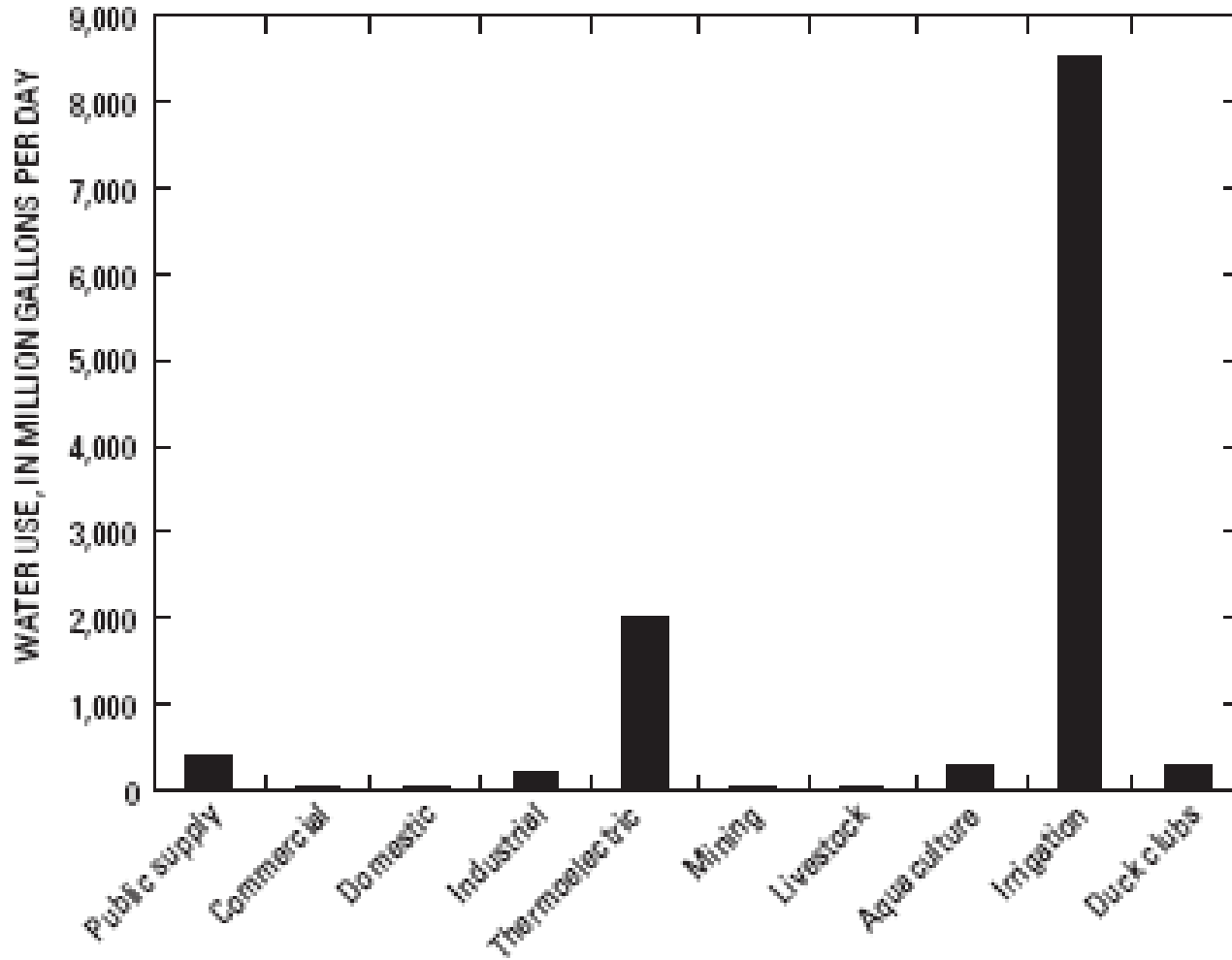


# Arkansas Fish-Flow Response Curves

Random thoughts



**Figure 6.** Total water use in Arkansas by category, 2005.

Source: Water use in Arkansas, USGS 2005

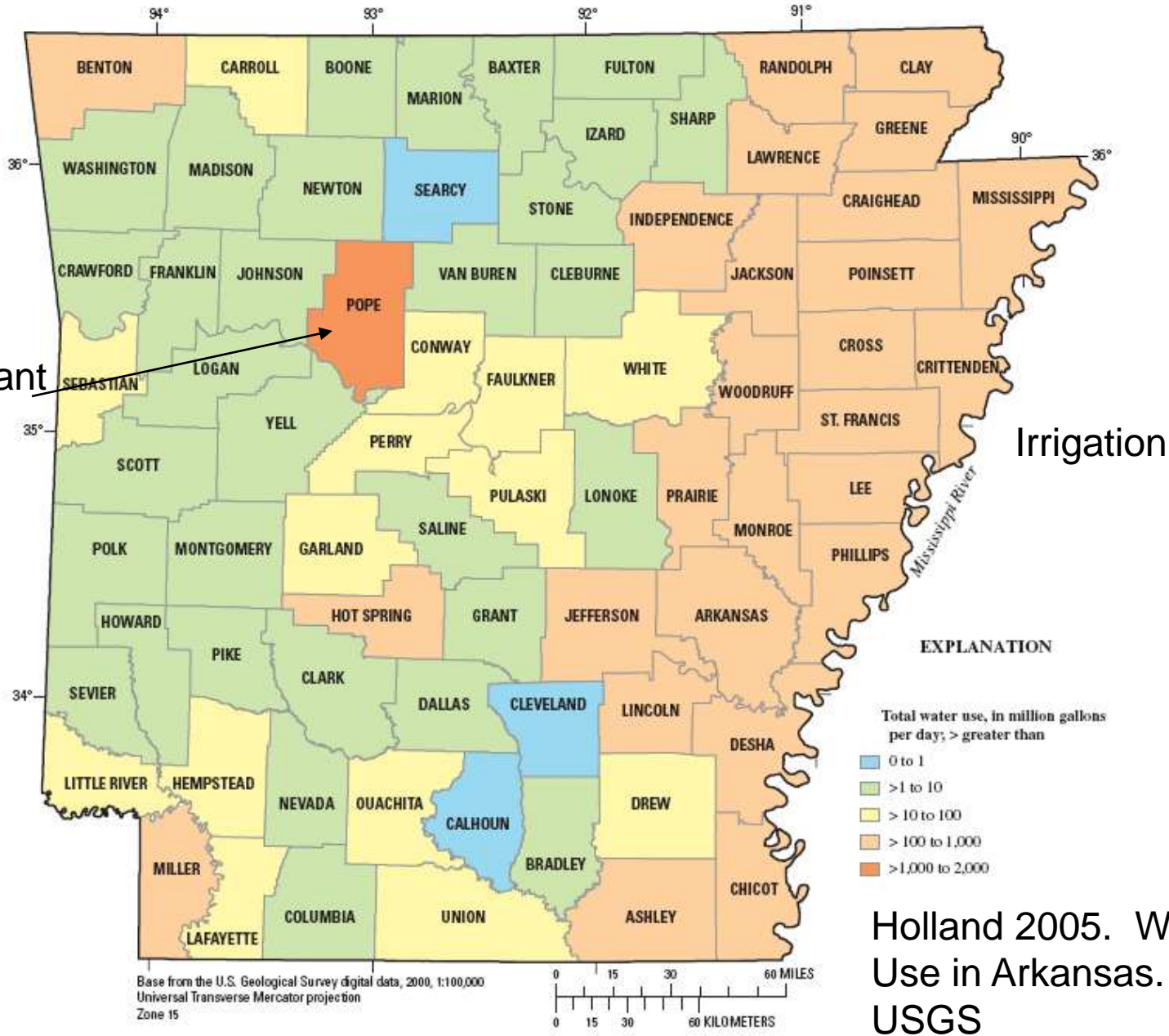
# Arkansas Total Water Use 2005

- 11,455 Mgal/day
- 7,510 Mgal/day from ground water- 66%
- 3,946 Mgal/day from surface water – 34%
- 1965 to 2005 - 435% increase in use

Holland 2005. Water Use in Arkansas. USGS

Poultry

Nuclear Plant



Irrigation

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# SOUTH STRUGGLES TO COPE WITH DROUGHT

Georgia's governor declared a state of emergency for 85 counties in the state Saturday.

by Patrik Jonsson | Staff writer of The Christian Science Monitor  
from the October 22, 2007 edition

E-mail Print Letter to the Editor Republish del.icio.us digg

Page 1 of 2

JEFFERSON, GA. - Kids in Jefferson, Ga., are shutting the tap off as they brush their teeth. Adults are doing bigger, better. They're taking shorter showers, doing fewer laundry loads. And just about everybody is standing nervously at the puddle passing for the town's reservoir.

