Boulder Darter
(Etheostoma wapiti)

5-Year Review:
Summary and Evaluation

Boulder darter

Boulder darter habitat in Shoal Creek

U.S. Fish and Wildlife Service
Southeast Region
Cookeville Ecological Services Field Office
Cookeville, Tennessee

5-YEAR REVIEW
Boulder Darter/*Etheostoma wapiti*

I. GENERAL INFORMATION

A. Methodology used to complete the review: In conducting this 5-year review, we relied on available information pertaining to historic and current distribution, life history, and habitat of this species. Our sources include the final rule listing this species under the Endangered Species Act; the Recovery Plan; peer reviewed scientific publications; unpublished field observations by Service, State and other experienced biologists; unpublished survey reports; and notes and communications from other qualified biologists or experts. A *Federal Register* notice announcing the review and requesting information was published on July 28, 2006 (71 FR 42871). Comments received and suggestions from peer reviewers were evaluated and incorporated as appropriate (see Appendix A). No part of this review was contracted to an outside party. This review was completed by the Service's lead Recovery biologist in the Cookeville Field Office, Tennessee.

B. Reviewers
Lead Region – Southeast Region: Kelly Bibb, 404-679-7132

Lead Field Office – Cookeville, Tennessee, Ecological Services Field Office: Stephanie Chance, 931-528-6481

Cooperating Field Office – Daphne, Alabama, Ecological Services Field Office: Jeff Powell, 251-441-5181

C. Background

1. Federal Register Notice citation announcing initiation of this review: July 28, 2006, 71 FR 42871

2. Species status: Uncertain, 2009 Recovery Data Call. In 2007, CFI collected boulder darters below Harms Mill on the Elk River in order to obtain broodstock for Shoal Creek reintroduction efforts. Although this collection was successful, no population estimates were conducted due to difficulties snorkeling in the Elk River. In 2008, CFI failed to locate boulder darters in surveys conducted below the release site in Shoal Creek. After four years of boulder darter reintroduction efforts into Shoal Creek, CFI noted a total of 19 fish of three age-classes, including young-of-year boulder darters in three surveys conducted during 2008 near the release site in Shoal Creek. This would indicate that successful reproduction is occurring. However, it remains too early to draw conclusions regarding the overall success of these reintroduction efforts.

3. Recovery achieved: 2 (2 = 26-50% recovery objectives achieved)

4. Listing history

Original Listing
FR notice: 53 FR 33996
Date listed: September 1, 1988
Entity listed: Species
Classification: Endangered

5. Associated rulemakings:

April 8, 2005. Establishment of a Nonessential Experimental Population for Two Fishes (Boulder Darter and Spotfin Chub) in Shoal Creek, Tennessee and Alabama. 70 FR 17916.

6. Review History:

Recovery Data Call: 2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000, 1999, and 1998
Final Recovery Plan: July 27, 1989

7. Species' Recovery Priority Number at start of review (48 FR 43098):

5 (high degree of threat/low recovery potential)

8. Recovery Plan

Name of plan: Recovery Plan for Boulder Darter (Etheostoma sp.)
Date issued: July 27, 1989

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

1. Is the species under review listed as a DPS? No.

2. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy? No

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes

2. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? Yes

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria? Yes
The recovery criteria do take into account the 5 listing factors.

3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.

Reclassification to threatened status would be considered when:

1) Through protection of the existing population in the Elk River and its tributaries and successful establishment of a reintroduced population in Shoal Creek or other historic habitat, or by discovery of an additional population, two distinct viable populations exist.

Viable Population – A reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes. The number of individuals needed and the amount and quality of habitat required to meet this criterion will be determined for the species as one of the recovery tasks.

This criterion has not been met.

