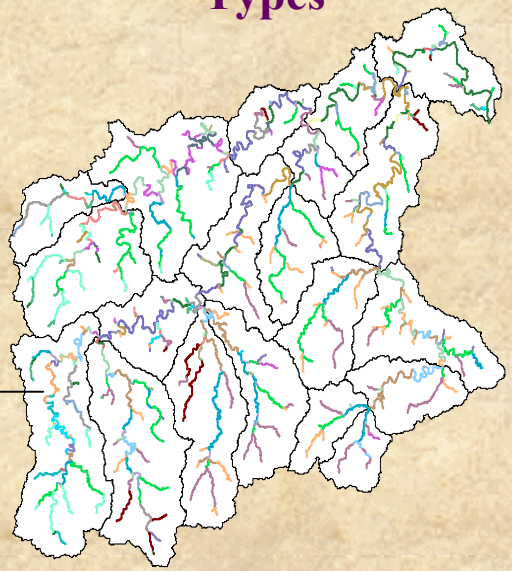
Level 5
Ecological Drainage Units



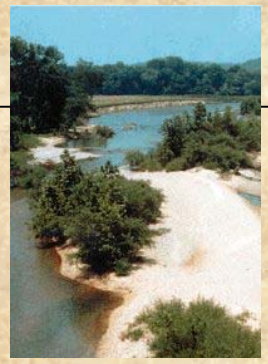
Level 6
Aquatic Ecological System Types



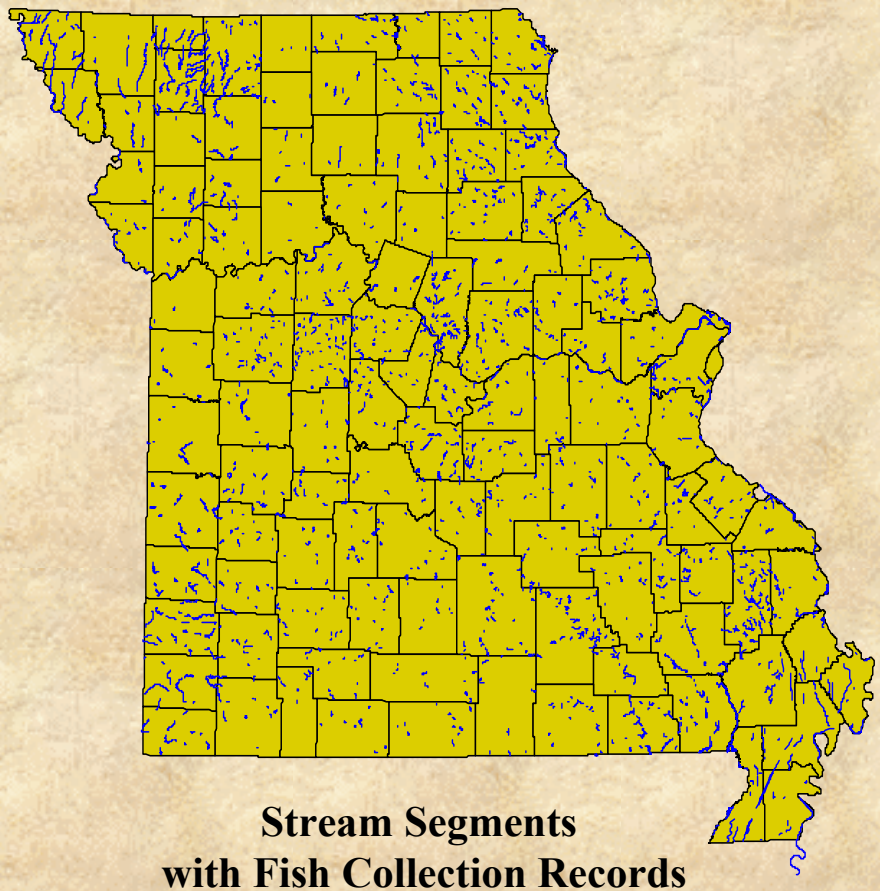
Level 7
Valley Segment Types



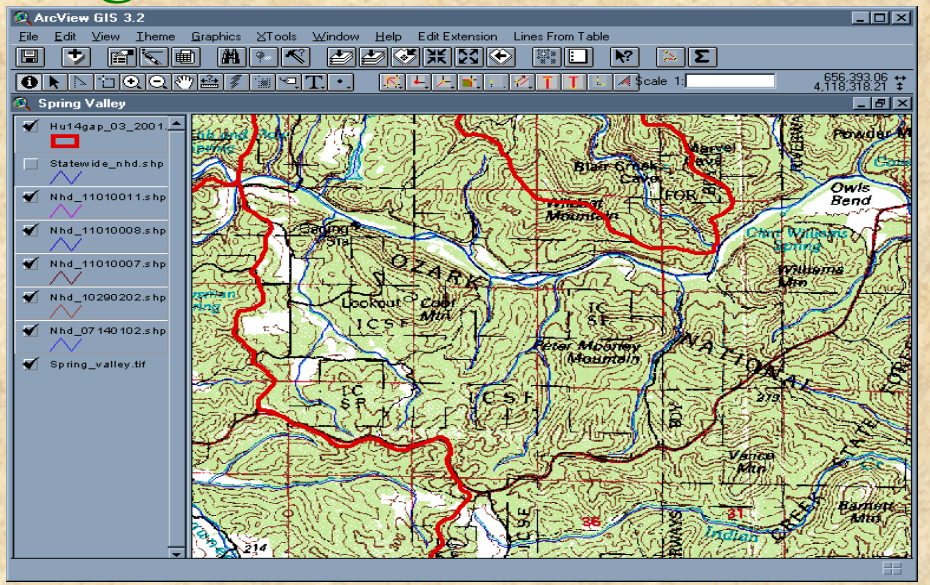
Zone:
Nearctic zoogeographic zone
Subzone:
Arctic/Atlantic Drainages
Region:
Mississippi Drainage
Subregion:
Ozark Plateau
Ecological Drainage Unit:
Ozark Plateau/Meramec Drainage
Aquatic Ecological System:
Upper Meramec/Dry Fork, Oak/Woodland Plain, sandstone dominated, low gradient and spring density stream complex
Valley Segment Type:
Warm, perennial, creek with a relatively high gradient, flowing through sandstone, and connecting to another creek

