Species Biological Report

Yellowcheek Darter (*Etheostoma moorei*)

Photo courtesy of: J.R. Shute, Conservation Fisheries, Inc.

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This Species Biological Report informs the Recovery Plan for the Yellowcheek Darter (*Etheostoma moorei*) (U.S. Fish and Wildlife Service (Service) 2018). The Species Biological Report is a comprehensive biological status review by the Service for the yellowcheek darter and provides an account of the species' overall viability. A Recovery Implementation Strategy, which provides the expanded narrative for the recovery activities and the implementation schedule, is available at https://www.fws.gov/arkansas-es/. The Recovery Implementation Strategy and Species Biological Report will be updated separately on a routine basis.

Executive Summary

The Yellowcheek Darter is a small fish endemic to the Devils, Middle, South, and Archey forks of the Little Red River and main stem Little Red River in Arkansas. It inhabits high gradient riffles with clear water, permanent flow, and gravel, cobble, and boulder substrates. The Yellowcheek Darter is threatened by habitat degradation, inadequate water quality, curtailment of habitat and range, small population size and low numbers, their resulting vulnerability to natural and human induced catastrophic events (e.g., drought, pollution spills, etc.).

To evaluate the biological status of the Yellowcheek Darter both currently and into the future, we consider the species' viability as characterized by resiliency, redundancy, and representation. The Yellowcheek Darter needs multiple resilient populations across its range to maintain its persistence into the future and to avoid extinction. Given the habitat deterioration, reduction of the range and small population size, the Yellowcheek Darter has low resilience and low to moderate redundancy, making it more difficult for the species to withstand and recover from stochastic or catastrophic events. Further, the species is likely suffering genetic isolation and reduced adaptive capabilities due to Greers Ferry Lake isolating populations in the Devils and Middle forks from each other and populations in the South and Archey forks, resulting in lower representation. These conditions combined, give the species a higher likelihood of extinction.

Introduction

The Species Biological Report is intended to be an in-depth review of the species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The biological report is intended to be an interim approach as we transition to using a species status assessment (SSA) as the standard format that the Service uses to analyze species as we make decisions under the Endangered Species Act. The intent is for the species biological report to be easily updated as new information becomes available and to support all functions of the Endangered Species Program from candidate assessment to listing to consultations to recovery. Many species will have a Species Biological Report or SSA developed during the listing process. However, for species that are currently listed, such as the yellowcheek darter, a Species Biological Report or an SSA may be the first to be developed during the recovery process. As such, the Species Biological Report or SSA will be a living document. In this document, we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Wolf *et al.* 2015).

- Resiliency is having sufficiently large populations for the species to withstand stochastic events (arising from random factors).

- Redundancy is having a sufficient number of populations for the species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations).

- Representation is having the breadth of genetic makeup of the species to adapt to changing environmental conditions. Representation can be measured through the genetic diversity within and among populations and the ecological diversity of populations across the species' range.

Status of the Species

The Yellowcheek Darter was federally listed as an endangered species on August 9, 2011 (76 FR 48722). The Yellowcheek Darter has a recovery priority number of 2C which indicates recovery potential is considered high because of the likelihood that conservation actions will alleviate threats to the species and bolster population sizes (48 FR 43098). This number (with the C) also indicates Yellowcheek Darter recovery is in conflict with economic interests that include natural gas production and the annual chuck wagon races held in Clinton, Arkansas. A total of 102 river miles (164 rkm) in four streams (Middle, South, Archey and Devils Forks of the Little Red River) was designated as critical habitat on October 16, 2012 (77 FR 63604). Critical habitat is located in Cleburne, Searcy, Stone, and Van Buren Counties, Arkansas.

The Yellowcheek Darter is ranked by the Arkansas Natural Heritage Commission (ANHC 2013) as an S1G1 species: extremely rare in Arkansas, and critically imperiled globally. The Arkansas Game and Fish Commission's (AGFC) Wildlife Action Plan describes the Yellowcheek Darter as a critically imperiled species with declining populations (Anderson 2006) and the agency designated the species as endangered (AGFC 2014).

Taxonomy and Species Description

The Yellowcheek Darter is a small, laterally-compressed fish that attains a maximum standard length of about 6.4 cm (2.5 in), and has a moderately sharp snout, deep body, and deep caudal peduncle (Raney and Suttkus 1964). The back and sides are grayish brown, often with darker brown saddles and lateral bars. Breeding males are brightly colored with a bright blue or brilliant turquoise throat and breast and a light-green belly, while breeding females possess orange and red-orange spots but are not brightly colored (Robison and Buchanan 1988).