Elk River
When listed in 1988, boulder darters were known from only about ten isolated localities in some 60 miles (mi) (96 kilometers (km)) of the Elk River in Giles and Lincoln counties, Tennessee, and Limestone County, Alabama, and the extreme lower ends of Richland Creek and Indian Creek, Giles County, Tennessee (USFWS 1989). The historic collections from these localities document fewer than 100 boulder darters in the Elk River system prior to 1990. Conservation Fisheries, Inc. (CFI) collection efforts from 1993 to 1997 produced only 11 additional specimens from Hamilton Mill and a new site, the Interstate 65 Bridge (Rakes and Shute 2001). Between 1998 and 2000, CFI observed boulder darters at two additional sites, below Harms Mill and at Hobbs Bridge (Rakes and Shute 2001).

In 1993, CFI began developing techniques for captive propagation of the boulder darter, using the bloodfin darter (*Etheostoma sanguifluum*) as a surrogate. The Service, Tennessee Wildlife Resources Agency (TWRA), and Tennessee Valley Authority (TVA) cooperated in a project to reintroduce the boulder darter into sections of the Elk River where it was no longer found (Rakes et al. 1999). CFI's methods used for captive breeding, husbandry, and rearing of young boulder darters are described in Rakes et al. (1999) and Rakes and Shute (2005; 2008).

Between 1997 and 2003, CFI released a total of 2,264 propagated boulder darters into 4 sites in the Elk River (Rakes et al. 1998, 2000; Rakes and Shute 2001, 2002a, 2003, and 2004) (see Table 1).

Table 1. Number of propagated boulder darters released by CFI into 4 sites in the Elk River, Tennessee (Rakes et al. 1998, 2000; Rakes and Shute 2001, 2002a, 2003, and 2004).

Year	TWRA/Frito Lay Access	Hamilton Mill	I-65 Bridge	Hwy 231/431 Bridge
2003	280			
2002	219	153	200	157
2001	265	180		300
2000			104	186
1999			100	
1998				
1997		120		
Total	764	453	404	643

Conservation Fisheries, Inc. surveys from 1997 to 2007 indicate that boulder darters are apparently still present at all locations with suitable habitat, in the mainstem Elk River, albeit in low numbers (CFI, field notes). CFI observed boulder darters at three new localities, expanding the distribution known at the time the recovery plan was written: below Harms Mill, at Hobbs Bridge, and at a shoal well above the I-65 Bridge (Rakes and Shute 2001). Between 1997 and 2007, CFI observed only 93 boulder darters in the Elk River (many were propagated individuals found at release sites), with catch rates (fish per person hour) ranging from 0 to 6.5 (CFI, field notes; Rakes and Shute 2004). Surveys from 2000 to the present were only conducted at the 4 sites where propagated individuals were released (see Table 1), except for 1 additional site in 2005 (CFI, field notes). The TWRA/Frito Lay Access, just upstream from Fayetteville, Tennessee, is the upstream extent of the boulder darter's current known range. Shepard et al. (2006) collected boulder darters between Elk River miles 17 and 33 in 2004-2006. These collections included adult specimens that were collected while boat electrofishing along rock bluffs in deepwater habitats with slabrock in the transition area between the Elk River and Wheeler Reservoir (Shepard et al. 2006).

Conservation Fisheries, Inc. did not conduct boulder darter sampling in the Elk River in 2004 due to rain events from hurricanes (Rakes and Shute 2005). Likewise, high water levels prevented sampling in 2006 (Rakes and Shute 2007). In 2007, CFI collected boulder darters below Harms Mill to obtain broodstock with the purpose of propagating individuals for Shoal Creek reintroduction efforts. However, no population estimates were made. Thorough surveys of previously monitored locations in the Elk River are needed to determine the current distribution and population estimates for this species. However, monitoring conditions are less than ideal in the Elk River due to fluctuations in flows from Tims Ford Dam. Snorkel surveys are also difficult to conduct in the Elk River due to low visibility in the water column from high suspended sediment levels (Rakes and Shute 2002b).