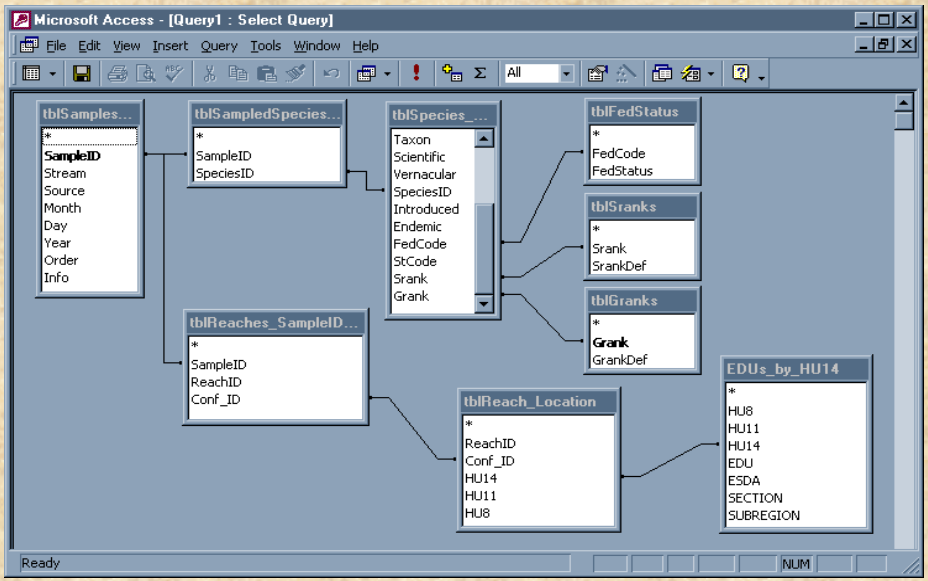


Defining the Biotic Community: Spatially-linked 1,000's of Collection Records to Valley Segment Coverage

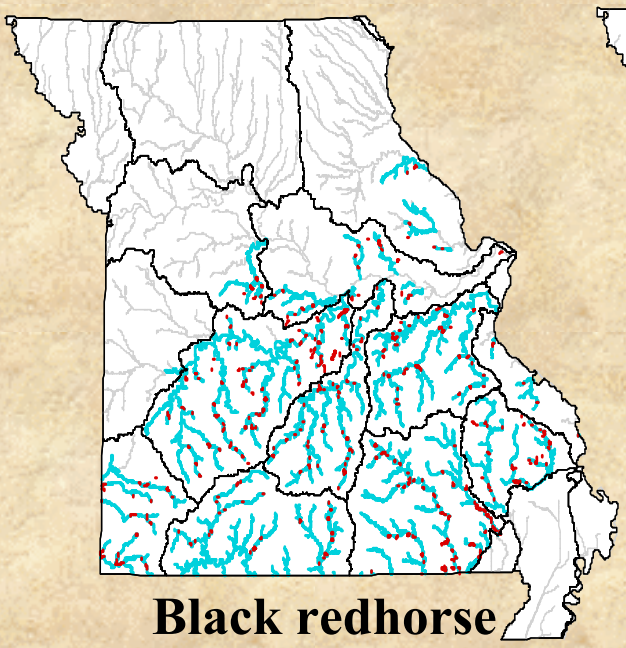


Stream Segments with Fish Collection Records

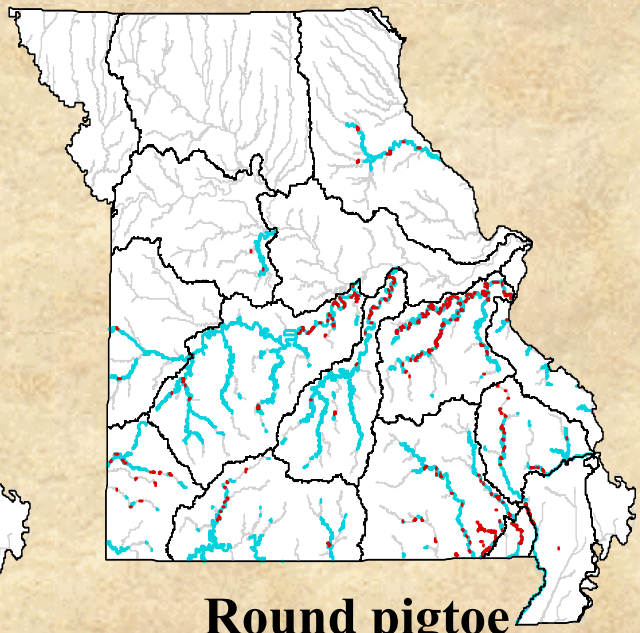




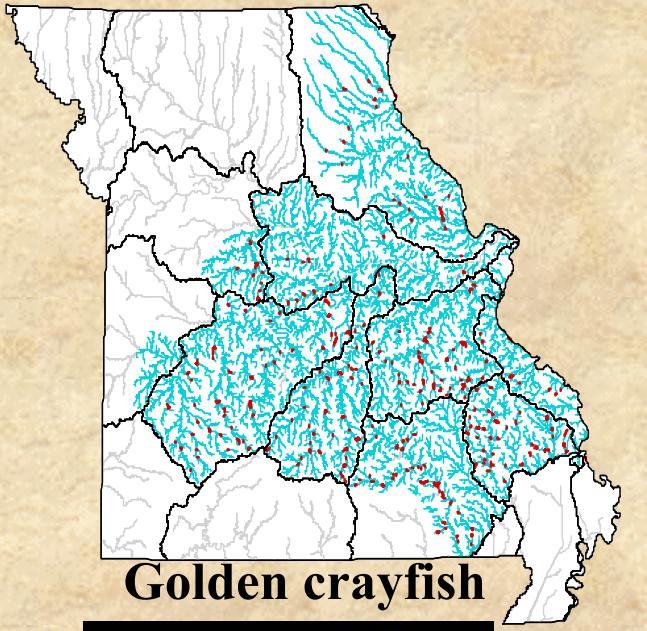
Constructed Models Separately for Each Species (decision tree analysis of variables attached to VST's)



