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Status and Conservation of the Fish Fauna of the Alabama River System

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Abstract.—The Alabama River system, comprising the Alabama, Coosa, and Tallapoosa subsystems, forms the eastern portion of the Mobile River drainage. Physiographic diversity and geologic history have fostered development in the Alabama River system of globally significant levels of aquatic faunal diversity and endemism. At least 184 fishes are native to the system, including at least 33 endemic species. During the past century, dam construction for hydropower generation and navigation resulted in 16 reservoirs that inundate 44% of the length of the Alabama River system main stems. This extensive physical and hydrologic alteration has affected the fish fauna in three major ways. Diadromous and migratory species have declined precipitously. Fish assemblages persisting downstream from large main-stem dams have been simplified by loss of species unable to cope with altered flow and water quality regimes. Fish populations persisting in the headwaters and in tributaries to the main-stem reservoirs are now isolated and subjected to effects of physical and chemical habitat degradation. Ten fishes in the Alabama River system (including seven endemic species) are federally listed as threatened or endangered. Regional experts consider at least 28 additional species to be vulnerable, threatened, or endangered with extinction. Conserving the Alabama River system fish fauna will require innovative dam management, protection of streams from effects of urbanization and water supply development, and control of alien species dispersal. Failure to manage aggressively for integrity of remaining unimpounded portions of the Alabama River system will result in reduced quality of natural resources for future generations, continued assemblage simplification, and species extinctions.

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Introduction

The Alabama River system, comprising the Alabama, Coosa, and Tallapoosa rivers and their tributaries (Figure 1), forms the eastern portion of the Mobile River drainage, one of the most biologically rich aquatic ecosystems in North America (Lydeard and Mayden 1995; Mettee et al. 1996; Neves et al. 1997). Physiographic diversity and a geologic history of relative isolation and protection from Pleis-

