Endangered Fish Species in Kansas: Historical vs Contemporary Distribution

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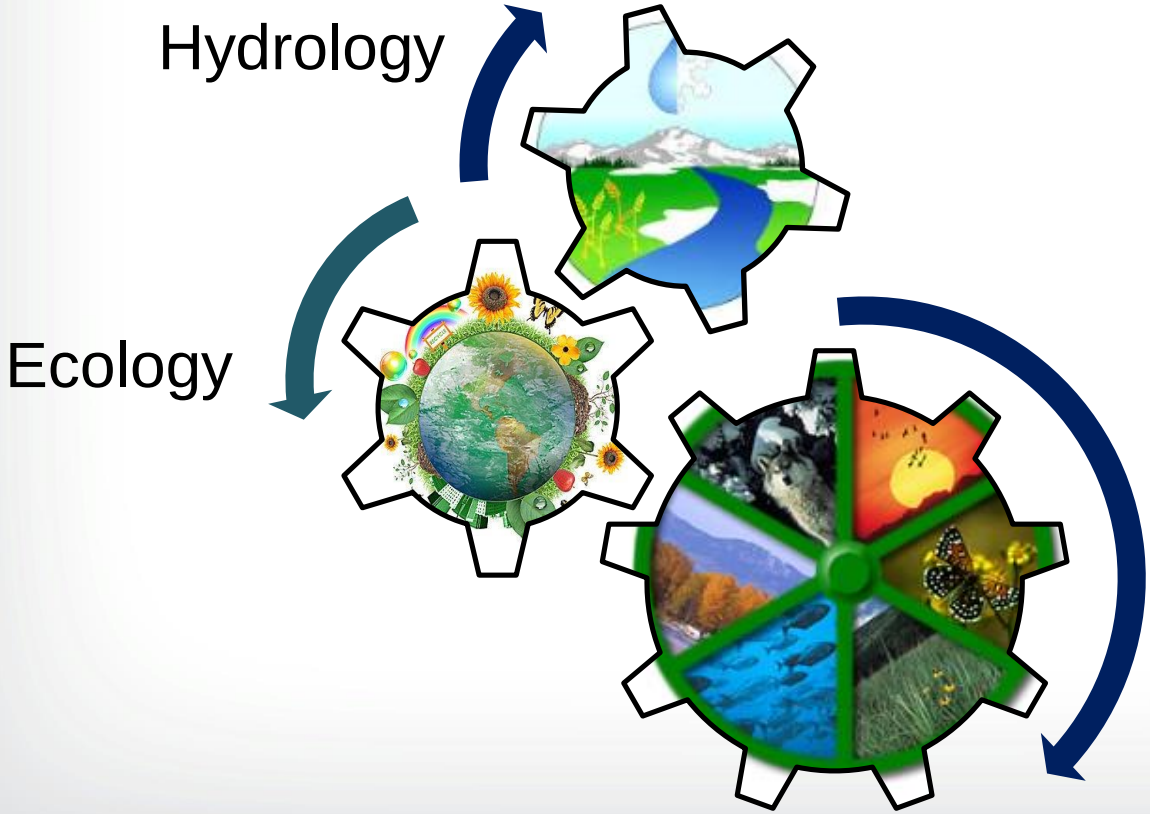
Outline

- Introduction
- Previous work: linking hydrological trends and fish presence and distribution
- Objective and methods
- Preliminary results and conclusion

The Need for Ecohydrology

"Science of water and ecology"

New scientific way of managing the water cycle in order to achieve the sustainable use of water

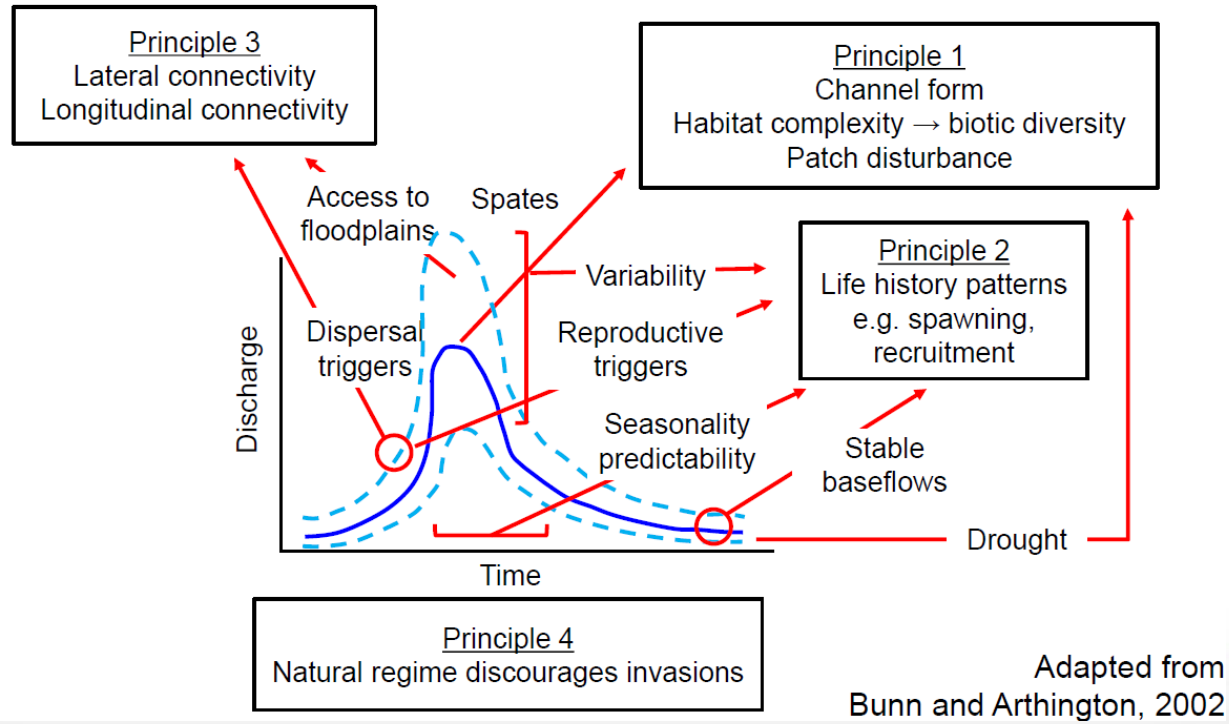


Ecohydrology: regulation of hydrological and ecological processes, an integrated approach needed for River Basin Management