Black redhorse



Round pigtoe



Golden crayfish

- 571 total models constructed for 315 different species

Individual Models were Merged into a Single Database

Plains: 10 Species

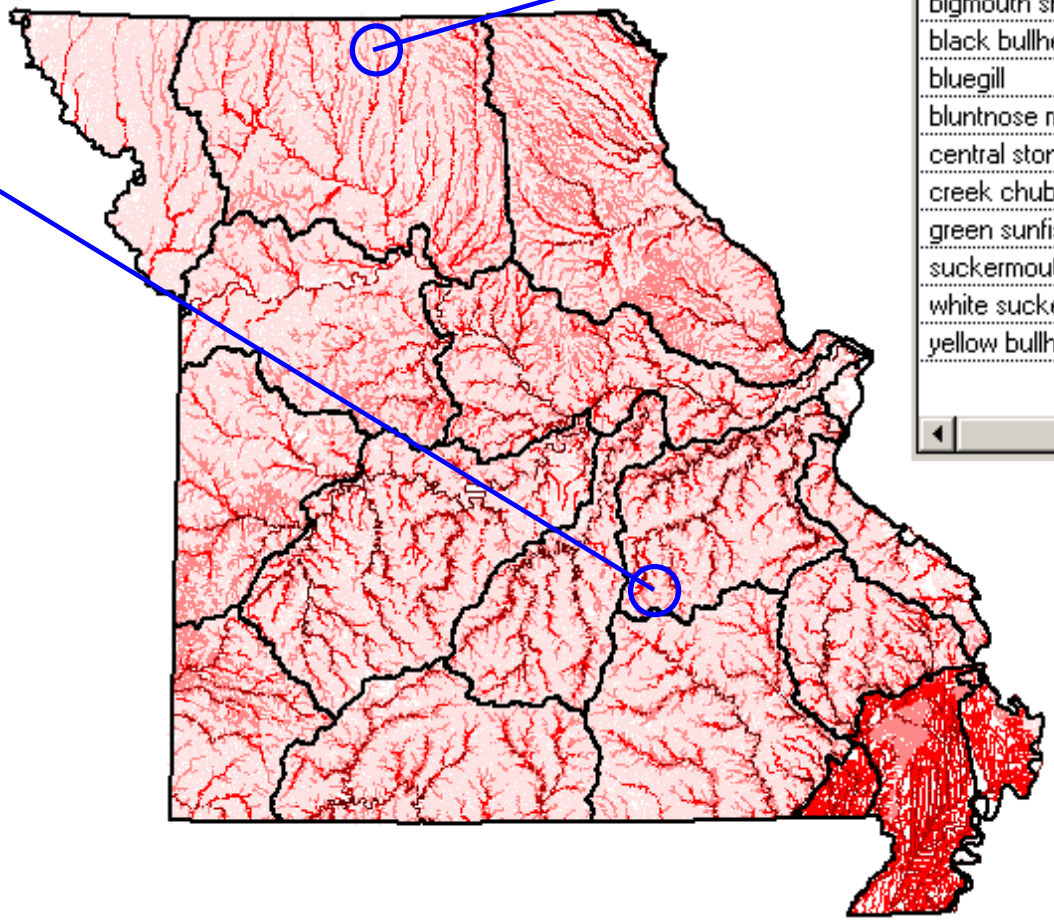
sum7.dbf

Vernacular
bigmouth shiner
black bullhead
bluegill
bluntnose minnow
central stoneroller
creek chub
green sunfish
suckermouth minnow
white sucker
yellow bullhead

Ozarks: 27 Species

sum6.dbf

Vernacular
Ozark minnow
bigeye chub
black bullhead
blackspotted topminnow
bleeding shiner
bluegill
bluntnose minnow
brook silverside
central stoneroller
common carp
creek chub
creek chubsucker
golden redhorse
golden shiner
green sunfish
greenside darter
largescale stoneroller
logperch
longear sunfish
northern hog sucker
northern studfish
plains topminnow
rainbow darter
slender madtom
smallmouth bass

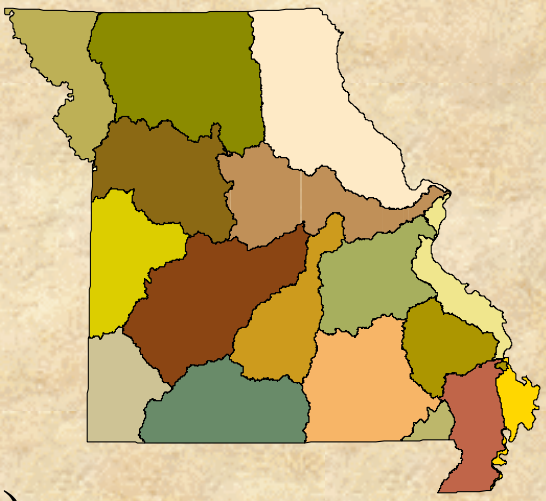


Conservation Assessment

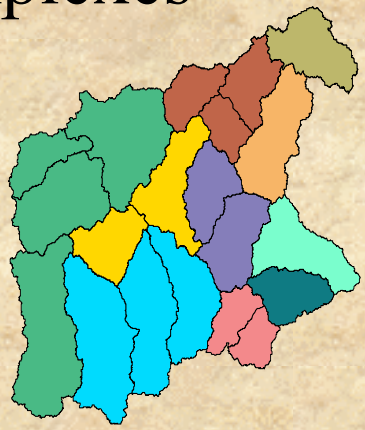
- Identify Planning Regions and Assessment Units
- Select Conservation Targets
  - Abiotic
    - Aquatic Ecological System Types
    - Valley Segment Types
  - Biotic
    - Endemics
    - Species of Special concern
    - Characteristic species
      - Ecologically important species (top predators, major prey species)
      - Geographically distinct populations
- Assess quality & select focus areas

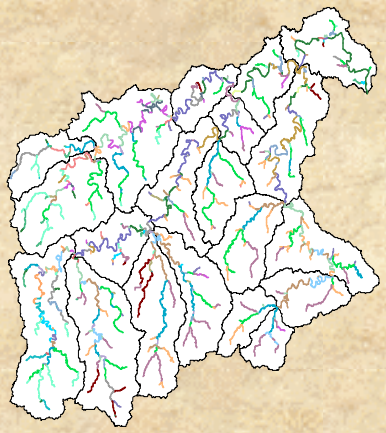
Planning Region & Assessment Unit

- Planning Region: generate separate conservation plans for each Ecological Drainage Unit (EDU)



- Assessment Unit: Select priority Aquatic Ecological Systems (AES's) and Valley Segment Type (VST) complexes



