Imperiled Fishes of the Lower Tennessee Cumberland Ecosystem, with Emphasis on the Non-Federally Listed Fauna

Prepared for the Lower Tennessee Cumberland Ecosystem Team
U.S. Fish and Wildlife Service

September 2002

by

Robert S. Butler
U.S. Fish and Wildlife Service
Asheville, North Carolina Field Office

Introduction

Freshwater fish diversity in the southern United States is unparalleled in the Temperate World. According to the American Fisheries Society (AFS), about 662 native freshwater fishes are known from drainages spanning the southern U.S. from Virginia to southeastern Kansas to Texas excluding the Rio Grande (Warren et al. 2000). This area is completely within the U.S. Fish and Wildlife Service's (Service) Southeast Region (Region 4). Well over 600 fishes are estimated to occur in Region 4 drainages.

Conservation status of southeastern fishes has been assessed by Deacon et al. (1979) and Williams et al. (1989). Warren et al. (2000) took status assessment a step further. They determined distributions of fishes within 51 regional drainage units, as well as assigned conservation status for all recognized taxa, and those formally undescribed taxa for which there was compelling evidence for taxonomic distinction. Approximately 28% of the southern fish fauna was deemed in need of conservation (Warren et al. 2000). This level of imperilment represents a 75% increase in jeopardized fishes from 1989 (Williams et al. 1989), and a 125% increase since 1979 (Deacon et al. 1979). Interestingly, 28% of the fish fauna were also shown to have native ranges restricted to a single drainage unit. Despite the relatively large size of their drainage units, distributional data for southern fishes indicates the profound threat from range fragmentation and isolation (Warren et al. 2000). The high degree of relatively narrow endemicity in southern fishes (Warren and Burr 1994) not only makes our fish fauna among the most unique in the world, but also a highly jeopardized one (Etnier 1997, Warren et al. 1997, Warren et al. 2000).

Recognized diversity among fishes is rapidly expanding, even in light of a century and a half of periodically intensive taxonomic investigations (Warren et al. 2000). Nearly 40 fishes have been discovered and/or described in the past 12 years alone in the Southeast, of which about two-thirds are darters (Burkhead and Jelks 2000). Ichthyologists recognize several other fishes whose present species concept includes a complex of putative (regarded as valid) taxa (Warren et al. 2000). Uncovering "cryptic biodiversity" among fishes continues to progress at an astounding level with advancing biotechnology and the application of phylogenetic analyses

(Mayden and Wood 1995). Complexes of fishes await rigorous taxonomic investigation (Warren et al. 2000). However, the number of formally described fish species is expected to continue to rise in this remarkably rich geographic region (Burkhead and Jelks 2000). Newly discovered fishes are oftentimes narrowly endemic and imperiled (Burkhead and Jelks 2000), making sound management efforts exceedingly difficult considering the dearth of ecological information requisite for their protection or recovery (Warren et al. 2000).

The inclusion of numerous putative, but undescribed, taxa by Warren et al. (2000) was an attempt at tallying total fish diversity from the region. Acceptance of undescribed forms by the conservation community awaits peer review and publication of formal taxonomic descriptions. An accurate accounting of diversity is imperative for the wise management, preservation, and recovery of regional fishes (Mayden and Wood 1995, Angermeier and Winston 1999).

Landscape scale habitat degradation has resulted in range reduction, fragmentation, and increasing isolation of southern fishes (Angermeier 1995, Warren et al. 1997). The high rate of human population growth in the "Sunbelt" coupled with increasing natural resource consumption is the foundation of significant threats to regional aquatic resources (Noss and Peters 1995, Folkerts 1997). Population growth increases the demand for dam construction, navigation channel maintenance, inter-basin water transfers for metropolitan areas, and aquifer depletion (Warren et al. 2000). These pervasive threats to aquatic habitats throughout the region (Walsh et al. 1995), coupled with the highly endemic fauna (Warren and Burr 1994), exacerbate the level of faunal imperilment. Clearly, the trend for fishes in recent decades has been the increasing threat of imminent extinction (Warren et al. 2000). Other aquatic faunal groups have also been determined to suffer even higher levels of imperilment (e.g., freshwater mussels, Williams et al. 1993; crayfishes, Taylor et al. 1996). The challenge to aquatic resource managers charged with their conservation is therefore both obvious and daunting.

In Region 4, 35 fishes are protected under the Endangered Species Act (ESA) and have recovery plans. Federally listed species represent less than 5% of southeastern fishes, but over 25% of the Region 4 fauna is deemed in need of conservation (Warren et al. 2000). The large number of jeopardized, but unlisted, fishes in our region emphasizes the need to manage and conserve this

fauna before listing becomes necessary. If present trends continue, the extreme rarity and imperilment of some taxa will likely require Federal protection. The immediate implementation of sound, scientifically-based conservation actions may preclude the need to list an increasingly large percentage of the regional fish fauna.

Since the early 1970's, aquatic resource managers have slowly made the transition from single-species to ecosystem management, which is a more holistic manner of managing all but the most highly endemic taxa (Shute et al. 1997). Unfortunately, many fishes are becoming so rare that propagation technology and the holding of captive populations is increasingly necessary, particularly among the highly endemic fauna (Rakes et al. 1999). Shute et al. (1997) presented a general outline for the sound holistic management of aquatic resources at the ecosystem scale. They stressed the role of multiple partners and the importance of implementing various aspects of sound science (e.g., managing habitat and water quality, life history requirements, population dynamics, genetic information, propagation/reintroduction technologies, monitoring). These steps are necessary to manage the increasingly large imperiled fish fauna.

The intent of this report is to enhance our knowledge and understanding of the Service's Lower Tennessee Cumberland Ecosystem (LTCE) imperiled fish fauna and to answer the call by Shute et al. (1997), Warren et al. (2000), and others to help manage aquatic faunas on an ecosystem scale. Objectives include: 1) generating an annotated table of potentially imperiled fishes, including putative taxa; 2) compiling a list of fishes protected under the ESA; 3) compiling a comprehensive list of fishes considered currently stable; 4) determining single drainage endemics and those fishes that occur exclusively in the LTCE; 5) providing a list of fishes recommended for addition to the Service's Region 4 "species of concern" list; 6) prioritizing a list of stream systems having extant populations of imperiled taxa; and 7) creating a "short list" of fishes with a relatively high potential for imperilment and deemed to have the greatest need for current conservation status assessment; and 8) suggesting critical research and conservation needs for those fishes. Throughout the report, emphasis is placed on the non-federally listed fish fauna of the LTCE. This focus in no way implies that listed forms should not be the recipient of concerted conservation attention. Rather the implication is that numerous non-listed LTCE

fishes need to be on conservation manager's "radar screens" if we are to manage and effect recovery for an ever larger portion of the imperiled southeastern fish fauna.

Study Area

The Lower Tennessee Cumberland Ecosystem encompasses 9,074,558 hectares (22,423,631 acres), and includes portions of four states (south-central Kentucky, central Tennessee, northern Alabama, and extreme northeastern Mississippi). This ecosystem is wholly contained within the Service's Region 4 (Figure 1). The entire Cumberland River system and lower half of the Tennessee River system below Walden Gorge (downstream from Chattanooga, Tennessee) comprise the LTCE. From its headwaters, the Cumberland drains southeastern Kentucky, north-central Tennessee, and western Kentucky. The Tennessee drains northern Alabama, northeastern Mississippi, south-central Tennessee, and western Kentucky. Both rivers flow northward into the lower Ohio River shortly before the latter empties into the Mississippi River.

Three physiographic provinces comprise the LTCE. The Highland Rim is a geologically complex province that comprises the bulk of the ecosystem, and drains most of the lower half of the Tennessee and middle to lower Cumberland River systems. It is a huge crater-like physiographic feature of limestones, cherts, and some shales formed from the fracturing and eroding of Pennsylvanian-aged (325 million years old) sandstones of the Nashville Dome. Mississippian-aged (345 million years old) limestone strata and erosion-resistant chert constitute the crater edge, divided as the Eastern and Western Highland Rim, respectively. The core now consists of mostly Ordovician (500 million years old) limestones. Once exposed, these limestones eroded more rapidly than surrounding strata. Thus, the Nashville Basin was formed, with its characteristic lower gradient and limestone substrata streams compared to the relatively higher gradient and chert gravels and sands of other Highland Rim streams. It is drained by the Stones River, lower Caney Fork system, other middle Cumberland River tributaries, and the middle Duck River system. A discreet physiographic district of the Eastern Highland Rim is the Barrens Plateau, which has many springs and drains the headwaters of the Caney Fork, Duck, and Elk Rivers.

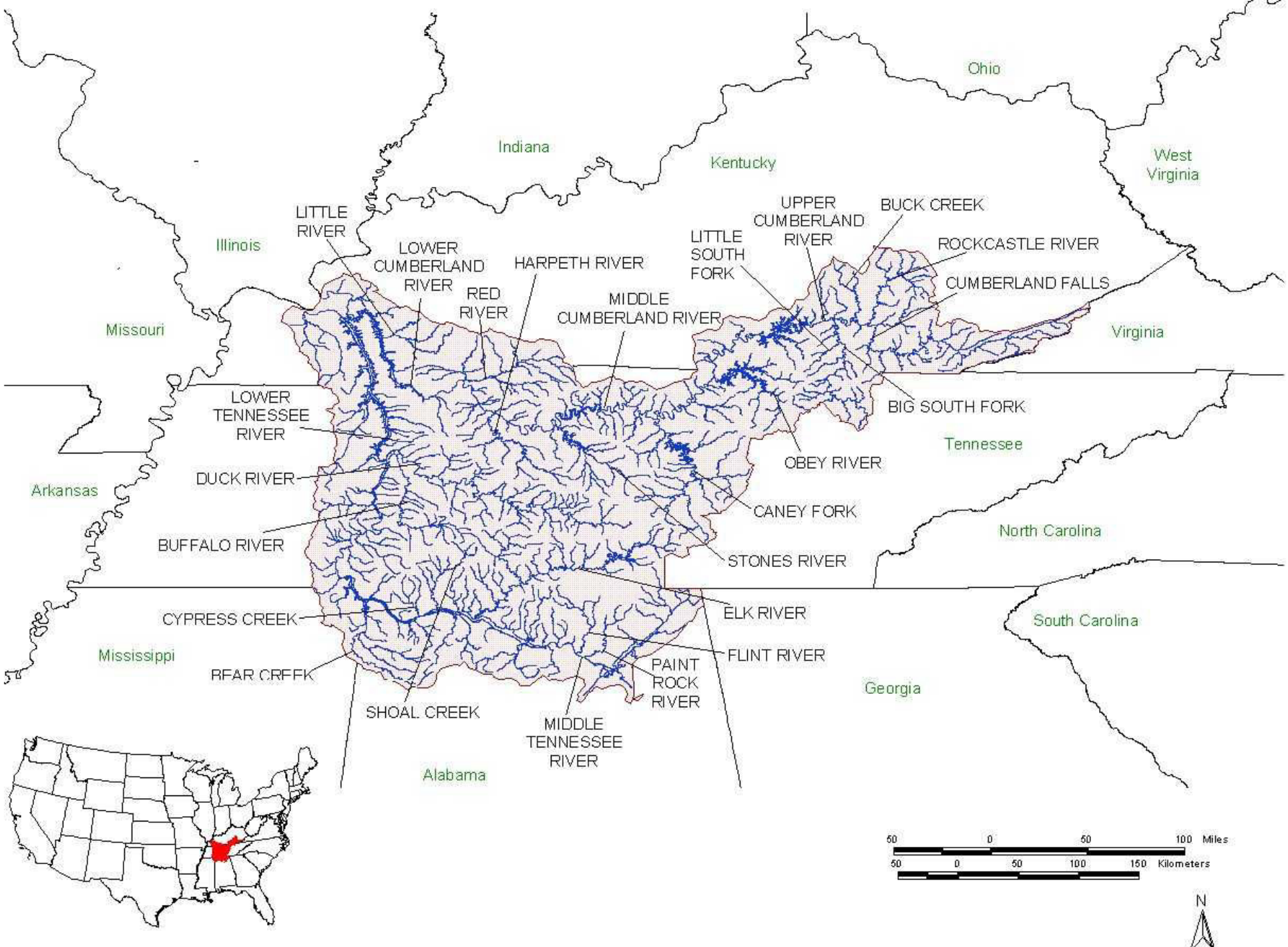

Figure 1. Lower Tennessee Cumberland Ecosystem

The Cumberland Plateau forms a relatively narrow band from southeastern Kentucky through east-central Tennessee into northeastern Alabama. It originated in the Permian (280 million years old), and represents an eroded plain composed of fairly erosion-resistant sandstones capping shales and limestones. Within the LTCE, significant coal deposits are located in southeastern Kentucky and north-central Tennessee. The eastern edge of the of the Cumberland Plateau is primarily comprised of Walden Ridge. Another feature is Cumberland Falls, which originally represented the western edge of the Cumberland Escarpment, but has eroded significantly upstream on the upper Cumberland River. The Cumberland Plateau is drained primarily by the upper and middle Cumberland River systems, but includes small portions of the middle (e.g., upper Elk River system) and lower (e.g., upper Duck River system) Tennessee River systems as well. Karst areas are prevalent in the LTCE in much of the Cumberland Plateau and particularly the southern portion of the Highland Rim where softer limestones have formed dissolution channels.

