GEORGIA
DEPARTMENT OF NATURAL RESOURCES
WILDLIFE RESOURCES DIVISION

Long-term Mussel Monitoring in the Lower Flint and Chattahoochee River Basins

Matthew Rowe
Georgia Department of Natural Resources
Wildlife Conservation

Matthew Rowe, GADNR Freshwater Mussels

- Central Michigan under Dr. David Zanata
  - Freshwater mussel population genetics
- Florida Fish and Wildlife Conservation Commission
  - Establish freshwater mussel monitoring program for the state of Florida
- Georgia Department of Natural Resources, Wildlife Conservation Section
  - Freshwater mussel conservation in Georgia

Outline

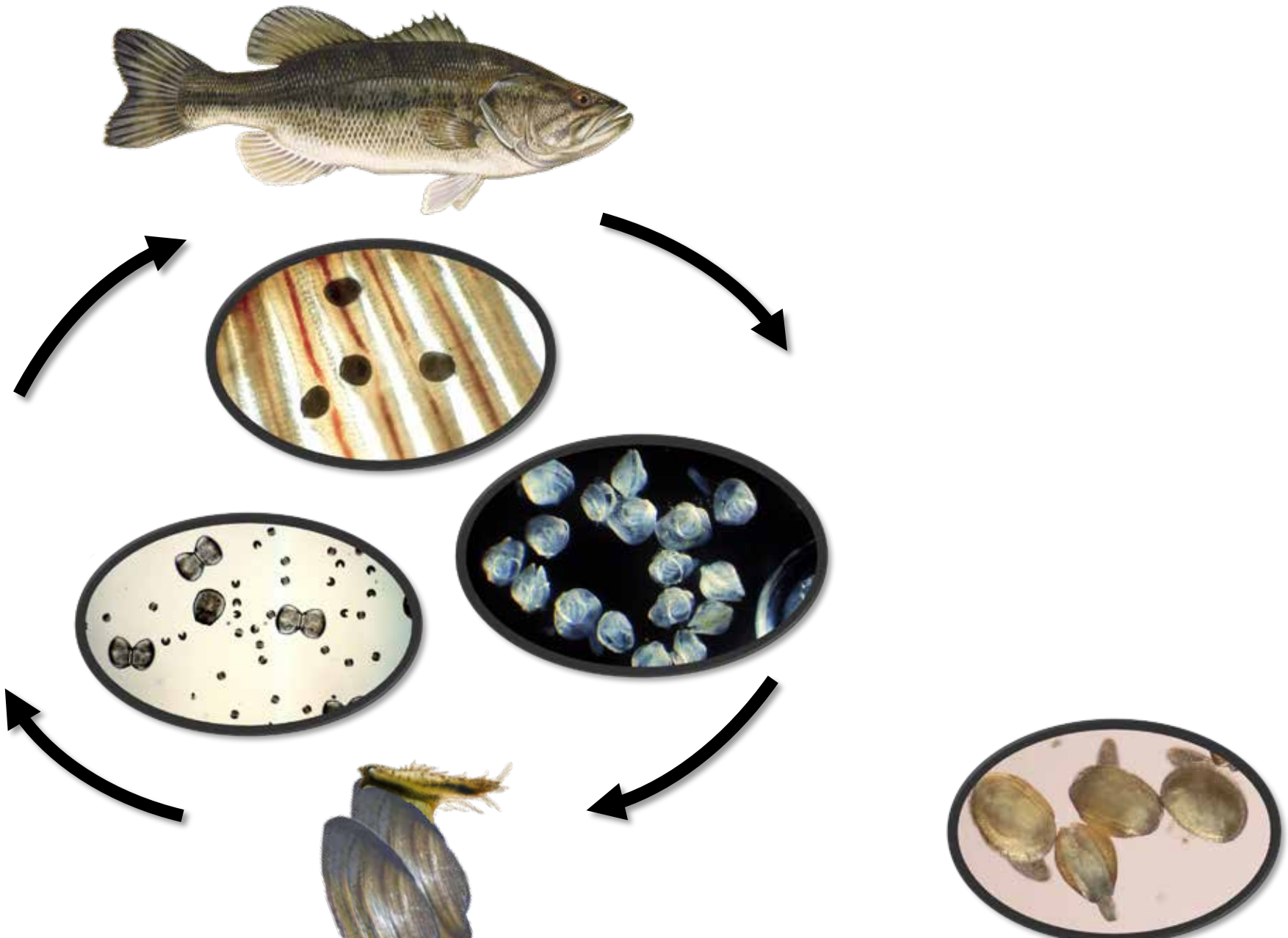
- What are Freshwater Mussels?
- Freshwater Mussels in the ACF Basin
- Threats to ACF Mussels
- History of Mussel Research in the ACF
- Long-term Monitoring of Mussels in the lower ACF
- Future Directions

Definition, Diversity, distribution

- Freshwater mussels are a diverse group of bivalve mollusks (clams) which occupy freshwater habitats across the world.
  - ~ 900 species worldwide
  - All continents except Antarctica and the Pacific Islands
  - Greatest diversity is in North America (~300 species)

Global diversity hotspot!

Freshwater Mussel Life Cycle



ACF Mussel Host Attraction Strategies

Other Host Attraction Strategies

Ecological Services

- Water Filters
  - Remove suspended particles from the water column
  - Deposit suspended nutrients to the bottom
  - Remove algae and bacteria from system
  - Increase substrate denitrification
- Food source
  - Fish, otter, muskrat, raccoon, waterfowl
- Bioturbation
  - Stir the substrate to mix and incorporate oxygen
- Epifauna
  - Provide habitat for bryozoans, sponges, insects, other mussel species, and other invertebrates

Conservation Status

- “Most endangered group of animals in the world” (> 70% of species threatened at some level)
- 88 Federally Listed Species in the Southeast
  - 73 Endangered, 15 Threatened
- 6 federally listed species in the ACF
  - 4 Endangered, 2 Threatened
- 4 more State Listed
  - 2 Endangered, 2 Threatened
- 2 species already extinct, one presumed extirpated

Lined Pocketbook

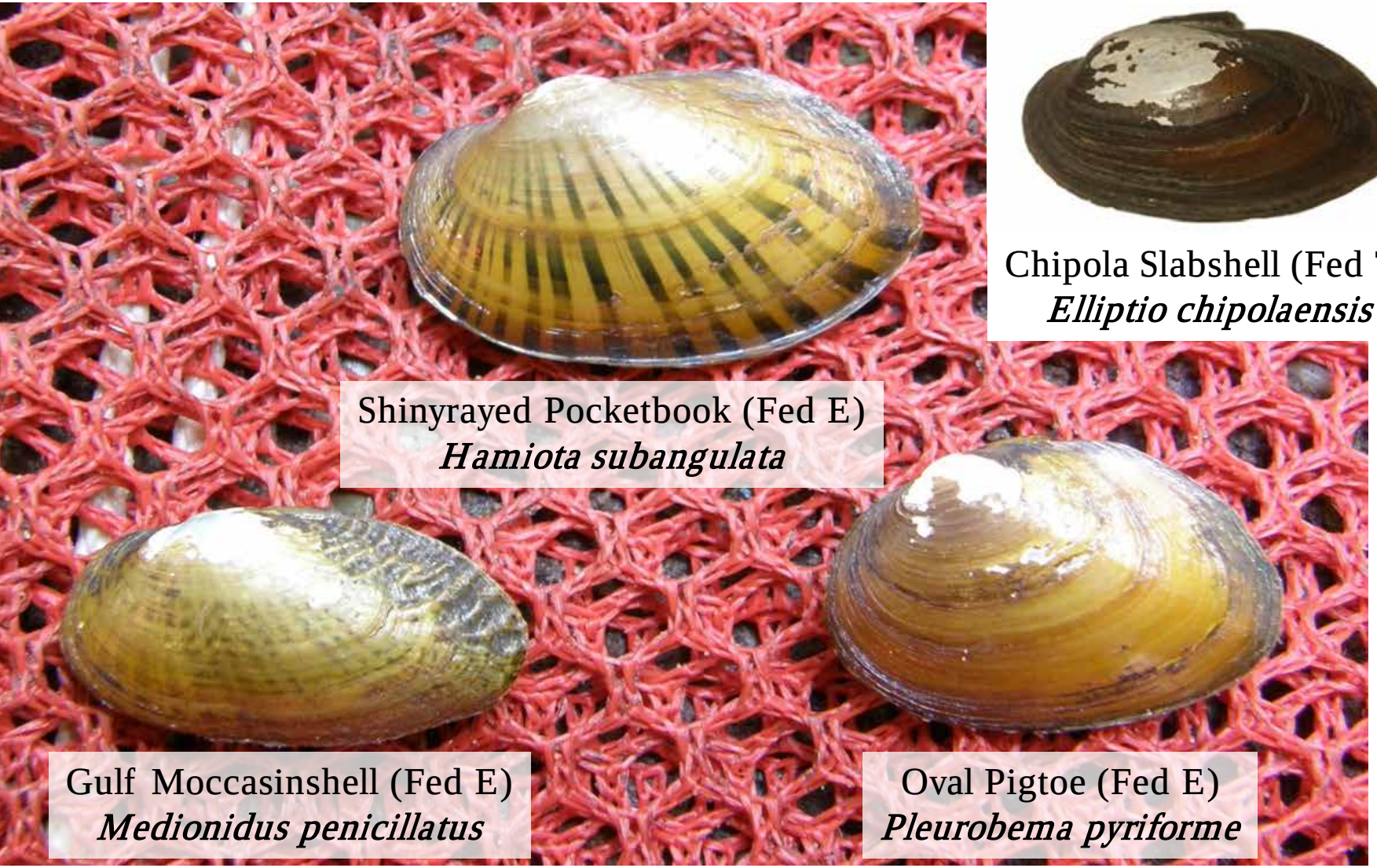
Lampsilis binominata

Last collected in 1978

Mussel Diversity in the ACF

- 32 species currently recognized in the basin
- 21 genera
- 7 endemic
- Share several species across the eastern gulf slope drainages

Freshwater Mussels in the ACF Basin



Shinyrayed Pocketbook (Fed E)
Hamiota subangulata

Gulf Moccasinshell (Fed E)
Medionidus penicillatus

Oval Pigtoe (Fed E)
Pleurobema pyriforme

Chipola Slabshell (Fed T)
Elliptio chipolaensis

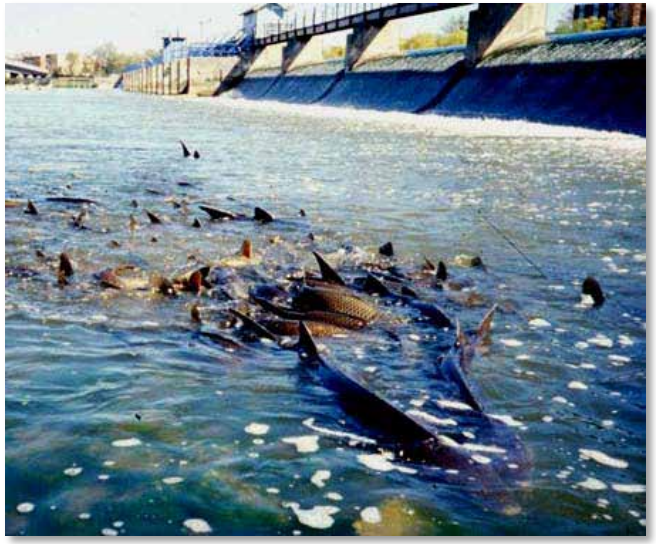
Fat Threeridge (Fed E)
Amblema nieslerii

Purple Bankclimber (Fed T)
Elliptoideus sloatianus

Recent History of Mussel Research in the ACF

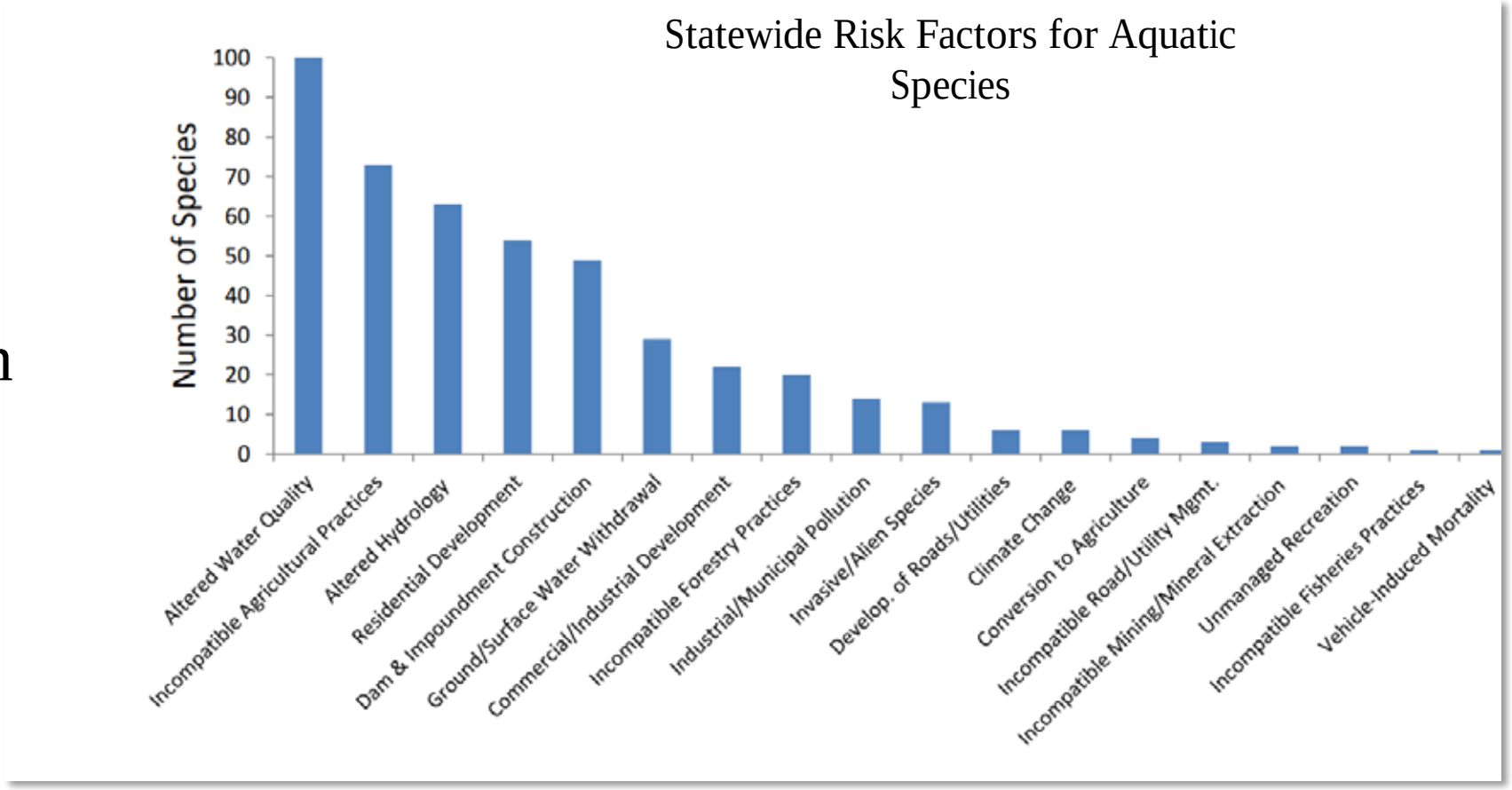
- William Clench and Ruth Turner 1954
  - Museum of Comparative Zoology at Harvard (MCZ) + FMNH
  - Surveyed the impoundment footprint of Jim Woodruff Lock and Dam as well as surrounding Tributaries to the Gulf of Mexico
  - Published as "*Freshwater Mollusks of Alabama, Georgia, and Florida From the Escambia to the Suwannee River*" (1956)
- Jayne Brim Box and Jim Williams 1991-1992
  - USGS survey of 324 sites basin-wide
  - Thorough review of available museum collections
  - Published as "*Unionid Mollusks of the Apalachicola Basin in Alabama, Florida, and Georgia*" (2000)
- Jason Wisniewski et al. 2004-2017
  - Georgia DNR sampled 272 sites in the Flint and Chattahoochee
- Susan Geda et al. 2014-2018
  - Florida Fish and Wildlife conducted 219 surveys in the Apalachicola and Chipola River Basins

