

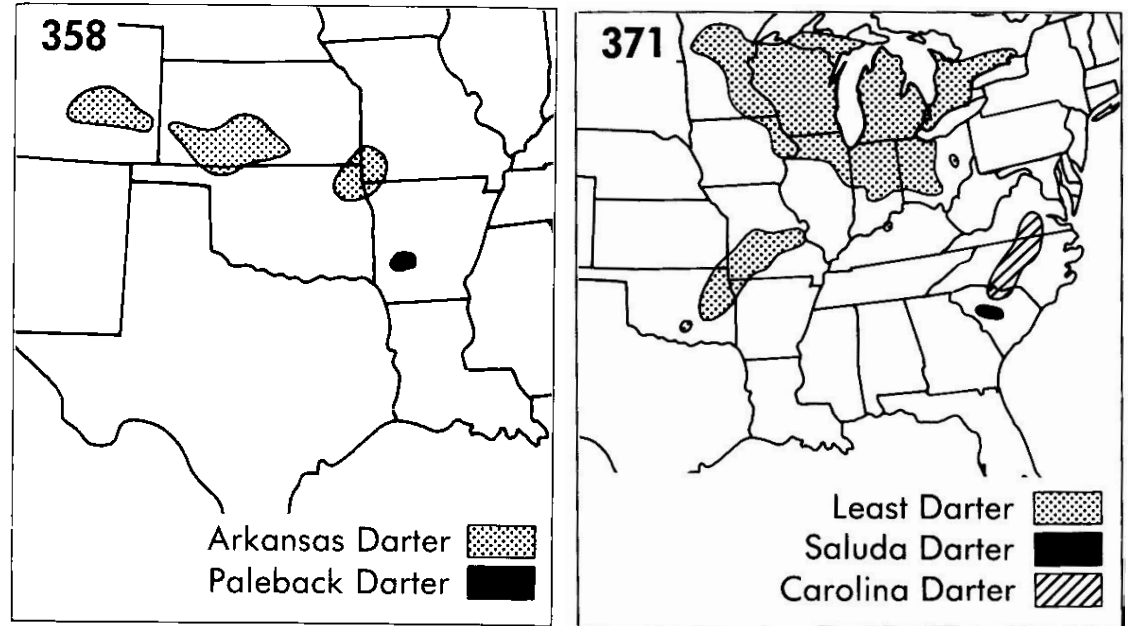


© Joseph R. Tomelleri

**GENE FLOW AND GENETIC  
STRUCTURE OF 2 RARE DARTERS IN  
ARKANSAS – *ETHEOSTOMA CRAGINI*  
& *ETHEOSTOMA MICROPERCA***

**J Baker, B Wagner, R Wood**

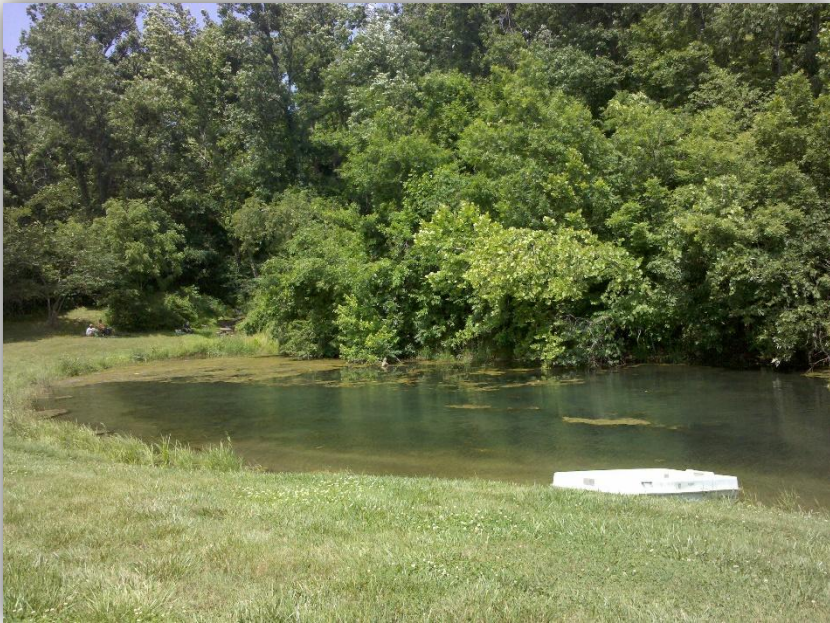
# INTRODUCTION



*From Freshwater Fishes, Page & Burr 1991*

- Wide ranging
- Associated with vegetated spring runs in NW-AR
- Limited dispersal
- Habitat fragmentation
- Urban development