First collected in 1959 from the Devils Fork Little Red River, Cleburne County, Arkansas, this species was eventually described by Raney and Suttkus in 1964, using 228 specimens from the Middle, South, and Devils forks of the Little Red River (Devils Fork, Turkey Fork, and Beech Fork represent one stream with three different names and are subsequently referred to as "Devils Fork"). Wood (1996) verified the taxonomic status of the Yellowcheek Darter within the subgenus *Nothonotus*. Complete taxonomy for the species is family Percidae, subfamily Percinae, tribe *Etheostomatini*, genus *Etheostoma*, subgenus *Nothonotus* and *E. tippecanoe* species group (Wood 1996). The Yellowcheek Darter is one of only two (including *E. juliae*) members of the subgenus *Nothonotus* known to occur west of the Mississippi River (Wood 1996).

Johnson *et al.* (2006) found no overall change in genetic diversity of Yellowcheek Darter. Yellowcheek Darter genetic diversity remains high relative to other darters and comparable to other freshwater fishes, despite declining populations. A high degree (26%) of Hardy-Weinberg disequilibrium among polyallelic loci exists for Yellowcheek Darter, which rarely (< 5%) has been observed in other studied darters. They found no evidence existed for presence of null alleles and linkage disequilibrium, but evidence suggested inbreeding. Repeated extirpation and colonization events may explain genetic disequilibrium in Yellowcheek Darter. Recolonization events in headwater streams reduce opportunities for divergence between samples within streams (Johnson *et al.* 2006).

Johnson (2009) characterized genetic structure of six Yellowcheek Darter populations, estimated gene flow within isolated streams, and compared amplified fragment length polymorphism (AFLP) genetic diversity and distance to Mitchell *et al.'s* (2002) allozyme data. AFLP data was concordant with previous work utilizing allozymes in regards to general trends. Genetic diversity was higher than expected for a species in decline. Yellowcheek Darter gene flow levels were indicative of a metapopulation structure within streams, with genetic structuring indicating distinct populations among streams (Johnson 2009). This information suggested that Yellowcheek Darter may recolonize upstream reaches from downstream refuge habitats, but recolonization is likely affected by many factors such as movement ability and biotic and abiotic environmental factors (e.g., discharge and predator presence) (Magoulick and Kobza 2003).

Certain genetic dissimilarities exist between Yellowcheek Darter within each of the respective headwater tributaries (Mitchell *et al.* 2002; Johnson 2009). Management decisions in this recovery plan consider known genetic differences among the four tributaries and their "populations". There is ongoing genetic research to compare the genetic structure of Yellowcheek Darter in the four forks of the Little Red River and determine if: (1) these reproductively isolated populations have disrupted gene flow resulting in significant genetic structuring; and (2) whether the Archey Fork may help enhance genetic diversity.

Life History and Habitat needs

The Yellowcheek Darter inhabits high-gradient headwater tributaries with clear water; permanent flow; moderate to strong riffles; and gravel, rubble, and boulder substrates (Robison and Buchanan 1988) that are relatively free from sedimentation (Brophy and Stoeckel 2006). Seasonal stream drying appears to limit the size and range of the Yellowcheek Darter (Wine *et al.* 2000; Wine and Blumenshine 2002; Brophy and Stoeckel 2006; Magoulick and Lynch 2015). Yellowcheek Darter prey items include aquatic fly larvae (Diptera), stonefly larvae (Plecoptera), mayfly nymphs (Ephemeroptera), and caddisfly larvae (Trichoptera) (McDaniel 1984).

Yellowcheek Darter generally avoids water depth < 5 cm, water velocity < 0.3 m/s, and dominant substrate size > 128 mm (Brophy and Stoeckel 2006). During low flow periods, their preferred water velocity is > 0.1 m/s. Brophy and Stoeckel (2006) observed that Yellowcheek Darter avoids water velocity < 0.1 m/s and selected water velocity ≥ 0.3 m/s when maximum riffle water velocity is 0.49 m/s. When maximum riffle water velocity is 0.5 – 0.89 m/s and ≥ 0.9 m/s, they avoid water velocity < 0.3 and 0.4 m/s, respectively, and select higher velocities. Summertime habitat includes high velocity (> 0.4 m/s) water over 8 – 128 mm gravel and cobble

substrate, except preferred water velocity drops to > 0.1 m/s during low flow periods. The Yellowcheek Darter is a crevice-dweller and takes cover within interstitial spaces of substrate materials. It prefers loose gravel and cobble substrate, not embedded, that provides suitable shelter.