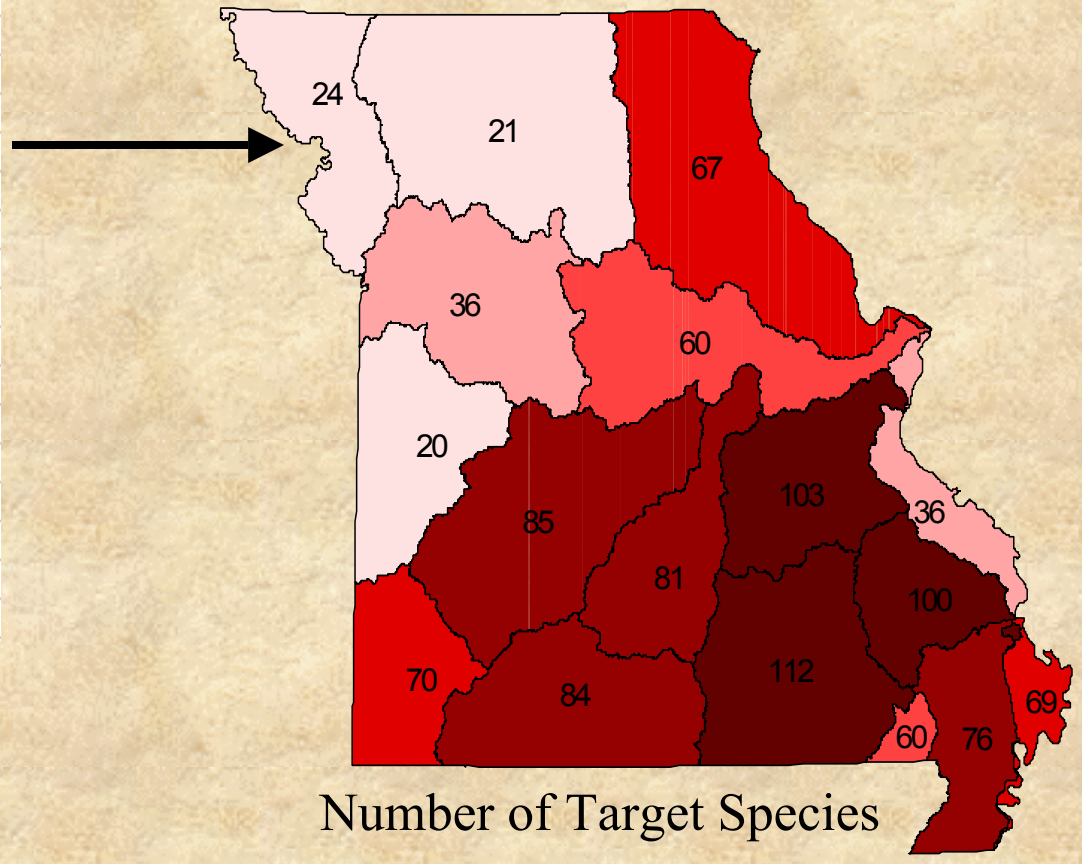


Biotic Conservation Targets

Scientific	Common
Acipenser fulvescens	lake sturgeon
Anodonta suborbiculata	flat floater
Arcidens confragosus	rock pocketbook
Cycleptus elongatus	blue sucker
Cyprinella lutrensis	red shiner
Fundulus zebrinus	plains killifish
Hiodon alosoides	goldeye
Hybognathus argyritis	western silvery minnow
Hybognathus hankinsoni	brassy minnow
Hybognathus placitus	plains minnow
Luxilus cornutus	common shiner
Macrhybopsis gelida	sturgeon chub
Macrhybopsis hyostoma	shoal chub
Macrhybopsis meeki	sicklefin chub
Macrhybopsis storeriana	silver chub
Notropis buchanani	ghost shiner
Notropis dorsalis	bigmouth shiner
Notropis topeka	Topeka shiner
Orconectes immunis	papershell crayfish
Pimephales promelas	fathead minnow
Platygobio gracilis	flathead chub
Polyodon spathula	paddlefish
Procambarus gracilis	grassland crayfish
Scaphirhynchus albus	pallid sturgeon

- Endemics
- Species of special concern
- Characteristic species

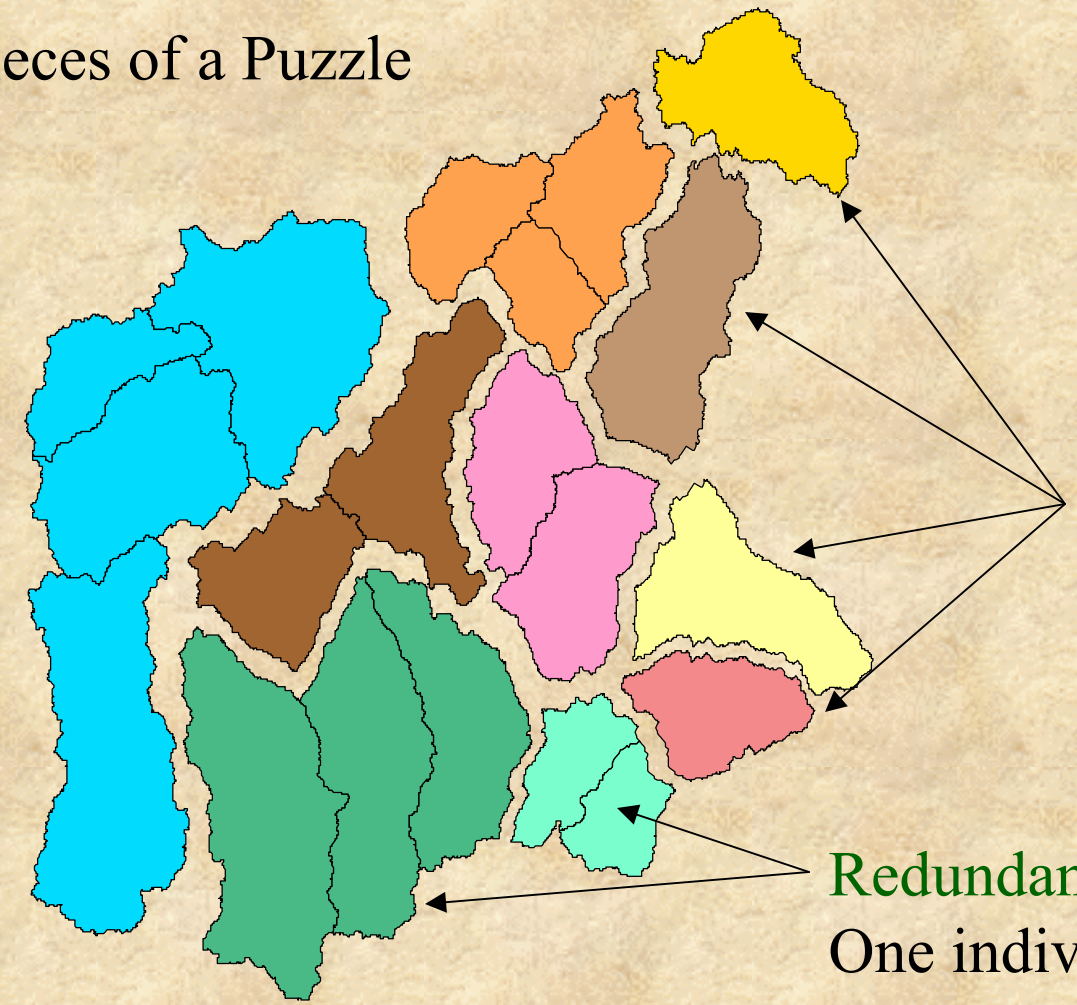
- Represent all endemic species, species of special concern, and characteristic species for each EDU



