Science and Policy of Environmental Instream Flows in the Tombigbee River Basin, Alabama and Mississippi: An Interstate Comparison

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Acknowledgements

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- Research assistant: Cehong Luo (University of Alabama, Department of Geography)

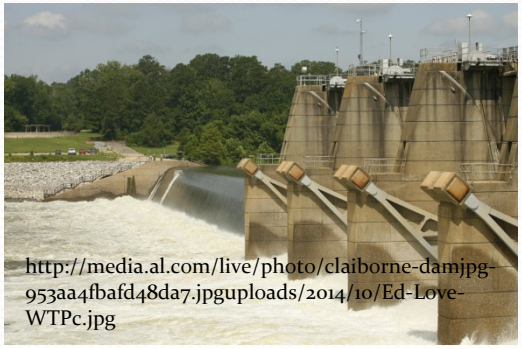
Benefits of Alabama's Rivers

Offstream

http://environmentalhistory.as.ua.edu/wp-content/uploads/2014/10/Ed-Love-WTPc.jpg

http://mediad.publicbroadcasting.net/p/wual/files/styles/x_large/public/201509/pivot.jpg

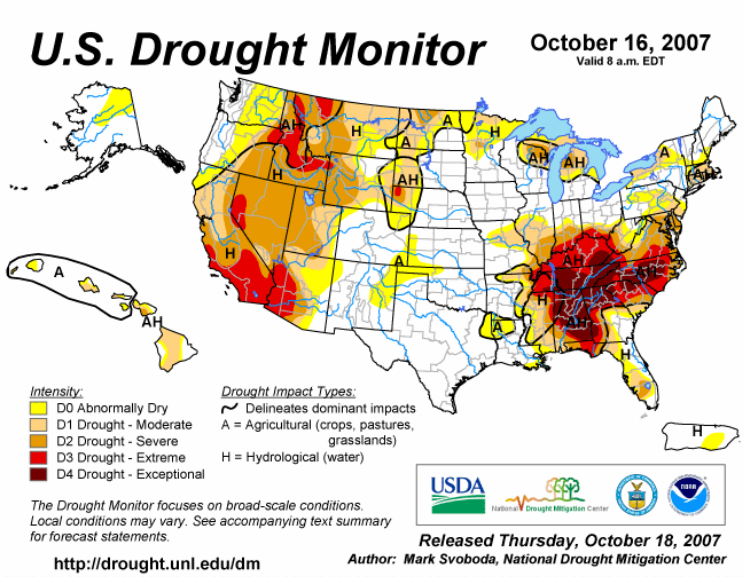
Instream



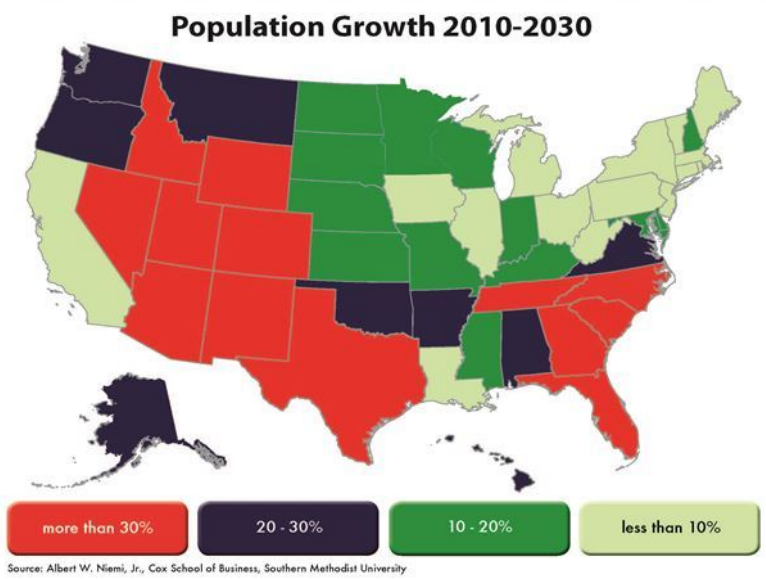
http://media.al.com/live/photo/claiborne-damjpg-953aa4fbafd48da7.jpguploads/2014/10/Ed-Love-WTPc.jpg

