

TECHNICAL/AGENCY DRAFT

RECOVERY PLAN

FOR

THE RELICT DARTER

(Etheostoma chienense)

TECHNICAL/AGENCY DRAFT RECOVERY PLAN
for
Relict Darter (*Etheostoma chienense*)

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Literature citations should read as follows:

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EXECUTIVE SUMMARY

Current Status: The relict darter, which was listed as an endangered species on December 27, 1993, is endemic to the Bayou du Chien drainage. Within this drainage the fish is now known from five sites in Graves and Hickman Counties, Kentucky, and it is known to spawn in only one Bayou du Chien tributary in Graves County. Historically, the fish may have also existed downstream in the Bayou du Chien into Fulton County.

Habitat Requirements and Limiting Factors: This small member of the perch family has been and continues to be impacted by water quality and habitat deterioration resulting from channel dredging, siltation contributed by poor land use practices, and by other water pollutants. The fish's limited distribution also makes it extremely vulnerable to toxic chemical spills.

Recovery Objective: Downlisting. As the species was historically and is currently known from only one population and available habitat for restoration is very limited, it is not likely that this fish can be recovered.

Downlisting Criteria: Establish a viable population of the relict darter in the Bayou du Chien and ensure that successful spawning is occurring in five tributaries or stream reaches in the main stem of the Bayou du Chien.

Actions Needed:

1. Utilize existing legislation/regulations to protect the species.
2. Determine threats and alleviate those which threaten the species' existence.
3. Determine species' life history requirements.
4. Solicit assistance of local landowners and initiate "Partners for Wildlife" projects to improve riparian habitat.
5. Develop and utilize an information/education program.
6. Through augmentation or reintroduction, protect and establish viable populations, with spawning occurring in five tributaries or main-stem stream reaches.
7. Search for additional populations.

Cost \$000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Need 7	Total
1995	5.0	10.0	10.0	20.0	15.0	20.0	0.0	80.0
1996	5.0	10.0	10.0	20.0	5.0	20.0	10.0	80.0
1997	5.0	10.0	10.0	20.0	5.0	20.0	0.0	70.0
1998	5.0	10.0	10.0	20.0	5.0	15.0	0.0	65.0
1999	5.0	0.0	0.0	0.0	0.0	15.0	0.0	20.0
2000	5.0	0.0	0.0	0.0	5.0	0.0	0.0	10.0
2001	5.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
2002	5.0	0.0	0.0	0.0	5.0	0.0	0.0	10.0
2003	5.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
2004	5.0	0.0	0.0	0.0	5.0	0.0	0.0	10.0
2005	5.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
Total	55.0	40.0	40.0	80.0	45.0	90.0	10.0	360.0

Date of Downlisting: 2006

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INTRODUCTION

The relict darter (*Etheostoma chienense*) was listed by the U.S. Fish and Wildlife Service (Service) as an endangered species on December 27, 1993 (Service 1993). This darter, which is endemic to the Bayou du Chien drainage, Fulton, Graves, and Hickman Counties, Kentucky, has recently been collected from only five sites within this drainage and is known to spawn in only one Bayou du Chien tributary. The relict darter has and continues to be impacted by water quality and habitat deterioration resulting from stream channelization, siltation contributed by poor land use practices, and water pollution. The present limited distribution of the species also makes it very vulnerable to extinction from toxic chemical spills.

Description

Although the relict darter was apparently first discovered in the Bayou du Chien by Webb and Sisk (1975; reported as *Etheostoma squamiceps*), it was first recognized as a distinct taxon by Page *et al.* (1992). The relict darter is one of ten recognized species in the *E. squamiceps* complex of the subgenus *Catonotus*. Distinguishing features of the subgenus *Catonotus* and the *E. squamiceps* complex were provided by Page *et al.* (1992). A complete description of the relict darter, as well as illustrations, is also presented by Page *et al.*

(1992). The following is a summary of the Page *et al.* (1992) description of the species.

The most distinctive aspects of the relict darter are features of pigmentation and morphology of the dorsal fins of breeding males. Morphologically, the species can be distinguished with certainty only by examination of breeding males. Bright breeding colors do not develop. General body coloration of females and nonbreeding males is typical of all members of the *E. squamiceps* complex and consists of brown mottling on a light tan background. Coloration of the dorsum is variable, usually similar to the sides, but may be paler and crossed by six to eight small, dark brown saddles. The venter is white and unmarked. The head has dark pre- and post-orbital bars.

There are three black spots at the caudal fin base and a black humeral spot. The first dorsal fin is clear, except for faint brown basal and marginal bands; the membrane is thickened at the base and slightly thickened at the tips of the spines. The second dorsal fin possesses clusters of melanophores along rays four to seven that are interrupted by brown bands and a faint basal band; the interradial membranes extend to the distal end of the rays; and the base of the fin is thickened. The pectoral fins are clear (or with five to eight brown bands); both the anal and pelvic fins are clear (Page *et al.* 1992).

Breeding males are gray or dark brown on the dorsum and side, with light tan on the venter. The head and nape are greatly swollen and black; the dark coloration obscures the nonbreeding pattern. Territorial and spawning males have alternating white and black bars on the side of the body. The first dorsal fin is black, except for a clear basal band, and has a small white knob on the tip of each spine, a small clear triangle behind each knob that narrows into a thin, clear margin, and a small clear teardrop posterior to each spine located two-thirds the distance from the base of the fin to its margin. The second dorsal fin is densely covered with melanophores, has a clear basal band, and has four to five clear ovals on the basal two-thirds of each ray (ovals often extending onto membranes); bars are not present on the portion of the rays that extends beyond fin membrane, and there is a small white knob on the tip of each ray. The caudal fin has a thin, clear margin and five to nine dark bands alternating with an equal number of clear to yellow bands that become increasingly wider and darker distally. The middle spot on the caudal fin base is darker than the other two. The anal and pelvic fins are dusky to black with narrow clear margins (Page *et al.* 1992).

