

## Conservation Assessment of the Yazoo Darter (*Etheostoma raneyi*)

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**Abstract** - We summarized all known historical and contemporary data on the geographic distribution of *Etheostoma raneyi* (Yazoo Darter), a range-restricted endemic in the Little Tallahatchie and Yocona rivers (upper Yazoo River basin), MS. We identified federal and state land ownership in relation to the darter's distribution and provided quantitative estimates of abundance of the species. We also quantified sex ratio and mean size of males and females, summarized abiotic and physical characteristics of streams supporting the species, and characterized the fish assemblage most often associated with the Yazoo Darter. Yazoo Darters are generally limited to headwater streams, have a female-skewed sex ratio, and have larger males than females. Individuals in the Yocona River drainage are larger than in the Little Tallahatchie River drainage. Abundance was highly variable among streams within the two major drainages, but was similar within and between drainages. Yazoo Darter habitat in the Little Tallahatchie River drainage has some protection because many streams supporting this species are on land managed by federal or state agencies. Streams with Yazoo Darters are far less common in the Yocona River drainage, have almost no protection, and face growing pressure from urban expansion. For these reasons, management action is urgently needed for Yocona River populations.

### Introduction

*Etheostoma raneyi* Suttkus and Bart (Yazoo Darter) (Percidae: subgenus *Adonia*) is a range-restricted fish endemic to the Yocona, Little Tallahatchie, and Tippah river systems of the upper Yazoo River basin in north-central Mississippi (Fig. 1; Johnston and Haag 1996, Suttkus et al. 1994, Thompson and Muncy 1986). The species is classified as vulnerable by the Southeastern Fishes Council (Warren et al. 2000) and American Fisheries Society (Jelks et al. 2008), as globally imperiled by the Nature Conservancy (NatureServe 2013), and as sensitive by the USDA Forest Service (USDA Forest Service 2013). The Mississippi Comprehensive Wildlife Conservation Strategy lists the Yazoo Darter as a Tier 1 species of greatest conservation need in the Upper East Gulf Coast Plain Ecoregion (Mississippi Natural Heritage Program 2002).

Yazoo Darters are small (<65 mm SL), benthic insectivores living  $\leq 3$  years, and most individuals do not survive their first year (Johnston and Haag 1996). Recent phylogenetic analyses using mitochondrial DNA recovered two monophyletic clades that are congruent with localities of Yazoo Darter specimens from the Little Tallahatchie River and Yocona River drainages (Powers and Warren 2009). Based on this genetic information, Powers and Warren (2009)

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recommended these two allopatric populations of Yazoo Darters be treated as separate management units.

Although not formally described until 1994 (Suttkus et al. 1994), the Yazoo Darter was recognized as distinct in earlier surveys (Randolph and Kennedy 1974, Thompson and Muncy 1986) within its range, which provided substantial historical distributional information from the 1960s, 1970s, and 1980s. Suttkus et al. (1994) indicated the first known collection of Yazoo Darters occurred in 1952 at Pumpkin Creek (Lafayette County, MS) and provided other collection localities through the early 1990s. S.T. Ross (2001; University of New Mexico, Albuquerque, NM, pers. comm.) furnished records primarily from the 1980s through the mid-1990s. Under the auspices of the USDA Forest Service (USFS), one of us (M.L. Warren, Jr.) conducted an extensive set of surveys throughout the range of the species from 1999 to 2003 (Warren et al. 2002) and again from 2009 to 2011.

The goal of this study was to summarize known distributional, habitat, and biological data for the species including new information from our recent work. Specifically we had six objectives: 1) summarize all known historical and contemporary data on geographic distribution of the species, 2) identify federal and state land ownership in relation to the darter's distribution, 3) provide quantitative estimates of the species' abundance, 4) quantify sex ratio and mean size of male and female fish, 5) summarize abiotic characteristics of streams supporting the species, and 6) characterize the fish assemblage most often associated with the Yazoo Darter. Our findings provide crucial information for the conservation of this species and a basis for future research.

### **Field-site Description**

The range of the Yazoo Darter lies within the Northern Hilly Gulf Coastal Plain Ecoregion (Chapman et al. 2004) of north-central Mississippi (Fig. 1), which consists of low rolling hills with elevations ranging from 80 to 180 m. The region has experienced significant anthropogenic habitat alteration. Beginning in the mid-19<sup>th</sup> century, forests were removed and land was converted to agricultural use, leading to widespread and dramatic erosion, which filled stream valleys with sediment and exacerbated flooding problems (Cooper and Knight 1991, Shields et al. 1994). Localized efforts toward flood prevention and land reclamation by straightening and channelizing streams met with little success (Shields et al. 1994). The so-called Great Flood of 1927 affected seven states including Mississippi and prompted the federal government to alter streams in an effort to prevent catastrophic flooding. Within the range of the Yazoo Darter, large (>40,000 ha) flood-control impoundments were constructed on the Yocona and Tallahatchie Rivers, extensive stream reaches were straightened and channelized, and hundreds of headwater streams were impounded by small dams. These actions, particularly stream channelization, altered stream gradients, which resulted in stream incisement and headcutting in nearly all headwater streams (Shields et al. 1998). Channelized and incised streams tend to be shallow, sandy, homogeneous, turbid, and unstable with flashy flows (Adams et al. 2004; Shields et al. 1994, 1998; Simon and Darby 1997).

## Methods

We used a hierarchical organization of sample locations based on watersheds for comparative analyses detailed later in the Methods section (Fig. 1). Hereafter, we use the phrases Yocona R. drainage and Tallahatchie R. drainage to refer to these two river systems. We use the term unit to refer to groups of sample locations within subdrainages of these two river systems. We grouped sample locations within the Yocona R. drainage into two units: the Otoucalofa Creek Unit and the Yocona R. Unit. We grouped locations in the Tallahatchie R. drainage into three units: the Cypress Creek Unit, the Tippah River Unit, and the Tallahatchie R. Tributaries Unit, which includes all locations within the Tallahatchie R. drainage except those within the Tippah River and Cypress Creek units. We used the terms drainage and unit to help distinguish these analytical groupings from more general references to watersheds and tributaries, which are defined in the usual way.

### Compilation of historical and current records

We compiled historical records (pre-1999) for Yazoo Darters from the following sources: published literature (Johnston and Haag 1996, Randolph and Kennedy 1974, Ross 2001, Suttkus et al. 1994, Thompson and Muncy 1986); unpublished data (Mississippi Museum of Natural Sciences [T. Slack, Jackson MS, unpubl. data], Tulane Museum of Natural History [H. Bart, Tulane University, Belle Chase LA, unpubl. data]); and collection records from other USFS colleagues (W. Haag, USFS, Oxford, MS, unpubl. data). We incorporated recent records (post-1998) from our own database for the 1999–2003 USFS surveys, and from our own recent samples (2009–2011) into the database (Appendix I). Here, we use the term location to refer to a physical site within a stream that was sampled for fishes (i.e., the unique site IDs in Appendix 1).

### Field methods

We predetermined reach lengths sampled for Yazoo Darters and other fishes in order to make sampling effort proportional to stream size (Angermeier and Smogor 1995, Paller 1995). In 1999, we calculated reach lengths of streams 4–14 m wide as 20 times the average width. In 2000–2003, we sampled reaches that were 30 times the average stream width. In 1999, we set a minimum reach length of 80 m for streams <4 m average width. In later samples, minimum reach length was 120 m for streams <4 m average width. We set a maximum reach length of 300 m for streams >15 m average width. Changes in reach length were made to more thoroughly characterize stream habitat and to increase the probability of detecting uncommon fishes.

For fish samples ( $n = 93$ ) collected in 1999–2003 (Warren et al. 2002), we standardized effort for single-pass backpack electrofishing and seining to reduce bias and ensure capture of a representative sample of all fishes. We predetermined electrofishing effort by multiplying the reach length (see preceding paragraph) by 5 seconds (i.e., we electrofished 5 seconds/m) and we allocated time fished along the entire reach and all available habitats. We indexed fish abundance as the number of fish sampled per minute of electrofishing. We conducted 8 seine-hauls for streams <5 m average width and 12 seine-hauls for streams >5 m average width. We defined

a haul as either a sustained pull within a stream habitat such as a pool or one set-and-kick in a riffle (Jenkins and Burkhead 1994). We allocated seine hauls along the entire reach and attempted to sample all available habitats (riffles, runs, and pools).

For our 2009–2011 fish samples ( $n = 97$ ), Yazoo Darters were specifically targeted using only single-pass backpack electrofishing. We quantified abundance of Yazoo Darters by electrofishing from 300–5734 seconds (mean = 1076.7, SE = 181.4) in a reach depending on the size of the stream. We sampled most streams from March 2009 through July 2009. We recorded all fishes captured and measured, and sexed all Yazoo Darters. Sex was determined by presence or absence of male breeding colors, primarily the orange pigment present year round on mature males. Immature fish (<30 mm) were not sexed but were used for all other analyses including abundance estimates.

In a related study, we sampled three locations (sites 7180, 6821, and 6852; Appendix 1) in separate streams periodically (June–July 2009, September–October 2009, January 2010, April–May 2010, September 2010, March 2011, June–July 2011). A fourth location (site 7053; Appendix 1) was added to our periodic sampling September–October 2009. At these locations, we used standardized fish-sampling methods described previously for 2000–2003. All data collected were used for all analyses, including abundance estimates.

We recorded habitat variables for our 1999–2003 samples after sampling for fishes. Within each reach, we established 12 equally spaced transects (distance between transects, 6.67–25 m) along the pre-determined fish-sampling reach. At each transect, we measured wetted width and visually estimated stability (eroding or stable) and height of each bank. However, because measures of right and left bank stability and right and left bank height were highly correlated (data available on request), we used data from the right bank only to reduce the number of variables used for analyses. We measured water depth (cm) and water velocity (m/sec at 0.6 depth) at equally spaced points along each transect. We also recorded presence or absence of detritus, small wood (<10 cm diameter or <1.5 m in length), large wood (>10 cm diameter or >1.5 m in length), and aquatic vegetation, and visually estimated percentage canopy cover at each point as 0, 25, 50, 75, or 100%. We adjusted the number of points per transect depending on stream width (transects >10 m in width = points at 2-m intervals; 5–10 m in width = points at 1-m intervals; <5 m in width = 5 sample points). Because the number of points used to measure variables varied depending on stream width, variables measured as present or absent are proportional.