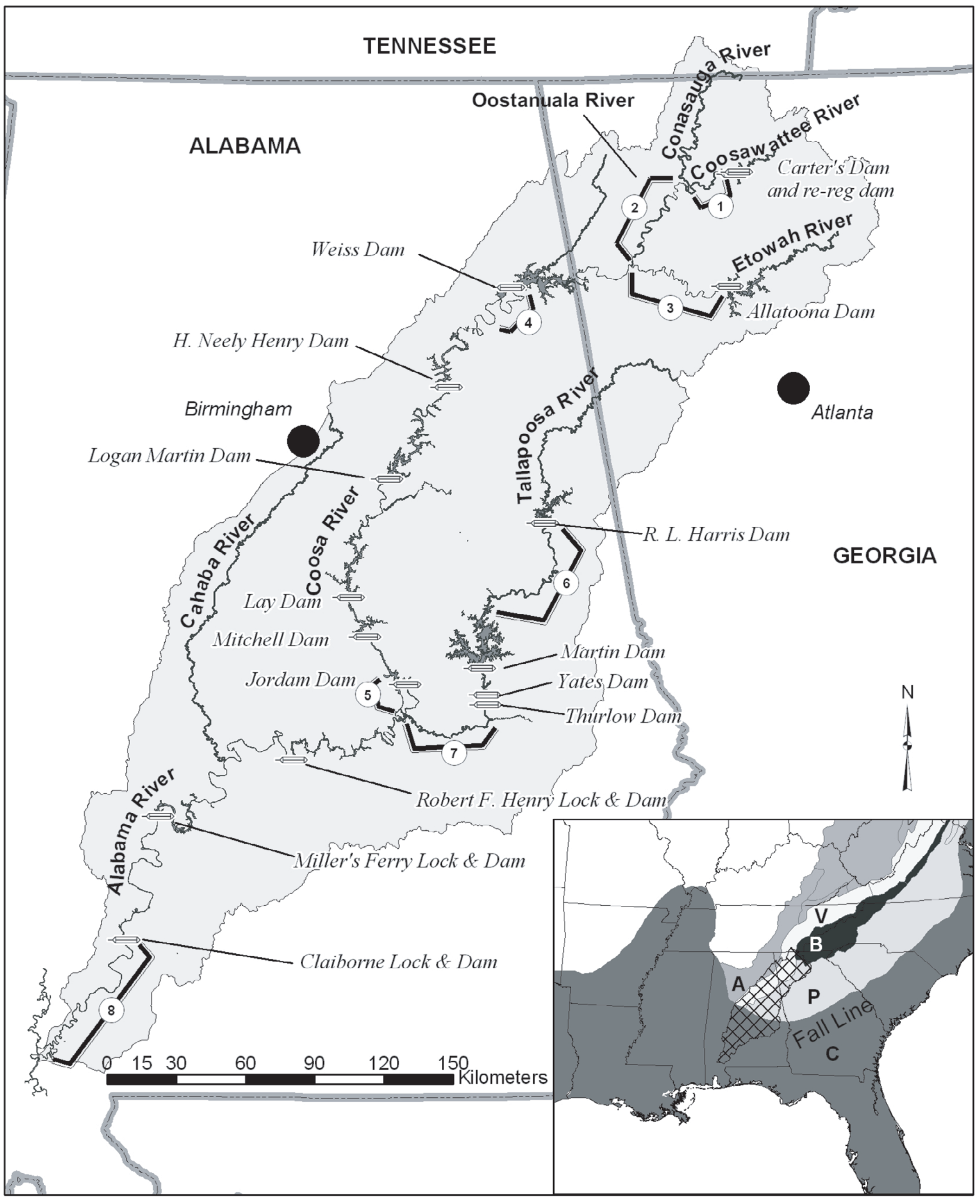

Figure 1.—Alabama River system, showing Alabama, Coosa and Tallapoosa main stems, major tributary systems, and locations of main-stem dams. Flow-regulated reaches are numbered to correspond with Table 1. Inset shows drainage (cross-hatched) overlain on physiographic provinces: Appalachian Plateau (A), Valley and Ridge (V), Blue Ridge (B), Piedmont (P), and coastal plain (C). The fall line separates the coastal plain from upland provinces.

tocene glaciation have fostered development in the Alabama River system of some of the highest levels of aquatic faunal diversity and endemism recorded in temperate freshwaters. At least 184 fishes are native to the system, including at least 33 endemic species (Appendix A).

Our knowledge of the Alabama River ichthyofauna began with the eclectic discovery and description of fishes in the mid-19th century, rapidly transitioned to more rigorous, systematic investigations by scholars at newly established national and regional natural history museums, and continues as diverse biological investigations conducted at state universities, natural history research collections, and by state and federal agencies. Boschung (1992) provides a brief synopsis of contributions by 19th century natural historians who initiated early ichthyofaunal exploration of the Alabama River. The list includes luminaries associated with ichthyological exploration of North America, but three scientists stand out by virtue of describing more than half the fishes known from the Alabama River. The anatomist Jean Louis Rodolphe Agassiz (1807–1873) described the first species from the Mobile River drainage, the blackbanded darter (as *Hadropterus nigrofasciatus*) and 28 other valid forms. The renowned scholar and humanist David Starr Jordan (1851–1931), and his student and colleague Charles Henry Gilbert (1859–1928), collectively described more than a hundred species. The first endemic species described from the Alabama River system, the blue shiner was described as being common by Jordan (1877); it is now a federally listed threatened species.