Habitat and Population Density

The relict darter occupies the same general habitat as most members of the *E. squamiceps* complex. Adults are concentrated in headwaters and creeks in quiet to gently flowing pools, usually over gravel mixed with sand and under or near cover such as fallen tree branches.

undercut banks, or overhanging riparian vegetation (Warren and Burr 1991).

Warren and Burr (1991) provided some measures of habitat characteristics at the five sites that yielded relict darters during their 1991 survey (Table 1). At most sites, the species was associated with slow flow, cover of undercut banks (and associated root mats), and substrates of fine gravel mixed with sand and overlain with leaf litter. At sites along the main stem of the Bayou du Chien, the species showed a decided affinity for undercut banks and adjacent narrow side channels (2 to 3 meters [m]) underlain by gravel mixed with sand.

For sites where the relict darter was most abundant, Warren and Burr (1991) estimated the extent (i.e., length in meters) of suitable habitat available. At Site 1 (Jackson Creek), they estimated approximately seven individuals for every 10 meters of suitable habitat. Of the 150 m of habitat examined at this site, about 110 m provide suitable habitat for the relict darter. Extrapolating, they estimated (conservatively) that 80 individuals might occupy the site (i.e., about 75 m upstream and downstream of the bridge).

At Site 3 (Bayou du Chien at Highway 1283), Warren and Burr (1991) took 36 individuals within suitable habitat in a 15-m stream reach (a narrow channel adjacent an undercut bank lined with root mats). Of the 100-m stretch they examined at Site 3, they stated that

Table 1. Microhabitat characteristics of the relict darter. Site numbers are referenced in Appendix II. D = Mean depth, nearest cm (range in parentheses); W = Mean width, nearest 0.1 m (range in parentheses); CW = Maximum stream channel width, nearest 0.1 m; V = Velocity, m/sec; No. = Number of individuals captured; Cover, predominant type; Substrate, predominant type (from Warren and Burr 1991).

Site	D	W	CW	V	No.	Cover	Substrate
1	9 (3-18)	2.5 (2.1-2.8)	2.8	.04	18	Undercut bank	Gravel/sand
2	10 (3-16)	3.0 (2.0-4.0)	4.0	.00	5	Undercut bank	Gravel/sand
3	18 (9-26)	2.5 (2.0-3.2)	13.0	.29	46	Undercut bank	Gravel/sand
4	13 (8-15)	11.0 (10-12)	12.0	.48	2	None	Sand/mud/ gravel
5	22 (9-32)	2.0	12.0	.55	1	Undercut bank	Gravel

approximately 50 m should provide excellent habitat for the relict darter. Extrapolating, they estimated (conservatively) that 120 individuals could occupy the site (i.e., about 50 m upstream and 50 m downstream of the bridge).

At sites where Warren and Burr (1991) took few individuals, they made the following estimates of suitable habitat: Site 2, < 15 m; Site 4, < 5 m; Site 5, 15 m.

Food Habits

Although information is available for other members of the *E. squamiceps* complex (Page 1974, 1980), the relict darter's food habits are unknown. As noted by Page (1980), the diet of related darters, like most other darters studied, consists mainly of aquatic insects and small crustaceans. The most commonly eaten organism in the diets of *E. squamiceps* and *E. crossopterum* are chironomid larvae. Juveniles feed on copepods, cladocera, ostracods, and chironomids; large adults feed mainly on amphipods, isopods, chironomids, and caddisflies.

Ecology

Presently, little is known of the ecology of the relict darter, other than its affinity for the undercut banks of small creeks (Warren and Burr 1991) (also, see comments in the "Habitat" and "Reproduction" sections). However, information is available on the ecology of other members of the *E. squamiceps* complex (Page 1974, 1980, 1983).

Etheostoma squamiceps and *E. crossopterum* males grow to a larger size than females and are territorial, particularly during the breeding season. Males and females average about 35 to 37 millimeters (mm) standard length (SL) at 1 year of age; males average 55 mm and females about 50 mm at 2 years of age; and males 63 mm and females 57 mm at 3 years of age. Females outnumber males, and the species lives to 3+ years (Page 1983).

Warren and Burr (1991) found the species associated with *Semotilus atromaculatus* and *Fundulus olivaceus* in Jackson Creek. Additional frequent associates in the main stem of the Bayou du Chien included *Percina ouachitae*, *Phenacobius mirabilis*, and *Noturus nocturnus*.

Reproduction

There is no published information on reproduction in the relict darter, but Page (1974, 1980, 1983) provided information on other members of the *E. squamiceps* complex. Males and females mature at 1 year of age at about 40 and 35 mm SL, respectively, but most males apparently do not spawn until their second year. Spawning occurs from late March to early June. Eggs averaging about 1.8 mm in diameter are deposited on the undersides of submerged objects, usually flat stones. In the case of the relict darter, eggs are frequently attached to the undersides of sticks or logs (P. A. Ceas and L. M. Page, Illinois Natural History Survey, personal communication, 1991); other *Catnotus* spawn on the undersides of slab rocks. The female and male invert briefly during egg laying and then both return to an upright position. Several females may spawn with a single male and nests may contain as many as 1,500 eggs. The eggs are guarded by the male, and incubation periods range from about 125 hours at 22 to 26°C to 270 hours at 18 to 22°C (Page 1983).