### **Data analyses**

We calculated abundance, sex ratios, and mean standard length (SL) of Yazoo Darters using post-1998 data (Warren et al. 2002) and data from our recent surveys (2009–2011). We estimated abundance at sampling locations as the number of Yazoo Darters captured per minute of electrofishing (CPUE)  $\pm$  95% confidence intervals. Yazoo Darters captured by seine are not included in the abundance estimates. We calculated sex ratios, mean SL of male and female darters, and mean SL of males and females combined for watershed units within the Tallahatchie R. drainage and the Yocona R. drainage and for all sample locations within each drainage

combined (Fig. 1). We tested if sex ratios deviated significantly from 1:1 in each unit within a drainage (chi-square goodness of fit, nonparametric exact *P*-values; StatXact version 8 [Cytel, Inc. 2007]) and for differences in SL between sexes among units within drainages and between drainages (ANOVA, PopTools [Hood

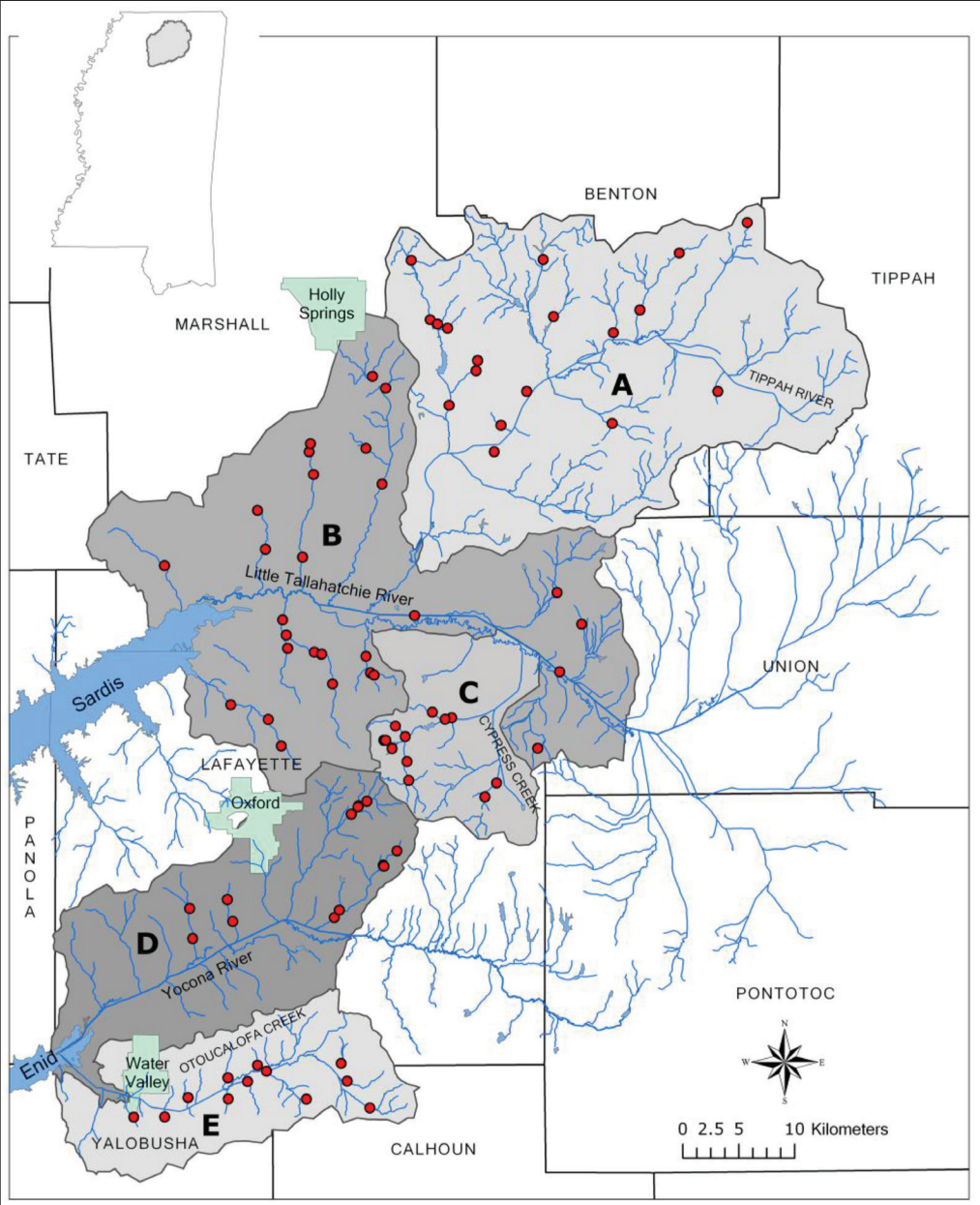


Figure 1. Major drainages, units, counties, and cities within the range of the Yazoo Darter in north-central Mississippi; red circles show location of all known Yazoo Darter collections. Tallahatchie R. units are outlined and lettered as: A = Tippah River Unit, B = Tallahatchie R. Tributaries Unit, and C = Cypress Creek Unit. Yocona R. watershed units are outlined and lettered as: D = Yocona R. Unit and E = Otoucalofa Creek Unit.

2010]). We calculated 95% confidence intervals for sex ratios and mean SL for all units and drainages.

Using data from the 1999–2003 locations at which Yazoo Darters were present, ( $n = 37$ ), we determined stream link (Osborne and Wiley 1992) and stream order (Strahler 1957) from USGS 7.5-minute topographic maps by counting perennial and intermittent streams. We counted perennial and intermittent streams because stream-flow designations are unreliable in our region. As a consequence, our estimates of these measures are inflated as compared to estimates obtained by counting only perennial streams as described in the original papers. We also determined watershed area ( $\text{km}^2$ ) for each of these locations using either USGS 7.5-minute topographic maps or DeLorme TopoUSA version 7.1.0. We then calculated means ( $\pm$  SD) for each of these variables and calculated mean values ( $\pm$  SD) for wetted width, water depth, and water velocity from each site.

We tested possible relationships between abiotic habitat variables and Yazoo Darter abundance and presence/absence data. First, we used principle components analysis (PCA; PC-Ord ver. 5 [McCune and Mefford 1999]) to reduce 12 abiotic variables (stream order, watershed area, wetted width, water depth, water velocity, detritus, small wood, large wood, aquatic vegetation, canopy cover, bank height, and bank stability) to a smaller number of synthetic variables that retained most of the information from the original data. Mean values per location were calculated for all variables except for proportional variables (detritus, small wood, large wood, aquatic vegetation, and bank stability). Proportions were calculated from the presence or absence of variables at sample points along transects (see Field methods section) except for bank stability, for which we used the proportion of transects with stable banks. We square-root transformed all data except proportional data, which we arc-sin square-root transformed. We determined the number of interpretable axes generated by PCA using the broken-stick method (Jackson 1993). We then correlated (Pearson coefficient, JMP 5.1 statistical software [SAS Institute 2002]) Yazoo Darter abundance at each location with the site scores from each PCA axis. We also used logistic regression to test for relationships between presence/absence data (likelihood ratio test; JMP 5.1 statistical software [SAS Institute 2002]) and site scores from each PCA axis.

We used indicator species analysis (ISA) as implemented in PC-ORD version 5.0 (McCune and Mefford 1999) to identify and test for significant fish species associations with Yazoo Darters using Monte Carlo methods. The test statistic is the maximum indicator value estimated for each species. Maximum indicator values result from multiplying the proportional abundance of a species in a given group relative to the abundance of that species in all groups and the proportional frequency of a species in each group (Dufrene and Legendre 1997). Presence or absence of Yazoo Darters per site was used as the grouping variable, and 10,000 permutations were used for Monte Carlo iterations. Species occurring at  $\leq 5$  ( $\approx 5\%$ ) sites were dropped from the analysis. Lampreys were not identified to species in the field because many individuals were larvae, but we believe that a high proportion of lampreys sampled were *Lampetra aepyptera* Abbott (Least Brook Lamprey). For this reason, we grouped all lampreys sampled.

We omitted two locations sampled in the 1999–2003 surveys (sites 6814 and 6819; Appendix 1) from all of our analyses because they were statistical outliers for watershed area, average wetted width, and average depth. We determined this using an outlier box plot (JMP 5.1 statistical software; SAS Institute 2002). Each location was from the mainstem Tallahatchie R. Canal, and each location had one juvenile Yazoo Darter recorded. We address the implications of omitting these sites in the Discussion section.

## Results

Our data compilation of historical and contemporary sampling records yielded 224 records of Yazoo Darters, including multiple samples at the same location over time, out of about 1200 total recorded samples for fishes within the known range of the species (Figs. 2, 3; Appendix 1). At any given location of occurrence, Yazoo Darters were detected from 1 to 23 times. A total of 2419 individual Yazoo Darters were captured across all locations and samples. Of the 55 locations yielding Yazoo Darters post-1998, 38 were new, previously unsampled locations. Sixteen locations from the pre-1999 collections were resampled post-1998, with 13 yielding Yazoo Darters. Two locations that yielded darters in 1999–2003 did not in 2009–2011 (sites 6820 and 6877).

Within its relatively narrow range, the Yazoo Darter is dispersed across numerous tributaries in the middle Tallahatchie R. and middle Yocona R. drainages. Within the Tallahatchie R. drainage, the species is known from 11 individual tributaries (18 locations) within the Tippah River Unit, 1 tributary (Puskus Creek: 15 locations) plus 2 locations in the mainstem within the Cypress Creek Unit, and 10 tributaries (31 locations) plus 2 locations in the mainstem within the Tallahatchie R. Tributaries Unit. Within the Yocona R. drainage, the species is known from 4 tributaries (13 locations) in the Yocona R. Unit, and 10 tributaries (10 locations) plus 2 locations in the mainstem within the Otoucalofa Creek Unit. All locations with Yazoo Darters are within the boundaries of the Northern Hilly Gulf Coastal Plain Ecoregion, with the possible exception of two locations (sites 6847 and 7175) that are near the boundary with the Loess Plains Ecoregion (Chapman et al. 2004).

Of 93 locations of known occurrence of the Yazoo Darter, only 26% (24) are on federally or state managed property. Twelve are on federal property managed by the Holly Springs National Forest, 6 are on federal property managed by the United States Army Corps of Engineers, and 6 are on state of Mississippi property (University of Mississippi Field Station and Wall Doxey State Park) (Figs. 2, 3; Appendix 1). These sites represent 9 separate tributary streams. Another 40 locations (43%) are  $\leq 2$  km from federal or state lands and represent 11 separate tributary streams. Most of these locations (33) are in the Tallahatchie R. Tributaries, Tippah River, and Cypress Creek units. The Yocona R. Unit has only 7 such locations, confined to 2 tributaries, and the Otoucalofa Creek Unit has none.

The Yazoo Darter is decidedly a species of small, flowing streams. At 37 locations yielding Yazoo Darters in the 1999–2003 survey, mean stream order, stream link, watershed area, wetted width, water depth, and water velocity all are

indicative of small, shallow, flowing streams (Table 1). The narrow confidence intervals on most of these variables suggest a high affinity for this range of habitat conditions. Examination of survey results in large streams in the area lends further support to the small-stream affinities of the species. A total of 91 samples in our compiled database from mainstem reaches of the Tippah River, Tallahatchie R.,