https://www.fws.gov/endangered/about/episodes/vp-37-2011/images/thumb.jpg

Threats to Alabama's Rivers

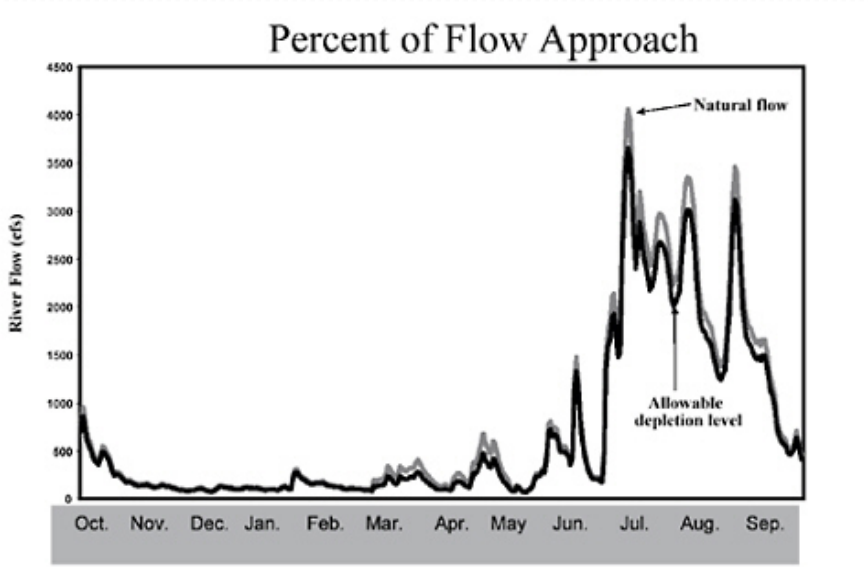


Uncertain supply



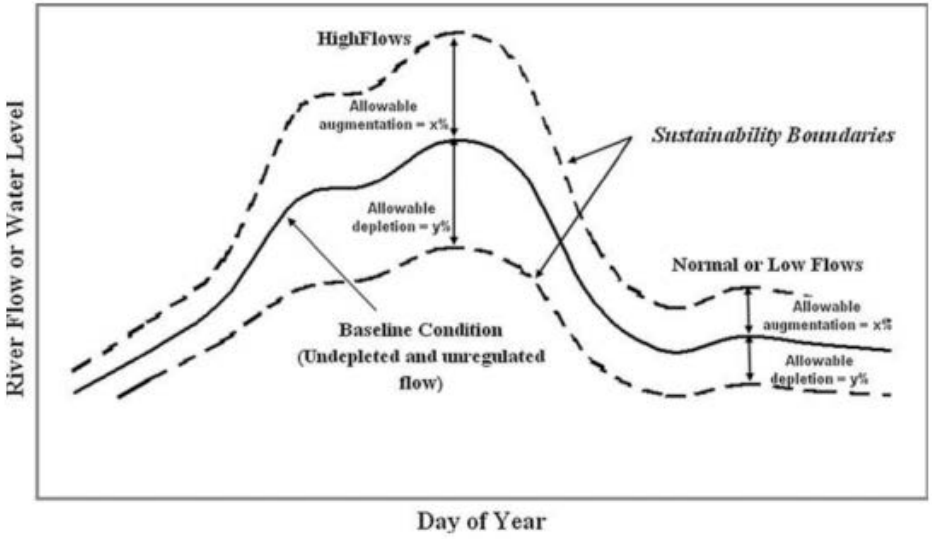
Increasing demand

Environmental Instream Flows

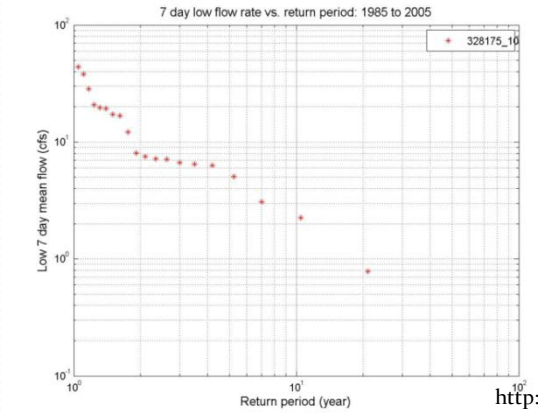


https://www.nap.edu/openbook/0309095662/xhtml/images/p2000c30ag49001.jpg

Sustainability boundaries



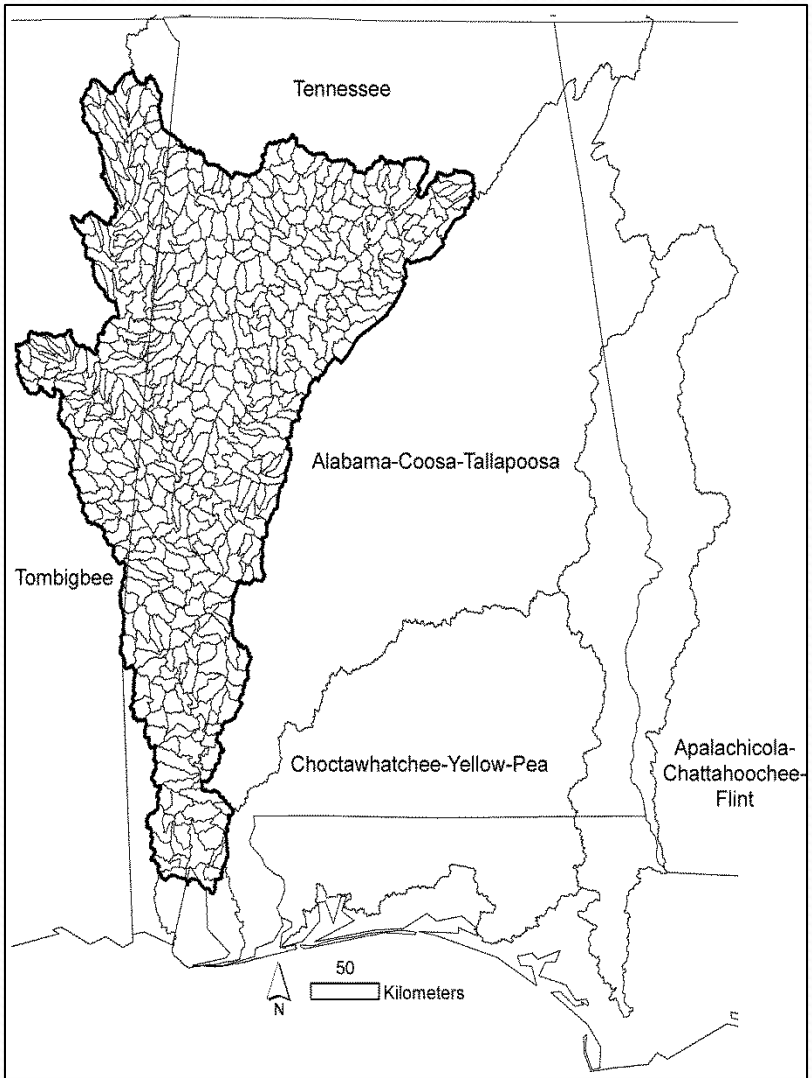
http://www.aquaticecosystems.org/wp-content/uploads/2014/02/E-Flow-ch6.pdf