Yellowcheek Darter males and females reach sexual maturity at one year of age, and maximum lifespan is around five years (McDaniel 1984). Spawning occurs from late May through June in portions of riffles with swift to moderately swift water velocities, often around or under the largest substrate particles (McDaniel 1984), although brooding females have been found at the head of riffles in smaller gravel substrate (Wine *et al.* 2000). During non-spawning months, there is a general movement to portions of the riffle with smaller substrate, such as gravel or cobble, and less turbulence (Robison and Harp 1981). Weston and Johnson (2005) observed that the Yellowcheek Darter moved very little during a one-year migration study. It was noted the Yellowcheek Darter appears to be a relatively non-mobile species, with 19 of 22 recaptured individuals found within nine meters (29.5 ft) of their original capture position after periods of several months (Weston and Johnson 2005).

A number of life-history characteristics including courtship patterns, specific spawning behaviors, egg deposition sites, number of eggs per nest, degree of nest protection by males and degree of territoriality are poorly studied in natural environments at this time. However, researchers have suggested the Yellowcheek Darter deposits eggs on the undersides of large cobble in swift water (McDaniel 1984). Wine and Blumenshine (2002) noted, during laboratory spawning, Yellowcheek Darter females bury themselves in fine gravel or sand substrates (often behind large cobble) with only their heads and caudal fin exposed. A male Yellowcheek Darter will then position upstream of the buried female and fertilize her eggs as she releases them in a vibrating motion. Clutch size and nest defense behavior were not observed by Wine and Blumenshine (2002), but laboratory spawning efforts by Conservation Fisheries, Inc. noted clutch sizes were routinely between 20-40 eggs (CFI 2007).

Fish known to coexist with the Yellowcheek Darter include the rainbow darter (*E. caeruleum*) and greenside darter (*E. blennioides*), which can use pool habitats during periods of low flow, as evidenced by the collection of these two species from pools during electrofishing activities. A single Yellowcheek Darter has been collected at the edge of a shallow pool in the Archey Fork during the summer of 2011 (Magoulick and Lynch 2015). The extent to which Yellowcheek Darters utilize pools during drought is not well understood at this time. An inability to use pools during low flows would make them much more vulnerable to seasonal fluctuations in flows that reduce riffle habitat.

Distribution and trends

The Yellowcheek Darter is endemic to the Little Red River and its four major forks, Devils, Middle, South, and Archey forks in Cleburne, Searcy, Stone, and Van Buren Counties, Arkansas (Robison and Buchanan 1988). The Yellowcheek Darter was known to historically occur in portions of these streams that maintained relatively permanent year-round flows. Populations have declined, in part, due to intense seasonal stream drying and inundation of the lower reaches. The Yellowcheek Darter also is threatened by water withdrawal, sedimentation, channelization, pollutants associated with natural gas extraction, and land use changes.

In 1962, the construction of a dam on the Little Red River to create Greers Ferry Lake impounded much of the range of this species, including the lower reaches of Devils Fork, Middle Fork, South Fork, and portions of the mainstem Little Red River, thus extirpating the species from these reaches. The Yellowcheek Darter was also extirpated from the Little Red River downstream of Greers Ferry Lake due to cold tailwater releases. The lake flooded optimal habitat for the species, and caused the genetic isolation of populations (McDaniel 1984), resulting in lower resiliency and redundancy.

In the 1978 – 1981 study by Robison and Harp (1981), Yellowcheek Darter occurred in greatest numbers in the Middle and South forks of the Little Red River, with populations estimated at 36,000 and 13,500 individuals, respectively, while populations in both Devils Fork and Archey Fork were estimated at approximately 10,000 individuals (Robison and Harp 1981). During this study, the four forks of the Little Red River supported an estimated Yellowcheek Darter population of 60,000 individuals, and the species was considered the most abundant riffle fish present (Robison and Harp 1981). Extensive sampling of the first two tributaries of the Little Red River below Greers Ferry Dam (both named Big Creek) failed to find any Yellowcheek Darter, and no darters were found in immediately adjacent watersheds (Robison and Harp 1981).