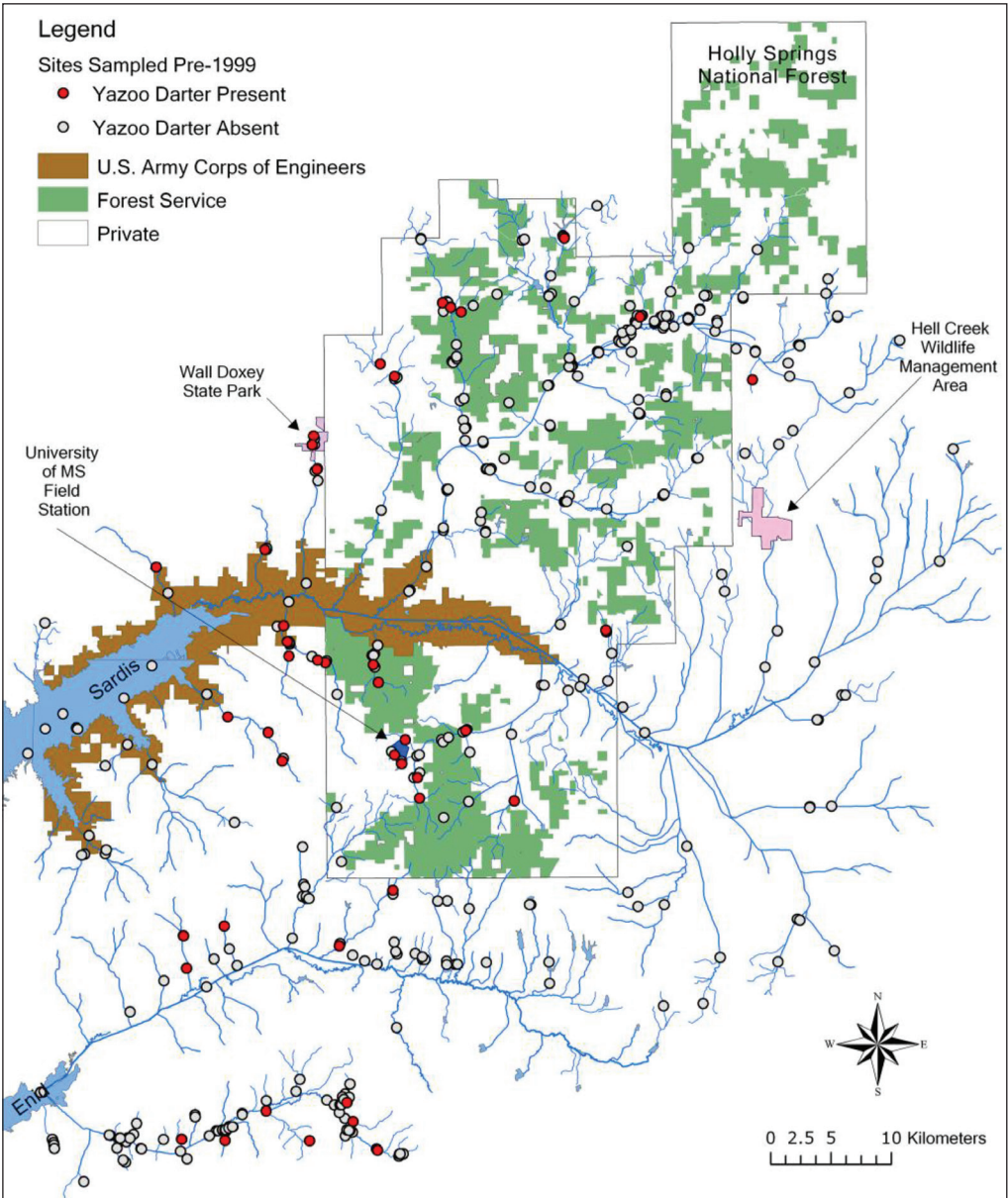


Figure 2. Results of pre-1999 stream samples and landownership across the range of the Yazoo Darter. Solid red circles represent locations that yielded Yazoo Darters, and open circles represent locations that did not yield Yazoo Darters. The polygon encloses the proclamation boundary of the Holly Springs National Forest; federal and state lands are color coded (see legend).

Cypress Creek, Yocona R., and Otoucalofa Creek did not yield Yazoo Darters. However, one juvenile Yazoo Darter was captured from each of two locations in the relatively large Tallahatchie R. Canal in August 1999. Two Yazoo Darters were taken in the mainstem of Otoucalofa Creek (Ross 2001; S.T. Ross, unpubl. data) at the confluence with Sarter Creek (site 4984) in May 1986. Two samples in July

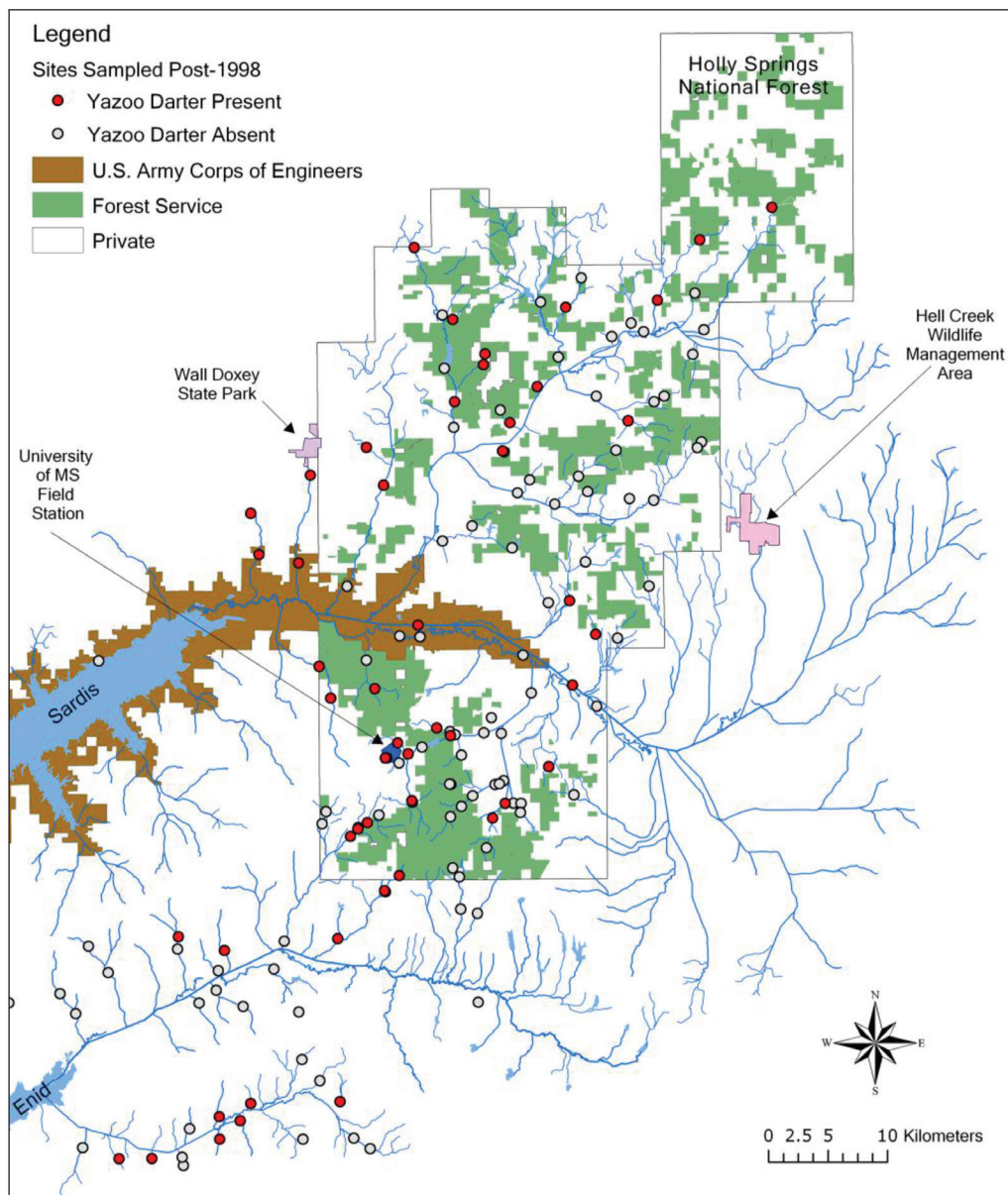


Figure 3. Results of post-1998 stream samples and land ownership across the range of the Yazoo Darter; solid red circles represent locations that have yielded Yazoo Darters, open circles represent locations that have not yielded Yazoo Darters. The polygon encloses the proclamation boundary of the Holly Springs National Forest; federal and state lands are color-coded (see legend).

1985 (Ross 2001, S.T. Ross, unpubl. data) contained 26 Yazoo Darters near the headwaters of Otoucalofa Creek in the mainstem of the stream (site 1129). Yazoo Darters were also present in 7 samples from near the headwaters of Cypress Creek in the mainstem (sites 6865 and 6867). We address these samples in the Discussion.

Mean abundance of Yazoo Darters at locations of occurrence varied among units but within-unit variability was high (Fig. 4). Mean abundance across all units ranged from 0.57 (Cypress Creek Unit) to 1.23 individuals/minute (Otoucalofa Creek Unit). Notably the Yocona R. and the Cypress Creek Units had considerably lower mean abundances ( $\approx 50\%$  lower) than other units within their respective river drainages, but confidence intervals showed broad overlap. Confidence intervals for most units were wide, indicating a high level of among-site variation. No differences in mean abundance were apparent between the Yocona R. and the Tallahatchie R. drainages.

Differences in standard length were apparent between sexes and between the Yocona R. and Tallahatchie R. drainages. Males were significantly larger than females in the Yocona R. drainage ( $df = 1, 95; F = 23.05; P \leq 0.0001$ ) and the Tallahatchie R. drainage ( $df = 1, 309; F = 114.63; P \leq 0.0001$ ). Females ( $df = 1, 305; F = 22.23; P \leq 0.0001$ ) and males ( $df = 1, 9; F = 4.11; P \leq 0.045$ ) were significantly larger in

Table 1. Means, standard deviation ( $\pm$  SD), and 95% confidence intervals (CI) for abiotic variables at locations with Yazoo Darters sampled from 1999–2003 across all units and drainages ( $n = 37$ ).

|              | Order | Link  | Area (km <sup>2</sup> ) | Width (m) | Depth (cm) | Velocity (m/sec) |
|--------------|-------|-------|-------------------------|-----------|------------|------------------|
| Mean         | 3.24  | 28.30 | 20.86                   | 4.25      | 14.77      | 0.22             |
| $\pm$ SD     | 0.98  | 41.33 | 23.96                   | 2.00      | 11.51      | 0.15             |
| Upper 95% CI | 3.54  | 43.22 | 29.10                   | 4.91      | 18.79      | 0.27             |
| Lower 95% CI | 2.92  | 16.89 | 13.79                   | 3.65      | 11.49      | 0.18             |

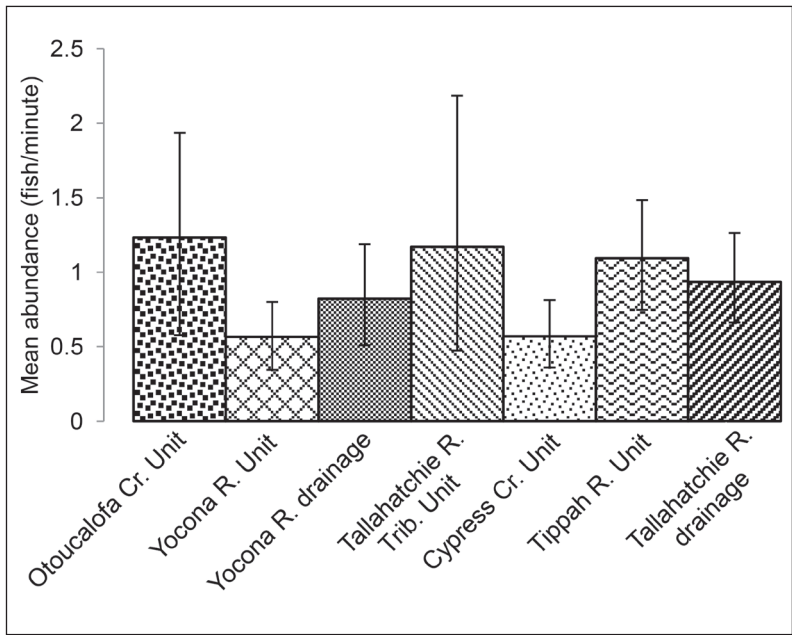


Figure 4. Mean abundance (fish/minute of electrofishing;  $\pm$  95% confidence intervals) of Yazoo Darters across locations of occurrence for each unit and river drainage. Otoucalofa Creek Unit,  $n = 8$ ; Yocona R. Unit,  $n = 13$ ; Cypress Creek Unit,  $n = 21$ ; Tippah R. Unit,  $n = 22$ ; Tallahatchie R. Tributaries Unit,  $n = 16$ .

the Yocona R. drainage than in the Tallahatchie R. drainage (Table 2). Mean sizes were similar among units in the Yocona R. drainage, but showed more variation among units in the Tallahatchie R. drainage.