Threats



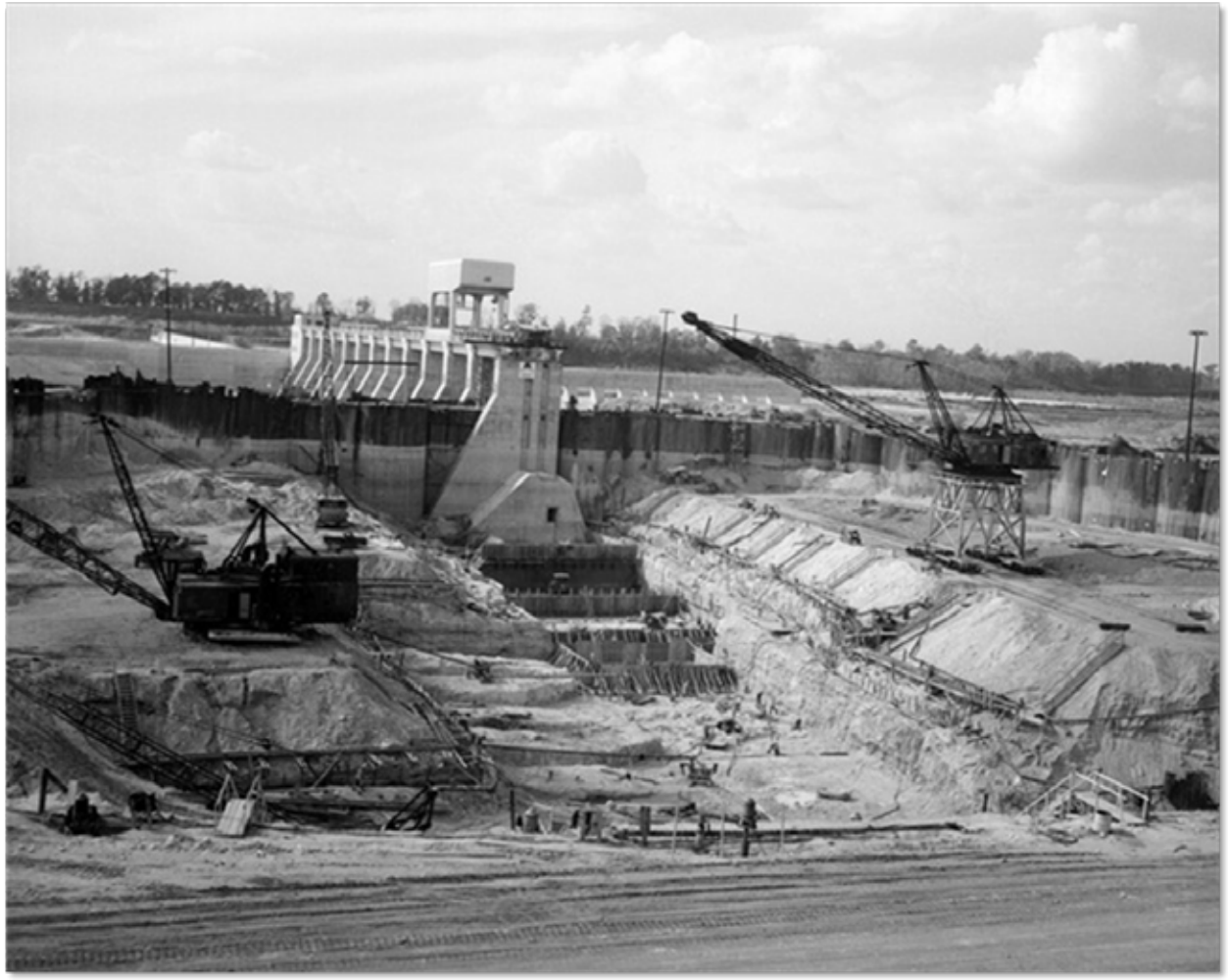
Mussel-specific Threats

- Impoundments
- Habitat Loss (water)
- Habitat Loss (substrate)
- Reproductive Disruption
- Pollution
- Eutrophication
- Invasive Species
- Dredging
- Harvest

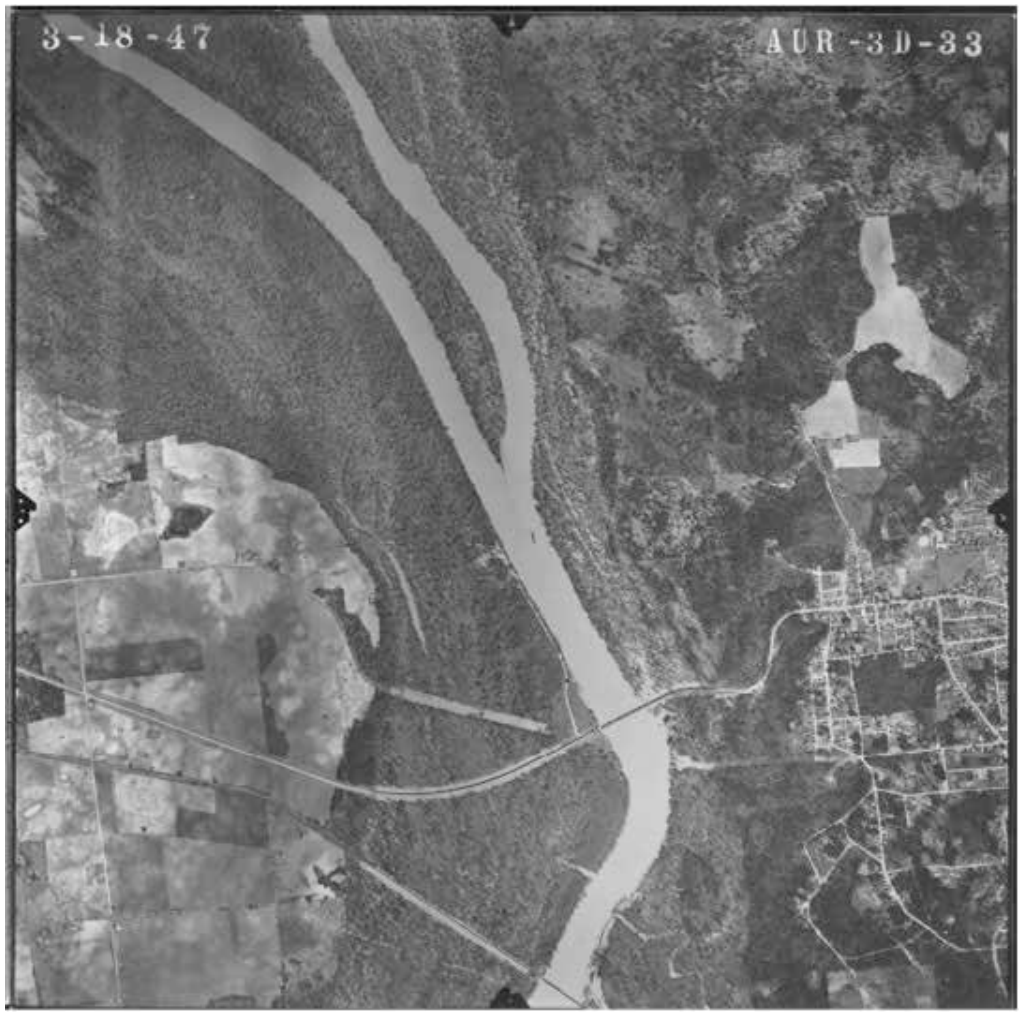


The Damming of the Rivers

- 1925 – Lake Blackshear
- 1926 – Lake Harding
- 1952 – Lake Seminole
- 1956 – Lake Lanier
- 1959 – Lake Oliver
- 1963 – Walter F. George
- 1975 – West Point Lake



Jim Woodruff Lock and Dam



Post-1970's flow alteration

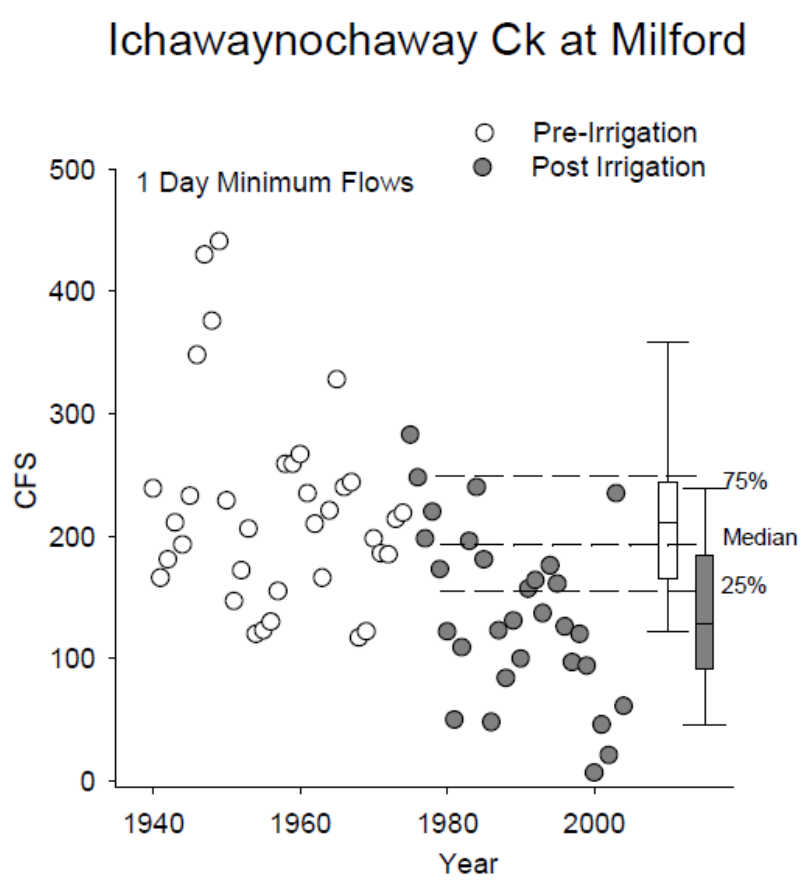


Figure 2. One-day minimum flows in Ichawaynochaway Ck.