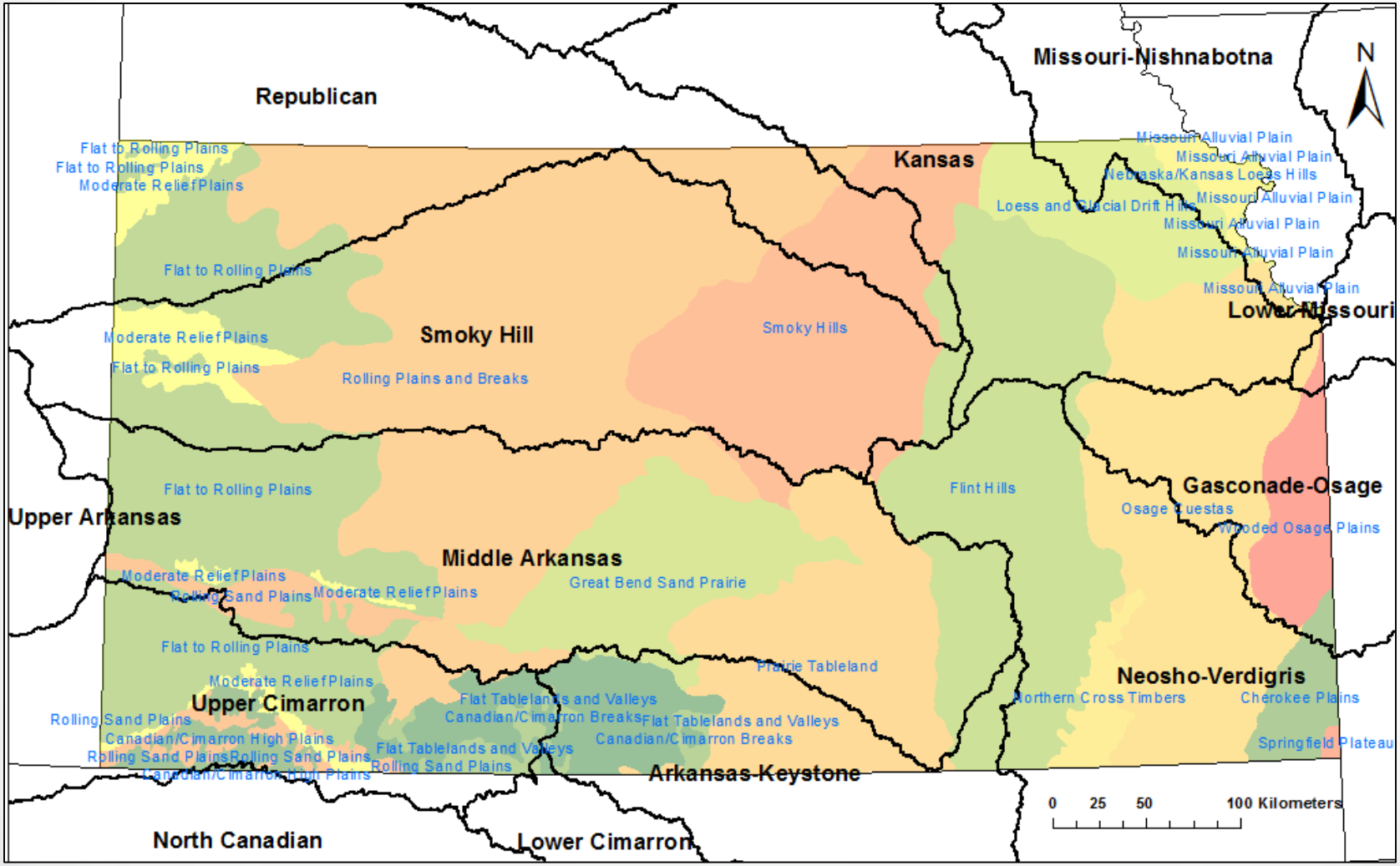
Ecological Engineering

Natural Flow Regime and Ecological Process

- Specifics of magnitude, frequency, duration, timing and rate-of-change dictate ecological processes and outcomes.



Major River Basins in Kansas



- Spatial variability in biophysical factors

Previous Work

Linking hydrological trends with fish presence and distribution

Ecohydrology

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RESEARCH ARTICLE

Ecohydrological index, native fish, and climate trends and relationships in the Kansas River basin

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Abstract

This study quantified climatological and hydrological trends and relationships to presence and distribution of 2 native aquatic species in the Kansas River basin over the past half century. Trend analyses were applied to indicators of hydrologic alteration (IHAs) at 34 streamgages over a 50-year period (1962–2012). Results showed a significant negative trend in annual streamflow for 10 of 12 western streamgages (up to −7.65 mm/50 years) and smaller negative trends for most other streamgages. Significant negative trends in western basin streamflow were more widespread in summer (12 stations) than in winter or spring (6 stations). The negative-trend magnitude and significance decreased from west to east for maximum-flow IHAs. Minimum-flow IHAs, however, significantly decreased at High Plains streamgages but significantly increased at Central Great Plains streamgages. Number of zero-flow days showed positive trends in the High Plains. Most streamgages showed negative trends in low- and high-flow pulse frequency and high-flow pulse duration, and positive trends in low-flow pulse duration. These results were consistent with increasing occurrence of drought. Shift in occurrence from present (1860–1950) to absent (2000–2012) was significantly related ($p < .10$) to negative trends of 1-day maximum flows (both species) and indices associated with reduced spawning-season flows for Plains Minnow and shifting annual-flow timing and increased flow intermittency for Common Shiner. Both species were absent for all western basin sites and had different responses to hydrological index trends at eastern basin sites. These results demonstrate ecohydrological index changes impact distributions of native fish and suggest target factors for assessment or restoration activities.

Methods: Ecological Influences

- 39 ecohydrological indicators
- Fish occurrence data (presence/absence) Kansas Aquatic Gap Database
- Close geographic proximity of fish survey and streamgage
- Two periods:
  - Historic (1860-1950) and
  - Present (2000-2012)
- A two-sample t-test (assuming unequal variance)

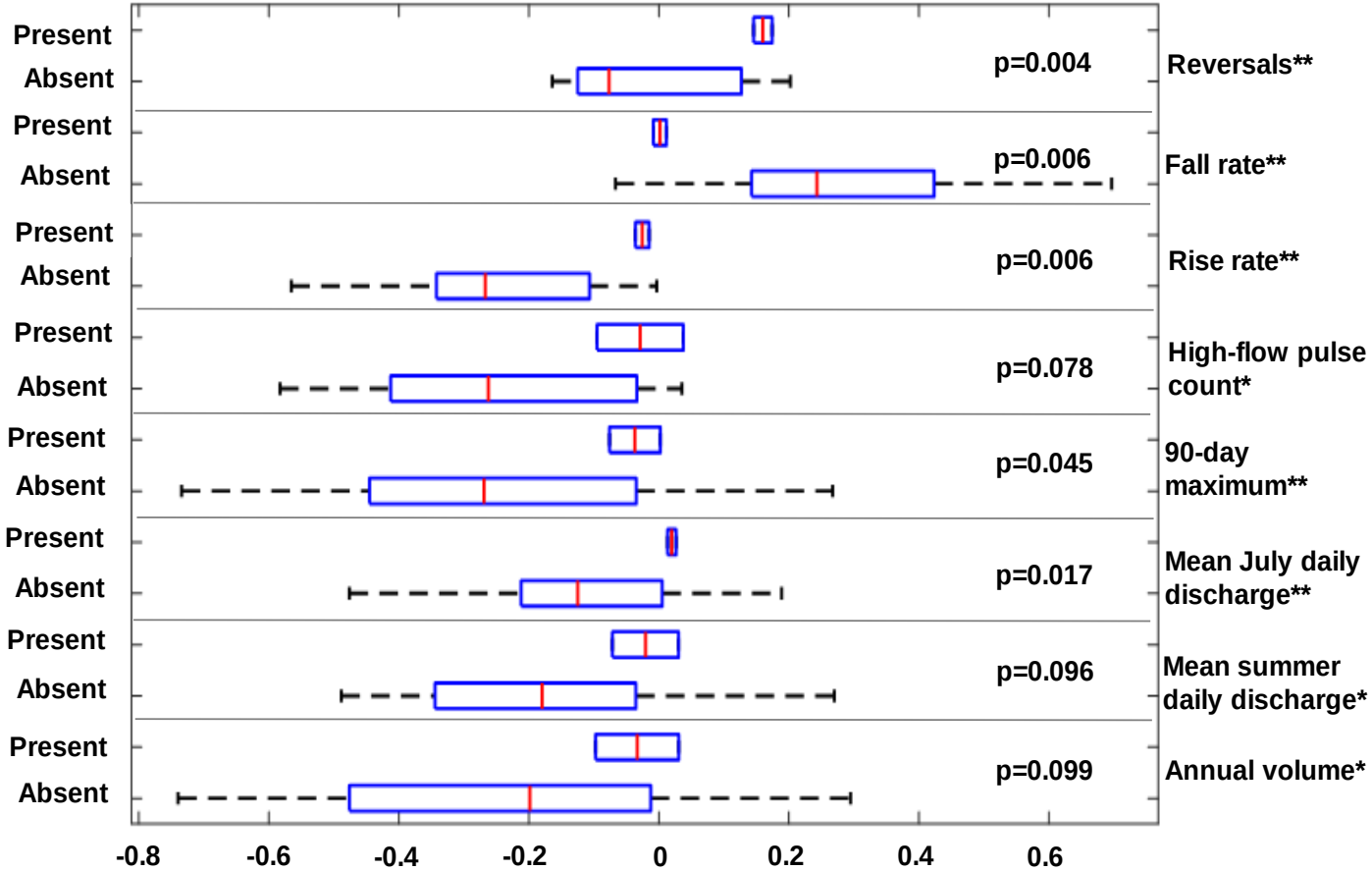
Table 4 Mean trends (Kendall tau, 1962-2012) of ecohydrological indicators for streamgages in the Kansas River Basin at which Plains Minnow or Common Shiner were either "Absent" or "Present" (2000-2012) after being present historically (1860-1950). Trend significance indicated at p = 0.05 ** and p = 0.10*.