Sex ratios were skewed toward females and significantly deviated from expected 1:1 sex ratios in all units (Table 2). Sex ratios were similar among units in the Yocona R. drainage. The percentage of males in those units was nearly identical and had broadly overlapping confidence intervals. The Tallahatchie R. drainage units were more variable. The percentage of males in the Tallahatchie R. Tributaries Unit were lower than the percentage recorded in the Tippah River Unit and their confidence intervals did not overlap. In the Cypress Creek Unit, the percentages of males were intermediate between these two units. The percentage of males was similar in the Yocona R. and Tallahatchie R. drainages, and the confidence intervals overlapped.

Among those locations where Yazoo Darters were present, ordination of abiotic variables described a stream-size gradient, and an aquatic vegetation, stream flow, and stream incision gradient. The first two PCA axes were regarded as interpretable, with axis 1 and axis 2 explaining 34.0% and 18.4% of the dataset variance, respectively. PCA axis 1 was positively correlated with forest canopy and bank height and negatively correlated with watershed area, wetted width, and water depth. PCA axis 2 was positively correlated with aquatic vegetation and stream-current velocity and negatively correlated with bank height and forest canopy

Table 2. Mean  $\pm$  SE standard length (SL, mm) of female and male Yazoo Darters by watershed unit and drainage as well as of female and male Yazoo Darters combined by watershed unit and drainage, percentage of male darters  $\pm$  95% confidence intervals (CI) in the sample, and male to female sex ratios. Different superscripted letters indicate significant differences in length between Yazoo Darters in the Yocona R. and Tallahatchie R. drainages.

|                          | Otoucalofa<br>Creek<br>Unit | Yocona R.<br>Unit | Yocona R.<br>Drainage | Tallahatchie R.<br>Tributaries<br>Unit | Cypress<br>Creek<br>Unit | Tippah<br>River<br>Unit | Tallahatchie R.<br>Drainage |
|--------------------------|-----------------------------|-------------------|-----------------------|----------------------------------------|--------------------------|-------------------------|-----------------------------|
| Female                   |                             |                   |                       |                                        |                          |                         |                             |
| mean SL                  | 43.19                       | 41.69             | 42.32 <sup>A</sup>    | 38.45                                  | 42.87                    | 40.15                   | 39.79 <sup>B</sup>          |
| $\pm$ SE                 | 0.776                       | 0.683             | 0.517                 | 0.213                                  | 0.545                    | 0.608                   | 0.244                       |
| <i>n</i>                 | 28                          | 39                | 67                    | 133                                    | 51                       | 56                      | 240                         |
| Male                     |                             |                   |                       |                                        |                          |                         |                             |
| mean SL                  | 47.69                       | 47.88             | 47.80 <sup>A</sup>    | 43.26                                  | 47.24                    | 46.44                   | 45.48 <sup>B</sup>          |
| $\pm$ SE                 | 2.027                       | 1.65              | 1.26                  | 0.748                                  | 1.252                    | 0.737                   | 0.522                       |
| <i>n</i>                 | 13                          | 17                | 30                    | 25                                     | 14                       | 32                      | 71                          |
| Male and female          |                             |                   |                       |                                        |                          |                         |                             |
| mean SL                  | 44.62                       | 43.57             | 44.014 <sup>A</sup>   | 39.21                                  | 43.81                    | 42.44                   | 41.09 <sup>B</sup>          |
| $\pm$ SE                 | 0.882                       | 0.782             | 0.585                 | 0.256                                  | 0.549                    | 0.57                    | 0.261                       |
| <i>n</i>                 | 41                          | 56                | 97                    | 158                                    | 65                       | 88                      | 311                         |
| Percentage males         | 31.7                        | 30.4              | 30.9                  | 15.8                                   | 21.5                     | 36.4                    | 22.8                        |
| $\pm$ 95% CI             | 14.24                       | 12.04             | 9.2                   | 5.69                                   | 9.99                     | 10.05                   | 4.67                        |
| Males:females            | 01:02.0                     | 01:02.3           | 01:02.2               | 01:05.3                                | 01:03.6                  | 01:01.8                 | 01:03.4                     |
| $\chi^2$ goodness of fit | 5.48                        | 8.64              |                       | 73.82                                  | 21.06                    | 6.55                    |                             |
| Exact <i>P</i>           | 0.028                       | 0.005             |                       | <0.0001                                | <0.0001                  | 0.014                   |                             |

(Table 3). Yazoo Darter abundance was not correlated with site scores of PCA axis 1 ( $r = 0.048$ ,  $P \leq 0.21$ ) or axis 2 ( $r = 0.004$ ,  $P \leq 0.7$ ).

Ordination of all sites sampled described a stream-size gradient, and a depth, woody debris, and stream-incisement gradient. Again, the first 2 PCA axes were regarded as interpretable, with axis 1 and axis 2 explaining 25.1% and 21.5% of the dataset variance, respectively. Axis 1 was positively correlated with watershed area, wetted width, and stream order, and negatively correlated with canopy, detritus, and small woody debris. Axis 2 was positively correlated with depth, large and small woody debris, and detritus, and negatively associated with bank height, stream order, and canopy. Presence/absence data for Yazoo Darters were not significantly associated with PCA axis 1 ( $\chi^2 = 0.14$ ,  $P \leq 0.71$ ) or axis two ( $\chi^2 = 2.05$ ,  $P \leq 0.15$ ).

Results from indicator species analysis show that 6 species were significantly associated with Yazoo Darters: *Noturus phaeus* Taylor (Brown Madtom) ( $P < 0.001$ ), lamprey ( $P < 0.001$ ), *Etheostoma lynceum* Hay (Brichteye Darter) ( $P < 0.002$ ), *Etheostoma swaini* Jordan (Gulf Darter) ( $P < 0.002$ ), *Percina sciera* Swain (Dusky Darter) ( $P < 0.002$ ), and *Hypentelium nigricans* Lesueur (Northern Hog Sucker) ( $P < 0.027$ ) (Table 4). Of the 71 fish species we recorded in our study, 60 of them occurred at least once at locations with Yazoo Darters.

Table 3. Loadings from principal components analysis (PCA) of abiotic variables for locations yielding Yazoo Darters (abundance data; PCA 1) and for locations yielding and not yielding Yazoo Darters (presence/absence data; PCA 2) sampled from 1999–2003.

| Abiotic variable   | PCA 1 axis 1 | PCA 1 axis 2 | PCA 2 axis 1 | PCA 2 axis 2 |
|--------------------|--------------|--------------|--------------|--------------|
| Stream order       | -0.7048      | -0.4407      | 0.5767       | -0.2967      |
| Area               | -0.8588      | -0.2841      | 0.7186       | 0.4104       |
| Width              | -0.8628      | -0.2585      | 0.8398       | 0.3432       |
| Depth              | -0.8087      | 0.3571       | 0.5367       | 0.6487       |
| Velocity           | -0.4718      | 0.5036       | 0.5054       | -0.1754      |
| Detritus           | -0.4064      | -0.222       | -0.4718      | 0.5694       |
| Small wood         | -0.5273      | 0.1426       | -0.3803      | 0.7082       |
| Bank height        | 0.3442       | -0.4881      | 0.4034       | -0.4513      |
| Bank stability     | -0.3488      | -0.2493      | 0.0622       | 0.1063       |
| Large wood         | -0.5142      | -0.344       | -0.1574      | 0.7885       |
| Aquatic vegetation | -0.1455      | 0.8894       | 0.0266       | 0.149        |
| Canopy             | 0.5134       | -0.4532      | -0.5957      | -0.2721      |

Table 4. Fish species significantly associated with Yazoo Darters (indicator species analysis) showing the number of locations (total locations,  $n = 93$ ) where a species was sampled ( $n$ ), the percent of sites yielding Yazoo Darters where a species was sampled (%), the maximum indicator value (MI value), and  $P$ -value.

| Species             | $n$ | %  | MI value | $P$ -value |
|---------------------|-----|----|----------|------------|
| Lamprey spp.        | 35  | 59 | 45.2     | 0.0002     |
| Brown Madtom        | 50  | 74 | 51.8     | 0.0003     |
| Brichteye Darter    | 29  | 50 | 36.7     | 0.0017     |
| Dusky Darter        | 47  | 68 | 45.9     | 0.0019     |
| Gulf Darter         | 14  | 29 | 24.5     | 0.0022     |
| Northern Hog Sucker | 19  | 32 | 22.8     | 0.0272     |

## Discussion

Additional sampling efforts will likely result in the discovery of new localities with Yazoo Darters, but our results and records from the combined database suggest that few additional tributary populations are likely to be discovered. Our sampling effort was mainly in the central and western portions of the Yocona and Tallahatchie R. drainages within the known range of the Yazoo Darter. Sampling along the eastern portions of the known range of Yazoo Darters has been less intense and appears to have the highest potential to yield new tributary records for the species.

Land ownership patterns in relation to Yazoo Darter distribution paint a mixed picture in terms of long-term persistence of the species. Many locations harboring Yazoo Darters in the Tallahatchie R. drainage are in watersheds offering some measure of protection due to state or federal management for timber, recreation, or research. As such, these locations should be at substantially less risk of degradation than streams traversing private land. In contrast, Yazoo Darter locations in the Yocona R. and Otoucalofa Creek Units are on private lands and lack the protection afforded by public or conservation ownership. In particular, Yazoo Darters apparently occur in only 4 small tributaries of the Yocona R. Unit, and all 4 of these tributaries are likely to be affected by continued urban expansion from the city of Oxford, MS. The uppermost headwaters of 2 of these tributaries, Pumpkin and Yellow Leaf Creeks, are on National Forest land. The other 2 tributaries, Taylor and Morris Creeks, flow completely through privately owned lands and have been impacted by development (K. Sterling, pers. observ.), and are subject to deforestation and urban development. Locations within the Otoucalofa Creek Unit face pressure from agricultural activities and from urbanization near the city of Water Valley, MS.

Our quantitative habitat analyses clearly indicated that Yazoo Darters consistently occupy small, shallow, headwater streams, an observation also made by others (Johnston and Haag 1996, Suttkus et al. 1994, Thompson and Muncy 1986). However, single young-of-the-year juvenile Yazoo Darters were captured at two locations (sites 6814 and 6819) in the Tallahatchie R. Canal in late summer. These two individuals may have been waifs from tributaries that were displaced downstream during a high-flow event, or were moving out of headwater streams to avoid adverse low-flow conditions of late summer. Alternatively, these fish may evidence a generalized movement of juvenile Yazoo Darters from headwaters to larger streams. If juvenile Yazoo Darters commonly disperse across drainages at around 6 months of age, then we would expect the numerous other fish samples from mainstem reaches of the Tippah R. (and large channelized tributaries like Potts Creek), Tallahatchie R., Yocona R., and Otoucalofa Creek to have also contained Yazoo Darters. We doubt that the Tallahatchie R. Canal provides quality Yazoo Darter habitat, and we do not believe that the degraded habitat present in the Canal could support reproducing, permanent populations. Two Yazoo Darters were sampled (Ross 2001) from the mainstem of Otoucalofa Creek (site 4984) at the confluence with Sarter Creek. Because the sample was taken in May, we doubt that these individuals could have been juveniles. The watershed area above this location is only about 110 km<sup>2</sup>, and channelized portions of the stream appear on maps

to be well downstream. This location may be considered normal habitat for Yazoo Darters. Alternatively, these individuals may have come from Sarter Creek. In any case, it is likely that Yazoo Darters occasionally venture into uncharacteristically large streams as evidenced by these unusual occurrences. Another location (site 1129) farther upstream in the mainstem Otoucalofa is certainly typical Yazoo Darter habitat because that section of Otoucalofa Creek is a second-order stream with a watershed area of about 9 km<sup>2</sup>. Yazoo Darters were also present in seven samples from near the headwaters of Cypress Creek in the mainstem (sites 6865 and 6867). At these locations, Cypress Creek is a second-order stream with a watershed area of about 15.5 km<sup>2</sup> and it also appears to be suitable Yazoo Darter habitat.