# METHODS – SAMPLE COVERAGE

- *E. cragini* (Arkansas Darter)
  - 13 locations in AR (67 fin clips)
  - Shoal Cr. & Spring R., MO
- *E. microperca* (Least Darter)
  - 6 locations in AR (86 fin clips)
  - 10 locations in IL, IN, MI, OH, WI, Ontario
- AR samples collected 2009-2011



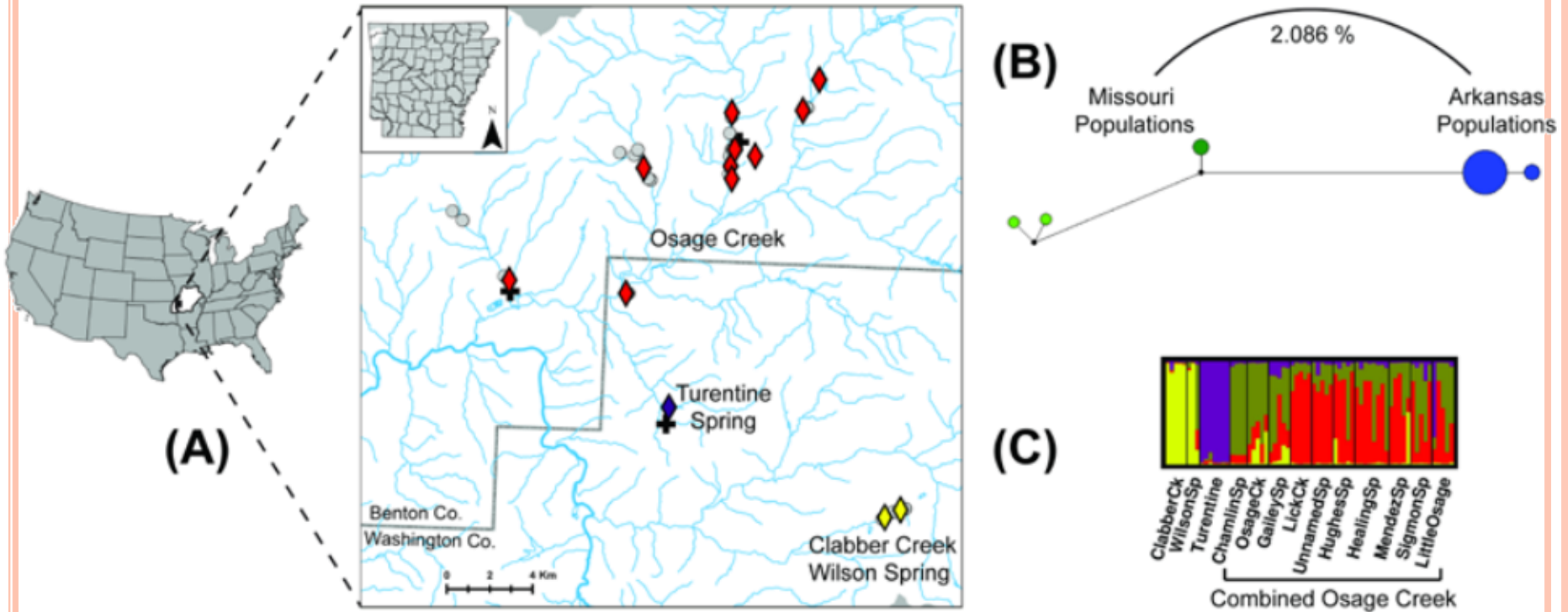
# METHODS – GENETICS



- *E. cragini* (Ark. Darter)
  - Mitochondrial cytochrome b
  - 1<sup>st</sup> intron of nuclear S7 ribosomal protein gene
  - 9 microsatellite loci
    - EosC117, EosC6, EosC112, EosC208, EosD108, EosD11, EosD107, EosC2, and Esc26b
- *E. microperca* (Least Darter)
  - Mitochondrial cytochrome b
  - 1<sup>st</sup> intron of nuclear S7 ribosomal protein gene
  - 7 microsatellite loci
    - EosC3, EosC6, EosD108, EosC208, EosC2, EosC124, and Esc26b