Distribution

The relict darter is known only from the Bayou du Chien system in western Kentucky, a small primarily sand- and mud-bottomed Coastal Plain stream in extreme western Kentucky that drains about 554 square kilometers (km) (Burr and Warren 1986). Warren and Burr (1991) surveyed the Bayou du Chien basin and provided the following detailed description of the species' current and historic distribution.

Although there is some vagueness to the Webb and Sick (1975) locality information, it is possible that the relict darter was collected as far downstream as Fulton County (Table 2). However, the most downstream relict darter collection record with good locality data is from the Bayou du Chien in the vicinity of Moscow, in Hickman County. The most upstream locality is from the Bayou du Chien, northwest of Water Valley (Site 2). Within the Bayou du Chien system, only one spawning area has been identified (Jackson Creek, 2.6 km northeast of Water Valley, Graves County, Kentucky) (Page *et al.* 1992). This site (see Table 2, Site 2) was surveyed by Warren and Burr (1991) and others (see Appendices I and II) in the months of March, April, August, and September and consistently yielded numerous relict darters.

The Warren and Burr (1991) survey revealed only one other site that harbored the species in abundance, the Bayou du Chien, 4.5 km north of Water Valley on Highway 1283 (Site 3, Appendix II, Table 2).

Table 2. Summary of present and historical distribution localities and numbers of individual relict darters (an endemic species of the Bayou du Chien in Fulton, Graves, and Hickman Counties, Kentucky) observed. Localities are arranged from upstream to downstream (complete locality information is referenced by site number and/or catalog number in Appendices I and II). ND = not determined; NA = not available (from Warren and Burr 1991).

Locality	Number of Individuals	
	1991	Pre-1991
Bayou du Chien (Site 2, Northeast of Water Valley)	5	NA*
Bayou du Chien (Highway 45)	ND	NA*
Jackson Creek (Site 1)	18	100+
Bayou du Chien (Site 3, Highway 1283)	46	2
Bayou du Chien (Site 4, Highway 307)	2	3
Sand Creek (Highway 307)	0	NA*
Bayou du Chien (Site 5, Davis Road)	1	2
Little Bayou du Chien (Highway 239 bridge)	0	NA*
Bayou du Chien (UT 91.2839, north of Moscow)	0	1
*Webb and Sisk (1975), specimens unavailable.		

Site 3 has been collected previously (e.g., INHS 68008, Appendix I), but yielded only a single individual. As judged from the number of specimens taken in collections from 1972 to 1991, the species is most abundant from Jackson Creek downstream in the Bayou du Chien to about the Highway 1283 bridge. Five individuals were also taken at Site 2 (Bayou du Chien, northeast of Water Valley) in isolated pools; the majority of the streambed was essentially dry.

Other relict darter localities within the Bayou du Chien apparently represent either emigrants or waifs from this extremely limited reach of the drainage. Warren and Burr (1991) based this assessment on the fact that numerous visits to sites yielding one or two individuals have failed to yield a single specimen. For example, the Highway 307 crossing of the Bayou du Chien south of Fulgham has been collected at least ten times by Warren and Burr (1991) or others from 1979 to 1991, but only five relict darters have been recorded from that site (July 16, 1980, and November 11, 1980, and their survey). Warren and Burr (1991) expended over 3 man-hours seining at this site and captured only three individuals of the relict darter. Likewise, between 1978 and 1991 at least 11 collections were made in the Bayou du Chien, Little Bayou du Chien, and their respective tributaries in the vicinity of Moscow, Hickman County, but the only positive records of the relict darter from this downstream reach are those reported by Webb and Sisk (1975; including UT 91.2839, one individual). In short, the occurrence of the species outside of the Jackson Creek drainage and reaches of the Bayou du Chien downstream of Jackson Creek is highly unpredictable.

The endemism of the relict darter in the Bayou du Chien is unique (Warren and Burr 1991). In fact, no other fish species shares a similarly restricted distribution anywhere on the northern Gulf Coastal Plain of Arkansas, Kentucky, Missouri, or Tennessee (Pflieger 1975, Burr and Warren 1986, Robison and Buchanan 1988, Etnier and Starnes, 1994). Other species restricted to the northern Gulf

Coastal Plain, such as *Noturus hildebrandi lautus* and *Etheostoma pyrrhogaster*, are unknown in the Bayou du Chien and are distributed in two or more Mississippi River tributaries (Warren and Burr 1991).

Likelihood of Existence in Other Drainages

Warren and Burr (1991) reviewed and summarized all survey work known to them within the adjacent drainages of Mayfield Creek and Obion Creek. They concluded that there was substantial survey information available within additional nearby drainages (e.g., the Clarks River, Sisk 1969, Kuhajda and Warren 1985; and the Obion River, records at SIUC, UT, INHS, and Dickinson 1973). They also stated that it was extremely unlikely that additional populations of the relict darter would be discovered outside of the Bayou du Chien given the following: (1) the habitat affinities of the relict darter (see "Habitat" section); (2) the complete allopatry between it and its closest relatives (i.e., *E. oophylax*, *E. pseudovulatum*, and *E. neopterum* all occur to the east in the Tennessee River drainage); (3) the absence of any other species in the *E. squamiceps* complex in Mississippi River tributaries in Kentucky and Tennessee, except the relict darter and *E. crossopterum*; and (4) the availability of summaries of species composition in these drainages that do not record the relict darter (Burr and Warren 1986, Etnier and Starnes 1994).