	Plains Minnow			Common Shiner		
	Absent (tau) n=14	Present (tau) n=2	p value	Absent (tau) n=7	Present (tau) n=4	p value
Annual volume	-0.237	-0.033	**0.095***	-0.044	-0.037	0.933
Center of timing of annual flow	-0.080	-0.028	0.216	-0.143	0.042	**0.025****
Mean spring daily discharge	-0.125	0.052	0.308	0.092	0.005	0.333
Mean summer daily discharge	-0.190	-0.021	**0.088***	-0.067	0.011	0.357
Mean autumn daily discharge	-0.189	-0.094	0.179	-0.038	-0.069	0.697
Mean winter daily discharge	-0.142	-0.014	0.150	0.091	-0.013	0.211
October	-0.117	-0.037	0.175	0.016	-0.049	0.278
November	-0.132	-0.095	0.640	0.007	-0.029	0.519
December	-0.127	-0.014	0.165	0.060	0.003	0.465
January	-0.089	-0.009	0.256	0.113	0.020	0.355
February	-0.132	-0.023	0.168	0.057	-0.053	0.185
March	-0.143	-0.004	0.234	0.061	-0.065	**0.075***
April	-0.086	0.057	**0.102***	0.115	0.028	0.343
May	-0.097	0.039	0.247	0.106	0.012	0.220
June	-0.137	-0.013	0.151	0.015	0.002	0.829
July	-0.113	0.020	**0.012****	0.003	0.006	0.965
August	-0.064	-0.012	0.216	0.011	0.015	0.952
September	-0.137	-0.036	**0.082***	-0.022	-0.042	0.781
1-day min. flow	-0.019	-0.020	0.971	0.037	0.051	0.859
3-day min. flow	-0.019	-0.003	0.721	0.052	0.057	0.954
7-day min. flow	-0.025	0.002	0.554	0.053	0.049	0.953
30-day min. flow	-0.063	0.028	**0.105***	0.049	0.013	0.604
90-day min. flow	-0.114	-0.026	0.147	0.002	-0.027	0.707
1-day max. flow	-0.201	-0.036	**0.081***	-0.110	0.035	**0.095***
3-day max. flow	-0.220	-0.029	**0.109**	-0.104	-0.011	0.255
7-day max. flow	-0.228	-0.054	0.208	-0.103	-0.034	0.399
30-day max. flow	-0.237	-0.069	0.166	-0.094	-0.055	0.616
90-day max. flow	-0.237	-0.037	**0.034****	-0.065	-0.073	0.914
Zero-flow days	0.079	0.025	0.433	-0.032	0.048	0.351
Baseflow	-0.002	-0.017	0.728	0.067	0.066	0.996
Date of min. flow	0.077	0.006	0.412	0.049	0.052	0.932
Date of max. flow	-0.085	-0.104	0.890	-0.147	-0.031	**0.090***
Low-flow pulse count	0.024	0.005	0.636	-0.090	-0.087	0.953
Low-flow pulse duration	0.086	-0.035	0.330	0.098	-0.005	0.211
High-flow pulse count	-0.220	-0.029	**0.109**	-0.104	-0.010	0.255
High-flow pulse duration	-0.069	0.050	0.339	0.022	0.003	0.785
Rise rate	-0.171	-0.025	**0.034****	-0.061	-0.034	0.732
Fall rate	0.202	0.002	**0.015****	0.054	-0.034	0.270
Reversals	-0.016	0.160	**0.006****	0.152	0.064	0.454

Draft

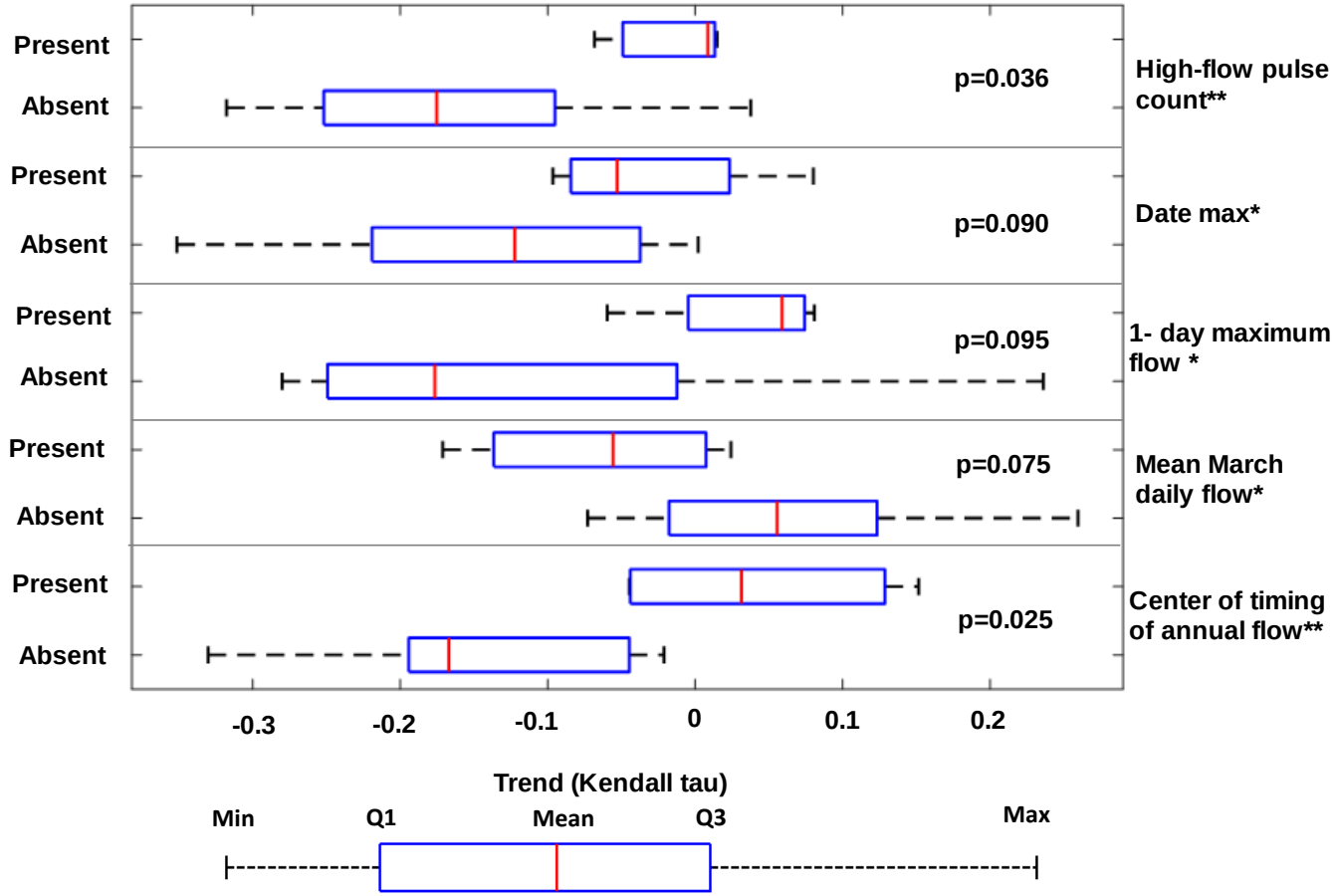
Result

Comparison of trends (Kendall tau, 1962-2012) in significant ecohydrological indicators at 16 streamgages in the Kansas River Basin at which Plains Minnow was either “Present” or “Absent” (2000-2012) after being present historically (1860-1950).