Our measures of abundance did not yield any clear patterns within or among watershed units. Because variation was relatively high, it seems likely that repeated sampling over time would be needed to precisely estimate relative abundances among watersheds.

Male Yazoo Darters were significantly larger than females, a pattern consistent with other snubnose darter species (Boschung et al. 1992, Powers and Mayden 2003, Suttkus and Etnier 1991). However, mean size of male and female Yazoo Darters from the Yocona R. drainage was greater than mean size in the Tallahatchie R. drainage. This finding may reflect genetic differences between populations in the respective rivers as revealed by MtDNA analysis (Powers and Warren 2009) but may also indicate disparity between the two drainages in factors such as food availability or survivorship. However, we are unaware of differences in the two drainages (e.g., productivity, predation) that would affect growth or survivorship. The size disparity between populations in the two drainages deserves further investigation.

Sex ratios were skewed toward females in all watershed units analyzed. This finding is consistent with more spatially and sample-limited work for Yazoo Darters (Johnston and Haag 1996). The pattern is typical of most other snubnose darters for which sex ratios have been reported (Carney and Burr 1989, Khudamrongsawat and Kuhajda 2007, Page and Mayden 1981, Suttkus and Bailey 1993, but see Clayton 1984 on *Etheostoma baileyi* Page and Burr [Emerald Darter]). We did not examine sex ratios by age class, but in one population, sex ratios of Yazoo Darters at hatching were close to 1:1 (Johnston and Haag 1996), as in some other snubnose darters (Barton and Powers 2010, Carney and Burr 1989), and then, presumably, male-biased mortality in the first year skewed sex ratios. Because skewed sex ratios can dramatically affect effective population sizes (Allendorf and Luikart 2007), further investigation of the driving mechanisms behind differential survival in the Yazoo Darter is warranted.

The relatively low variation in our measures of stream order, watershed area, and current velocity indicate that Yazoo Darters are generally constrained to smaller headwater streams, a conclusion supported by nearly all known records of Yazoo Darter samples as discussed previously. Thus, headwater habitat preservation and restoration will be essential to help ensure persistence of the species. Investigation of the mode and timing of dispersal between headwater streams is needed, as is identification of potential barriers to dispersal.

We did not find any relationships between Yazoo Darter abundance and measured habitat variables. It is possible that we failed to measure some variable of overriding importance, such as water temperature or dissolved oxygen, which would explain the insignificant results of the logistic regression. Another, not mutually exclusive, possibility is that the habitat requirements of Yazoo Darters represent thresholds. In this case, once the habitat requirements of the species are met, relative abundance is not influenced by variation in habitat. This theory may explain why we did not find a strong correlation between abundance and indicators of stream incision (bank height and bank stability). Other factors such as the influence of groundwater and springs may be important (Suttkus et al. 1994). Some of the densest populations we sampled were in streams receiving spring flow (e.g., Chewalla Creek tributary, site 6851; Big Spring tributary, site 6852; and Bay Springs Branch, site 7171; see Appendix 1). Our attempt to quantify habitat may have been at too large a spatial scale (120–300 m) because Yazoo Darters were not evenly distributed throughout a stream reach. As a result, we may have been measuring variables in unsuitable habitat as well as suitable habitat within our study reaches. Johnston and Haag (1996) concluded that Yazoo Darters were habitat generalists, but their study focused on a single population and, given their sample numbers, the habitat was likely of relatively high quality and not limiting. Based on the patchy nature of the Yazoo Darter's spatial distribution within and among watersheds, and our field observations of streams and mesohabitat in which it does and does not occur, we feel the species is likely habitat-limited at landscape and even meso- or microhabitat scales.

Across their ranges, species associates of Yazoo Darters occupy a range of stream sizes from the smallest headwater streams (Brown Madtom, lamprey) to medium-sized streams and small rivers (Briteye Darter, Dusky Darter, Northern Hog Sucker) (Etnier and Starnes 1993, Ross 2001). Our study was not designed to detect or describe fine-scale ecological interactions or even ecological similarities among these species. Even so, all of them co-occurred with the Yazoo Darter in small stream habitats more often than expected by chance, and some shared ecological traits among the associates are apparent. Similar to the Yazoo Darter, most of the associates are strongly rheophilic, benthic, and small bodied. Even for the largest associate, the Northern Hog Sucker, our catch was composed almost entirely of juveniles (M.L. Warren, pers. observ.). Interestingly, within the Yazoo R. basin, the brook lampreys encountered in our study streams (i.e., predominantly ammocoetes of Least Brook Lamprey), show a distribution nearly identical to that of the Yazoo Darter, and they are confined to portions of the Little Tallahatchie, Tippah, and Yocona rivers in the Northern Hilly Gulf Coastal Plain Ecoregion (Ross 2001). Northern Hog Suckers are similarly distributed in the area, being absent from most channelized main channels (Ross 2001). The Brown Madtom and Briteye Darter are more widespread in the Yazoo R. basin than the Yazoo Darter, but most records are along a north–south band describing the Northern Hilly Gulf Coastal Plain Ecoregion (Ross 2001). At the level of meso-habitat, the Brown Madtom often inhabits tiny streams and is strongly associated with stream flow and complex

habitat provided by woody structure that is missing from channelized and highly incised habitats in the region (Chan and Parsons 2000, Monzyk et al. 1997). Although many populations were likely eliminated by channelization within its range, the Brighteye Darter appears to be most common in better-quality streams that are least affected by channelization (Etnier and Starnes 1993). Similarly, Gulf Darters are associated with flow, woody debris, and *Sparganium* spp. (bur-reeds), which we and others noted is often present and abundant at sites with high Yazoo Darter densities (Suttkus et al. 1994). Overall, we believe this group of frequent associates is an indicator of high-quality habitats associated with the Yazoo Darter, and their confinement to particular sites is a result of stream degradation over much of the stream system in the region.

Our data show that populations of the Yazoo Darter in the Yocona R. drainage are far less numerous relative to the Tallahatchie R. drainage, and these populations have no protection from continued urban development or habitat modification (i.e., impoundments and stream alteration on private lands). Genetic work indicates that Yazoo Darters in the Yocona R. drainage have lower allelic richness, observed heterozygosity, and gene diversity relative to Yazoo Darters in the Tallahatchie R. drainage, and that they are isolated within tributary streams (Sterling et al. 2012). Personal observations (K. Sterling) suggest that suitable Yazoo Darter habitat within these highly modified tributary streams is uncommon due to habitat homogenization. For these reasons, and because populations of Yazoo Darters in the Yocona R. drainage are genetically distinct from those in the Tallahatchie R. drainage (Powers and Warren 2009), management action should be focused on Yocona R. drainage populations. Standardized, quantitative habitat surveys should be conducted throughout each Yocona R. drainage watershed that harbors Yazoo Darters in an effort to provide baseline data for monitoring efforts. This should also include quantification of watershed-scale land-use and land-cover variables to track changes due to urbanization. Our own first efforts at modeling Yazoo Darter and habitat associations should be improved upon. If satisfactory models can be produced, results could be coupled with results from stream habitat surveys, results from this study, and the existing literature to build a stream-habitat-restoration strategy.

Within the Tallahatchie R. drainage, sampling records indicate Yazoo Darter populations have not been extirpated. Even so, because sampling records only extend back several decades for most populations, this finding should be regarded with caution. Risk of extirpation within the entire drainage in the near term is somewhat minimized due to the fact that many populations are located on or near state- or federally managed lands. However, because Yazoo Darters are genetically differentiated among headwater tributaries within drainages, and the mainstem Tallahatchie, Tippah, and Yocona rivers are apparently barriers to dispersal (Sterling et al. 2012), continued monitoring of populations is warranted. Extirpation of any headwater population would result in loss of important genetic diversity and would preclude future efforts via human-assisted migration to increase genetic diversity and adaptive potential in the face of a changing climate.

The Yazoo Darter is a charismatic, endemic species that greatly enhances the natural heritage of northern Mississippi where few vertebrate endemics occur. Preservation of this fish in the short-term is an achievable goal that should be a priority for federal and state agencies and the public.

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Appendix 1. Records for all known samples yielding Yazoo Darters (1952–2011) listed by watershed unit (Fig. 1) and site. T = total number of Yazoo Darters sampled; CPUE = fish per hour; Unit = watershed unit; UT = Unnamed tributary. OC = Otoucalofa Creek; YR = Yocona River; CC = Cypress Creek; TRT = Tallahatchie River Tributaries; TR= Tippah River. USFS = USDA Forest Service; UMFS = University of Mississippi Field Station; USACE = US Army Corps of Engineers; WDSP = Wall Dooey State Park.

