Silver Carp Establishment in the Lower White River, Arkansas: Effects on Native Fishes

Gulf & South Atlantic Regional Panel

On Aquatic Invasive Species Meeting

April 11, 2018

Jackson, Mississippi

UAPB
UNIVERSITY of ARKANSAS AT PINE BLUFF
1873

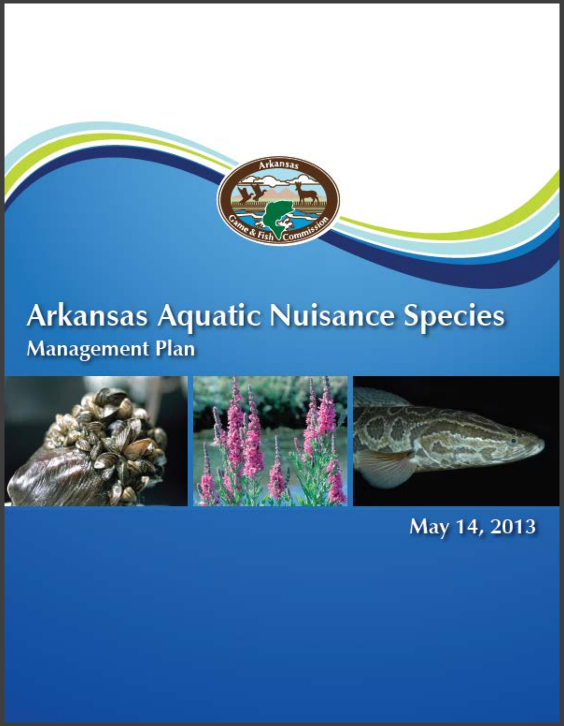
Aquaculture / Fisheries Center
University of Arkansas at Pine Bluff

University of Arkansas at Pine Bluff

Department of Aquaculture and Fisheries

Arkansas ANS Management Plan (2013)

1) The extent to which the species is invasive and becomes a nuisance



2) Economic damage

3) Ecological damage

4) Harm to human health

5) Feasibility of management or control

Bigheaded Carps

Invasive fishes whose population ranges have grown tremendously during the past 10-15 years

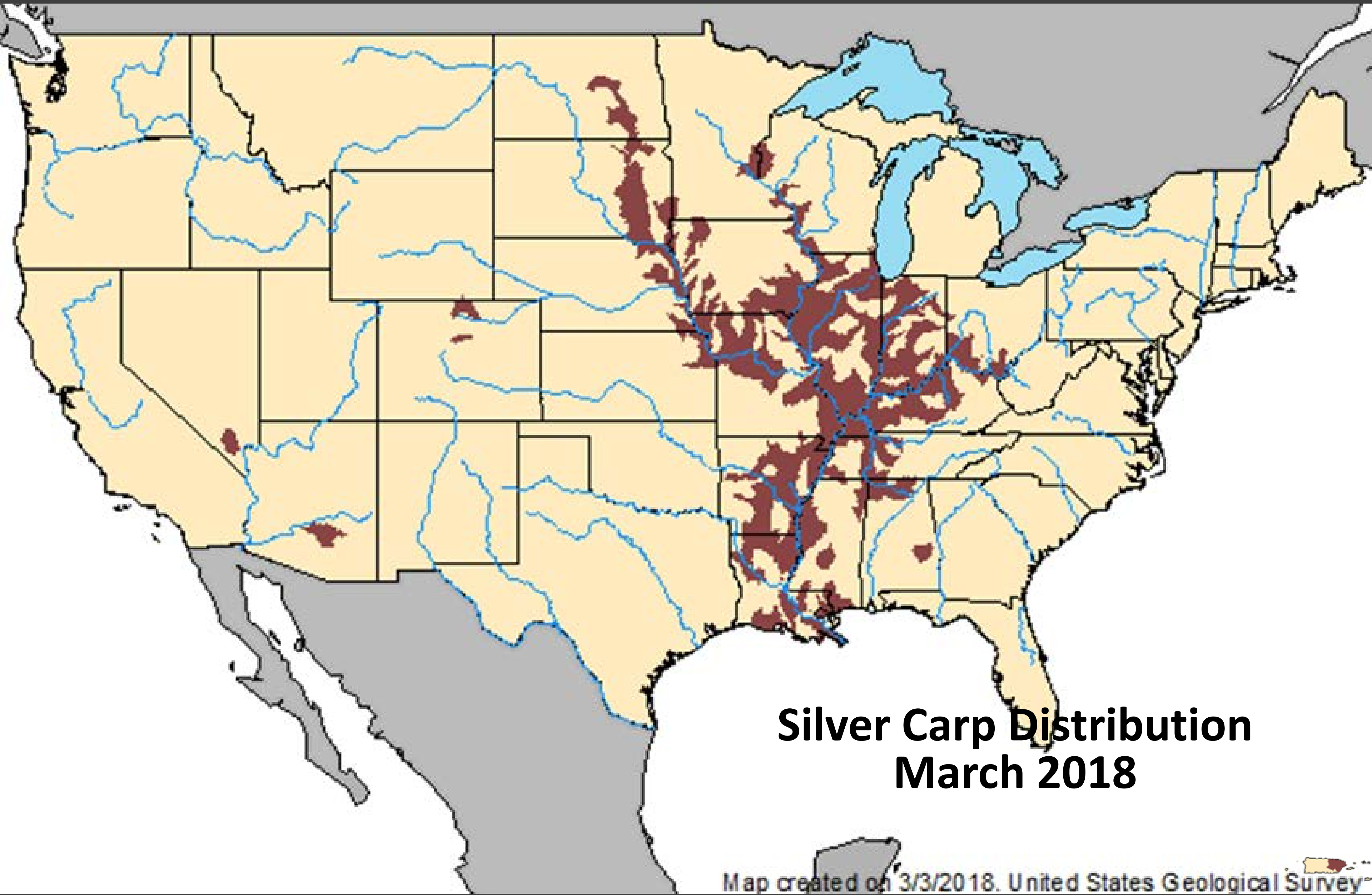
Bighead Carp
Hypophthalmichthys nobilis

Silver Carp
Hypopthalmichthys molitrix

Bigheaded Carps in Arkansas

Introduced in 1973…

- 1975: Found within the White River drainage (Kolar et al. 2005)
- 1980: Reported within the Arkansas and White River basins (Freeze and Henderson 1982)
- 1990s: Range extensions following several years of high flooding in the LMR and its tributaries (Kelly et al. 2011)
- 2000: Widespread expansion had heightened concern over potential impacts on native fishes
- 2005-2015: Recorded along the borders of 23 states with self-sustaining populations in the Mississippi, Missouri, Ohio, and Tennessee rivers (Kolar et al. 2005; Schofield et al. 2005; Nico et al. 2016a,b)


Silver Carp Distribution
March 2018
Map created on 3/3/2018. United States Geological Survey

Ecosystem Impacts

- High to extremely high abundances
- Highly planktivorous – compete directly with adults of some native species and juveniles of many species
- Feeding – consume particles as small as 10 µm in size (Vörös 1997)
- Broad tolerance for environmental factors
- Reproductive capacities – mature 1 year sooner than in China (Williamson and Garvey 2005)
- Large sizes – exceed mean sizes in China by 26% (Williamson and Garvey 2005)

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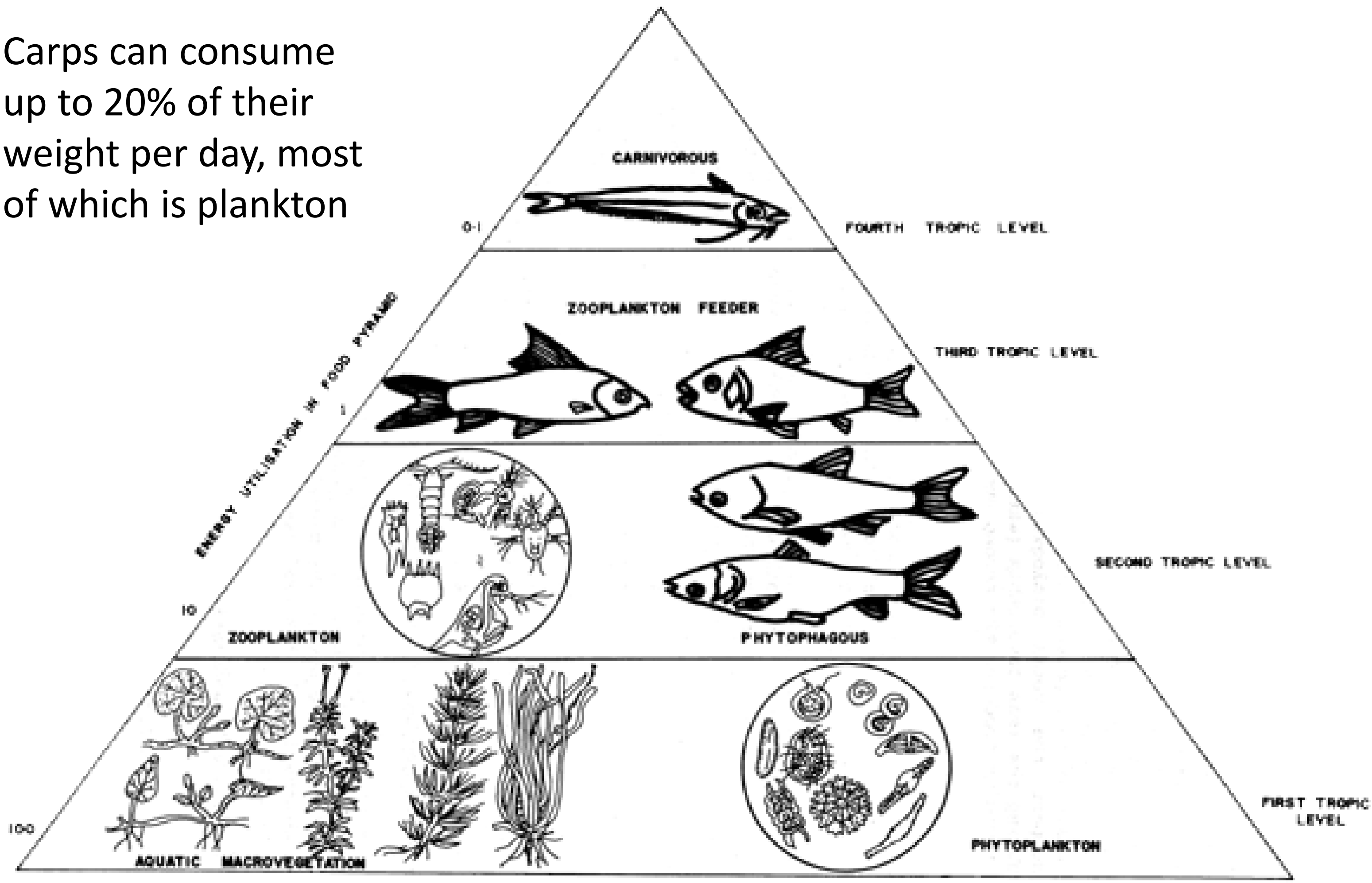
Ecosystem Impacts

Carps can consume up to 20% of their weight per day, most of which is plankton



https://www.nps.gov/miss/learn/nature/ascarpover.htm

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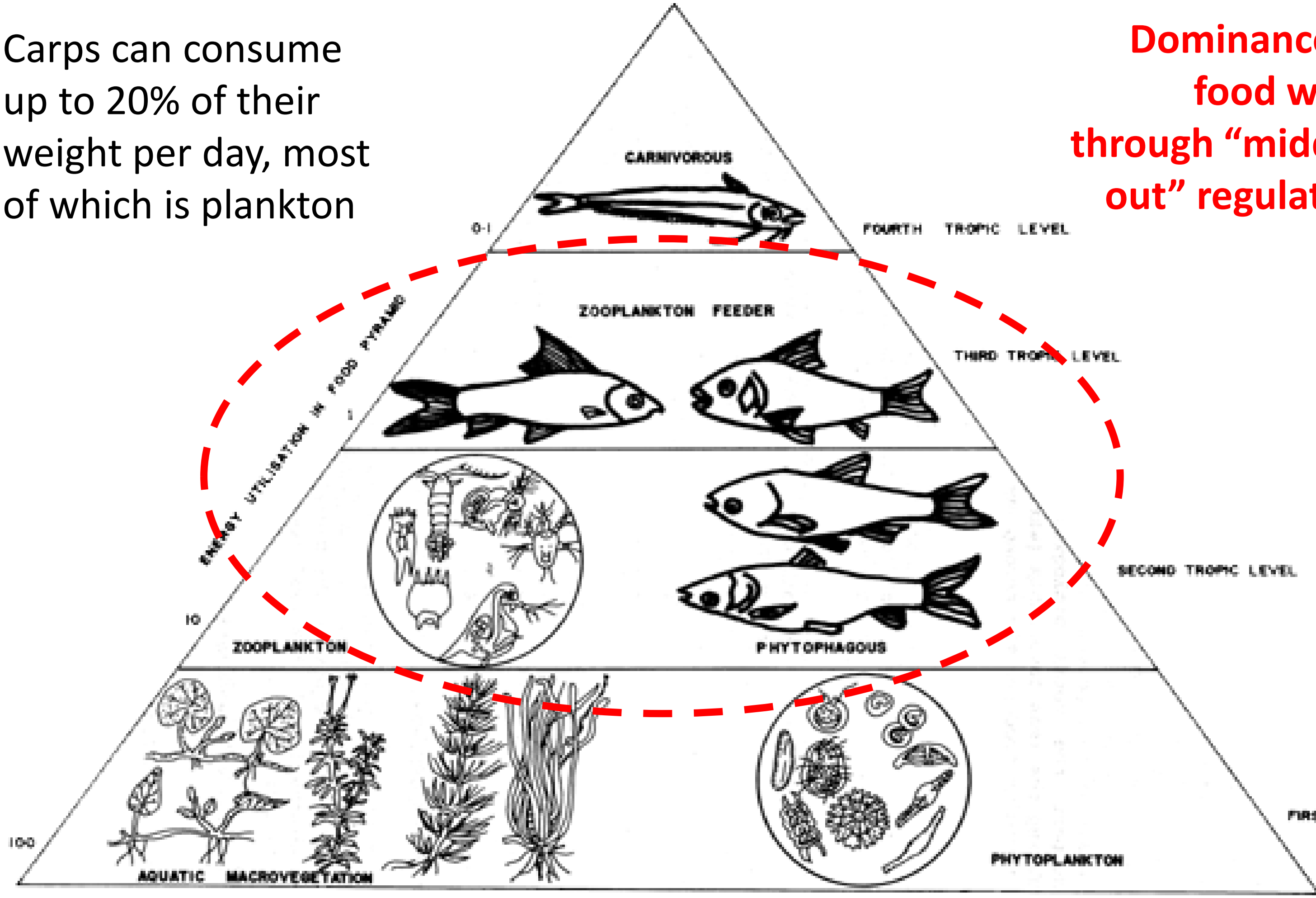
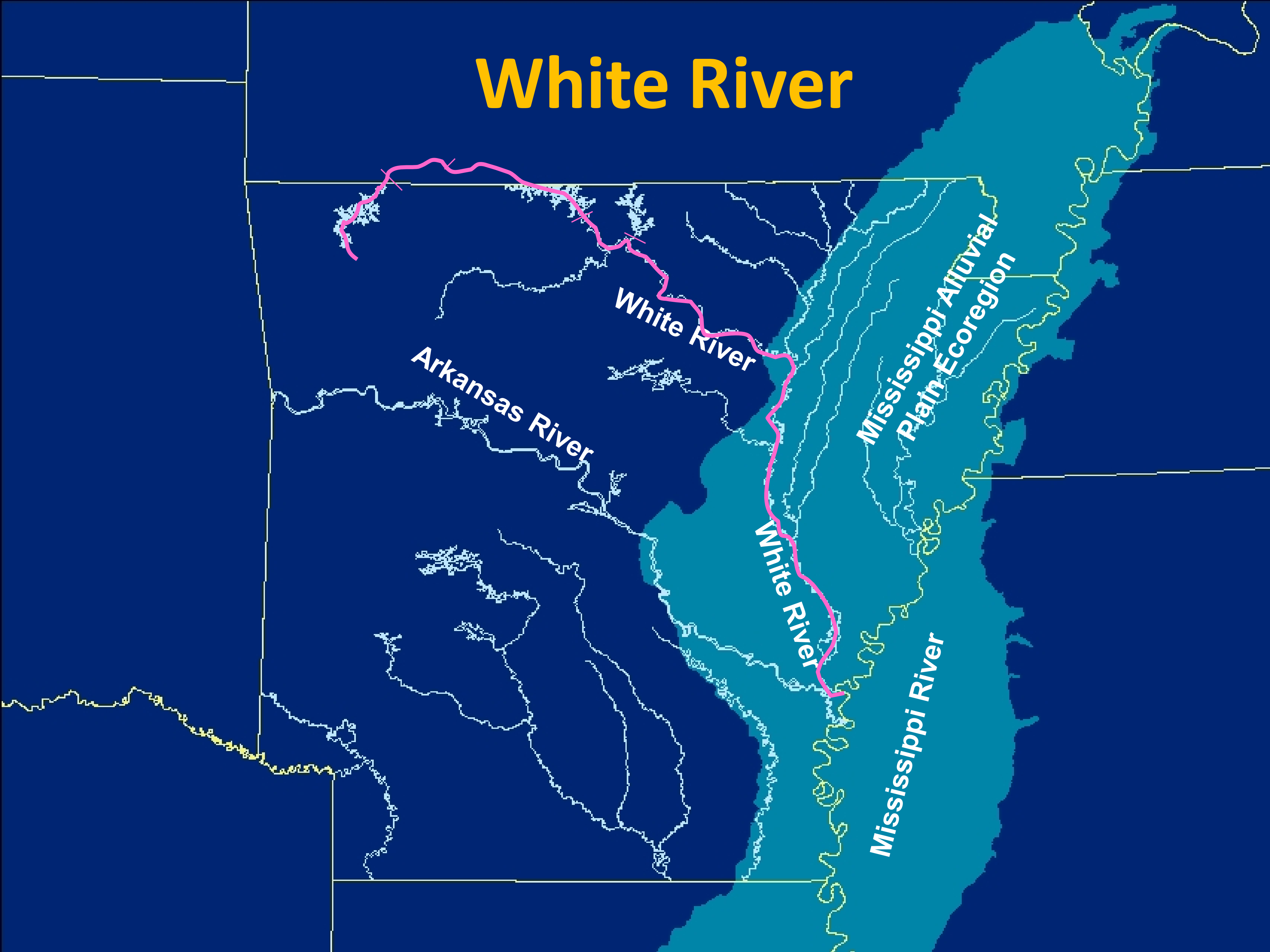