The Mississippi Embayment portion of the Coastal Plain Province is of secondary importance in the LTCE. It drains some lesser tributaries (e.g., Big Sandy, Beech River systems, several small creeks) of the north flowing lower Tennessee River in western Tennessee. This province represents a northern extension of the Gulf of Mexico during the Mesozoic and Tertiary eras (less than 225 million years old). The Embayment is dominated by Cretaceous to Quaternary (less than 136 million years old) geologic formations composed of sands, hard clays, and silts. Etnier and Starnes (1993) provide a more detailed discussion on these physiographic provinces and the two major river systems that drain the LTCE.

Methods

Several literature sources were indispensable in the synthesis of conservation status information for fishes contained in this report. These included Lee et al. (1980), Burr and Warren (1986), Etnier and Starnes (1993), Mettee et al. (1996), and Warren et al. (2000) for information on fish distributions, zoogeography, taxonomy, habitat, relative abundance, and threats. Original descriptions, taxonomic revisions, life histories, status survey reports, and personal

communications with experts provided additional information. Robins et al. (1991) was the source for official AFS scientific and common names, while suggested common names (depicted in quotations) were primarily provided by Warren et al. (2000). Scientific names are generally used throughout the text and tables, but common names are also given for those fish taxa mentioned in the text and in selected tables.

Table 1 lists those fish taxa that were assigned conservation status by the AFS and includes putative taxa that most likely warrant conservation status, but were not addressed by Warren et al. (2000). It should be noted that the endangered and threatened categories assigned by Warren et al. (2000) are relative and are not meant to imply that taxa assigned to these categories necessarily warrant Federal protection under the ESA. Taxa are listed alphabetically by family, genus, species, and subspecies; this order is maintained throughout all tables. Table 1 provides much of the specific information that was critical for the status assessments and recommendations made in subsequent tables in this report. Table 2 names fish taxa that are federally listed under the ESA. Table 3 includes those fishes deemed currently stable (Warren et al. 2000). Table 4 lists taxa that are endemic to both the LTCE and specific river drainages. Table 5 includes those fishes that are recommended for addition to the Service's Region 4 species of concern list. Table 6 lists stream systems having the highest priority for conservation attention based on their extant imperiled fish fauna (based on a point system weighted towards the more imperiled and endemic fauna; see Table 6 "Notes"). Table 7 is a list of imperiled LTCE fishes deemed to have the highest relative degree of imperilment and thus in the greatest need of additional conservation status assessment.

Basic research categories deemed requisite for prelisting and recovery actions are associated with taxa listed in Table 7. Status survey includes distributional and abundance data throughout the range. Life history research includes sex ratios, spawning season and habitat, fecundity estimates, early life history aspects, age and growth, food habits, and other aspects of biology that may be pertinent to recovery. Threat analysis includes habitat stressors, contaminants issues, potential adverse ecological interactions with native and introduced species, as well as remediation options (e.g., riparian habitat restoration). Taxonomic distinctiveness includes meristic and morphometric datasets (e.g., body proportions, coloration), genetic information (e.g., mitochondrial DNA, allozymes), phylogenetic analyses, and life history/ecological

attributes that may prove useful for distinguishing taxa. Propagation technology includes any research necessary to successfully procure, transport, hold, spawn, and rear fishes in captivity to an age suitable for return to the wild. Captive population is the knowledge and technology necessary to simply hold "Ark" population(s) of a species in captivity indefinitely, with the hope of someday returning it to suitable habitat.

Throughout Tables 1, 4, 6, and 7 references to the Tennessee River system have been rather arbitrarily divided into two reaches: the middle portion from Walden Gorge (below Chattanooga TN) downstream to the Alabama/Tennessee state line; and the lower portion downstream of the state line to the Ohio River. Similarly, the Cumberland River system has been divided into three reaches: the upper portion downstream to the Kentucky/Tennessee state line; the middle portion downstream from the state line to and including the Harpeth River; and the lower portion downstream of the Harpeth to the Ohio River.

Results and Discussion

The native fish fauna of the LTCE includes about 242 taxa in 24 families (Tables 1-3). Ranking a distant second to the remarkably diverse (and half again as large) Southern Appalachian Ecosystem (SAE) fish fauna of about 297 taxa (Butler 2002), the LTCE easily outdistances the third most diverse fish fauna, the adjacent Central Gulf Ecosystem (CGE) with roughly 190 taxa. The fish fauna of even the CGE is much more diverse than that of any other Service ecosystem in the U.S. These three ecosystems represent the core of biodiversity among fishes in Region 4, and over half of the total U.S. fish fauna.

Zoogeography

The diverse fish fauna of the LTCE can be attributed to several factors (Burkhead and Jelks 2000). Diversity of physiographic provinces (see "Study Area") and variable habitat gradients have resulted in complex zoogeographic patterns, and are major factors contributing to the diverse fish fauna (Hocutt and Wiley 1986). The majority of the LTCE has neither been glaciated nor inundated by oceans for at least 200 million years. This set of geologic conditions

has provided resident aquatic faunas with headwater refugia and allowed speciation to occur uninterrupted for eons. The physiographic complexity within the Highland Rim and its influence on stream habitats has resulted in the most diverse fish fauna of any region of comparable size in North America (Etnier and Starnes 1993). Presently unrecognized "cryptic" taxa will probably continue to be discovered from the LTCE further adding to this significant level of diversity. Unlike the Service's SAE, allopatric (non-overlapping) distributions and narrow endemicity in the LTCE are primarily a function of its complex physiography rather than the numerous component drainages of the former (Butler 2002).

Several fishes are discreetly distributed within specific portions of the LTCE's physiographic sections and districts. For instance, the Barrens Plateau is known for its endemic fishes (e.g., Barrens topminnow, *Fundulus julisia*; Barrens darter, *Etheostoma forbesi*) and other aquatic organisms. Certain other fishes have distributions heavily influenced by the Nashville Basin and its characteristic geology. The bedrock shiner (*Notropis rupestris*) and sooty darter (*E. olivaceum*) are globally restricted to this physiographic district. The only occurrences of some darters (e.g., bluebreast darter, *Etheostoma* camurum; fringed darter, E. *crossopterum*) in the Duck River system are in the Basin. Other fishes (e.g., blenny darter, *E. b. blennius*) are generally distributed in the Duck River upstream and downstream of the Basin, but not in it (Etnier and Starnes 1993).

The Imperiled Fauna

Current Status of the Fauna

Conservation status has been assigned to, or is deemed warranted for (in the case of putative taxa), 35 (14%) of the 242 taxa (Table 1). Two taxa, Alabama shad (*Alosa alabamae*) and Cumberland johnny darter (*Etheostoma susanae*), are currently candidates for Federal listing. Ten (4%) of the fishes known from the LTCE are protected under the ESA (Table 2). With the exception of the SAE with 16 species, no other ecosystem in the eastern U.S. has as many listed fishes. The LTCE and SAE collectively have more listed fishes (21) than all of the other Service ecosystems in its three eastern U.S. regions (3, 4, and 5) combined. Two taxa among the 35 listed in Table 1 have not been assigned conservation status by Warren et al. (2000), but are included here as putative undescribed taxa. Of the remaining 33 taxa, conservation status

breakdown is as follows: 2 endangered, 9 threatened, and 22 vulnerable (Warren et al. 2000). Two fishes formerly known from the LTCE, the harelip sucker (*Moxostoma lacerum*) and whitelined topminnow (*Fundulus albolineatus*), are considered extinct (Warren et al. 2000).

Historical Trends in the Status of the Fauna

Fourteen of the jeopardized fishes in Table 1 and two taxa in Table 3 have been assigned conservation status in previous assessments of the imperiled North American fauna. There appears to be no general trend in status for most of those taxa appearing on the lists generated in 1979 (Deacon et al. 1979), 1989 (Williams et al. 1989), and 2000 (Warren et al. 2000). Two taxa saw their status decline (from special concern to threatened for the ashy darter, *Etheostoma cinereum*; and trispot darter, *E. trisella*) from 1989 to 2000, while four others experienced positive changes in their status (from endangered or threatened to special concern or currently stable) over the 20-year period. Positive changes in status generally reflected better information, rather than actual recovery. Other trends are apparent for taxa in Table 1. Eleven taxa described or recognized before 1989 appeared for the first time in Warren et al. (2000) as fishes warranting conservation status. Twenty of 31 (65%) of the taxa described since approximately 1975 are also considered jeopardized.

Patterns of Imperilment

Recent studies have determined various predictors of imperilment in fishes that are useful for resource managers in conservation status assessment (Warren and Burr 1994, Angermeier 1995, Etnier 1997, Warren et al. 1997). Warren et al. (1997) statistically assessed variables of imperilment (e.g., range size, unique taxa, taxa richness, fish families, stream-type diversity) in southeastern drainages included in the LTCE. Following are some factors associated with fishes and imperilment.

Newly Recognized Taxa and Imperilment

Newly recognized taxa tend to be imperiled at a higher rate than the general fish fauna, oftentimes due to narrow endemicity (Burkhead and Jelks 2000). This correlation is apparent from data in Table 1 and "Historical Trends in the Status of the Fauna" above. Six of 16 (38%) of the formally undescribed taxa in Tables 1-3 are considered imperiled, while 65% of the taxa

described since about 1975 are also imperiled. Reasons for this apparent correlation may include the fact that these taxa are generally cryptic, difficult to catch, and/or benthic in nature. Information on actual taxonomic richness of LTCE fishes, including putative forms, is therefore critical for managing all components of the imperiled fauna.

Endemicity and Imperilment

A primary predictor of imperilment among fishes is range size, with the level of imperilment increasing with decreasing range size (Burkhead et al. 1997, Warren et al. 1997). Forty-three (18%) of the fish taxa are endemic to the LTCE (excluding the extinct *Fundulus albolineatus*). An astounding 88% of the LTCE endemic fishes are darters. About half of the LTCE endemic fishes are jeopardized (including federally listed), with 20 of 22 endemic to a single drainage system (Table 4). These fishes demonstrate the relationship between single drainage endemicity and imperilment.