Like many in the South, the people of this farm town turned Atlanta suburb have not given much thought to water consumption in the past. But with their well literally running dry, residents have curtailed water consumption by 25 percent. Now they just hope it's enough.

"We can't say we're surprised," says Bill Lawrence, an owner of a video-game shop here. "We knew it was coming, but with errors on page.

This feature requires a newer version of Macromedia Flash Player and javascript-enabled browser.



Reporter Patrik Jonsson discusses how the American Southeast is coping with the new phenomenon of water shortages.

BOOKS BACKSTORY MOVIES



Books  
**ALEX ROSS ON THE MUSIC OF AN UNTAMED ERA**

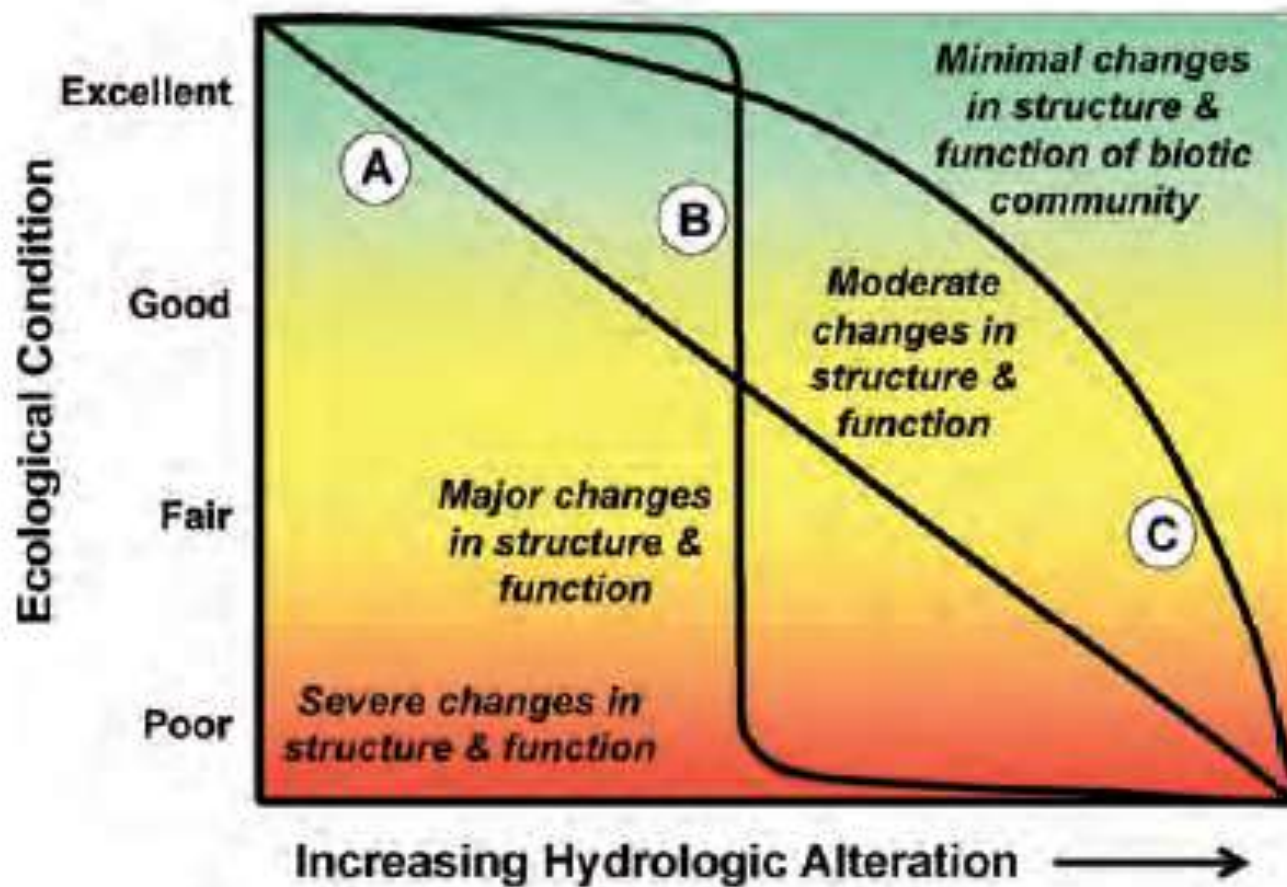
'The Rest Is Noise' considers the 'chaotic beauty' of 20th-century music.

[More book reviews](#)

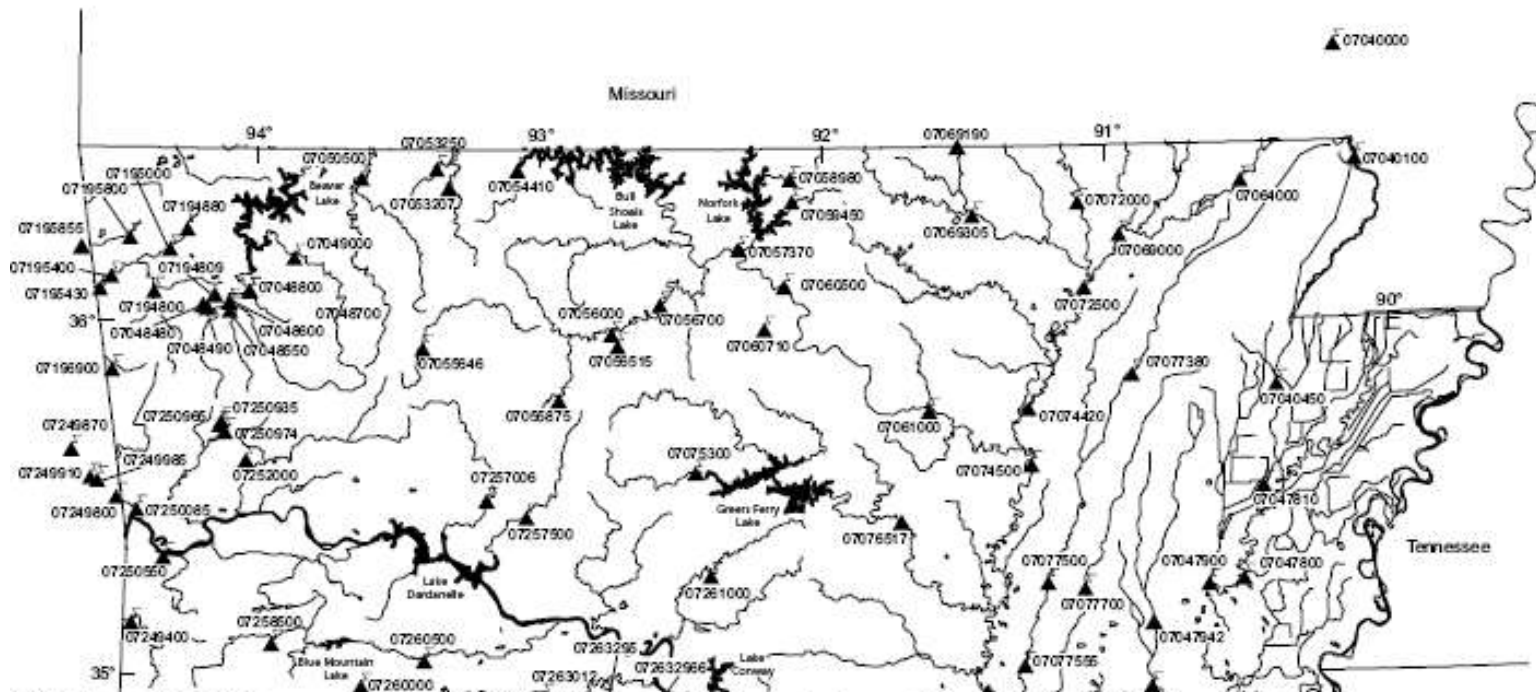
### WHAT ARE YOU READING?

Write to us and tell us about the book that's currently on your bedside table. Why did you pick it? Are you enjoying it? Let us know!