Dominance of food webs through “middle-out” regulation

https://www.nps.gov/miss/learn/nature/ascarpover.htm


ARKANSAS
CARPOCALYPSE!!!

White River



White River
Arkansas River
Mississippi Alluvial Plain Ecoregion
White River
Mississippi River

Lower White River

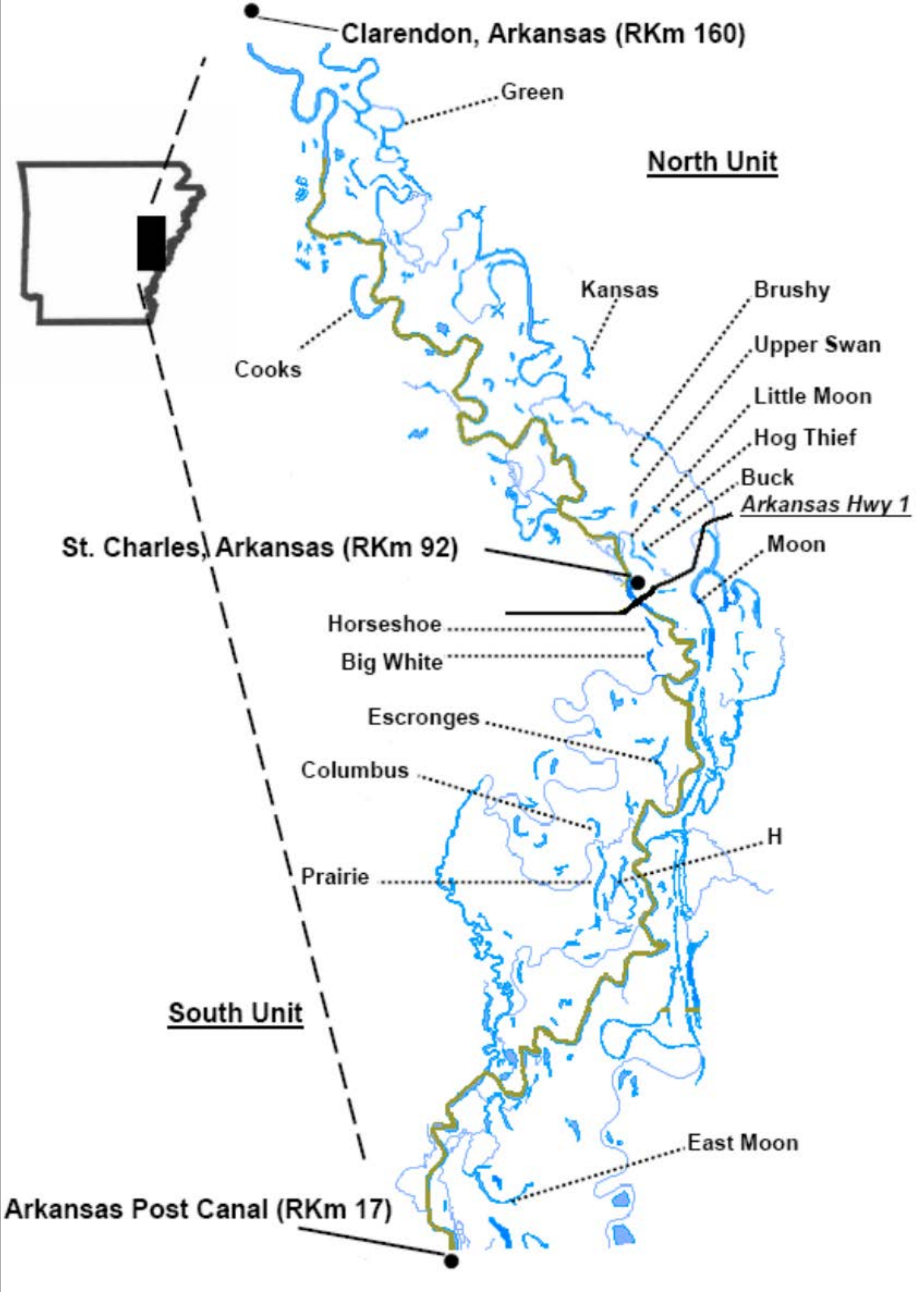
- Unique habitats and high fish diversity (~150 fish species with 11 endemics)
- Less altered than most river-floodplain ecosystems
- Nearby Cache-White River confluence listed as RAMSAR "Wetlands of International Significance"
- Extensive historical datasets available from WRNWR oxbow lakes (Lubinski 2004; Clark 2006)
- <u>Bighead and Grass carps</u> present, but at low densities
- <u>Silver carp</u> established within last decade, but now highly abundant in many areas
- <u>Black carp</u> still rare, but becoming more common in nearby drainages

Location for two new studies I'm overviewing today…

Study Area

Dale Bumpers White River National Wildlife Refuge (WRNWR)

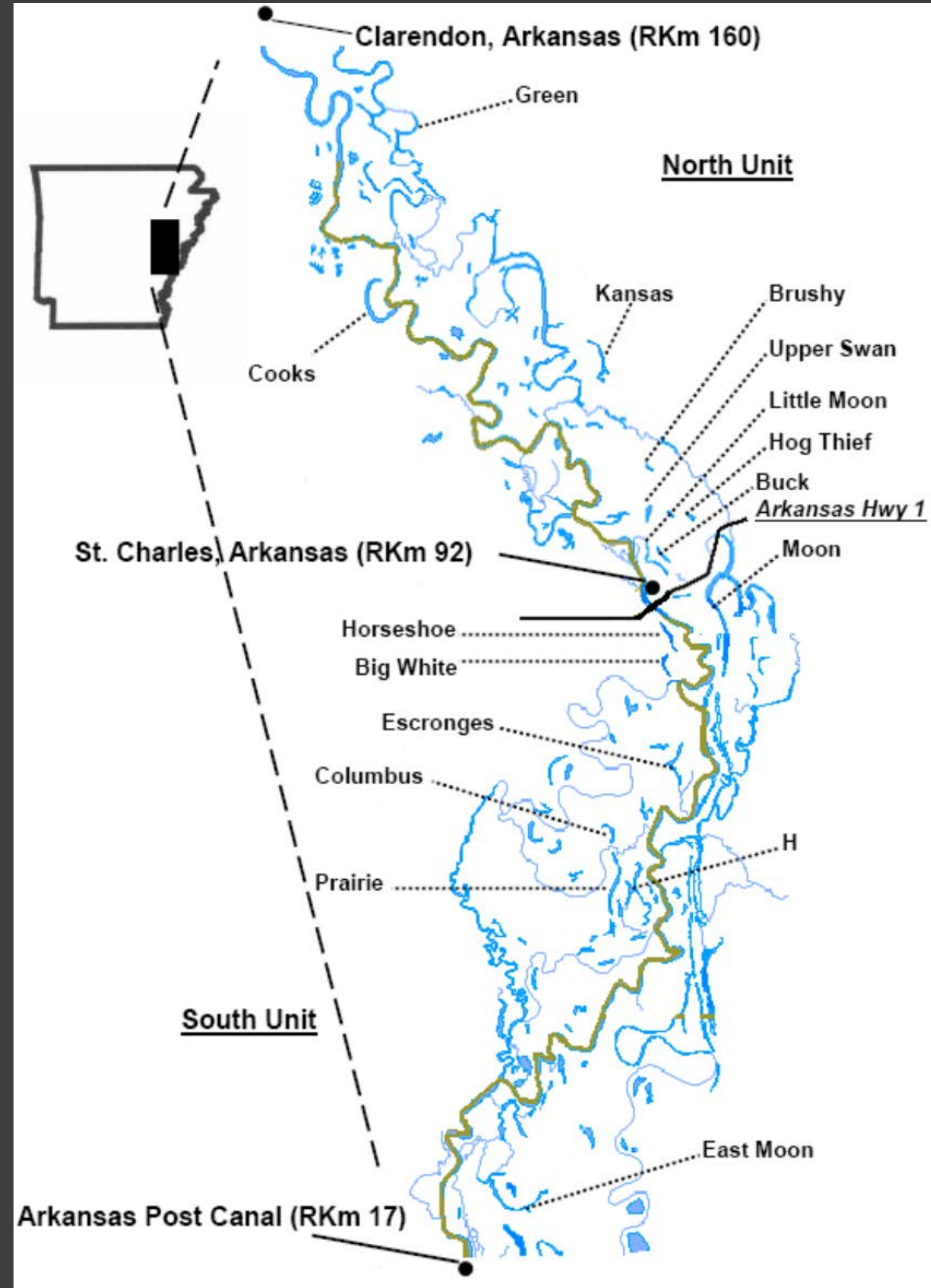
- 65,000 ha bottomland hardwood forest floodplain habitat
- Downstream of Clarendon, AR RKm 16-161
- ~360 floodplain lakes >2 ha 100s of lakes <2ha
- Levee-to-levee flooding 3 out of 5 years on average



Study Areas

Replicate oxbow lake sampling during "pre-carp" and "post-carp" periods

- 15 oxbow lakes total
- 7 lakes within North Unit
- 8 lakes within South Unit



Study 1
Cody Salzmann
M.S. Thesis

Objectives – Study 1

a pre-carp/post-carp comparison…

Objective 1: Compare present-day (i.e., post-carp) oxbow lake fish assemblage attributes* with historical datasets collected during 2002-2005 (i.e., pre-carp invasion)

*Attributes include abundance, richness, evenness, and diversity

Objective 2: Examine relationships between present-day oxbow lake fish assemblage attributes and Silver Carp densities in oxbow lakes

Multi-Gear Fish Collections

60-Hz and 15-Hz timed electrofishing, mini-fyke netting, and exp. gill netting
Done in replicate in all study lakes during July-August and
October-November 2002 (“pre-carp” period) and 2017 (“post-carp” period)

Objective 1: Fish Assemblage Variables

- Species-specific fish abundances – quantified by various measures of CPUE
  All CPUE measures will be gear-specific
  Ex: catch/net-night, catch/net, or catch/hr
- Total fish abundance, relative abundance of selected groups
  Ex: particular trophic guilds, age-0, or fish ≥400-mm TL
- Species indices – including richness and diversity
  All measures pooled across gears and seasons

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Current Information (2017)

using all datasets combined

Salzmann & Kaiser	Electrofishing* (60-Hz and 15-Hz)	Gillnetting	Mini-Fyke*	Total*
Fishes collected	21,499	1,446	12,090	35,035
Number of species	***56***	***34***	***43***	***65***

*identification of unidentified specimens pending
(4,470+ from mini-fykes, 876+ from electrofishing)

When using only summer netting & fall electrofishing…

Current Information (2017)

Salzmann & Kaiser	Electrofishing* (60-Hz and 15-Hz)	Gillnetting	Mini-Fyke*	Total*
Fishes collected	9,661	488	9,747	19,896
Number of species	***48***	***30***	***39***	***61***

Historical Information (2002)

Lubinski	Electrofishing (60-Hz and 15-Hz)	Gillnetting	Mini-Fyke	Total
Fishes collected	7,643	529	33,893	42,065
Number of species	***47***	***24***	***44***	***64***

Assemblage Characteristics

current vs. historical

Metric	Lubinski (2002)	Salzmann & Kaiser (2017)*
S (richness)	*64*	*61*
H' (diversity)	*2.351*	*2.357*
H'_{max}	*4.159*	*4.111*
E (evenness)	*0.565*	*0.573*
SRI (richness index)	*0.312*	*0.432*