Drainage Unit Correlates with Imperilment

Among the 20 jeopardized endemic taxa in Table 4, 12 are restricted to the Tennessee and 8 to the Cumberland River systems. The other two non-endemic fishes (i.e., *Fundulus julisia*; "Highland Rim form of Chucky madtom," *Noturus* sp. cf. *elegans*) are exclusively shared between the two systems. The lower Tennessee and Cumberland River systems represent the two most diverse drainages in the Southeast (Warren et al. 1997, 2000) and consequently North America. About 203 native fish taxa are known from the middle and lower Tennessee River system, with approximately 181 known from the entire Cumberland River system (Warren et al. 2000, this report). Not surprisingly, native species richness and unique taxa within drainages were correlated significantly with faunal imperilment, while drainage-unit area and stream-type diversity showed weaker correlations with faunal imperilment (Warren et al. 1997).

Warren et al. (1997) assessed various imperilment data among 33 southeastern drainage units. The two LTCE drainages have among the highest relative percentages (9.8%, Tennessee R.; 9.2%, Cumberland R.) of imperiled fishes in the region. These imperilment levels are exceeded only by the upper Tennessee and Coosa Rivers in the SAE (~13%) (Butler 2002). They experienced moderate to low levels of imperilment of their native fish faunas between 1979 and

1989 (1.5%, Tennessee R.; 0.6%, Cumberland R.) when compared to other regional drainages (range 0 to 3.5%). Again, the highest rates were for the SAE's upper Tennessee and Coosa Rivers (Warren et al. 1997).

Fish Family Correlates with Imperilment

Imperilment, manifest in range restriction and population declines, has been shown to occur across numerous taxonomic groups of fishes (Angermeier 1995, Warren et al. 1997). The families Ictaluridae (primarily madtoms) and Percidae (primarily darters), however, display disproportionate levels of imperilment than expected based on their representation of the total fauna (Etnier and Starnes 1991, Warren et al. 1997, Burkhead and Jelks 2000).

The pattern of imperilment associated with taxonomic groups also holds true especially for LTCE darters (26 of 79, or 33% imperiled *vs.* 19% among all LTCE fishes), but less so for madtoms (3 of 9, or 25%). Imperilment rates in the LTCE compared to the Southeast in general were half that for madtoms (25% *vs.* 50%), but comparable for darters (33% *vs.* ~35%) (Warren et al. 2000). Among the 10 LTCE federally listed fishes, 5 are darters and 1 is a madtom.

Habitat Correlates with Imperilment

Among habitat types, benthic-dependent and spring habitat fishes experience a higher relative degree of imperilment than fishes found in other habitat types (Burkhead et al. 1997, Warren et al. 1997, 2000). Benthic dependency as used herein refers to fishes that spawn, feed, and shelter on the stream bottom (Burkhead et al. 1997). Benthic-dependent fishes, such as madtoms and darters, have several attributes that contribute inordinately to their imperilment from substrata degradation and impoundments. These factors include small body size, low fecundity, benthic specialization, and rheophilic (current-loving) orientation (Burkhead and Jelks 2000).

The correlation of certain habitats with imperilment also holds true in the LTCE, where 6 of 10 federally listed fishes (Table 2) are benthic dependent, as are over 70% of those taxa in Table 1. All three spring habitat fishes known from the LTCE (i.e., *Fundulus julisia*; flame chub, *Hemitremea flammea*; Tuscumbia darter, *Etheostoma tuscumbia*) are jeopardized. Another highly imperiled habitat group, troglobitic species, are also disproportionately imperiled. All

regional troglobitic fishes are imperiled (Williams et al. 2000); the federally endangered Alabama cavefish (*Speoplatyrhinus poulsoni*) is one of two LTCE troglobites. Troglobites are highly adaptive to karst environments and may be particularly susceptible to pollution and other changes in groundwater and substrate quality in their sensitive habitats (Williams et al. 2000).

Species of Concern Status for Region 4 Fishes

Currently, 23 (10%) of the fish taxa found in the LTCE are considered species of concern by the Service's Region 4. All 23 taxa with the exception of the blotched chub (*Erimystax i. insignis*) have been assigned conservation status (Table 1). After this assessment, this number appears to be artificially low, and not indicative of recent declines in several taxa.

I recommend that 11 additional taxa (Table 5) be added to the regional species of concern list. All of the taxa in Table 5 have been assigned conservation status by Warren et al. (2000) or are deemed to warrant such (for putative taxa). In addition, they are mostly considered "narrow endemics" (Table 1), and as such may be relatively more susceptible to habitat perturbations from human population growth than are more widespread forms (Gilpin and Soulé 1986, Burkhead and Jelks 2000). For this reason alone, some taxa may perpetually be deserving of species of concern status. In general, the more wide-ranging forms (at least for the Region 4 portion of their range) have experienced multiple population extirpations, currently have disjunct populations, and are generally rare throughout much if not all of their respective ranges because of various anthropogenic factors.

High Priority Stream Systems

Stream systems having the highest priority for extant jeopardized fish taxa are listed in Table 6. This list provides conservation managers with basic information on focus drainages in which to address fish conservation activities at the watershed scale (e.g., riparian restoration). The weighted point system indicated that the Duck and Buffalo Rivers in the lower Tennessee River system were easily the highest priority stream systems in the LTCE, with the Caney Fork, a middle Cumberland River tributary, third. The cluster of smaller drainages comprising the middle Tennessee River system also ranked high as important refugia, attributed partially to several endemic fish taxa.

The diversity of imperiled fishes in the entire Duck River system should make it one of the most important drainages for conservation and restoration efforts for fishes in all of Region 4. Several middle Tennessee and upper Cumberland River tributaries also ranked fairly high in Table 6. Tributary systems having low diversity of imperiled fishes dominated the lower Cumberland River system and portions of the middle Cumberland River system. The Obey, Stones, and Red Rivers appear to have been especially impacted by habitat alteration and degradation as evidenced by the low number of extant fish taxa when compared to species of historical occurrence noted in Table 1.

The Critically Imperiled Fauna

Based on the status information gathered in this report, 17 taxa (including 5 putative forms) are relatively highly imperiled and are deemed to have the greatest need for current conservation status assessment (Table 7). The Duck River, which was determined to be the highest priority watershed in the LTCE for imperiled fish conservation efforts (Table 6), harbors six of these taxa. Its major tributary, the Buffalo River, has extant populations of four of these high priority fishes (Table 6). Twelve of the 17 taxa in Table 7 are endemic to the LTCE, and 10 of them are restricted globally to a single drainage system (Warren et al. 2000, this report). As discussed above, narrow endemicity is a major predictor in identifying jeopardized fishes. More important is realizing that within the Service the LTCE team has sole management responsibility for over three-quarters of these fishes.

Most of the fishes in Table 7 have experienced multiple stream extirpations, currently have highly disjunct populations, and/or are generally rare rangewide. The majority of the taxa are also considered threatened or endangered by Warren et al. (2000). As a cautionary note, this does not imply that any of the taxa in Table 7 should be emergency listed under the ESA. It is only meant to imply that these taxa exhibit a higher relative degree of imperilment and additional information on their conservation status is warranted. That stated, many of the taxa Warren et al. (2000) considered to be threatened or endangered are currently protected under the ESA. The urgent need to implement status assessments for these taxa becomes obvious.

Research and Conservation Needs

An attempt has been made to identify broad categories of basic but critical research and conservation needs for the high priority fishes (Table 7). Recovery actions generally needed for most of these taxa include status survey, life history, threat analysis, and propagation technology. Taxonomic distinctiveness research is imperative to determine the validity of putative forms (Warren et al. 2000) (e.g., ashy darter complex, *Etheostoma* sp. cf. *cinereum*; redline darter complex, *Etheostoma* sp. cf. *rufilineatum*) and defining evolutionarily significant units (Mayden and Wood 1995) within species complexes (e.g., *E. tuscumbia*). Establishing captive populations becomes increasingly necessary for the most critically jeopardized fishes (Rakes et al. 1999) (e.g., *Noturus* sp. cf. *elegans*).

Summary

The LTCE fish fauna, with about 242 taxa, ranks second behind the SAE (~297 taxa) among Service ecosystems nationwide in total native fish diversity. Thirty-five of 242 (14%) of the non-federally listed fishes have been assigned, or are in need of, conservation status. An additional 10 fishes are federally listed. Forty-three (18%) of the fish taxa are endemic to the LTCE. The lower Tennessee and Cumberland River systems represent the two most diverse drainages in North America for fishes. Among the ecosystem's physiographic provinces, the Highland Rim has had the most profound influence on fish diversity. The Highland Rim's longtime stability, physiographic diversity, and influence on stream habitats has resulted in complex zoogeographic patterns, particularly among the darters, which account for the vast majority of the endemic fauna.

Newly recognized taxa in the LTCE, including those fishes described since ~1975 and putative forms, appear to be imperiled at a higher rate (65 and 38%, respectively) than the general fish fauna (28%, Warren et al. 2000). Benthic-dependent fishes, particularly the madtoms and darters, are disproportionately jeopardized. Eleven taxa are recommended for addition to the Service's Region 4 species of concern list. This would bring the regional list total to 34 (14%) of the fish taxa known from the LTCE, which is half the regional imperilment rate of 28% (Warren et al. 2000). The Duck and Buffalo Rivers, Caney Fork, and lesser drainages in the middle

Tennessee river system are determined to be the highest priority watersheds in the ecosystem for imperiled fish conservation. Half of the 34 imperiled fish taxa exhibit a relatively high degree of imperilment and are deemed to have the greatest need for current conservation status assessment. Six of these high priority taxa currently occur in the Duck River, while four inhabit the Buffalo River. The fact that 12 of these 17 highly imperiled fishes are ecosystem endemics places exclusive management and conservation responsibility on LTCE team members. Continual status assessment work in LTCE drainages is needed to keep the information in this report current and useful as a tool critical for imperiled fish conservation and recovery.

Presented with predicted future fish extinction rates of 2.4% per decade in the U.S. (Ricciardi and Rasmussen 1999), the task of resource managers in implementing recovery actions, to say nothing of societal changes, needed to reverse this trend is indeed overwhelming. Ongoing efforts to recover jeopardized species, coupled with this attempt to elucidate highly imperiled taxa in the LTCE, help to promote the conservation of the Southeast's magnificent fish fauna.

Acknowledgments

I wish to thank M.L. Warren, Jr., and the rest of the Southeastern Fishes Council Technical Advisory Committee for holistically tackling the issue of southern fish imperilment and producing a publication that provided the necessary impetus to make my work possible. The following individuals graciously gave their time and provided much information on fishes over the past several years during personal conversations, email correspondence, and/or provided reprints: H.L. Bart, Jr., and K.L. Piller (Tulane University); R.G. Biggins (U.S. Fish and Wildlife Service); N.M. Burkhead and M. Freeman (U.S. Geological Survey); R.R. Cicerello (Kentucky State Nature Preserves Commission); B.J. Freeman (University of Georgia Institute of Ecology); R.L. Mayden and R.M. Wood (Saint Louis University); S.J. Fraley, C.F. Saylor, E.M. Scott, and P.W. Shute (Tennessee Valley Authority); P.L. Rakes and J.R. Shute (Conservation Fisheries, Inc.); and C.E. Skelton (Georgia Department of Natural Resources). P. Hunsucker (U.S. Fish and Wildlife Service) produced the drainage map. R.R. Cicerello, P.L. Rakes, C.F. Saylor, and the LTCE Aquatic Subgroup reviewed drafts of the report. Special thanks go to B.A. Branson (formerly at Eastern Kentucky University) and R.R. Cicerello, who instilled my interest in

imperiled fish conservation 25 years ago. And lastly, I thank my supervisor, B.P. Cole, for providing the freedom to pursue a broad array of conservation endeavors.

Literature Cited

Angermeier, P.L. 1995. Ecological attributes of extinction-prone species: loss of freshwater fishes of Virginia. Conservation Biology 9:143-158.