Aside from Richland Creek, boulder darters appear to be absent, or present in such low numbers as to be undetectable, in all Elk River tributaries (CFI, field notes). CFI's

propagation efforts suggest that nearly all tributaries to the Elk River are too small to support reproducing populations of this species except in the lowest reaches (Rakes and Shute 2001). Boulder darter larvae are pelagic feeders, which probably require gently flowing pools in sufficiently large streams to provide drifting zooplankton prey. Only the lower few miles of Richland Creek appear to be large enough to provide these gently flowing pools (Rakes and Shute 2001). Boulder darters have not been found during TVA routine monitoring efforts in Indian Creek (Amy Wales, TVA, personal communication, 2008). In 2004, two boulder darters were found at the mouth of Shoal Creek just upstream of the embayment of Wheeler Reservoir, representing a new tributary record for the species (Shepard et al. 2006). Additional specimens were found in 2005 and 2006 (Shepard et al. 2006). Shepard et al. (2006) speculated that these Shoal Creek specimens represent a reproducing population because they are separated by the Elk River by the Wheeler Reservoir embayment.

Shoal Creek (Tennessee River tributary)

In 1999, CFI conducted field assays in Shoal Creek in an effort to locate suitable habitat for possible reintroductions. Habitat that appeared suitable for boulder darters was observed to be relatively common in portions of the middle and lower reaches of Shoal Creek. Water quality, habitat quality and quantity, and lack of sedimentation all appeared to be far superior in Shoal Creek when compared with the Elk River. An even more significant factor is that Shoal Creek, unlike the Elk River, is not subject to the flow and temperature impacts of a tailwater stream below a reservoir. In 2005, the Service designated a portion of Shoal Creek from creek mile 41.7 (66.7 km) downstream to creek mile 14 (22 km) (Lauderdale County, Alabama and Lawrence County, Tennessee) as a nonessential experimental population (NEP) (USFWS 2005). The NEP allows reintroduction of the boulder darter into this portion of its historical range (USFWS 2005). CFI's methods used for captive breeding, husbandry, and rearing of young boulder darters are described in Rakes et al. (1999) and Rakes and Shute (2005; 2008).

Since 2005, CFI has stocked 1,593 propagated boulder darters into Shoal Creek near Iron City, Tennessee (Rakes and Shute 2008). In September 2007, fourteen adult boulder darters were observed in the release area. Seven adult boulder darters were sampled at this location in early August 2009. It is assumed that all or a portion of the fish sampled were wild progeny of previous stocked boulder darters (Pat Rakes, CFI, personal communication, 2009). Additional surveys of Shoal Creek will be conducted to better determine the over-wintering survivorship, downstream dispersal, natural reproduction and recruitment success of these fish.

Recovery Task 1.3.5. Determine number of individuals to maintain a viable population.

This recovery task has not been completed. Given the rarity of this species, and the continued threat from current Tims Ford Reservoir operations, the Elk River boulder darter population is likely not demographically viable. Current status and genetic assessments are needed to determine the species' abundance, genetic viability, and population trends. (See section III.C.2. for further discussion on threats to the Elk River population). The presumed small population size and apparently fragmented distribution

of individuals in the Elk River leaves the boulder darter vulnerable to heightened risk of reductions in genetic variation through the processes of inbreeding and random genetic drift.

2) Studies of the fish's biological and ecological requirements have been completed, and the implementation of management strategies developed from these studies have been or are likely to be successful.

This criterion has been partially met. In a laboratory study, Burkhead and Williams (1992) found that spawning habitat consists of boulders in flowing water with a velocity of about 1 to 2 feet (ft) (0.3 to 0.6 meters (m)) per second. Burkhead and Williams (1992) stated that nesting sites must have the following specific attributes: 1) the space must be between boulders, not between a boulder and gravel or a boulder and pieces of rubble, although a space created between a boulder and bedrock might be acceptable; 2) it must have a wedge-shaped configuration, with the two boulders touching at a relative narrow angle, creating a space into which the female wedges her eggs; 3) the site must have current flowing across it; 4) the cavity must be roughly horizontal (no vertical or nearly vertical spaces were selected); and 5) the boulders must not only be in the correct depth and current ranges, but they must also occur in a certain configuration relative to the current and to each other.