Assemblage Differences

species lost and gained (all gears)

Lubinski (2002)		Salzmann & Kaiser (2017)	
Count	Species	Species	Count
1	CNLP	AGGR	2
257	CYMW	BHCP	1
57	DLSF	BHMW	21
1	GDTM	BKCARP	1
1	GSPK	BNMW	3
1	HFCS	CYDR	12
4	LKCS	FLIR	1
1,322	MMSN	GDYE	5
5	NSTM	GSCP	6
27	PDSN	QLBK	1
7	SGER	RVDR	2
14,928	SVMW	SRBS	6
		SRML	1

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Objective 2: Examining Relationships Between Fish Assemblages and Carp Densities

Establishment of a Silver Carp Density Gradient Across Replicate Lakes…

- Pop-Shocking (from boat electrofishing)
  - 60-Hz/500-V for 30 seconds
  - Visual observations of all carp "jumps" from three observers
- Boat electrofishing
  - Six 10-minute transects with GoPro cameras mounted and running
- Gill nets
  - Two net types, with experimental meshes ranging from 2.54-cm to 20-cm (1-8")

Silver Carp abundances

ranks averaged across gears & seasons

Lake	Summer	Fall	Mean Rank*
Cooks	3.5	1.4	2.5
Prairie	3.9	2.4	3.2
Kansas	5.3	3.3	4.3
Escronges	3.7	7.1	5.4
Columbus	4.0	8.3	6.2
Little Moon	6.9	6.9	6.9
Hog Thief	8.9	8.4	8.7
Moon	10.5	7.8	9.2
H	9.3	10.3	9.8
Buck	7.9	11.7	9.8
Green	11.5	8.2	9.9
Brushy	11.2	9.6	10.4
Horseshoe	10.7	10.2	10.5
Big White	11.2	11.3	11.3
Upper Swan	10.6	13.1	11.9

*averaged across all gears and both seasons

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Increasing carp abundances

Silver Carp abundances

ranks averaged across gears & seasons

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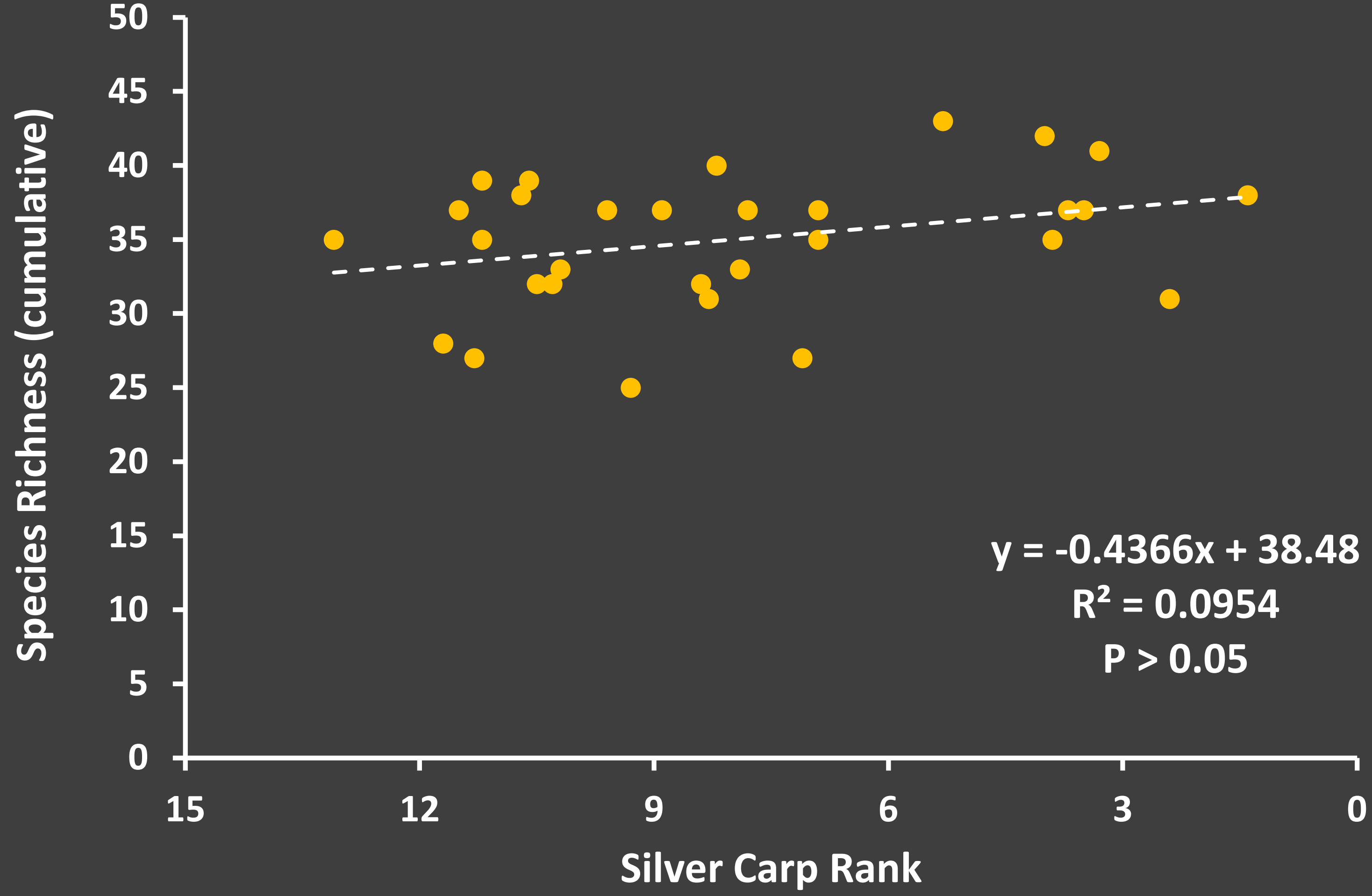
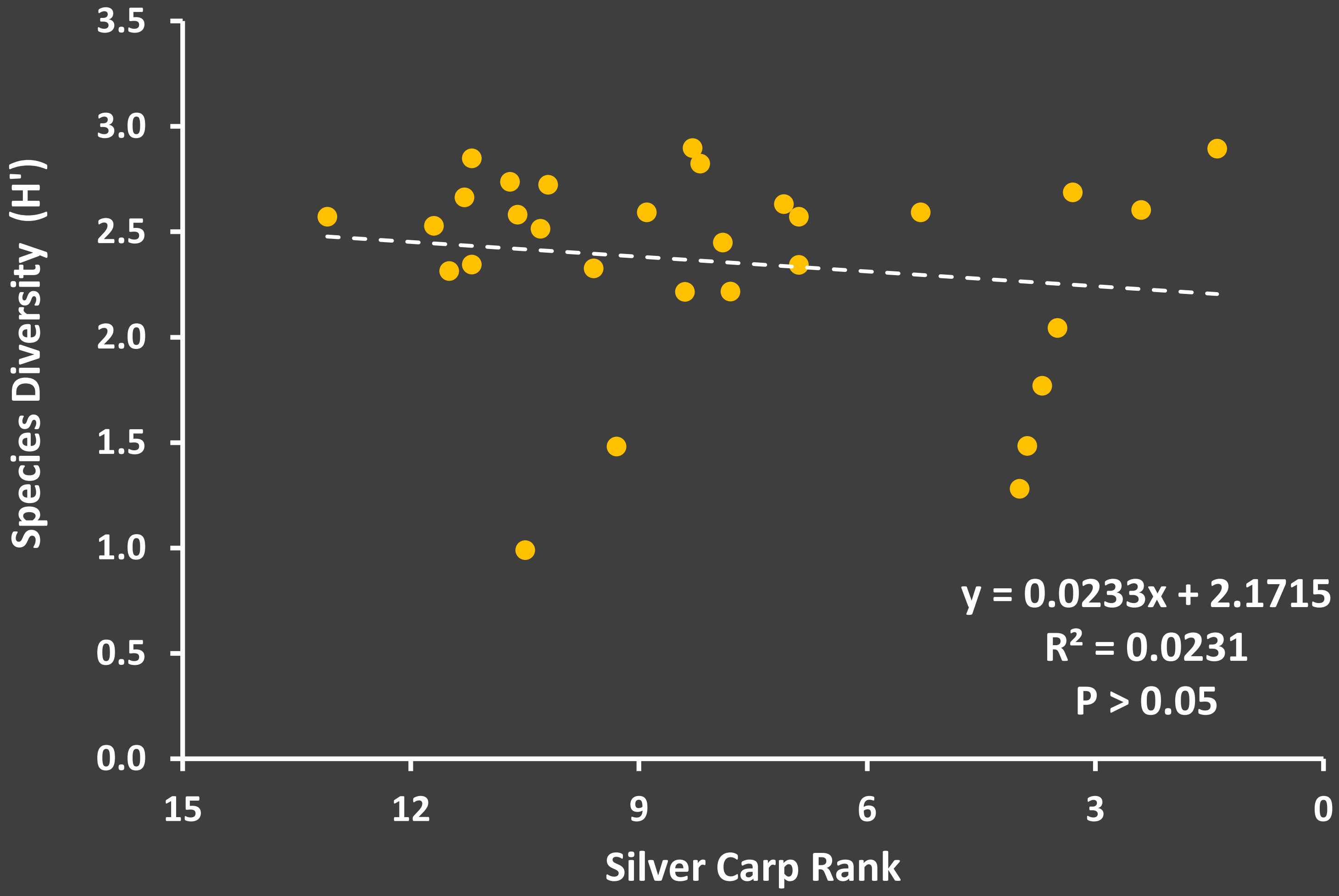
Escronges		5.4
Columbus		6.2
Little Moon		6.9
Hog Thief		8.7
Moon	Moderate	9.2
H		9.8
Buck		9.8
Green		9.9
Brushy		10.4
Horseshoe	Low	10.5
Big White		11.3
Upper Swan		11.9

Increasing carp abundances

Species Richness vs. Carp Abundance



Species Diversity vs. Carp Abundance



Multivariate analyses

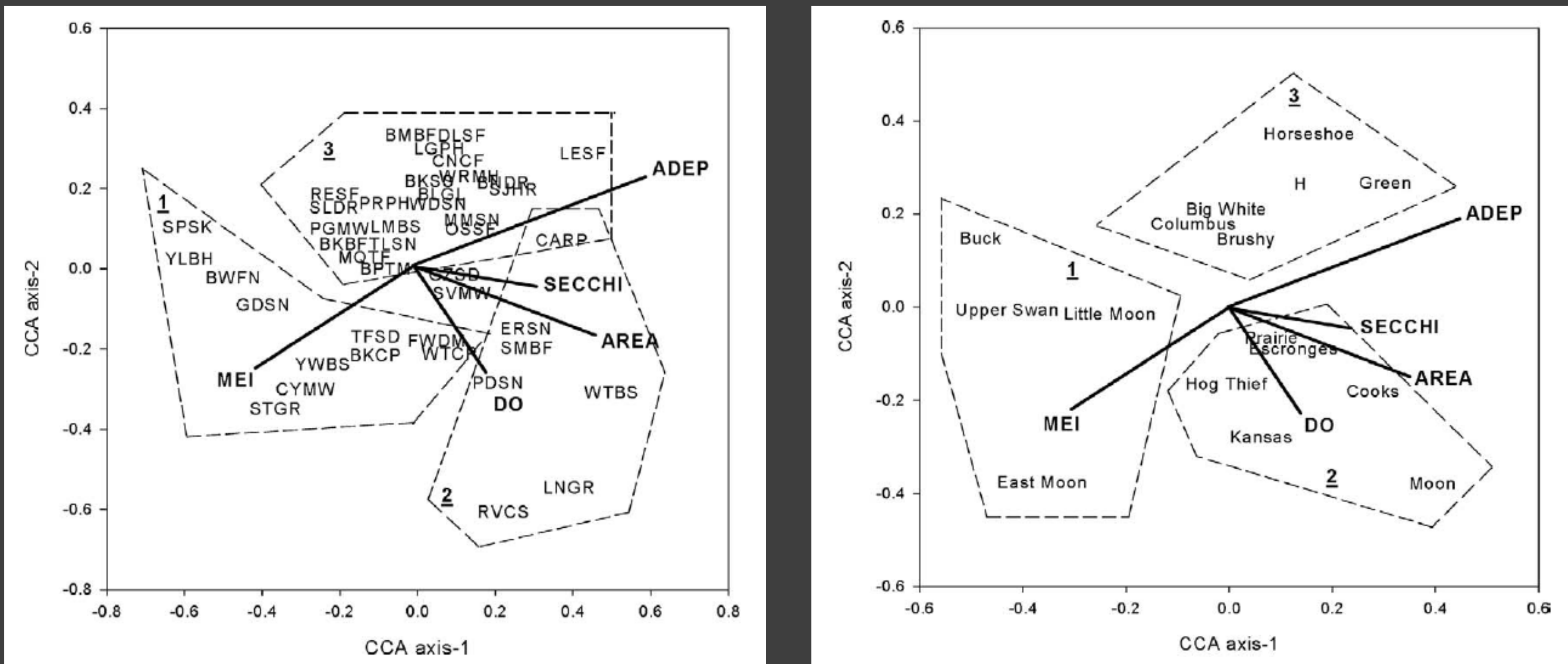
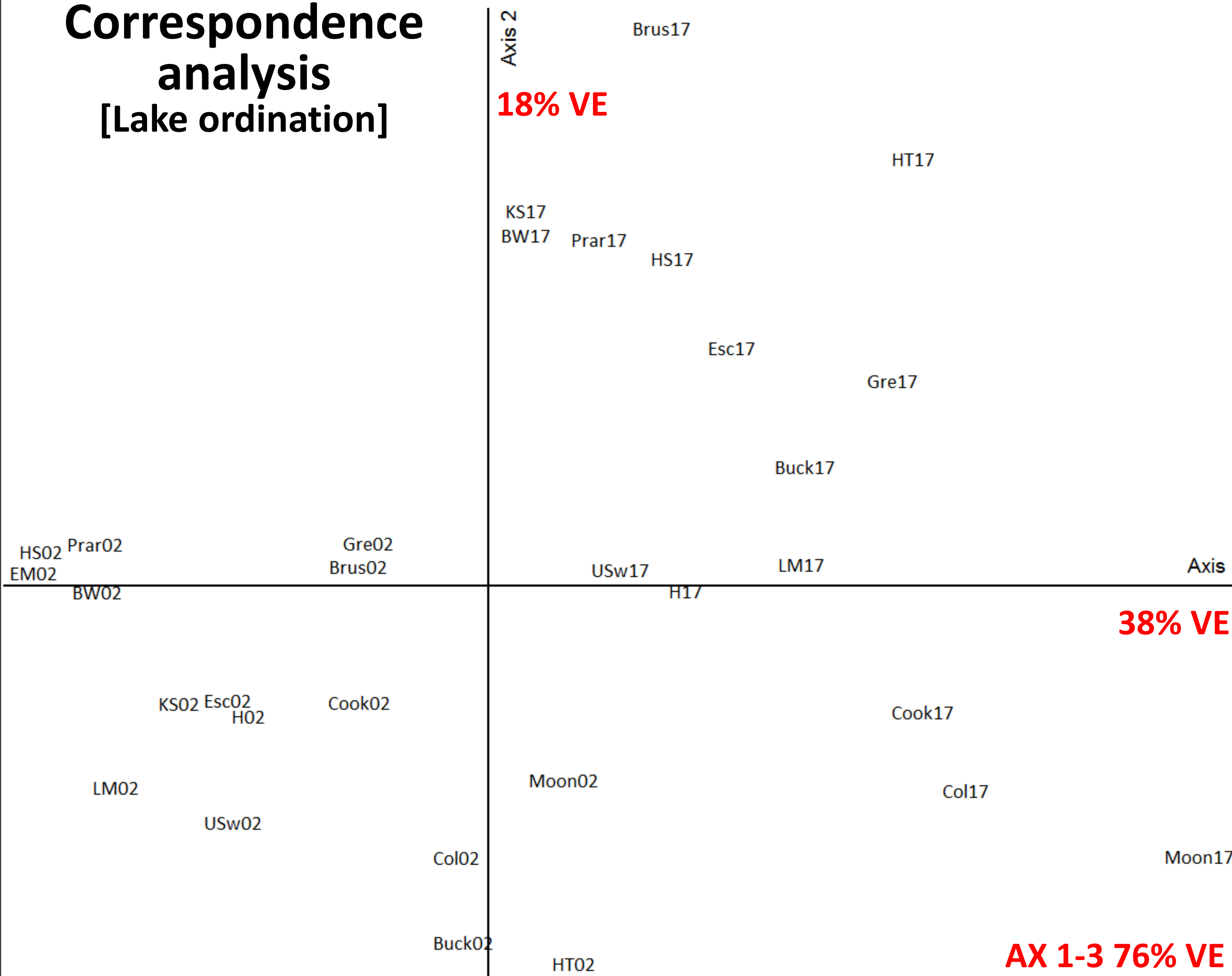