7Q10

http://deq1.bse.vt.edu/sifnwiki/images/thumb/4/45/7Q10.png/700px-7Q10.png

Alabama's Interstate Basins



Objectives

- Conduct a systematic review of the legal and policy frameworks for environmental instream flows in Alabama and Mississippi.
- **Compile a geodatabase for the Tombigbee River Basin, including available hydrological and biological data.**
- **Analyze existing hydrological data, with the goal of determining whether the implementation of a 7Q10 standard in Mississippi was effective in maintaining ecologically relevant hydrological parameters.**

Study Area


https://en.wikipedia.org/wiki/Tombigbee_River#/media/File:USACE_Coffeeville_Lock_and_Dam_Tombigbee.jpg


https://en.wikipedia.org/wiki/Tombigbee_River#/media/File:White_Bluff_Demopolis.jpg

Tombigbee River

Sipsey River


http://www.outdooralabama.com/sites/default/files//images/Image/SipseyRiver245.jpg

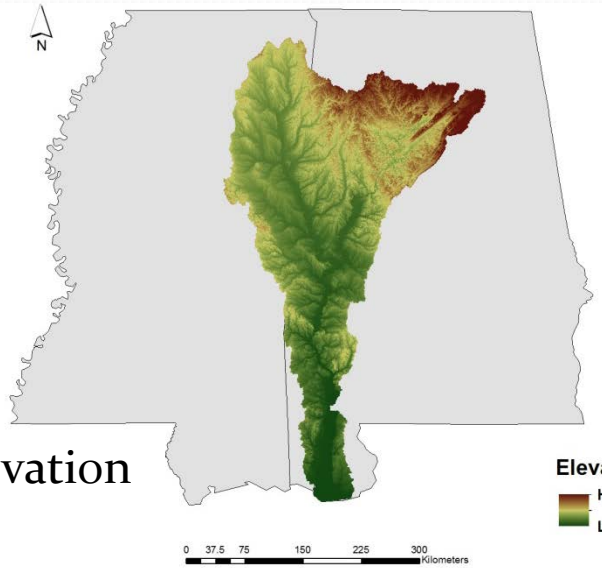

https://en.wikipedia.org/wiki/Locust_Fork_of_the_Black_Warrior_River#/media/File:Sandstone_Riverscour_Cumberland_Plateau.jpg

Locust Fork

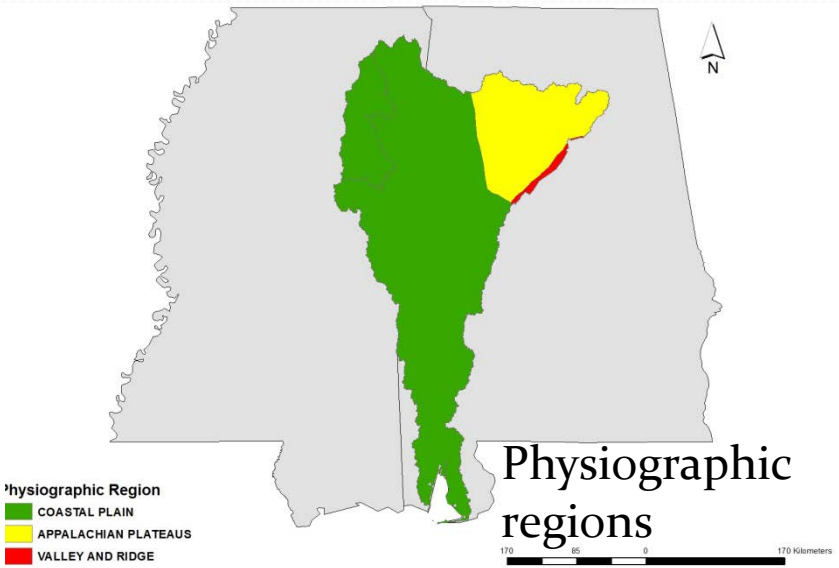
Methods: Geodatabase

- Currently:
  - National Hydrography Dataset Plus
  - National Elevation Dataset
  - National Land Cover Database
  - STATSGO Soils
  - Physiographic provinces
  - USGS gaging stations
- To be added:
  - Lithology
  - Strategic Habitat Units
  - Biological survey data
  - Critical habitat
  - Clean Water Act designated beneficial uses

