RECOVERY PLAN

Duskytail Darter

(Etheostoma {Catonotus} sp.)

U.S. Fish and Wildlife Service

RECOVERY PLAN

for

Duskytail Darter (*Etheostoma* [*Catonotus*] sp.)

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Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect the species. Plans are prepared by the U.S. Fish and Wildlife Service, sometimes with the assistance of recovery teams, contractors, State agencies, and others. Objectives will only be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans do not necessarily represent the views nor the official positions or approvals of any individuals or agencies, other than the U.S. Fish and Wildlife Service, involved in the plan formulation. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1993. Duskytail Darter Recovery Plan. Atlanta, GA. 25 pp.

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Cost ($000's) (continued):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Need 7	Total
2002	10.0	0.0	0.0	5.0	0.0	5.0	5.0	25.0*
2003	10.0	0.0	5.0	5.0	0.0	5.0	5.0	30.0*
Total:	110.0	10.0	30.0	65.0	75.0	310.0*	110.0	710.0*

*Some habitat improvement costs needed for the species' recovery will not be known until the magnitude of specific threats is determined through research. Therefore, costs for habitat restoration may be considerably more expensive.

Date of Recovery: 2004

EXECUTIVE SUMMARY

Current Status: The duskytail darter is listed as endangered. The species presently has a very fragmented, relict distribution, but it was probably at one time much more widespread within the upper Tennessee River and the middle Cumberland River. The duskytail darter is presently known from only four populations in short stream reaches--the Little River, Blount County, Tennessee; Citico Creek, Monroe County, Tennessee; Big South Fork of the Cumberland River, Scott County, Tennessee; and Copper Creek and Clinch River, Scott County, Virginia. Two other historic duskytail darter populations are extirpated.

Habitat Requirements and Limiting Factors: This small darter inhabits rocky areas in gently flowing shallow pools and runs in large creeks and moderately large rivers in the Tennessee and Cumberland River systems. The species has been and continues to be impacted by water quality deterioration. This deterioration results from siltation (contributed by coal mining and poor land use practices), other water pollution, and impoundments.

Recovery Objective: Delisting.

Recovery Criteria: The species will be considered for recovery when five distinct viable populations exist. This can include some or all of the currently known populations and any newly discovered or reestablished populations.

Actions Needed:

1. Utilize existing legislation/regulations to protect the species.
2. Search for new populations.
3. Monitor existing populations.
4. Develop and utilize an information/education program.
5. Determine the species' life history requirements.
6. Determine threats and alleviate those which threaten the species' existence.
7. Through reintroduction and protection, establish five viable populations.

Cost ($000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Need 7	Total
1993	10.0	10.0	5.0	15.0	25.0	70.0	25.0	160.0
1994	10.0	0.0	0.0	5.0	25.0	70.0	20.0	130.0
1995	10.0	0.0	5.0	5.0	25.0	70.0	20.0	135.0
1996	10.0	0.0	0.0	5.0	0.0	30.0	10.0	55.0
1997	10.0	0.0	5.0	5.0	0.0	20.0	5.0	45.0*
1998	10.0	0.0	0.0	5.0	0.0	10.0	5.0	30.0*
1999	10.0	0.0	5.0	5.0	0.0	10.0	5.0	35.0*
2000	10.0	0.0	0.0	5.0	0.0	10.0	5.0	30.0*
2001	10.0	0.0	5.0	5.0	0.0	10.0	5.0	35.0*

> The head became dark and swollen, and the humeral spot and lateral vertical bars intensified. The first dorsal saddle and vertical bar formed a particularly intense dark yoke. A dark border of melanophore developed along the pectoral and anal fin margins, and the anal fin whitens proximally. Brilliant gold, fleshy knobs develop on the tips of the dorsal fin spines and were conspicuous in contrast to the clear medial and dark basal portions of the fin membrane.

The duskytail inhabits the edges of gently flowing shallow pools, eddy areas, and slow runs in usually clear water of large creeks and moderately large rivers (10 to 80 meters [33 to 264 feet]). Snorkel observations in Citico Creek by Rakes *et al.* (1992) and in the Little River, Copper Creek, and the Big South Fork of the Cumberland River (Shute *et al.* 1993) indicate that they are apparently very discriminatory about preferred microhabitat type, being found over heterogenous mixtures of rock sizes from pea gravel, rubble/cobble, slab-rock, and boulder substrates (Starnes and Etnier 1980, Burkhead and Jenkins 1991, Layman 1991, Rakes *et al.* 1992).