FIGURE 2.—Scatterplot of canonical correspondence analysis (CCA) scores for floodplain lake fish communities in the lower White River system, Arkansas, 2002. Scores for axes 1 and 2 are plotted for individual lakes (top panel) and fish species (bottom panel; codes are defined in Table 4) and are based on rank-ordered abundances as described in Methods. Group numbers are defined in Discussion. Environmental variables are average lake depth (ADEP; m), lake surface area (AREA; km^2), water clarity (SECCHI; Secchi depth, cm), dissolved oxygen (DO; mg/L), and morphoedaphic index (MEI). Vectors were rescaled by a factor of 2.

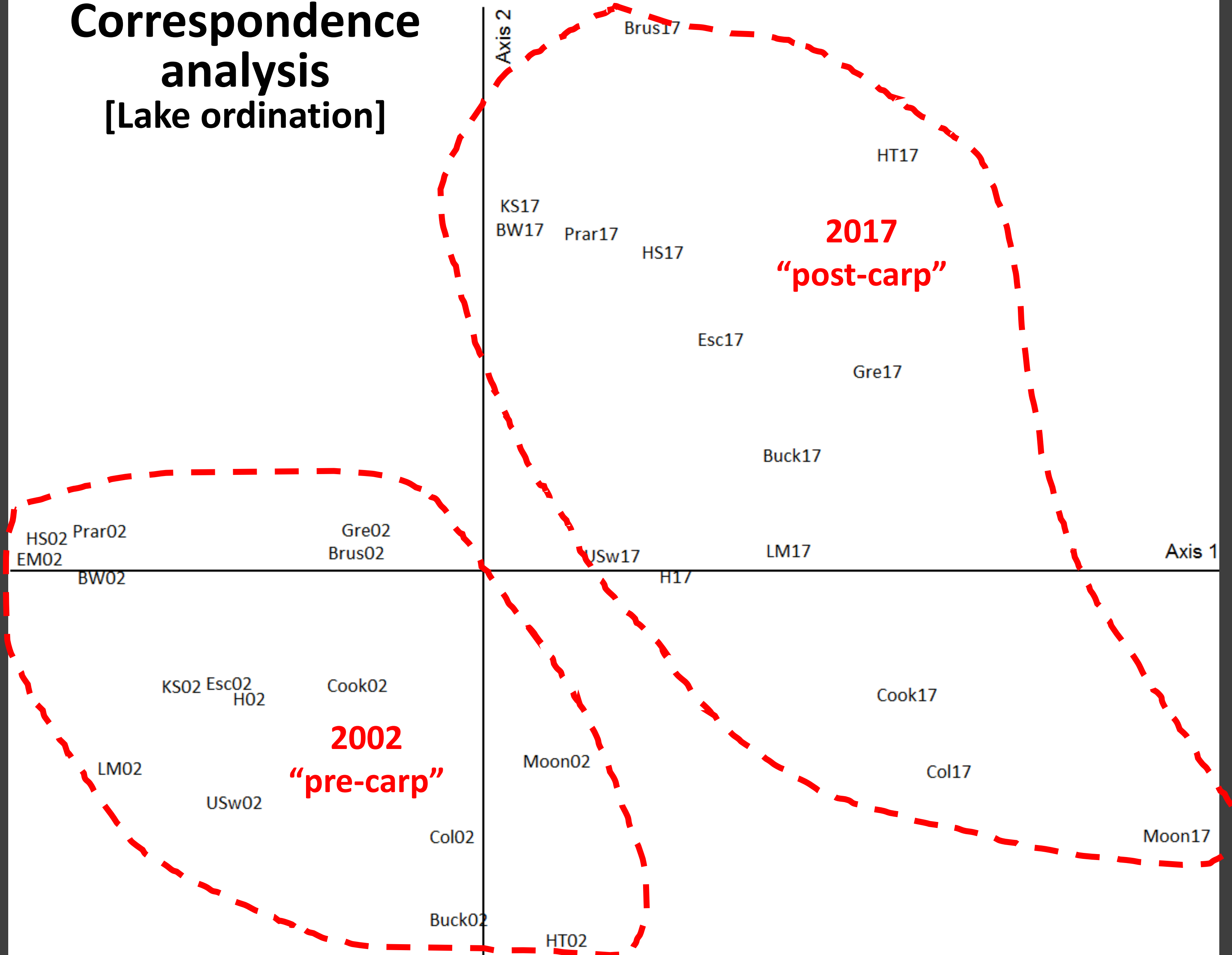
Multivariate analyses of fish assemblages present a more complete picture of possible carp responses...

Correspondence analysis
[Lake ordination]



Correspondence analysis

[Lake ordination]



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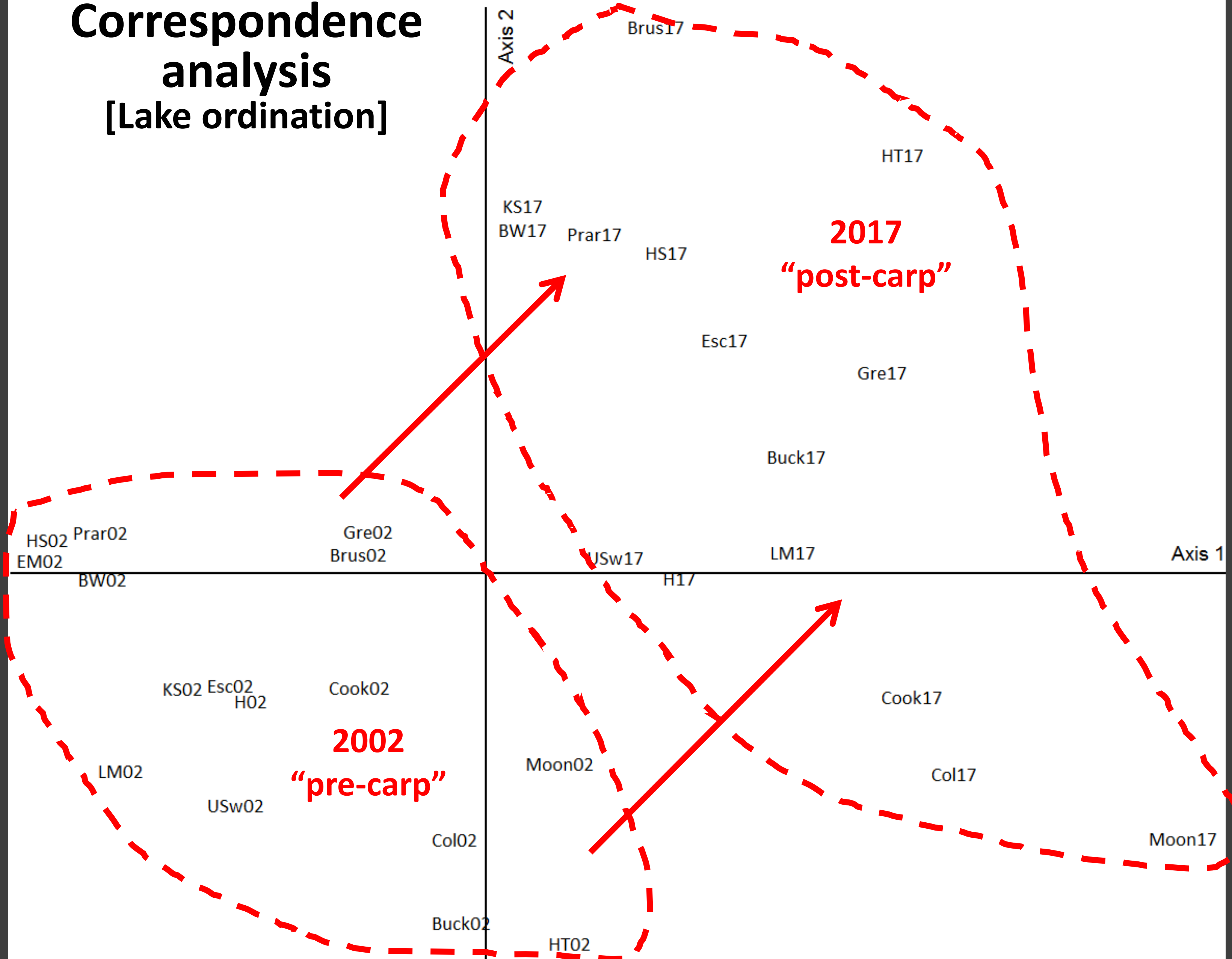

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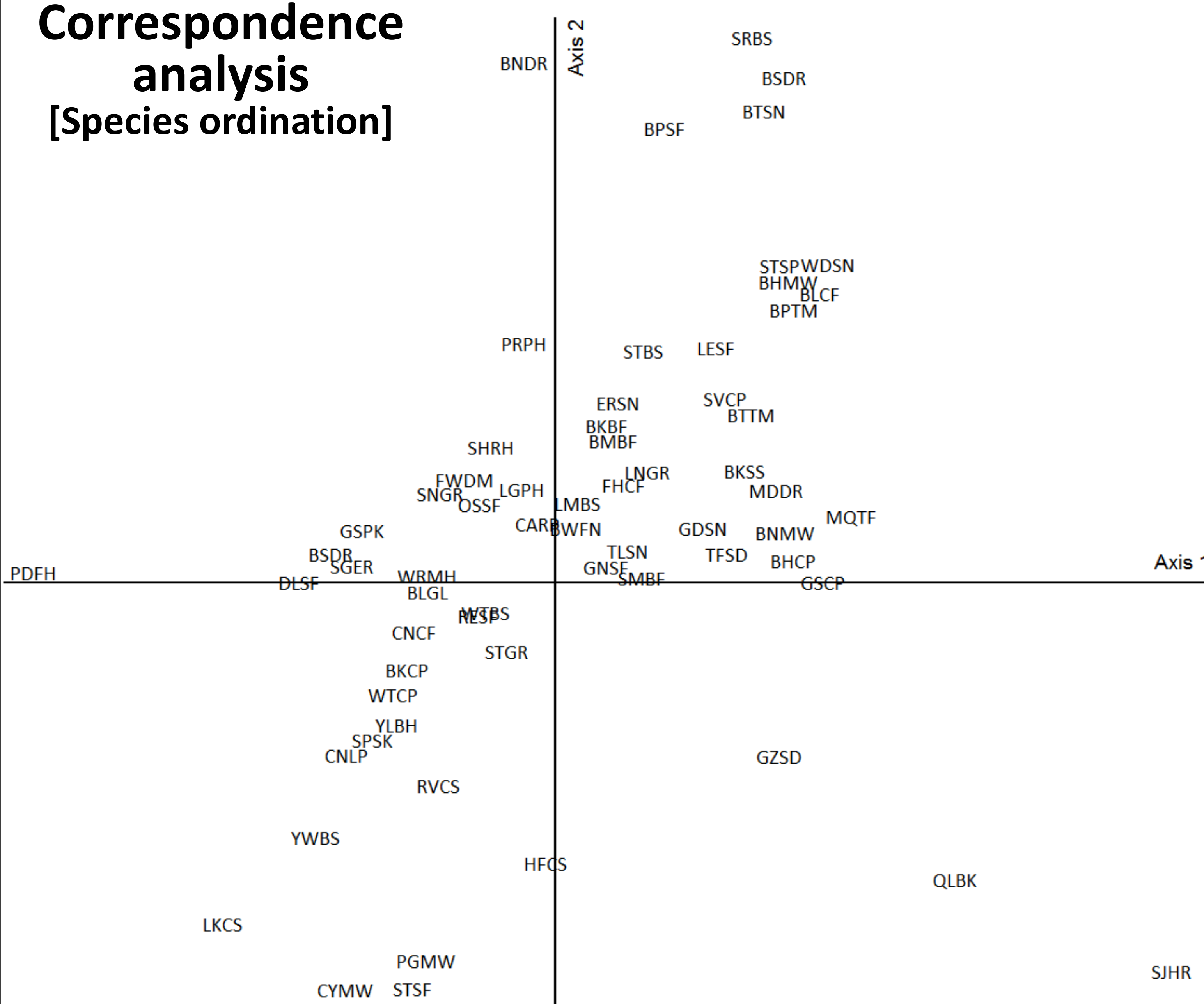