Robison and Harp (1981) surveyed 20 km of the South Fork documenting the exact number of riffles (86). Thirty-three percent of the riffles were sampled, and three percent of the total riffle area. Their kick seining method was estimated to capture 27% (N = 3 Middle Fork trials) of Yellowcheek Darter individuals. We acknowledge there is a level of uncertainty associated with the capture efficiency (e.g., small sample size) and population estimates do not include confidence intervals. Their estimate of "true" population was most likely a slight underestimate since they never obtained a zero on an electro-kick seine pass. However, given the sample effort and methodology in the South Fork and similar population densities in the South and Middle forks, their South Fork population estimate of 13,500 fish represents the best available science.

A greater level of uncertainty exists with the Robison and Harp (1981) extrapolated population estimates for the Archey, Middle, and Devils forks. Samples in Archey and Devils forks indicated a lower population density (e.g., 50% and 40%, respectively) compared to the South Fork. Whereas, samples in the Middle Fork indicated similar population density to the South Fork. Robison and Harp's (1981) data indicate that their kick seining method typically yields approximately 25 – 33% of the actual number of Yellowcheek Darter individuals per riffle. Uncertainty with the kick seining capture efficiency is due to small sample size in the Middle Fork and assumptions that the capture efficiency is applicable across all four forks absent supporting data. It is important to recognize that uncertainty exists with the Robison and Harp (1981) extrapolated population estimates for the Middle, Archey and Devils forks when evaluating future status of the species (i.e., declining, stable, increasing populations).

Two subsequent studies have failed to observe Yellowcheek Darter in the Turkey Fork reach of the Devils Fork Little Red River (Wine *et al.* 2000; Wine and Blumenshine 2002), since four individuals were last collected by Arkansas State University (ASU) researchers in 1999 (Mitchell *et al.* 2002). They have been observed downstream in the Beech Fork reach, where flows are more permanent (Brophy and Stoeckel 2006). Brophy and Stoeckel (2006) collected 55 Yellowcheek Darters at two Beech Fork sites. The Devils Fork reach downstream of Ramer

Ford Road is influenced by inundation from Greers Ferry Lake and no longer supports Yellowcheek Darter (77 FR 63604).

The U.S. Army Corps of Engineers channelized approximately 5.6 km (3.5 mi) of the lower Archey and South Forks Little Red River within the city limits of Clinton, Arkansas, in 1985, for flood control purposes. Yellowcheek Darter was collected infrequently within this reach following channelization; however, recent stream restoration within this reach has greatly improved habitat conditions and Yellowcheek Darter has recolonized the area. The Yellowcheek Darter currently inhabits most of its historical range not affected by Greers Ferry Lake, although in greatly reduced numbers (Wine *et al.* 2000).

While collecting specimens for the 1999 genetic study, ASU researchers discovered Yellowcheek Darters were no longer the most abundant riffle fish and were more difficult to find throughout its historical range (Wine *et al.* 2000). A thorough status survey conducted in 2000 found the Yellowcheek Darter in three of four historically occupied forks in greatly reduced numbers (Wine *et al.* 2000; Wine *et al.* 2008). Populations in the Middle Fork were estimated at approximately 6,000 individuals, the South Fork at 2,300, and the Archey Fork at 2,000 (Wine *et al.* 2000). Yellowcheek Darter was not collected from the Devils Fork during this study. Fish community composition was similar from 1978 – 1981 and 2000 studies, but the proportion of Yellowcheek Darter declined from approximately 28 to six percent of the overall composition (Wine *et al.* 2000).

Weston and Johnson (2005) surveyed for Yellowcheek Darter at four Middle Fork and two South Fork sites from 2003 – 2004 using methods similar to Robison and Harp (1981) and Wine *et al.* (2008). They estimated the Yellowcheek Darter population within the Middle Fork to be 15,191 using Robison and Harp's (1981) capture efficiency to 41,864 using Wine *et al. 's* (2008) capture efficiency. They also used Wine *et al. 's* (2008) distance estimate of 43.3 km as the linear reach of occupied habitat. Their estimated population for the 17.5 km occupied reach of the South Fork ranged from 16,922 using Robison and Harp's capture efficiency to 13,102 using *Wine et al. 's* (2008) capture efficiency. This method of estimating populations assumes the percentage of high and medium quality riffles suitable for Yellowcheek Darter remain constant over a given distance, which may or may not be true (Weston and Johnson 2005). The disparity between the differing capture efficiencies using Robison and Harp (1981) and Wine *et al.* (2008) method to correct for gear efficiency (e.g., kick seining) highlights concerns with application of variable capture efficiencies based on small sample size and extrapolation to different streams. The three aforementioned studies collected valuable kick seine data, which provides valuable Yellowcheek Darter density information that will be useful for understanding site specific trends.