Number of Target Species

Abiotic Targets: AES Types

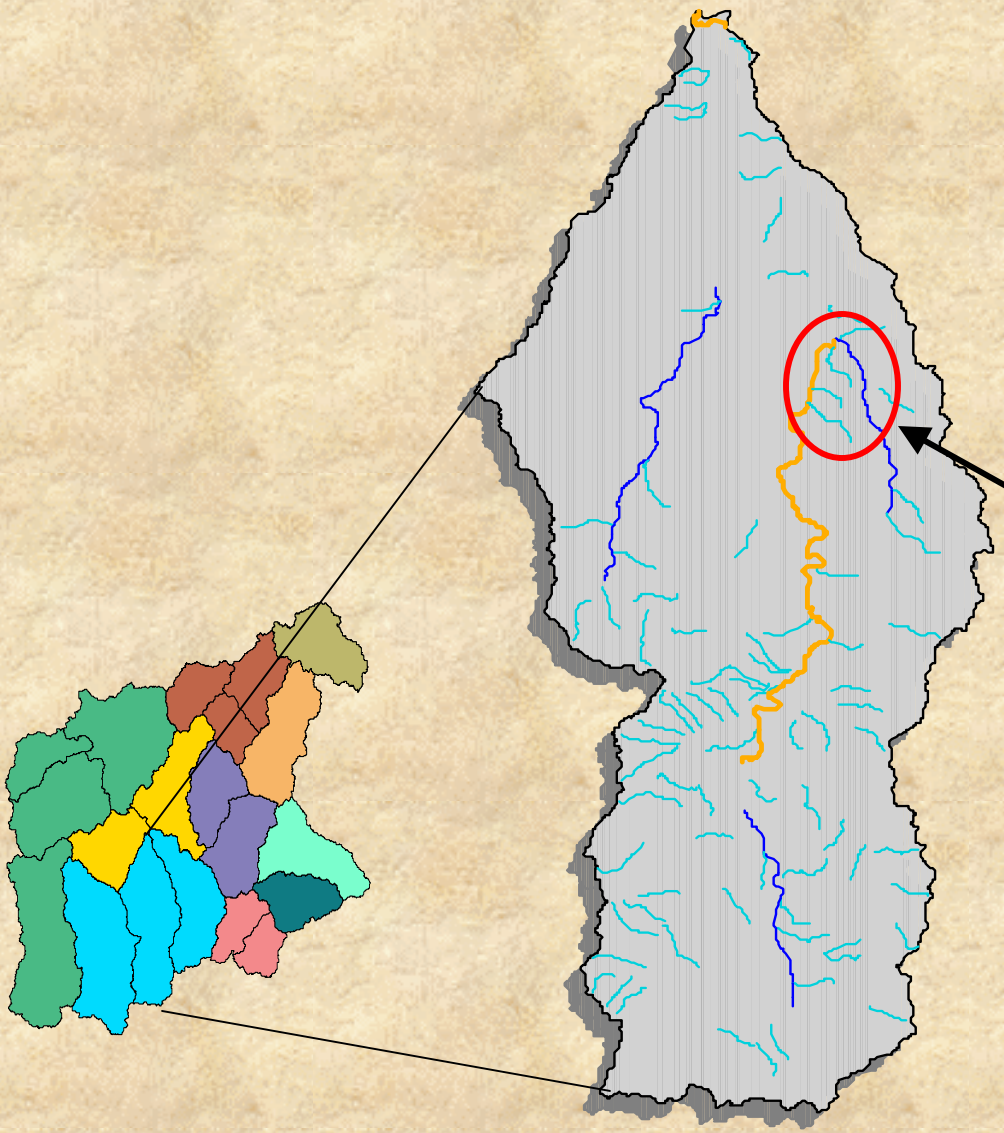
Pieces of a Puzzle



Distinct types:
Each one warrants conservation

Redundant types:
One individual AES warrants conservation

Abiotic Targets: Dominant VST's



- Representation of dominant VST's (by stream size)
- Within a single AES
- Should address issue of connectivity

Stream Size Classes

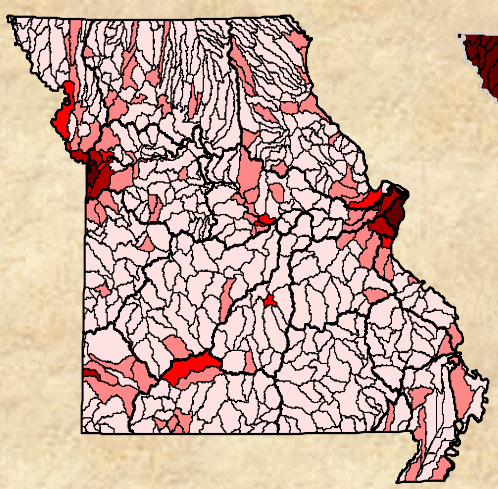
Headwater

Creek

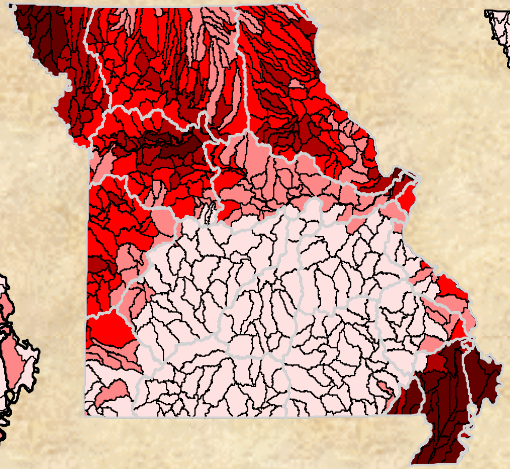
Small River

Dominant Valley Segment Types by Size Class For Huzzah River AES

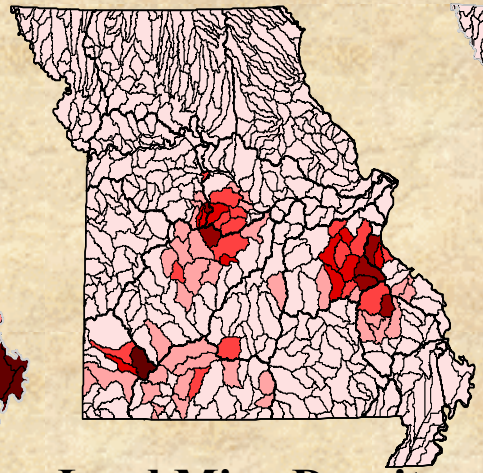
Assessing Quality at the AES Level: Human Stressors