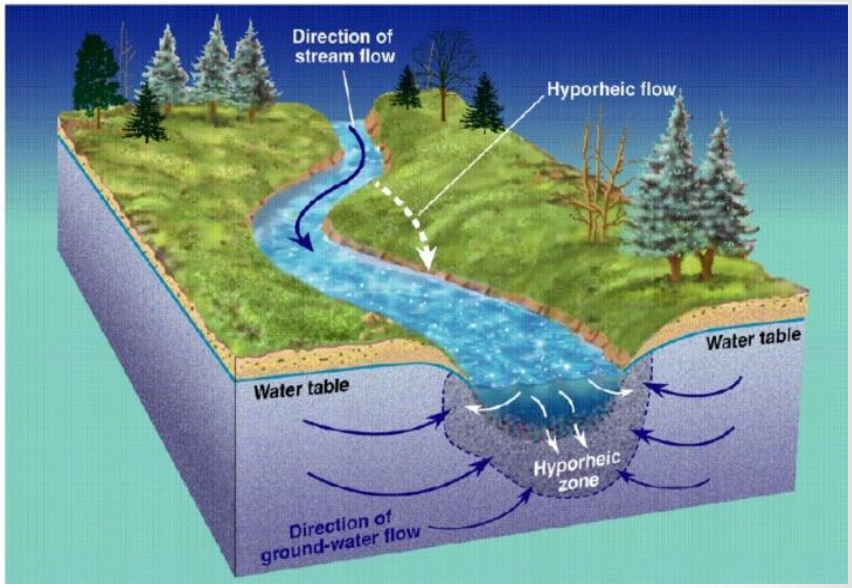
Result

Comparison of trends (Kendall tau, 1962-2012) in significant ecohydrological indicators at 16 streamgages in the Kansas River Basin at which Common Shiner was either "Present" or "Absent" (2000-2012) after being present historically (1860-1950).



Ecological Influences

- Summer flow
  - Plains minnow: needs stable low flow for spawning, eggs are semi-buoyant in the current which allows the egg to develop above stream bed
  - Common shiner: spawns on riffles
- High flow pulses (count and duration)- loss of spawning cue (precise moment)
- Hyporheic zone (ecotone)
- Role of spring flow in sediment transport



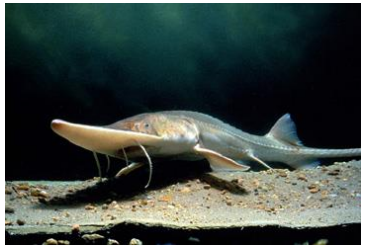
EPA, 2009

Current Study Objectives

- Correlate fish presence with land use, hydrology and water quality changes

Endangered Species Selection

Arkansas River Shiner
Notropis Girardi
NOTGIR



Pallid Sturgeon
Scaphirhynchus albus
SCAALB

Sicklefin Chub
Macrohybopsis meeki
MACMEE

Peppered Chub
Macrohybopsis tetranema
MACTET

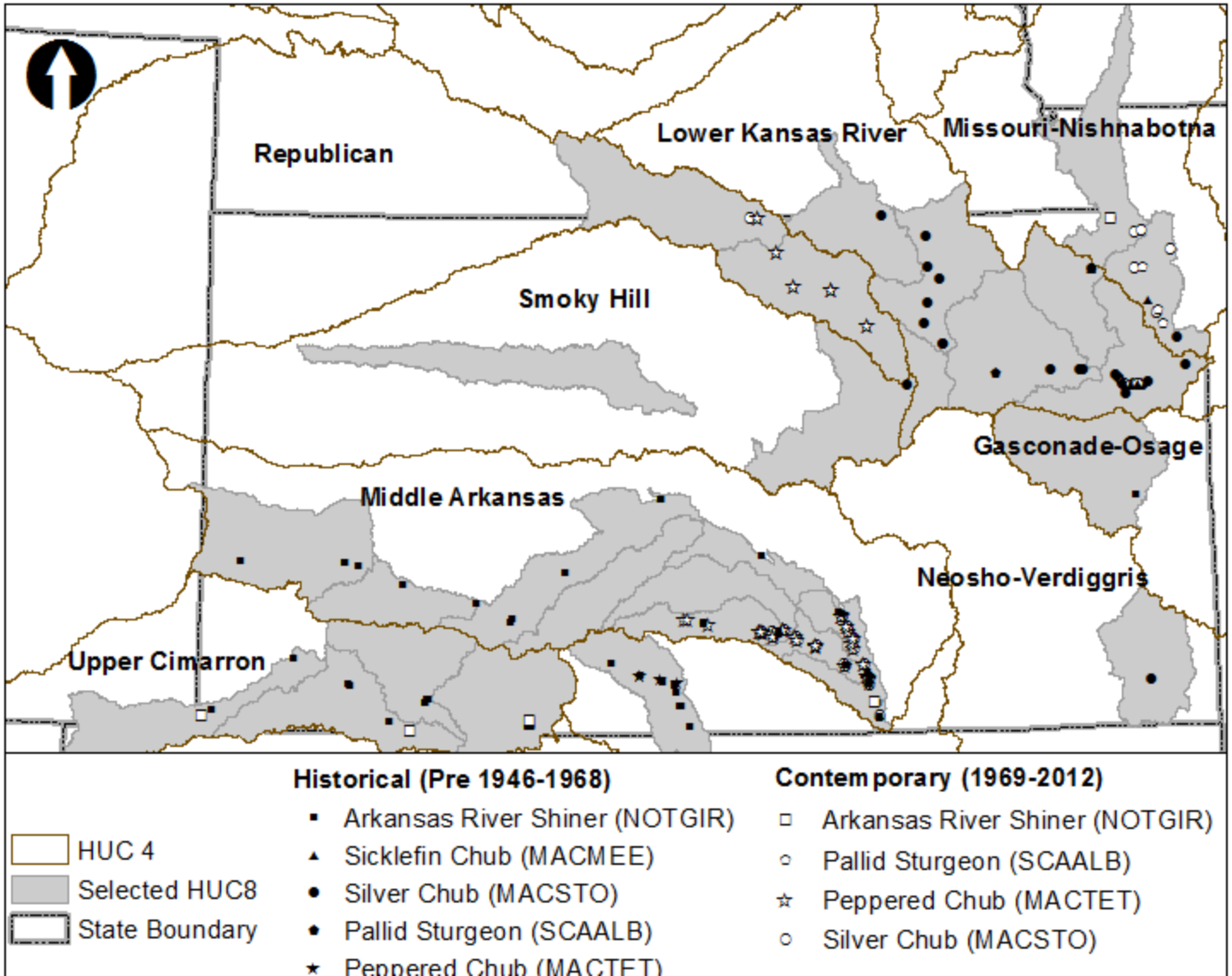
Silver Chub
Macrohybopsis storeiana
MACSTO