As a result of this research, the TWRA began constructing artificial spawning structures to enhance existing habitat in the Elk River. In September 1996, 54 structures were placed below Hamilton Mill in Lincoln County, Tennessee. The structures were inspected in May 1997, and no boulder darters were observed. In September 1997, 175 more structures were installed at Hamilton Mill for a total of 229; and 98 structures were placed at the I-65 Bridge in Giles County, Tennessee. Many of the structures placed at the site in 1996 could not be relocated, and approximately half of those that were relocated were clogged with sediment and debris (Rakes et al. 1998). While 3 other fish species were found near the structures, the 7 boulder darters located during the 1997 surveys were found in association with natural slabrocks and were not observed near the structures (Rakes et al. 1998). However, according to CFI, the most important habitat requirement for boulder darters is open cavities for cover and spawning sites in areas with at least moderate velocity (Rakes and Shute 1999).

Between 1998 and 2000, CFI conducted surveys to determine the status of existing populations and to locate habitat suitable for reintroduction and augmentation efforts in the Elk River (Rakes and Shute 2002b). Boulder darter populations were found wherever there was available habitat; however, appropriate habitat was sparse in the Elk River (Rakes and Shute 2002b). These efforts supported earlier conclusions that spawning habitat enhancements would benefit the boulder darter; however, CFI hypothesized that natural slabrocks would be more successful (Rakes and Shute 2002b).

In 1999, the Service, TWRA, and CFI placed 3.5 tons of natural limestone slabrock in the Elk River at the I-65 Bridge crossing adjacent to the remaining TWRA artificial spawning structures which did not appear to be providing habitat for the boulder darter.

In 2001, the Service, TWRA, CFI, and International Paper (IP) placed 18 tons of limestone slabrock in the river at the Highway 231/431 Bridge in Fayetteville and 23 tons at Hamilton Mill. In 2000, CFI conducted surveys near the I-65 Bridge site and collected 16 boulder darters, the greatest number seen in a single survey since the late 1980s (Rakes and Shute 2002b). CFI noted that most of these boulder darters were found beneath slabrock that had been placed in the river in 1999 (Rakes and Shute 2002b). Snorkel surveys conducted in 2003 at the Highway 231/431 Bridge revealed that none of the slabrocks added to the river to augment habitat were visible; the rocks were now buried by shifting gravel substrates (Rakes and Shute 2004). However, almost all monitoring attempts from 2001 to 2004 were hindered due to low visibility conditions. (Surveys were only attempted at the 4 sites included in Table 1). Elk River conditions are seldom suitable for snorkeling, the most effective monitoring technique for boulder darters (Rakes and Shute 2003). Late summer and fall are the optimal times of the year for conducting snorkel surveys, as agriculture and livestock impacts decrease and water clarity improves (Rakes and Shute 2002a). Therefore, no conclusions can be made about the effectiveness of adding slabrock habitat to the Elk River. What little monitoring has been done indicates that the slabrock was buried by sediments or washed downstream during flood events and no longer provides habitat for the boulder darters.

Based on laboratory and field observations, CFI determined that water depth is not a critical factor in the boulder darter's preferred habitat (Rakes and Shute 1999). CFI collected adults and sub adults from the Elk River in less than 12 inches (in) (30.5 centimeters (cm)) of water and at low velocities (Rakes and Shute 1999); while others had only observed them in greater than 2 ft (0.61 m) of water (O'Bara and Etnier 1987; Etnier and Williams 1989).

In 2000, CFI determined that elastomer tags were an effective method for tagging boulder darters (Rakes and Shute 2002b). They did not observe mortality with the elastomer tags, but they observed a high mortality rate with acrylic tags.