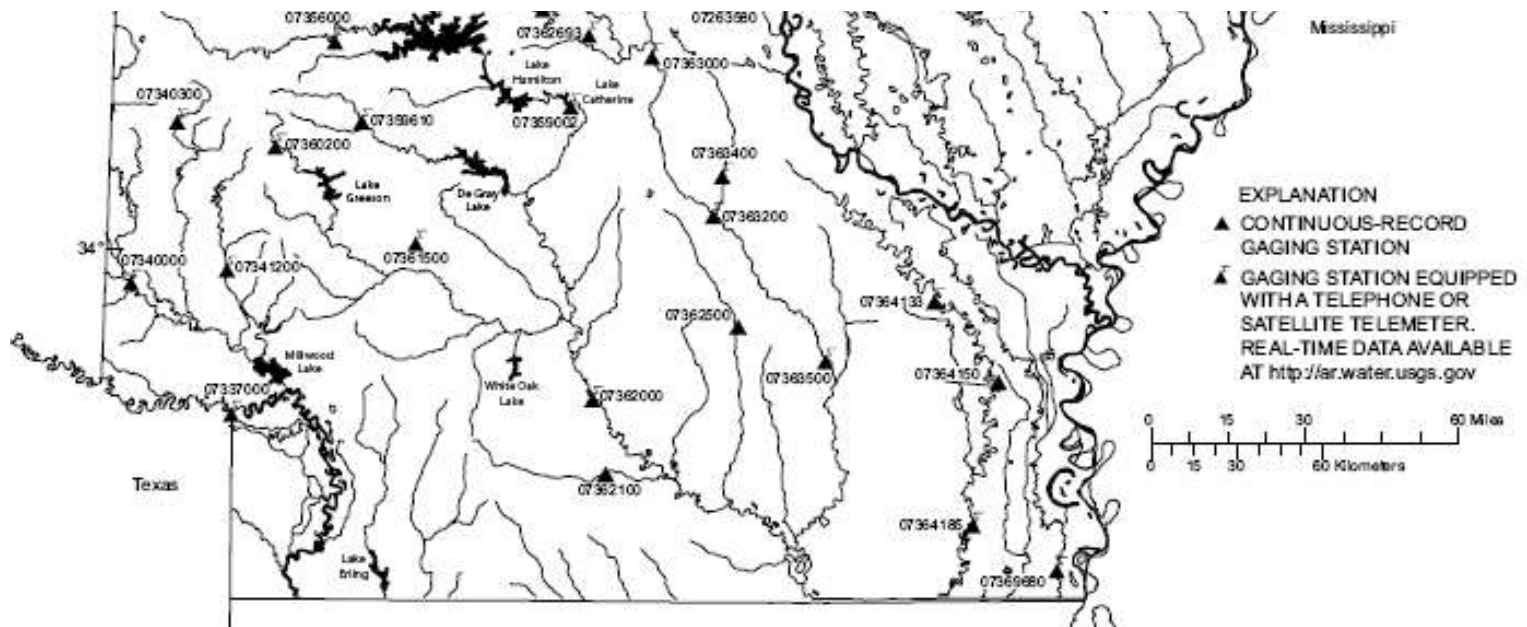
Click here for a **FREE** KraftMaid Idea Book.



Conceptual flow alteration-ecological response relationships. Possible forms include: linear (A), threshold (B), and curvilinear (C). The form of the relationship depends on the specific ecological and flow statistics analyzed<sup>2</sup>



244 stations with historical records, 144 with real time data



# Fish Community Response Variables

- Index of biotic integrity
- Fluvial specialist species
- Sport fish communities
- Electrofishing

# Fish Data

- What Fish Data is Available?
  - ADEQ
  - USGS NAQWA
  - EPA
  - USACE
  - USFS

# ADEQ FISH DATA

- 346 samples in database
- ~35 Boston Mountain Sites
- ~ 33 Arkansas River Valley Sites
- ~ 95 Ozark Highland Sites
- ~ 59 Ouachita Sites
- ~ 21 Channel altered Delta
- ~ 7 Least disturbed delta
- ~ 7 Spring water influenced Gulf Coastal Plain
- ~82 Gulf Coastal Plain Typical
- Sample: all available habitats

# ADEQ Ecoregion Reference Streams

General location of each sample site on the selected reference streams within Arkansas' six ecoregions are shown in Figure 1. A list of the reference streams with the size of the watershed and the stream gradient at the sample site is given in Table 1. Also included are the