The rich fauna of Alabama has attracted many students of fishes in the 20th century, far too many to list. However, two southeastern colleagues, Herbert T. Boschung (Professor Emeritus, Department of Biology, University of Alabama) and Royal D. Suttkus (Professor Emeritus, Tulane University, Museum of Natural History), and several decades of their graduate students, made outstanding contributions to our knowledge of the composition and distribution of the Alabama River ichthyofauna. Collectively with their graduate students, Suttkus and Boschung described 36 species from Alabama, 31 of which occur in or are endemic to the Alabama River system. Boschung published the first annotated list of Coosa River fishes (Boschung 1961) and a catalog of freshwater and marine fishes (Boschung 1992). His student, James D. Williams, surveyed the Tallapoosa River for his Master's thesis (Williams 1965). William Smith-Vaniz (1968) authored the first book on the fishes of Alabama, primarily an illustrated key accompanied by black and white photographs. More recently, Maurice F. Mettee and Patrick E. O'Neil (both graduate students of Boschung) and J. Malcolm Pierson authored a beautifully illustrated book on the fishes of Alabama and the Mobile basin (Mettee et al. 1996). A third book on Alabama's fishes, by Boschung and Richard L. Mayden and illustrated by Joseph R. Tomelleri (Boschung and Mayden 2004), provides a comprehensive treatment of the systematics, distribution, biology and conservation status of the state's ichthyofauna.

Remarkably, new species discovery continues in the system (e.g., 12 fish species have been described since 1990), partly driven by recognition of cryptic species (Suttkus and Etnier 1991; Wood and Mayden 1993; Suttkus et al. 1994a, 1994b; Bauer et al. 1995; Thompson 1997a, 1997b; Burr and Mayden 1999). Our objectives are to describe how the rivers and fish assemblages of the Alabama River system have changed over the past century and a half, to highlight conservation issues, and to discuss management activities that are either in place or are needed to prevent undesirable faunal changes in the future.

The Alabama River system drains approximately 59,000 km^2, including substantial portions of northwest Georgia, east-central Alabama, and a small area of southeastern Tennessee. Physiographic diversity of the system creates a mosaic of lotic habitats that, prior to construction of large dams, formed a fluvial continuum from the mountains to the Gulf. The northernmost headwaters of the Coosa River system dissect the southern terminus of the Blue Ridge, Valley and Ridge, and upland Piedmont along the southern bend of Appalachia. These headwater rivers derive their distinctiveness from the varied lithography and soil horizons of these provinces in northwestern Georgia and northeastern Alabama (Wharton 1978). The main stem of the Coosa River

(460 km in length) originates in the relatively open Great Valley subsection of the Valley and Ridge, at Rome, Georgia. The lower third of the Coosa River main stem historically cascaded through a series of large virtually unnavigable bedrock shoals (Jackson 1995). The shoals abruptly disappear just below the fall line where the Alabama River is formed by the junction of the Coosa River with the Tallapoosa River near Montgomery, Alabama. The Tallapoosa River has similar physiographic diversity, flowing 415 km from Piedmont uplands in west Georgia and east Alabama, crossing the fall line in another set of large falls (i.e., prior to impoundment), and continuing across the coastal plain to join the Coosa River. The Cahaba River forms the western-most large tributary of the Alabama River and is the system's longest unregulated river (Figure 1). The Cahaba flows over 300 km from the Valley and Ridge province, across the fall line, onto the coastal plain and into the Alabama River near Selma, Alabama. The Alabama River main stem winds 500 km across the coastal plain, joining with the Tombigbee River approximately 72 km from Mobile Bay.

Rainfall is abundant in most years in the Alabama River system, averaging from about 127–142 cm/year across most of the basin, to more than 150 cm/year in the Coosa system headwaters and in the lower Alabama River. Natural flow regimes include seasonally highest flows in February, March, and April and lowest flows in September, October, and November. Streams on the coastal plain typically experience spring high flows that inundate riparian habitats. Annual flow in the lower Alabama River averages about 950 m^3/s; seasonal high flows (e.g., exceeding 2,250 m^3/s) spread into historically forested floodplain areas for up to 50% of days from March through September (Irwin et al. 1999).