CFI developed methods currently in use for captive breeding, husbandry, and rearing of young boulder darters; these are described in Rakes et al. (1999) and Rakes and Shute (2005; 2008). Boulder darters exhibit breeding color when water temperatures reach 64.4-73.4 °F (18-23 °C), usually beginning in April (Rakes et al. 1999; Rakes and Shute 2002a). Females cluster eggs in crevices, as described above, and yolk-sac larvae alternate swimming with resting on the bottom for a day or two (Rakes et al. 1999; Pat Rakes, CFI, personal communication, 2009). The larvae become fully pelagic when their yolk-sac is absorbed and they begin feeding (Pat Rakes, CFI, pers. comm., 2009). Larvae feed at the top and in the water column, unlike other darter species. These pelagic larvae eat a variety of plankton (Rakes et al. 2000).

Removal from the endangered species list would be considered when:

1) Through protection of the existing population and successful establishment of reintroduced populations or discovery of additional populations, three distinct viable populations exist. The existing Elk River population, including the two tributary segments, must be secure from river mile 90 downstream to river mile 30.

This criterion has not been met. See reclassification criterion discussions above.

2) Studies of the fish's biological and ecological requirements have been completed, and the implementation of management strategies developed from these studies has been successful.

This criterion has not been met. See reclassification criterion discussions above.

3) No foreseeable threats exist that would likely threaten survival of any of the populations.

This criterion has not been met. See Section III.C.2.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:
Thorough population monitoring has not been conducted since 1999 (Rakes and Shute 2001). Therefore, boulder darter abundance, population trends, and demographic trends are unknown. However, monitoring efforts associated with the release of captive propagated individuals at specific locations in the Elk River have verified the continued existence of the boulder darter at these locations and have resulted in the successful collection of individuals for broodstock (Rakes and Shute 2008, CFI field notes).

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
The phylogeny of the boulder darter, and other species in the subgenus *Nothonotus*, is described in Etnier and Williams (1989). There have been no further genetic analyses conducted on the boulder darter since the Recovery Plan was written in 1989. However, species such as the boulder darter, that are restricted in range and population size, are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007).

c. Taxonomic classification or changes in nomenclature:
Etheostoma wapiti Etnier and Williams, 1989 is the recognized classification of the boulder darter (Nelson et al. 2004). The species was recognized as *Etheostoma* sp. at the time the Recovery Plan was written in 1989.

d. Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

CFI has identified three new sites within the boulder darter's current range since the recovery plan was written and the Geological Survey of Alabama has found a potentially reproducing population in Shoal Creek (see Reclassification Criterion 1, on pages 5-6).

e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

In 2005, TVA initiated formal consultation with the Service regarding routine operation and maintenance of TVA's water control structures. As a result of this consultation, concluded in 2006, TVA agreed to modify operations at Tims Ford Dam in an attempt to more closely simulate natural flow regimes and to warm water temperatures downstream from the dam. TVA is using an adaptive management process to determine which combination of sluicing, spilling, and hydropower generation at Tims Ford Dam will produce the desired flow and temperature conditions for the boulder darter. This process is ongoing, but is expected to improve habitat conditions for the boulder darter in the entire 133 mile tailwater. In addition, the changes in operations at Tims Ford Dam are anticipated to provide 30 miles of additional habitat to the boulder darter by warming temperatures from Fayetteville upstream to Beans Creek, allowing the darter to expand its current range.

2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

a. Present or threatened destruction, modification or curtailment of its habitat or range:
As indicated in the Recovery Plan (USFWS 1989), toxic chemical spills, siltation, improper pesticide use, and cold water releases from Tims Ford Reservoir remain threats to the boulder darter. Additional threats to the boulder darter include gravel dredging and agricultural practices.