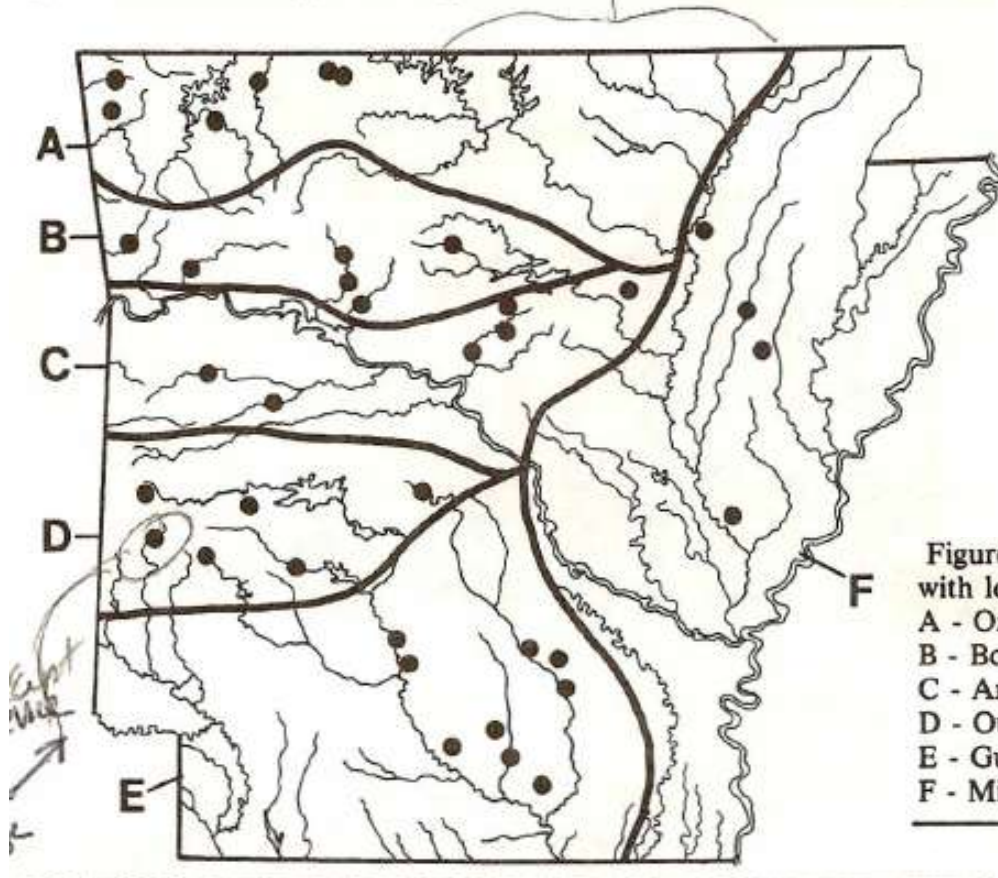


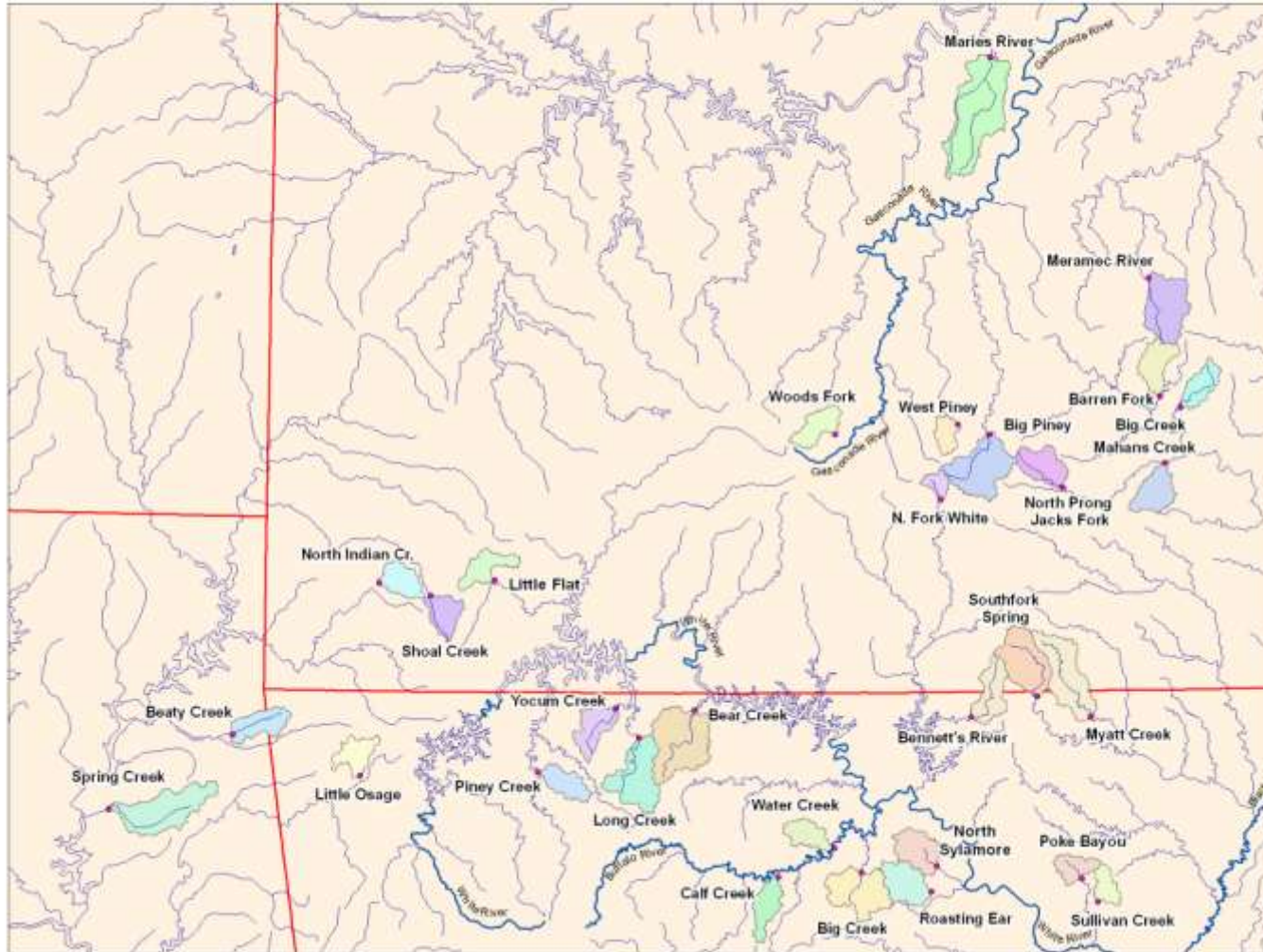
Figure 1. Reference stream sample sites within Arkansas Ecoregions with locations of sample sites on reference streams.

- A - Ozark Highlands;
- B - Boston Mountains;
- C - Arkansas River Valley;
- D - Ouachita Mountains;
- E - Gulf Coastal Plains;
- F - Mississippi Alluvial Plains (Delta)

# Ozark NAQWA DATA 1993-1995

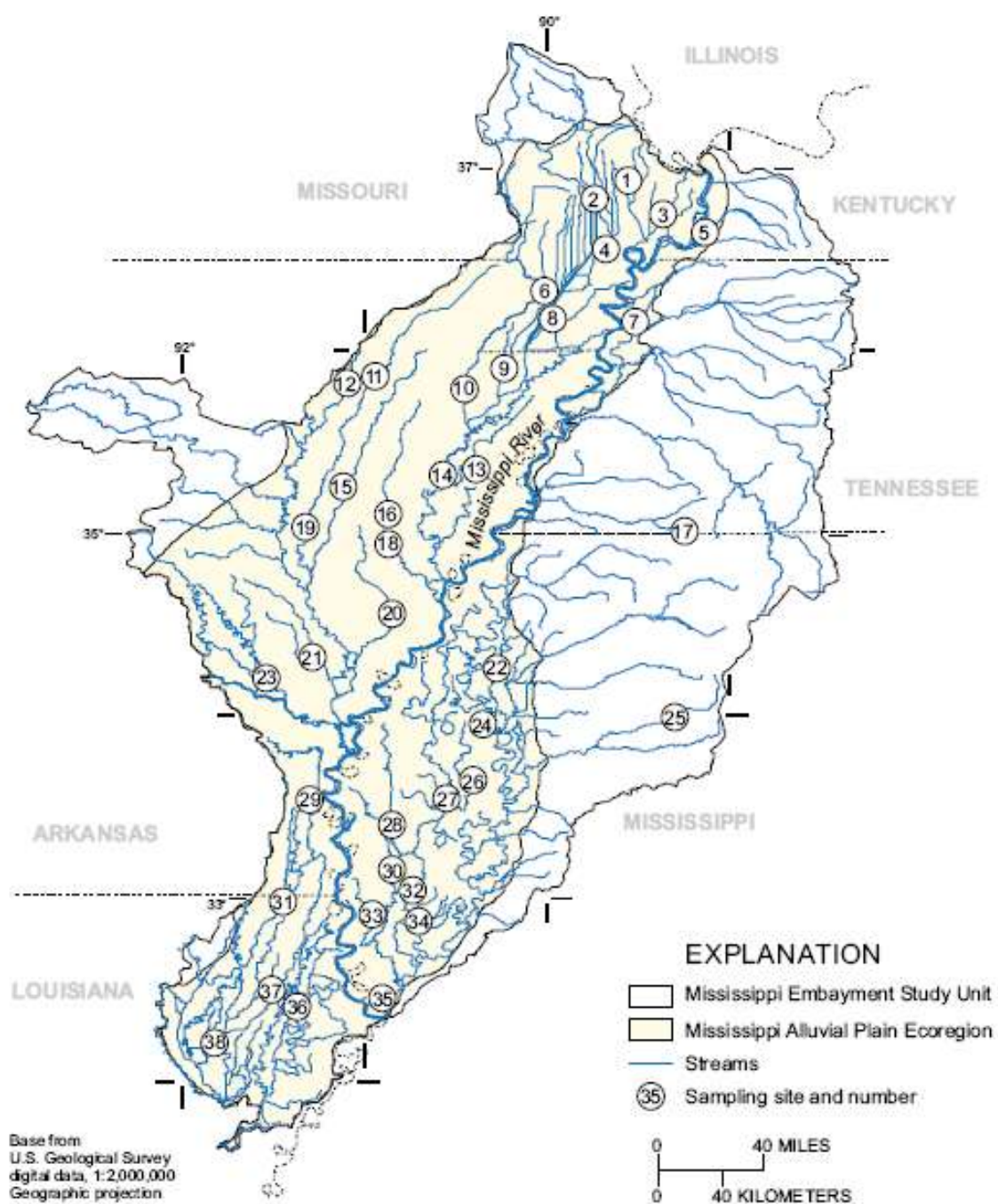
- 22 Reaches at 18 stations
- Physical, chemical, biological data available
- 61 to 2,500 km<sup>2</sup> watersheds
- Springfield, Salem, and Boston Mts
- 4 ecoregions
- 150-550 m reaches
- Backpack or towed electrofishing
- Median Q = 0.8 – 81 m<sup>3</sup>/s

# Ozark NAQWA SITES – 2006-07



# Mississippi Embayment NAQWA

- 38 fish sampling units; 1996-98
- IBI created for the Delta
- Could mesh with ERDC data from Yazoo, Bayou Meto, and Grand Prairie regions.