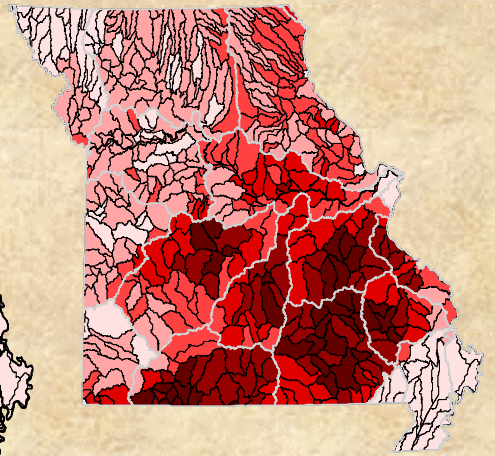
Percent Urban



Percent Cropland



Lead Mine Density



Riparian Forest

Attributes of Mo_aes_no_atts.shp

N_index_a	Pfor	Purb	Popchg	Stordcar	Pfor_a	Pwetl	Pwetl_a	Purb_a	Pagp	Pagp_a	Pagc
63129600.0	4.6733	0.7236	1.950	0.02911	30719700.0	1.8081	11885400.0	4756500.0	21.1641	139122000.0	68.5054
44426700.0	8.3388	1.1371	-2.259	0.02734	28229400.0	1.6302	5518800.0	3849300.0	31.4877	106596000.0	54.2490
87714000.0	11.5990	1.8831	19.094	0.00987	53461800.0	1.6080	7411500.0	8679600.0	46.4294	214002000.0	32.3911
38376900.0	11.0445	0.1387	-3.261	0.00804	22499100.0	1.2021	2448900.0	282600.0	44.7170	91094400.0	36.2694
17636400.0	2.5608	0.6827	-10.089	0.00000	5620500.0	2.8572	6271200.0	1498500.0	17.7593	38979000.0	73.5226
117477000.0	12.7244	1.5937	9.233	0.03354	74214900.0	1.0420	6077700.0	9295200.0	50.6270	295281900.0	27.6202
46512000.0	13.4467	1.9184	-3.716	0.01482	33314400.0	1.8963	4698000.0	4752900.0	33.1771	82197000.0	46.1276
21305700.0	10.3359	2.0993	5.626	0.03312	14294700.0	2.0648	2855700.0	2903400.0	33.0934	45768600.0	49.2965
26120700.0	9.1666	0.0644	11.042	0.03643	15754500.0	1.8632	3202200.0	110700.0	42.8112	73578600.0	41.9058
17995500.0	7.3856	0.1121	-6.551	0.05027	9483300.0	1.9065	2448000.0	144000.0	31.8226	40860900.0	54.0503
65268000.0	7.8013	1.2999	15.010	0.04766	37684800.0	1.1018	5322600.0	6279300.0	39.2811	189751500.0	45.9077

Final Human Stressor Index List

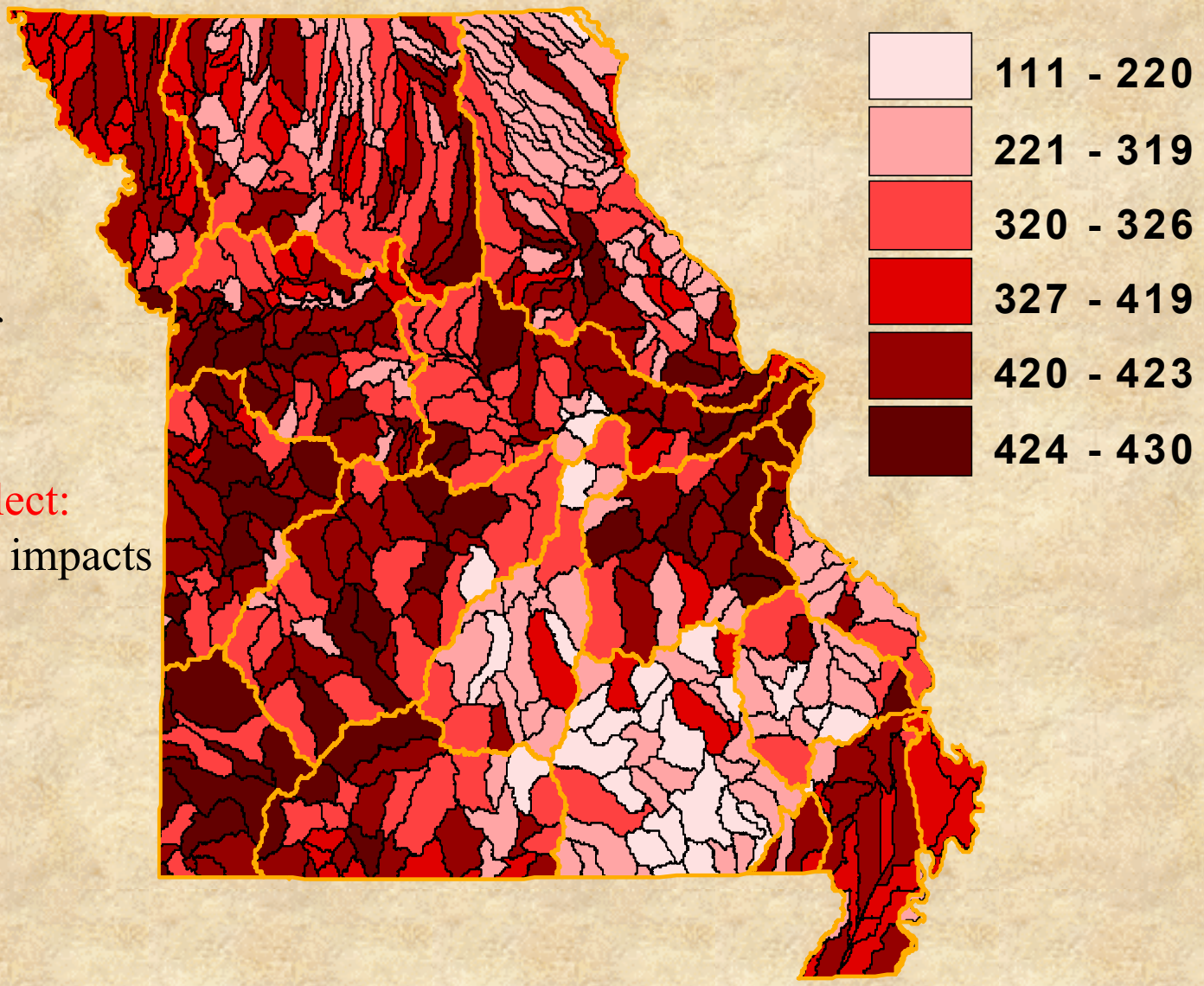
(metrics relatively uncorrelated; r-square<0.5)

- % Urban
- % Agriculture
- Density of Road/Stream crossings
- Population change
- Degree of fragmentation/hydrologic alteration
- Density of small impoundments
- Density of coal mines
- Density of lead mines
- Density of industrial discharges
- Density of Confined Animal Feeding Operations
- Number of Exotic Species