Rakes *et al.* (1992) described the habitat as follows:

> ...shallow (4-30 inch/10-120 CM deep) slow runs or edges of pools. Substrates where they were observed were best characterized as "heterogenous," with a wide range of rock sizes from pea gravel to cobble, slabrock and boulders.

This apparent preference for a mixture of various substrate sizes often results in patchy distributions. There may be locally dense clumps of individuals within a relatively short distance, and then long stretches can be surveyed without observing a single specimen (Shute, personal observation, 1993).

Layman (1984b) noted that adult duskytail darters were observed only beneath the cover of rocks, except when moving between rocks. Rakes *et al.* (1992) observed highly territorial behavior between young duskytails in aquariums. This behavior was greatly reduced when enough rocks of various sizes were available to provide cover for all individuals (Shute, personal observation, 1993).

This fish is often found associated with detritus and is sometimes found on slightly silted substrates (Layman 1991, Burkhead and Jenkins 1991). However, Rakes *et al.* (1992) noted that the species is rarely found in heavily silted areas; and, in areas where silt was present, the silt did not fill or obscure the spaces between the rocks.

The duskytail is primarily an insectivore (Layman 1991). The youngest individuals consume microcrustaceans, chironomid larvae, and sometimes large quantities of heptageniid nymphs. Larger individuals are also mainly benthic insectivores, but they generally feed on larger prey items (chironomid larvae, ephemeropteran nymphs,

PART I

INTRODUCTION

The duskytail darter (*Etheostoma* [*Catonotus*] sp.) was listed as an endangered species on April 27, 1993 (U.S. Fish and Wildlife Service, 1993). This small darter inhabits rocky areas in gently flowing shallow pools and runs (deep water areas with moderate to fast current but where the water surface generally remains unbroken, as in riffles) in large creeks and moderately large rivers in the Tennessee and Cumberland River systems. The duskytail presently has a very fragmented, relict distribution, but the species was probably at one time much more widespread within the upper Tennessee River and the middle Cumberland River. Duskytail darters are presently known from only four populations in short stream reaches--the Little River, Blount County, Tennessee; Citico Creek, Monroe County, Tennessee; Big South Fork of the Cumberland River, Scott County, Tennessee; and Copper Creek and Clinch River (this is one population), Scott County, Virginia. Two other historic duskytail darter populations (Abrams Creek, Blount County, Tennessee, and South Fork Holston River, Sullivan County, Tennessee) are extirpated. Populations of this species have been fragmented by habitat alteration, and habitats used by the remaining populations are impacted by deteriorated water quality primarily resulting from poor land use practices. The species' present limited distribution also leaves populations very vulnerable to extirpation from toxic chemical spills.

Description, Ecology, and Life History

The duskytail darter (*Etheostoma* sp.), which was first recognized as a distinct species by Jenkins (1976), is a member of the subgenus *Catonotus* and is closely related to the fantail darter (*E. flabellare*) and the stripetail darter (*E. kennicotti*). The duskytail is being scientifically described by Robert Jenkins (Roanoke College, *in litt.*, 1992). The Tennessee Wildlife Resources Agency and the Tennessee Heritage Program of the Tennessee Department of Environment and Conservation recognize this fish as a threatened species (Starnes and Etnier 1980). The species is recognized as an endangered species by the Virginia Department of Game and Inland Fisheries (Sue Bruenderman, Virginia Department of Game and Inland Fisheries, *in litt.*, 1992; Burkhead and Jenkins 1991).

This small (6.4-centimeters [2 1/2-inch]) fish has a straw to olivaceous colored body, the top of the head is medium to dark gray, and the belly is dingy white to pale gray. It has 10 to 15 long dark vertical bars on the sides of its body, 38 to 48 (usually 40 to 45) lateral scales, and 17 to 20 (usually 18 to 19) dorsal spines and rays (fantail darters have 19 to 23 dorsal spines and rays). (See Burkhead and Jenkins [1991] for more descriptive information on nonbreeding individuals.) It is difficult to determine the sex of nonbreeding individuals in the field. However, during the breeding season, the males become very distinctive. Layman (1991) provides the following detailed description of breeding males:

Because the existing duskytail darter populations inhabit short river reaches, they are vulnerable to extirpation from accidental toxic chemical spills. Because of the duskytail darter's apparent microhabitat specificity and its relatively short life span, the species is extremely vulnerable to short-term and/or localized habitat alterations. In addition, as the populated stream reaches are isolated from each other by impoundments, recolonization of any extirpated population would not be possible without human intervention. The absence of natural gene flow among populations of these fishes leaves the long-term genetic viability of these isolated populations in question.

microcrustaceans, and trichopteran larvae) than the young. Heptageniids were the dominant food item in the three largest duskytail size classes Layman (1991) examined, and large duskytails sometimes feed on fish eggs. Layman (1991) suggested that because heptageniids occupy the interstices between rocks, duskytails may feed on the undersides of rocks.

In the Little River, Layman (1991) found that the spawning season commenced in late April or early May and ended in June. Water temperatures were between 17.5 to 24°C. In Copper Creek, Burkhead and Jenkins (1991) reported that the earliest spawning was observed on April 6 but that most spawning occurred in May. Rakes *et al.* (1992) noted that in 1992, spawning occurred in Citico Creek a bit later than Layman had reported for the Little River population (May 16 and June 26). They also noted that the spring and summer of 1992 was wetter and cooler than normal and more information was needed to determine if these observations were typical for the Citico Creek population.

Layman (1991) noted that spawning occurred in the Little River within the same habitat that the species occupied during the rest of the year. Burkhead and Jenkins (1991) found many apparently breeding adults in a gravel/rubble run with moderate current in Copper Creek. In Citico Creek, nests and nest-guarding males were found beneath slab rocks in the margins of pool areas (Rakes *et al.* 1992). They also found nests in relatively swift shallow water in run areas, as long as appropriately sized slab rocks were available for nest cover.

Prior to the spawning act, the male chooses and cleans a spawning site under a rock. The male chases the female into the nest cavity, both fish invert their bodies, and the eggs are deposited individually into an egg cluster on the underside of the nest rock (Layman 1984a). Males stay at the nest site, guard the eggs, and may spawn with multiple females. The result is a clutch of 23 to 150 eggs. After several days, to allow for more ova to mature, the female can spawn with other males. Duskytail darters can spawn as 1-year-olds. In fact, Layman (1984b) found that less than half of the individuals in the Little River population survived to age 2. He noted that most individuals that survive to spawn as 2-year-olds die shortly after spawning, and a very small percentage of the Little River population survived to age 3 (Layman 1984b). (See Layman [1991] for a detailed description of duskytail spawning.)

Distribution, Reasons for Decline, and Threats to Its Continued Existence

Historically, the duskytail was likely widespread in the middle reaches of the Cumberland River and the upper reaches of the Tennessee River. However, it presently has a very fragmented, relict distribution (Etnier and Starnes, in press; Jenkins and Burkhead, in press). Historic and current duskytail collection records show the species from only seven short river reaches--Little River, Blount

County, Tennessee; Citico Creek, Monroe County, Tennessee; Big South Fork of the Cumberland River, Scott County, Tennessee; Abrams Creek, Blount County, Tennessee; South Fork Holston River, Sullivan County, Tennessee; and Copper Creek and Clinch River, Scott County, Virginia. The duskytail is apparently extirpated from Abrams Creek and South Fork Holston River as it has not been found in either area in recent years (Jenkins and Burkhead, in press).

The Abrams Creek duskytail darter population was presumably extirpated in 1957 by a reclamation project (designed to improve the trout fishery in the stream) that eliminated most native species from the stream (Lennon and Parker 1959). The South Fork Holston River population was also presumably extirpated by impoundment.

In the Little River, the duskytail darter population has been documented from two localities that are about 15 kilometers (9 river miles) apart (Layman 1991). Although there have been no intensive surveys to determine abundance of the species in this river reach, the population is probably not continuous throughout this distance.

Despite yearly intensive sampling, there have been very few collections of the species from the upstream Little River localities since their discovery there in the 1970s (David Etnier, University of Tennessee, personal communication, 1993). Certainly, the relative abundance in the upper reaches is much less than what Layman (1984b, 1991) observed at the lower site in the Little River. Layman (1984b) indicated that in the Little River the stronghold for the species may be limited to a short river reach just upstream from the backwaters of the Fort Loudon Reservoir (lower Little River site).