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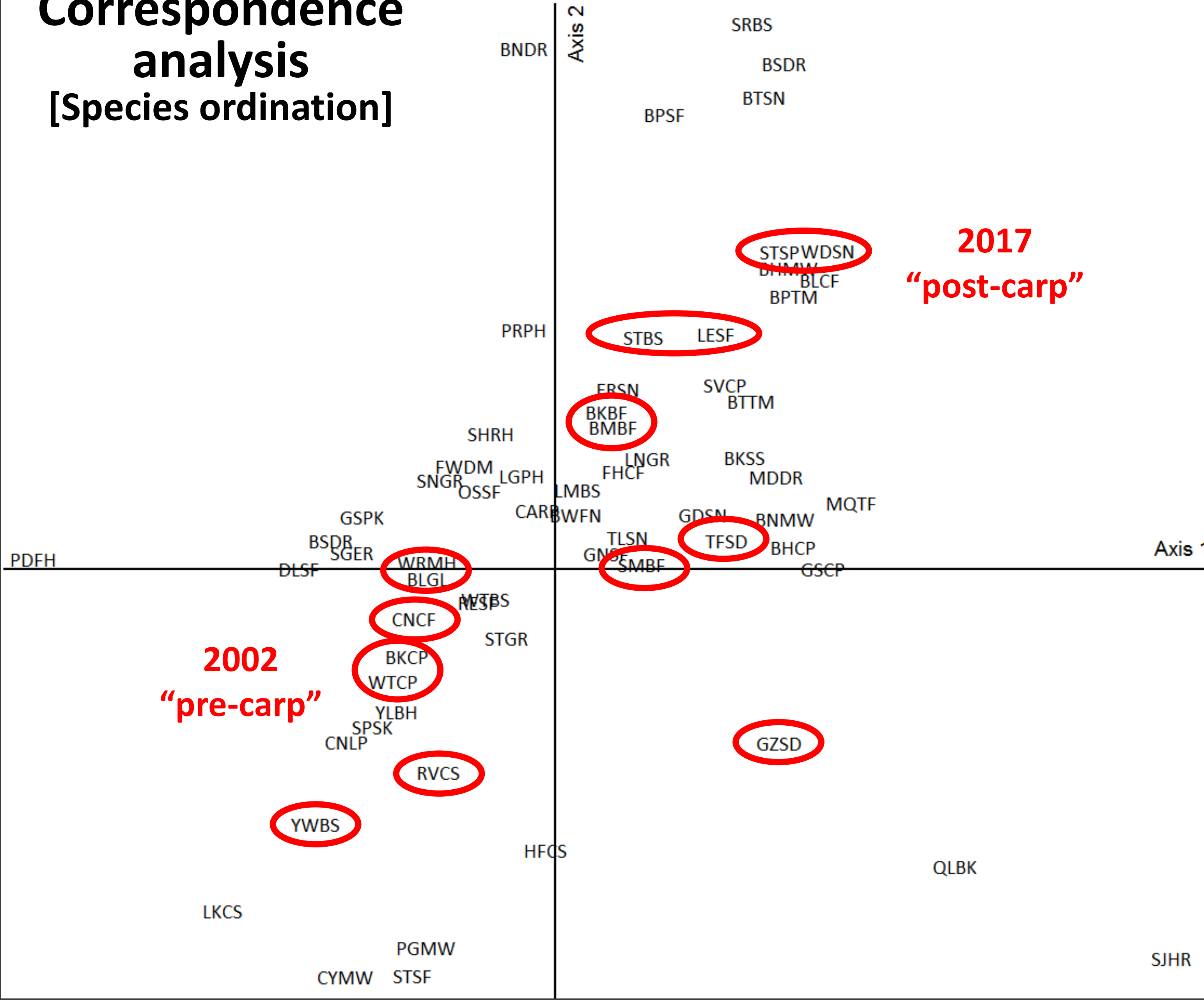

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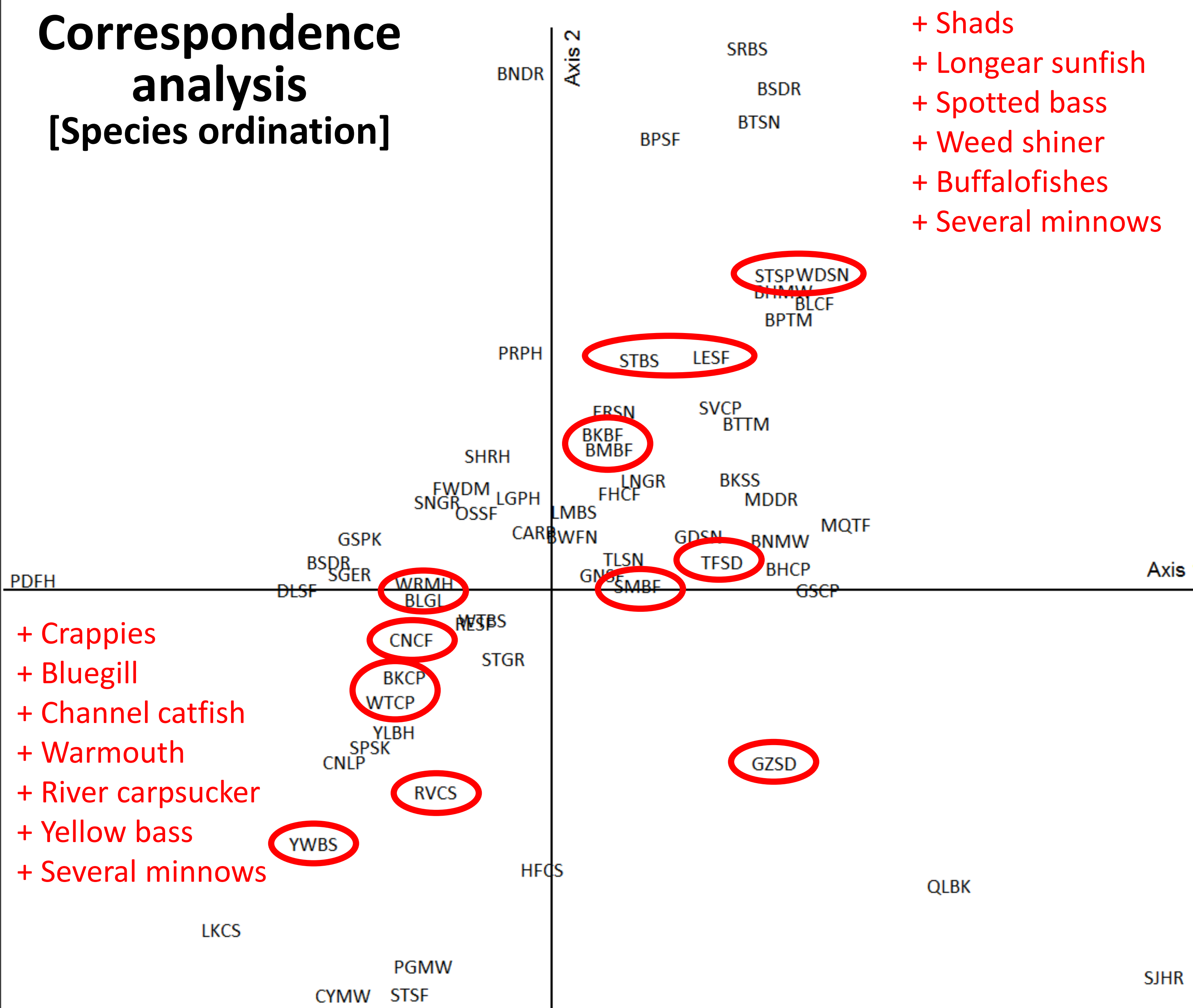
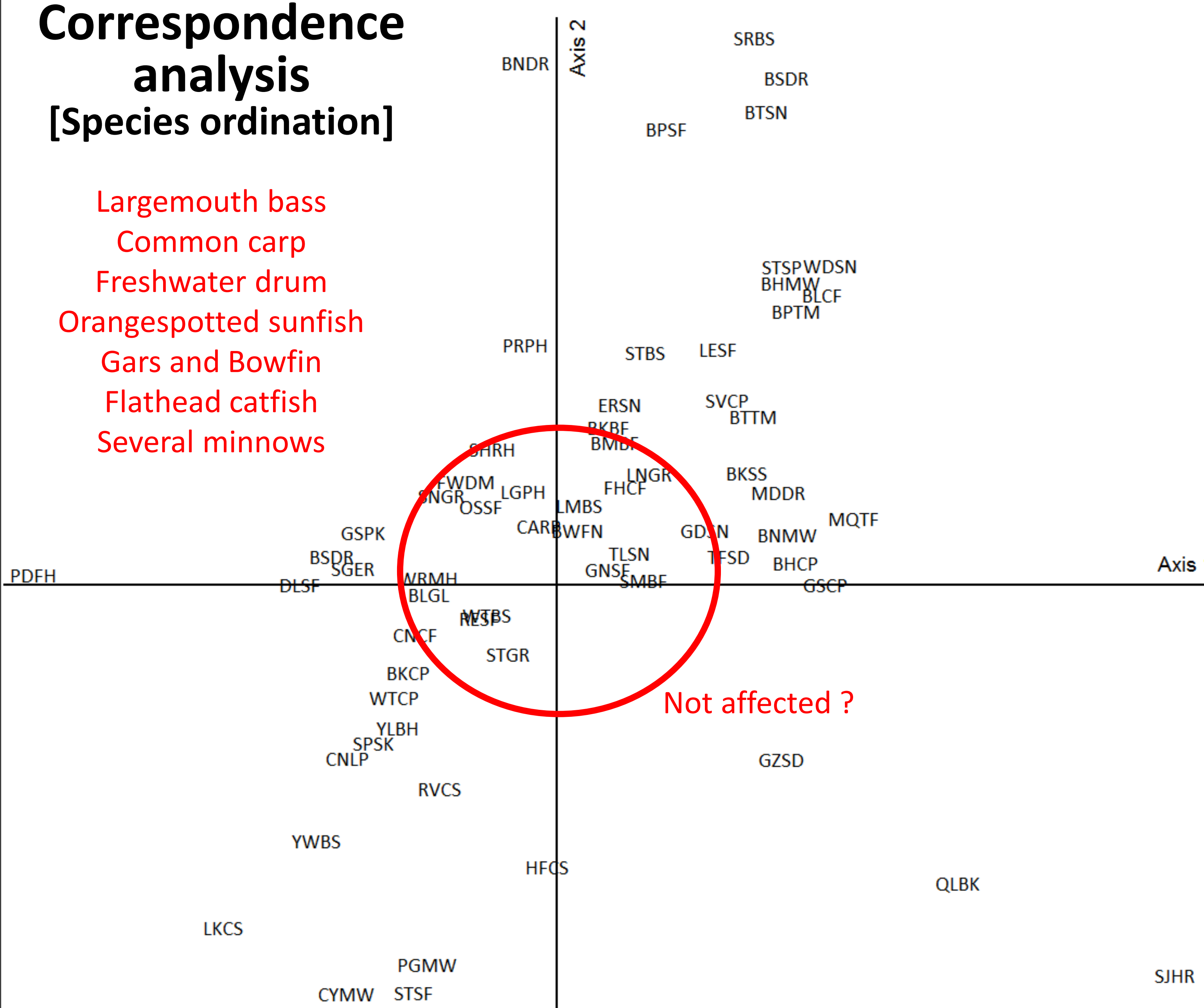


Correspondence analysis
[Species ordination]

Largemouth bass
Common carp
Freshwater drum
Orangespotted sunfish
Gars and Bowfin
Flathead catfish
Several minnows



Summary – Study 1

- Richness and diversity results not detectable, but are only part of the story...
- In 2017, 12 species not found compared to historical (2002) datasets, but 13 new species collected
  - most species lost or gained were historically rare
  - possibly due to gear and/or seasonal differences
- Shifts in fish assemblage structure likely, with some sport fishes affected
  - *Bluegill findings especially interesting*
- Cannot state unequivocally that assemblage shifts are due to carps...
  - periodic or constant assemblage shifts could be normal for these types of systems
- Additional analyses comparing W-L equations of key species...

Study 2
Joe Kaiser
M.S. Thesis

If carps are having effects, when do they begin to occur?

VS.

Effects on age-0 fishes

- Highly planktivorous – competes directly with adults of some native species and juveniles of many species

- Germany (Costa-Pierce 1992)
- Missouri River scour basins (Tibbs and Galat 1997)
- Murray State University - stable isotope niche overlap with juvenile gizzard shad (preliminary)

- **Important to understand the effects on early life stage in fishes, which may relate to effects on adult fishes**

Objectives – Study 2

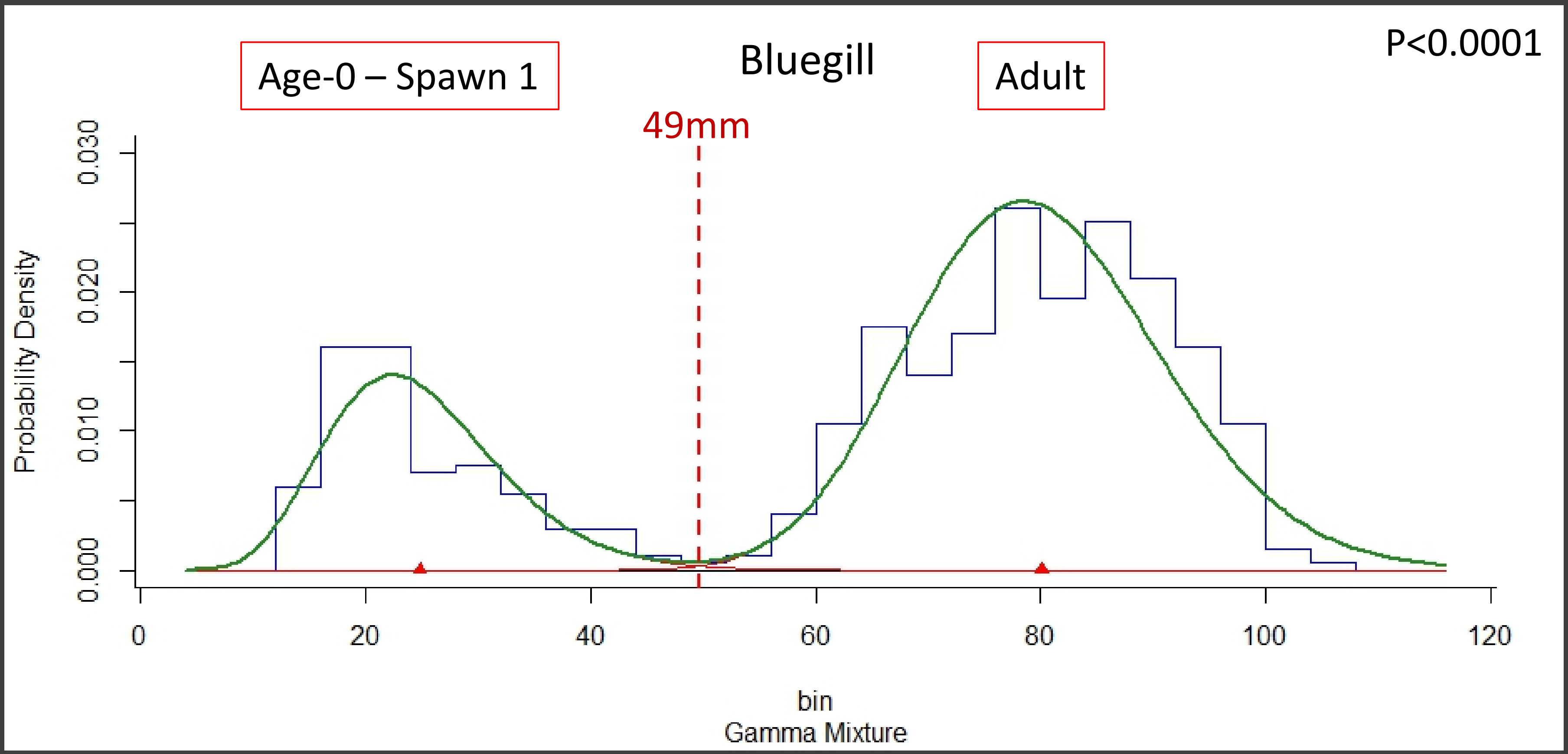
1. Quantify juvenile (age-0) fish characteristics (e.g., abundance, growth, and condition) of selected fish species in lower White River oxbow lakes, and