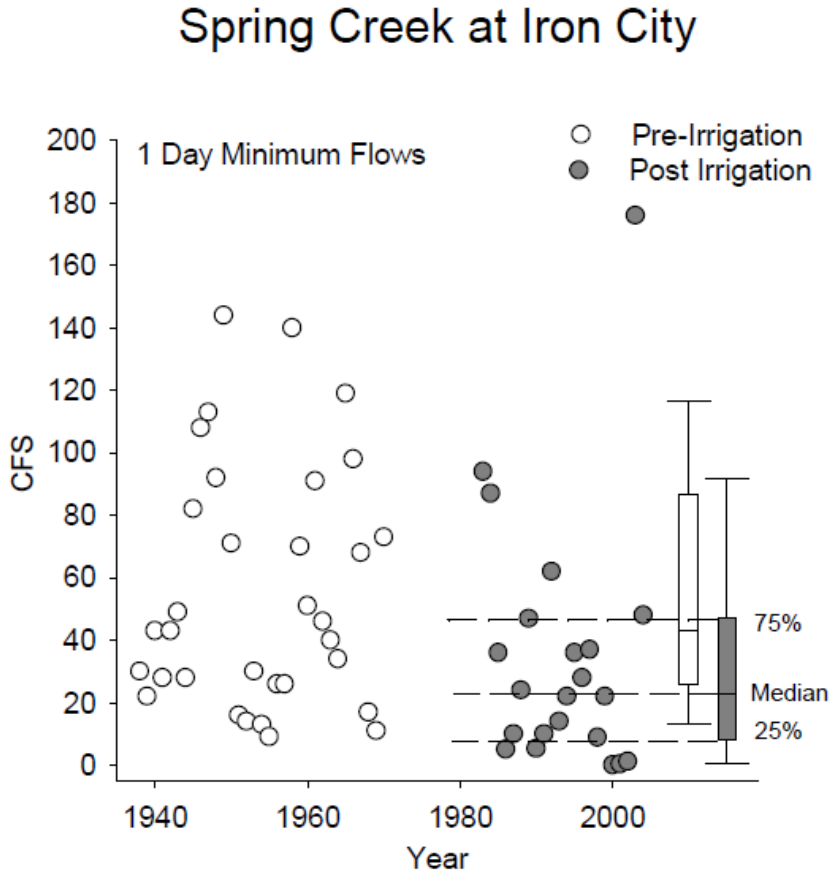
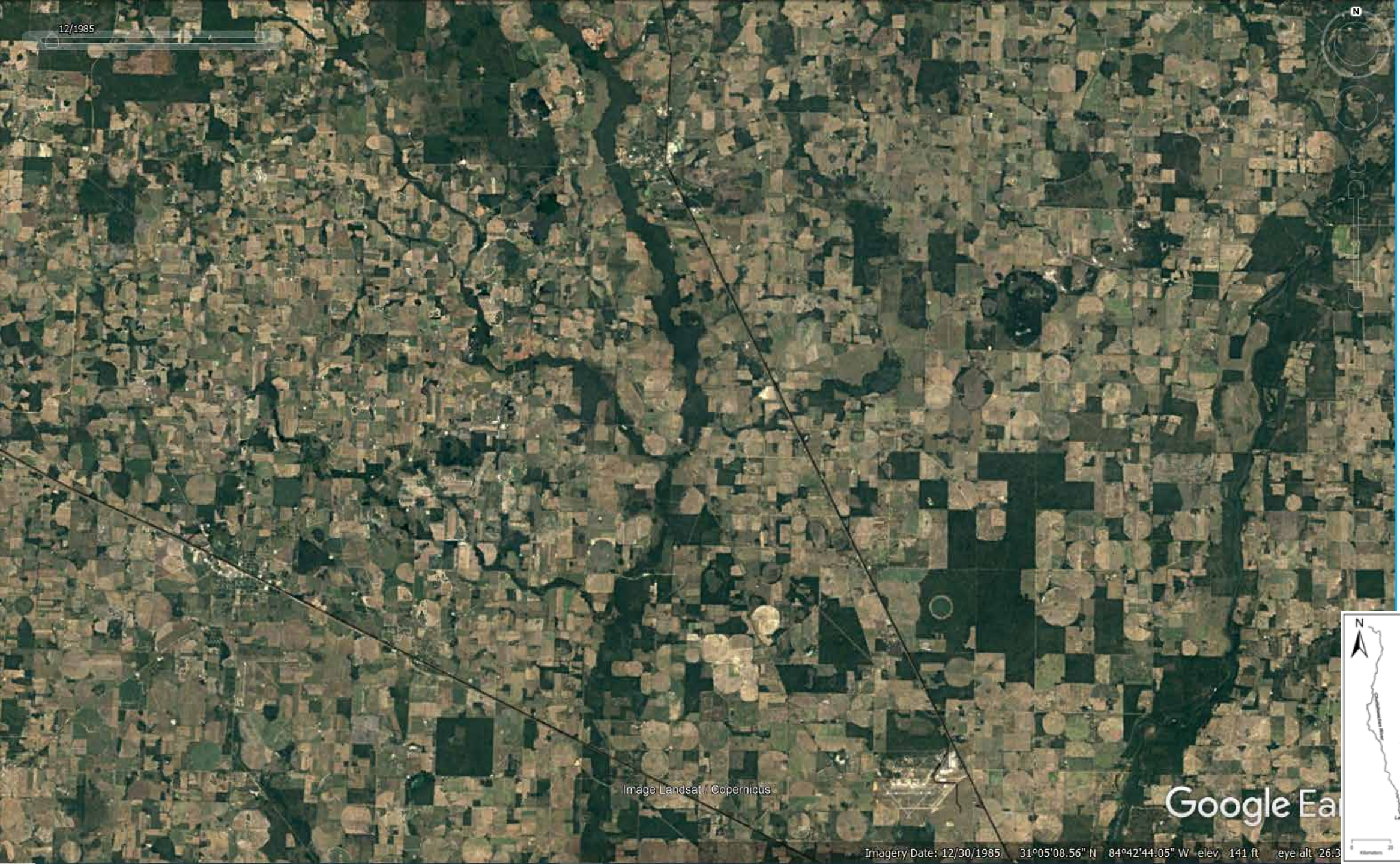
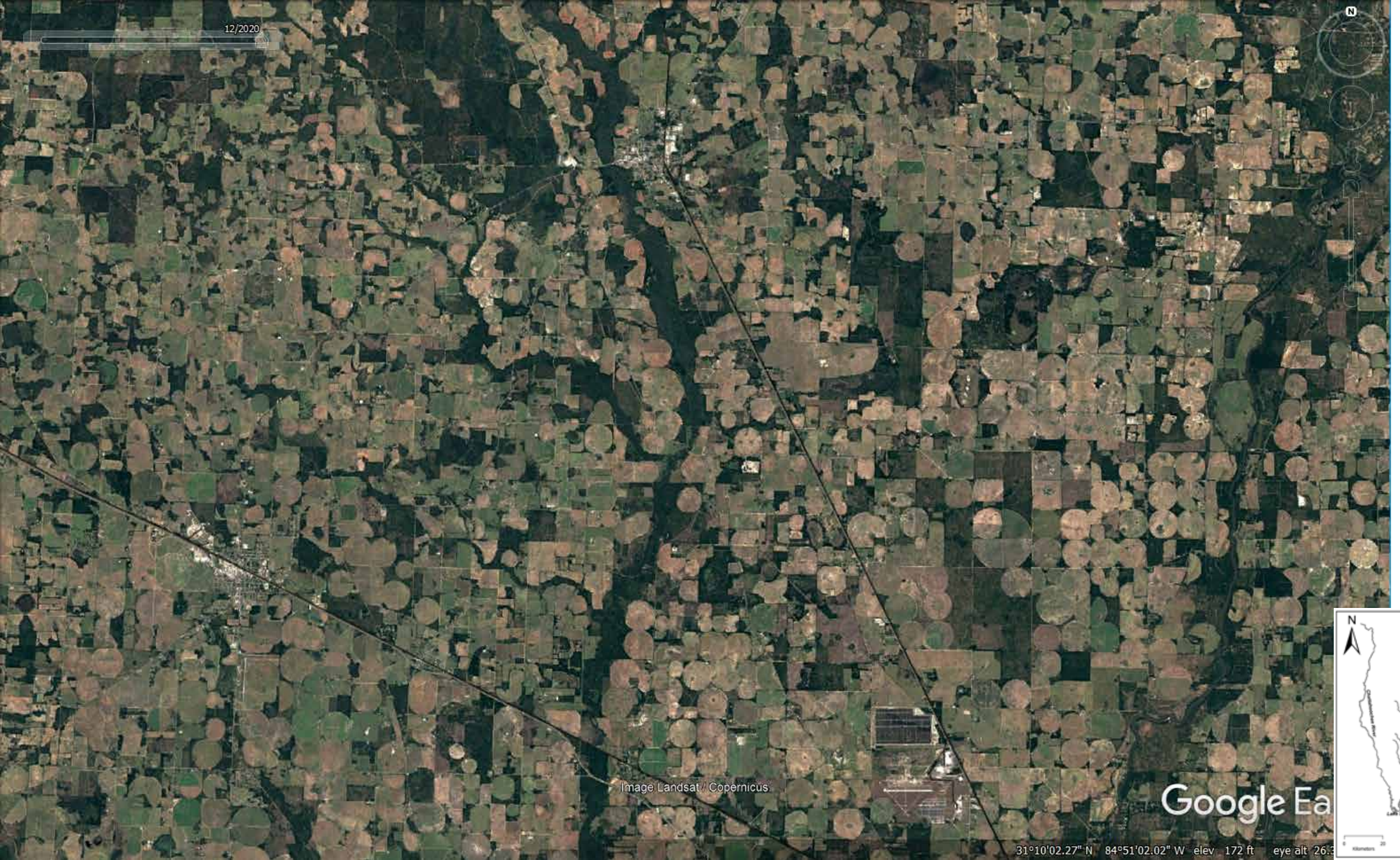


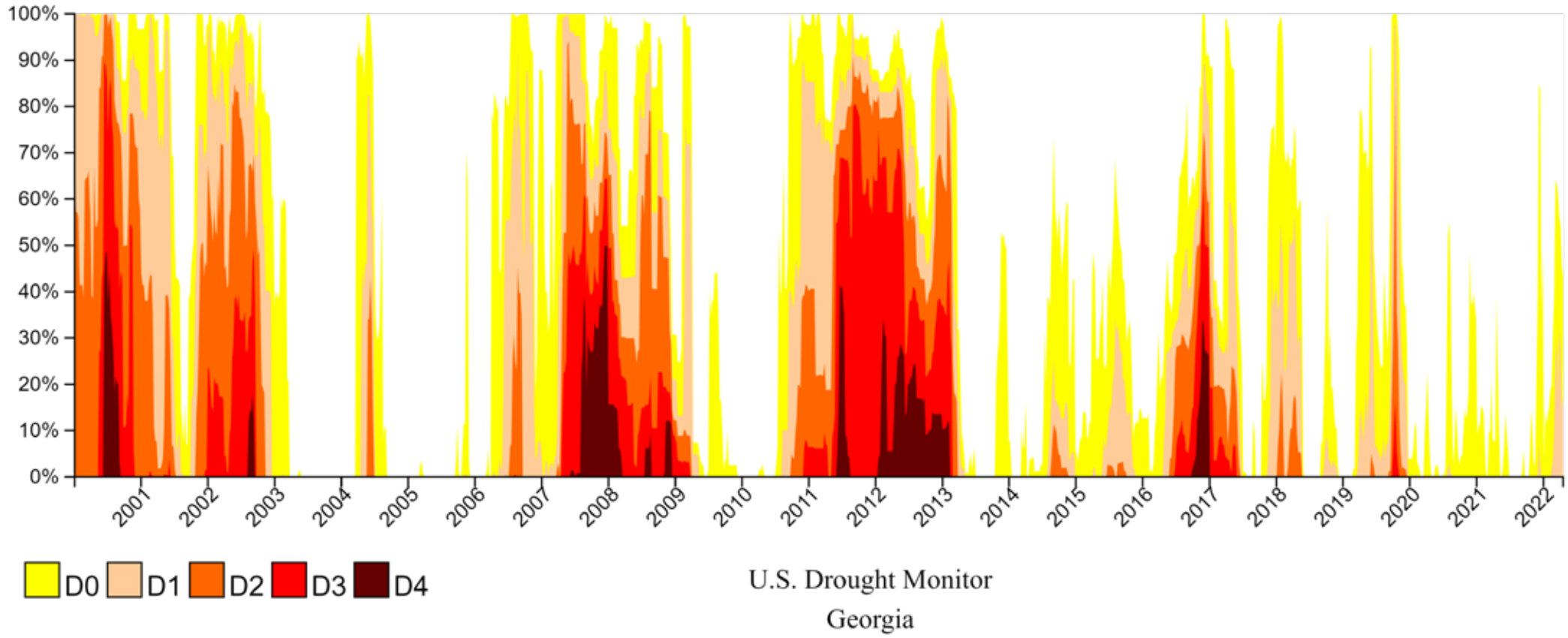
Figure 4. One day minimum flows for Spring Ck.

Golladay et al. 2007


12/1985
N
Image Landsat / Copernicus
Google Ea
Imagery Date: 12/30/1985 31°05'08.56" N 84°42'44.05" W elev 141 ft eye alt 26.3
N
Georgia


12/2020
N
Image Landsat / Copernicus
Google Ea
31°10'02.27" N 84°51'02.02" W elev 172 ft eye alt 26.3
N
Georgia