# *Etheostoma cragini* (Arkansas Darter)



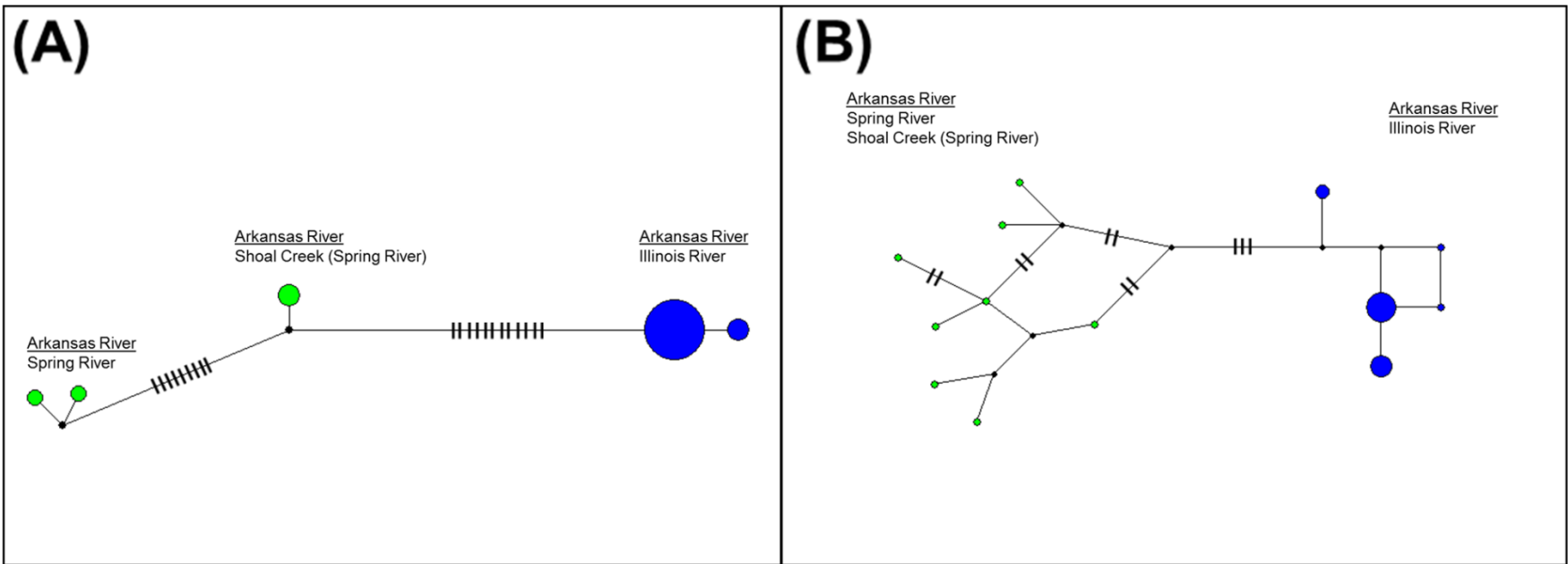
- (A) Map of Sample Locations
- (B) Haplotype Network
- (C) STRUCTURE Diagram



# *Etheostoma cragini* (Arkansas Darter) HAPLOTYPE NETWORK COMPARISON

MITOCHONDRIAL CYTOCHROME *B*

1<sup>ST</sup> INTRON NUCL. S7 RIBOSOMAL PROTEIN



# *Etheostoma cragini* (Arkansas Darter)

## EFFECTIVE POPULATION SIZE

Population	Historical $N_e$ (MIGRATE)	Recent $N_e$ (COLONY)
Osage Creek	544 (0-1360)	31 (19-53)
ClabberCk/WilsonSp	349 (0-1160)	19 (7-∞)
Turentine Spring	208 (0-960)	12 (5-130)

Estimates of contemporary and historical effective population sizes ( $N_e$ ), with 95% confidence intervals shown in parentheses.