2. Examine the relationships between juvenile fish characteristics and carp densities in these same lakes.

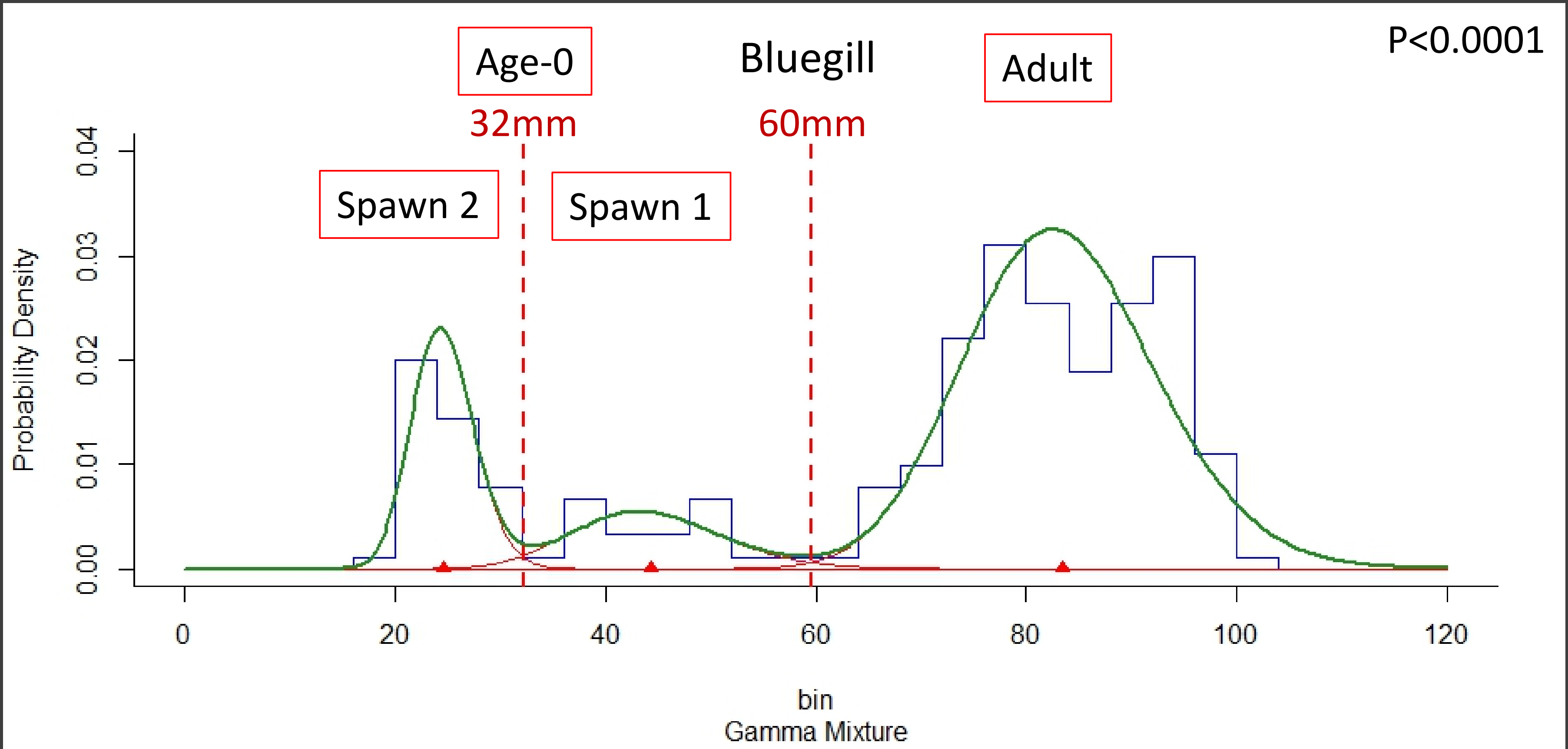
Species examined

- Nine (9) "target species":
  - Four piscivores
    - *Micropterus salmoides, M. punctulatus,* and *Pomoxis spp.*
  - Two planktivores
    - *Dorosoma cepedianum* and *D. petenense*
  - Two omnivores
    - *Lepomis macrochirus* and *L. humilis*
  - One common cyprinid (omnivorous)
    - *Notropis texanus*
- Representatives from most major trophic guilds and a common cyprinid

Cohort determination - Summer



Cohort determination - Fall



Age-0 maximum length
from summer data only

Crappie spp. – 100 mm

Bluegill – 49 mm

Gizzard Shad – 120 mm

Largemouth Bass – 130 mm

Orangespotted Sunfish – 40 mm

Spotted Bass – 116 mm

Threadfin Shad – 100 mm*

Weed Shiner – 100 mm*

**Small-bodied species- cohort determination problematic*

Results




Summer Lengths and Weights

July-Aug 2017

Target Species	TL (mm)	± SD	Weight (g)	± SD	K	± SD
Black Crappie	63	7	2.3	0.7	0.84	0.05
Bluegill	25	5	0.3	0.2	1.11	0.13
Gizzard Shad	86	13	5.7	2.2	0.83	0.04
Largemouth Bass	97	11	10.4	3.8	1.05	0.09
Orangespotted Sunfish	31	5	0.5	0.2	1.26	0.09
Spotted Bass	81	8	5.7	1.5	0.97	0.06
Threadfin Shad	59	10	1.7	0.8	0.76	0.02
Weed Shiner	41	2	0.5	0.1	0.66	0.02
White Crappie	64	8	2.2	0.8	0.74	0.05

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Weed Shiner	41	2	0.5	0.1	0.66	0.02
White Crappie	64	8	2.2	0.8	0.74	0.05

Fall 2017 numbers pending….

Silver Carp abundances

ranks averaged across gears & seasons

Lake		Mean Rank
Cooks	High	2.5
Prairie		3.2
Kansas		4.3
Escronges		5.4
Columbus	Moderate	6.2
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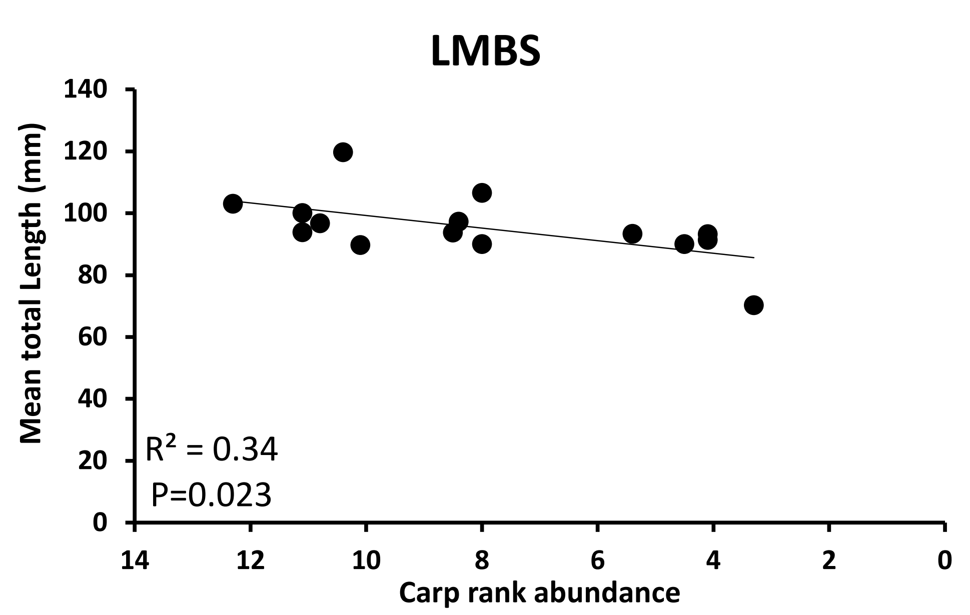
Brushy	Low	10.4
Horseshoe		10.5
Big White		11.3
Upper Swan		11.9

Increasing carp abundances

Summer
July-Aug 2017

- LMBS: Mean length inversely related to carp abundance

  Possible competition?

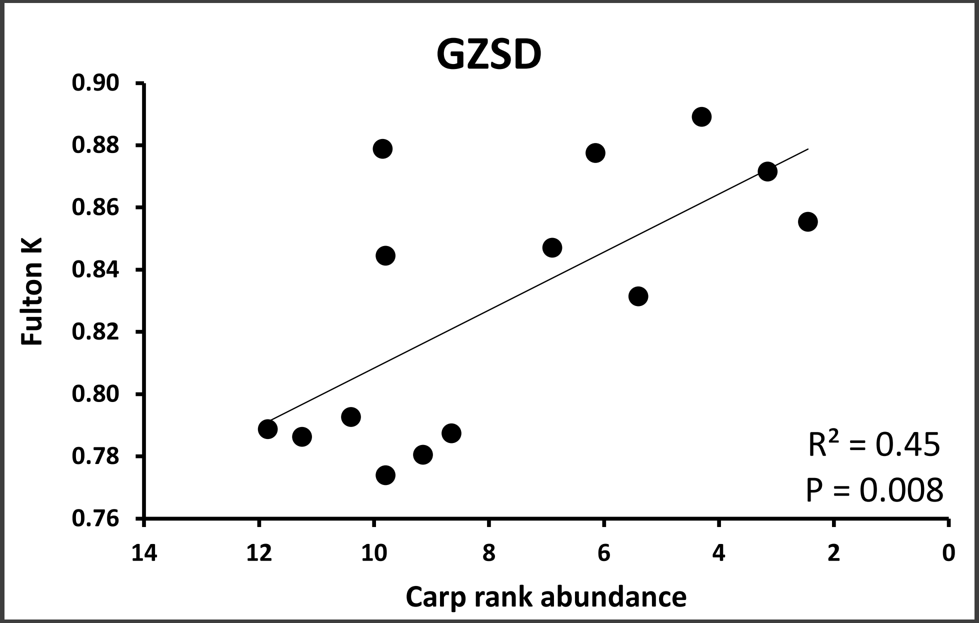


Summer
July-Aug 2017

- GZSD: Fulton K directly related to increased carp abundance

  Possible habitat or lake productivity influence?

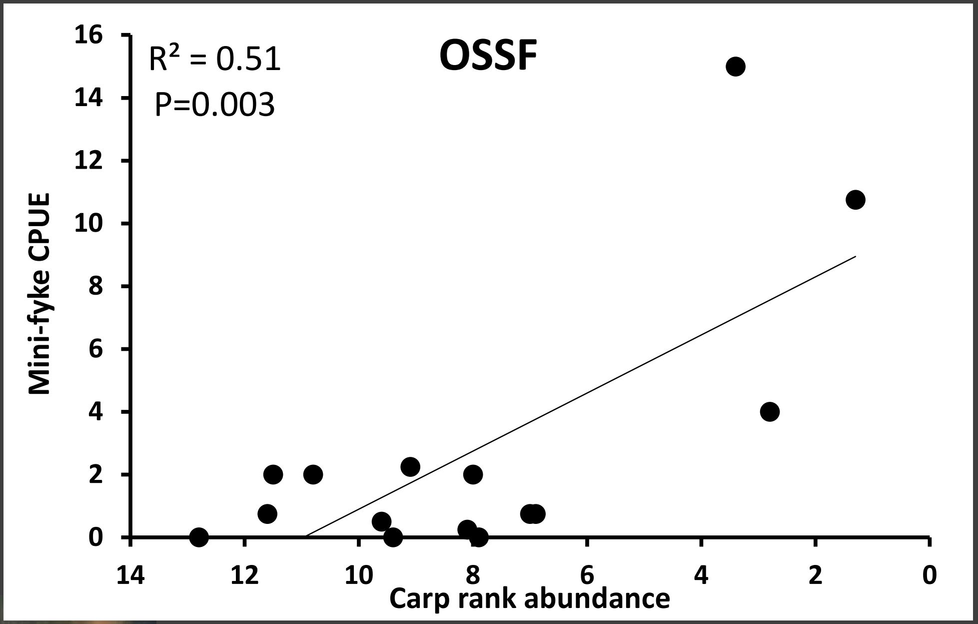
  Consistent with preliminary ordination findings, though they reflected an abundance response



Fall

Oct-Nov 2017

- OSSF: CPUE directly related to carp abundance, but model dominated by two data points



Environmental influence?

Consistent with ordination findings

Pending work – Study 2

- Currently processing samples that will be used to estimate ***total fat content*** from composite samples of each target species and lake…

- One total fat estimate generated per species and lake (n = 135), with fat estimates modeled vs. carp rank abundances (n = 15)

- Reflects general condition and fitness after first growing season and entering first winter – *critical to future year-class strength for many species*

- Additional juvenile measures modeled vs. carp rank abundances

- Pending multivariate analyses focused on juvenile assemblages

Utility of the Research

- Again, cannot state unequivocally that responses observed are entirely due to carps...