Angermeier, P.L., and M.R. Winston. 1999. Characterizing fish community diversity across Virginia landscapes: prerequisite for conservation. Ecological Applications 9:335-349.

Burkhead, N.M., S.J. Walsh, B.J. Freeman, and J.D. Williams. 1997. Status and restoration of the Etowah River, an imperiled Southern Appalachian ecosystem. Pp. 375-441 *in*: G.W. Benz and D.E. Collins, eds. Aquatic fauna in peril: the Southeastern perspective. Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Burkhead, N.M., and H. Jelks. 2000. Diversity, levels of imperilment, and cryptic fishes in the southeastern United States. Essay 1, pp. 30-32 *in*: R.A. Abell, D.M. Olson, E. Dinerstein, P.T. Hurley, J.T. Diggs, W. Eichbaum, S. Walters, W. Wettengel, T. Allnutt, C.J. Loucks, and P. Hedao, eds. Freshwater ecoregions of North America: a conservation assessment. World Wildlife Fund, United States. Island Press, Washington DC.

Burr, B.M., and M.L. Warren, Jr. 1986. A distributional atlas of Kentucky fishes. Kentucky Nature Preserves Commission, Science Technical Series 4, Frankfort. 398 pp.

Butler, R.S. 2002. Fishes of the Southern Appalachian Ecosystem, with emphasis on the non-federally listed fauna. Unpublished report, U.S. Fish and Wildlife Service, Asheville, North Carolina.

Ceas, P.A., and L.M. Page. 1995. Status surveys of the crown darter (*Etheostoma corona*) and the lollypop darter (*Etheostoma neopterum*) in the Cypress and Shoal Creek systems of Tennessee and Alabama, and the egg-mimic darter (*Etheostoma pseudovulatum*) in the Duck River system of Tennessee. Illinois Natural History Survey, Center for Biodiversity Technical Report 1995(14). 43 pp.

Deacon, J.E., G. Kobetich, J.D. Williams, and S. Contreras. 1979. Fishes of North America endangered, threatened, or of special concern. Fisheries 4(2):30-44.

Etnier, D.A. 1997. Jeopardized southeastern freshwater fishes: a search for causes. Pp. 87-104 *in*: G.W. Benz and D.E. Collins, eds. Aquatic fauna in peril: the Southeastern perspective.

Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Etnier, D.A., and W.C. Starnes. 1993. The fishes of Tennessee. University of Tennessee Press, Knoxville. 681 pp.

Eisenhour, D.J., B.M. Burr, K.M. Cook, and C.A. Taylor. 1996. Conservation status review of the saddled madtom, *Noturus* (*Rabida*) sp, (Siluriformes: Ictaluridae) in the Duck River system, Tennessee. Journal of the Tennessee Academy of Science 71(2):41-46.

Folkerts, G.W. 1997. State and fate of the world's aquatic fauna. Pp. 1-16 *in*: G.W. Benz and D.E. Collins, eds. Aquatic fauna in peril: the Southeastern perspective. Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Jenkins, R.E., and N.M. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland. 1029 pp.

Kinziger, A.P., R.M. Wood, and S.A.Welsh. 2001. Systematics of *Etheostoma tippecanoe* and *Etheostoma denoncourti* (Perciformes: Percidae). Copeia 2001(1):235-239.

Layman, S.R., A.M. Simons, and R.M. Wood. 1993. Status of the [sooty] darter, *Etheostoma olivaceum*, and bluemask darter, *Etheostoma* (*Doration*) sp., with notes on fishes of the Caney Fork River system, Tennessee. Journal of the Tennessee Academy of Science 68(2):65-70.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. 1980 et seq. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh. 854 pp.

Mayden, R.L., and R.M. Wood. 1995. Systematics, species concepts, and the evolutionarily significant unit in biodiversity and conservation biology. Pp. 58-113 *in*: J.L. Nielson, ed. Evolution and the aquatic ecosystem: defining unique units in population conservation. American Fisheries Society Symposium 17.

Mettee, M.F., P.E. O'Neil, and J.M. Pierson. 1996. Fishes of Alabama and the Mobile Basin. Oxmoor House, Inc., Birmingham, Alabama. 820 pp.

Noss, R.F., and R.L. Peters. 1995. Endangered ecosystems: a status report on America's vanishing habitat and wildlife. Defenders of Wildlife, Washington DC.

Page, L.M. 1978. Redescription, distribution, variation and life history notes on *Percina macrocephala* (Percidae). Copeia 1978(4):655-664.

Page, L.M., P.A. Ceas, D.L. Swofford, and D.G. Buth. 1992. Evolutionary relationships within the *Etheostoma squamiceps* complex (Percidae; subgenus *Catonotus*) with descriptions of five new species. Copeia 1992(3):615-646.

Rakes, P.L., and J.R. Shute. 2001. Surveys and assays of habitat for the endangered boulder darter, *Etheostoma wapiti*, in the Elk River system in Tennessee and Alabama. Unpublished report, Conservation Fisheries, Inc., Knoxville, Tennessee. 18 pp.

Rakes, P.L., J.R. Shute, and P.W. Shute. 1999. Reproductive behavior, captive breeding, and restoration ecology of endangered fishes. Environmental Biology of Fishes 51:1-12.

Ricciardi, A., and J.B. Rasmussen. 1999. Extinction rates of North American freshwater fauna. Conservation Biology 13:1220-1222.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1991. Common and scientific names of fishes from the United States and Canada. American Fisheries Society Special Publication 20, Bethesda, Maryland. 183 pp.

Shepard, T.E., and B.M. Burr. 1984. Systematics, status, and life history aspects of the ashy darter, *Etheostoma cinereum* (Pisces: Percidae). Proceedings of the Biological Society of Washington 97:693-715.

Stauffer, J.R., Jr., and E.S. van Snik. 1997. New species of *Etheostoma* (Teleostei: Percidae) from the upper Tennessee River. Copeia 1997(1):116-122.

Walsh, S.W., N.M. Burkhead, and J.D. Williams. 1995. Southeastern freshwater fishes. Pp. 144-147 *in*: E.R. Larue, ed. Our living resources. A report to the nation on the abundance, distribution, and health of U.S. plants, animals, and ecosystems. U.S. Department of Interior, National Biological Service, Washington DC.

Warren, M.L., Jr., P.L. Angermeier, B.M. Burr, and W.R. Haag. 1997. Decline of a diverse fish fauna: patterns of imperilment and protection in the southeastern United States. Pp. 105-164 *in*: G.W. Benz and D.E. Collins, eds. Aquatic fauna in peril: the Southeastern perspective. Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Warren, M.L., Jr., and B.M. Burr. 1994. Status of freshwater fishes of the United States: overview of an imperiled fauna. Fisheries 19(1):6-18.

Warren, M.L., Jr., B.M. Burr, S.J. Walsh, H.L. Bart, Jr., R.C. Cashner, D.A. Etnier, B.J. Freeman, B.R. Kuhajda, R.L. Mayden, H.W. Robison, S.T. Ross, and W.C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. Fisheries 25(10):7-29.

Williams, J.E., J.E. Johnson, D.A. Hendrickson, S. Contreras-Balderas, J.D. Williams, M. Navarro-Mendoza, D.E. McAllister, and J.E. Deacon. 1989. Fishes of North America endangered, threatened, or of special concern. Fisheries 14(6):2-20.

Williams, J.D., M.L. Warren, Jr., K.S. Cummings, J.L. Harris, and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18(9):6-23.

Table 1. Imperiled Non-Listed Fishes of the Lower Tennessee Cumberland Ecosystem According to the American Fisheries Society (Warren et al. 2000).

Family/ Species, Common Name	LTCE Range	CS	Comments on Status, Distribution, Taxonomy, Etc.
Acipenseridae			
Acipenser fulvescens lake sturgeon	upper, middle, lower Cumberland Rs.; middle Tennessee R., lower Tennessee R. system (Indian Creek, Hardin Co.)	T T T	**Currently R4 Species of Concern; very** widespread distribution mostly in the Midwest and known from 20 states and 7 Canadian provinces; 3 TN (Etnier & Starnes 1993), 2 AL (Mettee et al. 1996), and 3 KY sites (Burr & Warren 1986); multi-partner reintroduction efforts underway in the lower French Broad R.; warrants Federal protected status (Etnier 1997); also in ORVE, SAE, and elsewhere
Amblyopsidae			
Typhlichthys subterraneus southern cavefish	upper, middle, lower Cumberland R. systems; middle, lower Tennessee R. systems	V	**Currently R4 Species of Concern;** relatively widespread east and west of the Mississippi R.; LTCE occurrences in Cumberland Plateau and Highland Rim caves; ~27 TN sites (Etnier & Starnes 1993); 2 KY sites (Burr & Warren 1986); and ~45 AL sites (Mettee et al. 1996); low fecundity, coupled with reduced breeding female populations, presumably limits recruitment (Etnier & Starnes 1993); considered "in no immediate danger" as long as water quality is not threatened (*ibid.*); also in ORVE, SAE, and elsewhere
Catostomidae			
Cycleptus elongatus blue sucker	upper, middle, lower Cumberland Rs.; middle Tennessee R. system (Tennessee R.; Bear Creek), lower Tennessee R. system (Duck R.)	V SC	**Currently R4 Species of Concern;** very widespread distribution mostly west of the Mississippi R. and known from 23 states and Mexico; majority of occurrences in regulated rivers; total of 10 sites in AL (2 sites, Mettee et al. 1996), KY (4, Burr & Warren 1986), and TN (4, Etnier & Starnes 1993), plus Bear Creek record (C.F. Saylor, Tennessee Valley Authority, pers. comm., 2002); inhabits big swift rivers over firm substrata; "[s]tatus assessment problematic due to difficulty in capture" (Burr & Warren 1986); warrants Federal protected status (Etnier 1997); also in ORVE, SAE, and elsewhere
Clupeidae			
Alosa alabamae Alabama shad	middle Cumberland R. system (Stones R.), lower Tennessee R.	V	**Currently a Candidate** (National Marine Fisheries Service lead); widespread anadromous species; extralimital in LTCE (1986 record, lower Tennessee R.; Saylor, pers. comm., 2002) due to dams on Cumberland and Tennessee Rivers
Cyprinidae			
*Hemitremia flamme*a flame chub	upper, middle Cumberland R. systems; middle, lower Tennessee R. systems	V SC SC	**Currently R4 Species of Concern;** a spring species primarily in LTCE on Barrens Plateau in TN (~35 total sites, Etnier & Starnes 1993) and Highland Rim in AL (78 total sites, Mettee et al. 1996); also 3 KY extirpated sites (Burr & Warren 1986); "relatively rare" (Lee et al. 1980), but "sometimes abundant" (Mettee et al. 1996); also in SAE
Hybopsis amnis pallid shiner	upper Cumberland R. system (Otter Creek), middle Cumberland R.	V	Widespread, but highly disjunct species, and generally declining (Etnier & Starnes 1983); Cumberland R. system