Drought Conditions in Georgia: 2000-2022

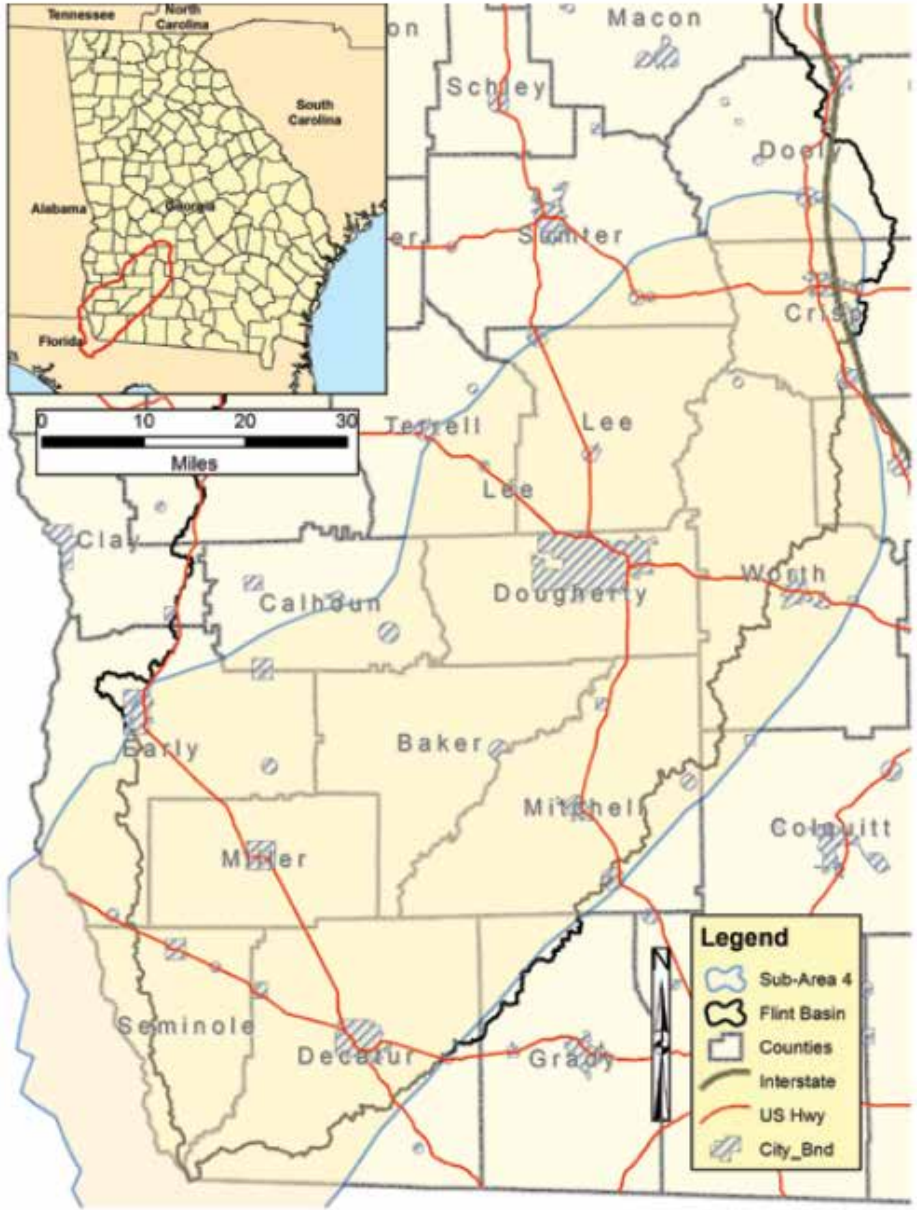


~4 km of creek were dry (bank to bank) during 2006-2010 drought

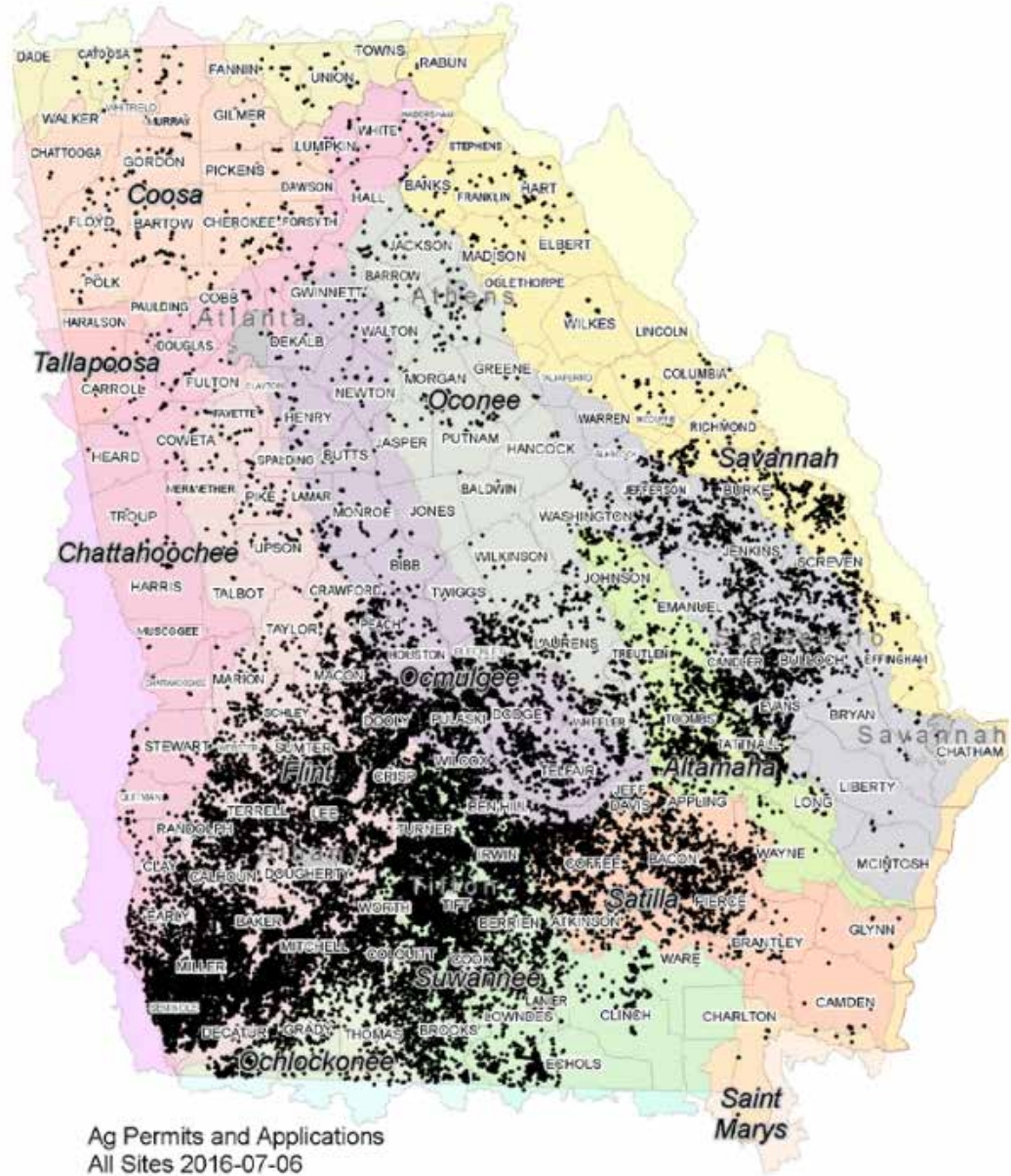
June 2007

Aug 2010

Figure 8. **Sub-Area 4 of Lower Chattahoochee and Flint River Basins**

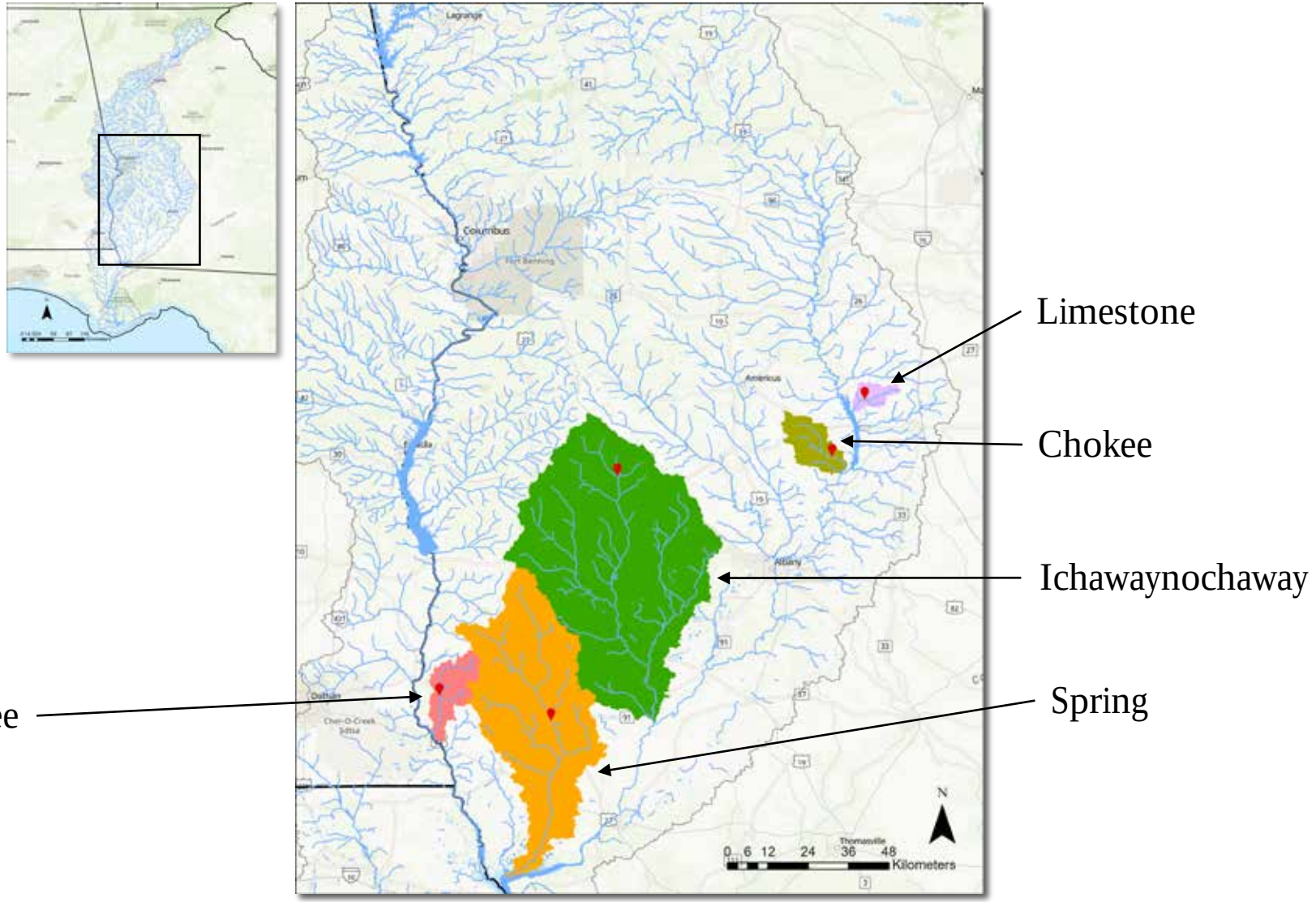


Locations for Water Withdrawal Permits and Pending Applications (EPD)



Manganiello 2017

Long-term Monitoring in the ACF



Long-term Monitoring Methods

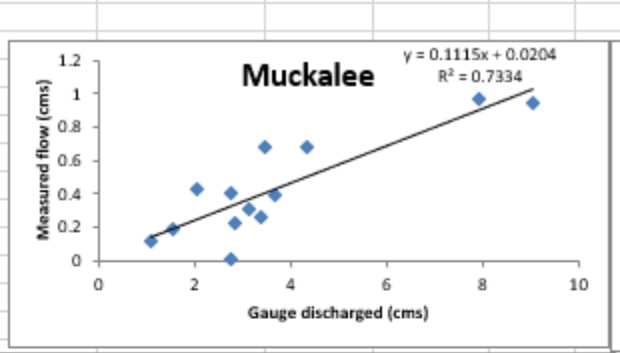
- Established sites with robust mussel populations in drought sensitive areas, preferably including rare and listed species
- Designate permanent 100m study reaches
- Sample sites annually using single pass, full coverage bank-to-bank tactile searches
- Collected mussels are tagged on each valve using unique vinyl shellfish tags
- Data collected includes:
  - Species
  - Length
  - Sex/Reproductive status
  - Flow
  - Water Quality

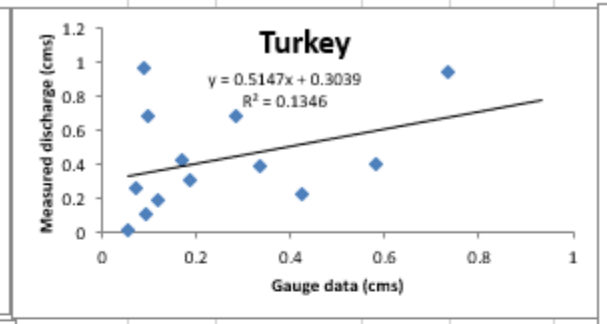
Long-term Monitoring Methods: Outcomes

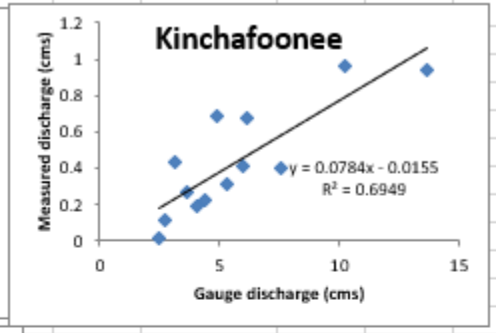
- Survival
- Growth
- Recruitment
- Population Demographics
- Emigration / Immigration
- Detection Probability
- Drought Response
- Disturbance Response
- Tag Retention

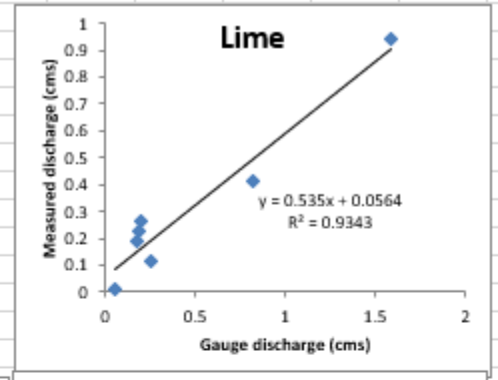
- To Date:
  - 10-17 years of continuous (mostly) data
  - Collected and tagged 17,103 unique individuals
  - Generated four publications
  - Established Flow Calibrations for LTM sites
- Limitations:
  - Only tracking mature adults
  - Not excavating
  - Somewhat variable

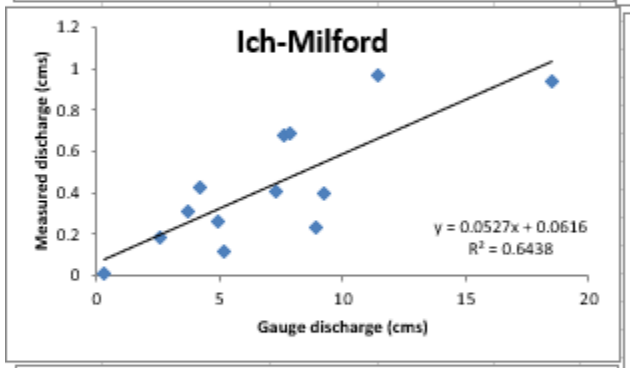
Flow Calibrations

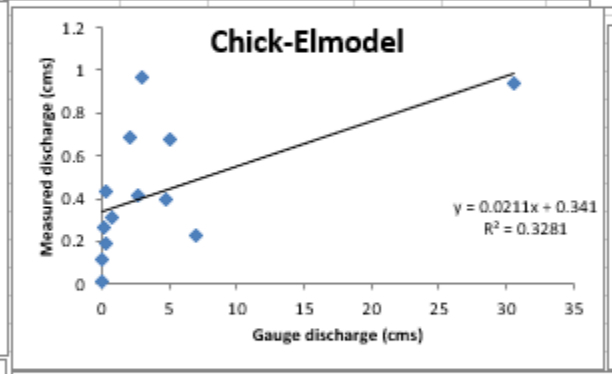


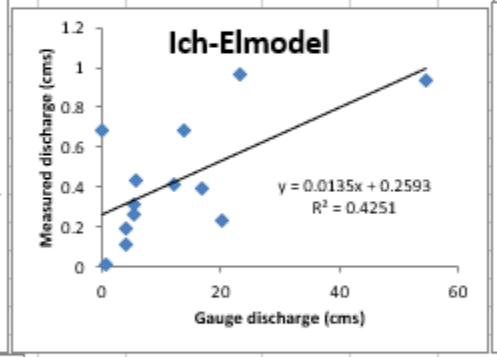


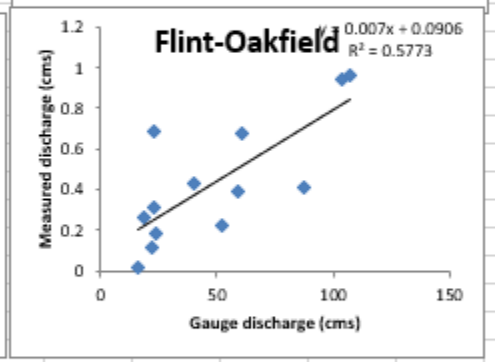


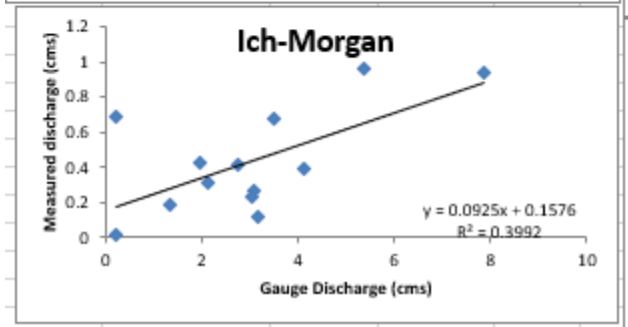


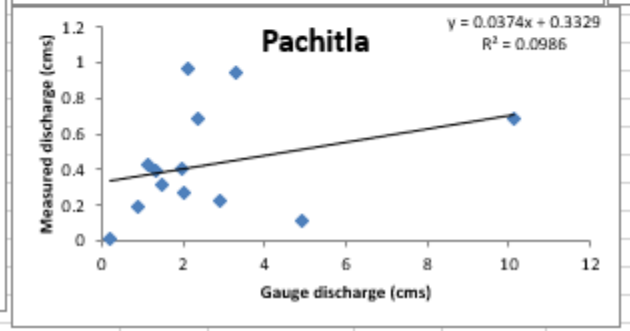












Spring Creek Augmentation Project

RIVER RESEARCH AND APPLICATIONS

River Res. Applic. (2015)

Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/rra.2937

AN EVALUATION OF STREAMFLOW AUGMENTATION AS A SHORT-TERM FRESHWATER MUSSEL CONSERVATION STRATEGY

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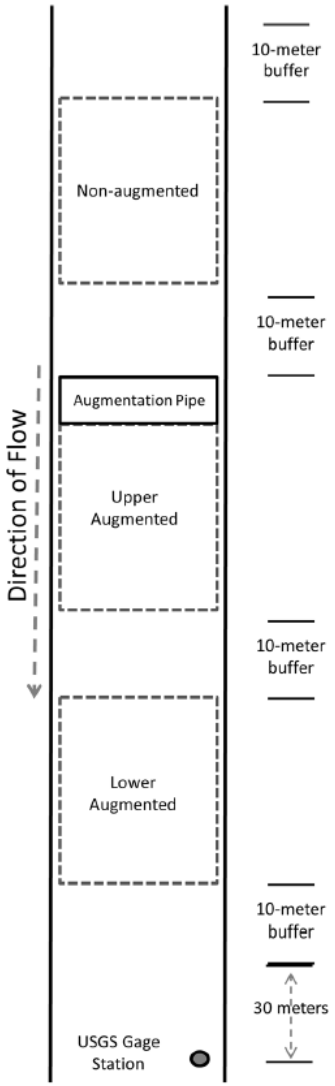
[b] *Georgia Ecological Services, United States Fish & Wildlife Service, Fort Benning, Georgia, USA*

Spring Creek Methodology

- Agreement between GADNR, GAEPD, the Water Policy and Planning Center, and Golden Triangle RC&D
- Installed two 20cm wells at the wastewater treatment facility 400m from the stream.
- Water was delivered on demand via a 24cm flexible vinyl hose
- The hose would be deployed 72hrs after flows at the Colquitt gage dropped below 1.5 feet
- Flow would be turned on after flows dropped below 1.0 feet and would be maintained until flows returned to >1.0 feet.