Family:

- Pallid Sturgeon: Acipenseridae, Sturgeon family
- Others: Cyprinidae, Carp and Minnow family

Photo courtesy of Center for Biological Diversity, US Fish and Wildlife services, KSU, David Ostendorf, Ohio Department of Natural Resources

Study Area

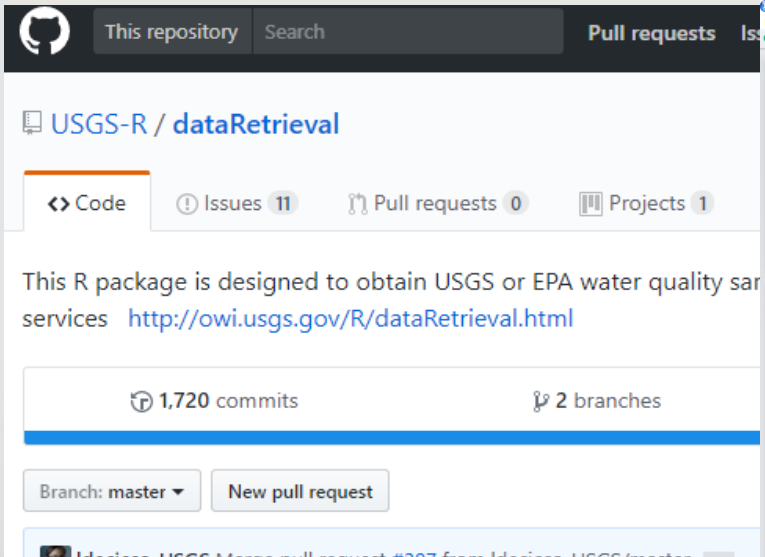

Republican
Lower Kansas River
Missouri-Nishnabotna
Smoky Hill
Gasconade-Osage
Middle Arkansas
Neosho-Verdiggris
Upper Cimarron
HUC 4
Selected HUC8
State Boundary
Historical (Pre 1946-1968)
Arkansas River Shiner (NOTGIR)
Sicklefin Chub (MACMEE)
Silver Chub (MACSTO)
Pallid Sturgeon (SCAALB)
Peppered Chub (MACTET)
Contemporary (1969-2012)
Arkansas River Shiner (NOTGIR)
Pallid Sturgeon (SCAALB)
Peppered Chub (MACTET)
Silver Chub (MACSTO)

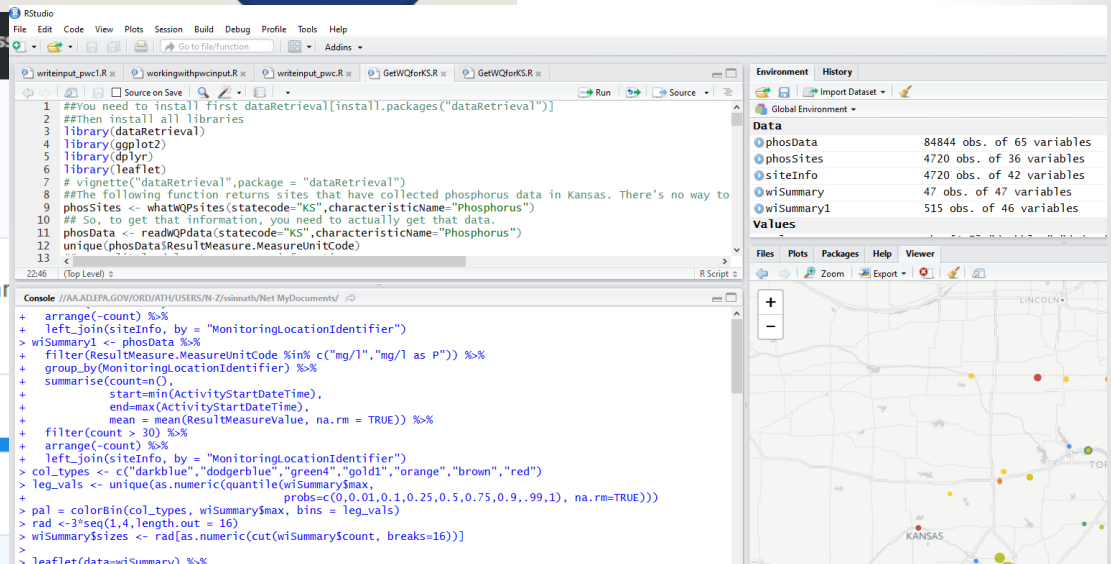
Variables

1. Land use: % Natural, % Agriculture, % Developed
2. Streamflow (IHA)
3. Average annual precipitation (mm)
4. Suspended sediment concentration- SSC (mg/L)
5. Nitrate (mg/L)
6. Water temperature (^{o}C)
7. Total phosphorous(mg/L)
8. Atrazine (ug/L)
9. Major dams and fragmentation (with 50 feet or more in height, or with a normal storage capacity of 5,000 acre-feet) (https://nationalmap.gov/small_scale/mld/dams00x.html)

Water Quality Data Retrieval

- Water Quality Portal (WQP) data was downloaded using modified USGS-R/ dataRetrieval tool
- USGS data comes from the NWIS database and EPA data comes from the STORET database.





Methodology

- Two different groups for statistical tests
- Identify differences between historic (pre-1968) and contemporary (1969–2012) parameter means
- Identify differences in fish distribution through time (done separately for each species)
  - ✓ Stable sites: historically and currently present
  - ✓ Flourishing/booming sites: historically absent, currently present
  - ✓ Extirpated sites: historically present, currently absent

Preliminary Results

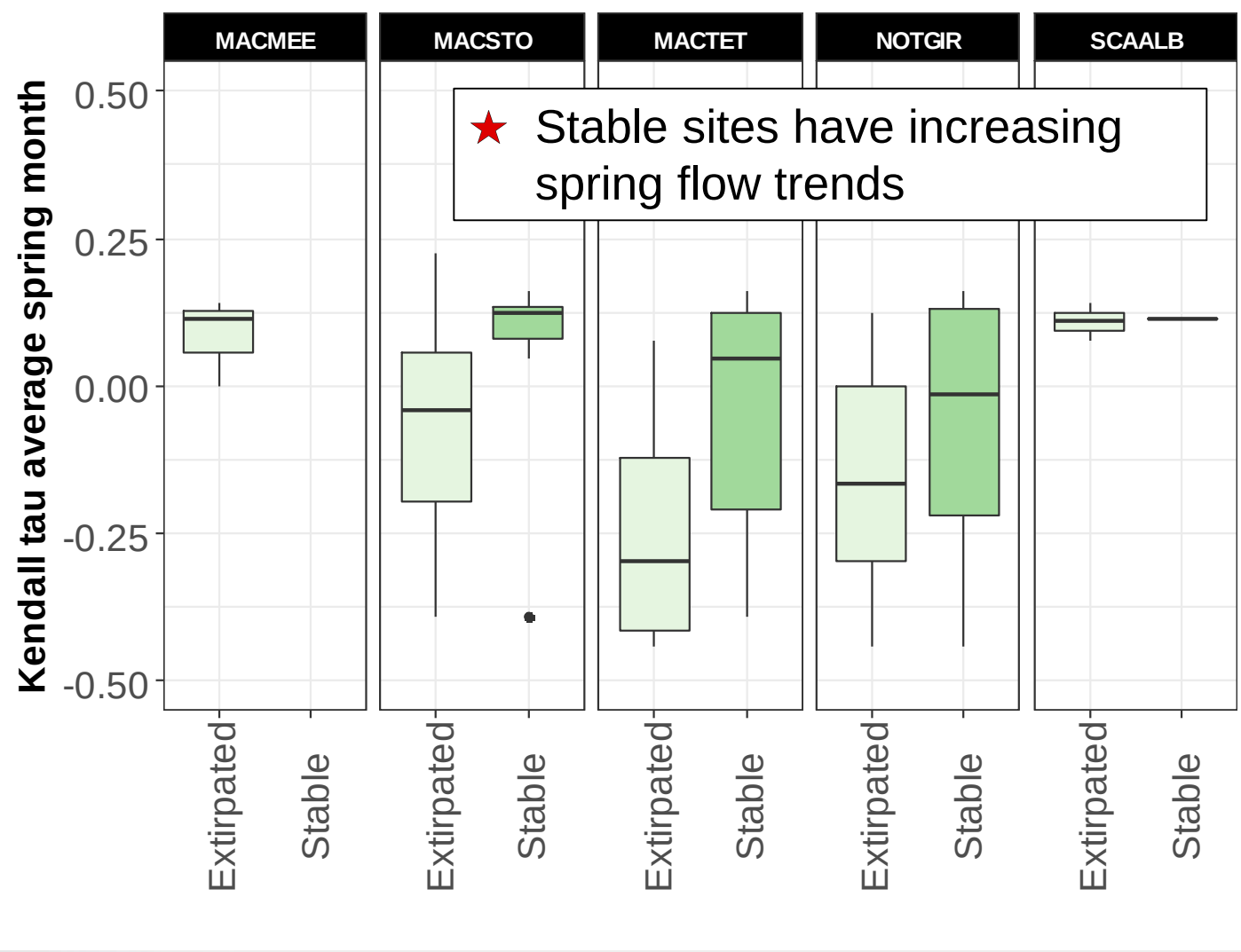
2-sample test for equality of proportions