| Site ID | Date       | Source              | T  | CPUE   | Unit | Stream              | Ownership | Lat    | Long   |
|---------|------------|---------------------|----|--------|------|---------------------|-----------|--------|--------|
| 1090    | 10/10/1985 | Ross et al. 2001    | 1  |        | OC   | Dickey Creek        | Private   | 34.168 | 89.438 |
| 1090    | 6/17/2009  | 2009–2011 data      | 1  | 8.49   | OC   | Dickey Creek        | Private   | 34.168 | 89.438 |
| 640     | 6/19/2009  | 2009–2011 data      | 7  | 54.90  | OC   | Johnson Creek       | Private   | 34.123 | 89.641 |
| 749     | 6/14/1989  | Suttkus et al. 1994 | 26 |        | OC   | UT Otoucalofa Creek | Private   | 34.141 | 89.589 |
| 749     | 5/18/1990  | Suttkus et al. 1994 | 2  |        | OC   | UT Otoucalofa Creek | Private   | 34.141 | 89.589 |
| 749     | 4/12/1992  | Suttkus et al. 1994 | 1  |        | OC   | UT Otoucalofa Creek | Private   | 34.141 | 89.589 |
| 7177    | 6/30/2009  | 2009–2011 data      | 2  | 21.88  | OC   | Spring Creek        | Private   | 34.153 | 89.529 |
| 7178    | 6/18/2009  | 2009–2011 data      | 2  | 8.91   | OC   | Moore Creek         | Private   | 34.156 | 89.548 |
| 7179    | 6/18/2009  | 2009–2011 data      | 16 | 116.10 | OC   | Mill Creek          | Private   | 34.166 | 89.520 |
| 7186    | 6/19/2009  | 2009–2011 data      | 13 | 144.00 | OC   | UT Otoucalofa Creek | Private   | 34.125 | 89.610 |
| 841     | 6/15/1989  | Suttkus et al. 1994 | 3  |        | OC   | Gordon Branch       | Private   | 34.140 | 89.549 |
| 841     | 6/30/2009  | 2009–2011 data      | 15 | 169.80 | OC   | Gordon Branch       | Private   | 34.140 | 89.549 |
| 990     | 7/23/1985  | Ross et al. 2001    | 4  |        | OC   | Smith Creek         | Private   | 34.138 | 89.474 |
| 1129    | 7/8/1985   | Ross et al. 2001    | 14 |        | OC   | Otoucalofa Creek    | Private   | 34.133 | 89.412 |
| 1129    | 7/8/1985   | Ross et al. 2001    | 12 |        | OC   | Otoucalofa Creek    | Private   | 34.133 | 89.412 |
| 4984    | 5/14/1986  | Ross et al. 2001    | 2  |        | OC   | Otoucalofa Creek    | Private   | 34.162 | 89.512 |
| 5034    | 7/10/1985  | Ross et al. 2001    | 1  |        | OC   | Shippy Creek        | Private   | 34.153 | 89.433 |
| 6858    | 6/11/1999  | 1999–2003 data      | 2  | 8.87   | YR   | Pumpkin Creek       | Private   | 34.327 | 89.397 |
| 6859    | 6/11/1999  | 1999–2003 data      | 6  | 52.68  | YR   | Pumpkin Creek       | Private   | 34.339 | 89.384 |
| 5028    | 5/6/1974   | Suttkus et al. 1994 | 3  |        | YR   | Pumpkin Creek       | Private   | 34.286 | 89.445 |
| 1164    | 5/24/1952  | Suttkus et al. 1994 | 11 |        | YR   | Pumpkin Creek       | Private   | 34.327 | 89.397 |
| 1164    | 4/17/1969  | Suttkus et al. 1994 | 7  |        | YR   | Pumpkin Creek       | Private   | 34.327 | 89.397 |
| 1164    | 5/10/1988  | Suttkus et al. 1994 | 22 |        | YR   | Pumpkin Creek       | Private   | 34.327 | 89.397 |
| 1164    | 10/22/1988 | Suttkus et al. 1994 | 14 |        | YR   | Pumpkin Creek       | Private   | 34.327 | 89.397 |
| 1164    | 7/27/1989  | Suttkus et al. 1994 | 4  |        | YR   | Pumpkin Creek       | Private   | 34.327 | 89.397 |

| Site ID | Date       | Source                 | T  | CPUE  | Unit | Stream              | Ownership | Lat    | Long   |
|---------|------------|------------------------|----|-------|------|---------------------|-----------|--------|--------|
| 1164    | 6/16/2009  | 2009–2011 data         | 1  | 5.19  | YR   | Pumpkin Creek       | Private   | 34.327 | 89.397 |
| 1164    | 5/18/1990  | Suttkus et al. 1994    | 3  |       | YR   | Pumpkin Creek       | Private   | 34.327 | 89.397 |
| 7181    | 6/30/2009  | 2009–2011 data         | 1  | 8.28  | YR   | UT of Pumpkin Creek | Private   | 34.291 | 89.440 |
| 6860    | 9/1/2009   | 1999–2003 data         | 2  | 11.98 | YR   | Yellow Leaf Creek   | Private   | 34.368 | 89.428 |
| 6861    | 6/9/1999   | 1999–2003 data         | 5  | 34.04 | YR   | Yellow Leaf Creek   | Private   | 34.375 | 89.421 |
| 6862    | 6/9/1999   | 1999–2003 data         | 3  | 18.00 | YR   | Yellow Leaf Creek   | Private   | 34.374 | 89.421 |
| 6863    | 6/9/1999   | 1999–2003 data         | 7  | 81.55 | YR   | Yellow Leaf Creek   | Private   | 34.379 | 89.413 |
| 765     | 5/11/1988  | Suttkus et al. 1994    | 10 |       | YR   | UT of Taylor Creek  | Private   | 34.123 | 89.641 |
| 765     | 6/26/2009  | 2009–2011 data         | 12 | 64.96 | YR   | UT of Taylor Creek  | Private   | 34.123 | 89.641 |
| 768     | 8/20/1991  | Ross et al. 2001       | 1  |       | YR   | Taylor Creek        | Private   | 34.271 | 89.580 |
| 7176    | 3/24/1993  | Johnston and Haag 1996 | 24 |       | YR   | Morris Creek        | Private   | 34.300 | 89.549 |
| 7176    | 4/26/1993  | Johnston and Haag 1996 | 9  |       | YR   | Morris Creek        | Private   | 34.300 | 89.549 |
| 7176    | 3/11/1994  | Johnston and Haag 1996 | 40 |       | YR   | Morris Creek        | Private   | 34.300 | 89.549 |
| 7176    | 4/7/1994   | Johnston and Haag 1996 | 27 |       | YR   | Morris Creek        | Private   | 34.300 | 89.549 |
| 7176    | 5/2/1994   | Johnston and Haag 1996 | 11 |       | YR   | Morris Creek        | Private   | 34.300 | 89.549 |
| 7176    | 5/17/1994  | Johnston and Haag 1996 | 8  |       | YR   | Morris Creek        | Private   | 34.300 | 89.549 |
| 7180    | 9/24/1993  | Johnston and Haag 1996 | 21 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 10/21/1993 | Johnston and Haag 1996 | 18 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 11/19/1993 | Johnston and Haag 1996 | 19 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 12/14/1993 | Johnston and Haag 1996 | 10 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 1/12/1994  | Johnston and Haag 1996 | 21 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 2/23/1994  | Johnston and Haag 1996 | 11 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 5/20/1993  | Johnston and Haag 1996 | 14 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 3/23/1994  | Johnston and Haag 1996 | 10 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 6/25/1993  | Johnston and Haag 1996 | 17 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 4/20/1994  | Johnston and Haag 1996 | 11 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 7/26/1993  | Johnston and Haag 1996 | 22 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 8/27/1993  | Johnston and Haag 1996 | 30 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 3/24/1993  | Johnston and Haag 1996 | 19 |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |
| 7180    | 4/26/1993  | Johnston and Haag 1996 | 5  |       | YR   | Morris Creek        | Private   | 34.283 | 89.544 |

| Site ID | Date       | Source                  | T  | CPUE  | Unit | Stream        | Ownership | Lat    | Long   |
|---------|------------|-------------------------|----|-------|------|---------------|-----------|--------|--------|
| 7180    | 5/2/1994   | Johnston and Haag 1996  | 4  |       | YR   | Morris Creek  | Private   | 34.283 | 89.544 |
| 7180    | 5/17/1994  | Johnston and Haag 1996  | 8  |       | YR   | Morris Creek  | Private   | 34.283 | 89.544 |
| 7180    | 6/2/2009   | 2009–2011 data          | 11 | 50.83 | YR   | Morris Creek  | Private   | 34.282 | 89.543 |
| 7180    | 9/10/2009  | 2009–2011 data          | 13 | 67.05 | YR   | Morris Creek  | Private   | 34.282 | 89.543 |
| 7180    | 1/14/2010  | 2009–2011 data          | 3  | 10.56 | YR   | Morris Creek  | Private   | 34.282 | 89.543 |
| 7180    | 4/23/2010  | 2009–2011 data          | 12 |       | YR   | Morris Creek  | Private   | 34.282 | 89.543 |
| 7180    | 9/10/2010  | 2009–2011 data          | 8  |       | YR   | Morris Creek  | Private   | 34.282 | 89.543 |
| 7180    | 3/2/2011   | 2009–2011 data          | 4  |       | YR   | Morris Creek  | Private   | 34.282 | 89.543 |
| 7180    | 7/1/2011   | 2009–2011 data          | 25 |       | YR   | Morris Creek  | Private   | 34.282 | 89.543 |
| 6865    | 3/9/1982   | Thompson and Muncy 1986 | 1  |       | CC   | Cypress Creek | Private   | 34.393 | 89.286 |
| 6865    | 6/1/1999   | 1999–2003 data          | 4  | 30.13 | CC   | Cypress Creek | Private   | 34.393 | 89.286 |
| 6865    | 4/1/2009   | 2009–2011 data          | 11 | 23.02 | CC   | Cypress Creek | Private   | 34.393 | 89.286 |
| 6867    | 6/4/1999   | 1999–2003 data          | 9  | 62.53 | CC   | Cypress Creek | Private   | 34.382 | 89.298 |
| 6867    | 7/23/2009  | 1999–2003 data          | 4  | 23.41 | CC   | Cypress Creek | Private   | 34.382 | 89.298 |
| 6867    | 3/30/2009  | 2009–2011 data          | 2  | 12.83 | CC   | Cypress Creek | Private   | 34.382 | 89.298 |
| 6867    | 4/7/2009   | 2009–2011 data          | 1  | 6.50  | CC   | Cypress Creek | Private   | 34.382 | 89.298 |
| 6875    | 10/17/1980 | Thompson and Muncy 1986 | 9  |       | CC   | Puskus Creek  | Private   | 34.396 | 89.372 |
| 6875    | 7/27/1981  | Thompson and Muncy 1986 | 13 |       | CC   | Puskus Creek  | Private   | 34.396 | 89.372 |
| 6875    | 9/29/1983  | Thompson and Muncy 1986 | 12 |       | CC   | Puskus Creek  | Private   | 34.396 | 89.372 |
| 6875    | 6/2/1999   | 1999–2003 data          | 6  | 44.08 | CC   | Puskus Creek  | Private   | 34.396 | 89.372 |
| 6875    | 3/25/2009  | 2009–2011 data          | 10 |       | CC   | Puskus Creek  | Private   | 34.396 | 89.372 |
| 6874    | 6/2/1999   | 1999–2003 data          | 2  |       | CC   | Puskus Creek  | USFS      | 34.394 | 89.371 |
| 6878    | 8/3/1999   | 1999–2003 data          | 1  | 4.89  | CC   | Puskus Creek  | USFS      | 34.445 | 89.336 |
| 6878    | 5/25/2000  | 1999–2003 data          | 1  | 3.99  | CC   | Puskus Creek  | USFS      | 34.445 | 89.336 |
| 6878    | 7/24/2009  | 1999–2003 data          | 2  | 3.27  | CC   | Puskus Creek  | USFS      | 34.445 | 89.336 |
| 7183    | 3/25/2009  | 2009–2011 data          | 5  | 27.48 | CC   | Puskus Creek  | USFS      | 34.445 | 89.336 |
| 7183    | 3/30/2009  | 2009–2011 data          | 7  | 20.47 | CC   | Puskus Creek  | USFS      | 34.445 | 89.336 |
| 1267    | 10/9/1970  | Suttkus et al. 1994     | 17 |       | CC   | Puskus Creek  | Private   | 34.415 | 89.372 |
| 1267    | 4/7/1972   | Suttkus et al. 1994     | 2  |       | CC   | Puskus Creek  | Private   | 34.415 | 89.372 |
| 1267    | 9/7/1973   | Suttkus et al. 1994     | 4  |       | CC   | Puskus Creek  | Private   | 34.415 | 89.372 |