10-meter buffer
Non-augmented
10-meter buffer
Augmentation Pipe
Upper Augmented
10-meter buffer
Lower Augmented
10-meter buffer
30 meters
USGS Gage Station
Direction of Flow

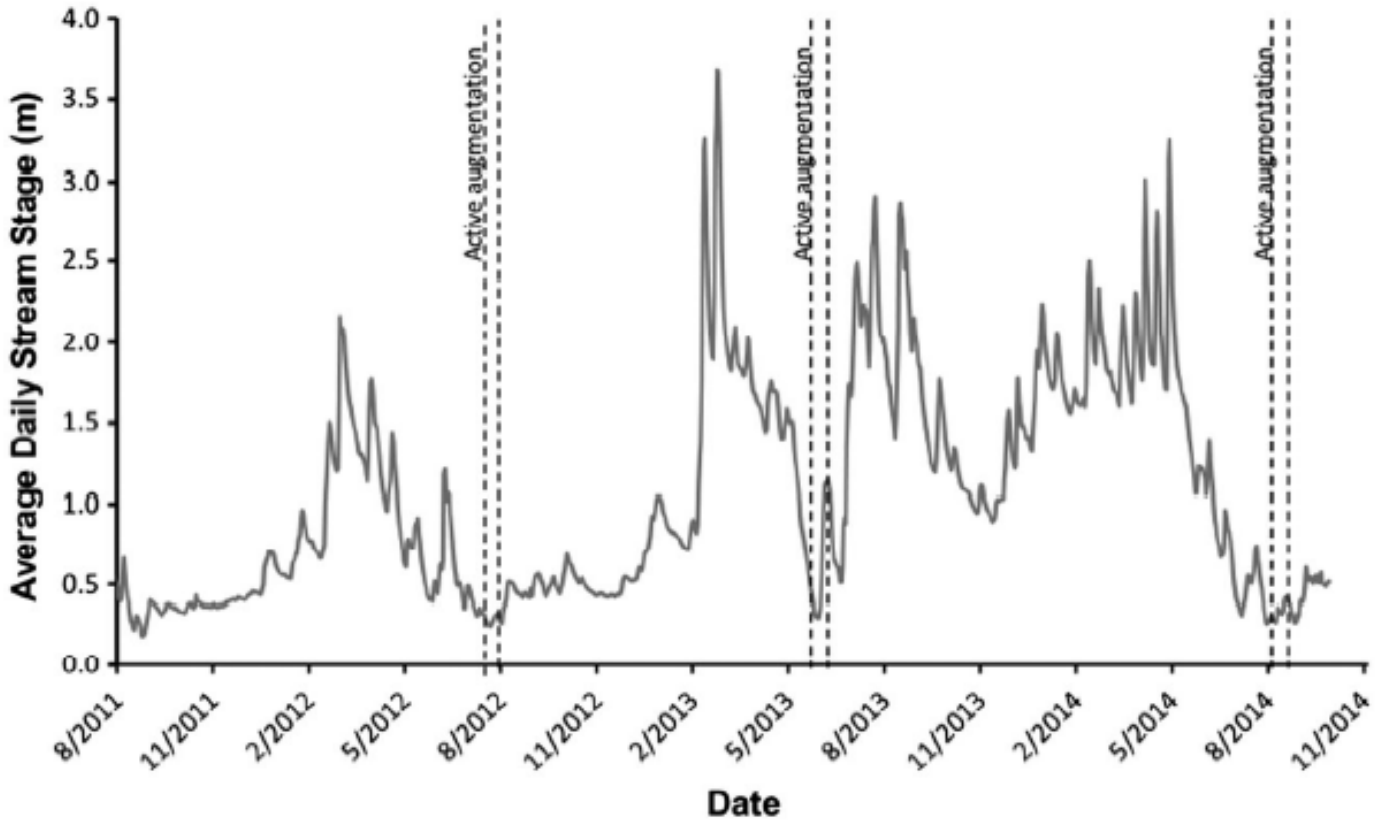


Figure 2. Daily stream stage measured at the USGS gage station (USGS 02356638) on Spring Creek between August 2011 and September 2014. Augmentation encompassing the 4 August 2012 occasion includes two separate occasions occurring from 12 July 2012 to 30 July 2012 and from 2 August 2012 until 7 August 2012

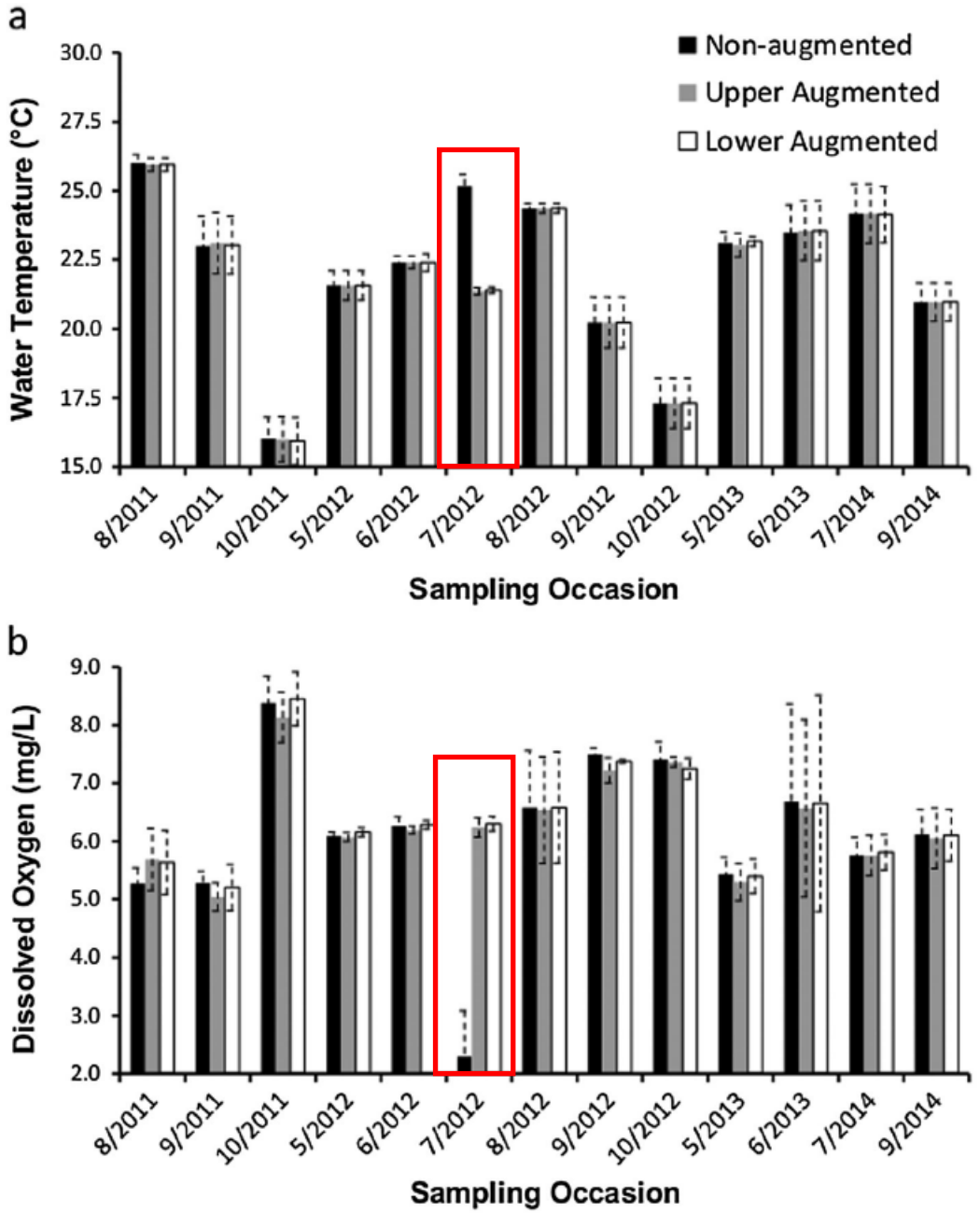


Figure 4. (a) Water temperature and (b) dissolved oxygen concentration by primary sampling occasion and sampling reach of Spring Creek, Georgia, from August 2011 to September 2014. The July 2012 sampling occasion occurred during active augmentation

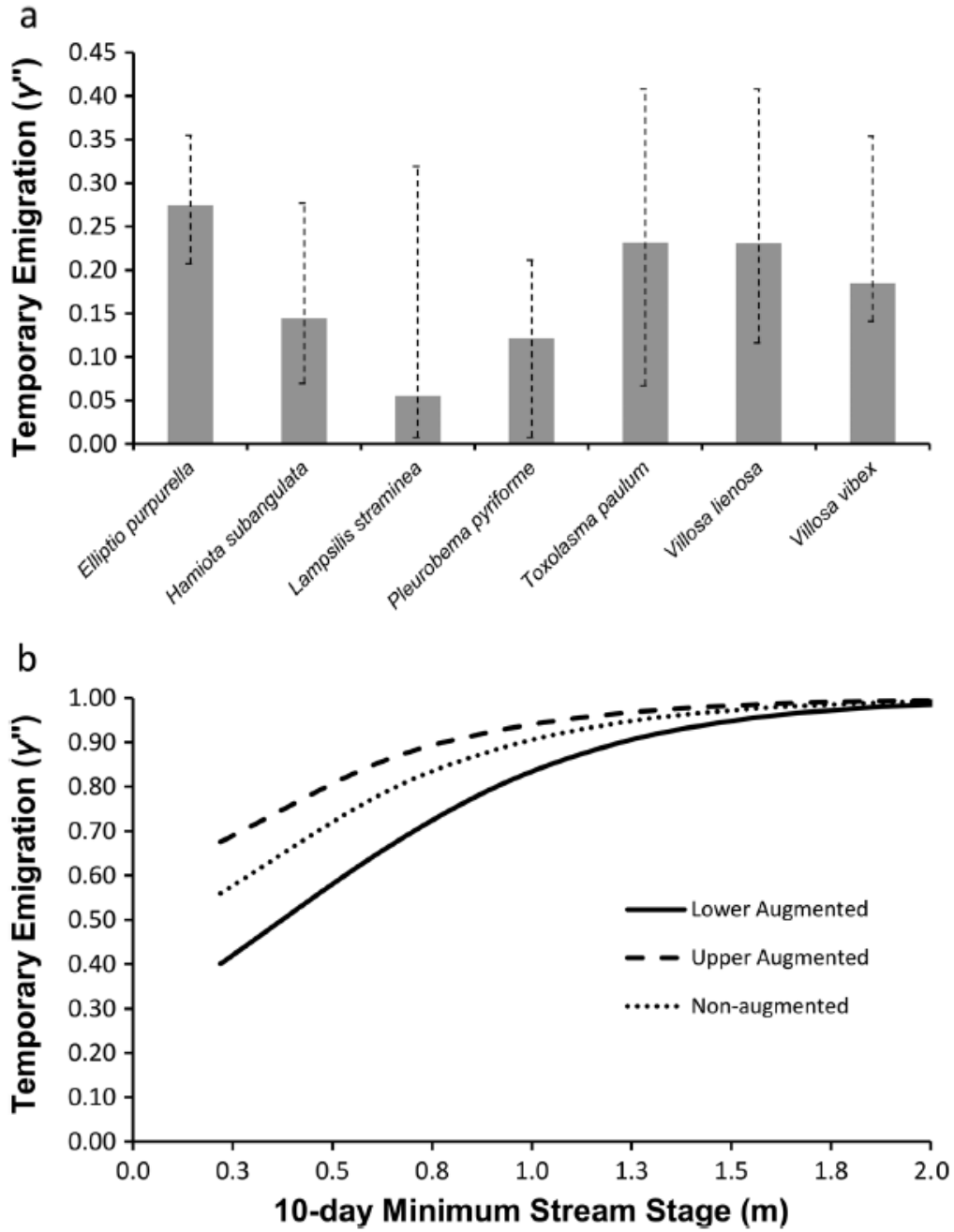


Figure 6. Estimated temporary emigration (γ'') among (a) species (95% confidence intervals) and (b) stream augmentation reach by stream stage for freshwater mussels in Spring Creek, Georgia, from August 2011 to September 2014

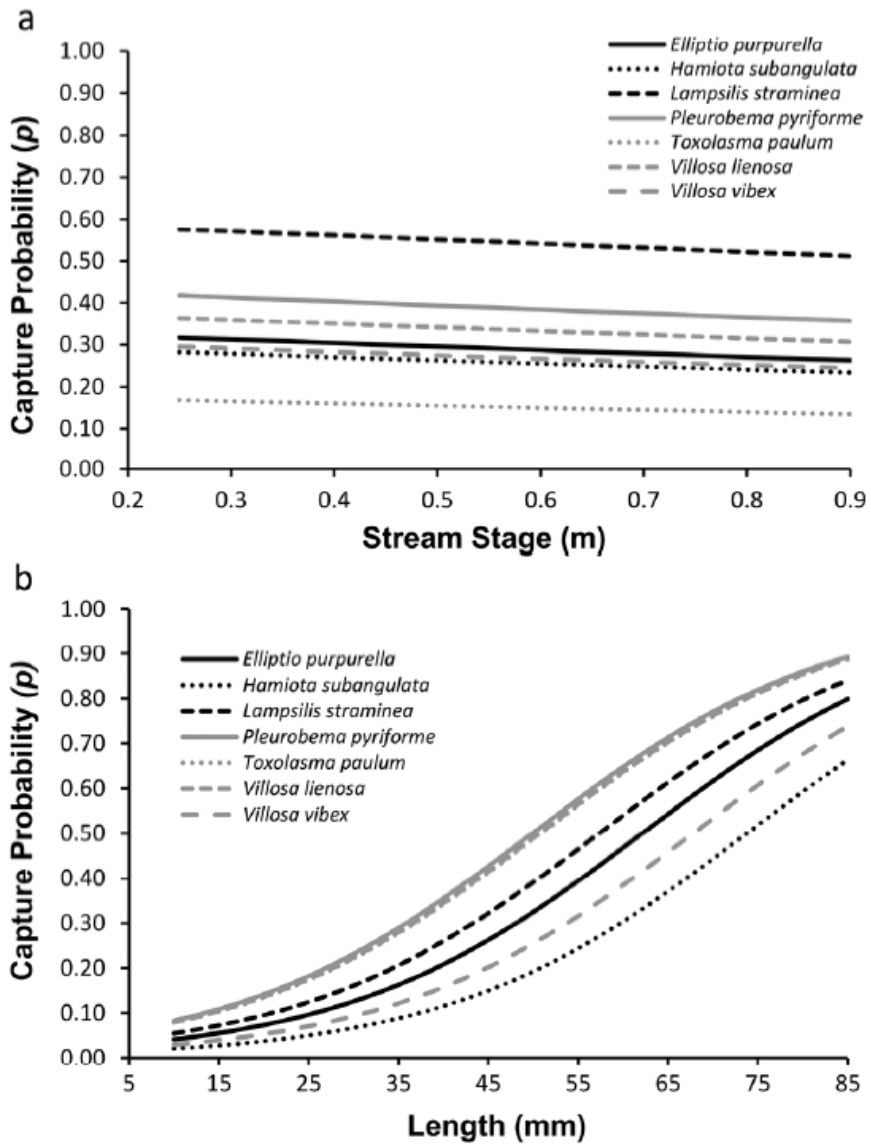
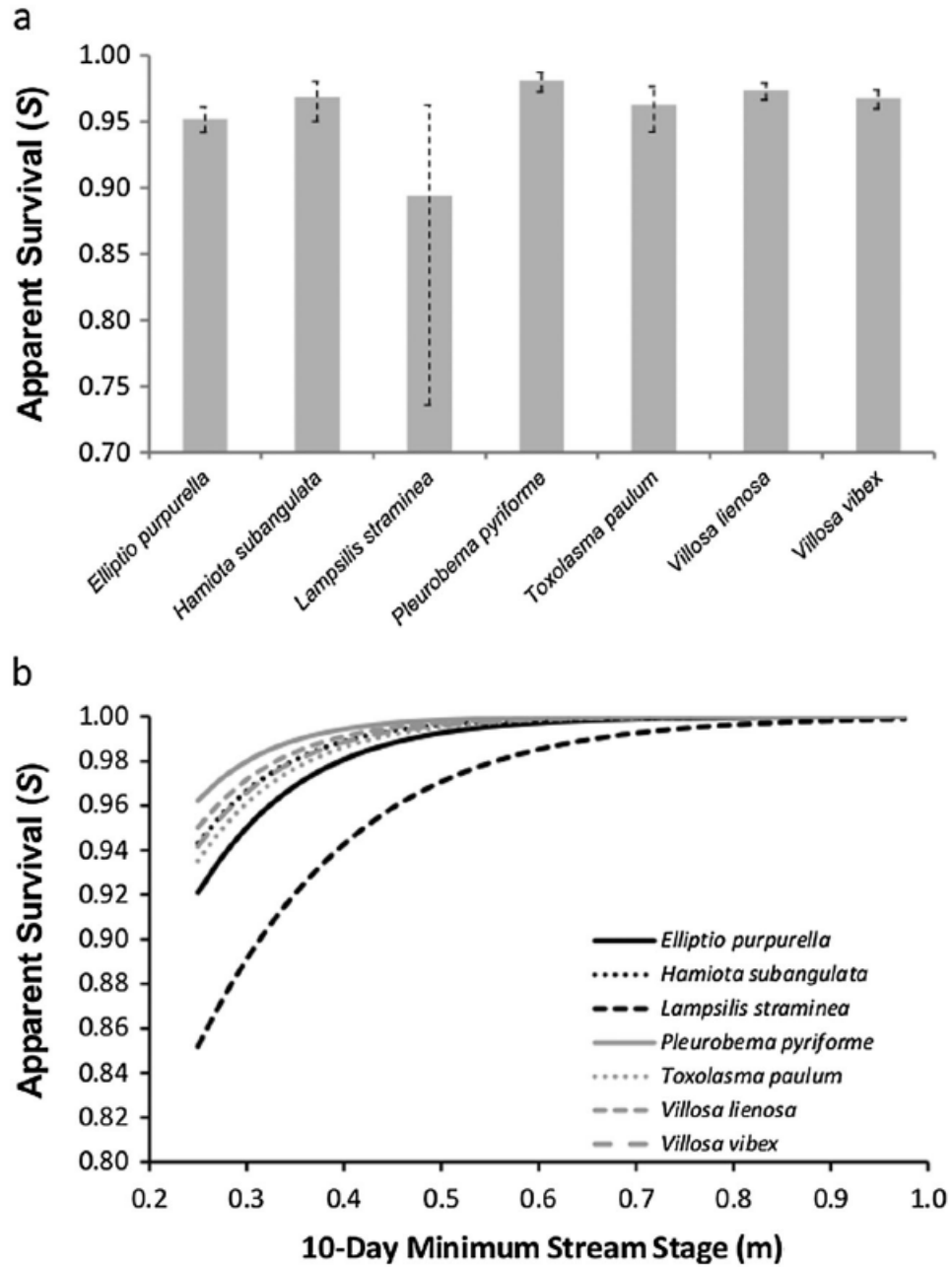