Magoulick and Lynch (2015) collected Yellowcheek Darter at seven of 12 sites in the Middle and South Forks during August 2011. Yellowcheek Darter was collected at five of six sites with prior Yellowcheek Darter presence. Occupancy estimates suggested that Yellowcheek Darter may be present at two additional sites. Water velocity was the only environmental variable with a significant correlation to Yellowcheek Darter density. Yellowcheek Darter average abundance per riffle habitat sampled was estimated at 1.32±0.87SE (95% CI 0.36 – 4.81) with a detection probability per individual of 0.38±0.24SE (95% CI 0.08 – 0.81). Magoulick and Lynch (2015) found Yellowcheek Darter occupancy rates were high, but densities were low. Occupancy rates

in the two major rivers still known to contain Yellowcheek Darter may be artificially inflated relative to a random sample within the entire range. While Yellowcheek Darter densities were highly variable, similar to previous studies, densities were within the range found in previous studies, albeit on the lower end. Detection variability likely varies with current velocity and substrate size, and therefore varies substantially among sites and riffles.

Critical Habitat

Critical habitat was designated for the Yellowcheek Darter on October 16, 2012 (77 FR 63604). A total of 102 river miles (rmi) in four streams (Middle, South, Archey and Devils Forks of the Little Red River) was designated as critical habitat for the species. The designation includes the following four units:

- Unit 1: Middle Fork of the Little Red River, 73.2 rkm (45.5 rmi), Searcy, Stone, and Van Buren Counties, Arkansas.

- Unit 2: South Fork of the Little Red River, 33.8 rkm (21.0 rmi), Van Buren County, Arkansas.

- Unit 3: Archey Fork of the Little Red River, 28.5 rkm (17.7 rmi), Van Buren County, Arkansas.

- Unit 4: Devils Fork of the Little Red River (including Turkey Creek and Beech Fork), 28.0 rkm (17.4 rmi), Stone and Cleburne Counties, Arkansas

The primary constituent elements of critical habitat for the Yellowcheek Darter are:

1 – Geomorphically stable, second- to fifth-order streams with riffle habitats, and connectivity between spawning, foraging, and resting sites to promote gene flow within the species' range where possible.

2 – Stable bottom composed of relatively silt-free, moderate to strong velocity riffles with gravel, cobble, and boulder substrates.

3 – An instream flow regime (magnitude, frequency, duration, and seasonality of discharge over time) sufficient to provide permanent surface flows, as measured during years with average rainfall, and to maintain benthic habitats utilized by the species.

4 – Adequate water quality characterized by moderate stream temperatures, acceptable dissolved oxygen concentrations, moderate pH, and low levels of pollutants. Adequate water quality is defined for the purpose of this rule as the quality necessary for normal behavior, growth, and viability of all life stages of the yellowcheek darter.

5 – Prey base of aquatic macroinvertebrates, including blackfly larvae, stonefly larvae, mayfly nymphs, and caddisfly larvae.

Summary of current resiliency, redundancy, and representation

Resiliency is assessed at the population level and reflects a species' ability to withstand stochastic events. Demographic measures that reflect population health (e.g. fecundity, survival, population size, etc.) are metrics used to evaluate resiliency. Resilient populations are better able to withstand disturbances such as fluctuations in recruitment and mortality (demographic stochasticity), variations in discharge (environmental stochasticity), and effects of anthropogenic activities. Demographic data on recruitment and survival of Yellowcheek Darter populations are unknown. Population data for each fork indicate declining populations. Relative abundance of Yellowcheek Darter declined from approximately 28 percent to six percent during two decades (1980 – 2000). Population size is small for two populations (Archey and Devils forks). Populations have declined, in part, due to intense seasonal stream drying and inundation of the lower reaches. Yellowcheek Darter also is threatened by water withdrawal, sedimentation, channelization, pollutants associated with natural gas extraction, and land use changes. Yellowcheek Darter populations may not be able to withstand environmental stochasticity and effects of ongoing anthropogenic activities due to range curtailment, reduction in historical refugia due to inundation, declining populations, and sensitivity to increasing stream drying. A paucity of stream flow data for Archey and Devils forks also hinders our current understanding of effects associated with seasonal stream drying. Due to the close proximity (same watershed) of the four streams, we expect lower resiliency to environmental stochasticity (e.g. drought) than would be expected for four populations occurring in different watersheds spread over a larger geographic area. Estimates of effective population size would provide more information on resiliency. Likewise, historical estimates of effective population size compared to recent estimates of population size and estimated divergence times between the four forks may better inform our understanding of resiliency. This species has low resiliency because it is a riffle obligate habitat specialist with low population size, it is susceptible to extirpation due to drought and habitat disturbance, and potential downstream refuge habitats have been destroyed by Greer's Ferry Lake.