Other threats to the boulder darter include physical habitat destruction resulting from a variety of human-induced impacts such as siltation, disturbance of riparian

corridors, and changes in channel morphology. The most significant of these impacts is siltation caused by excessive releases of sediment from activities such as agriculture, resource extraction (e.g., coal mining, silviculture), road construction, and urban development (Waters 1995). Another possible contributor to sediment in the Elk River is bank sloughing due to hydropower peaking operations at Tims Ford Dam and the resultant wet-dry cycle on stream bank soils. Activities that contribute sediment discharges into a stream system change the erosion or sedimentation pattern, which can lead to the destruction of riparian vegetation, bank collapse, excessive instream sediment deposition, and increased water turbidity and temperatures. Sediment has been shown to abrade and or suffocate bottom-dwelling algae and other organisms by clogging gills; reducing aquatic insect diversity and abundance; impairing fish feeding behavior by altering prey base and reducing visibility of prey; impairing reproduction due to burial of nests; and, ultimately, negatively impacting fish growth, survival, and reproduction (Waters 1995). Wood and Armitage (1997) identified at least five impacts of sedimentation on fish, including (1) reduction of growth rate, disease tolerance, and gill function; (2) reduction of spawning habitat and egg, larvae, and juvenile development; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency. The effects of these types of threats will likely increase as human populations grow in the Elk River and Shoal Creek watersheds in response to human demands for housing, transportation, and places of employment.

Non-point source pollution from land surface runoff can originate from virtually any land use activity and may be correlated with impervious surfaces and storm water runoff. Pollutants may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of affected streams such that the habitat and food sources for species like the boulder darter are negatively impacted. Construction and road maintenance activities associated with urban development typically involve earth-moving activities that increase sediment loads into nearby streams. Other siltation sources, including timber harvesting, clearing of riparian vegetation, and mining and agricultural practices, allow exposed earth to enter streams during or after precipitation events.

The TVA (John Baxter, TVA, pers. comm., 2009) indicated that they are receiving an increasing number of 26a permit requests for water withdrawals in the Elk River and Richland Creek, Giles and Lincoln counties, Tennessee. Water withdrawals might be an increasing threat in the Elk River if global climate change results in an increase in the occurrence and severity of drought in the Southeast.

b. Overutilization for commercial, recreational, scientific, or educational purposes:
Overutilization is not known to be a factor in the decline of this species.

c. Disease or predation:
Disease and predation are not known to be factors in the decline of this species.

d. Inadequacy of existing regulatory mechanisms:
The boulder darter and its habitats are afforded limited protection from water quality degradation under the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.) and the Tennessee Water Quality Control Act of 1977. These laws focus on point-source discharges, and many water quality problems are the result of non-point source discharges. Therefore, these laws and corresponding regulations have been inadequate to halt population declines and degradation of habitat for the boulder darter.

In addition to the Federal listing, the boulder darter is listed as Endangered by the State of Tennessee. Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112), "…it is unlawful for any person to take, attempt to take, possess, transport, export, process, sell or offer for sale or ship nongame wildlife, or for any common or contract carrier knowingly to transport or receive for shipment nongame wildlife." Further, regulations included in the Tennessee Wildlife Resources Commission Proclamation 00-15 Endangered Or Threatened Species state the following: except as provided for in Tennessee Code Annotated, Section 70-8-106 (d) and (e), it shall be unlawful for any person to take, harass, or destroy wildlife listed as threatened or endangered or otherwise to violate terms of Section 70-8-105 (c) or to destroy knowingly the habitat of such species without due consideration of alternatives for the welfare of the species listed in (1) of this proclamation, or (2) the United States list of Endangered fauna. Potential collectors of this species would be required to have a state collection permit.

Since listing, section 7 of the Act has required Federal agencies to consult with the Service when projects they fund, authorize, or carry out may affect the species. However, the lack of Federal authority over the many actions likely impacting boulder darter habitat has become apparent. Many of the threats (including those identified at the time of listing, during recovery planning, and since development of the Recovery Plan) involve activities that likely do not have a Federal nexus (such as water quality changes resulting from development, water withdrawals, or indiscriminate logging) and, thus, may not result in section 7 consultation. Although the take prohibitions of section 9 of the Act do apply to these types of activities and their effects on the boulder darter, enforcement of the section 9 prohibitions is difficult, at best. The Service is not informed

when many activities are being considered, planned, or implemented; therefore, we have no opportunity to provide input into the design of the project or to inform project proponents of the need for a section 10 permit. Unlike higher profile species, conservation of the boulder darter is not valued by most of the public to the extent that citizens would report to the Service the likelihood of habitat destruction or illegal taking. A non-regulatory approach to providing for conservation of the boulder darter may be most effective in alleviating threats and providing for conservation of the fish.