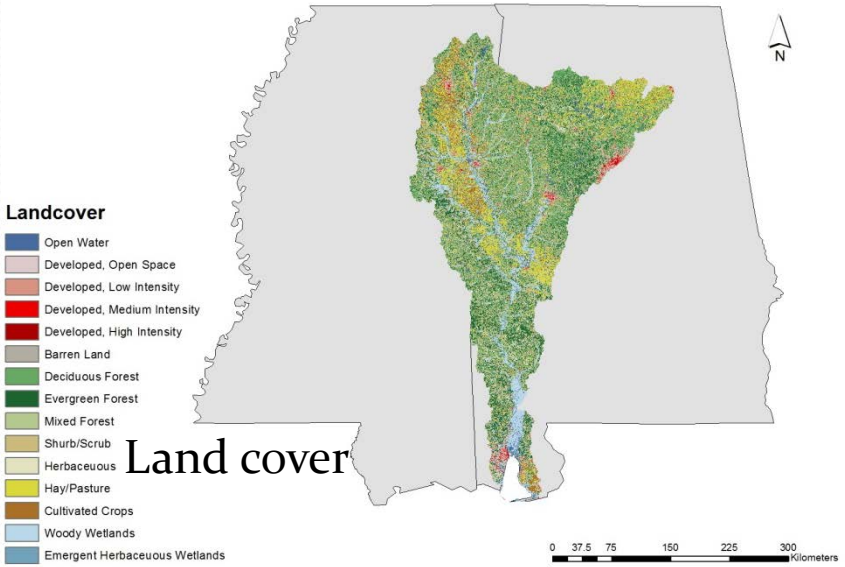
Results: Geodatabase



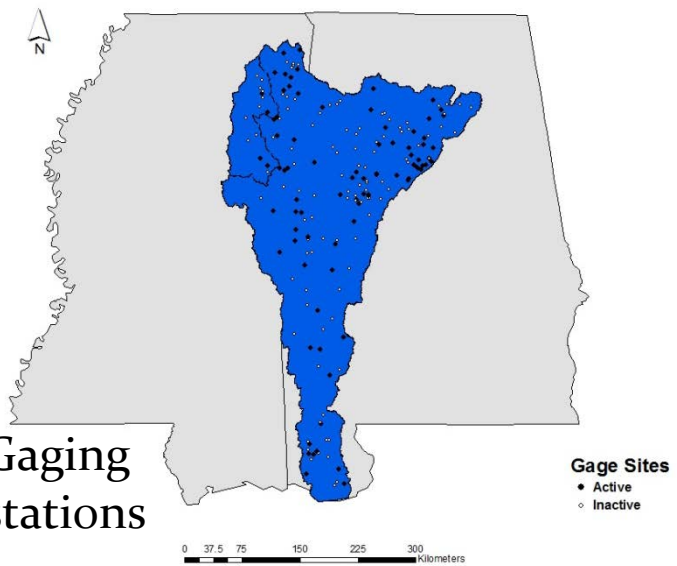
Elevation



Physiographic regions

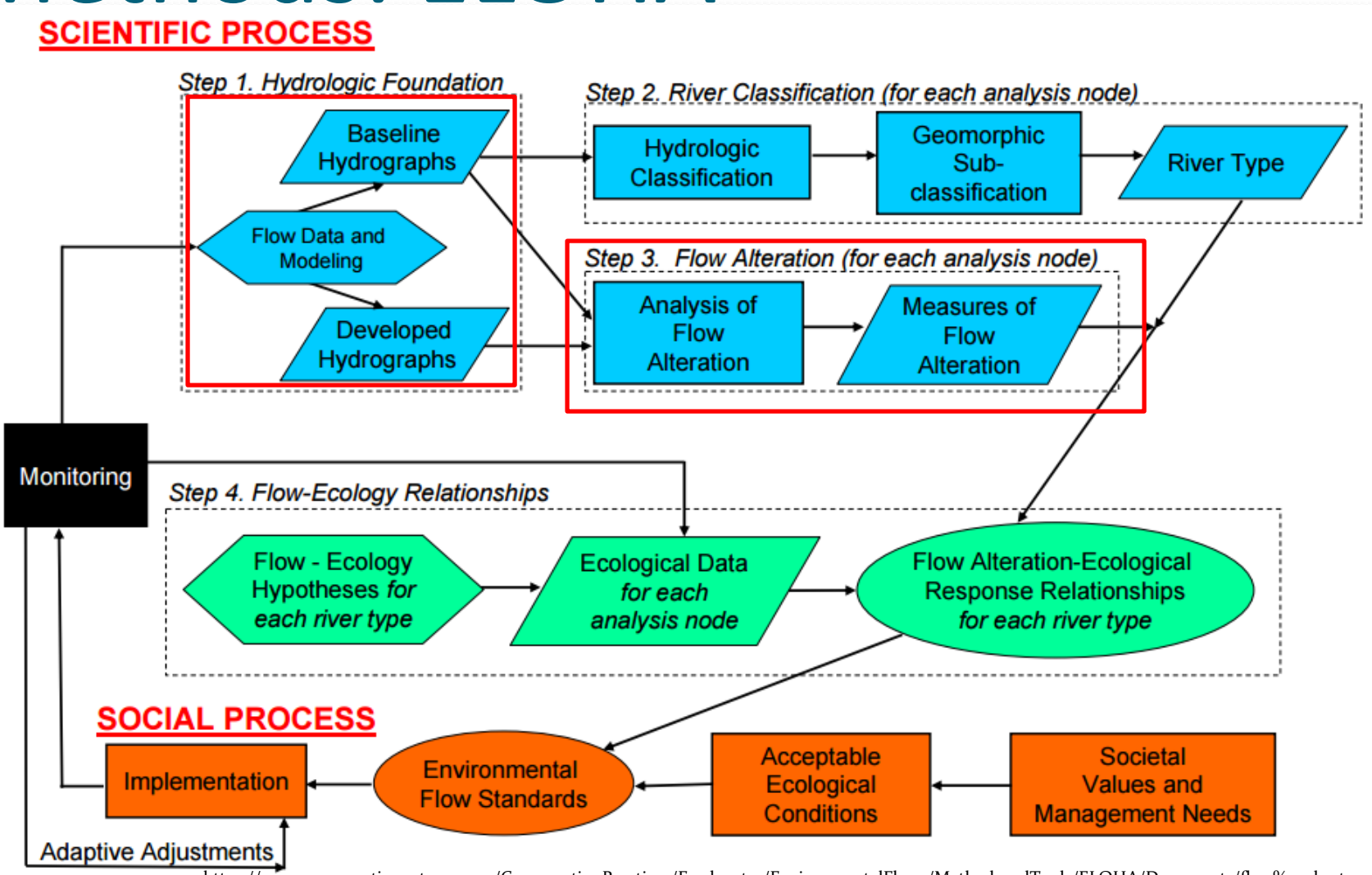


Land cover



Gaging stations

Methods: ELOHA