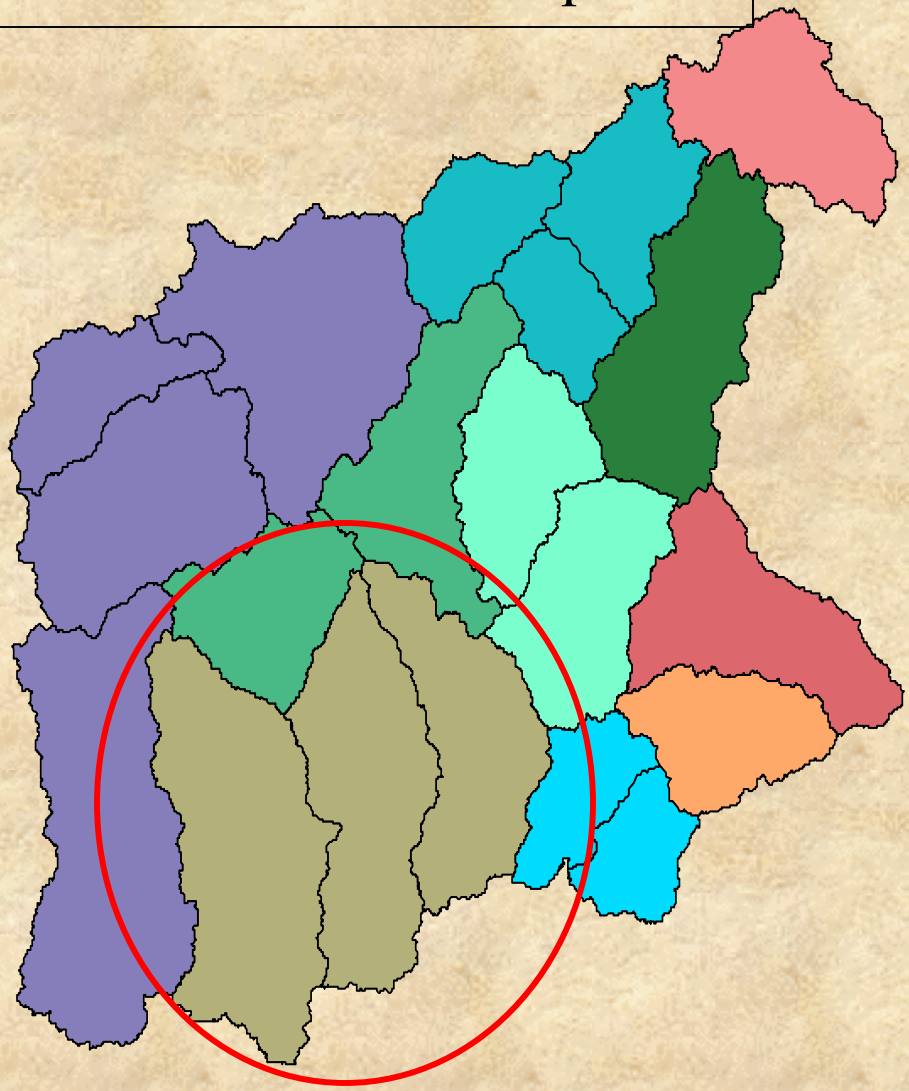
Human Stressor Index (not simply cumulative but disjunctive & cumulative)

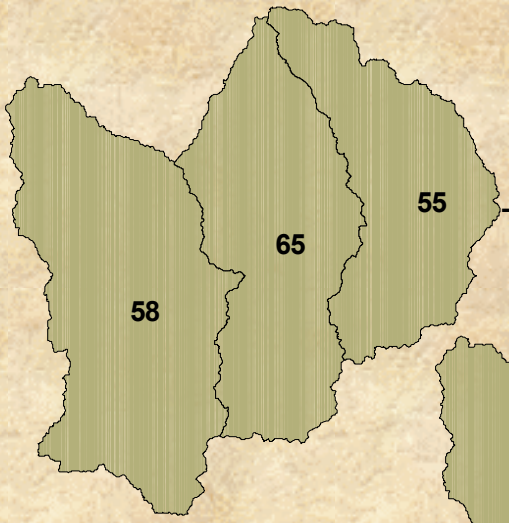
First number reflects:
Highest magnitude of individual stressor

Last two numbers reflect:
Degree of cumulative impacts



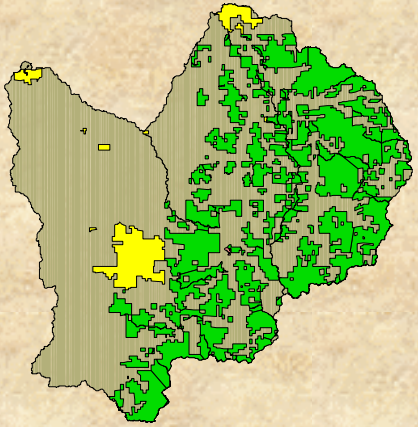
Selecting AES's: human interaction required