Species	Prop (Historical)	Prop (Contemporary)	P-value	chi-square
MACSTO	0.44	0.19	0.01	5.90
MACMEE	0.50	0.00	0.04	4.05*
MACTET	0.50	0.17	0.01	7.60
NOTGIR	0.50	0.13	0.00	12.10
SCAALB	0.50	0.17	0.35	0.87*

* low n approximation

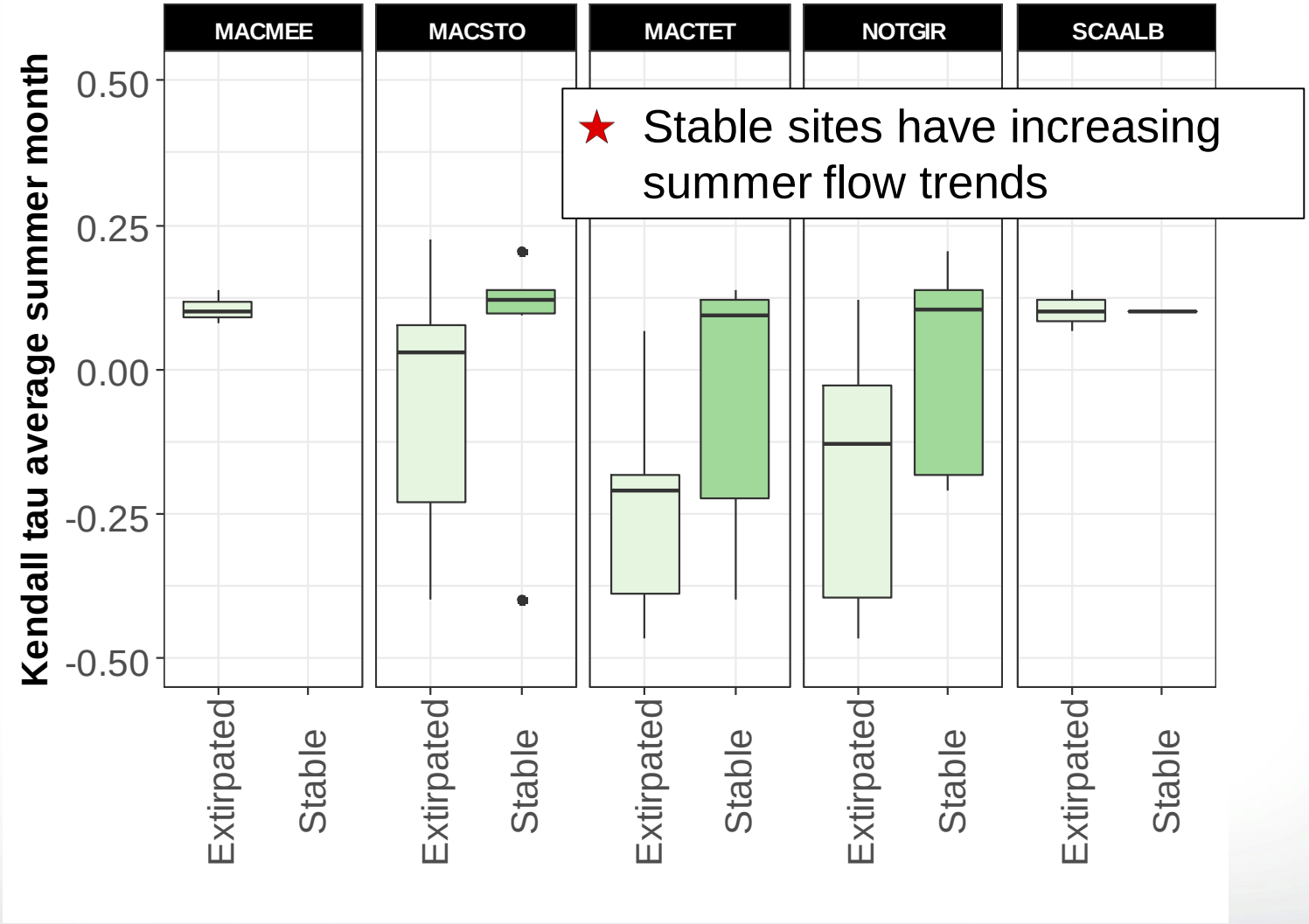
★ Historical and contemporary are significantly different for four species except SCAALB