https://www.conservationgateway.org/ConservationPractices/Freshwater/EnvironmentalFlows/MethodsandTools/ELOHA/Documents/flow%20chart-english.pdf

Methods: IHA

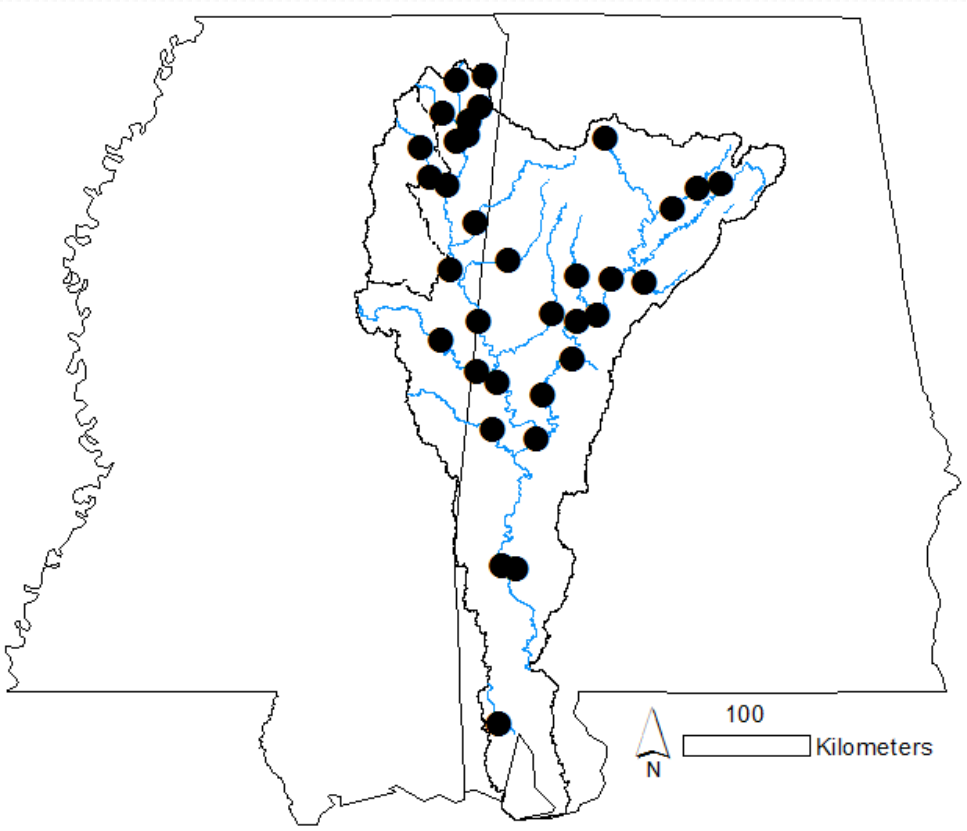
Table I. Summary of hydrologic parameters used in the RVA, and their characteristics