In October 1993, habitat conditions were found to be substantially degraded at this lower Little River site, compared to conditions observed while collecting duskytail darters for Layman's life history analysis (Shute *et al.* 1993; Layman, University of Alabama, personal communication, 1993). Layman (1984b) estimated that this area was inhabited by more than 1,000 adult duskytail darters in the fall of 1993. Shute *et al.* (1993) found no duskytail darters at this site in the fall of 1993 after an extensive snorkel survey (more than three person hours of effort) in formerly occupied habitat. The area was heavily silted, and extensive algal growth was noted in the rocky area normally inhabited by these darters. This degradation apparently resulted when flow was restricted by a logjam at a bridge; this allowed silt to settle in the slower current sections of the duskytail darter's preferred habitat.

The Little River is also impacted by the cumulative effects of agricultural development in the lower part of the watershed. The population here is also potentially threatened by water withdrawal and increasing residential and commercial development (Clyde Voigtlander, Tennessee Valley Authority, *in litt.*, 1991).

PART II

RECOVERY

A. Recovery Objectives

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

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. Three distinct viable populations* exist, through protection and enhancement of the existing populations in the Little River, Blount County, Tennessee; Citico Creek, Monroe County, Tennessee; Big South Fork of the Cumberland River, Scott County, Tennessee; and Copper Creek and Clinch River, Scott County, Virginia, and successful establishment of a reintroduced population in Abrams Creek or other historic habitat or the discovery of an additional population.

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.

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

Removal from Endangered Species Act protection:

The species will be considered for removal from Endangered Species Act protection when the likelihood of the species' becoming threatened in the foreseeable future has been eliminated by the achievement of the following criteria:

1. Through protection and enhancement of the existing population and successful establishment of reintroduced populations or the discovery of additional populations, five distinct viable populations* exist.

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.

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

*Viable populations: 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.

B. Narrative Outline

1. Preserve present population and presently used habitat. Because only four populations exist, it is essential that these populations 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 habitats. 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.

The duskytail population in the Big South Fork of the Cumberland River is within the National Park Service's BSFNRRA, and the populations in the Little River and Citico Creek occur within, but mostly below, lands controlled by the National Park Service and U.S. Forest Service, respectively. These Federal agencies are aware of these populations and have taken proactive measures to protect them. Populations with a Federal connection have greater opportunities for protection under existing laws than the population in Copper Creek, which is totally on private lands.

1.2 Solicit help in protecting the species and its essential habitats through developing cooperation and partnerships with Federal and State agencies, local governments, industry and 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. However, these programs alone cannot recover the duskytail darter. The assistance of Federal and State agencies and conservation groups, as well as local governments, will be essential. Also, support of the local industrial and business community, as well as local individuals and landowners, will be needed to meet the goal of recovering the species. Without a commitment from the people who live in the vicinity of 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 local business, industry, and 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, business groups, 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. Layman (1991) provided extensive information on the life history of the Little River population. However, Burkhead and Jenkins (1991) point out that some aspects of the duskytail darter's life history are different in Copper Creek. Life history studies of the other populations would be valuable in fine tuning the management needs of these populations. The amount of genetic differentiation present in the existing populations also needs to determine. Jenkins (Roanoke College, personal communication, 1993) noted some morphological differences and suggested possible genetic differences between some of the extant populations. This genetic information will also be valuable in determining which stocks should be used in any attempted reintroductions.

1.3.2 Characterize the species' habitat (relevant physical, biological, and chemical components) for all life history stages. Apparently, the duskytail darter has been able to withstand some degree of habitat degradation. However, some habitat has been so severely altered that the species is extirpated or the population is reduced in size and vigor. Knowledge of the species' specific microhabitat requirements and the ecological associations for each population is needed in order 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 poor land use and road construction 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 these factors is not entirely understood, and the extent to which the species can withstand these impacts is not known. Also, other factors may be impacting the species.

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 viable populations. Specific components of the species' habitat, such as spawning habitat, may be lacking, and these may be limiting the species' potential expansion. Restoration of riparian habitat is needed, especially in the Little River and Copper Creek. The critical areas within these watersheds need to be identified and restoration efforts begun.

1.3.5 Develop cooperative ventures with private landowners to restore riparian habitat through programs like "Partners for Wildlife." The Nature Conservancy and the U.S. Fish and Wildlife Service have begun programs to restore riparian habitat and control agricultural waste. These programs should be encouraged in order to protect and enhance duskytail habitat.