	system (Cumberland, Roaring Rs.; Caney Fork)		population persists in Center Hill Reservoir, but no recent specimens available elsewhere in the entire system; 5 sites in TN (*ibid.*), and 2 in KY (Burr & Warren 1986); also in ORVE and elsewhere
Notropis ariommus popeye shiner	upper Cumberland R. system (Big South Fork system (Big South, Little South Forks), Rockcastle R.; Buck Creek), middle Cumberland R. system (Stones R.), middle Tennessee R. system (Elk R.), lower Tennessee R. system (Duck R. system (Duck, Buffalo Rs.))	V	Primarily restricted to Ohio R. system (formerly in Maumee R., Lake Erie Drainage), but sporadically distributed, rare or uncommon; extirpated from north of the Ohio R. (Jenkins & Burkhead 1993); ~15 KY sites (Burr & Warren 1986), ~15 TN sites (Etnier & Starnes 1993), and 1 extirpated AL site (Mettee et al. 1996); "habitat restricted" in flowing pools over small gravel, and having an "apparent intolerance of silt" (Etnier & Starnes 1993), which may account for its relative rarity in many streams; abundance extremely variable from year to year (Gilbert 1969); also in ORVE, SAE
N. rupestris bedrock shiner	middle Cumberland R. system (Stones R., Caney Fork system (Hickman, Mulherrin Creeks; Smith Fork), Cumberland R. tribs (Bransons, Round Lick Creeks; Jennings Fork)), lower Tennessee R. system (upper Duck R.)	V	**Endemic (narrow) TN;** probably endemic to middle Cumberland R. system and restricted to Nashville Basin; known from 4 counties (Cannon, Rutherford, Smith, Wilson) and 14 sites (Etnier & Starnes 1993); Duck R. records "may represent minnow bucket releases" (*ibid.*); occurs in bedrock pools, and is considered the most common fish species of some small, often intermittent streams, where it has an "extreme ability to tolerate...stagnant conditions" (Page & Beckham 1987); warrants Federal protected status (Etnier 1997)
Elassomatidae			
Elassoma alabamae spring pygmy sunfish	middle Tennessee R. system (Beaverdam Creek system (Moss Spring; unnamed spring run), Cave Spring, Pryor Springs, Pryor Springs Branch)	E T E	**Currently R4 Species of Concern; Endemic (very narrow) AL;** endemic to middle Tennessee R. system; recently described taxon; restricted to 2 counties (Lauderdale, Limestone) and 2 spring systems; 5 sites (Mettee et al. 1996), 1 historical site (Pryor Spring) was stocked from Beaverdam Creek system specimens; inhabits thick vegetation along margins of springs and spring runs (*ibid.*); its habitat is subject to alteration and water withdrawals; highly imperiled
Fundulidae			
Fundulus julisia Barrens topminnow	middle Cumberland R. system (upper Caney Fork system (Duke, Little Hickory, McMahan, West Fork Hickory Creeks; Meadow Branch; Summitville Mountain Spring; 4 unnamed ponds or tribs)), middle Tennessee R. system (upper Elk R. system (Pond Spring)), lower Tennessee R. system (Duck R. system (Little Duck; Doak, Short, Wiley Springs; Ovoca Lake))	E SC E	**Currently R4 Species of Concern; Endemic (very narrow) TN;** restricted to Barrens Plateau of Eastern Highland Rim; a spring species restricted to 3 counties (Cannon, Coffee, Warren); ~20 historical populations known, but currently reduced to 2 "natural" populations, 1 each in the Caney Fork and upper Elk R. systems; inhabits heavily vegetated pools of springs and sluggish streams (Etnier & Starnes 1993); the focus of concerted, multi-partner conservation efforts, with several populations in captivity; warrants Federal protected status (Etnier 1997)
Ictaluridae			
Noturus sp. cf. *elegans* form 1 "Chucky madtom, Highland Rim form"	middle Cumberland R. system (Roaring R.), middle Tennessee R. system (West Fork Flint, Paint Rock Rs.; Bear?, Piney Creeks)	T	**Currently R4 Species of Concern; Endemic AL, TN;** restricted to Cumberland and Tennessee R. systems; newly recognized taxon; highly disjunct; middle Tennessee R. system population possibly distinct from Cumberland R. population (R.L. Mayden, Saint Louis University, pers. comm., 2000); inhabits gravel shoals or shallow pools (Etnier & Starnes 1993); SAE population is considered

			separate and endemic (as "Chucky madtom"), and Cookeville FO is preparing a candidate elevation package for it
N. sp. cf. *elegans* form 2 "saddled madtom"	lower Tennessee R. system (Duck R. system (Duck R.; Beaverdam, Bigby, Big Bigby, Big Swan, Blue, Brushy Fork, Hurricane, Little Swan, Tumbling Creeks; unnamed trib Big Swan Creek), Buffalo R. system (Buffalo, Green, Little Buffalo Rs.; Cane, East Fork Cane, Fortyeight, Moccasin, Rockhouse Creeks)), Tennessee R. tribs (Bear, Indian, Rogers, Wetherford Creeks)	V	**Currently R4 Species of Concern; Endemic (narrow) TN;** endemic to lower Tennessee R. system; newly recognized taxon; known from 39 sites in 23 streams, but thought to be extirpated from 10 sites in several Duck system streams; inhabits gravel shoals or shallow pools (Etnier & Starnes 1993); status review conducted in 1992 (Eisenhour et al. 1992); "declined in abundance over the past 10-20 years;" quality of habitat at several historical sites thought to be declining; mean of 2 specimens collected from 13 of 33 sites surveyed in 1992; Tennessee R. tribs (Indian, Horse Creek systems) were not surveyed; State, but not Federal, listing as threatened was recommended (*ibid.*)
Lepisosteidae			
Atractosteus spatula alligator gar	lower Cumberland R. , lower Tennessee R.	V	Widespread, big river lowland species; "may...be extirpated" from Tennessee (Etnier & Starnes 1993), and probably from the LTCE; the largest fish recorded in the LTCE (>3 m); warrants Federal protected status (Etnier 1997); also in ORVE and elsewhere
Percidae			
Ammocrypta. clara western sand darter	upper Cumberland R.	V	Widespread distribution mostly in the Midwest and known from 13 states; only LTCE collection is preimpoundment (Cumberland Reservoir) in 1925 (Burr & Warren 1986); typically found in low to moderate gradient streams in sandy substrate (Jenkins & Burkhead 1993), who thought its habitat was marginal in SAE, which also could be true for LTCE, at least once the large impoundments on the lower Cumberland and Tennessee were built; extralimital to, and probably extirpated from, LTCE; also in ORVE, SAE, and elsewhere
Crystallaria asprella complex crystal darter	upper Cumberland R. system (Big South Fork), middle Cumberland R. system (Cumberland, Roaring Rs.)	V SC SC	**Currently R4 Species of Concern;** widespread distribution; a species complex (Warren et al. 2000) with highly disjunct populations; last LTCE collection in 1939 (Etnier & Starnes 1993); habitat of deep, swift sand and gravel shoals (Etnier & Starnes 1993) makes it a difficult species to collect; possibly still occurs in Big South Fork, which recently yielded the thought to be extirpated *Percina burtoni* (see below), or in Tennessee R. system (*ibid.*); warrants Federal protected status (Etnier 1997); probably extirpated from LTCE; also in ORVE and elsewhere
Etheostoma aquali coppercheek darter	lower Tennessee R. system (Duck R. system (Piney, Duck Rs.; Big Bigby, Big Swan, Flat, Hurricane, Leipers, Lick Creeks), Buffalo R. system (Buffalo, Little Buffalo Rs.))	V T T	**Currently R4 Species of Concern; Endemic (narrow) TN**; endemic to the Duck R. system in the Nashville Basin and Western Highland Rim; known from ~25 sites (Etnier & Starnes 1993); considered rare, but difficult to collect in its habitat of deep runs, riffles, and flowing pools over large rocky substrata; generally known from Duck and Buffalo R. main stems, with most trib populations restricted to the lowermost sections; "dozens of individuals [were located] with little effort at numerous sites in the Buffalo River recently" (Rakes & Shute 2001); deserving of Federal threatened status according to Etnier & Starnes (1993) and Etnier (1997), but is here considered to be fairly common (Rakes & Shute 2001; P.L. Rakes, Conservation Fisheries,

			Inc.; and Saylor, pers. comm., 2002)
E. cinereum ashy darter	middle Tennessee R. system (upper Elk R.), lower Tennessee R. system (Duck R. system (upper Duck R., Garrison Fork), Buffalo R.))	T SC SC	**Currently R4 Species of Concern;** endemic to the middle and lower Tennessee R. system, if the putative forms in the upper Tennessee River system and Cumberland R. system (Mayden and S.L. Powers, University of Alabama, pers. comm., 2002) are valid; only in the Highland Rim in LTCE; 8 TN sites (Etnier & Starnes 1993) and only 1 (<1845) AL site (Tennessee R., Muscle Shoals, the type locality) (Mettee et al. 1996); in early 1980s, Buffalo R. thought to be 1 of 2 (with Little R., SAE) viable Tennessee R. system populations (Shepard & Burr 1984); Elk R. record a single 1981 specimen (*ibid.*); upper Duck R. population currently considered viable (Powers and Saylor, pers. comm., 2002); its requirement of silt-free pools (Etnier & Starnes 1993), an increasingly degraded habitat type, has probably exacerbated its imperilment (Shepard & Burr 1984); its pool habitat is difficult to collect due to boulders, which indicates that it may be "under-represented in collections" (P.W. Shute, Tennessee Valley Authority, pers. comm., 2002); warrants Federal protected status (Etnier 1997); also in SAE
E. sp. cf. *cinereum* ashy darter "Cumberland form"	upper Cumberland R. system (Rockcastle R. system (Rockcastle R.; Little Rockcastle R. system (Hazel Patch Creek); Horse Lick Creek; Middle, South Forks), Big South Fork system (New R., Big South, Little South Forks; Roaring Paunch, Rock Creeks), Buck Creek), middle Cumberland R. system (Roaring, Stones Rs.; Obey R. system (Obey, West Fork Obey, Wolf Rs.)), lower Cumberland R. system (Red R. system (Red, East Fork Red Rs.))	?	**Endemic KY, TN;** putative form (Mayden & Powers, pers. comm., 2002) endemic to the Cumberland R. system; preliminary meristic, genetic, and color evidence supports taxonomic distinction (Powers, pers. comm., 2002); ~12 TN sites (Etnier & Starnes 1993) and ~13 KY sites (Burr & Warren 1986); viable populations remain in the Big South Fork and Rockcastle R. systems (Shepard & Burr 1984; Powers, pers. comm., 2002), but several of their streams are threatened by coal mining activities (*ibid.*); recently rediscovered in Buck Creek (1 specimen) after 50-year hiatus; extirpated from the Stones and possibly Red Rs., but status unknown in the Roaring R. and Obey R. system (*ibid*.); its requirement of silt-free pools (Etnier & Starnes 1993), an increasingly degraded habitat type, has probably exacerbated its imperilment (Shepard & Burr 1984); its pool habitat is difficult to collect due to boulders, which indicates that it may be "under-represented in collections" (Shute, pers. comm., 2002)
E. corona crown darter	middle Tennessee R. system (Cypress Creek system (Burcham, Cox, Cypress, Greenbrier, Lindsey, Little Cypress, Middle Cypress, North Fork Cypress, Threet, Wilson Creeks; Bruton, Cemetary, Chisholm, Dry, Gray, Greenbrier, Ijams, Latham, Lyles, May, Miles, Moore, Oakley Spring, Spain Branches; Buffler, Olive Springs; 1 spring and 5 tribs unnamed)	V	**Currently R4 Species of Concern; Endemic (very narrow) AL, TN;** endemic to the middle Tennessee R. system (Cypress Creek system) in the Highland Rim; restricted to 2 counties (Lauderdale, AL; Wayne, TN); inhabits small streams and springs in gently flowing pools over sand, gravel, and with slab rocks or other cover (Ceas & Page 1995); "fairly common within its small range" (Page et al. 1992); "usually abundant within its preferred habitat," according to (Mettee et al. (1996), who plotted 28 AL sites; common to abundant at 34 of 45 sites of occurrence rangewide during 1994-95 status survey (Ceas & Page 1995); warrants Federal protected status (Etnier 1997)
E. denoncourti golden darter	lower Tennessee R. system (Duck R. system (Duck, Buffalo Rs.))	V	Endemic to the Tennessee R. system; recently described taxon (Stauffer & van Snik 1997); Etnier & Starnes (1993) plotted ~7 LTCE sites all in the Duck R. system, where it is "locally abundant"; habitat widespread in main stems of Duck and Buffalo Rs. (Saylor, pers. comm., 2002); inhabits