General group	Regime characteristics	Streamflow parameters used in the RVA	Examples of ecosystem influences
1: Magnitude of monthly discharge conditions	Magnitude, timing	Mean discharge for each calendar month	Habitat availability for aquatic organisms Soil moisture availability for plants Availability of water for terrestrial animals Availability of food/cover for fur-bearing mammals Reliability of water supplies for terrestrial animals Access by predators to nesting sites Influences water temperature, oxygen levels, photosynthesis in water column
2: Magnitude and duration of annual extreme discharge conditions	Magnitude, duration	Annual maxima one-day means Annual minima one-day means Annual minima 3-day means Annual maxima 3-day means Annual minima 7-day means Annual maxima 7-day means Annual minima 30-day means Annual maxima 30-day means Annual minima 90-day means Annual maxima 90-day means Number of zero-flow days 7-day minimum flow divided by mean flow for year ('base flow')	Balance of competitive, ruderal, and stress-tolerant organisms Creation of sites for plant colonization Structuring of aquatic ecosystems by abiotic vs. biotic factors Structuring of river channel morphology and physical habitat conditions Soil moisture stress in plants Dehydration in animals Anaerobic stress in plants Volume of nutrient exchanges between rivers and floodplains Duration of stressful conditions such as low oxygen and concentrated chemicals in aquatic environments Distribution of plant communities in lakes, ponds, floodplains Duration of high flows for waste disposal, aeration of spawning beds in channel sediments
3: Timing of annual extreme discharge conditions	Timing	Julian date of each annual one-day maximum discharge Julian date of each annual one-day minimum discharge	Compatibility with life cycles of organisms Predictability/avoidability of stress for organisms Access to special habitats during reproduction or toavoid predation Spawning cues for migratory fish Evolution of life history strategies, behavioral mechanisms
4: Frequency and duration of high/low flow pulses	Magnitude, frequency duration	No. of high pulses each year No. of low pulses each year Mean duration of high pulses within each year Mean duration of low pulses within each year	Frequency and magnitude of soil moisture stress for plants Frequency and duration of anaerobic stress for plants Availability of floodplain habitats for aquatic organisms Nutrient and organic matter exchanges between river and floodplain Soil mineral availability Access for waterbirds to feeding, resting, reproduction sites Influences bedload transport, channel sediment textures, and duration of substrate disturbance (high pulses)
5: Rate/frequency of hydrograph changes	Frequency, rate of change	Means of all positive differences between consecutive daily values Means of all negative differences between consecutive daily values No. of flow reversals	Drought stress on plants (falling levels) Entrapment of organisms on islands, floodplains (rising levels) Desiccation stress on low-mobility stream edge (varial zone) organisms

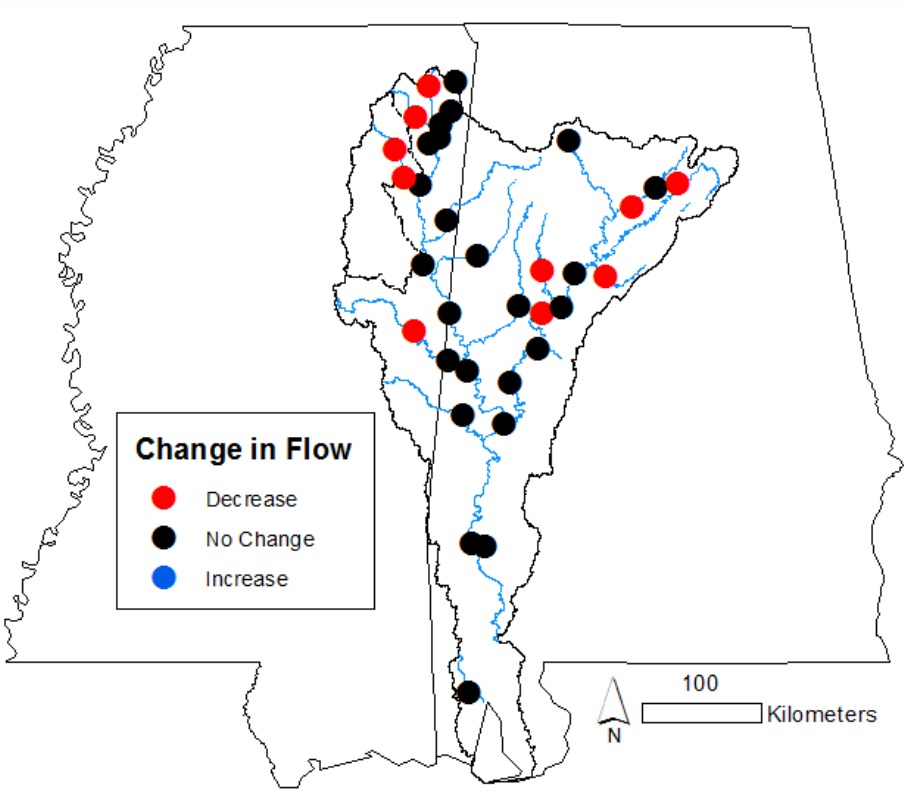
Source: Richter et al. (1998)