Rule of thumb: *500-5,000 to maintain evolutionary potential long-term*





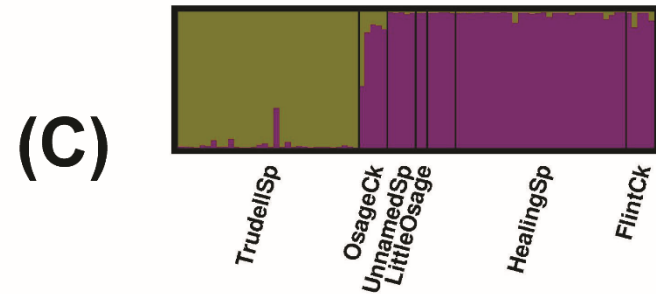
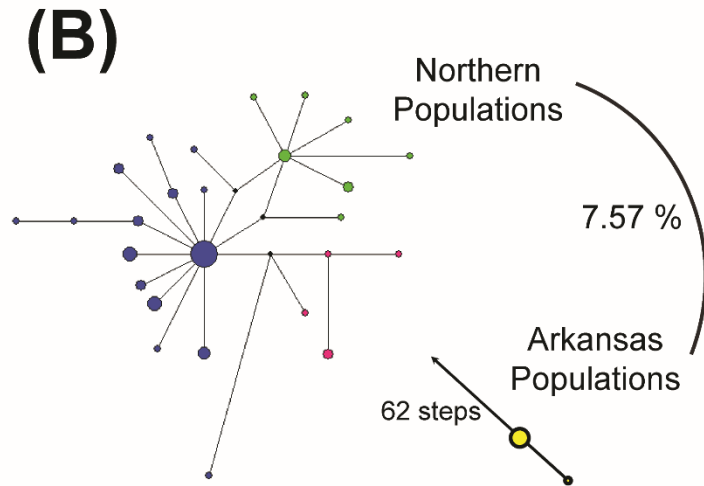
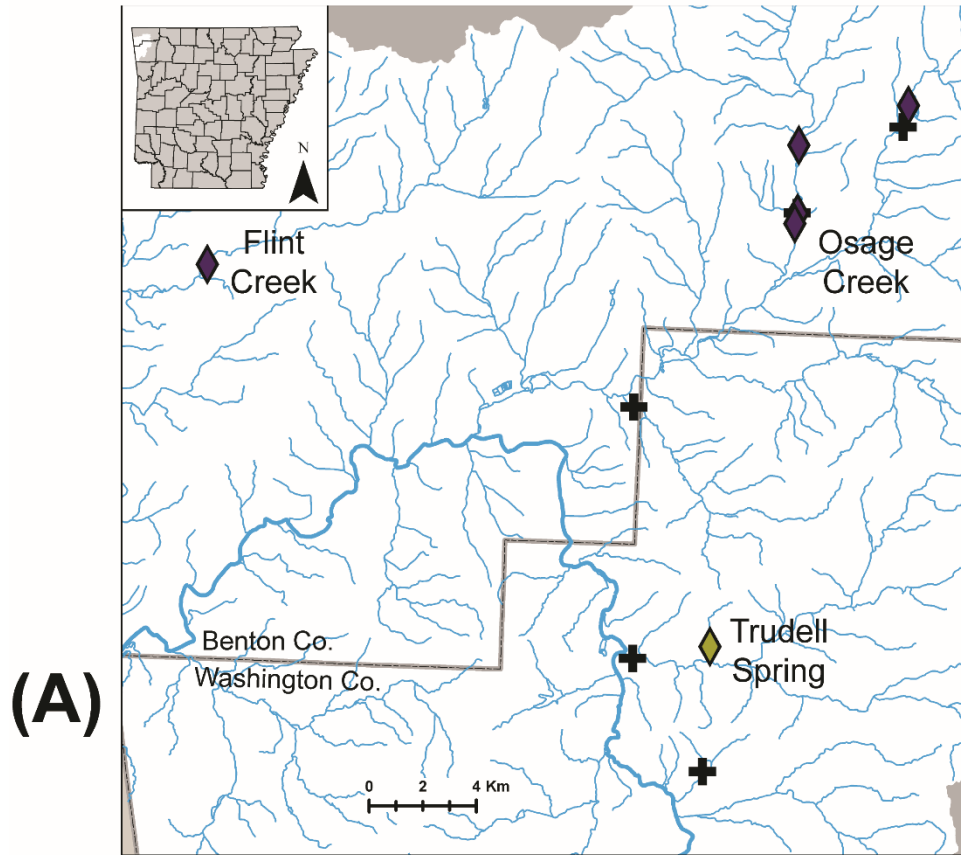
# *Etheostoma cragini* (Arkansas Darter)

## GENETIC DIVERSITY & TRENDS

- Three AR populations deviate from HWE:
  - Clabber Creek
  - Healing Spring
  - Osage Creek
- Low haplotype diversity compared to MO.
- Historical bottlenecks (M-ratios)
- More recent population declines:
  - Turentine Spring (mode-shift test)
  - Clabber Creek/Wilson Spring (Wilcoxon's sign rank test & mode-shift test)