			shallow shoals areas over fine cherty gravel (*ibid*.); historically found sporadically throughout Tennessee R. system (*contra* Stauffer & van Snik 1997); Duck R. populations, not addressed in the description (*ibid.*), are considered consistent with upper Tennessee R. system material (Kinziger et al. (2001); also in SAE
E. forbesi Barrens darter	middle Cumberland R. system (upper Caney Fork system (Collins R.; Charles, Duke, Hayes, Liberty, McMahan, West Fork Hickory, Witty Creeks)), Duck R?	T	**Currently R4 Species of Concern; Endemic (very narrow) TN;** possibly endemic to the upper Caney Fork system in the Barrens Plateau of the Highland Rim; known from 3 counties (Cannon, Coffee, Warren); possibly occurred in upper Duck R. (Page et al. 1992); inhabits small streams in gently flowing pools over sand, gravel, and with slab rocks or other cover (Ceas & Page 1995); warrants Federal protected status (Etnier 1997)
E. microlepidum smallscale darter	middle Cumberland R. system (Harpeth R. system (Harpeth R.; Big Turnbull Creek), Stones R. system (Stones, East Fork Stones Rs.)), lower Cumberland R. system (Little, Red Rs.)	V	**Currently R4 Species of Concern; Endemic (narrow) KY, TN;** endemic to the lower Cumberland R. system, mostly in the Western Highland Rim; known from 4 trib systems, with ~4 in KY (Burr & Warren 1986) and ~11 sites in TN (Etnier & Starnes 1993); occurs in deep, swift boulder and rubble riffles (*ibid.*); habitat in Stones R. reduced (*ibid.*); Harpeth and Little Rs. becoming increasingly developed; apparently stable in Little R., but many other fishes are declining in that system, as is water quality (R.R. Cicerello, Kentucky State Nature Preserves Commission, pers. comm., 2001); warrants Federal protected status (Etnier 1997)
E. neopterum lollypop darter	middle Tennessee R. system (Shoal Creek system (Big Butler, Butler, Factory, First Butler, Last Butler, Little Butler, Luker, Middle Butler, Robinson Creeks; Brewer, Fantail, Mill, Scab, Sour, Stoeball, Stults, Swanegan, Sweetwater Branches; Thompson Hollow; 2 springs and 3 tribs unnamed))	V	**Currently R4 Species of Concern; Endemic (very narrow) AL, TN;** endemic to the middle Tennessee R. system (Shoal Creek system) in the Highland Rim; restricted to 3 counties (Lauderdale AL; Lawrence, Wayne, TN); inhabits small streams and springs in gently flowing pools over sand, gravel, and with slab rocks or other cover (Ceas & Page 1995); "relatively uncommon...but appears to be in no immediate danger of extirpation" (Page et al. 1992); a status survey found 13 known spawning sites, all in southeastern Wayne Co. (Ceas & Page 1995); common to abundant at 13 of 26 sites of occurrence surveyed during 1994-95 (*ibid.*); warrants Federal protected status (Etnier 1997)
E. olivaceum sooty darter	middle Cumberland R. system (lower Caney Fork system (Brush, Dry, Hickman, Indian, Leach, Little Indian, Mine Lick, Pine, Snow, Sunset Creeks; Clear, Dry, Saunders Forks; Dismal, Morgan, Newbell, Rock Springs Branches), Cumberland R. tribs (Dixon, Hogan, Peyton Creeks)	V	**Endemic (narrow) TN;** endemic to the middle Cumberland R. system in the Nashville Basin, and restricted to 6 counties (Cannon, DeKalb, Putnam, Smith, Trousdale, Wilson); status survey conducted in 1990-92 (Layman et al. 1993); known from ~25 small headwater streams (mostly in Caney fork system), several of which are isolated by impoundments; inhabits slab rocks in slow to moderate current (*ibid.*); "occurs abundantly" in some Caney fork tribs, but sporadic elsewhere (Page et al. 1992, Lee et al. 1980); should retain its "deemed in need of management" status (Layman et al. 1993); warrants Federal protected status (Etnier 1997)
E. pseudovulatum egg-mimic darter	lower Tennessee R. system (lower Duck R. system (East Piney, Piney, West Piney Rs.; Beaver, Beaverdam, Big Spring, Coon, East	T	**Currently R4 Species of Concern; Endemic (very narrow) TN;** endemic to the lower Duck R. system in the Western Highland Rim; known from 6 trib systems in 2 counties (Dickson, Hickman); inhabits small streams in

	Fork Wolf, Happy Hollow, Little Piney, Little Spring, Mill, Only, Water Fork Creeks; Brushy, Piney, Sulphur Forks; Milam, Wades Branches; Cow Hollow; unnamed trib))		gently flowing pools over sand, gravel, and with slab rocks or other cover (Ceas & Page 1995); common to abundant at only 7 of 17 sites of occurrence during 1994-95 status survey (Ceas & Page 1995); picked up in 3 additional streams since 1997 (Saylor, pers. comm., 2002); warrants Federal protected status (Etnier 1997)
E. sp. cf. *rufilineatum* redline darter "Clarks River form"	lower Tennessee R. system (Clarks R. system (West Fork Clarks R.))	?	**Endemic (very narrow) KY;** putative form (R.M. Wood, St. Louis University, pers. comm., 2002) endemic to the Tennessee R. system, and representing only Coastal Plain population of the *E. rufilineatum* complex; preliminary morphometric and genetic evidence supports taxonomic distinction; known only from a few sites (Burr & Warren 1986); occurs in shallow riffles; restriction to a single stream makes it highly susceptible to perturbations (e.g., toxic spills); apparently common, with 142 specimens sampled from a site in 1996 (Saylor, pers. comm., 2002); recent creation of Clarks River National Wildlife Refuge provides a level of protection
E. striatulum striated darter	lower Tennessee R. system (upper Duck R. system (Duck R.; Big Bigby, Flat, Wilson Creeks; Garrison, North Forks)	T SC	**Currently R4 Species of Concern; Endemic (very narrow) TN;** endemic to the upper Duck R. system with all but 1 site in the Nashville Basin; known from ~12 tributaries in 4 counties (Bedford, Lewis, Marshall, Maury) (Etnier & Starnes 1993); occurs in slabrock pools in small to medium sluggish creeks (*ibid*.); "uncommon" and status declining, extirpated from 4 historical sites (Etnier & Starnes 1993); oftentimes found in the lower main stems of tribs in habitat that may dry seasonally or during droughts, where they may perish, but where repopulation from the Duck R. main stem is possible (Saylor, pers. comm., 2002); several streams within its historical range are considered impaired by the Tennessee Department of Environment and Conservation; warrants Federal protected status (Etnier 1997)
E. susanae Cumberland johnny darter	upper Cumberland R. system above Falls (Cumberland R.; Jellico, Gum, Marsh, Indian Creeks; Clear Fork)	T T	**Currently a Candidate; Endemic (narrow) KY, TN;** endemic to the upper Cumberland R. system in the Cumberland Plateau; newly elevated species (formerly a subspecies of *E. nigrum*) known from 3 counties (McCreary, Whitley, KY; Scott, TN); ~12 KY sites (Burr & Warren 1986) and 2 TN sites (Etnier & Starnes 1993); inhabits moderate runs with coarse sand (*ibid*.)
E. tippecanoe Tippecanoe darter	upper Cumberland R. system (Big South Fork), middle Cumberland R. system (Harpeth, Stones Rs), lower Cumberland R. system (Red R.)	V	Endemic to the Ohio R. system, but with highly disjunct populations; ~6 TN sites (Etnier & Starnes 1993) and ~3 KY sites (Burr & Warren 1986; Cicerello, pers. comm., 2002); inhabits shallow shoal areas over fine cherty gravel (Etnier & Starnes 1993); persists in at least the Big South Fork and Red R. (TN) systems (Cicerello, pers. comm., 2002); generally uncommon, but considered to be more common than previously thought in parts of KY; Tennessee R. populations recently described as distinct (see *E. denoncourti*); warrants Federal protected status (Etnier 1997); mostly in ORVE
E. tuscumbia complex Tuscumbia darter	middle Tennessee R. system (Flint R. system), lower Tennessee R. system	V T T	**Currently R4 Species of Concern; Endemic (narrow) AL, TN;** complex (Mayden & B.R. Kuhajda, University of Alabama, pers. comm., 2002) endemic to the middle Tennessee R. system in the Highland Rim; a spring species

			with 2 "ecological" forms, diurnal and nocturnal; historically known from ~26 vegetated limestone springs, but extirpated from TN (2 Hardin Co. preimpoundment sites 1940s, Etnier & Starnes 1993) and ~10 AL sites (Kuhajda, pers. comm., 2002); water withdrawal a major threat, as is habitat degradation; warrants Federal protected status (Etnier 1997)
E. sp. cf. *zonistium* "blueface darter"	middle Tennessee R. system (upper Bear Creek system)	T	Highly restricted in the headwaters of 2 AL stream systems (shared with Hubbard Creek, upper Sipsey Fork system, Mobile Basin) on the Cumberland Plateau; ~11 sites (Mettee et al. 1996); occurs in "clear cool streams with sand and bedrock substrates," very different from the habitat of the typical *E. zonistium*, which occurs in low gradient Coastal Plain streams in gentle riffles and pools over fine gravel (Etnier & Starnes 1993); highly localized and imperiled; also in CGE
Percina burtoni blotchside logperch	upper Cumberland R. system (Big South Fork system (Big South, Little South Forks), middle Cumberland R. system (Obey R. system (Obey, Wolf Rs.)), middle Tennessee R. system (Paint Rock R. system (Estill, Larkin Forks), Shoal Creek system (Little Butler, Shoal Creeks)), lower Tennessee R. system (Duck R. system (upper upper Duck R.; Beaverdam?, Big Swan Creeks), Buffalo R. system (Buffalo, Green Rs.; Fortyeight Creek)), lower Tennessee R. tribs (Whiteoak Creek)	V SC SC	**Currently R4 Species of Concern;** restricted to Tennessee and Cumberland R. systems; known from ~12 Tennessee localities (Etnier & Starnes 1993), but only 1 KY (Burr & Warren 1986) and 2 AL sites (Mettee et al. 1996); occurs in larger streams in deep runs with gravel and cobble, is intolerant of silt, and is generally "rare and localized" (Etnier & Starnes 1993), with many populations extirpated; fairly common in Big Swan Creek, which may represent best population in LTCE (Saylor, pers. comm., 2002); thought to be extirpated from Cumberland R. system (not collected in over 50 years) until an observation was made by the author in Big South Fork, KY, in October 2001 (the first KY sighting in ~110 years); warrants Federal protected status (Etnier 1997); also in SAE
P. macrocephala longhead darter	upper Cumberland R. system (Big South Fork system (Little South Fork)), middle Cumberland R. system (East Fork Obey R.), lower Tennessee R. system (Duck R. system (Duck, Buffalo Rs.))	T T T	**Currently R4 Species of Concern;** endemic to the Ohio R. system; sporadic and rare over most of its range (Page 1978); probably extirpated from Cumberland R. system, where its known from 3 ~1891 records (*ibid.*), also 3 Duck R. system sites (Etnier & Starnes 1993), but not known from recent collections in the lower Tennessee R. system (Saylor, pers. comm., 2002); inhabits deep, flowing pools over clean sand and boulders, and its requirement of silt-free pools (*ibid.*), an increasingly degraded habitat type, has probably exacerbated its imperilment; a large darter whose diet includes crayfish (Page 1978); may represent a complex with at least 3 putative forms (*ibid.*), 1 in LTCE; Service is funding Mayden (Saint Louis University) to study this taxonomic issue; "probably warrants Threatened status throughout its range" (Etnier & Starnes 1993); warrants Federal protected status (Etnier 1997); mostly in ORVE, also in SAE
P. squamata olive darter	upper Cumberland R. system (Rockcastle R. system (Rockcastle R.; Horse Lick Creek), Big South Fork system (Big South Fork, Clear Fork, New? R.))	V	**Currently R4 Species of Concern;** restricted to the Tennessee and Cumberland R. systems, but to the latter in the LTCE; highly disjunct populations; known from ~7 KY (Burr & Warren 1986) and ~5 TN sites (Etnier & Starnes 1993); considered to be "often a very abundant and successful species in localized suitable habitat" of fast boulder and bedrock chutes, despite probably being "unusually sensitive" to silt and other pollutants (*ibid.*), but

			populations appear to be declining in recent years in the Big South Fork and possibly elsewhere (J.R. Shute, Conservation Fisheries, Inc.; and Rakes, pers. comm., 2002), although they found it in the Clear Fork in 2002; majority of range in SAE
Polyodontidae			
Polyodon spathula paddlefish	upper Cumberland R. system (Cumberland R., Big South Fork), middle Cumberland R. system (Obey R. system (Wolf R.), Cumberland, Stones Rs., Caney Fork)), lower Cumberland R. system (Cumberland R.), middle Tennessee R. system (Tennessee, Elk Rs.), lower Tennessee R. system (Tennessee R.)	V SC SC	**Currently R4 Species of Concern;** very widespread distribution mostly in large rivers west of the Mississippi R. and known from 27 states; ~20 TN (Etnier & Starnes 1993),~6 AL (Mettee et al. 1996), and ~10 KY sites (Burr & Warren 1986) sites; managed as a commercial and/or sportfish species throughout its' range; tolerant of impoundments (Etnier & Starnes 1993) if access to riverine spawning habitat present; also in ORVE, SAE, and elsewhere