Representation is assessed at the species' level and characterizes the ability of a species to adapt to changing environmental conditions. Metrics such as a species' adaptive potential and genetic and ecological variability can be used to assess representation. Genetic studies indicate the genetic diversity of Yellowcheek Darter is high (Johnson et al. 2006; Johnson 2009), there is some structuring among streams (F_{ST} = 0.003 – 0.010) (Mitchell et al. 2002; Johnson 2009), and there is evidence the populations may be undergoing genetic change (Johnson et al. 2006). Johnson (2009) suggested genetic diversity (polymorphism = 92.7; heterozygosity = 0.496) was higher than expected for a species in decline. Genetic structuring among stream populations is consistent with the isolation of stream populations by the physical barrier of Greers Ferry Lake over the past five decades (Johnson 2009). Representation for Yellowcheek Darter appears to be moderate to high based on the best available science.

Redundancy is assessed at the species level and reflects a species' ability to withstand catastrophic events. Redundancy can be measured by the number and distribution of resilient populations across the range of a species. Number of populations (N = 4) is low. Yellowcheek Darter gene flow levels are indicative of a metapopulation structure within each stream (Johnson 2009). Low population resiliency increases the possibility of extirpation due to a catastrophic event thereby reducing redundancy. For these reasons, the best available science indicates Yellowcheek Darter redundancy is low to moderate.

Reasons for Listing/Threats Assessment

Below, we present a summary of threats affecting the Yellowcheek Darter and its habitat. A detailed evaluation of factors affecting the species can be found in the listing determination and critical habitat designation (76 FR 48722; 77 FR 63603). Threats include impoundment, sedimentation, poor livestock grazing practices, improper timber harvest practices, nutrient enrichment, gravel mining, channelization/channel instability, stream drying, and natural gas development. Primary concerns for the species are related to curtailment of habitat and range, small population sizes, and their resulting vulnerability to natural or human induced catastrophic events.

Range Curtailment (Factors A and E)

The Yellowcheek Darter has experienced local extirpations from portions of its historical range. Wine *et al.* (2008) documented drastic extirpations in the upstream ranges of the Yellowcheek Darter (coinciding with drought/drying conditions) during a 1999 – 2000 study and subsequent re-colonization in 2005. The Yellowcheek Darter inhabits most of its historical range not currently affected by Greers Ferry Lake, although in greatly reduced numbers in the Middle, South, Archey, and Devils forks of the Little Red River.

Dams and Impoundments (Factor A)

The suspected primary cause of the species' historical decline is the impoundment of the Little Red River and downstream reaches of the Devils, Middle, and South forks, areas that in the past provided optimal habitat for this species. The creation of Greers Ferry Lake in 1962 converted optimal Yellowcheek Darter habitat (clear, cool, perennial flow with large substrate particle size (Robison and Buchanan 1988)) to a deep, standing water environment. This dramatic change in habitat resulted in flooded spawning sites and changed chemical and physical characteristics in the streams that provide habitat for the species. Impoundments profoundly alter channel characteristics, habitat availability, and flow regime with serious consequences for biota (Allan and Flecker 1993; Ward and Stanford 1995). Some of these consequences include converting flowing to still waters, increasing depths and sedimentation, decreasing dissolved oxygen, drastically altering resident fish populations (Neves *et al.* 1997), disrupting fish migration, and destroying spawning habitat (Ligon *et al.* 1995).

Additionally, earthen dams were constructed across a riffle in the lower South Fork to create a pool for annual chuckwagon races (attendance of 20,000 to 30,000 people) for many years leading up to 2003. The Service and U.S. Army Corps of Engineers met with the responsible landowner in 2004 and suggested an alternative to dam construction that would minimize adverse effects to the Yellowcheek Darter. These recommendations were followed for several years; however, another earthen dam was constructed in 2008 using material from the South

Fork to facilitate events associated with the annual chuckwagon races. The same landowner also constructed an unpermitted dam at the confluence of an intermittent tributary to the South Fork adjacent to a known Yellowcheek Darter site in 2012.