- However, by comparing fish assemblage characteristics to carp densities…
  - Trends may suggest causation
  - Direction of trend suggests positive or negative effect

- Research will allow for development of further hypotheses on carp effects…
  - Possibly the basis for future experimental work

- Much more analysis pending for this spring and summer

Acknowledgements

- University of Arkansas at Pine Bluff

  Funding, equipment & facilities

  Jeremiah Salinger, Susie Frawley & Kyler Hecke

- U.S. Fish and Wildlife Service

  Funding & facilities

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  Jay Hitchcock & staff (WRNWR)

  Tim Strakosh / Cindy Williams (Atlanta)

- Gulf States Marine Fisheries Commission

  James Ballard

- Arkansas Game and Fish Commission

  Jimmy Barnett (ANS Coordinator)

- U.S. Geological Survey

  Billy Justus (Little Rock)

FYI

None found in entire study…

Two captured with one swimming away in good shape…

And we found one of these…

Questions

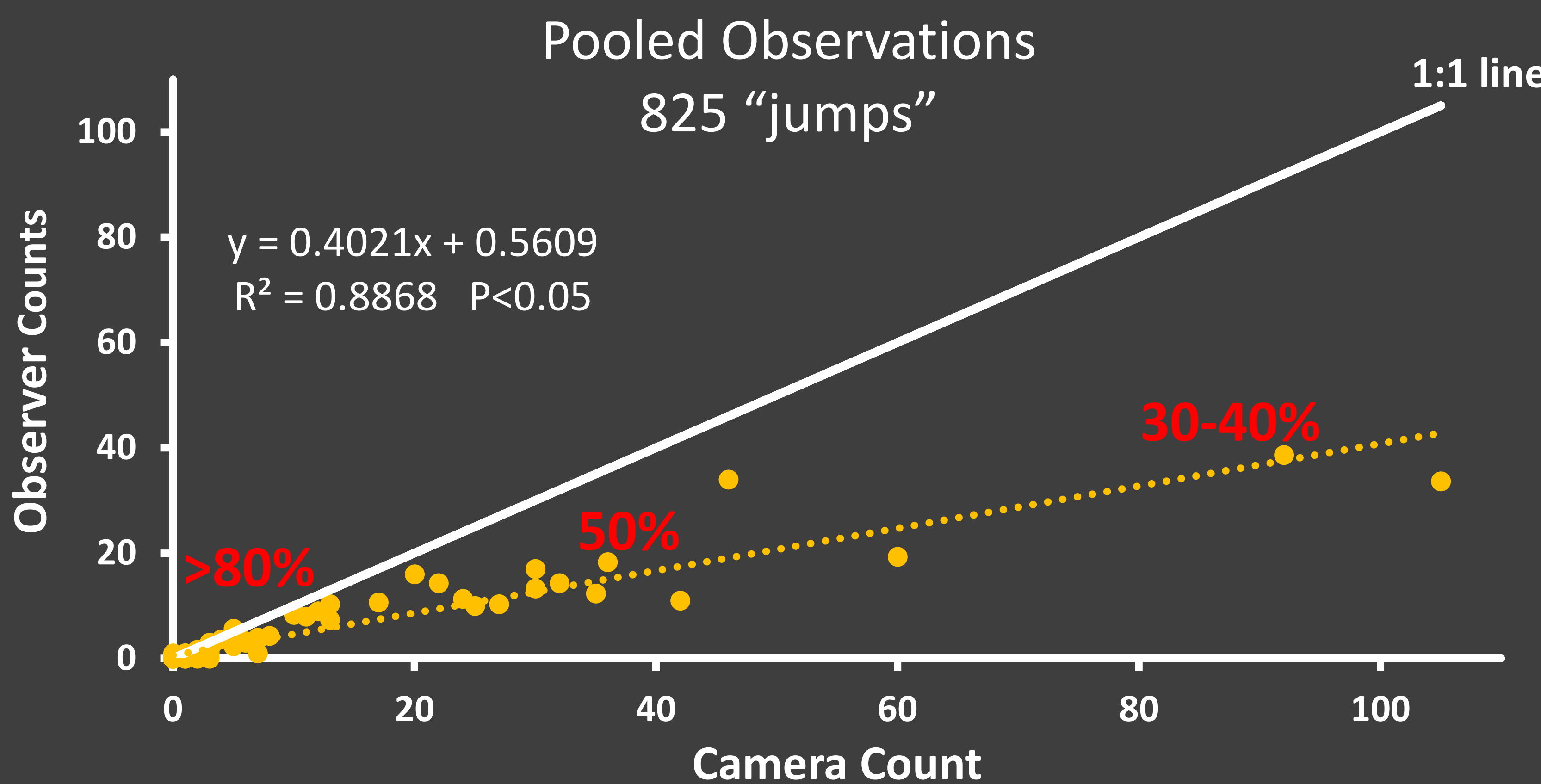






Visual Observations

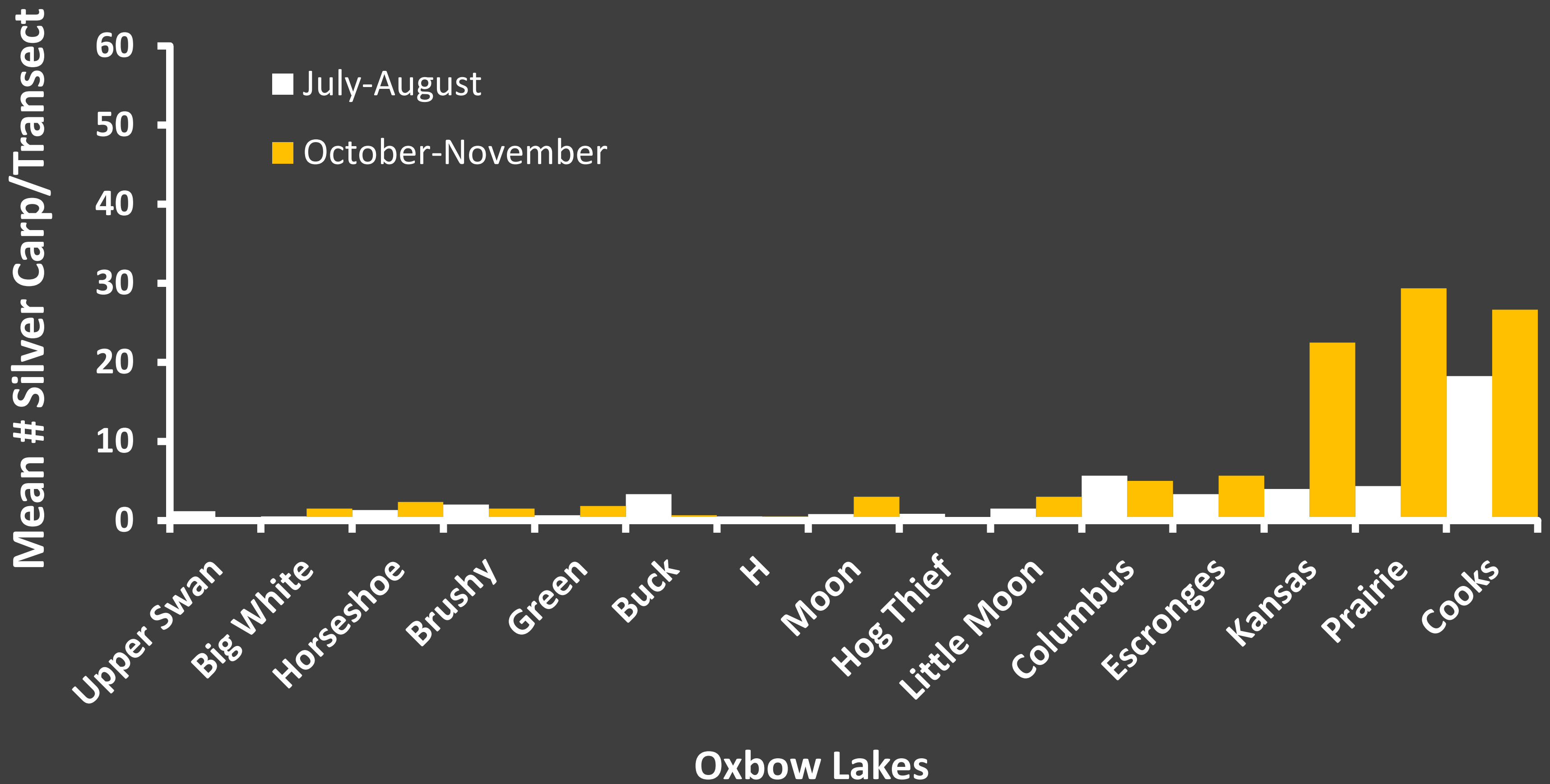
comparing observed carp “jumps” vs. camera counts



P < 0.0001

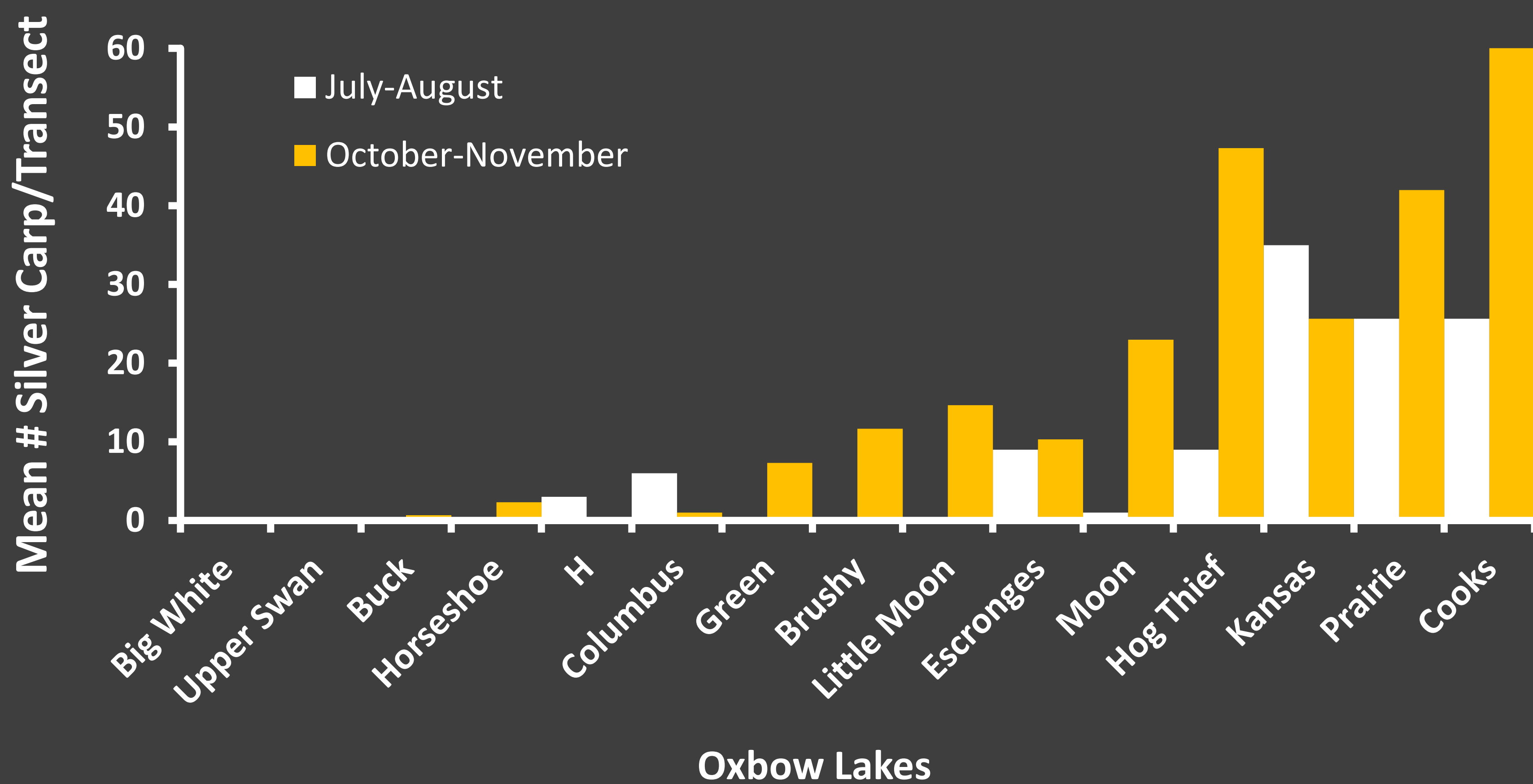
Camera Counts from Boat Electrofishing

seasonal variation within lakes

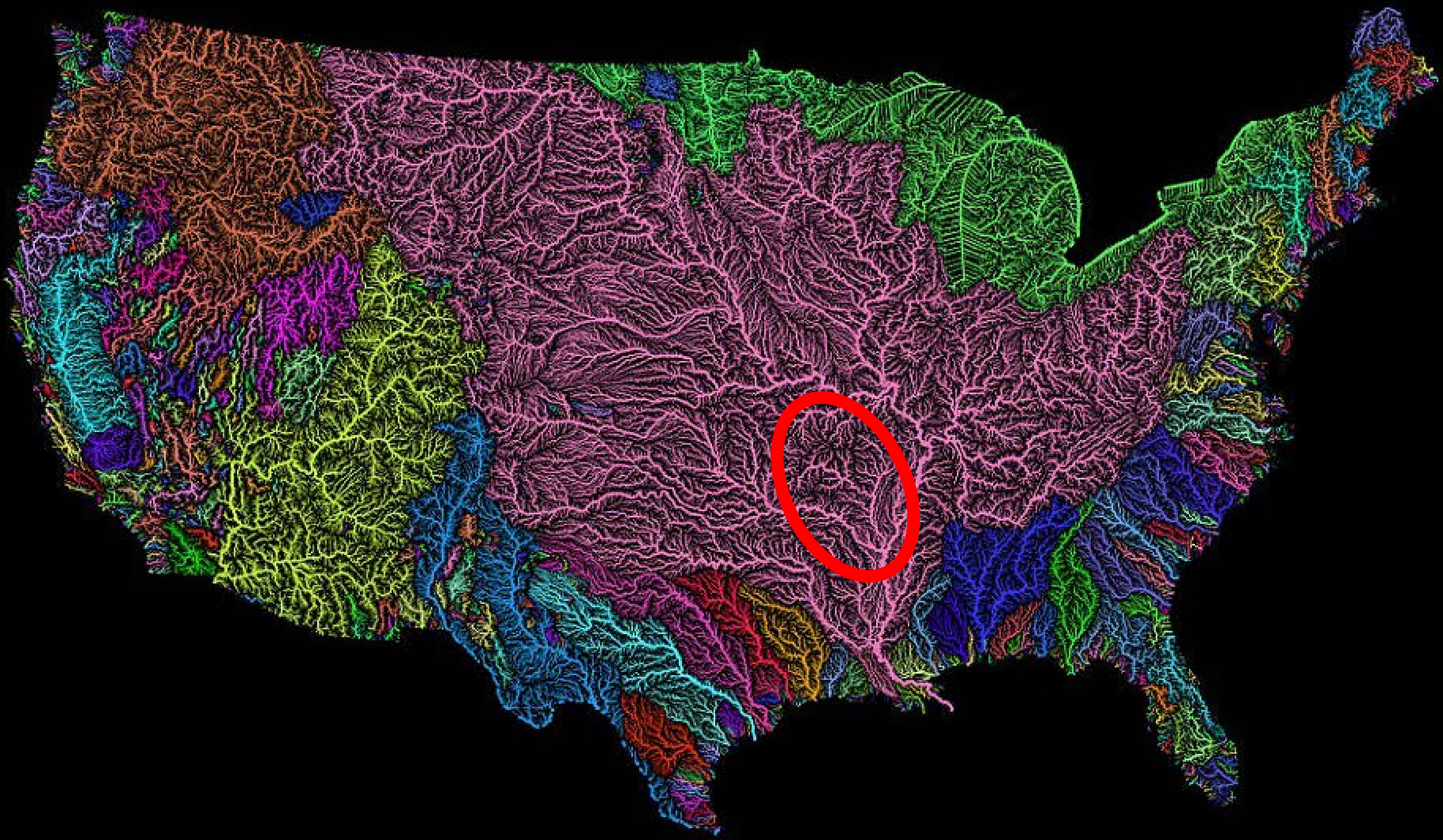


Camera Counts from Pop-Shocking

seasonal variation within lakes



U.S. River Basins



“Asian carps”

Bighead carp *Hypophthalmichthys nobilis*

Silver carp *H. molitrix*

Black carp *Mylopharyngodon piceus*

Grass carp *Ctenopharyngodon idella*

Ben Lubinski (2004) and Sandy Clark (2006) M.S. theses

Significant historical database that preceded widespread carp establishment…

Transactions of the American Fisheries Society 137:895–908, 2008

DOI: 10.1577/T06-112.1

[Article]