Preliminary Results: Spring Flow Trend

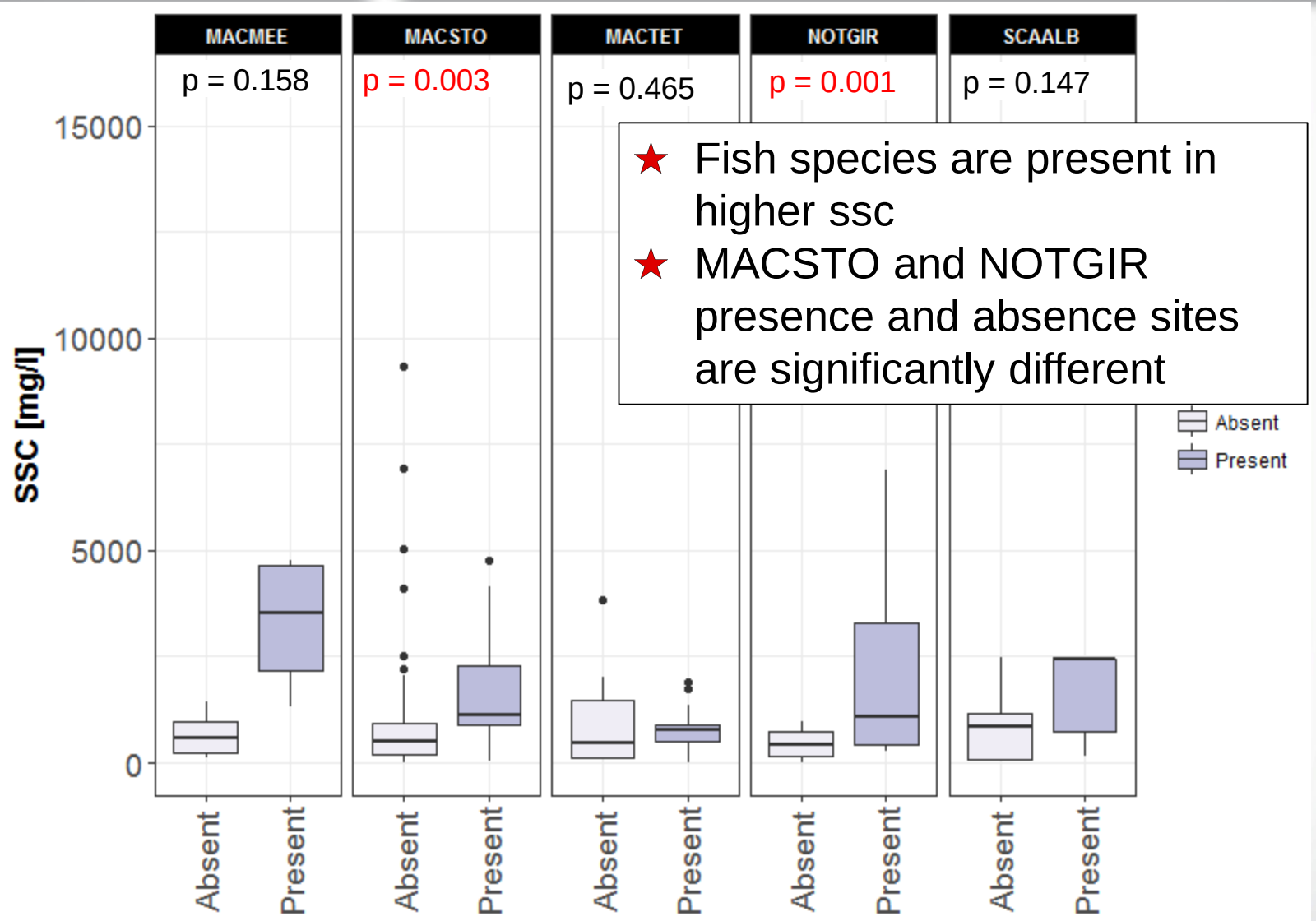


- IHA
- Mann-kendall trend test (MATLAB)

Preliminary Results: Summer Flow Trend

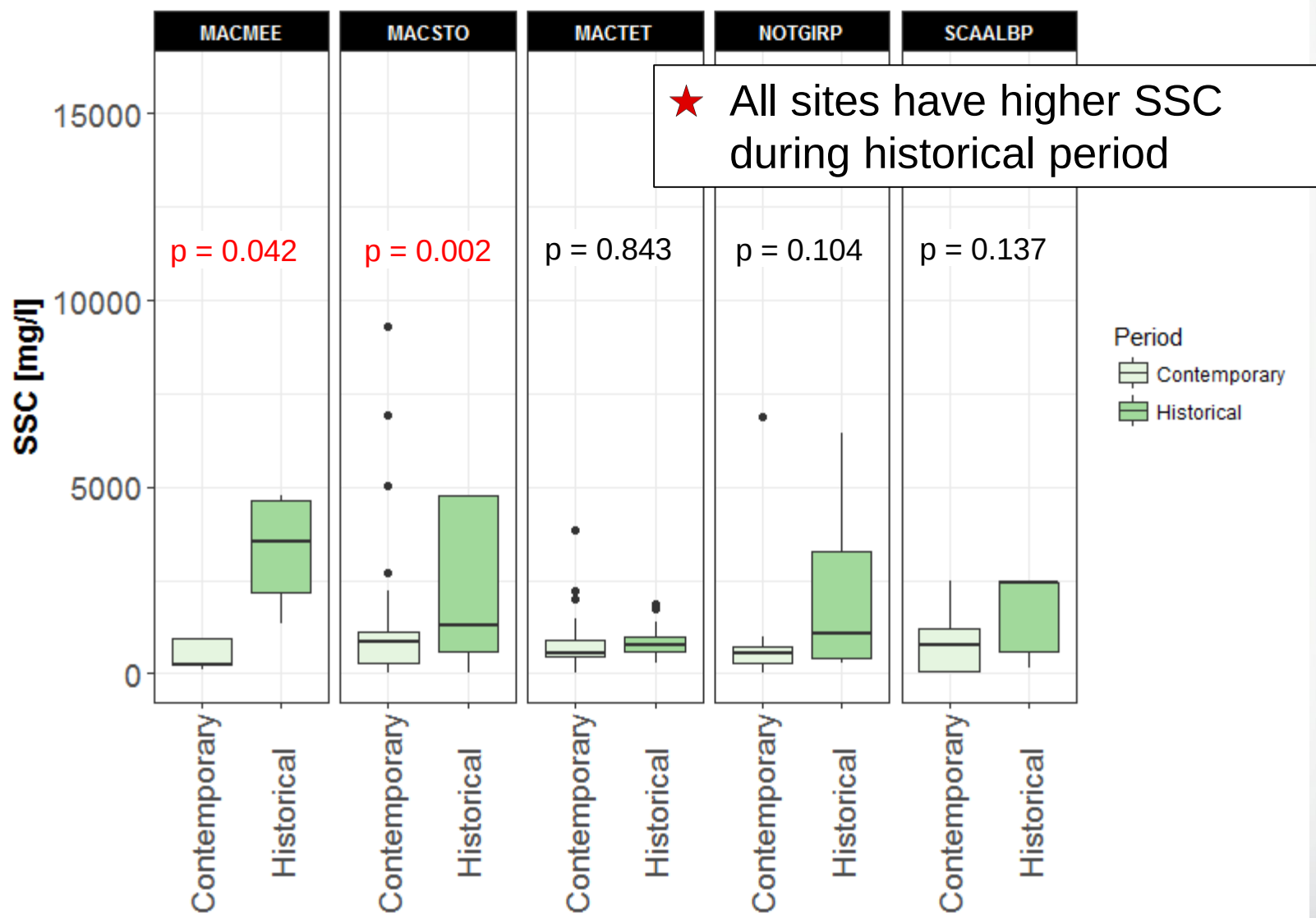


Preliminary Results: Suspended Sediment Concentration (SSC)