Habitat Alteration and Degradation and resulting Water and Habitat Quality Changes (Factors A, D, and E)

Bottom-dwelling fish species are especially susceptible to sedimentation and other pollutants that degrade or eliminate habitat and food sources (Berkman and Rabeni 1987; Richter *et al.* 1997; Waters 1995). Robison and Harp (1981), McDaniel (1984), and Robison and Buchanan (1988) have attributed the decline in Yellowcheek Darter populations in the four forks of the Little Red River and mainstem Little Red River to habitat alteration and degradation. Based upon current knowledge and a 2004 – 2005 threats assessment (Davidson and Wine 2004; Davidson 2005), gravel mining, unrestricted cattle access into streams, water withdrawal for agricultural and recreational purposes (e.g., golf courses), lack of adequate riparian buffers, construction and maintenance of county roads, and non-point source pollution arising from a broad array of activities also appear to be degrading suitable habitat for the species. The threats assessment documented the aforementioned activities and found 52 sites on the Middle Fork, 28 sites on the South Fork, eight sites on Archey Fork (Davidson 2005), and one site in the Turkey/Beech/Devils Fork system affected by these activities.

Timber harvesting activities involving clear-cutting entire steep hillsides were observed during 1999 – 2000 in the Devils Fork watershed (Wine pers. comm. 2008). When timber harvests involve clear cutting to the water's edge, without leaving a riparian buffer, silt and sediment enter streams lying at the bottom of steep slopes. The lack of streamside vegetation also promotes bank erosion that alters stream courses and introduces large quantities of sediment into the channel (Allan 1995). Timber harvest haul roads also can carry silt and sediment from the road into the stream. Logging impacts on sediment production are considerable, but often erosion of access and haul roads produces more sediment than the land harvested for timber (Brim Box and Mossa 1999, p. 102). Implementation of voluntary forestry best management practices varies slightly from year to year but generally the implementation rate is highest on public and industry sites and lowest on non-industrial sites. Overall, the implementation rate is around 90% for the Ozark region, which includes the upper Little Red River watershed, but typically the implementation rate for streamside management zones ranks among the lowest categories at 80 – 85% compared to road, harvesting, and regeneration (Arkansas Forestry Commission 2011).

Natural gas exploration and development continues to threaten Yellowcheek Darter populations. Erosion and sedimentation issues associated with natural gas development activities, particularly pipelines, were first documented by Service biologists during 2007 in the South Fork Little Red River watershed. In June 2008, the Service began documenting substantial erosion and sedimentation issues associated with natural gas pipeline construction and maintenance as natural gas development activities expanded into the watershed. Service biologists documented erosion and sedimentation at almost every new pipeline stream crossing in the South and Middle forks of the Little Red River watersheds. Channel incision was documented at numerous tributary stream crossings in these respective watersheds. The incision increased erosion and sedimentation, as well as altering hydrology and geomorphology characteristics of the streams.

Pipeline rights-of-way were found to have one of the following conditions: (1) No best management practices (i.e., silt fences, grade breaks, non-erodible stream crossing materials) installed to prevent erosion and sedimentation; (2) ineffective erosion minimization practices in place; (3) effective erosion minimization practices that had not been maintained and, thus, had become ineffective; or (4) final reclamation of the pipeline right-of-way had not occurred for months and in some cases greater than a year after construction activities ceased, leading to prolonged periods of erosion and sedimentation. The magnitude of the impacts to the South and Middle forks of the Little Red River from 2007 – 2008 also was exacerbated due to above-normal rainfall, which led to more frequent and larger pipeline erosion events. Fayetteville Shale production peaked in 2012 has been slowly declining with few new wells being drilled from 2016 – 2017.

Due to climate and geology, seasonal drought and stream drying are common in the upper Little Red River basin (Magoulick 2000). Magoulick and Lynch (2015) noted a trend towards increased stream drying over time. Yellowcheek Darter populations are threatened by seasonal drought and drying from upstream and inundation of downstream reaches by Greers Ferry Lake. Despite their sensitivity to stream drying, the Arkansas State Water Plan (http://arkansaswaterplan.org) indicated "excess surface water" available for non-riparian diversion from the watershed to be 36,900, 36,300, and 24,600 acre-feet/year for the South, Middle, and Devils forks, respectively (http://arkansaswaterplan.org; Appendix C, Table 3-2). The 7Q10 flow (or the lowest average discharge over a period of one week with a recurrence interval of 10 years) for both U.S. Geological Survey gages on the Middle Fork (07075000) and South Fork (07075300) was reported to be zero cubic feet/second.