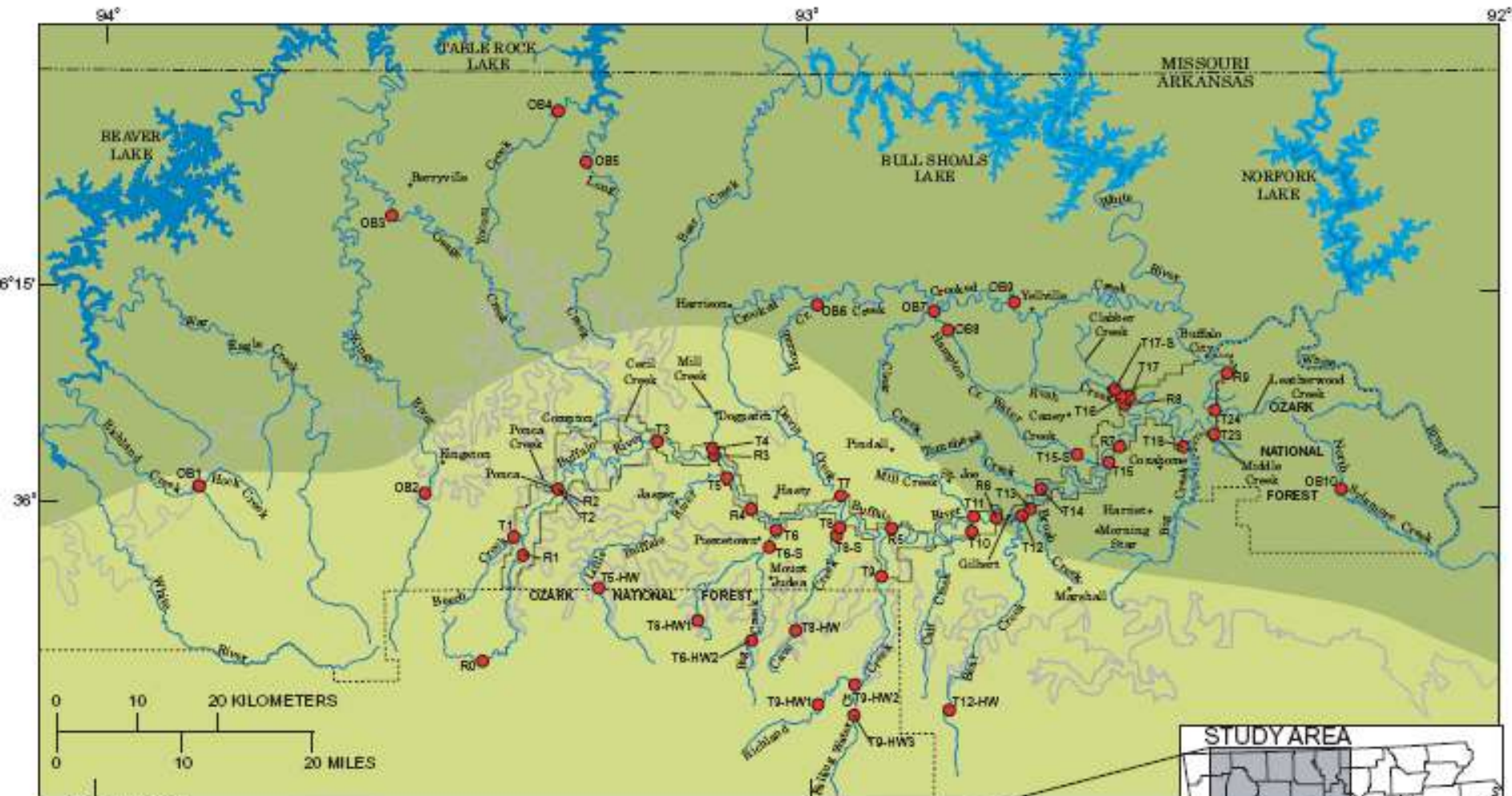


**Table 1.** Information (listed by site number) for 38 fish sampling sites in the Mississippi Embayment Study Unit (km<sup>2</sup>, square kilometers; m<sup>3</sup>/s, cubic meters per second; m, meters; m/s, meters per second).

Site name	Site number	No. of times sampled	Station number	Latitude	Longitude	Drainage basin area (km <sup>2</sup> )	Percent of basin in agriculture*	Discharge at gage (m <sup>3</sup> /s)	Mean channel width (m)	Mean channel depth (m)	Mean instantaneous velocity (m/s)
St. Johns Ditch near Silkeston, MO	1	1	07043300	365608	893302	101	79	2.22	10.9	0.52	0.25
Little River Ditch no. 1 near Morehouse, MO	2	3	07043500	365003	894348	1,144	61	2.96	33.7	0.35	0.13
Spillway Ditch at Hwy 102 near East Prairie, MO	3	1	07024160	364454	892119	186	81	0.93	10.5	0.40	0.15
Little River Ditch no. 251 near Lilbourn, MO	4	1	07042500	363320	894012	627	87	3.60	22.4	0.73	0.27
Oblon Creek near Hickman, KY	5	1	07023800	363858	890721	784	32	1.22	12.5	0.84	0.17
Main Ditch at Hwy 153 near White Oak, MO	6	1	07041120	361927	900020	356	88	2.20	19.9	0.33	0.36
Running Reeffoot Bayou at Hwy 103, TN	7	1	07027050	360944	893036	751	37	0.68	13.9	0.16	0.26
Elk Chute near Gobler, MO	8	1	07046515	361018	895734	218	95	0.70	11.7	0.20	0.14
Cockle Burr Slough Ditch near Monette, AR	9	1	07040496	355139	901949	146	96	3.31	53.1	1.06	0.08
St. Francis River at Lake City, AR	10	1	07040450	354916	902556	6,150	28	11.0	24.6	2.90	0.45
Cache River at Egypt, AR	11	3	07077380	355128	905600	1,816	78	8.84	21.7	2.34	0.18
Village Creek near Swifton, AR	12	1	07074660	354910	910505	410	92	4.71	115.8	0.74	0.11
Tyronza River near Twist, AR	13	1	07047700	352229	902805	1,367	92	4.59	19.0	0.81	0.21
St. Francis River near Coldwater, AR	14	1	07047520	352152	903436	13,774	59	36.1	58.9	1.27	0.46
Bayou DeVlew at Morton, AR	15	1	07077700	351507	910637	1,081	73	4.61	28.8	2.62	0.06
Second Creek near Palestine, AR	16	1	07047947	350221	905440	111	65	2.52	15.1	0.73	0.28
Wolf River at LaGrange, TN	17	3	07030392	350157	891448	543	14	5.04	15.6	1.29	0.30
L'Anguille River near Palestine, AR	18	1	07047950	345820	905310	1,983	77	8.69	24.6	2.09	0.18
Cache River near Cotton Plant, AR	19	5	07077555	350207	911919	2,996	79	14.6	35.0	2.00	0.22
Big Creek at Poplar Grove, AR	20	1	07077950	343320	905044	1,160	77	6.33	17.8	2.21	0.23
LaGrue Bayou near Dewitt, AR	21	1	07078040	341900	911657	594	71	0.00	8.1	0.61	0.00
Coldwater River at Marks, MS	22	1	07279950	341522	901557	4,937	43	90.7	37.5	4.60	0.50
Bayou Meto near Bayou Meto, AR	23	1	07265099	341205	913145	2,078	55	0.00	25.5	3.54	0.00
Cassidy Bayou at Webb, MS	24	1	07280900	336659	902028	536	85	2.41	62.2	0.85	0.04
Skuna River at Bruce, MS	25	3	07283000	336825	892050	668	19	0.49	37.4	1.18	0.26
Quiver River near Doddsville, MS	26	1	07288570	333825	902405	651	81	5.77	16.3	1.65	0.24
Big Sunflower River at Sunflower, MS	27	1	07288500	333250	903235	2,010	81	15.0	23.2	2.19	0.56
Bogue Phalia near Leland, MS	28	5	07288650	332347	905047	1,301	80	5.35	37.7	1.34	0.09
Bayou Macon near Hailey, AR	29	1	073676595	333216	911736	376	85	9.80	14.6	1.20	0.45
Deer Creek near Hollandale, MS	30	1	07288770	330859	905047	231	81	0.00	19.2	1.71	0.00
Boeuf River near Arkansas/LA State Line, LA	31	1	07357700	325825	912625	1,822	83	6.17	45.0	2.32	0.07
Big Sunflower River near Angulla, MS	32	1	07288700	325818	904640	6,675	78	46.0	89.8	3.98	0.15
Steele Bayou East Prong near Rolling Fork, MS	33	1	07288870	325441	905710	1,122	81	2.88	49.6	2.02	0.08
Silver Creek near Bayland, MS	34	1	0728872008	325208	904145	47.9	56	0.00	20.4	0.13	0.00
Yazoo River below Steele Bayou near Long Lake, MS	35	3	07288955	322640	905400	34,850	41	405	91.4	5.92	0.49
Tensas River at Tensas, LA	36	3	07369500	322555	912200	721	74	2.35	19.3	1.26	0.26
Bayou Macon near Delhi, LA	37	1	07370000	322725	912830	2,141	78	6.80	55.4	2.02	0.08
Big Creek near Silgo, LA	38	1	07368580	321220	914911	1,311	76	1.56	48.4	1.75	0.02

\* Includes all areas used for the production of crops such as corn, soybeans, vegetables, tobacco, and cotton, as well as small grains such as wheat and rice. Excludes areas used for the production of hay and pasture.