Threats to the Species

Warren and Burr (1991) summarized observations on riparian, floodplain, and in-stream conditions at each of the five sites at which they captured relict darters (see also Appendix II):

Site 1. Jackson Creek: The riparian zone consists of a wooded strip about 15 m wide. The remainder of the floodplain is in cropland, but at the time of sampling was not being actively cultivated. Of the known localities for the relict darter, this is the only site positively identified as a spawning area (Page *et al.* 1992; Ceas and Page, personal communication, 1991); logs and undercut banks are numerous in Jackson Creek. Ditching, channelization, and/or clearing of the riparian buffer zone could reduce or eliminate the in-stream cover and spawning substrate of the relict darter.

Site 2. Bayou du Chien: The downstream floodplain and riparian zone are completely developed as cropland; there is no riparian buffer zone. The upstream floodplain is wooded. Undercut bank and in-stream cover was much less extensive than at Site 1. Seasonal drying of the stream and heavy siltation are likely limiting, notwithstanding the availability of potential, but sparse, spawning habitat.

Site 3. Bayou du Chien: The riparian zone consists of a wooded strip about 5 m wide; the remaining floodplain is dedicated to crops

and pasture. In-stream habitat consists of a number of flat rocks and logs in the stream as well as undercut banks at the stream margins. The habitat present at this site also may afford spawning sites for the species, although no observations of spawning at the site have been made. Warren and Burr (1991) commented that any future channelization or channel modification essentially would destroy habitat for the relict darter because of removal of both in-stream and bank cover.

Site 4. Bayou du Chien: The riparian buffer consists of a wooded strip about 25 m wide; the surrounding floodplain is developed as cropland. In-stream habitat for the relict darter is limited; the channel width is uniform, most of the gravel is concentrated in the middle, and the stream edge is mud and sand. Presently the site is habitat limited, and Warren and Burr (1991) regarded the species' presence as representing waifs/emigrants from upstream habitat.

Site 5. Bayou du Chien: The riparian zone is a 10-m-wide wooded strip; the remainder of the floodplain is primarily agricultural. Heavy coatings of creosote were noted on bridge pilings (a known fish toxin). In-stream gravel substrates are limited, as are undercut banks. Warren and Burr (1991) regarded this site, like Site 4, as habitat limited.

Warren and Burr (1991) speculated that in prehistoric times the species likely was more widespread in the Bayou du Chien but still

was restricted to reaches of the watershed lying upstream of the Mississippi River floodplain (i.e., presently upstream near Moscow). They noted that prior to channelization the Bayou du Chien followed a very sinuous course to the Mississippi River floodplain. Channel sinuosities likely afforded a plethora of both undercut banks and associated gravel deposits, both of which, as indicated by Warren and Burr (1991), supported most of the relict darters in the drainage (see Table 1). Aside from eliminating sinuosities, channelization also removed in-stream cover, such as flat rocks and logs, as well as riparian vegetation. Channelization and land use practices dewatered the floodplains and curtailed perennial flow in many small tributaries, further limiting the species' habitat. Warren and Burr (1991) stated that their survey indicated that many small streams in the watershed are completely dry or consist of isolated pools during the fall months (Appendix II). Warren and Burr's (1991) Site 2 (Bayou du Chien, northeast of Water Valley) yielded five specimens of the darter from isolated pools in an otherwise practically dry streambed. Occurrences of the species in isolated pools may subject both adults and young-of-the-year to increased pressure from predation. Warren and Burr (1991) noted that these observations suggest that dispersal of the species upstream of the Jackson Creek area and into many downstream tributaries may be limited by in-stream flow.

Finally, Warren and Burr (1991) speculated that if Jackson Creek is the primary area of recruitment, those individuals which do disperse

from the tributary may not spawn or may spawn infrequently in flowing reaches of the Bayou du Chien because of the limited amount of spawning substrate. The distribution and microhabitat of the relict darter implies that the current extent of distribution is habitat limited; likewise, recruitment may be constrained by the limited amount of spawning substrate. The result is that the species is now very restricted in the drainage and may be dependent primarily on the integrity of one small tributary for continued recruitment (Warren and Burr 1991).

In short, probable historic reasons that may have restricted the spawning area and habitat of the relict darter include: (1) past channelization of extensive reaches of the Bayou du Chien (Webb and Sisk 1975), with the concomitant homogenization of in-stream habitat, as well as dewatering of floodplain tributaries; (2) ditching of tributaries and removal of shade-producing riparian vegetation and the concomitant decrease in habitat and increase in maximum stream temperatures; (3) increased siltation associated with poor agricultural practices; and (4) deforestation and drainage of riparian wetlands, with the concomitant decreases in in-stream low flow, especially in potential spawning areas. All of these factors have the continued potential to reduce or eliminate the species (Warren and Burr 1991).

PART II

RECOVERY

A. Recovery Objectives

The ultimate goal of this recovery plan is to restore viable populations* of the relict darter (*Etheostoma chienense*) to a significant portion of its historic range and remove the species from the Federal List of Endangered and Threatened Wildlife and Plants.

*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.