Brief History of Alteration in the Alabama River System

Channel alteration of the main stems.—Early changes to the system's rivers brought about by European settlers include construction of small dams to power grist and textile mills and efforts to improve the rivers for navigation. Examples of the navigation improvements include rock removal, construction of rock dikes, and channel straightening in reaches of the upper Coosa system in the late 19th century (Corps of Engineers reports to the U.S. Congress, compiled by Bill Frazier, Decatur, Georgia). Steep gradient and numerous, large shoals prevented access by barges to the lower Coosa River, but the lower-gradient Alabama River provided a major corridor of river-borne commerce through the 19th century (Jackson 1995). In 1878, Congress authorized maintenance of a 1.2 × 61 m navigation channel on the length of the Alabama River, largely achieved by construction of jetties and dykes and by snag removal (Jackson 1995). The U.S. Army Corps of Engineers (USACE) presently dredges sand and gravel from shoals to facilitate travel in low-flow periods.

Beginning in 1914 and continuing to the 1980s, dam construction for hydropower generation and navigation resulted in 16 reservoirs in the Alabama River system. The first hydropower dams were constructed on the Coosa and Tallapoosa rivers in the vicinity of the fall line, where steeper gradients erode beds down to former continental shelf bedrock. Eventually, 12 hydropower projects (10 private, 2 federal) were constructed in the Coosa and Tallapoosa systems (Figure 1). The USACE constructed three additional lock and dam projects on the Alabama River main stem between 1963 and 1972 for purposes of hydropower generation and to provide a 2.7 × 61 m navigational channel. These projects resulted in extensive alteration of free-flowing, large river habitat in the Alabama River system; approximately 74% of the length of the Alabama River main stem, 87% of the Coosa River main stem and 29% of the Tallapoosa River main stem were eventually impounded by the pools behind navigation and hydropower dams.

Free-flowing riverine habitat in the Alabama River system now consists of unimpounded main-stem sections below dams and major tributary streams (many of which are now truncated by main-stem impoundments). The main-stem dams regulate flow regimes in nearly all remaining large-river habitat, with three segments experiencing the hourly flow fluctuations produced by peaking hydropower operations (Table 1). Water releases during nonpower generation periods have been as low as

Table 1.—Flow-regulated segments of the Alabama River system, showing year of initial flow regulation, segment length, and flow regime characteristics (hydropower releases and base flow levels). Numbers in parentheses correspond to numbered segments in Figure 1.

River segment	Year regulated	Length (km)	Flow regime characteristics
Coosawattee River below Carter's Dam and reregulation dam (1)	1975	40	Hydropeaking, releases buffered by the reregulation dam; base flow = 20% mean annual flow.
Oostanala River below Carter's Dam and rereg dam (2)	1975	76	Hydropeaking, releases buffered by the reregulation dam and by Conasauga River inflow.
Etowah River below Allatoona Dam (3)	1950	77	Hydropeaking; base flow = 13% mean annual flow.
Coosa River bypass, below Weiss Dam (4)	1962	36	Bypassed; flow supplied by tributaries. Flow reversed in the lower portion of the reach during power generation.
Coosa River below Jordan Dam (5)	1929[a]	13	Hydropeaking (1929–1967, 1975–1980) or bypassed (1967–1975; 1980–1990); Presently, seasonally varied baseflows with periodic hydro power releases.
Tallapoosa River below Harris Dam (6)	1982	78	Hydropeaking; base flow = 2% mean annual flow.
Tallapoosa River below Thurlow Dam (7)	1930	80	Hydropeaking; base flow increased from leakage to 25% mean annual flow in 1989.
Alabama River below Claiborne Lock and Dam (8)	1969	132	Navigation lock and dam; upstream hydropower dams operated to maintain mean daily flow = approx. 20% mean annual flow.