# *Etheostoma microperca* (Least Darter)



- (A) Map of Sample Locations
- (B) Haplotype Network
- (C) STRUCTURE Diagram

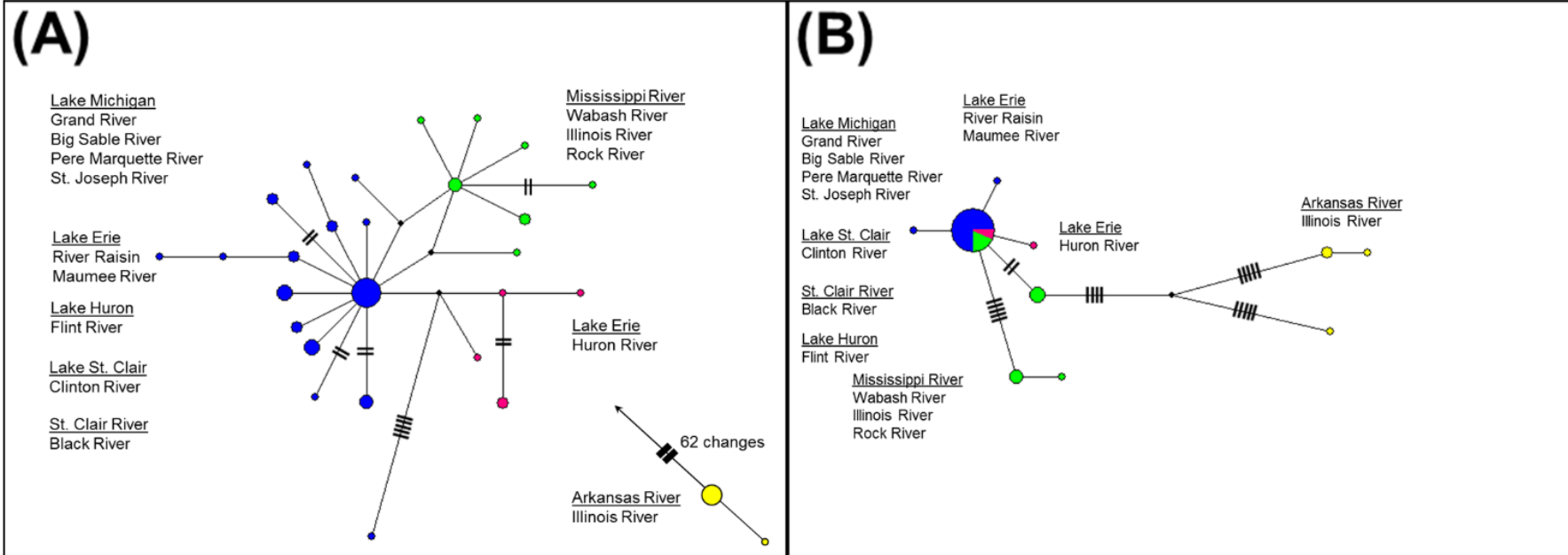


# *Etheostoma microperca* (Least Darter)

## HAPLOTYPE NETWORK COMPARISON

MITOCHONDRIAL CYTOCHROME *B*

1<sup>ST</sup> INTRON NUCL. S7 RIBOSOMAL PROTEIN



# *Etheostoma microperca* (Least Darter)

## EFFECTIVE POPULATION SIZE

Population	Historical $N_e$ (MIGRATE)	Recent $N_e$ (COLONY)
OsageCk/FlintCk	2715 (810-4040)	35 (22-59)
Trudell Spring	660 (0-1460)	19 (11-38)

Estimates of contemporary and historical effective population sizes ( $N_e$ ), with 95% confidence intervals shown in parentheses.