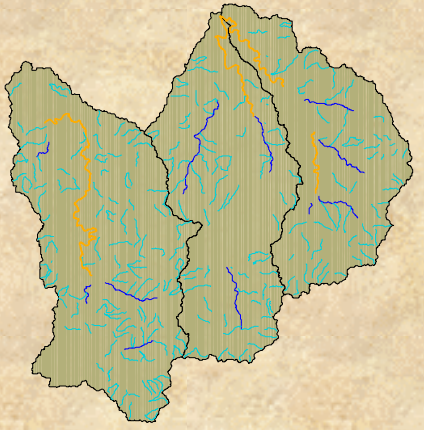


- Target Species Richness

Human Stressor Index -

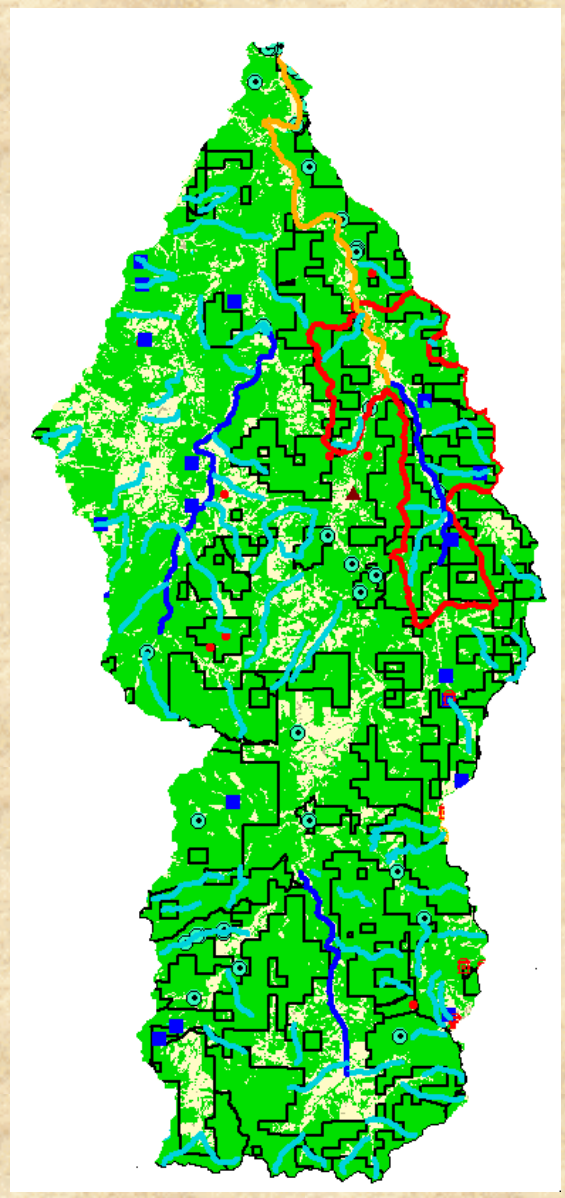


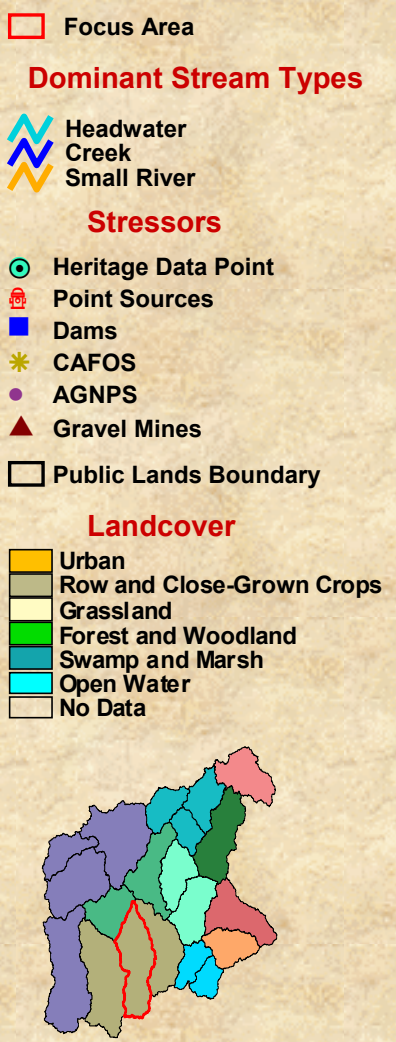
- Public Lands



Ability to Achieve Connectivity among - Dominant VST's

Selecting Priority VST Complexes
Selection Criteria and Important Data Layers





Criteria:

Connectivity

Stressors

Public Ownership

Stressors:

Point sources

Dams (small impoundments)

Cafos

Agricultural non-point sources

303d listed streams

Gravel mines

Other mines

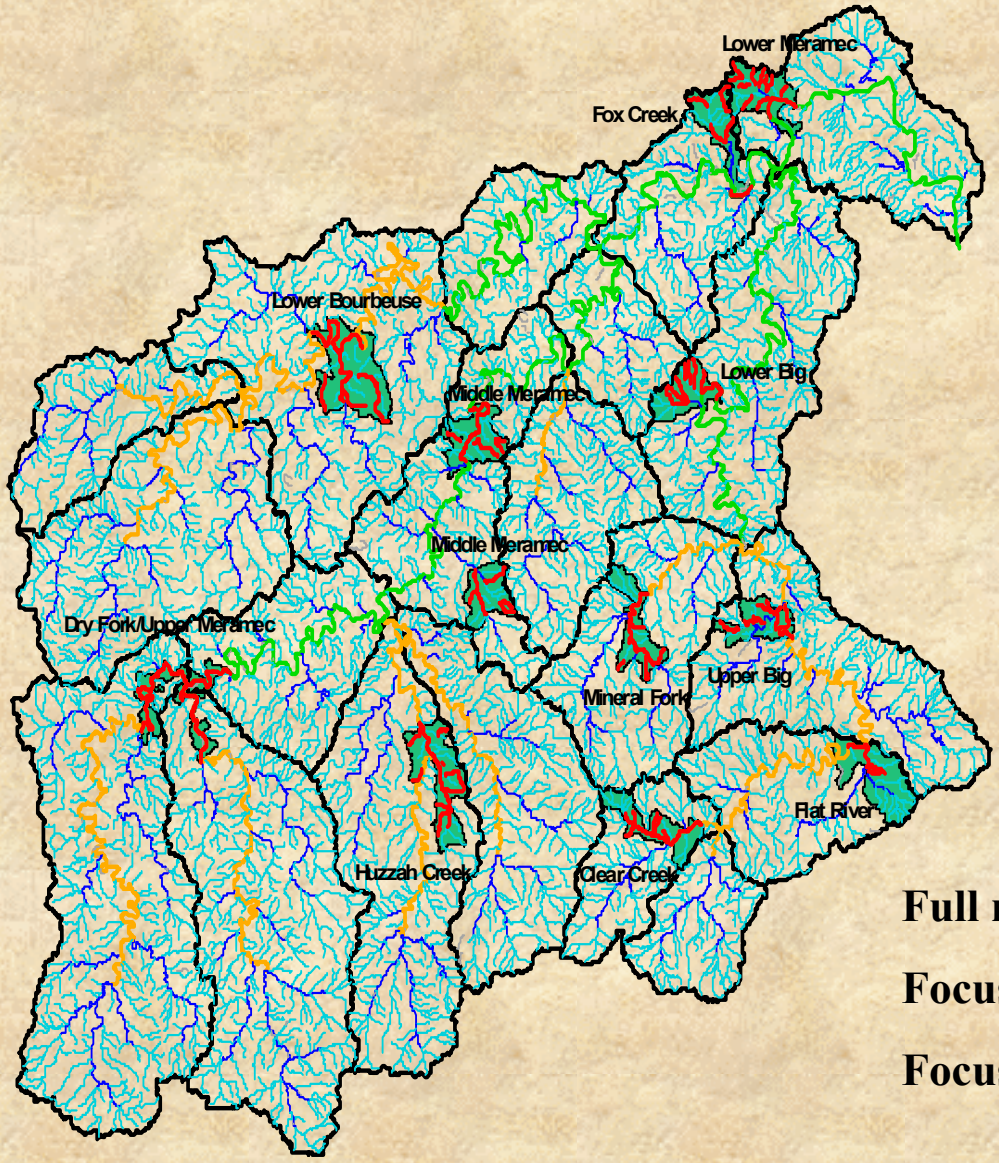
Roads

Exotic species

Hazardous material generators

Industrial Facility Discharges

Conservation Focus Areas and Potential Reference Sites for the Meramec Drainage



Focus Areas

AES Boundaries

Headwater

Creek

Small River

Large River

Full network: 10,684 km

Focus Area network: Only 300 km

Focus area represents 2.8% of entire network

Linking Biomonitoring with Biodiversity Conservation

- Linking biomonitoring and biodiversity conservation efforts is critical to conserving our nation's natural resources and without integrating such efforts we will likely not achieve the goals of either

  Hughes and Noss 1992; Moyle 1994; Davis and Simon 1995; Karr 1995

Contact Information

Scott P. Sowa & David D. Diamond
MoRAP
University of Missouri
4200 New Haven Road
Columbia, MO 65201

scott_sowa@usgs.gov

diamondd@missouri.edu

http://www.cerc.usgs.gov/morap/