Figure 7. Estimated capture probability (p) of freshwater mussel species in Spring Creek, Georgia, by (a) stream stage at time of sampling and (b) individual animal length from August 2011 to September 2014

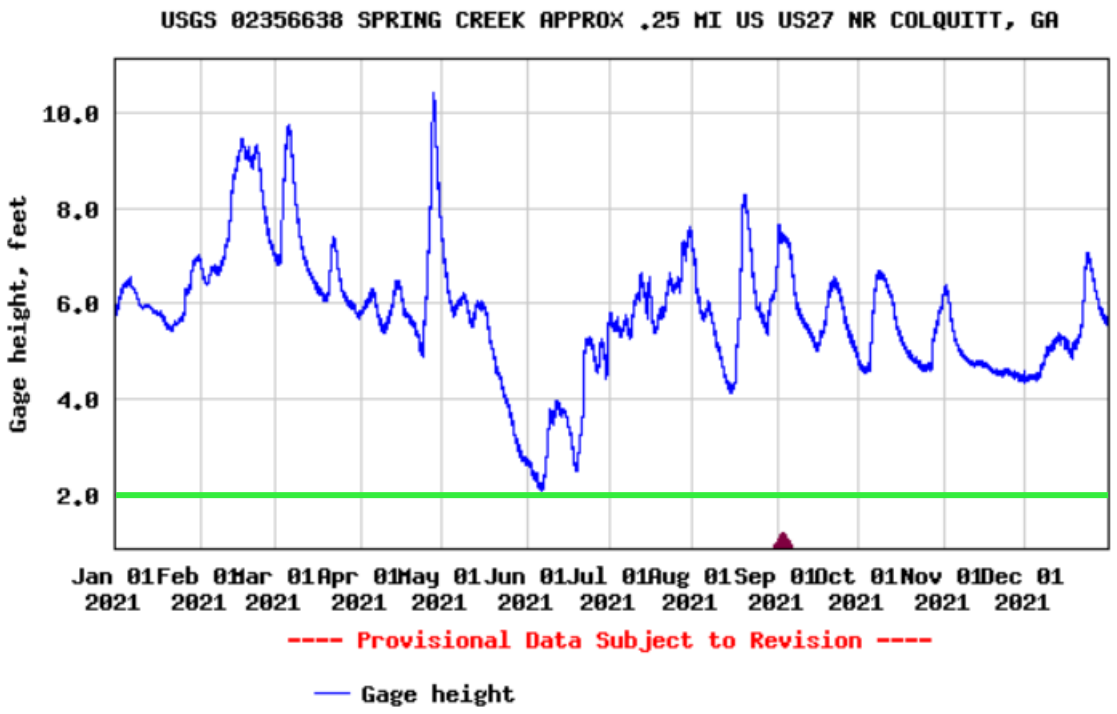


Estimated apparent survival (S) of (a) individual species at a stream stage of 0.30 m, including 95% confidence intervals and (b) species by 10-day minimum stream stage in Spring Creek, Georgia, from August 2011 to September 2014

Major Conclusions

- Survival was related to flow
- Survival was high and similar in all three treatment reaches, likely indicating that augmentation levels were not sufficient to mitigate flow related mortality at the levels observed.
- Variability in temporary emigration was not sufficient to trigger burrowing behavior in mussels
- Sever drought conditions were not experienced during the study and the efficacy of augmentation as a short-term strategy has not yet been adequately assessed

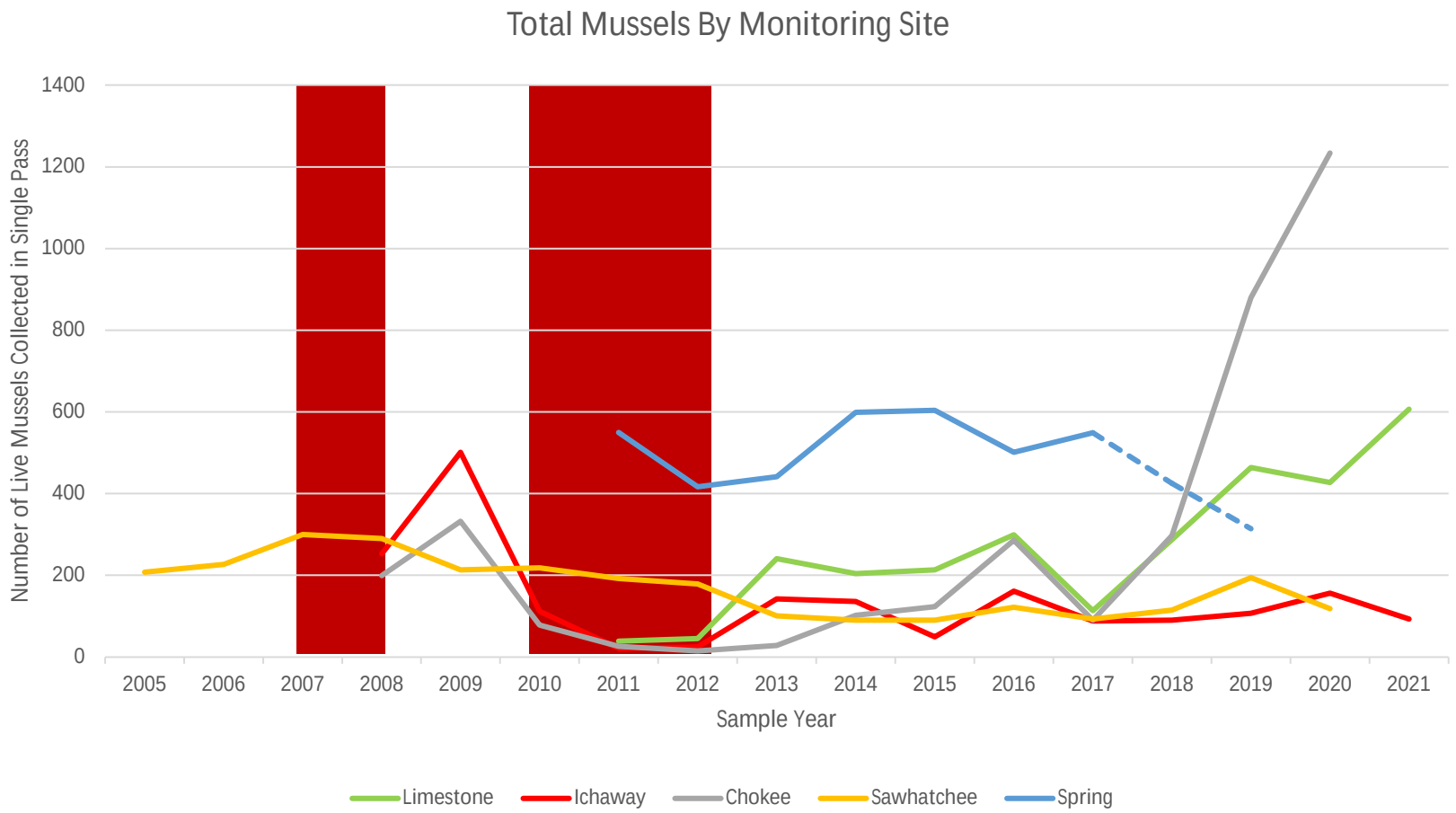
Challenges



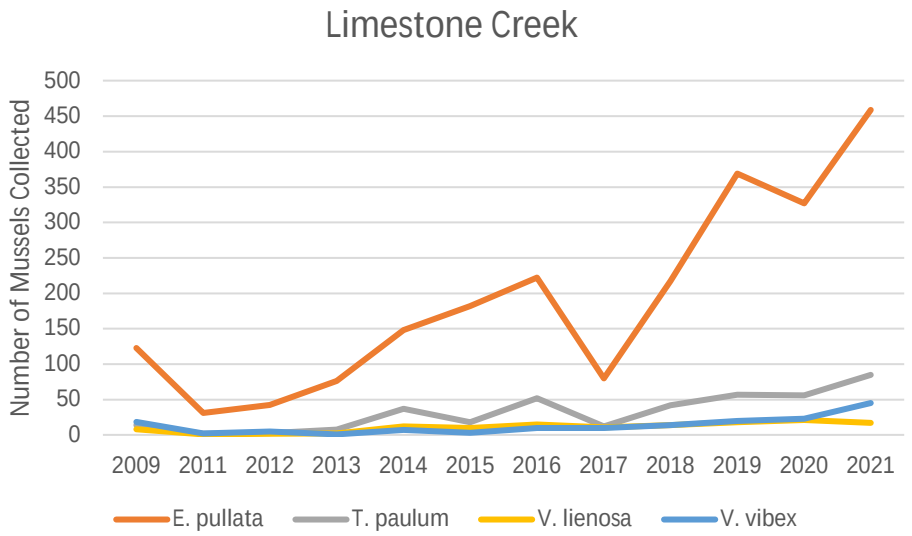
Gauge Hight for Spring Creek Monitoring Site
Jan-Dec 2021

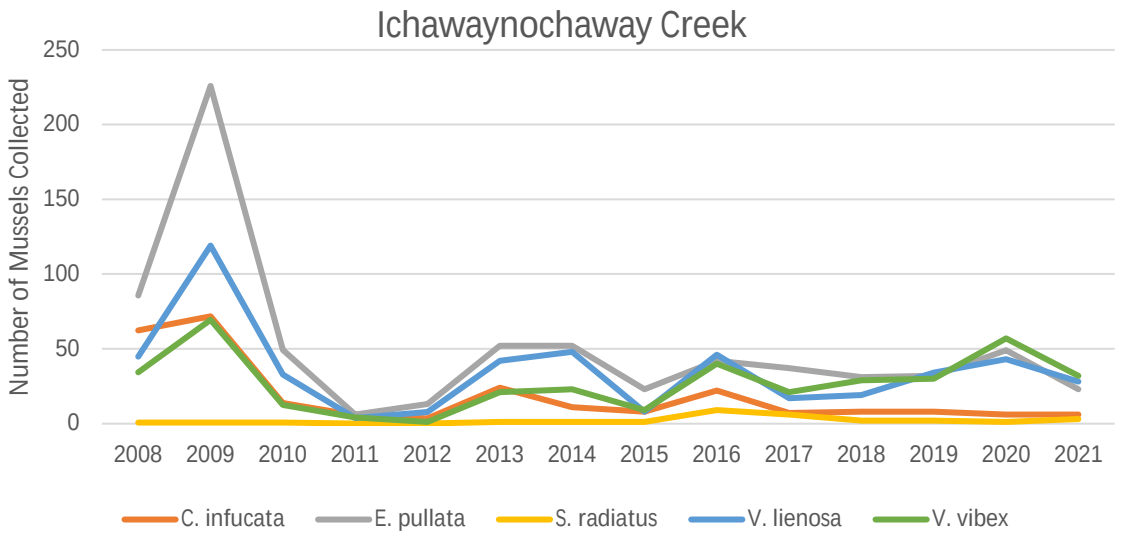
Spring Creek, May 2019

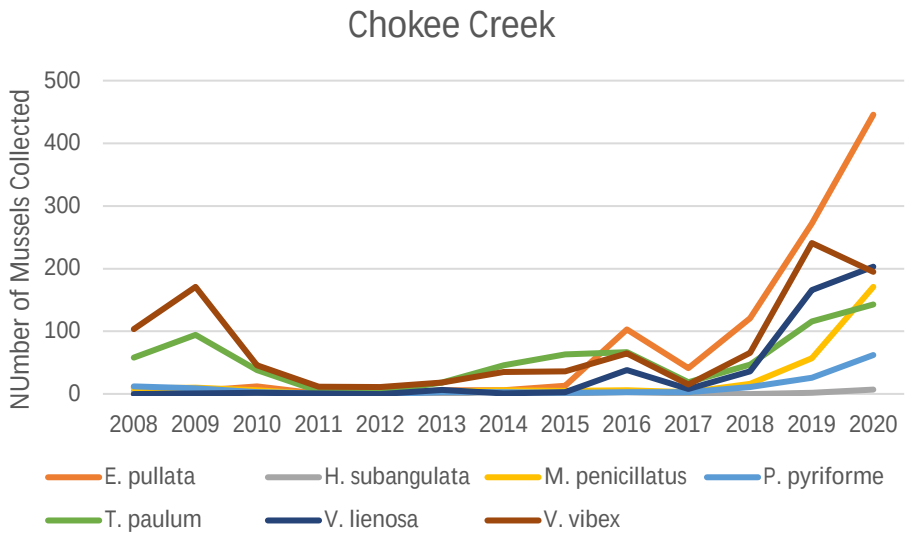
Trends

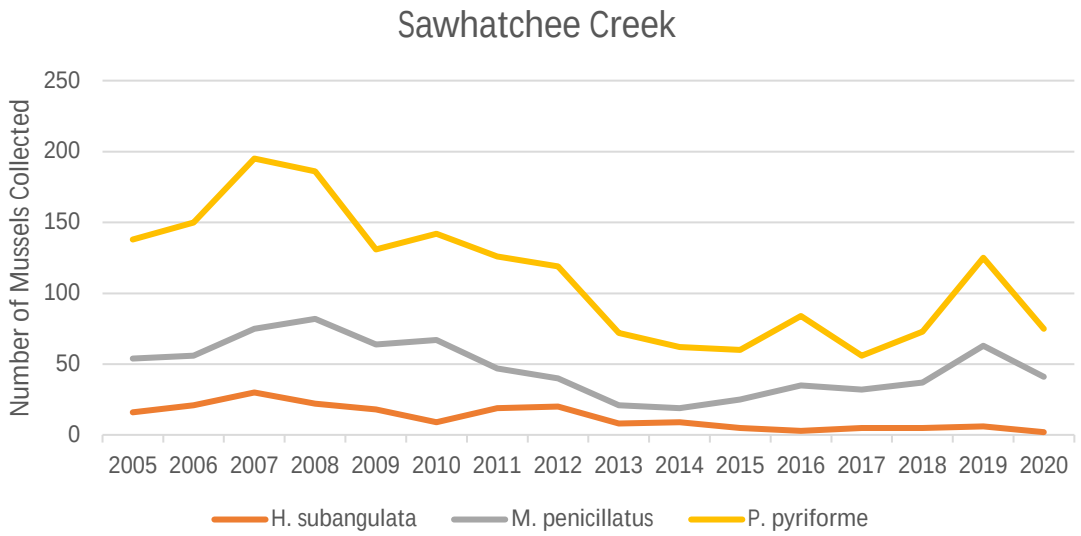

Total Mussels By Monitoring Site
Number of Live Mussels Collected in Single Pass
1400
1200
1000
800
600
400
200
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Sample Year
Limestone
Ichaway
Chokee
Sawhatchee
Spring