1.3.6 Determine the number of individuals required to maintain a viable population. Inbreeding depression can be a major obstacle to species recovery, especially if the remaining population sizes are small and/or have 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 needed. 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-forth 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 remaining duskytail darter populations needs to be determined in order to calculate whether these populations are capable of long-term self-maintenance or whether a breeding program should be initiated (moving individuals between populations). Some of these factors can be addressed under Task 1.3.3, while others will need to be addressed as part of this task on a need-to-know basis.

2. Search for additional populations and/or habitat suitable for reintroduction efforts. The Tennessee and Cumberland Rivers have been extensively surveyed. However, it is possible that some small populations were missed. Further study may reveal additional populations; suitable habitat for transplants may also be identified during these surveys.

3. Determine the feasibility of reestablishing the duskytail darter into historic habitat and reintroduce where feasible. The extent of the duskytail darter's historic distribution is not known, but based on the widely disjunct nature of existing populations, it is likely that the species was at one time more widespread in the middle reaches of the Cumberland River and the upper reaches of the Tennessee River. Presently, it is known from only four populations. The construction of dams has caused these populations to become isolated from each other and from other areas containing suitable habitat; therefore, it is unlikely that the species can naturally recolonize any historical habitat. If suitable stream reaches are available or can be made suitable (such as in Abrams Creek and the Holston River system), populations should be reintroduced into appropriate habitat within the historic range of the species or into habitat that was likely to have been within the historic range.

   3.1 Develop successful techniques for reestablishing populations. Sufficient stock of the duskytail darter may not be available to allow for the removal of enough adults to establish additional populations. Techniques for rearing the species and introduction techniques

should be developed to help ensure success. As part of any propagation and reintroduction effort, extreme care must be given to ensuring that the genetic integrity of the animals in culture is maintained. It will not benefit the recovery process if the overall fitness of the species is diminished by short-sighted culturing and stocking procedure. Genetic analysis should be included, ideally, as a standard protocol prior to any stocking activity. However, there may not be a sufficient number of animals to sacrifice for genetic testing, and funding is usually limited. When a detailed genetic analysis is not feasible, reintroduction attempts will be made using founders that (1) have as diverse a genetic background as possible and (2) are from the most appropriate river system.

3.2 Reintroduce the species into its historic range and evaluate success. Using the techniques developed in Task 3.1, reintroduce the duskytail darter into areas where populations are known to have been extirpated and other probable historical localities and monitor success.

3.3 Implement the same protective measures for any introduced populations as outlined for established populations.

4. Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as newly discovered, introduced, or expanding populations. 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.

C. Literature Cited

Burkhead, N. M., and R. C. Jenkins. 1991. Fishes, IN: Virginia's Endangered Species. McDonald and Woodward Co., Blacksburg, VA. 671 pp.

Chambers, S. M. 1983. Genetic principles for managers. Pp. 44-45 IN: C. S. Schonewald-Cox, S. M. Chambers, B. MacBryde, W. Thomas (eds.). 1983. Genetics and Conservation - A reference for managing wild animal and plant populations. The Benjamin/Cummings Publ. Co., Inc., New York. 722 pp.

Etnier, D. A., and W. C. Starnes. In press. The Fishes of Tennessee. University of Tennessee Press, Knoxville, TN.

Frankel, O. H., and M. E. Soulé. 1981. Conservation and Evolution. Cambridge Univ. Press. England.

Franklin, R. I. 1980. Evolutionary changes in small populations. IN: Conservation biology, an evolutionary-ecological perspective. Michael E. Soulé and Bruce A. Wilcox (eds.). Published by Sinauer Assoc., Inc., Sunderland, MA. Pp. 135-149.

Jenkins, R. C. 1976. A list of undescribed freshwater fish species of continental United States and Canada, with additions to the 1970 checklist. *Copeia*, pp. 642-644.

Jenkins, R. C., and N. M. Burkhead. In press. The Freshwater Fishes of Virginia. American Fisheries Society, Bethesda, MD.

Layman, S. R. 1991. Life history of the relict duskytail darter, *Etheostoma* (*Catonotus*) sp., in the Little River in Tennessee. *Copeia*, pp. 471-485.

------. 1984a. The duskytail darter, *Etheostoma* (*Catonotus*) sp., confirmed as an egg-clusterer. *Copeia*. 1984:992-994.