Reclassification to threatened:

The species will be considered for reclassification to threatened status when the likelihood of the species' becoming extinct in the foreseeable future has been eliminated by achievement of the following criteria:

1. Through protection and enhancement of the existing population in the Bayou du Chien system a viable population* of the relict darter exists in the main stem of the Bayou du Chien from the vicinity of Moscow, Hickman County, Kentucky, upstream to northeast of Water Valley, Graves County, Kentucky.
2. The relict darter spawns successfully in at least five separate the Bayou du Chien tributaries or main-stem reaches over a 5-year period. Successful spawning is defined here as production of juveniles in at least four of the five sites every year for five years with juvenile production at any one site at least 3 of the 5 years.
3. Studies of the fish's biological and ecological requirements have been completed and the implementation of management strategies developed from these studies have been successful in increasing the density and range of the relict darter in the Bayou du Chien system.
4. No foreseeable threats exist that would likely threaten the survival of a significant portion of the species' range in the main stem of the Bayou du Chien or likely threaten the suitability for spawning of any of the five spawning tributaries or main-stem reaches.

Removal from Endangered Species Act protection:

The final step in the recovery process would be to remove the relict darter from the Act's protection. However it is unlikely that this can be accomplished. The species is endemic to the Bayou du Chien system and within this system it is very limited in distribution. It is unlikely that the relict darter can be reestablished to sufficient habitat within this system to eliminate threats to the species to the point that it can be removed from the Federal Endangered Species List.

B. Narrative Outline

1. Preserve present population and presently used habitat.

Because only one population exists, it is essential that it be protected.

1.1 Continue to utilize existing legislation and regulations (Federal Endangered Species Act, Federal and State surface mining laws, water quality regulations, stream alteration regulations, Federal Energy Regulatory Commission licensing, etc.) to protect the fish and its habitat. Prior to and during implementation of this recovery plan, the species and its habitat should be protected by the full enforcement of existing laws and regulations.

1.2 Solicit help in protecting the species and its essential habitat through the development of cooperation and partnerships with Federal and State agencies, local governments, farming groups, conservation organizations, and local landowners and individuals. Section 7 consultation under the Endangered Species Act and Fish and Wildlife Coordination Act activities can assist in the protection of the species, but these programs alone cannot recover the relict darter. The assistance of Federal and State agencies and local governments will be

essential. However, more importantly, the support of the local farming community, as well as local individuals and landowners, will be essential in order to meet the recovery goals for the relict darter. Without a partnership with the people who live in the watersheds and who have an influence on habitat quality, recovery efforts will be doomed.

1.2.1 Meet with local government officials and regional and local planners to inform them of our plans to attempt recovery and request their support.

1.2.2 Meet with farming interests and try to elicit their support in implementing protective actions.

1.2.3 Develop an educational program using such items as slide/tape shows, brochures, etc. Present this material to schools, farmers, civic groups, youth groups, church organizations, etc.

Educational material outlining the recovery goals, with emphasis on the other benefits of maintaining and upgrading habitat quality, will be extremely useful in informing the public of our actions.

1.3 Determine threats to the species, conduct research necessary for the species' management and recovery, and implement management where needed.

1.3.1 Conduct life history research on the species to include such factors as reproduction, food habits, age and growth, and mortality. Warren and Burr (1991) provided some information on the life history of the relict darter, and information is available on closely related species (Page 1974, 1980, and 1983). However, relict darter life history studies that can be accomplished without sacrificing any individuals would be helpful in fine-tuning the species' management.

1.3.2 Characterize the species' habitat (relevant physical, biological, and chemical components) for all life history stages. The relict darter has been able to withstand some degree of habitat degradation. However, some habitat has been so severely altered that the species is extirpated from some stream reaches, and other population segments are reduced in size and vigor. Knowledge of the species' specific microhabitat requirements and ecological associations are

needed to focus management and recovery efforts on the specific problems within the species' habitat.

1.3.3 Determine present and foreseeable threats to the species. Siltation from some farming practices has contributed and continues to contribute to substrate and water quality degradation. The mechanism by which the species and its habitat are impacted by this factor is not entirely understood, and the extent to which the species can withstand the impacts of silt is not known. Other environmental factors impacting the species also need to be studied.

1.3.4 Based on the biological data and threat analysis, investigate the need for management, including habitat improvement. Implement management, if needed, to secure a viable population. Specific components of the species' habitat, such as spawning habitat and cover, may be lacking, and these may be limiting the species' potential expansion. Habitat improvement programs, such as the placement of artificial spawning structures may be needed to increase spawning success.

Structures may also be needed to provide cover and stabilize the stream bank and streambed.

1.3.5 Develop cooperative ventures with private landowners to restore riparian habitat through programs like "Partners for Wildlife." The Service, in cooperation with landowners, has begun to implement programs to restore riparian habitat and control agricultural runoff in other streams in the southeastern United States. Such programs should be pursued in the Bayou du Chien system to help minimize soil erosion and enhance relict darter habitat.

1.3.6 Determine the number of individuals required to maintain a long-term viable population.

Inbreeding depression can be a major obstacle to the recovery of the species, especially if the remaining population size is small and/or it has gone through some type of genetic bottleneck.

The actual number of individuals in a population is not necessarily a good indication of a population's genetic viability; rather, the "effective population" size is important. The effective population size is the size of an "ideal" population in which genetic drift takes

place at the same rate as in the actual population (Chambers 1983). Franklin (1980) suggested that the inbreeding coefficient should be limited to no more than 1 percent per generation, a figure which implies that the short-term, maintenance effective-population-size should be no fewer than 50 individuals (Frankel and Soulé 1981, Franklin 1980, Soulé 1980). Because the effective population size is typically only one-third to one-fourth the actual population size (being affected by sex ratio, overlapping generations, generally nonrandom distribution of offspring, and nonrandom mating) (Soulé 1980), a population of 150 to 200 individuals is needed for short-term population maintenance. Soulé (1980) further suggests that for long-term viability, an effective population of 500 individuals is necessary, translating into a population size of 1,500 to 2,000 individuals. The effective population size of the relict darter population needs to be determined in order to calculate whether this population is capable of long-term self-maintenance or whether a breeding program should be initiated. Some of these factors can

be addressed under Task 1.3.3, while others will be addressed as needed.