# USGS BUFFALO RIVER DATA



## EXPLANATION

- OZARK HIGHLANDS ECOREGION
- BOSTON MOUNTAINS ECOREGION
- BUFFALO NATIONAL RIVER BOUNDARY
- PHYSIOGRAPHY BOUNDARY (BOUNDARY BETWEEN PENNSYLVANIAN AND MISSISSIPPIAN AGE ROCKS)

● SAMPLING SITE AND SITE IDENTIFIER (Table 1)



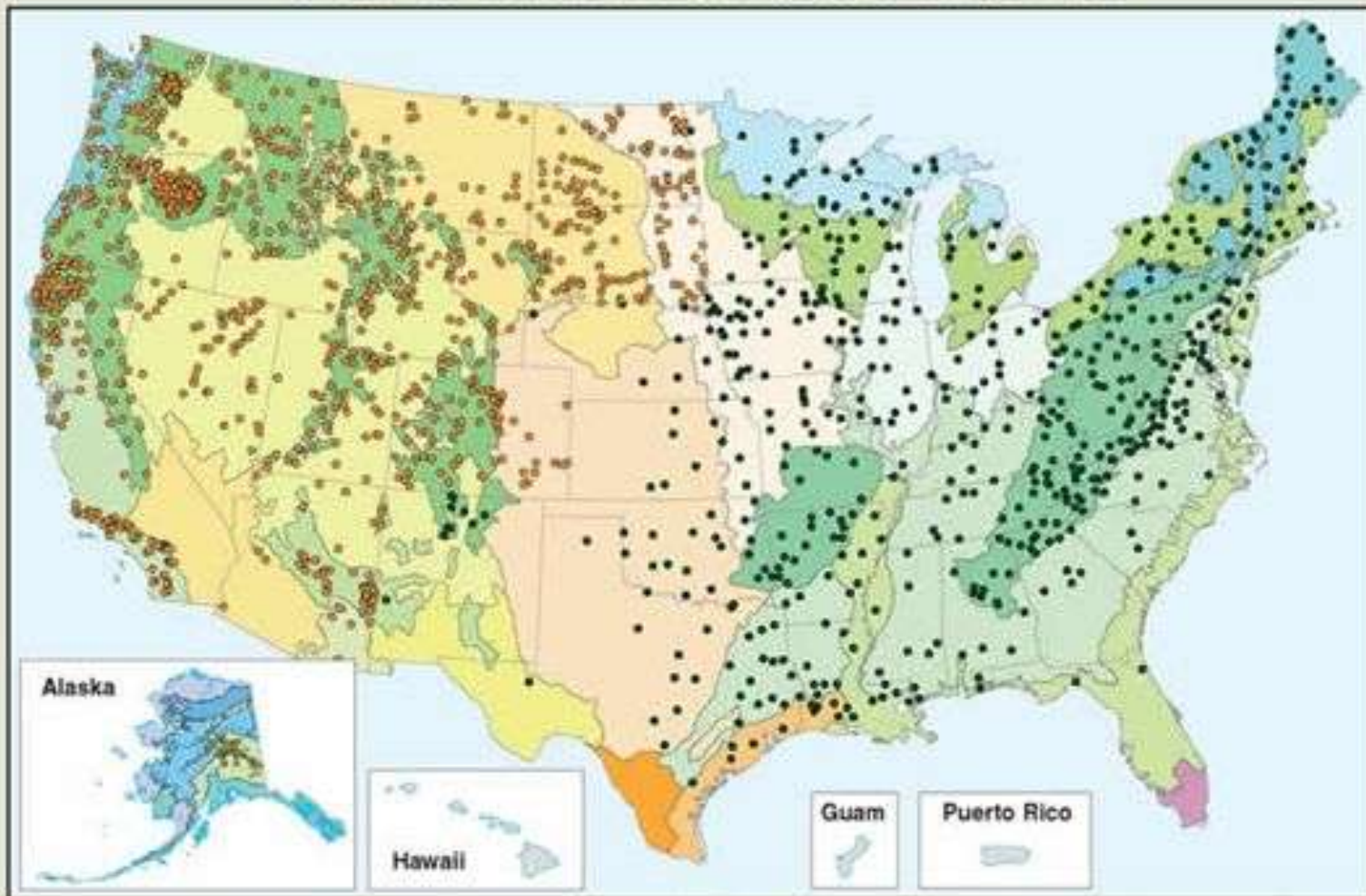
# USACE

- Jack Kilgore – ERDC in Vicksburg, MS
  - Problem accessing military data
  - Developed a delta IBI
  - Significant sampling coverage statewide
    - Bayou Meto drainage
    - Lagrue Bayou drainage
    - White River drainage
    - Ouachita River

# EPA

- Wadeable Streams Assessment
  - 23 Arkansas Sites
  - 25 Ozark Sites among 3 states
  - 24 Gulf Coastal plain sites among 3 states
  - 13 Delta Sites among 4-5 states

# Sites for Wadeable Streams Assessment



- 6.2 Mixed Wood Shield
- 6.3 Atlantic Highlands
- 6.2 Western Cordillera
- 7.1 Marine West Coast Forest
- 8.1 Mixed Wood Plains
- 8.2 Central Plains
- 8.3 Southeastern Plains
- 8.4 Ozark, Ouachita-Appalachian Forests

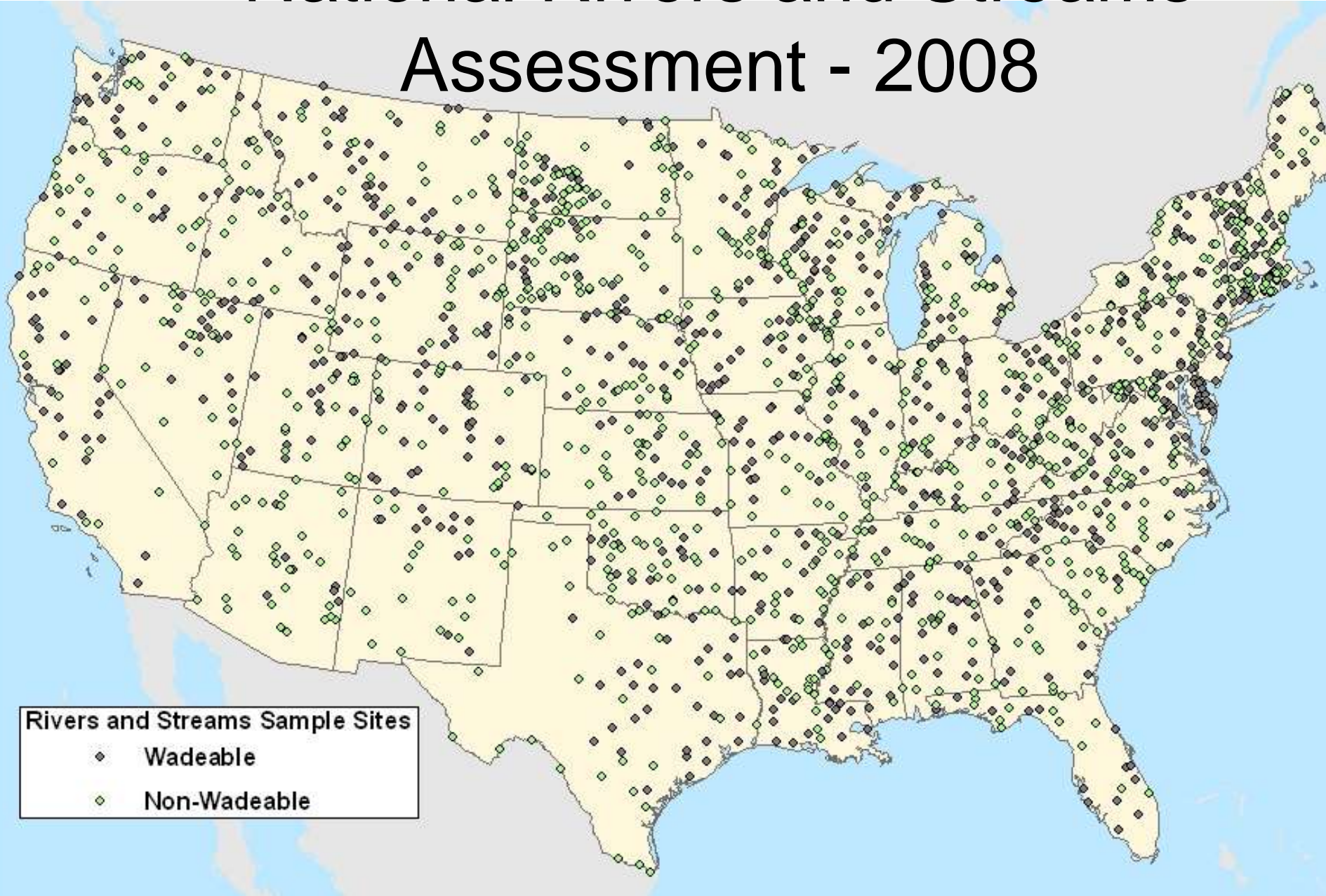
- 8.5 Mississippi Alluvial / Southeast Coastal Plains
- 9.2 Temperate Prairies
- 9.3 West-Central Semi-Arid Prairies
- 9.4 South-Central Semi-Arid Prairies
- 9.5 Texas-Louisiana Coastal Plain
- 9.6 Tamaulipas-Texas Semi-Arid Plain

- 10.1 Western Interior Basins and Ranges
- 10.2 Sonoran and Mohave Deserts
- 10.4 Chihuahuan Desert
- 11.1 Mediterranean California
- 12.1 Western Sierra Madre Piedmont
- 13.1 Upper Gila Mountains
- 16.4 Everglades