Portions of the Elk River and its tributaries are listed as impaired by the State of Tennessee due to *Escherichia coli*, siltation, physical substrate alterations, flow alteration, low DO, alteration of stream-side vegetative cover, nutrient levels, and thermal modifications (Tennessee Department of Environment and Conservation (TDEC) 2008a). State and federal water quality laws have not been used to their full potential in preventing pollution from agricultural, municipal, and industrial sources. Major sources of pollution in the Elk River basin include pasture grazing, upstream impoundment, industrial and municipal point-source discharges, sand and gravel mining, nonirrigated crop production, and off-road vehicles (TDEC 2008a). However, TDEC is currently developing nutrient Total Maximum Daily Loads (TMDL) for the Upper and Lower Elk River watersheds. As a part of the TMDL process, TDEC will determine the sources and extent of nutrient impairment, quantify nutrient loadings and source contributions, and develop cause and effect relationships between nutrient loadings and response parameters in the Elk River basin (TDEC 2008b).

In the 1990's, the Service met with TVA to discuss cold-water releases from Tims Ford Dam and their effects on boulder darters in the Elk River. In 1993, TVA installed a liquid oxygen diffuser system into Tims Ford Reservoir to maintain a target DO (dissolved oxygen) level of 6 milligrams per liter (mg/L) (2.7 pounds per acre foot of water (lbs./acre ft)) in Tims Ford tailwater (Scott et al. 1996). Fish diversity did not change from 1993 to 1995 below the dam, and although physical habitat was present along with increased DO levels, fluctuations in flows along with subsequent changes in water velocity and temperature were thought to hinder establishment of a diverse fish community (Scott et al. 1996).

In 2005, TVA initiated formal consultation with the Service regarding routine operation and maintenance of TVA's water control structures. As a result of this consultation, concluded in 2006, TVA agreed to modify operations at Tims Ford Dam in an attempt to more closely simulate natural flow regimes and to warm water temperatures downstream from the dam. TVA is using an adaptive management process to determine which combination of sluicing, spilling, and hydropower generation at Tims Ford Dam will produce the desired flow and temperature conditions for the boulder darter. This process is ongoing, but is expected to improve habitat conditions for the boulder darter in the entire 133 mile tailwater. In addition, the changes in operations at Tims Ford Dam are

anticipated to provide 30 miles of additional habitat to the boulder darter by warming temperatures from Fayetteville upstream to Beans Creek, allowing the darter to expand its current range.

e. Other natural or manmade factors affecting its continued existence: The boulder darter's limited geographic range and apparent small population size leaves the species extremely vulnerable to localized extinctions from accidental toxic chemical spills or other stochastic disturbances and to decreased fitness from reduced genetic diversity. Potential sources of such spills include potential accidents involving vehicles transporting chemicals over road crossings of streams inhabited by boulder darter and accidental or intentional release into streams of chemicals used in agricultural or residential applications. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007).

D. Synthesis

When listed in 1988, boulder darters were known from only about ten isolated localities in some 60 mi (96 km) of the Elk River in Giles and Lincoln counties, Tennessee, and Limestone County, Alabama, and the extreme lower ends of Richland Creek and Indian Creek, Giles County, Tennessee. Between 1998 and 2000, CFI observed boulder darters at three new sites in the Elk River. Recent surveys conducted by CFI and TVA indicate that boulder darters are still present at all locations with suitable habitat in the mainstem Elk River and in Richland Creek; however, there are no recent records of the species in Indian Creek. Since 2005, CFI has conducted annual stocking of captive propagated boulder darters into Shoal Creek. However, overwintering survival is unknown and there has been no evidence of natural reproduction or recruitment. As indicated in the Recovery Plan (USFWS 1989), toxic chemical spills, siltation, improper pesticide use, and cold water releases from Tims Ford Reservoir remain threats to the boulder darter. Additional threats to the boulder darter include gravel dredging and agricultural practices.