Relationships between Floodplain Lake Fish Communities and Environmental Variables in a Large River–Floodplain Ecosystem

Benjamin J. Lubinski[1]
Aquaculture/Fisheries Center, University of Arkansas at Pine Bluff, 1200 North University, Box 4912, Pine Bluff, Arkansas 71601, USA

John R. Jackson
Department of Biological Sciences, Arkansas Tech University, 1701 North Boulder Avenue, Russellville, Arkansas 72801, USA

Michael A. Eggleton*
Aquaculture/Fisheries Center, University of Arkansas at Pine Bluff, 1200 North University, Box 4912, Pine Bluff, Arkansas 71601, USA

North American Journal of Fisheries Management 27:676–680, 2007

DOI: 10.1577/M06-197.1

[Management Brief]

A Comparison of Shoreline Seines with Fyke Nets for Sampling Littoral Fish Communities in Floodplain Lakes

Sandra J. Clark[1] and John R. Jackson*
Department of Biological Sciences, Arkansas Tech University, 1701 North Boulder Avenue, Russellville, Arkansas 72801, USA

Steve E. Lochmann
Department of Aquaculture and Fisheries, University of Arkansas at Pine Bluff, 1200 North University Drive, Mail Slot 4912, Pine Bluff, Arkansas 71601, USA

Fisheries Technical Articles

Potential for a Minimum-length Limit Regulation to Improve Floodplain Lake Crappie Fisheries in Arkansas

Michael A. Eggleton, *Aquaculture/Fisheries Center, University of Arkansas at Pine Bluff, 1200 N. University, Box 4912, Pine Bluff, AR 71601*

John R. Jackson, *Arkansas Tech University, Department of Biological Sciences, 1701 North Boulder, Russellville, AR 72801*

Benjamin J. Lubinski, *Illinois Natural History Survey, Great Rivers Field Station, 8450 Montclair Avenue, Brighton, IL 62012*

North American Journal of Fisheries Management 30:928–939, 2010

DOI: 10.1577/M09-127.1

[Article]

Comparison of Gears for Sampling Littoral-Zone Fishes in Floodplain Lakes of the Lower White River, Arkansas

Michael A. Eggleton*
Aquaculture/Fisheries Center, University of Arkansas at Pine Bluff, 1200 North University, Box 4912, Pine Bluff, Arkansas 71601, USA

John R. Jackson
Department of Biological Sciences, Arkansas Tech University, 1701 North Boulder, Russellville, Arkansas 72801, USA

Benjamin J. Lubinski
Illinois Natural History Survey, Great Rivers Field Station, 8450 Montclair Avenue, Brighton, Illinois 62012, USA

When using only summer netting & fall electrofishing…

Current Information (2017)

Salzmann & Kaiser	Electrofishing* (60-Hz and 15-Hz)	Gillnetting	Mini-Fyke*	Total*
Fishes collected	9,661	488	9,747	19,896
Number of species	***48***	***30***	***39***	***61***

Historical Information (2002)

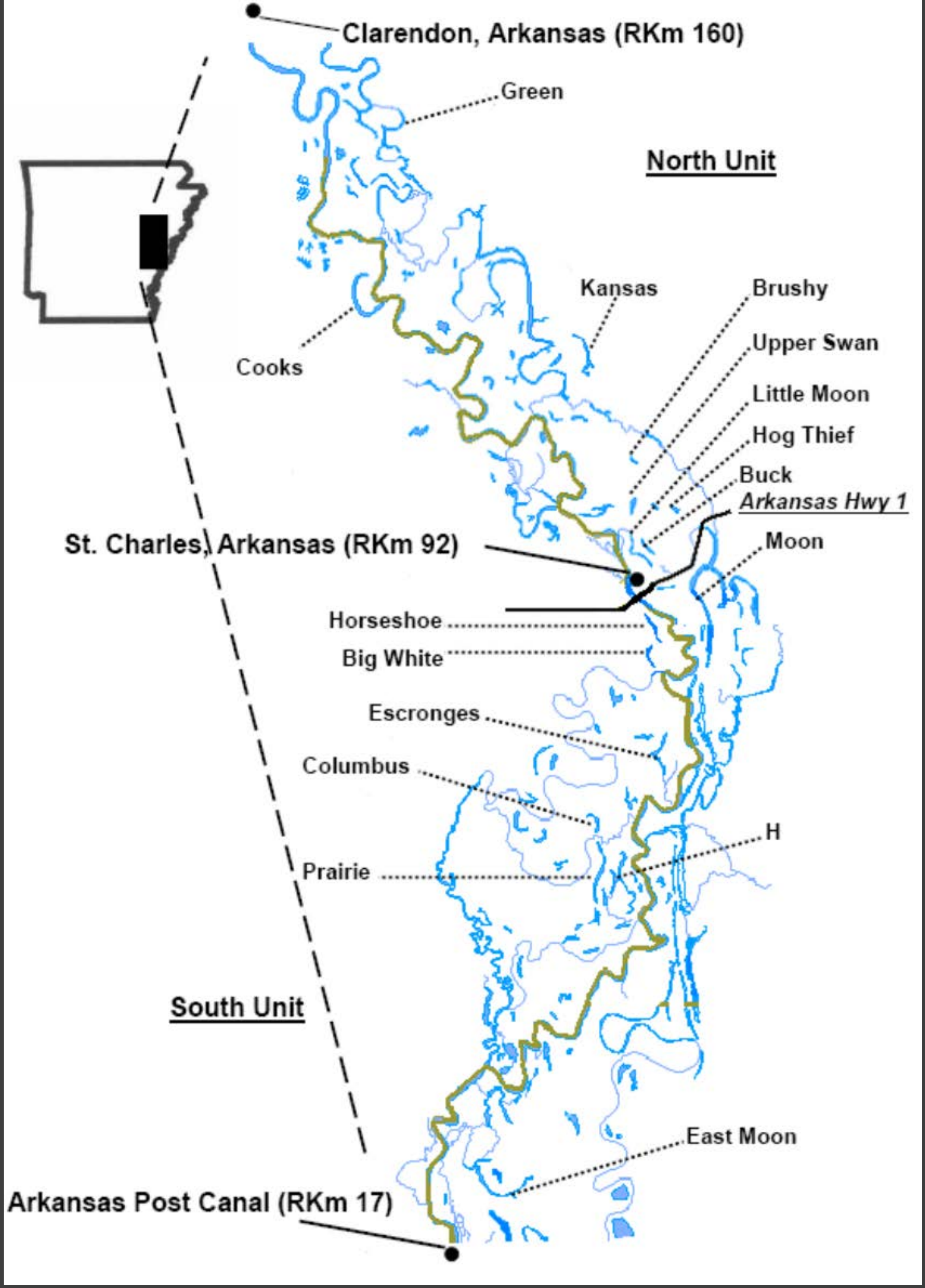
Lubinski	Electrofishing (60-Hz and 15-Hz)	Gillnetting	Mini-Fyke	Total
Fishes collected	7,643	529	33,893	42,065
Number of species	***47***	***24***	***44***	***64***

*identification of unidentified specimens pending
(3,935 from mini-fykes, 583+ from electrofishing)

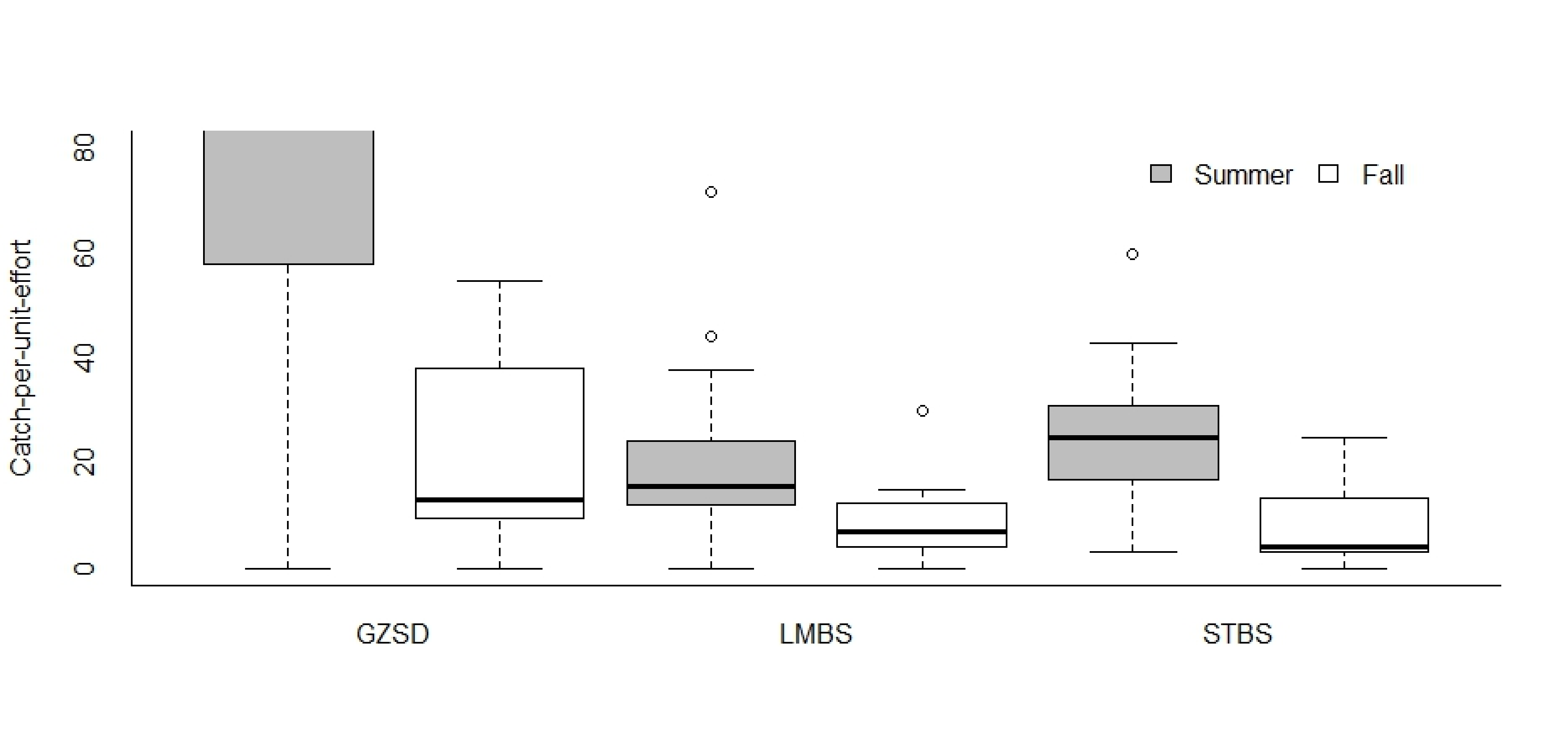
Study Area

Dale Bumpers White River National Wildlife Refuge (WRNWR)

- Area – 25 ha
  - Minimum – 4.0 ha
  - Maximum – 49.4 ha
- Average Depth – 2.9 m
  - Minimum – 1.6 m
  - Maximum – 5.0 m
- Maximum length – 3.4 km

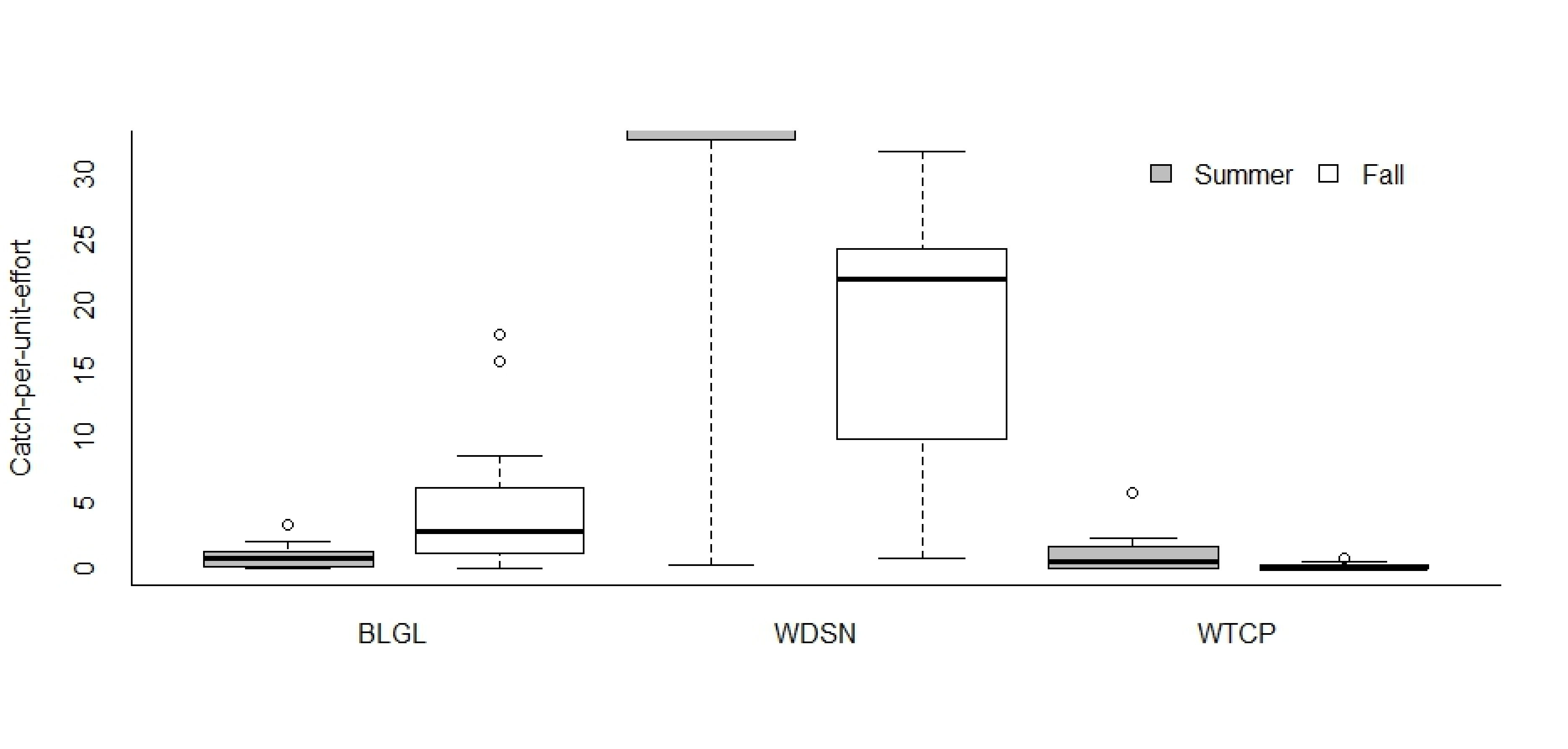


Electrofishing CPUE
Summer & Fall comparison



Mini-fyke CPUE

Summer & Fall comparison



Summer
July-Aug 2017

- LMBS: Mean length inversely related to carp abundance

  Possible competition?

- WTCP: CPUE directly related to carp abundance

  Possible habitat or lake productivity influence?