NOTES

Column 1: Common names applied to undescribed taxa are generally from Warren et al. (2000), but are subject to change.

Column 2: Range (historical and current) within the LTCE is generally given. See "Methods" for delineations of the stream reaches (e.g., lower Cumberland R., middle Tennessee R.) used in this column. Streams in parentheses refer to tributaries in the previously labeled "parent" stream system. Distributional data are generally derived from state treatises on fishes, original descriptions and revisions, other published papers, and unpublished status survey reports. Many of the streams are derived from dot distribution maps, with difficult stream identifications in question marks. These include: Alabama (Mettee et al. 1996), Kentucky (Burr and Warren 1986), and Tennessee (Etnier & Starnes 1993). However, streams of occurrence for some taxa, such as cave (e.g., *Typhlichthys subterraneus*) and spring habitat (e.g., *Hemitremia flammea*) forms are not provided. Small stream forms (e.g., *Etheostoma corona, E. forbesi, E. neopterum, E. olivaceum*) may have named streams of occurrence, but they may not be clustered as to subdrainages like they are for most larger stream forms.

Column 3: Conservation status categories have been assigned for some fish taxa by the American Fisheries Society three times since 1979. In this column, Warren et al. (2000) is the first, Williams et al. (1989) is the second, and Deacon et al. (1979) is the third. "Special concern" status is equivalent to "vulnerable." A question mark in the column indicates a putative taxon not included in Warren et al. (2000), but deemed deserving of conservation status.

Column 4: Endemic in bold denotes a taxon that is endemic to the LTCE (with relative degree of endemicity), and state(s) of occurrence (including historical).

General: Two former LTCE taxa, *Moxostoma lacerum* (harelip sucker) and *Fundulus albolineatus* (whitelined topminnow), are considered extinct (Warren et al. 2000) and have been omitted from the table.

CODES

CGE = Central Gulf Ecosystem, CS = conservation status, E = endangered, *ibid.* = same reference, ORVE = Ohio River Valley Ecosystem, R4 = Service Region 4, SAE = Southern Appalachian Ecosystem, SC = special concern, sp. cf. = species to be compared with, T = threatened, USGS= U.S. Geological Survey, V = vulnerable

Table 2. Fish taxa of the Lower Tennessee Cumberland Ecosystem federally protected under the Endangered Species Act.

Family/Species	Common Name	States	T/E
Amblyopsidae			
Speoplatyrhinus poulsoni	Alabama cavefish	AL	E
Cyprinidae			
Erimonax monacha	spotfin chub	AL, GA, NC, TN, VA	T
Notropis albizonatus	palezone shiner	AL, KY, TN	E
Phoxinus cumberlandensis	blackside dace	KY, TN	T
Ictaluridae			
Noturus stanauli	pygmy madtom	TN	E
Percidae			
Etheostoma boschungi	slackwater darter	AL, TN	T
E. percnurum	duskytail darter	KY, TN, VA	E
***E.* sp. cf. *stigmaeum* form 4**	"bluemask darter"	TN	E
E. wapiti	boulder darter	AL, TN	E
Percina tanasi	snail darter	AL, GA, TN	T

NOTES

Column 1: Taxa in bold are endemic to the Lower Tennessee Cumberland Ecosystem (LTCE).

Column 2: Common names applied to undescribed taxa are generally from Warren et al. (2000), but are subject to change.

Column 3: Range includes historical states of occurrence.

General: Taxa not endemic to the LTCE are shared exclusively with the Southern Appalachian Ecosystem (SAE). *Notropis albizonatus* is extirpated from the SAE, and is now globally restricted to the LTCE. *Etheostoma percnurum* is considered to represent two taxa, with one each restricted to LTCE (Big South Fork) and SAE (upper Tennessee R. system), respectively (B.M. Burr, Southern Illinois University, pers. comm., 2002).

CODES

E = endangered, T = threatened, T/E = Federal status

Table 3. Currently stable (Warren et al. 2000) native fishes of the Lower Tennessee Cumberland Ecosystem.

Acipenseridae		
Scaphirhynchus platorynchus		
Amblyopsidae		
Forbesichthys agassizi		
Amiidae		
Amia calva		
Anguillidae		
Anguilla rostrata		
Aphredoderidae		
Aphredoderus sayanus		
Atherinopsidae		
Labidesthes sicculus	*Menidia beryllina*	
Belonidae		
Strongylura marina ?		
Catostomidae		
Carpiodes carpio	*Hypentelium nigricans*	*M. carinatum*
C. cyprinus complex	*Ictiobus bubalus* complex	*M. duquesnei*
C. velifer complex	*I. cyprinellus* complex	*M. erythrurum*
Catostomus commersoni	*I. niger*	*M. macrolepidotum breviceps*
Erimyzon oblongus claviformis	*Minytrema melanops*	
E. sucetta	*Moxostoma anisurum*	
Centrarchidae		
Ambloplites rupestris	*L. macrochirus*	*Micropterus dolomieu*
Centrarchus macropterus	*L. marginatus*	*M. punctulatus*
Lepomis cyanellus	*L. megalotis* complex	*M. salmoides*
L. gulosus	*L. microlophus* complex	*Pomoxis annularis*
L. humilus	*L. miniatus*	*P. nigromaculatus*
Clupeidae		
Alosa chrysochloris	*Dorosoma cepedianum*	*D. petenense*
Cottidae		
Cottus b. bairdi	*C. c. carolinae*	
Cyprinidae		
Campostoma a. anomalum	*L. lirus*	*N. r. rubellus*
C. oligolepis	*L. umbratilus cyanocephalus*	*N. shumardi*
Clinostomus funduloides estor	*Macrhybopsis hyostoma*	*N.* sp. cf. *spectrunculus*
Cyprinella camura	*M. storeiana*	*N. stilbius* ?
C. galuctura	*Nocomis effusus*	*N. telescopus*
C. spiloptera	*N. leptocephalus bellicus*	*N. volucellus*
C. whipplei	*N. micropogon*	*N. wickliffi*
Ericymba buccata	*Notemigonus crysoleucas*	*Opsopoeodus e. emiliae*
Erimystax dissimilis	*Notropis ammophilus*	*Phenacobius mirabilis*
E. i. insignis	*N. atherinoides*	*P. uranops*
Hybognathus hayi	*N. baileyi*	*Phoxinus erythrogaster*
H. nuchalis	*N. blennius*	*Pimephales notatus*

Hybopsis amblops	*N. boops*	*P. promelas*
Luxilus c. chrysocephalus	*N. buchanani*	*P. vigilax*
L. c. isolepis	*N. chrosomus*	*Rhinichthys atratulus obtusus*
L. coccogenis	*N. leuciodus*	*R. cataractae*
Lythrurus b. bellus	*N. ludibundus*	*Semotilus atromaculatus*
L. fasciolaris	*N. photogenis*	*S. thoreauianus*
L. fumeus	*N. rubellus micropteryx*	
Elassomatidae		
Elassoma zonatum		
Esocidae		
Esox americanus vermiculatus	*E. masquinongy*	*E. niger*
Fundulidae		
Fundulus catenatus	*F. notatus*	
F. dispar	*F. olivaceus*	
Hiodontidae		
Hiodon alosoides	*Hiodon tergisus*	
Ictaluridae		
Ameiurus melas	*Noturus elegans*	*N. gyrinus*
A. natalis	*N. eleutherus*	*N. miurus*
A. nebulosus	*N. exilis*	*N. nocturnus*
Ictalurus furcatus	*N.* sp. cf. *flavus*	*N. phaeus*
I. punctatus	*N. funebris*	*Pylodictis olivaris*
Lepisosteidae		
Lepisosteus oculatus	*L. osseus*	*L. platostomus*
Moronidae		
Morone chrysops	*M. mississippiensis*	
Percidae		
Ammocrypta vivax	***E. luteovinctum***	*E. stigmaeum*
E. asprigene	*E. nigripinne*	***E.* sp. cf. *stigmaeum* form 5**
E. baileyi	*E. n. nigrum*	***E.* sp. cf. *stigmaeum* form 6**
E. bison	***E. obeyense***	*E. swaini*
E. blennioides newmani	***E. oophylax***	*E. virgatum*
E.* sp. cf. *blennioides	*E. parvipinne*	*E. zonale*
E. b. blennius	*E. proeliare*	*E. zonistium*
E. c. caeruleum	*E. rufilineatum* complex	*Percina c. caprodes*
E. camurum	***E.* sp. cf. *rufilineatum***	*P. copelandi*
E. chlorosoma	***E. s. sagitta***	*P. e. evides*
E. crossopterum	***E. sanguifluum***	*P. maculata*
E. duryi	***E. simoterum atripinne***	*P. phoxocephala*
E. etnieri	*E. s. simoterum*	*P. s. sciera*
E. flabellare complex	***E. smithi***	*P. shumardi*
E. flavum	***E.* sp. cf. *spectabile* form 1**	*P. vigil*
E. gracile	***E.* sp. cf. *spectabile* form 2**	*Stizostedion canadense*
E. histrio	*E.* sp. cf. *spectabile* form 3	*S. vitreum*
E. jessiae	***E.* sp. cf. *spectabile* form 5**	
E. kennicotti	*E. squamiceps*	

Petromyzontidae		
Ichthyomyzon bdellium	*I. greeleyi*	*L. appendix*
I. castaneus	*I. unicuspus*	
I. gagei	*Lampetra aepyptera*	
Poecilidae		
Gambusia affinis		
Sciaenidae		
Aplodinotus grunniens		
Umbridae		
Umbra limi		

NOTES

Columns 1-3: Taxa in bold are endemic to the LTCE. A question mark denotes a taxon whose native or introduced status is uncertain. Numbered undescribed complexes and "forms" are from Warren et al. (2000), except *Ictiobus bubalus* and *I. cyprinellus* (H.L. Bart, Jr., Tulane University, pers. comm., 2002); *Etheostoma* sp. cf. *blennioides* (K.L. Piller, University of Wisconsin, pers. comm., 2002), which is endemic to the Cumberland River system; and *E. rufilineatum* and *E.* sp. cf. *rufilineatum* (R.M. Wood, St. Louis University, pers. comm., 2002), the latter also endemic to the Cumberland River system.