Rule of thumb: *500-5,000 to maintain evolutionary potential long-term*



# *Etheostoma microperca* (Least Darter)

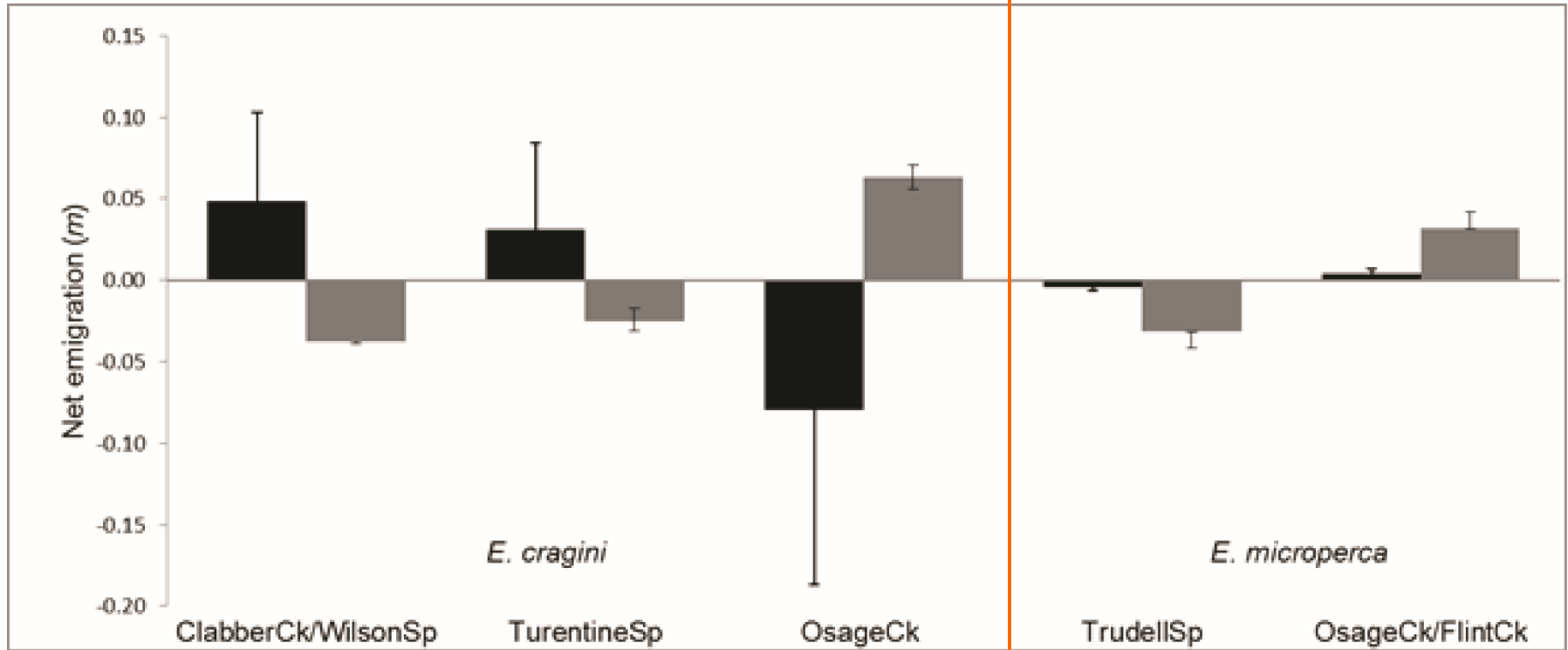
## GENETIC DIVERSITY & TRENDS

- One AR population deviates from HWE:
  - Healing Spring
- Low haplotype diversity compared to northern populations.
- Historical bottlenecks (M-ratios).
- More recent population decline:
  - Osage Creek (Wilcoxon's sign rank test)