Due to its limited distribution, unknown population trends, and continued threats, the boulder darter continues to be in danger of extinction throughout its range. Therefore, the status of the boulder darter listed as endangered remains appropriate.

Although TVA is currently implementing operational changes at Tims Ford Reservoir, the adaptive management process is experimental and the probability of success is uncertain. The boulder darter has been successfully propagated; however, the threat of Tims Ford Reservoir operations has prevented the successful reintroduction and recovery of this species in the Elk River. The recovery priority number for the boulder darter should remain 5, as the degree of threat remains high and the potential for recovery remains low.

III. RESULTS

A. Recommended Classification:

__X_ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS -

- Develop population monitoring techniques that will be effective in the Elk River. According to Rakes and Shute (2002), late summer and fall are the optimal times of year for conducting snorkel surveys, as agricultural impacts decrease and water clarity improves. Monitoring conditions, especially for snorkeling, are less than ideal in the Elk River due to fluctuations in flows from Tims Ford Dam. Initiate a long-term monitoring program in the Elk River and Shoal Creek to observe population levels/trends and habitat conditions of presently established populations as well as reintroduced and expanding populations.

- Determine demographic viability of the boulder darter in the Elk River and assess the short-term feasibility of continued propagation and reintroduction efforts in the Shoal Creek NEP. Assess need for additional captive propagation and augmentation efforts in the Elk River. Review available population genetics data to determine whether they provide a sufficient basis for developing a broodstock management plan. Conduct additional genetics studies as necessary.

- Continue the adaptive management process of implementing operational changes at Tims Ford Reservoir that TVA initiated in 2008. Monitor progress of boulder darter dispersal upstream of Fayetteville with releases of warmer water temperatures from Tims Ford Dam.

- Assess additional sites in the Elk River within the species' historic range to determine the availability and location of suitable augmentation sites for future recovery efforts (as needed).

- Determine feasibility of additional habitat improvement activities in the Elk River. In the mid- 1990s, the TWRA, Service, CFI, IP, and other partners attempted to augment spawning structures (i.e., man-made structures and natural slabrocks) in the Elk River. However, monitoring conducted after placement in the river, indicates that the slabrock and man-made structures were buried by sediments or washed downstream during flood events and no longer provided habitat for boulder darters.

- Continue to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat.

- Continue efforts to reduce non-point pollution from agricultural activities by working through the Partners for Fish and Wildlife, USDA Farm Bill, and other landowner incentive programs to implement best management practices.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Boulder Darter (*Etheostoma wapiti*)

Current Classification: Endangered
Recommendation resulting from the 5-Year Review

__X__ No change is needed

Review Conducted By Stephanie Chance

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Mary E Jennings Date 9-8-09

REGIONAL OFFICE APPROVAL:

Acting
Lead Regional Director, Fish and Wildlife Service

Approve Aaron L Valenta Date 9-18-09

Appendix A

Summary of peer review for the 5-year review of the Boulder darter (*Etheostoma wapiti*)

A. Peer Review Method: On August 29, 2008, an email was sent to Conservation Fisheries, Inc. (CFI) and biologists from the Tennessee Valley Authority (TVA) Natural Heritage Program asking for peer review of the draft boulder darter 5 year review. These individuals are considered to be species experts.

B. Peer Review Charge: Peer reviewers were asked for scientific peer review of presented data. Peer reviewers were provided with the conclusion that no change in status was warranted for the species, but were not asked for their review of the legal status recommendation.

C. Summary of Peer Review Comments/Report –TVA did not respond back with comments on the review. Conservation Fisheries, Inc. responded that the yolk-sac larvae of boulder darter are not benthic and inactive, but instead alternate between swimming and resting on the bottom before becoming fully pelagic.

D. Response to Peer Review – Based on the comments received from CFI, the yolk-sac larvae information was corrected on page eight of this review.