General: *Erimystax i. insignis* is the only Region 4 species of concern not assigned a conservation status by Warren et al. (2000). *Forbesichthys agassizi* and *Etheostoma luteovinctum* were assigned special concern status in 1979 (Deacon et al. 1979), while the latter species retained that status in 1989 (Williams et al. 1989). The following are native eastern North American fishes introduced into LTCE streams from adjacent drainages: *Micropterus coosae, Alosa aestivalis, A. pseudoharengus, Cyprinella lutrensis, C. venusta stigmatura, Notripis texanus, Noturus h. hildebrandi, Morone saxatilis,* and *Salvelinus fontinalis*. Numerous other fishes have been introduced into the SAE from western states (e.g., salmonids) and foreign countries (e.g., carps).

CODES

LTCE = Lower Tennessee Cumberland Ecosystem, sp. cf. = species to be compared with

Table 4. Jeopardized fish taxa (those assigned or deemed deserving of conservation status, and federally listed species) that are endemic to both the Lower Tennessee Cumberland Ecosystem and specific river drainages.

Species	CS	Drainage System				
		Middle Tennessee	Lower Tennessee	Upper Cumb.	Middle Cumb.	Lower Cumb.
Speoplatyrhinus poulsoni	FE	X				
Notropis rupestris	V				X	
Phoxinus cumberlandensis	FT			X		
Elassoma alabamae	E	X				
Noturus sp. cf. *elegans* form 2	V		X			
Etheostoma aquali	V		X			
E. boschungi	FT	X	X			
E. sp. cf. *cinereum*	?			X	X	X
E. corona	V	X				
E. forbesi	T				X	
E. microlepidum	V				X	X
E. neopterum	V	X				
E. olivaceum	V				X	
E. pseudovulatum	T		X			
E. sp. cf. *rufilineatum*	?		X			
E. sp. cf. *stigmaeum* form 4	FE				X	
E. striatulum	T		X			
E. susanae	T			X		
E. tuscumbia complex	V	X	X			
E. wapiti	FE	X				
TOTAL	-	7	7	3	6	2

NOTES

Column 2: Conservation status categories assigned by the American Fisheries Society (Warren et al. 2000). A question mark in this column indicates that the putative taxon was not recognized by Warren et al. (2000) and has not been given American Fisheries Society conservation status.

Columns 3-7: See "Methods" for delineations of the stream reaches used. Species are not necessarily restricted to a single stream reach within a river to be considered endemic. Data includes historical stream reaches of occurrence.

General: Although not a single drainage endemic, *Fundulus julisia* is very narrowly endemic to the Barrens Plateau of the Eastern Highland Rim. Similarly, *Etheostoma* sp. cf. *zonistium* is very narrowly endemic to a small portion of the Cumberland Plateau spanning the headwaters of two stream systems and two Service ecosystems (see Table 1).

CODES

CS = conservation status, E = endangered, FE = federally endangered, FT = federally threatened, T = threatened, V = vulnerable

Table 5. Fish taxa of the Lower Tennessee Cumberland Ecosystem suggested for addition to Region 4's Species of Concern list.

Species	Common Name	Region 4 States
Hybopsis amnis	pallid shiner	KY, TN
Notropis ariommus	popeye shiner	AL, KY, TN
N. rupestris	bedrock shiner	TN
Atractosteus spatula	alligator gar	AL, AR, FL, KY, LA, MS, TN
Ammocrypta clara	western sand darter	AR, KY, LA, TN
Etheostoma denoncourti	golden darter	TN
E.* sp. cf. *cinereum	"Cumberland form"	KY, TN
E. olivaceum	sooty darter	TN
E. sp. cf. *rufilineatum*	"Clarks River form"	KY
E. tippecanoe	Tippecanoe darter	KY, TN
E. sp. cf. *zonistium*	"blueface darter"	AL

NOTES

Column 1: Taxa in bold are endemic to the LTCE.

Column 2: Common names according to American Fisheries Society (Robins et al. 1991), except where quotation marks indicate a suggested, but "unofficial," common name for putative taxa (see "Methods").

Table 6. Priority drainages for imperiled fishes in the Lower Tennessee Cumberland Ecosystem.

Drainage (States)	Pts.	Extant Taxa
Tennessee River system		
Duck River (TN)	26	*Hemitremia flammea, Notropis ariommus,* ***Noturus* sp. cf. *elegans,*** *N. stanauli, Etheostoma aquali,* ***E. cinereum,*** *E. denoncourti,* ***E. pseudovulatum, E. striatulum, Percina burtoni, P. macrocephala***
Buffalo River (TN)	22	*Typhlichthys subterraneus, Erimonax monacha, Notropis ariommus,* ***Noturus* sp. cf. *elegans,*** *Etheostoma aquali, E. boschungi,* ***E. cinereum****, E. denoncourti,* ***Percina burtoni, P. macrocephala***
middle Tennessee River (mainstem, other tribs) (AL, TN)	19	*Speoplatyrhinus poulsoni, Typhlichthys subterraneus, Cycleptus elongatus, Hemitremia flammea,* ***Elassoma alabamae****, Etheostoma boschungi,* ***E. tuscumbia***
Elk River (TN, AL)	16	*Typhlichthys subterraneus, Hemitremia flammea, Notropis ariommus,* ***Fundulus julisia, Etheostoma cinereum****, E. wapiti*
lower Tennessee River (other tribs) (TN)	13	*Typhlichthys subterraneus, Alosa alabamae, Hemitremia flammea,* ***Noturus* sp. cf. *elegans, Etheostoma* sp. cf. *rufilineatum****, Percina burtoni***
Paint Rock River (AL, TN)	12	*Typhlichthys subterraneus, Hemitremia flammea, Notropis albizonatus,* ***Percina burtoni****; P. tanasi* ?
Cypress Creek (AL, TN)	11	*Hemitremia flammea, Etheostoma boschungi, E. corona,* ***E. tuscumbia****; Typhlichthys subterraneus* ?
Shoal Creek (AL, TN)	9	*Typhlichthys subterraneus, Hemitremia flammea, Etheostoma boschungi, E. neopterum,* ***Percina burtoni***
Flint River (AL. TN)	8	*Typhlichthys subterraneus, Hemitremia flammea, Etheostoma boschungi,* ***E. tuscumbia***
Bear Creek (AL, MS)	4	*Cycleptus elongatus,* ***Etheostoma* sp. cf. *zonistium***
Cumberland River System		
Caney Fork (TN)	19	*Typhlichthys subterraneus, Hemitremia flammea, Hybopsis amnis, Notropis rupestris,* ***Fundulus julisia, Etheostoma forbesi****, E. olivaceum, E.* sp. cf. *stigmaeum* form 4
Big South Fork (TN, KY)	13	*Notropis ariommus,* ***Etheostoma* sp. cf. *cinereum****, E. percnurum, E. tippecanoe,* ***Percina burtoni, P. squamata***
Rockcastle River (KY)	10	*Notropis ariommus, Phoxinus cumberlandensis,* ***Etheostoma* sp. cf. *cinereum, Percina squamata***
Little South Fork (KY)	8	*Notropis albizonatus, N. ariommus,* ***Etheostoma* sp. cf. *cinereum***
upper Cumberland River (tribs above Cumberland Falls) (KY, TN)	8	*Phoxinus cumberlandensis,* ***Etheostoma susanae***
middle Cumberland River (other tribs) (TN)	7	*Typhlichthys subterraneus, Hemitremia flammea, Notropis rupestris, Etheostoma olivaceum*; ***E.* sp. cf. *cinereum*** ?
Stones River (TN)	5	*Typhlichthys subterraneus,* ***Etheostoma microlepidum****; Notropis*

		ariommus ? *E. tippecanoe* ?
Buck Creek (KY)	4	*Notropis ariommus*, ***Etheostoma* sp. cf. *cinereum***
Obey River (TN)	4	*Typhlichthys subterraneus*; ***Etheostoma* sp. cf. *cinereum*** ?
Red River (TN, KY)	4	*Typhlichthys subterraneus,* ***Etheostoma microlepidum,*** *E. tippecanoe*
Harpeth River (TN)	3	***Etheostoma microlepidum***; *E. tippecanoe* ?
Little River (KY)	3	*Typhlichthys subterraneus,* ***Etheostoma microlepidum***
lower Cumberland River (mainstem, other tribs) (TN, KY)	2	*Typhlichthys subterraneus, Cycleptus elongatus*

NOTES

Column 1: Priority stream systems are derived from a point system (see Column 2). They are listed in priority order in the two drainage categories presented. Drainages are treated independently in this table, despite the fact that some are tributaries or parent drainages of others. States are given in order of largest approximate portion of the drainage contained within. Ties are arbitrarily listed.

Column 2: The point system used to prioritize drainages in this table is weighted towards the more imperiled fishes and includes only those taxa thought to be extant. The point system is as follows: 4 for federally listed taxa, 3 for endangered status (Warren et al. 2000) and Federal candidates, 2 for threatened status (Warren et al. 2000) and putative taxa not assigned conservation status, and 1 for vulnerable status (Warren et al. 2000). An extra point is awarded for those taxa endemic to a single drainage system (that appears as a single row in this table), for the last known extant population of a taxon, or for a critically imperiled taxon appearing in Table 7. Five is thus the highest point total per fish.

Column 3: Taxa in bold are those non-listed fishes deemed to have the greatest need for current conservation status assessment in the ecosystem (see Table 7). A question mark indicates a taxon that may or may not be extant in that drainage, but whose points are included in the drainage totals.

General: Introduced (e.g., *Notropis rupestris* in Duck R.) and commercial (e.g., *Polyodon spathula*) taxa are not included in this table. Drainages with only a single "one point" taxon are also omitted.

Table 7. Fish taxa of the Lower Tennessee Cumberland Ecosystem deemed to have the greatest need for current conservation status assessment.

Species	Needs	LTCE Range (States)
Elassoma alabamae	2,3,4,5,6	middle Tennessee R. system (AL)
Fundulus julisia	4,6	Barrens Plateau (TN)
Noturus sp. cf. *elegans* form 1	1,2,3,4,5,6	middle Cumberland, middle Tennessee R. systems (AL, TN)
Noturus sp. cf. *elegans* form 2	1,2,3,4,5	lower Tennessee R. system (TN)
E. cinereum	1,3,4,5	middle, lower Tennessee R. systems (AL, KY, TN)
E. sp. cf. *cinereum*	1,3,4,5	throughout Cumberland R. system (KY, TN)
E. forbesi	1,2,3,5	upper Caney Fork system (TN)
E. microlepidum	1,2,3,5	middle, lower Cumberland R. systems (KY, TN)
E. pseudovulatum	2,3,5	lower Duck R. system (TN)
E. sp. cf. *rufilineatum*	1,2,3,4,5	West Fork Clarks R. (KY)
E. striatulum	1,3,5	upper Duck R. system (TN)
E. susanae	1,2,3,5	upper Cumberland R. system (KY, TN)
E. tuscumbia complex	3,4,5	middle, lower Tennessee R. systems (AL, TN)
E. sp. cf. *zonistium*	1,2,3,4,5,6	upper Bear Creek system (AL)
Percina burtoni	1,2,3,4,5	upper Cumberland and Tennessee R. systems (AL, KY, TN)
P. macrocephala	1,2,3,4,5	upper, middle Cumberland; Duck R. systems (KY, TN)
P. squamata	1,2,3,4,5	upper Cumberland R. system (KY, TN)

NOTES

Column 1: Taxa in bold are endemic to the LTCE.

Column 2: Refers to those research activities that are necessary for prelisting and recovery actions (coded below).

Column 3: - Includes historical states and drainages of occurrence.

CODES

1 = status survey, 2 = life history, 3 = threat analysis, 4 = taxonomic distinctiveness, 5 = propagation technology, 6 = captive population