- Sites sampled, 2004
- Sites sampled, 2000-2004
- Alaska Pilot Project

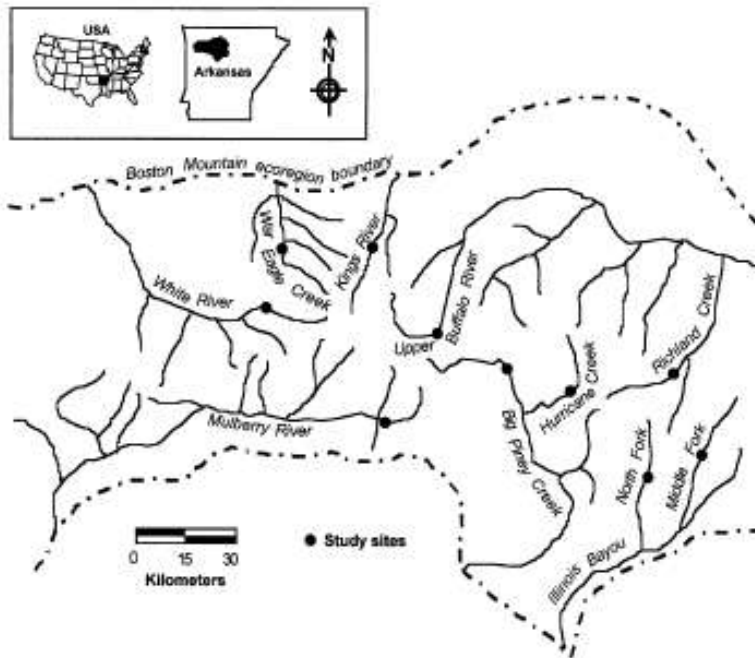
Ecoregions (North America Level II)

# National Rivers and Streams Assessment - 2008



# Radwell and Kwak

- Studied 10 Rivers
- Boston Mountains
- IBI metrics
- Lots of land use, fish variables
- Could add hydrologic variables to analyses (e.g., IHA parameters)



**Figure 1.** Map of Boston Mountain ecoregion showing study rivers and sites.

Table 1. Statistical characteristics of metrics incorporated in cluster analysis and unidimensional scaling

Metric	Mean	Median	Standard deviation	Coefficient of variation	Range
<b>Fish assemblage characteristics</b>					
Density (fish/ha)	22,328.20	<u>18,052.50</u>	11,489.11	51.46	8,676–46,150
Biomass (kg/ha)	117.87	<u>120.76</u>	51.66	43.83	26.82–202.85
Species richness	14.90	<u>15.00</u>	3.41	22.91	<u>10–19</u>
Darter species	4.40	4.50	1.17	26.68	<u>3–6</u>
Sunfish species	2.40	2.50	0.70	29.13	<u>1–3</u>
Sucker species	1.20	1.00	0.79	65.73	<u>0–2</u>
Intolerant species	3.90	3.50	1.91	49.02	<u>1–7</u>
% Green sunfish	2.13	1.04	2.21	103.92	<u>0–5.75</u>
% Omnivores	23.05	16.04	18.29	79.36	<u>0.34–51.09</u>
% Insectivorous cyprinids	9.35	7.39	7.40	79.16	<u>0.38–26.93</u>
% Piscivores	5.12	4.89	4.06	79.40	<u>0–13.09</u>
<b>Invertebrate assemblage characteristics</b>					
Taxa richness	22.90	24.00	4.15	18.12	<u>15–28</u>
Density (invertebrates/m <sup>2</sup> )	2,229.90	<u>1457.50</u>	2,264.64	101.56	523–8,019
% EPT	42.30	<u>37.50</u>	18.80	44.44	<u>22–75</u>
% Chironomidae	8.00	<u>5.00</u>	9.32	116.52	<u>0–27</u>
EPT/Chironomidae	22.49	12.27	34.79	154.69	<u>1.52–117</u>
Dominance	66.00	67.00	9.57	14.50	<u>46–77</u>
<b>Riparian vegetation and instream habitat</b>					
% Riparian forest	85.45	91.65	14.86	17.39	<u>57.5–100</u>
Mean depth (cm)	30.16	<u>32.24</u>	11.36	37.65	11.7–47.36
Mean velocity (m/s)	0.02	<u>0.01</u>	0.03	126.38	0–0.082
% Sand and silt	5.74	6.54	4.23	73.65	<u>0.98–13.3</u>
Pool /riffle ratio	0.90	<u>0.63</u>	0.72	79.99	<u>0.12–2.5</u>
% Eroded bank	28.25	<u>26.50</u>	18.41	65.18	0–65.5
% Fish cover	32.67	<u>35.35</u>	12.59	38.53	<u>15.2–54.65</u>
<b>Water quality</b>					
Nitrate summer (mg/L)	0.14	0.05	0.23	166.46	<u>0.002–0.735</u>
Nitrate winter (mg/L)	0.26	0.10	0.37	145.17	<u>0.003–1.203</u>
Alkalinity summer (mg/L CaCO <sub>3</sub> )	20.20	<u>16.00</u>	10.30	51.01	<u>12–38</u>
Alkalinity winter (mg/L CaCO <sub>3</sub> )	8.80	<u>7.00</u>	4.34	49.33	4–16
Turbidity summer (NTU)	3.41	<u>2.95</u>	2.00	58.64	<u>0.7–7.5</u>
Turbidity winter (NTU)	3.76	3.60	1.16	30.77	<u>2.1–5.7</u>
<b>Watershed attributes</b>					
% Forested	93.20	96.00	4.87	5.23	<u>84–98</u>
% Private land	36.60	24.00	30.77	84.07	<u>9–99</u>
Road density (km/ha)	0.0135	0.0129	0.0020	14.98	<u>0.0108–0.0167</u>
Buffer road density (km/ha)	0.0021	0.0016	0.0012	60.19	<u>0.0007–0.0050</u>

Note: Metric values for a conceptually ideal headwater reach are underlined. Coefficient of variation was calculated as SD/mean × 100.

# Discussion with Dan Dauwalter

- Use all electrofishing databases:
  - Most IBI metrics do well with short sampling reaches.
  - Standardization of sample reach length not that important for IBI
- Species richness = much longer reach
- Use data from Oklahoma and Missouri

# Flow Altered Streams

- 74 sites identified already – looking at map
  - Most below dams
  - ID more continuous withdrawal sites from USGS data
  - Target for fish sampling
- Ecoregional
  - Arkansas Valley – 15 sites
  - Boston Mountains – 9 sites
  - Delta – 6 sites
  - Gulf Coastal Plain – 10 sites
  - Ouachita – 23 sites
  - Ozark – 9 sites

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Reply with Changes... End Review...

C23 Gulf Coastal Plain

A	B	C	D	E	F	G
Stream	County	Ecoregion	Stream Size	Type of Impact to flow	Nearby Reference Stream	Land Ownership
Alum Fork Saline	Saline	Ouachita	Medium	Lake Winona Dam	poor selection	
Middle Fork Saline	Saline	Ouachita	Medium	Diamonte Pump, HSV dams	poor selection	
Flint Creek	Benton	Ozark	Small	Silom Springs Lake and SWEPCO		
Creeks on Bella Vista	Benton	Ozark	Small	impoundments/developments	okay selection	
Caney Creek	Calhoun	Gulf Coastal Plain	Small	Below Tricounty Lake	Should be several nearby	
Leatherwood Creek	Carrol	Ozark	Small	Below Lake Leatherwood		
Stream Below Corning lake	Clay	Delta	Small	Dam	Something on Black River WMA	
Beech Creek	Columbia	Gulf Coastal Plain	Medium	Below Lake Columbia	Big Carnie Creek	
Cyprus Creek	Conway	Boston	Medium	Brewer Lake Dam	North Cadron	
Overcup Creek	Conway	Arkansas Valley	Small	Lake Overcup	Point remove?	
Lee Creek	Crawford	Boston	Medium	Lee Creek Lake	Mulberry River	
Frog Bayou	Crawford	Boston	Medium	Lake Fort Smith	Mulberry River	
Rock Creek	Crawford	Boston	Small	TJ House Reservoir		
Little Frog Bayou	Crawford	Boston	Small	Below Lake Alma		
Beaver Fork Creek	Faulkner	Arkansas Valley	Small	Below Beaverfork Lake	Middle Cypress Bayou??	
Palarm Creek	Faulkner	Arkansas Valley	Medium	Lake Conway Dam	Cadron Creek	
Black Fork	Faulkner	Arkansas Valley	Small	Below Woolly Hollow	Nearby streams in drainage	
Salt Fork	Franklin	Boston	Small	Below Shores Lake	Plenty nearby	
South Fork	Franklin	Boston	Small	Below Huspeth Lake near Ozark	Plenty nearby	
Prairie Creek	Franklin	Arkansas Valley	Small	below Darby Lake Fort Chaffee	Plenty nearby	
Doctors Creek	Franklin	Arkansas Valley	Small	below Lake Charleston	Plenty nearby	
Cox Creek	Grant	Gulf Coastal Plain	Small	Dam	available	
Big Creek	Greene	Delta	Medium	Lake Fierson	good question	
Cedar Creek	Hempstead	Gulf Coastal Plain	Small	Bois Darc lake	Bois D' Arc Creek on management area.	
Little River	Hempstead	Gulf Coastal Plain	Large	Millwood Lake	?	
Ouachita River	Hot Spring	Ouachita	Large	Lake Catherine	Saline	
Ouachita River	Hot Spring	Gulf Coastal Plain	Large	Lake Catherine	Saline	
Cossatot	Howard	Ouachita	Large	below Gillham		
Saline River	Howard	Ouachita	Large	below Dierks Lake		