Climate Change (Factor E)

Small population sizes and limited distribution of the Yellowcheek Darter make it more vulnerable to drought, severe storm events, and other potential effects of climate change. There is a growing concern that climate change may lead to increased frequency of severe storms and drought (Golladay *et al.* 2004, Cook *et al.* 2004). The number of very warm nights (>75°F) has generally been above average for Arkansas since 1995, with a record number of such events occurring during the most recent five year period (2010 – 2014) (https://statesummaries.ncics.org/ar). A rise in number of very warm nights may increase water temperatures. Thermal tolerance data is unknown for Yellowcheek Darter. The Yellowcheek Darter appears susceptible to drought conditions based on life history characteristics (Wine *et al.* 2008; Magoulick and Lynch 2015) such as the apparent need for perennially flowing surface water. Reduction in local water supplies due to drought is also compounded by increased human demand and competition for surface and ground water resources for power production, irrigation, and consumption (Golladay *et al.* 2004).

Ongoing Conservation Efforts

The Service, along with conservation partners, completed a basin-wide conservation strategy for the Yellowcheek Darter to begin addressing threats to the species (Service 2005). From 2007 until its listing, the Yellowcheek Darter was covered under a candidate conservation agreement with assurances (CCAA) in the upper Little Red River watershed in Arkansas, along with the endangered speckled pocketbook mussel under a Safe Harbor Agreement (SHA). An amendment to move Yellowcheek Darter to the SHA was finalized in April 2015. Of the

205,761 hectares (508,446 acres) of property within the upper Little Red River watershed adjacent to one of the four forks that support Yellowcheek Darter, approximately 35,208 ha (87,000 ac) are owned by private parties (Service 2007b). To date, 18 landowners have enrolled 5,955 ha (14,714 ac) (as of January 26, 2018) in the program since its inception in mid-2007, and six more landowners with approximately 1,417 ha (3,502 ac) have pending draft agreements. A total of 59.8 river miles of perennial and intermittent streams have been protected as a result of these efforts. Lands enrolled in these conservation programs include areas within the critical habitat as well as riparian and upland areas outside the critical habitat.

The Service working with The Nature Conservancy, Arkansas Game and Fish Commission, U.S. Army Corps of Engineers, City of Clinton, private landowners, other partners and stakeholders recently completed a restoration plan that will provide flood protection to Clinton and private landowners while enhancing habitat and restoring connectivity for the Yellowcheek Darter. The effort restored 6.7 rkm of the lower Archey and South Forks that were disturbed as a result of channelization for flood control purposes. Phases I and II, which includes stream reaches upstream of the Archey Fork confluence, have been completed for the project with Phase III planned for a future date as funding is acquired. The restoration of these stream reaches provided a valuable connection between the two streams that will promote genetic diversity within Yellowcheek Darter populations while improving habitat availability.

The Nature Conservancy acquired 973 acres adjacent to the Archey Fork in 2013, perpetually protecting approximately four rkm. All pastureland (300 acres) in the floodplain has been replanted in trees as part of Southwestern Energy's ECH$_2$O program to become water neutral regarding their natural gas extraction operations within the Fayetteville Shale of Arkansas. The Nature Conservancy also purchased 970+ acres adjacent to the South Fork in 2015 for the purpose of ecological restoration and protection, perpetually protecting approximately five rkm.

All unpaved roads in the upper Little Red River Watershed have been assessed for sediment delivery and prioritized accordingly. In 2015, The Arkansas Legislature enacted enabling legislation to develop the Arkansas Unpaved Roads Program modeled after Pennsylvania's unpaved roads program. A coalition of partners pledged their support for implementing the Program with approximately $1 million per year budgeted for projects in the first two years. Currently, several pilot projects have been completed in the watershed with additional projects planned. Watersheds such as the upper Little Red will be prioritized under the program to target recovery of listed species.

Other conservation efforts include a captive propagation program for the Yellowcheek Darter that is a cooperative effort between the University of Arkansas at Pine Bluff and Greers Ferry National Fish Hatchery. This propagation effort will ensure that the species can be effectively reared in a laboratory environment, should the future need arise to augment populations or reintroduce the species following catastrophic events.

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