2. Search for additional populations and/or habitat suitable for reintroduction efforts. The Bayou du Chien system has been surveyed extensively. However, it is possible that some small spawning populations were missed. Further study may reveal additional spawning populations; suitable unoccupied spawning habitat for transplants and/or spawning habitat improvement also may be identified during these surveys.

3. Determine the feasibility of reestablishing the relict darter into historic habitat and reintroduce where feasible. The exact historic range of the relict darter within the Bayou du Chien system is not known. However, based on the existing collection records, the species has been taken from the Bayou du Chien from as far downstream as the vicinity of Moscow, Hickman County, to as far upstream as northwest of Water Valley, Graves County (Warren and Burr 1991). The species no longer inhabits the downstream reaches of the Bayou du Chien. If habitat conditions improve in the lower Bayou du Chien system, the relict darter may be able to reinvade these currently uninhabited areas. However, it may be necessary to reintroduce individuals into appropriate habitat in order to increase the species' range.

- 3.1 Develop successful techniques for reestablishing populations. Sufficient stock of the relict darter may not be available to allow for the removal of enough adults to establish spawning populations or expand the species' range in the Bayou du Chien. Techniques for rearing the species and introduction techniques should be developed to help ensure success.
- 3.2 Reintroduce the species into its historic range and evaluate success. Using the techniques developed in Task 3.1, reintroduce the relict darter into areas where it has been extirpated and into other areas where spawning populations could be established. Monitor the progress of the transplants.
- 3.3 Implement the same protective measures for any introduced population segments as outlined for established population segments.
4. Develop and implement a program to monitor population levels and habitat conditions of currently existing population segments as well as newly discovered, introduced, or expanded population segments. During and after recovery actions are implemented, the status of the species and its habitat must be monitored to assess any progress toward recovery. This should be conducted on a biennial schedule.

5. Annually assess overall success of the recovery program and recommend action (changes in recovery objectives, delist, continue to protect, implement new measures, other studies, etc.). The recovery plan must be evaluated periodically to determine if it is on track and to recommend future actions. As more is learned about the species, the recovery objectives may need to be modified.

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PART III
IMPLEMENTATION SCHEDULE

Priorities in column one of the following implementation schedule are assigned as follows:

1. Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
2. Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.
3. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

- FWS - U.S. Fish and Wildlife Service
- TE - Endangered Species Division, Fish and Wildlife Service
- LE - Law Enforcement Division, U.S. Fish and Wildlife Service
- FA - Other Federal Agencies - Includes the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, and U.S. Soil Conservation Service
- R4 - Region 4 (Southeast Region), U.S. Fish and Wildlife Service
- SCA - State Conservation Agencies - Includes the Kentucky Department of Fish and Wildlife Resources and Kentucky State Nature Preserves Commission
- TNC - The Nature Conservancy

RELICT DARTER IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates (\$000's)			Comments
				FNS	Other	FY1	FY2	FY3	
1	1.1	Continue to utilize existing legislation and regulations to protect species and its habitat.	Continuous	R4/TE and LE	FA, SCA	5.0	5.0	5.0	
1	1.2.3	Develop information and education program and present.	1 year (then continuous)	R4/TE	FA, SCA, TNC	15.0	5.0	5.0	
1	1.3.1, 1.3.2, 1.3.3	Conduct research necessary for species management and recovery; i.e., habitat requirements, biology, and threat analysis.	3 years	R4/TE	FA, SCA, TNC	20.0	20.0	20.0	
1	1.3.4	Based on biological and threat analysis, investigate need for management and implement where needed.	3 years	R4/TE	FA, SCA, TNC	5.0	5.0	5.0	
1	1.3.5	Develop cooperative ventures with private landowners to restore riparian habitat.	3 years	R4/TE	FA, SCA, TNC	20.0	20.0	20.0	
1	3	Develop techniques, select sites, reintroduce the species back into historic habitat, and evaluate and protect any populations established.	3 years	R4/TE	FA, SCA, TNC	15.0	15.0	15.0	
2	1.2.1, 1.2.2	Meet with local governmental officials and business interests and elicit their support for recovery.	3 years	R4/TE	FA, SCA, TNC	5.0	5.0	5.0	
2	1.3.6	Determine number of individuals required to maintain viable population.	1 year	R4/TE	FA, SCA, TNC	---	---	20.0	
2	2	Search for additional populations and suitable habitat.	1 year	R4/TE	FA, SCA, TNC	---	10.0	---	

RELICT DARTER IMPLEMENTATION SCHEDULE (continued)

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates (\$000's)			Comments
				FWS	Other	FY1	FY2	FY3	
2	4	Develop and implement a monitoring program.	Biennial	R4/TE	FA, SCA, TNC	2.0	---	2.0	
3	5	Annually assess recovery program and modify program and plan where required.	Continuous	R4/TE	FA, SCA, TNC	0.5	0.5	0.5	

PART IV

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APPENDIX I. SUMMARY OF ALL KNOWN COLLECTION LOCALITIES, PRIOR TO Warren and Burr (1991), OF THE RELICT DARTER.
 INSTITUTIONAL ACRONYMS: INHS = ILLINOIS NATURAL HISTORY SURVEY; KU = UNIVERSITY OF KANSAS; SIUC = SOUTHERN ILLINOIS UNIVERSITY AT CARBONDALE; UAIC = UNIVERSITY OF ALABAMA ICHTHYOLOGICAL COLLECTION; UL = UNIVERSITY OF LOUISVILLE; UMMZ = UNIVERSITY OF MICHIGAN, MUSEUM OF ZOOLOGY; USNM = UNITED STATES NATIONAL MUSEUM; UT = UNIVERSITY OF TENNESSEE; WEBB AND SISK (1975) = SPECIMENS REPORTED BY THESE AUTHORS (AS *E. SQUAMICEPS*), DISPOSITION OF MOST VOUCHER SPECIMENS UNKNOWN (from Warren and Burr 1991).