Trends


Limestone Creek
Number of Mussels Collected
500
450
400
350
300
250
200
150
100
50
0
2009 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
E. pullata
T. paulum
V. lienosa
V. vibex


Ichawaynochaway Creek
Number of Mussels Collected
250
200
150
100
50
0
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
C. infucata
E. pullata
S. radiatus
V. lienosa
V. vibex


Chokee Creek
NUmber of Mussels Collected
500
400
300
200
100
0
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
E. pullata
H. subangulata
M. penicillatus
P. pyriforme
T. paulum
V. lienosa
V. vibex


Sawhatchee Creek
Number of Mussels Collected
250
200
150
100
50
0
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
H. subangulata
M. penicillatus
P. pyriforme


03883915
30-412-1
6"/.001" DIAL CAL
DIAL PLASTIC CALIPER
1 CM

Thanks to:

Golden Triangle RC&D

Resource Conservation and Development Council

Southwest Georgia

GEORGIA Water PLANNING & POLICY CENTER

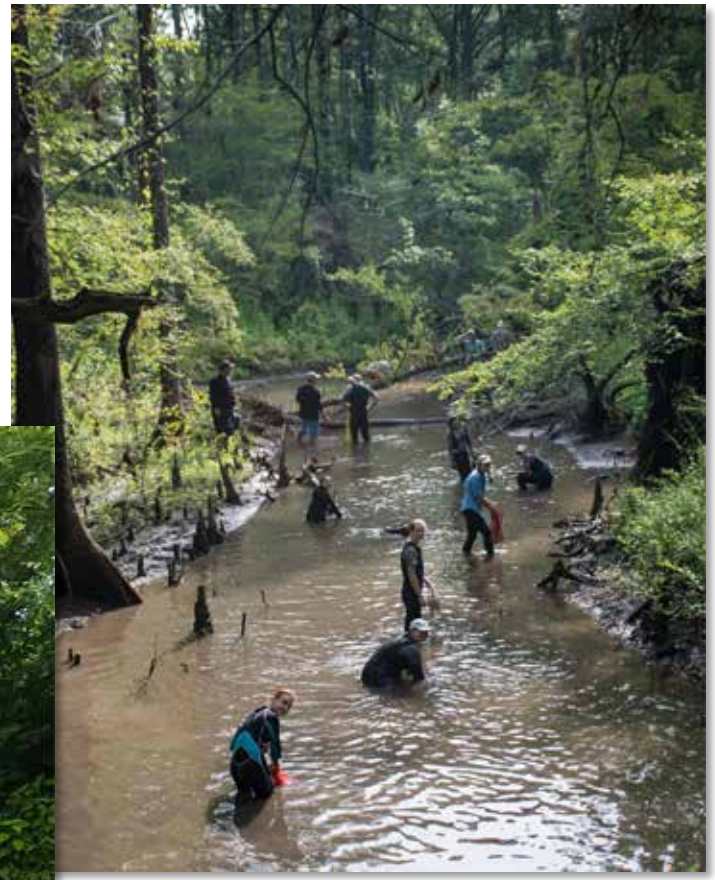
ALBANY STATE UNIVERSITY

U.S. FISH & WILDLIFE SERVICE

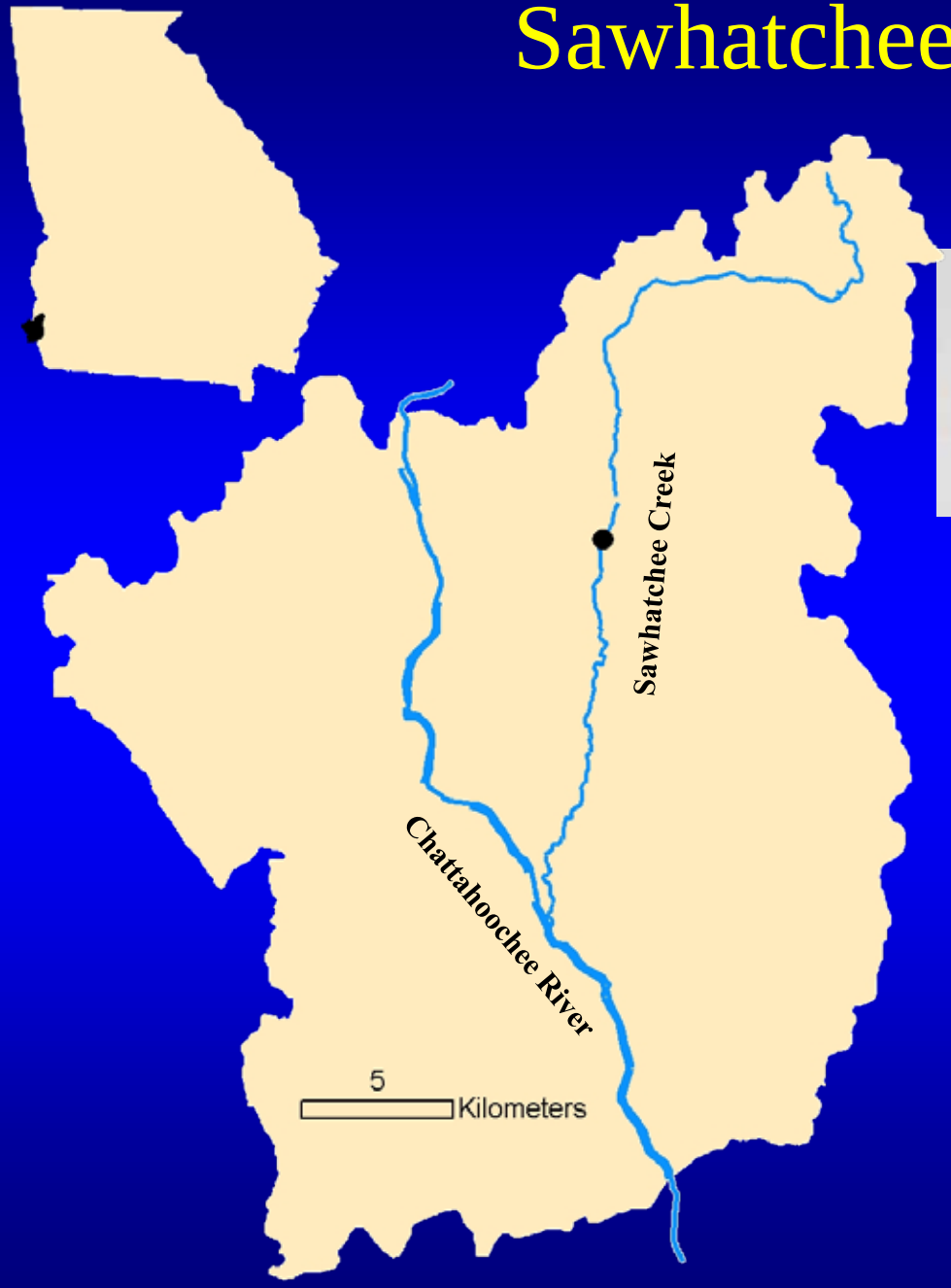
DEPARTMENT OF THE INTERIOR

THE JONES CENTER AT ICHAUWAY

ACF Mussel Workshop Aug 1-4 2022



Sawhatchee Creek



One of the last measurable populations of 3 listed unionids

14 total unionid species

~ 7 meters wide

Mostly sand substrate with ample woody debris

Relatively undisturbed watershed

Sawhatchee Creek Population Monitoring

Objectives:

1. Assess the population of endangered unionids
2. Verify recent recruitment
3. Verify gravidity
4. Measure long-term individual growth

Methods:

150 meter stream reach sampled

Mark-recapture endangered unionids

Sampled once annually in May/June beginning in 2005

Generated detection CJS models in MARK

Detection Probability

Definition:

The probability that a species/individual is detected given that the species/individual is present at a location

Why is it important?

3 states:

Present and collected

Present and not collected

Not present

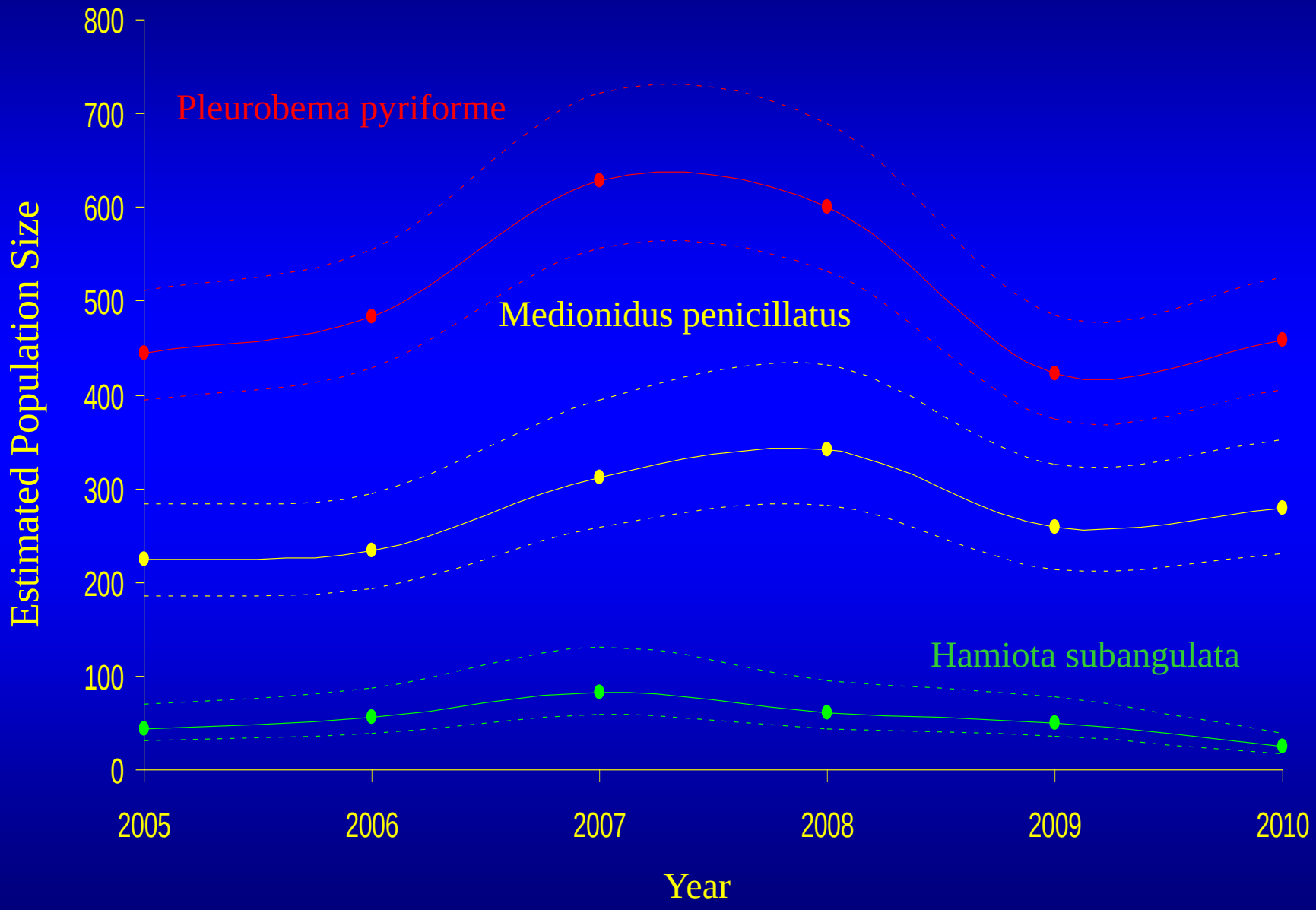
We only collect a small proportion of the animals within the site and can estimate this proportion