# ASYMMETRIC MIGRATION

## HISTORIC MIGRANTS / GENERATION



- Gray – historical rates
- Black – contemporary rates



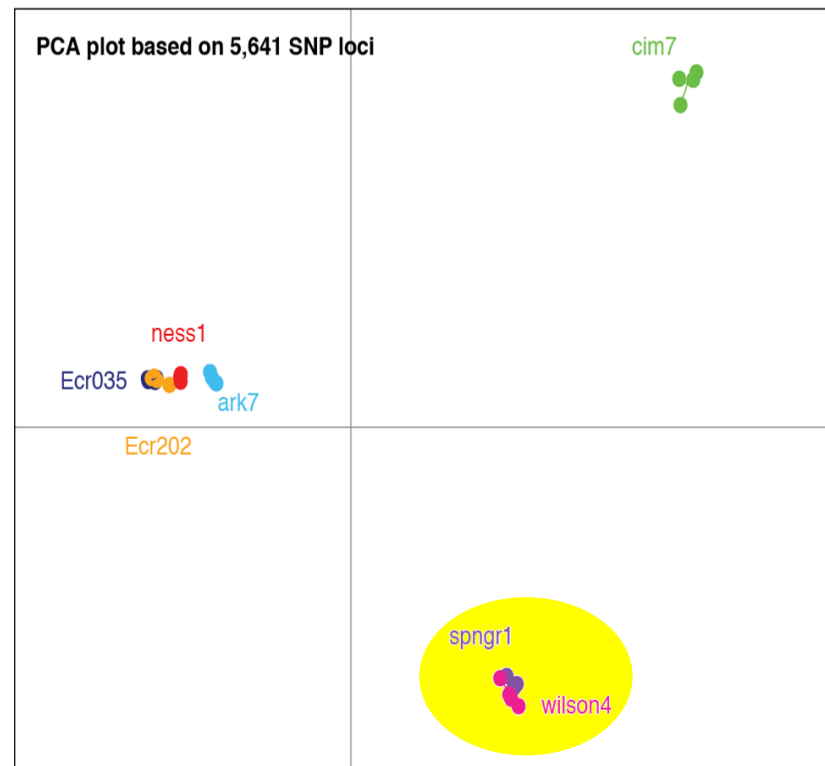
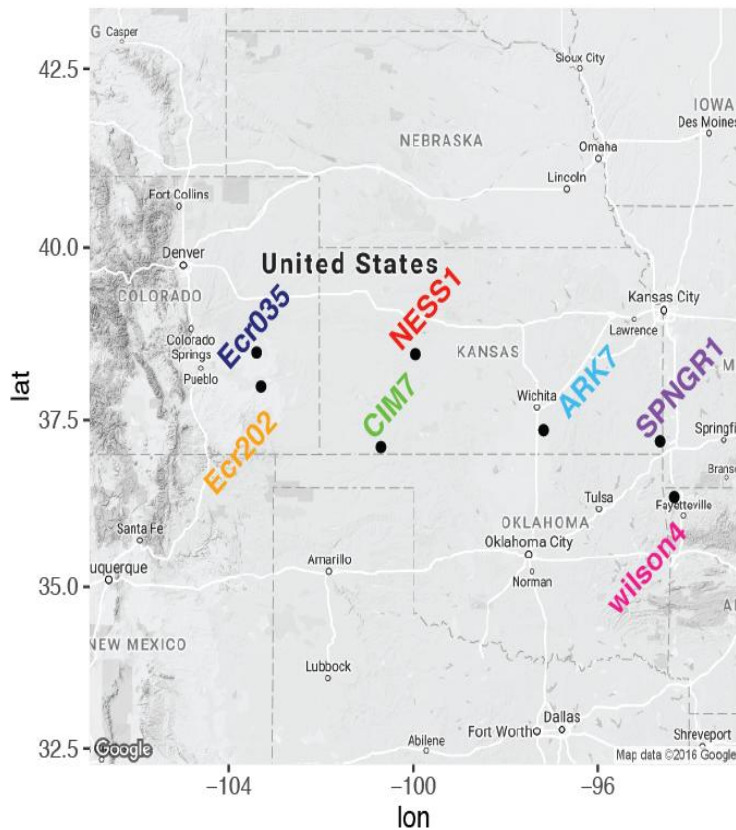
# SUMMARY

- Highly divergent from other populations
- Past and recent bottlenecks & low  $N_e$
- Historical asymmetric migration among AR populations
- Osage Creek source population
- Peripheral pop's critical to overall genetic diversity