- INHS 61720 (33) Jackson Creek (Bayou du Chien drainage), 2.6 km NE Water Valley, on Roy Lawrence Dr., Graves Co., KY, 24 Apr 1986.
- INHS 63526 (45), as above, 18 Aug 1987.
- INHS 63920 (21), as above, 7 Apr 1988.
- INHS 58454 (1), as above, 18 Mar 1990.
- INHS 58221 (33), as above, 18 Mar 1990.
- SIUC 18067 (5), UAIC 9998.01 (5), UMMZ 217893 (5), USNM 313758 (5), UT 91.3849 (5), as above, 7 Apr 1988.
- INHS 87178 (1), Bayou du Chien, 4.8 km S Fulgham, Hickman Co., KY, 16 July 1980.
- INHS 68008 (1), Bayou du Chien, 4.5 km N Water Valley, Hickman Co., KY, 23 Aug 1984.
- SIUC 1175 (2), Bayou du Chien, same as INHS 87178, at Rt. 307, 11 Nov 1980.
- SIUC 1185 (2), Bayou du Chien, 4.8 km SW Fulgham, Hickman Co., KY, 11 Nov 1980.
- UL 5992 (1), Bayou du Chien system, Hickman Co., KY (as *E. neopteron* in M. E. Braasch and R. L. Mayden. 1985. Review of the subgenus *Catonotus* (Percidae) with descriptions of two new darters of the *Etheostoma squamiceps* species group. Occas. Pap., Mus. Natural Hist., University of Kansas. 119:1-83).
- UT 91.2839 (1), Bayou du Chien, 0.8 km NW Moscow, Hickman Co., KY, 7 Aug 1973.
- KU 20900 (1), Bayou du Chien, N of Water Valley, Graves Co., KY, 5 Apr 1981.

Webb and Sisk (1975), Station 9, [Little?] Bayou du Chien, 6.4 km N Cayce at Hwy. 239, Fulton Co., KY, day/month unknown, 1972-73. [Note: this station is either Bayou du Chien at Hwy. 239, Hickman Co. or Little Bayou du Chien, at Hwy. 239, Fulton Co.]

Webb and Sisk (1975), Station 10, Bayou du Chien, same as UT 91.2839.

Webb and Sisk (1975), Station 14, same as SIUC 1185, day/month unknown, 1972-73.

Webb and Sisk (1975), Station 15, same as SIUC 1175, day/month unknown, 1972-73.

Webb and Sisk (1975), Station 16, Sand Creek, 4 km S Fulgham, at Hwy. 307, Hickman Co., KY, day/month unknown, 1972-73.

Webb and Sisk (1975), Station 17, same as INHS 68008, day/month unknown, 1972-73.

Webb and Sisk (1975), Station 18, 1.6 km NW [NE?] Water Valley, at Hwy. 45, Graves Co., KY, day/month unknown, 1972-73.

Webb and Sisk (1975), Station 19, 3.2 km NE Water Valley, near Bayou du Chien Church, Graves Co., KY, day/month unknown, 1972-1973.

APPENDIX II. SITES SURVEYED AND RECONNOITERED FOR THE RELICT DARTER
1991 (from Warren and Burr 1991).

A. SITES YIELDING RELICT DARTERS (ALL BAYOU du CHIEN DRAINAGE).
CATALOG NUMBERS PRECEDE LOCALITY (ALL SOUTHERN ILLINOIS
UNIVERSITY ICHTHYOLOGICAL COLLECTION, SIUC). SUMMARIZED FIELD
OBSERVATIONS (IN PARENTHESES) FOLLOW LOCALITY:

1. SIUC 18787, Jackson Creek, 2.6 km NE Water Valley on Roy Lawrence Dr., Graves Co., KY, 21 Sept 1991.
2. SIUC 18802, Bayou du Chien, 3.2 km NE Water Valley on Bayou du Chien Rd., 0.4 km S jct. with Roy Lawrence Dr., Graves Co., KY, 21 Sept 1991 (same as Webb and Sisk 1975, station 19).
3. SIUC 18759, Bayou du Chien, 4.5 km N Water Valley on Hwy. 1283, Graves/Hickman county line, 21 Sept 1991.
4. SIUC 18779, Bayou du Chien, at Hwy. 307 bridge, 4.8 km S Fulgham, Hickman Co., KY, 21 Sept 1991.
5. SIUC 18792, Bayou du Chien, at Davis Rd. bridge, 4.8 km SW Fulgham, Hickman Co., KY, 21 Sept 1991.