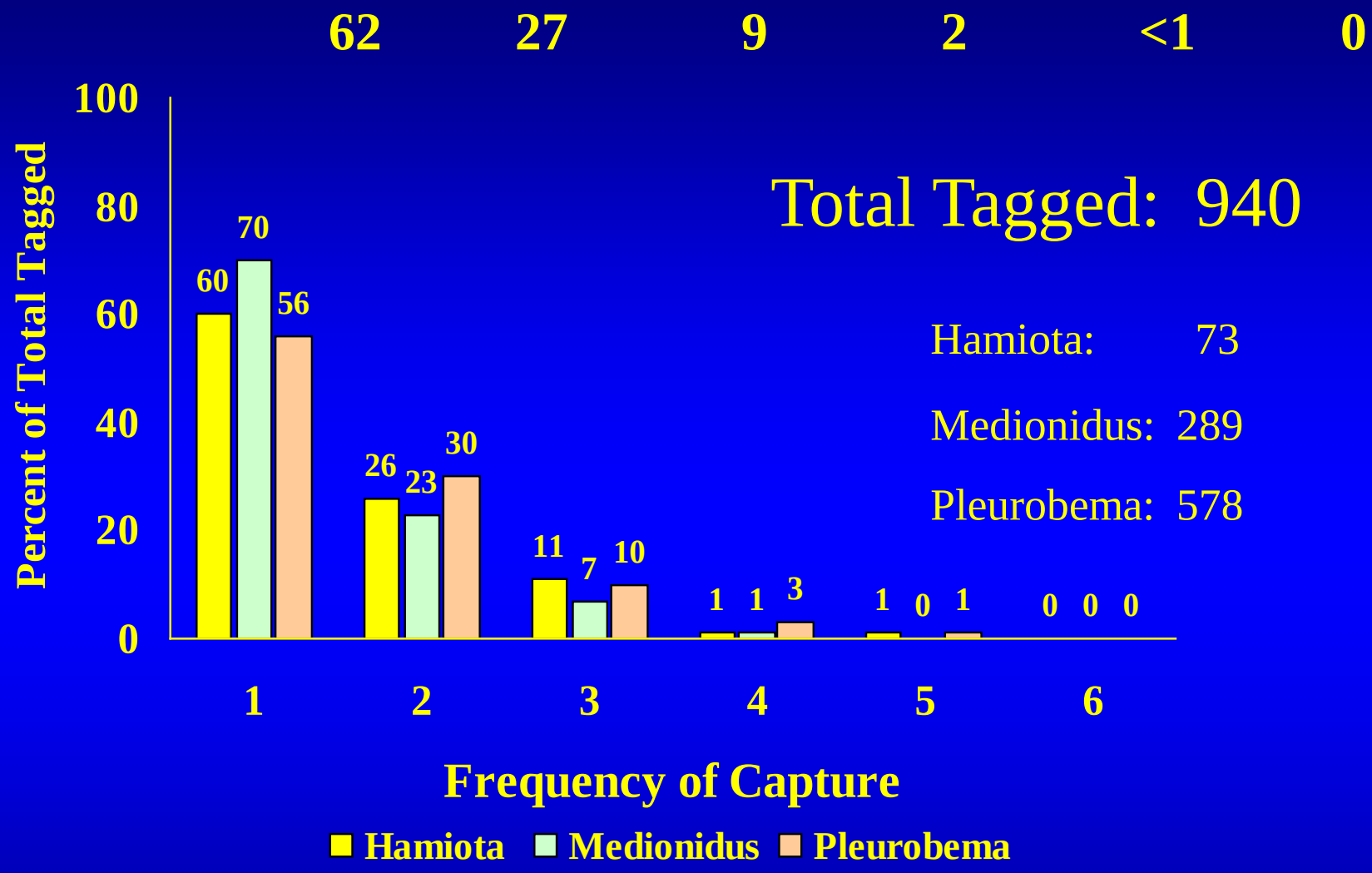
Total Catch by Year

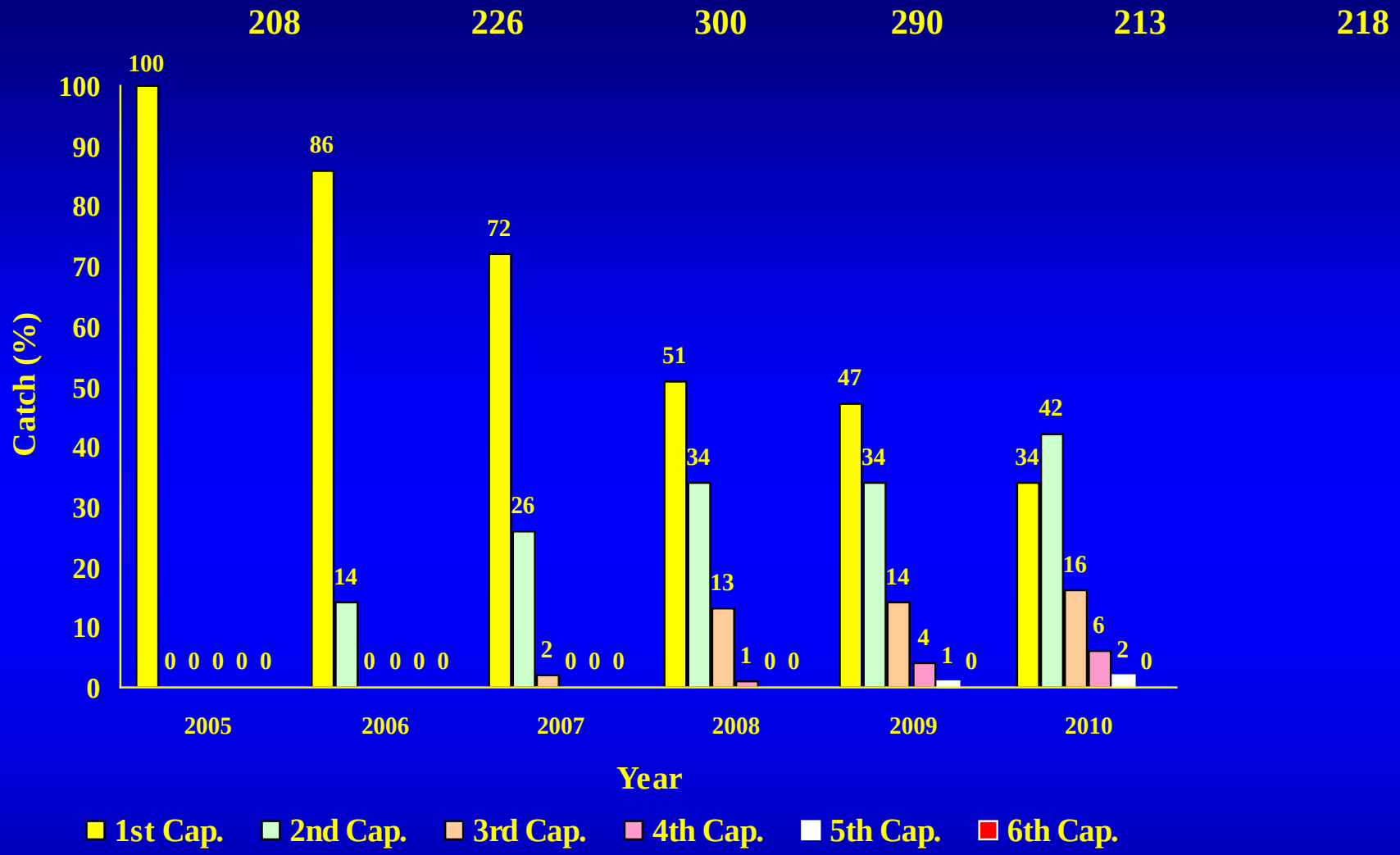
	05	06	07	08	09	10	Mean	St. Dev.
P.p.	138	150	195	186	131	142	157	27
M.p.	54	56	75	82	62	67	66	11
H.s.	16	20	30	22	18	9	19	7
Total	208	226	300	290	213	218	242	42

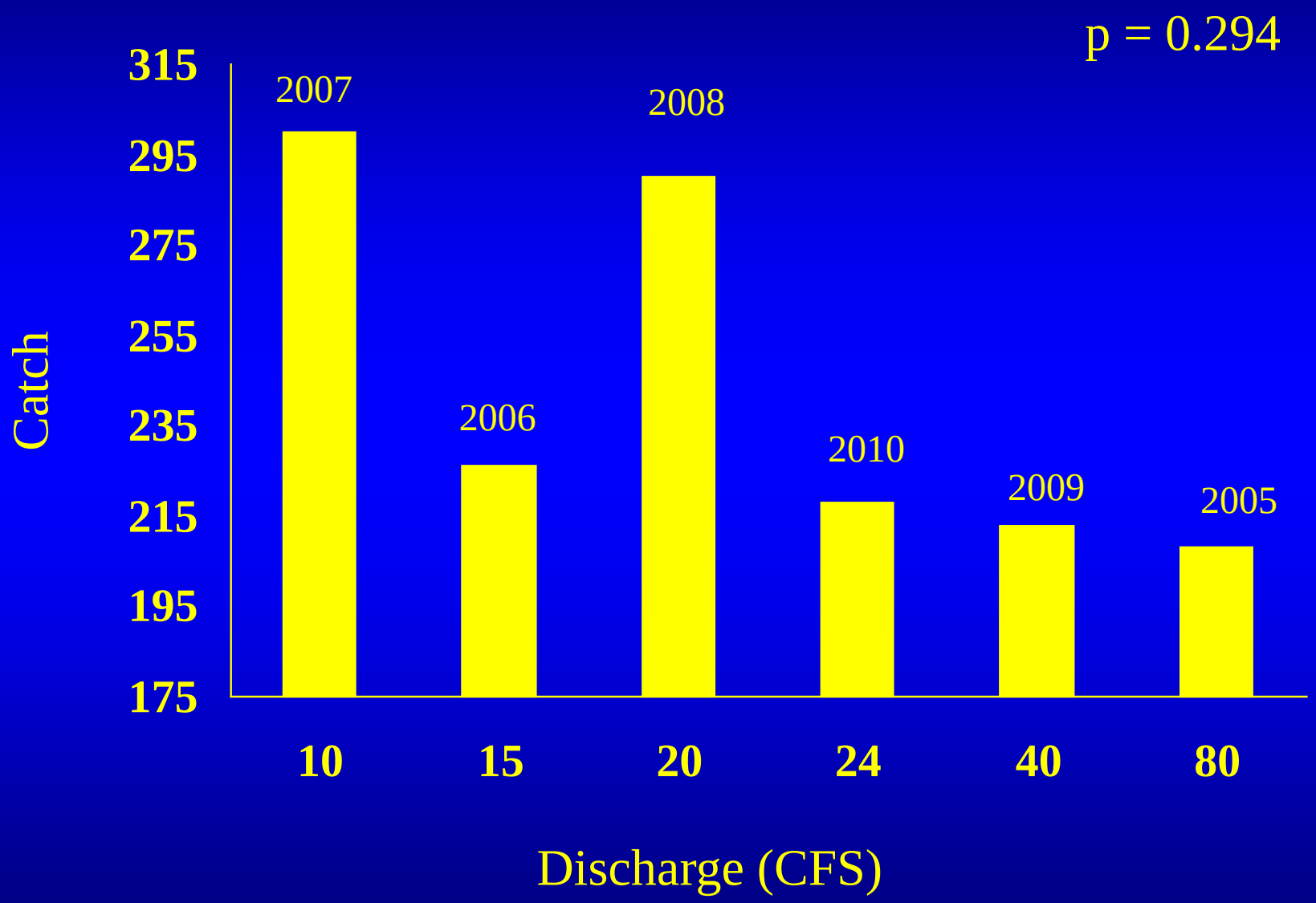
Species	Capture probability	95% CI LL	95% CI UL
Pleurobema pyriforme	0.36	0.27	0.35
Medionidus penicillatus	0.24	0.19	0.29
Hamiota subangulata	0.31	0.23	0.51

Population Estimate

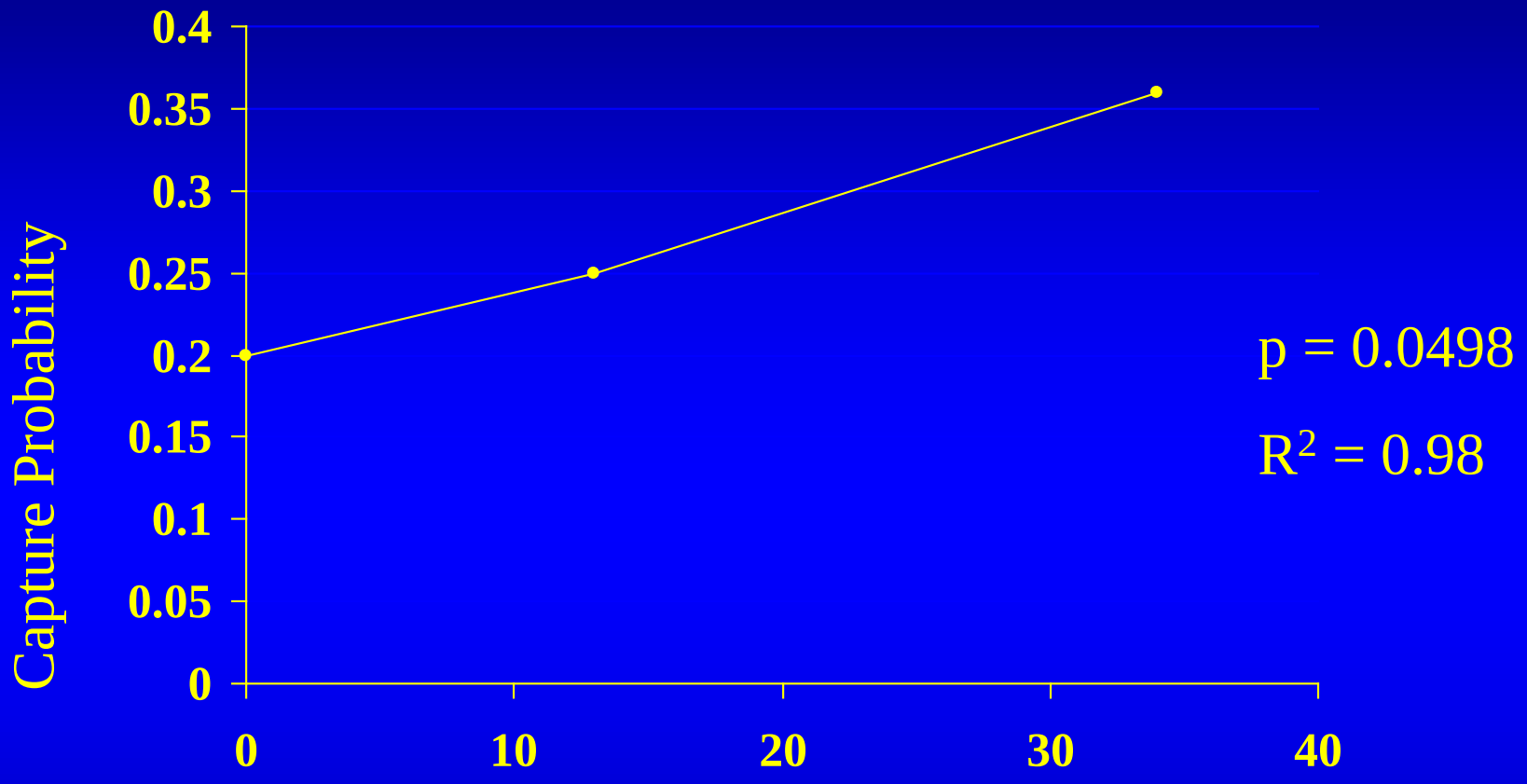



62
27
9
2
<1
0
Total Tagged: 940
Hamiota: 73
Medionidus: 289
Pleurobema: 578
Percent of Total Tagged
100
80
60
40
20
0
60
70
56
26
23
30
11
7
10
1
1
3
1
0
1
0
0
0
1
2
3
4
5
6
Frequency of Capture
Hamiota
Medionidus
Pleurobema


208
226
300
290
213
218
Catch (%)
100
90
80
70
60
50
40
30
20
10
0
100
0 0 0 0 0
86
14
0 0 0 0
72
26
2
0 0 0
51
34
13
1
0 0
47
34
14
4
1
0
34
42
16
6
2
0
2005
2006
2007
2008
2009
2010
Year
1st Cap.
2nd Cap.
3rd Cap.
4th Cap.
5th Cap.
6th Cap.


p = 0.294
Catch
315
295
275
255
235
215
195
175
2007
2006
2008
2010
2009
2005
10
15
20
24
40
80
Discharge (CFS)

Pleurobema detection



Conclusions

Mean capture probabilities of the 3 focal species was approximately 0.30

- Varied by species and year

~3% of tagged individuals were captured more than 50% of sampling occasions

- 5 sampling occasions needed until recaps outnumbered 1st captures

- 54% of individuals tagged in 2005 have not been recaptured

Capture probabilities may increase when individuals are brooding

Bigger waters will likely result in even lower detection