| Site ID | Date       | Source                  | T   | CPUE   | Unit | Stream                | Ownership | Lat    | Long   |
|---------|------------|-------------------------|-----|--------|------|-----------------------|-----------|--------|--------|
| 1267    | 10/13/1973 | Suttkus et al. 1994     | 11  |        | CC   | Puskus Creek          | Private   | 34.415 | 89.372 |
| 1246    | 5/7/1974   | Suttkus et al. 1994     | 2   |        | CC   | Puskus Creek          | Private   | 34.411 | 89.377 |
| 1267    | 5/5/1976   | Suttkus et al. 1994     | 22  |        | CC   | Puskus Creek          | Private   | 34.415 | 89.372 |
| 1267    | 3/24/1982  | Ross et al. 2001        | 2   |        | CC   | Puskus Creek          | Private   | 34.415 | 89.372 |
| 1261    | 8/20/1991  | Ross et al. 2001        | 6   |        | CC   | Puskus Creek          | Private   | 34.411 | 89.374 |
| 1358    | 8/8/1984   | Thompson and Muncy 1986 | 8   |        | CC   | Puskus Creek          | Private   | 34.446 | 89.330 |
| 1358    | 7/18/1977  | Ross et al. 2001        | 10  |        | CC   | Puskus Creek          | Private   | 34.446 | 89.330 |
| 7170    | 8/8/1984   | Thompson and Muncy 1986 | 4   |        | CC   | UT Puskus Creek       | Private   | 34.439 | 89.385 |
| 7170    | 4/1/2009   | 2009–2011 data          | 3   | 6.07   | CC   | UT Puskus Creek       | Private   | 34.439 | 89.385 |
| 6877    | 7/28/1999  | 1999–2003 data          | 2   | 9.07   | CC   | UT Puskus Creek       | USFS      | 34.450 | 89.349 |
| 7182    | 4/14/2009  | 2009–2011 data          | 10  | 38.42  | CC   | UT Puskus Creek       | Private   | 34.431 | 89.375 |
| 6879    | 9/14/1999  | 1999–2003 data          | 4   | 26.60  | CC   | Bay Springs Branch    | UMFS      | 34.428 | 89.396 |
| 7171    | 2/21/1981  | Thompson and Muncy 1986 | 1   |        | CC   | Bay Springs Branch    | UMFS      | 34.428 | 89.395 |
| 7171    | 3/11/1982  | Thompson and Muncy 1986 | 5   |        | CC   | Bay Springs Branch    | UMFS      | 34.428 | 89.395 |
| 7171    | 3/14/1984  | Thompson and Muncy 1986 | 2   |        | CC   | Bay Springs Branch    | UMFS      | 34.428 | 89.395 |
| 7171    | 4/22/1984  | Thompson and Muncy 1986 | 7   |        | CC   | Bay Springs Branch    | UMFS      | 34.428 | 89.395 |
| 7171    | 10/29/1984 | Thompson and Muncy 1986 | 11  |        | CC   | Bay Springs Branch    | UMFS      | 34.428 | 89.395 |
| 1268    | 3/14/1980  | Suttkus et al. 1994     | 4   |        | CC   | Bay Springs Branch    | UMFS      | 34.425 | 89.386 |
| 1268    | 3/14/1980  | Suttkus et al. 1994     | 3   |        | CC   | Bay Springs Branch    | UMFS      | 34.425 | 89.386 |
| 7171    | 4/14/2009  | 2009–2011 data          | 10  | 52.17  | CC   | Bay Springs Branch    | UMFS      | 34.428 | 89.395 |
| 7171    | 2/25/2009  | 2009–2011 data          | 156 | 120.50 | CC   | Bay Springs Branch    | UMFS      | 34.428 | 89.395 |
| 7171    | 9/30/2009  | 2009–2011 data          | 74  | 49.79  | CC   | Bay Springs Branch    | UMFS      | 34.428 | 89.395 |
| 7171    | 2/10/2010  | 2009–2011 data          | 190 | 117.40 | CC   | Bay Springs Branch    | UMFS      | 34.428 | 89.395 |
| 1187    | 8/21/1991  | Ross et al. 2001        | 5   |        | CC   | UT Bay Springs Branch | UMFS      | 34.421 | 89.388 |
| 1187    | 8/21/1991  | Ross et al. 2001        | 4   |        | CC   | UT Bay Springs Branch | UMFS      | 34.421 | 89.388 |
| 7187    | 7/26/1984  | Thompson and Muncy 1986 | 1   |        | TRT  | Graham Mill Creek     | USACE     | 34.511 | 89.494 |
| 7187    | 11/6/1984  | Thompson and Muncy 1986 | 2   |        | TRT  | Graham Mill Creek     | USACE     | 34.511 | 89.494 |
| 5000    | 10/5/1995  | Ross et al. 2001        | 1   | 1      | TRT  | Lee Creek             | USACE     | 34.513 | 89.490 |
| 5000    | 5/20/1996  | Ross et al. 2001        | 1   | 1      | TRT  | Lee Creek             | USACE     | 34.513 | 89.490 |
| 5000    | 8/5/1996   | Ross et al. 2001        | 1   | 1      | TRT  | Lee Creek             | USACE     | 34.513 | 89.490 |

| Site ID | Date       | Source                  | T  | CPUE   | Unit | Stream                | Ownership | Lat    | Long   |
|---------|------------|-------------------------|----|--------|------|-----------------------|-----------|--------|--------|
| 971     | 5/19/1988  | Suttkus et al. 1994     | 18 |        | TRT  | Graham Mill Creek     | Private   | 34.503 | 89.490 |
| 971     | 5/18/1990  | Suttkus et al. 1994     | 3  |        | TRT  | Graham Mill Creek     | Private   | 34.503 | 89.490 |
| 971     | 4/12/1992  | Suttkus et al. 1994     | 4  |        | TRT  | Graham Mill Creek     | Private   | 34.503 | 89.490 |
| 5038    | 10/2/1995  | Ross et al. 2001        | 8  |        | TRT  | Bagley Creek          | USFS      | 34.495 | 89.413 |
| 5038    | 7/30/1996  | Ross et al. 2001        | 1  |        | TRT  | Bagley Creek          | USFS      | 34.495 | 89.413 |
| 5041    | 5/17/1996  | Ross et al. 2001        | 2  |        | TRT  | Bagley Creek          | USFS      | 34.482 | 89.409 |
| 5041    | 7/30/1996  | Ross et al. 2001        | 8  |        | TRT  | Bagley Creek          | USFS      | 34.482 | 89.409 |
| 6881    | 6/7/1999   | Ross et al. 2001        | 1  |        | TRT  | Bagley Creek          | USFS      | 34.481 | 89.405 |
| 6814    | 8/10/1999  | 1999–2003 data          | 1  | 8.35   | TRT  | Bagley Creek          | USACE     | 34.528 | 89.366 |
| 6819    | 8/9/1999   | 1999–2003 data          | 1  | 2.36   | TRT  | Tallahatchie R. Canal | Private   | 34.482 | 89.225 |
| 5188    | 10/4/1995  | Ross et al. 2001        | 4  |        | TRT  | Tallahatchie R. Canal | Private   | 34.519 | 89.203 |
| 5188    | 5/21/1996  | Ross et al. 2001        | 3  |        | TRT  | Mitchell Creek        | Private   | 34.519 | 89.203 |
| 5188    | 8/6/1996   | Ross et al. 2001        | 1  |        | TRT  | Mitchell Creek        | Private   | 34.519 | 89.203 |
| 6820    | 8/2/1999   | 1999–2003 data          | 4  | 36.00  | TRT  | Mitchell Creek        | Private   | 34.521 | 89.203 |
| 6853    | 7/29/1999  | 1999–2003 data          | 2  | 8.05   | TRT  | Mitchell Creek        | Private   | 34.634 | 89.397 |
| 7175    | 4/7/1984   | Thompson and Muncy 1986 | 6  |        | TRT  | Big Spring Creek      | Private   | 34.721 | 89.406 |
| 1201    | 5/18/1988  | Suttkus et al. 1994     | 4  |        | TRT  | Big Spring Creek      | Private   | 34.711 | 89.394 |
| 1215    | 5/20/1981  | Suttkus et al. 1994     | 8  |        | TRT  | Big Spring Creek      | Private   | 34.711 | 89.391 |
| 1215    | 4/13/1984  | Ross et al. 2001        | 9  |        | TRT  | Big Spring Creek      | Private   | 34.711 | 89.391 |
| 1201    | 3/16/1983  | Ross et al. 2001        | 4  |        | TRT  | Big Spring Creek      | Private   | 34.711 | 89.394 |
| 1201    | 4/29/1982  | Ross et al. 2001        | 2  |        | TRT  | Big Spring Creek      | Private   | 34.711 | 89.394 |
| 1215    | 5/12/1982  | Ross et al. 2001        | 2  |        | TRT  | Big Spring Creek      | Private   | 34.711 | 89.394 |
| 6852    | 7/30/1999  | 1999–2003 data          | 32 | 163.90 | TRT  | UT Big Spring Creek   | Private   | 34.663 | 89.412 |
| 6852    | 6/23/2009  | 2009–2011 data          | 73 | 411.30 | TRT  | UT Big Spring Creek   | Private   | 34.663 | 89.412 |
| 6852    | 9/11/2009  | 2009–2011 data          | 24 | 131.50 | TRT  | UT Big Spring Creek   | Private   | 34.663 | 89.412 |
| 6852    | 10/19/2009 | 2009–2011 data          | 52 |        | TRT  | UT Big Spring Creek   | Private   | 34.663 | 89.412 |
| 6852    | 1/26/2010  | 2009–2011 data          | 62 | 185.80 | TRT  | UT Big Spring Creek   | Private   | 34.663 | 89.412 |
| 6852    | 5/24/2010  | 2009–2011 data          | 51 |        | TRT  | UT Big Spring Creek   | Private   | 34.663 | 89.412 |
| 6852    | 9/2/2010   | 2009–2011 data          | 54 |        | TRT  | UT Big Spring Creek   | Private   | 34.663 | 89.412 |
| 6852    | 3/3/2011   | 2009–2011 data          | 45 |        | TRT  | UT Big Spring Creek   | Private   | 34.663 | 89.412 |