Methods: IHA Alabama/Mississippi

- Alabama: 21 total, 14 independent
- Mississippi: 13 total, 8 independent



Results: 7-Day Maximum Flows



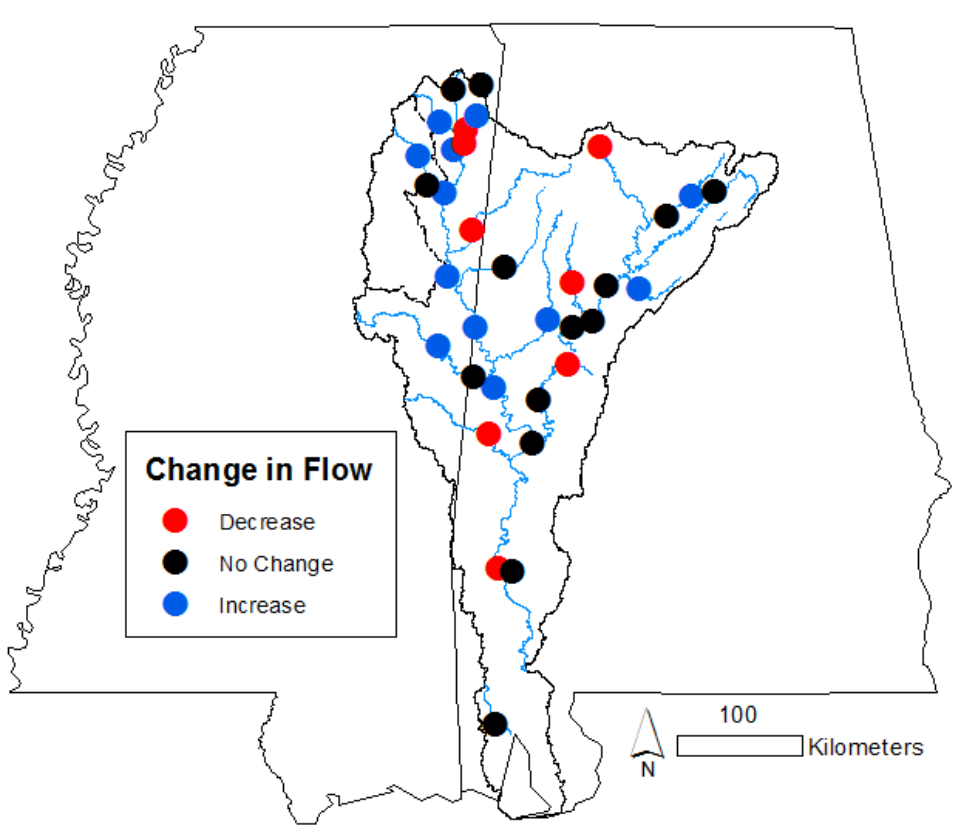
Alabama (all): 24% decreased, 0% increased, 76% no change
Alabama (independent): 29% decreased, 0% increased, 71% no change
Mississippi (all): 38% decreased, 0% increased, 62% no change
Mississippi (independent): 50% decreased, 0% increased, 50% no change

Results: 7-Day Maximum Flows

	Site	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
		Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Alabama	Black Warrior - Northport	57340.00	49670.00	0.58	0.65	0.13	0.13	0.09	0.69
	Locust - Cleveland	4380.00	1218.00	0.59	2.66	0.72	3.52	0.03	0.01
	Mulberry - Arkadelphia	7250.00	1956.00	0.80	2.28	0.73	1.86	0.22	0.04
	North - Samantha	3498.00	2803.00	0.60	0.54	0.20	0.11	0.04	0.80
	Valley - Oak Grove	2906.00	1588.00	1.03	0.40	0.45	0.61	0.02	0.19

	Site	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
		Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Mississippi	Big Brown - Booneville	450.50	301.30	0.69	1.13	0.33	0.64	0.50	0.09
	Noxubee - Macon	9663.00	8194.00	0.75	0.61	0.15	0.19	0.08	0.43
	Town - Nettleton	9043.00	3576.00	0.78	1.61	0.60	1.07	0.09	0.06
	Town - Tupelo	4530.00	2776.00	0.62	0.63	0.39	0.02	0.03	0.97
	Twentymile - Guntown	2984.00	1777.00	0.33	0.45	0.40	0.38	0.03	0.40

Results: 7-Day Minimum Flows



Alabama (all): 24% decreased, 24% increased, 52% no change
Alabama (independent): 21% decreased, 21% increased, 58% no change
Mississippi (all): 23% decreased, 54% increased, 23% no change
Mississippi (independent): 25% decreased, 38% increased, 37% no change

Results: 7-Day Minimum Flows

Alabama

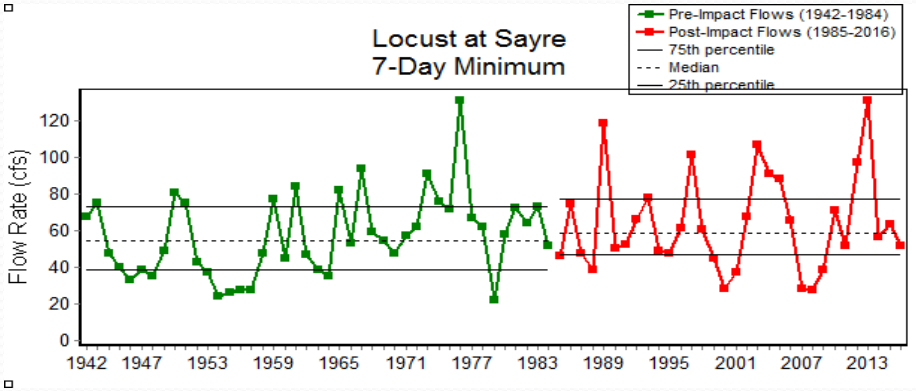
Site	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Elliotts - Moundville	14.93	12.07	0.22	0.32	0.19	0.45	0.06	0.21
Mulberry - Garden City	10.64	16.86	0.79	0.32	0.59	0.60	0.00	0.05
North - Samantha	6.61	4.51	1.05	1.92	0.32	0.82	0.26	0.06
Sipsey - Elrod	54.29	63.71	0.59	0.67	0.17	0.14	0.09	0.68
Sipsey Fork - Grayson	3.54	3.35	0.53	1.24	0.05	1.36	0.71	0.00
Sucarnoochee - Livingston	100.60	93.64	0.34	0.51	0.07	0.52	0.43	0.05
Tombigbee - Coffeeville	2414.00	2007.00	0.32	0.63	0.17	0.98	0.12	0.04
Tombigbee - Gainesville	354.70	578.20	0.59	0.55	0.63	0.07	0.01	0.88
Tombigbee - Pickensville	438.40	635.90	0.32	0.60	0.45	0.89	0.01	0.10
Valley - Oak Grove	57.86	76.36	0.34	0.29	0.32	0.15	0.00	0.74