B. SITES SAMPLED OR RECONNOITERED THAT DID NOT YIELD THE RELICT
DARTER IN THE BAYOU du CHIEN DRAINAGE:

6. South Fk. Bayou du Chien, at Pea Ridge Rd., 0.4 km NE Water Valley, Graves Co. KY, 21 Sept 1991 (no gravel, no flow, no undercut banks).
7. Sand Creek (Bayou du Chien dr.), at Hwy. 307 bridge, 4.2 km S Fulgham, Hickman Co., KY (no flow, only isolated pools, nearly dry, no fish collected).
8. Bayou du Chien, at Howell Rd., 5.6 km SW Fulgham, Hickman Co., KY, 21 Sept 1991 (reasonably diverse fish fauna, but gravel limited, steep banks, slow current).
9. Unnamed trib., Bayou du Chien, at Rose Rd. bridge, 6.7 km SE Fulgham, Hickman Co., KY, 21 Sept 1991 (extreme headwater fauna [creek chubs, topminnows, mosquitofish], very small, no current, little gravel, no undercut banks).
10. Kane Creek, Bayou du Chien dr., at Hwy. 1529 bridge, 0.6 km E Moscow, Hickman Co., KY, 22 Sept 1991 (lowland stream, primarily mud bottom, turbid water, littered with solid waste, some gravel in one riffle but did not yield relict darter).

11. Little Bayou du Chien, at Hwy. 239 bridge, 1.6 km S Moscow, Hickman/Fulton county line, KY, 22 Sept 1991 (lowland stream, soft, mud bottom, little flow, no riffle habitat).
 12. Bayou du Chien, at Hwy. 239 bridge, 0.8 km E Moscow, Hickman Co., KY, 22 Sept 1991 (limited but suitable habitat for relict darter, but none taken; good fish diversity, many lowland species; gravel limited, good flow, undercut banks present; little spawning habitat available for relict darter).
 13. Mud Creek, Bayou du Chien dr., at Hwy. 94 bridge, 5.6 km W Cayce, Fulton Co., KY, 5 Oct 1991 (very narrow, no flow, steep muddy banks, mud bottom).
 14. Bayou du Chien, just N Moscow, Fulton Co., KY, 21 Sept 1991 (mud bottom, no flow, steep banks, wide stream).
 15. Little Bayou du Chien, at Hwy. 94 bridge, 3.2 km W Cayce, Fulton Co., KY, 5 Oct 1991 (small bayou with bald cypress, fairly deep, no flow, mud bottom).
 16. Little Bayou du Chien, at Hwy. 1125 bridge, 5.2 km SSW Buda, Fulton Co., KY, 5 Oct 1991 (turbid, mostly mud bottom, no flow, small stream lowland fish fauna).
- C. SITES SAMPLED OR RECONNOITERED THAT DID NOT YIELD THE RELICT DARTER IN OBION CREEK DRAINAGE (from Warren and Burr 1991):**
17. Brush Creek, at Cuba Rd., 8 km ENE Water Valley, Graves Co., KY, 5 Oct 1991 (almost dry, one pool contained only creek chubs).
 18. Brush Creek, at Ira Bell Rd., 6.8 km NE Water Valley, Graves Co., KY, 5 Oct 1991 (closest to headwaters of Bayou du Chien, but almost dry, water turbid, no undercut banks, gravel soft, negligible flow).
- D. LOCALITIES CHECKED BUT COMPLETELY DRY IN OBION CREEK DRAINAGE:**
19. Brush Creek, at Hwy. 58 bridge, Graves Co., KY.
 20. Brush Creek, at Hwy. 45 bridge, Graves Co., KY.
 21. Barn Creek, at Wingo Rd. bridge, Graves Co., KY.
- E. LOCALITIES CHECKED BUT COMPLETELY DRY IN THE BAYOU du CHIEN DRAINAGE:**
22. Pond Br., at Hwy. 307 bridge, Hickman Co., KY.
 23. Cane Creek, at Hwy. 307 bridge, Hickman Co., KY.

24. Cane Creek, at Hwy. 924 bridge, Hickman Co., KY.
25. Cane Creek, at Cooley Rd. bridge, Hickman Co., KY.
26. Cane Creek, at Howell Rd. bridge, Hickman Co., KY.
27. Trib., Cane Creek, at Byrd Rd. bridge, Hickman Co., KY.
28. Rush Creek, at Hwy. 94 bridge, Fulton Co., KY.
29. Verhine Creek, at Hwy. 94 bridge, Fulton Co., KY.
30. Little Bayou du Chien, at Thompson Fields Rd. bridge, Fulton Co., KY.

F. SITES CHECKED BY P. A. CEAS ON 18 APR 1991:

31. Browder Creek, at Hwy. 166 bridge, Fulton Co., KY (0.6 m wide, sand bottom, no flow).
32. Little Bayou du Chien, at Hwy. 1125, Fulton Co., KY (ditched, no flow, mud and sand bottom; same as Site 16).
33. Trib., Little Bayou du Chien, Hwy. 166 bridge, Fulton Co., KY (no flow, sand and mud bottom).
34. Little Bayou du Chien, Hwy. 1907 bridge, Fulton Co., KY (no flow, sand and mud bottom).
35. Mud Creek, Hwy. 1127 bridge, Fulton Co., KY (mud and sand bottom).
36. Mud Creek, Hwy. 1128 bridge, Fulton Co., KY (little flow, turbid, mud and sand bottom).
37. Trib., Little Bayou du Chien, Hwy. 1125 bridge, Fulton Co., KY (small; same as Site 32).
38. Trib., Bayou du Chien, Hwy. 924 bridge, Fulton Co., KY (sand bottom, small).
39. Cane Creek, Hwy. 924 bridge, Hickman Co., KY (sand bottom, small; same as Site 24).
40. Cane Creek, Hwy. 1698 bridge, Hickman Co., KY (littered with solid waste, sand and some gravel).
41. Cane Creek, at Rushton Rd. bridge, Hickman Co., KY (small, sand bottom).