| Site ID | Date       | Source                  | T  | CPUJE | Unit | Stream              | Ownership | Lat    | Long   |
|---------|------------|-------------------------|----|-------|------|---------------------|-----------|--------|--------|
| 6852    | 6/29/2011  | 2009–2011 data          | 11 |       | TRT  | UT Big Spring Creek | Private   | 34.663 | 89.412 |
| 6882    | 8/5/1999   | 1999–2003 data          | 5  | 43.27 | TRT  | Lee Creek           | Private   | 34.473 | 89.446 |
| 6883    | 5/24/2000  | 1999–2003 data          | 5  | 22.75 | TRT  | Lee Creek           | USFS      | 34.497 | 89.456 |
| 6883    | 8/5/1999   | 1999–2003 data          | 1  | 7.79  | TRT  | Lee Creek           | USFS      | 34.497 | 89.456 |
| 4993    | 5/20/1996  | Ross et al. 2001        | 3  |       | TRT  | Lee Creek           | USFS      | 34.498 | 89.457 |
| 4993    | 7/28/1995  | Ross et al. 2001        | 2  |       | TRT  | Lee Creek           | USFS      | 34.498 | 89.457 |
| 4993    | 8/5/1996   | Ross et al. 2001        | 1  |       | TRT  | Lee Creek           | USFS      | 34.498 | 89.457 |
| 4997    | 5/7/1993   | Ross et al. 2001        | 1  |       | TRT  | Lee Creek           | USACE     | 34.513 | 89.491 |
| 5015    | 5/20/1993  | Ross et al. 2001        | 2  |       | TRT  | Lee Creek           | Private   | 34.499 | 89.465 |
| 7049    | 7/3/2002   | 1999–2003 data          | 4  |       | TRT  | Mill Creek          | Private   | 34.546 | 89.227 |
| 1053    | 10/27/1973 | Suttkus et al. 1994     | 6  |       | TRT  | Little Spring Creek | Private   | 34.642 | 89.464 |
| 1053    | 5/7/1974   | Suttkus et al. 1994     | 1  |       | TRT  | Little Spring Creek | Private   | 34.642 | 89.464 |
| 1053    | 5/10/1988  | Suttkus et al. 1994     | 1  |       | TRT  | Little Spring Creek | Private   | 34.642 | 89.464 |
| 7083    | 5/30/2003  | 1999–2003 data          | 1  | 2.58  | TRT  | Little Spring Creek | Private   | 34.642 | 89.464 |
| 7174    | 7/13/1984  | Thompson and Muncy 1986 | 9  |       | TRT  | Little Spring Creek | WDSP      | 34.667 | 89.467 |
| 7174    | 8/17/1984  | Thompson and Muncy 1986 | 3  |       | TRT  | Little Spring Creek | WDSP      | 34.667 | 89.467 |
| 7174    | 3/8/1985   | Thompson and Muncy 1986 | 16 |       | TRT  | Little Spring Creek | WDSP      | 34.667 | 89.467 |
| 7184    | 4/2/2010   | 2009–2011 data          | 1  |       | TRT  | Little Spring Creek | USACE     | 34.576 | 89.475 |
| 1039    | 10/13/1973 | Suttkus et al. 1994     | 1  |       | TRT  | Little Spring Creek | WDSP      | 34.66  | 89.467 |
| 7089    | 10/16/1981 | Thompson and Muncy 1986 | 2  |       | TRT  | Oak Chewalla Creek  | USACE     | 34.582 | 89.511 |
| 7089    | 9/14/1983  | Thompson and Muncy 1986 | 1  |       | TRT  | Oak Chewalla Creek  | USACE     | 34.582 | 89.511 |
| 7089    | 5/22/2003  | 1999–2003 data          | 1  | 3.12  | TRT  | Oak Chewalla Creek  | USACE     | 34.582 | 89.511 |
| 942     | 5/18/1988  | Suttkus et al. 1994     | 5  |       | TRT  | Oak Chewalla Creek  | USACE     | 34.582 | 89.509 |
| 942     | 5/19/1988  | Suttkus et al. 1994     | 5  |       | TRT  | Oak Chewalla Creek  | USACE     | 34.582 | 89.509 |
| 942     | 5/18/1990  | Suttkus et al. 1994     | 1  |       | TRT  | Oak Chewalla Creek  | USACE     | 34.582 | 89.509 |
| 7090    | 5/22/2003  | 1999–2003 data          | 3  | 15.84 | TRT  | Oak Chewalla        | Private   | 34.613 | 89.518 |
| 7091    | 5/23/2003  | 1999–2003 data          | 2  | 11.76 | TRT  | Fice Creek          | Private   | 34.421 | 89.246 |
| 7173    | 8/26/1982  | Thompson and Muncy 1986 | 10 |       | TRT  | Blackwater Creek    | USACE     | 34.569 | 89.609 |
| 7173    | 8/11/1984  | Thompson and Muncy 1986 | 5  |       | TRT  | Blackwater Creek    | USACE     | 34.569 | 89.609 |
| 935     | 4/12/1992  | Suttkus et al. 1994     | 1  |       | TRT  | Hurricane Creek     | Private   | 34.446 | 89.509 |

| Site ID | Date       | Source                    | T  | CPUE   | Unit | Stream              | Ownership | Lat    | Long   |
|---------|------------|---------------------------|----|--------|------|---------------------|-----------|--------|--------|
| 935     | 4/12/1992  | Suttkus et al. 1994       | 14 |        | TRT  | Hurricane Creek     | Private   | 34.446 | 89.509 |
| 935     | 5/19/1988  | Suttkus et al. 1994       | 6  |        | TRT  | Hurricane Creek     | Private   | 34.446 | 89.509 |
| 935     | 3/11/1989  | Suttkus et al. 1994       | 64 |        | TRT  | Hurricane Creek     | Private   | 34.446 | 89.509 |
| 935     | 5/18/1990  | Suttkus et al. 1994       | 8  |        | TRT  | Hurricane Creek     | Private   | 34.446 | 89.509 |
| 935     | 5/24/1992  | Suttkus et al. 1994       | 13 |        | TRT  | Hurricane Creek     | Private   | 34.446 | 89.509 |
| 4994    | 4/7/1984   | Thompson and Muncy 1986   | 18 |        | TRT  | Hurricane Creek     | Private   | 34.425 | 89.496 |
| 4994    | 4/18/1984  | Thompson and Muncy 1986   | 4  |        | TRT  | Hurricane Creek     | Private   | 34.425 | 89.496 |
| 4994    | 4/22/1984  | Thompson and Muncy 1986   | 3  |        | TRT  | Hurricane Creek     | Private   | 34.425 | 89.496 |
| 4994    | 11/10/1984 | Thompson and Muncy 1986   | 4  |        | TRT  | Hurricane Creek     | Private   | 34.425 | 89.496 |
| 7172    | 8/2/1984   | Thompson and Muncy 1986   | 1  |        | TRT  | Hurricane Creek     | Private   | 34.457 | 89.545 |
| 6821    | –          | Randolph and Kennedy 1974 | 0  |        | TR   | Yellow Rabbit Creek | USFS      | 34.819 | 89.105 |
| 6821    | 7/21/1999  | 1999–2003 data            | 6  | 15.35  | TR   | Yellow Rabbit Creek | USFS      | 34.819 | 89.105 |
| 6821    | 6/25/2009  | 2009–2011 data            | 13 | 91.59  | TR   | Yellow Rabbit Creek | USFS      | 34.819 | 89.105 |
| 6821    | 7/2/2009   | 2009–2011 data            | 25 | 91.93  | TR   | Yellow Rabbit Creek | USFS      | 34.819 | 89.105 |
| 6821    | 10/21/2009 | 2009–2011 data            | 12 | 57.37  | TR   | Yellow Rabbit Creek | USFS      | 34.819 | 89.105 |
| 6821    | 1/27/2010  | 2009–2011 data            | 13 | 24.55  | TR   | Yellow Rabbit Creek | USFS      | 34.819 | 89.105 |
| 6821    | 5/26/2010  | 2009–2011 data            | 12 |        | TR   | Yellow Rabbit Creek | USFS      | 34.819 | 89.105 |
| 6821    | 9/7/2010   | 2009–2011 data            | 27 |        | TR   | Yellow Rabbit Creek | USFS      | 34.819 | 89.105 |
| 6821    | 3/15/2011  | 2009–2011 data            | 9  |        | TR   | Yellow Rabbit Creek | USFS      | 34.819 | 89.105 |
| 6821    | 6/30/2011  | 2009–2011 data            | 12 |        | TR   | Yellow Rabbit Creek | USFS      | 34.819 | 89.105 |
| 6822    | –          | Randolph and Kennedy 1974 | 0  |        | TR   | Yellow Rabbit Creek | Private   | 34.773 | 89.144 |
| 6822    | 7/22/1999  | 1999–2003 data            | 4  | 15.50  | TR   | Yellow Rabbit Creek | Private   | 34.773 | 89.144 |
| 6827    | 7/12/1999  | 1999–2003 data            | 15 | 103.80 | TR   | Wagner Creek        | Private   | 34.768 | 89.229 |
| 6829    | 6/17/1999  | 1999–2003 data            | 20 | 159.60 | TR   | UT Tippah River     | USFS      | 34.708 | 89.255 |
| 6829    | 6/25/2009  | 2009–2011 data            | 11 | 110.90 | TR   | UT Tippah River     | USFS      | 34.708 | 89.255 |
| 6830    | 6/17/1999  | 1999–2003 data            | 2  | 17.60  | TR   | UT Tippah River     | Private   | 34.681 | 89.281 |
| 6832    | 7/9/1999   | 1999–2003 data            | 6  | 53.33  | TR   | UT Tippah River     | USFS      | 34.660 | 89.287 |
| 6847    | 6/16/1999  | 1999–2003 data            | 13 | 112.80 | TR   | Chewalla Creek      | Private   | 34.814 | 89.368 |
| 6849    | 6/21/1999  | 1999–2003 data            | 1  | 6.41   | TR   | Chewalla Creek      | USFS      | 34.697 | 89.331 |
| 1325    | 5/20/1981  | Suttkus et al. 1994       | 1  |        | TR   | Chewalla Creek      | Private   | 34.767 | 89.349 |

| Site ID | Date       | Source                    | T  | CPUE   | Unit | Stream                  | Ownership | Lat    | Long   |
|---------|------------|---------------------------|----|--------|------|-------------------------|-----------|--------|--------|
| 6851    | 7/8/1999   | 1999–2003 data            | 28 | 209.60 | TR   | UT Chewalla Creek       | USFS      | 34.733 | 89.303 |
| 7085    | 7/12/1984  | Thompson and Muncy 1986   | 3  |        | TR   | UT Chewalla Creek       | USFS      | 34.76  | 89.332 |
| 7085    | 7/2/2003   | 1999–2003 data            | 13 | 53.46  | TR   | UT Chewalla Creek       | USFS      | 34.76  | 89.332 |
| 7085    | 6/24/2009  | 2009–2011 data            | 4  | 19.20  | TR   | UT Chewalla Creek       | USFS      | 34.76  | 89.332 |
| 7085    | 6/25/2009  | 2009–2011 data            | 5  |        | TR   | UT Chewalla Creek       | USFS      | 34.76  | 89.332 |
| 7185    | 6/24/2009  | 2009–2011 data            | 7  | 68.29  | TR   | UT Chewalla Creek       | Private   | 34.725 | 89.305 |
| 1348    | 9/7/1968   | Randolph and Kennedy 1974 | 1  |        | TR   | UT Chewalla Creek       | Private   | 34.764 | 89.343 |
| 1550    | 2/24/1984  | Thompson and Muncy 1986   | 2  |        | TR   | Big Snow Creek          | Private   | 34.815 | 89.240 |
| 1687    | 9/11/1968  | Randolph and Kennedy 1974 | 1  |        | TR   | Rhoden Creek            | Private   | 34.757 | 89.169 |
| 1878    | 10/5/1968  | Randolph and Kennedy 1974 | 3  |        | TR   | Sorghum Creek           | Private   | 34.707 | 89.071 |
| 7053    | 5/24/2002  | 1999–2003 data            | 1  |        | TR   | South Fork Chilli Creek | Private   | 34.682 | 89.172 |
| 7053    | 9/1/2009   | 1999–2003 data            | 22 | 119.80 | TR   | South Fork Chilli Creek | Private   | 34.682 | 89.172 |
| 7053    | 10/20/2009 | 2009–2011 data            | 3  | 14.50  | TR   | South Fork Chilli Creek | Private   | 34.682 | 89.172 |
| 7053    | 1/15/2010  | 2009–2011 data            | 11 | 37.43  | TR   | South Fork Chilli Creek | Private   | 34.682 | 89.172 |
| 7053    | 5/27/2010  | 2009–2011 data            | 1  |        | TR   | South Fork Chilli Creek | Private   | 34.682 | 89.172 |
| 7053    | 9/8/2010   | 2009–2011 data            | 14 |        | TR   | South Fork Chilli Creek | Private   | 34.682 | 89.172 |
| 7053    | 3/4/2011   | 2009–2011 data            | 3  |        | TR   | South Fork Chilli Creek | Private   | 34.682 | 89.172 |
| 7053    | 6/29/2011  | 2009–2011 data            | 3  |        | TR   | South Fork Chilli Creek | Private   | 34.682 | 89.172 |
| 7080    | 7/2/2003   | 1999–2003 data            | 2  | 5.82   | TR   | Shelby Creek            | Private   | 34.843 | 89.039 |