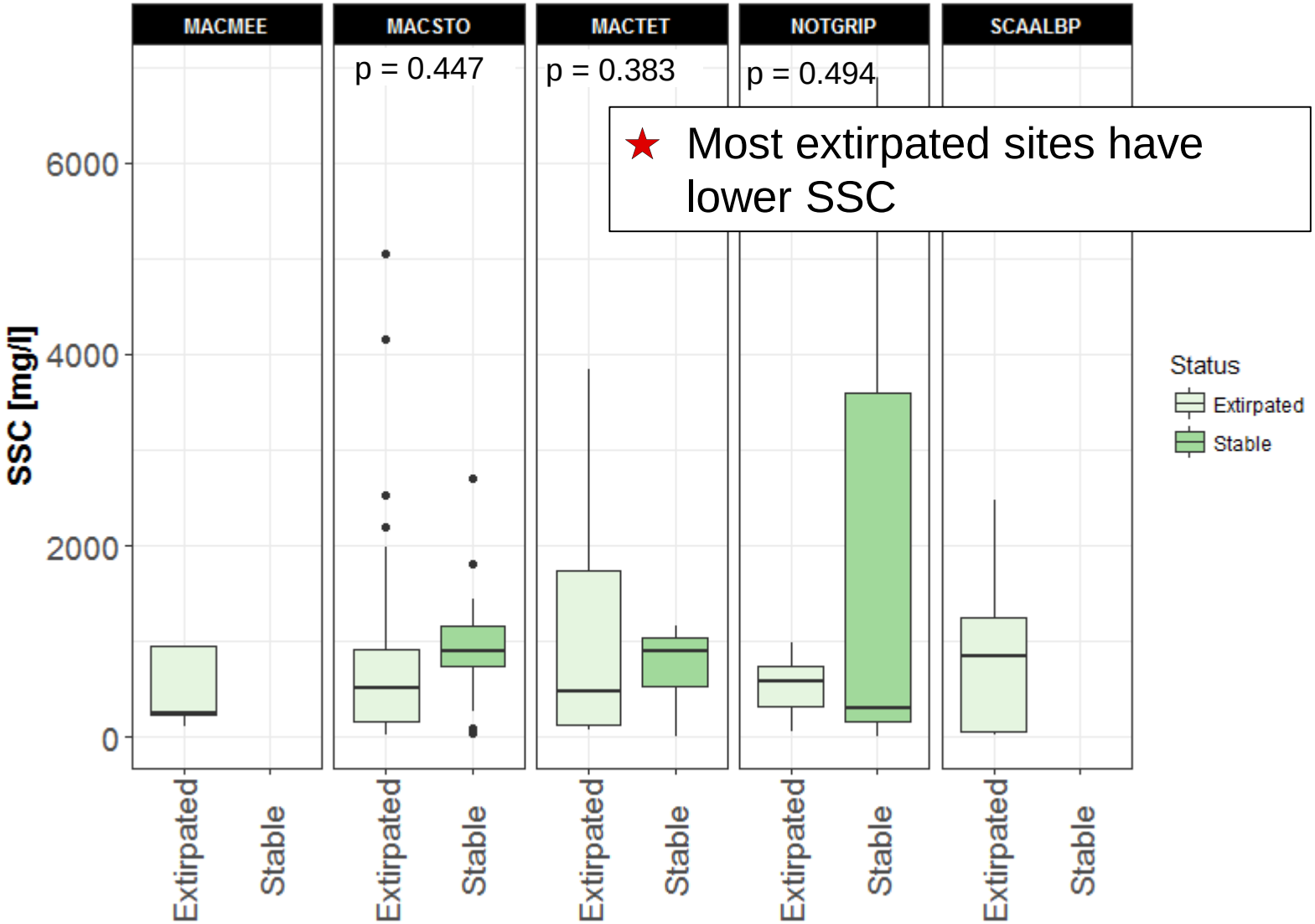
- ★ Fish species are present in higher ssc
- ★ MACSTO and NOTGIR presence and absence sites are significantly different

Preliminary Results: SSC Contemporary vs Historical



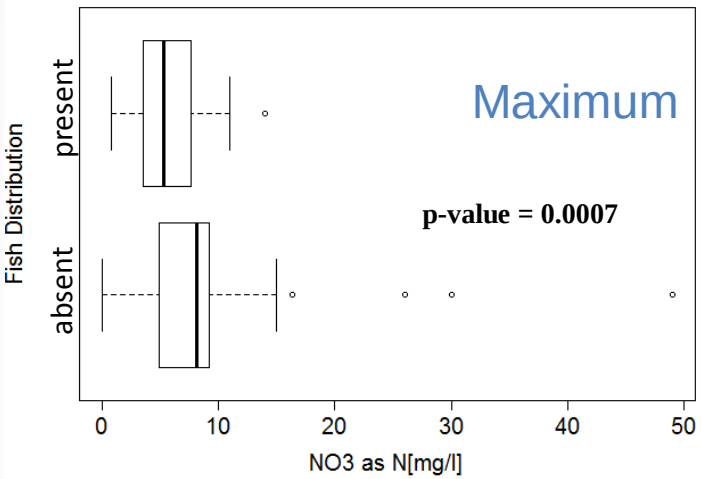
★ All sites have higher SSC during historical period

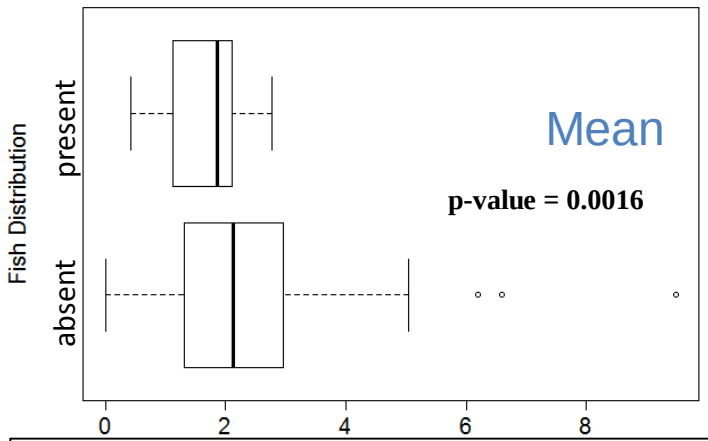
Preliminary Results: SSC Extirpated vs Stable



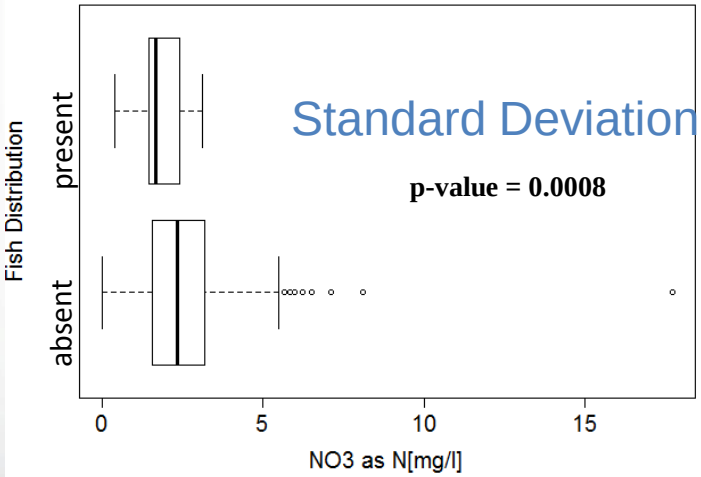
★ Most extirpated sites have lower SSC

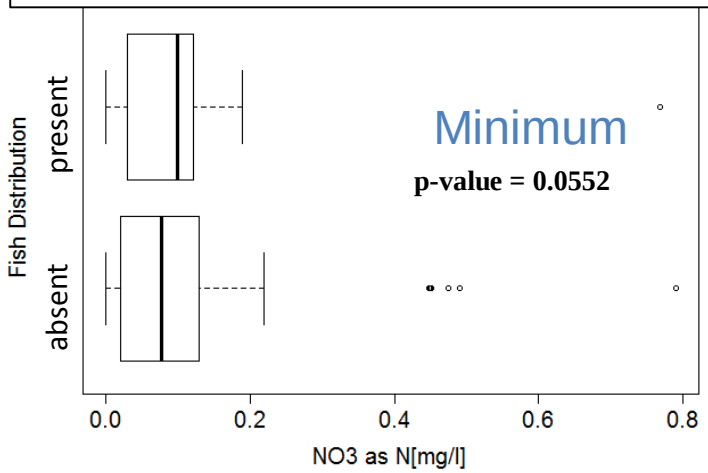
Preliminary Results: Silver Chub – NO_3^-





★ Silver Chub absent sites have higher NO3 ($p < 0.05$)





Conclusions

- Water quality parameters and flow characteristics significantly affected the presence/absence of fish species in Kansas streams
- The proportions of occurrence for all species examined declined in the contemporary period relative to the historic period
- Higher SSC was related to higher occurrence of endangered species
- Lower NO_3 concentration was related to higher occurrence of silver chub
- Similar analyses will be performed for the remaining species once all necessary data have been processed

Acknowledgments

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This presentation has been reviewed and approved in accordance with Agency policy. The views expressed in this presentation are those of the author(s) and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.