------. 1984b. The life history and ecology of the duskytail darter, *Etheostoma* (*Catonotus*) sp., in Tennessee's Little River. Master's Thesis. University of Tennessee, Knoxville, TN. December 1984. 57 pp.

Lennon, R. E., and P. S. Parker. 1959. The reclamation of Indian and Abrams Creeks, Great Smoky Mountains National Park. U.S. Fish and Wild. Serv. Sp. Sci. Rept. - Fish. 306.

Rakes, P. L., J. R. Shute, and P. W. Shute. 1992. Quarterly status report for captive propagation of the duskytail darter (*Etheostoma* [*Catonotus*] sp.). Unpublished report to Tennessee Wildlife Resources Agency; U.S. Fish and Wildlife Service, Asheville Field Office; Cherokee National Forest; and National Park Service, Great Smoky Mountains National Park. October 15, 1992. 5 pp.

Shute, J. R., P. W. Shute, and P. L. Rakes. 1993. Captive propagation and population monitoring of rare southeastern fishes by Conservation Fisheries, Inc. 1993. Final Report to Tennessee Wildlife Resources Agency for Fiscal Year 1992-1993 (Contract #FA-2-09667-2-02) and First Quarter Report for Fiscal Year 1993-1994 (Contract #FA-4-10792-4-00). November 29, 1993. 27 pp.

Soulé, M. E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. IN: Conservation biology, an evolutionary perspective. Michael E. Soulé and Bruce A. Wilcox (eds.). Published by Sinauer Assoc., Inc., Sunderland, MA. Ch. 8, pp. 151-169.

Starnes, W. C., and D. A. Etnier. 1980. Fishes. Pp. B1-B134 IN: D. C. Eagar and R. M. Hatcher (eds.). Tennessee's Rare Wildlife Volume 1: The Vertebrates. Tennessee Heritage Program.

U.S. Fish and Wildlife Service. 1993. Endangered and Threatened wildlife and plants; determination of the duskytail darter (*Etheostoma* [*Catonotus*] sp.) to be an endangered species. Federal Register 58(79):25758-25763.

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. Forest Service, National Park Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Soil Conservation Service, and Tennessee Valley Authority
R4 - Region 4 (Southeast Region), U.S. Fish and Wildlife Service
R5 - Region 5 (Northeast Region), U.S. Fish and Wildlife Service
SCA - State Conservation Agencies - Includes the Kentucky Department of Fish and Wildlife Resources, Kentucky State Nature Preserves Commission, Tennessee Department of Environment and Conservation, Tennessee Wildlife Resources Agency, and Virginia Department of Game and Inland Fisheries
TNC - The Nature Conservancy

DUSKYTAIL DARTER IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	Responsible Agency Other	Cost Estimates ($000's) FY1	FY2	FY3	Comments
1	1.1	Continue to utilize existing legislation and regulations to protect species and its habitat.	Continuous	R4 and R5/TE and LE	FA, SCA	10.0	10.0	10.0	
1	1.2.3	Develop information and education program and present.	1 year (then continuous)	R4 and R5/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 and R5/TE	FA, SCA, TNC	40.0	40.0	40.0	
1	1.3.4	Based on biological and threat analysis, investigate need for management and implement where needed.	3 years	R4 and R5/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 and R5/TE	FA, SCA, TNC	50.0	50.0	50.0	
1	3	Develop techniques, select sites, reintroduce the species back into historic habitat, and evaluate and protect any populations established.	3 years	R4 and R5/TE	FA, SCA, TNC	25.0	20.0	20.0	

DUSKYTAIL DARTER IMPLEMENTATION SCHEDULE (continued)

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	Responsible Agency Other	Cost Estimates ($000's) FY1	FY2	FY3	Comments
2	1.2.1, 1.2.2	Meet with local governmental officials and business interests and elicit their support for recovery.	3 years	R4 and R5/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 and R5/TE	FA, SCA, TNC	---	---	20.0	
2	2	Search for additional populations and suitable habitat.	1 year	R4 and R5/TE	FA, SCA, TNC	10.0	---	---	
2	4	Develop and implement a monitoring program.	Biennial	R4 and R5/TE	FA, SCA, TNC	5.0	---	5.0	
3	5	Annually assess recovery program and modify program and plan where required.	Continuous	R4 and R5/TE	FA, SCA, TNC	0.5	0.5	0.5	

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