README Altered Stream Data Reference Streams Possibilitiesandquestions Altere

AutoShapes

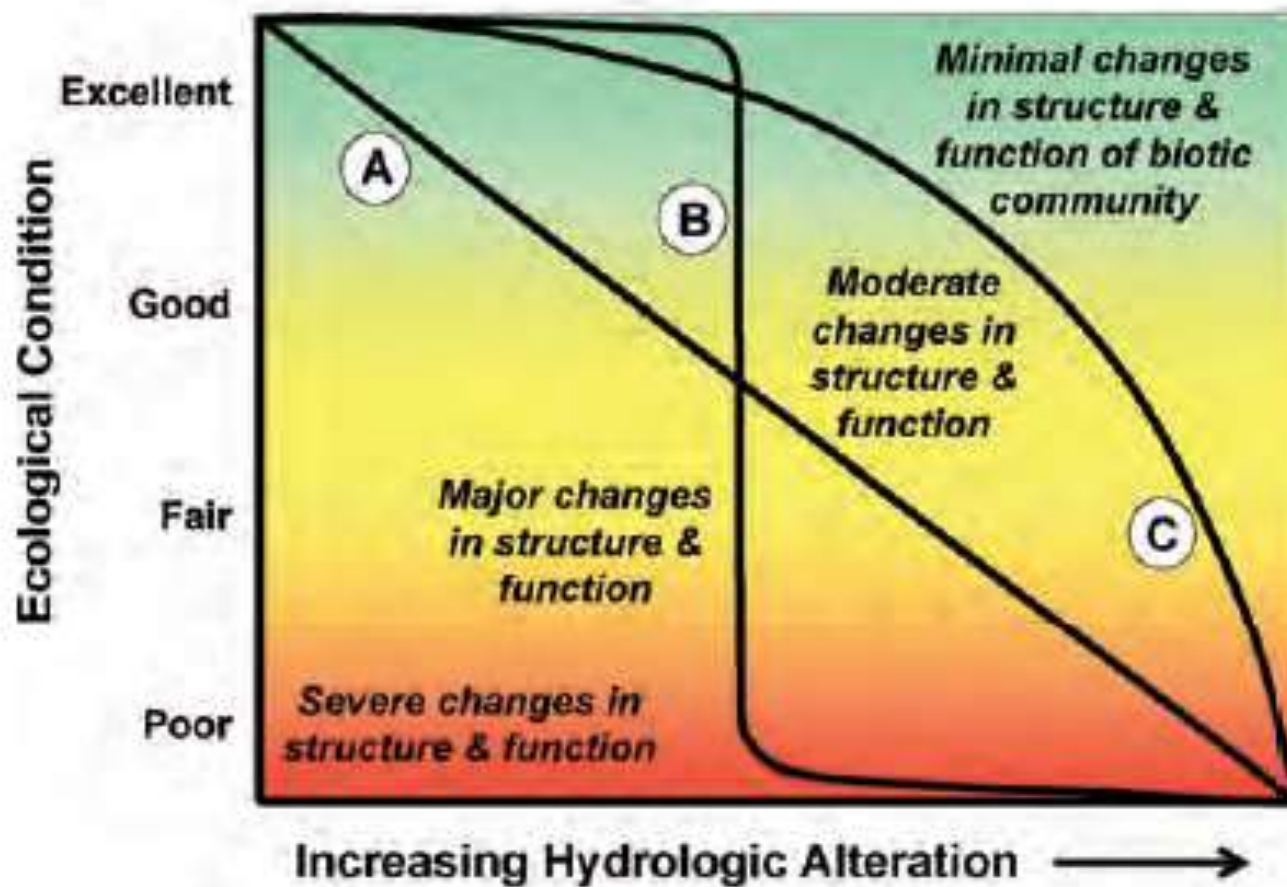
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Reply with Changes... End Review...

G24 ARKANSAS RIVER

	A	B	C	D	E	F	G	H	I	J	K	L
1	use	county_cc	mpid	latitude	longitude	source	stream_name	well_dept	aquifer_code	mgal/d	year_repc	CFS
2	PH	001	335845091183503	335845	911835	SW	ARKANSAS RIVER	N/A	N/A	28682178.00	2007	44,371,3
3	PH	051	342634093013401	342634	930134	SW	OUACHITA RIVER	N/A	N/A	1327033.90	2007	2,052,9
4	PH	059	342535092534001	342535	925340	SW	OUACHITA RIVER	N/A	N/A	730782.44	2007	1,130,5
5	PF	007	361521094312301	361521	943123	SW	SWEPCO LAKE	N/A	N/A	412684.47	2007	638,4
6	PF	059	342630092544502	342607	925425	SW	LAKE CATHERINE	N/A	N/A	62963.57	2007	97,4
7	IN	003	331500092030001	331500	920300	SW	SALINE RIVER	N/A	N/A	59857.36	2007	92,5
8	WS	119	345119092291901	345119	922919	SW	LAKE MAUMELLE	N/A	N/A	47378.25	2007	73,2
9	IN	063	354229091312801	354229	913128	SW	WHITE RIVER	N/A	N/A	41199.41	2007	63,7
10	WS	007	361500094070001	361532	940410	SW	BEAVER RES	N/A	N/A	30300.45	2007	46,8
11	IR	091	333213093482401	333213	934824	SW	RED RIVER	N/A	N/A	30000.00	2007	46,4
12	WS	125	344755092504301	344755	925043	SW	LAKE WINONA	N/A	N/A	25630.65	2007	39,6
13	WS	033	354015094071501	353859	940855	SW	FROG BAYOU	N/A	N/A	22703.71	2007	35,1
14	IR	001	342105091370001	342052	913651	SW	BAYOU METO	N/A	N/A	22000.00	2007	
15	PF	069	342523092071101	342523	920711	SW	ARKANSAS RIVER	N/A	N/A	20279.06	2007	
16	WS	007	361538094041001	361538	940410	SW	BEAVER RESERVOI	N/A	N/A	20211.55	2007	
17	WS	051	343304093105801	343304	931058	SW	LAKE HAMILTON	N/A	N/A	15362.90	2007	
18	IR	001	340959091260401	340959	912604	SW	MILL BAYOU	N/A	N/A	13500.00	2007	
19	IN	041	334140091134401	334227	911411	SW	MISSISSIPPI RIVER	N/A	N/A	11729.27	2007	
20	IR	001	341618091332601	341618	913326	SW	KANEY BAYOU	N/A	N/A	11400.00	2007	
21	PF	063	353915091242501	353915	912425	SW	WHITE RIVER	N/A	N/A	11119.88	2007	
22	WS	029	351440092354001	351440	923540	SW	JAMES H BREWER	N/A	N/A	10087.61	2007	
23	WS	033	352906094232601	352906	942326	SW	LEE CREEK	N/A	N/A	10017.10	2007	
24	PF	047	352744093481701	352744	934817	SW	ARKANSAS RIVER	N/A	N/A	9429.19	2007	
25	WS	115	353015093112501	353015	931125	SW	HUCKLEBERRY CRK	N/A	N/A	9397.85	2007	
26	IR	091	333235093492901	333235	934929	SW	RED RIVER	N/A	N/A	9000.00	2007	
27	WS	007	36212094004802	362120	940048	SW	BEAVER LAKE	N/A	N/A	8931.23	2007	



Conceptual flow alteration-ecological response relationships. Possible forms include: linear (A), threshold (B), and curvilinear (C). The form of the relationship depends on the specific ecological and flow statistics analyzed<sup>2</sup>