# RECENT / FUTURE WORK – *E. CRAGINI* (ARKANSAS DARTER)

- Fitzpatrick project, Michigan State University





# RECENT / FUTURE WORK – *E. CRAGINI* (ARKANSAS DARTER)

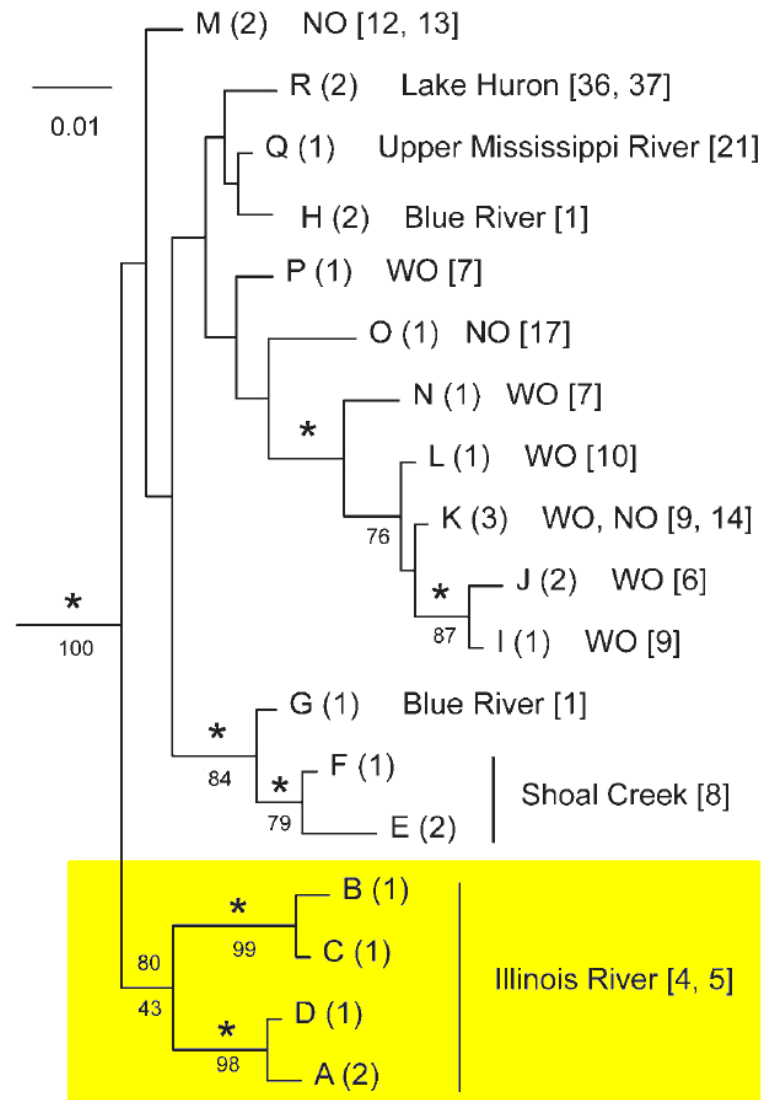
FST values	Ecr202	Ark7	CIM7	NESS1	SPNGR1	WILSON
Ecr035	0.16	0.22	0.37	0.29	0.42	0.66
Ecr202		0.19	0.35	0.25	0.41	0.64
Ark7			0.29	0.18	0.38	0.60
CIM7				0.34	0.36	0.55
NESS1					0.40	0.64
SPNGR1						0.37

- “...with Fst values above 0.6 I have to wonder if those are even the same species...”



# RECENT / WORK – *E. MICROPERCA* (LEAST DARTER)

- Echelle et al. 2015



**Fig. 3.** Bayesian tree for the S7 intron 1 alleles detected in *E. microperca*. Outgroups not shown. Haplotype labels (capital letters) are followed by the number detected; NO = Northern Ozarks (Missouri

# RECENT WORK –

## *E. MICROPERCA* (LEAST DARTER)

*Illinois River and Shoal Creek clades.*—The results for mtDNA and, more weakly, the nuclear S7 gene indicate that the Illinois River populations represent a cryptic species. The *cyt b* estimate of age for the clade places its origin around the Miocene-Pliocene boundary (5.4 mya; CI = 7.1–3.9), which is earlier than that of many darter species. For example, the estimate for the *E. fonticola*-*E. proeliare* sister-pair (3.7 mya; CI = 5.1–2.5) indicates a middle Pliocene origin, and 16 of 20 species in the *Nothonotus* darter clade appear to have originated in early Pliocene (~4 mya) or later (Near and Keck, 2005). Two other taxa show evidence of long-term isolation in the Illinois River: the crayfish *Orconectes nana*, which is effectively endemic to the Illinois River, is 9% divergent at cytochrome oxidase I (mtDNA) from its sister species, *O. macrus*, in the Neosho River (Dillman et al., 2010a), and the Illinois River population of Ozark cavefish, *Amblyopsis rosae*, which diverged from its Ozark sister group in early Miocene (Dillman et al., 2010b).

# FUTURE WORK – *E. MICROPERCA* (LEAST DARTER)

- Fluker project, Arkansas State University



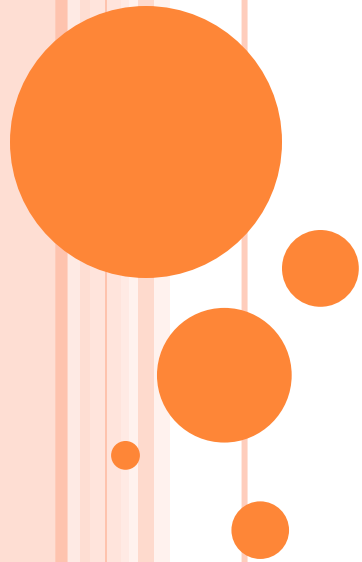
*Photo by Mike Slay, TNC*



# ACKNOWLEDGEMENTS

- Funded through a State Wildlife Grant
- Mike Slay, The Nature Conservancy
- Mark Kottmyer, Daniel Millican
- Justin Stroman, Jason Throneberry, Sean Saunders, and others





**QUESTIONS?**