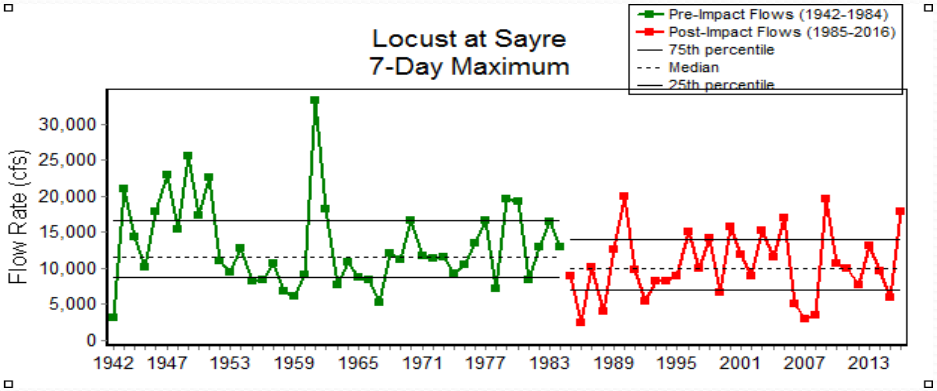
Mississippi

Site	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Big Brown - Booneville	0.61	0.58	1.06	2.11	0.05	0.99	0.84	0.13
Buttahatchee - Aberdeen	175.10	146.00	0.26	0.54	0.17	1.11	0.05	0.01
Cummings - Fulton	8.14	5.50	0.45	0.70	0.32	0.55	0.08	0.13
Mud - Fairview	3.72	3.16	0.37	0.98	0.15	1.63	0.47	0.01
Noxubee - Macon	48.29	54.29	0.44	0.36	0.12	0.18	0.07	0.59
Redbud - Moores Mill	2.78	3.15	0.29	0.59	0.13	1.02	0.42	0.02
Tombigbee - Bigbee	139.30	269.90	0.43	0.27	0.94	0.37	0.00	0.21
Tombigbee - Fulton	49.86	104.40	0.55	0.49	1.10	0.10	0.00	0.86
Tombigbee - Stennis	376.20	529.00	0.51	0.52	0.41	0.03	0.00	0.92
Town - Tupelo	3.95	4.32	0.61	1.58	0.09	1.59	0.73	0.02
Twentymile - Guntown	0.56	0.92	0.52	1.61	0.65	2.08	0.15	0.08

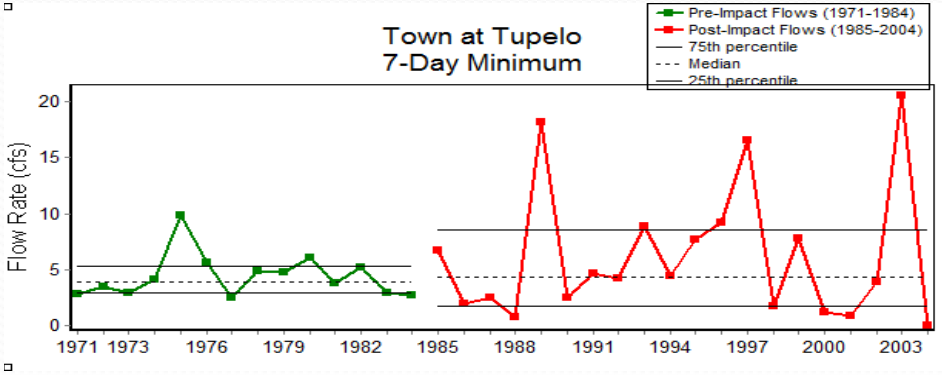
Results: IHA Alabama/Mississippi

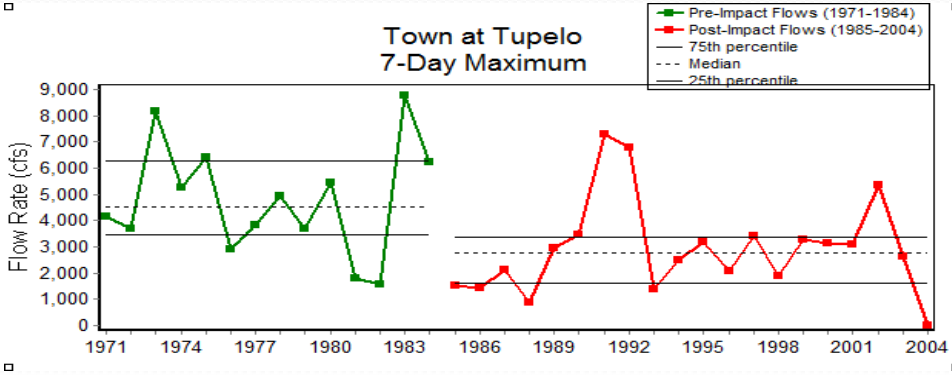
Locust Fork, Alabama





Town Creek, Mississippi





Conclusions

- In both Alabama and Mississippi, most sites experienced a decrease in maximum flows, with some experiencing a decrease (and none an increase)
- Approximately equal numbers of sites in Alabama and Mississippi experienced a decrease in minimum flows, but more sites in Mississippi experienced an increase
- A 7Q10 standard is ineffectual in preserving maximum flows, and only weakly effective in preserving minimum flows

Future Research