[a] Flow in the lower Coosa River initially was altered by construction of Lay Dam (1914) and Mitchell Dam (1923), both located upstream of Jordan Dam (1929).

flow leakage from the dams in the Coosa River below Jordan Dam and the Tallapoosa River downstream from Thurlow Dam, and remain low in the Tallapoosa River below Harris Dam (Table 1). Two segments of the Coosa River are bypassed, with flows for power generation usually released through artificial channels. Downstream from Jordan Dam, the Coosa River presently is afforded continuous, seasonally varied flows. Flow in the bypassed section below Weiss Dam is entirely from tributary inflow except during power generation, when flow is reversed as a portion of the released water is forced back upstream through the bypassed channel. Carters Dam and reregulation dam (in the upper Coosa system) operate as a pump-storage peaking project; water is released through Carters Dam to generate power during high-demand periods and is pumped back upstream from the reregulation pool when demand is low. The reregulation dam dampens the effects of peaking releases on the downstream segments of the Coosawattee and Oostanaula rivers.

Alterations from watershed activities.—Expanding agriculture in the 19th century brought extensive conversion of forests to agricultural fields and consequently enormous increases in sediment loading to streams and rivers. Mining activities, (e.g., for gold in the upper Coosa system, coal in the Cahaba system) also added increased bedload and contaminants to river segments (Ward et al. 1992; Leigh 1994; Shepard et al. 1994). Tributaries and main-stem sections were channelized to improve drainage from the eroding agricultural landscape, a practice that began a century ago and continues to present. Tributary systems have also been shortened and fragmented by construction of thousands of farm ponds and watershed dams.

Ecological integrity of the Alabama River system presently is threatened by human population expansion and urbanization. Through the 1990s, the Atlanta metropolitan area (which extends northward and westward into the Coosa and Tallapoosa systems) was included among the fastest growing counties in the United States (U.S. Census Bureau, http://www.census.gov/population/www/cen2000/phc-t4.html). Urban growth in and surrounding Birmingham also affects flows, water quality, and biological integrity in the Cahaba River system (Shepard et al. 1994). The expanding human population is placing increasing pressures on the Alabama River system for water supply. The states of Alabama and Georgia have been struggling to resolve a plan for sharing waters in the system for over a decade through joint study of water availability and demands, and since 1997, through formal negotiations under an interstate compact (USACE 1998). Symptomatic of Georgia's increasing water needs, at least six new water-supply reservoirs are proposed for streams in the upper Coosa and Tallapoosa systems.

Methods

To describe the status of the Alabama-Coosa-Tallapoosa (ACT) River basin fish fauna, we examined evidence of species imperilment and extirpations, the occurrence of alien fishes, and the condition of assemblages persisting in the longest flow-regulated main-stem segments. We initially listed all freshwater and diadromous fish species known from eight major ACT subsystems (Appendix A), based on historic records plotted by Mettee et al. (1996) and Walters (1997), supplemented with observations by Jordan (1877) for the Oostanaula and Etowah systems, and additional recent records for the upper Coosa (N. M. Burkhead and B. J. Freeman, unpublished data) and Tallapoosa (E. R. Irwin and M. C. Freeman, unpublished data) systems. We also listed fishes that are primarily marine but that commonly occur in the downstream portion of the Alabama River system. The establishment of alien species was assessed from Mettee et al. (1996) and Fuller et al. (1999).

We followed Warren et al. (2000) in listing the conservation status of each taxon, except for species listed as threatened or endangered under the Endangered Species Act (ESA), in which case we listed the species' status under the ESA. To illustrate trends in faunal conservation status, we compared number of species by conservation category in earlier assessments (Miller 1972; Deacon et al. 1979; Williams et al. 1989) with the more recent assessment by Warren et al. (2000). We also examined changes in imperilment of the Alabama River system fauna in comparison to changes for the entire fish fauna of the southeastern United States. For these comparisons, we followed Warren et al. (2000) in equating the "special concern" category used in the earlier assessments with "vulnerable" (i.e., may become threatened or endangered as a result of relatively minor habitat disturbances).

The lack of extensive faunal surveys prior to dam construction and other major habitat disturbances, along with the difficulty of sampling species that may be rare or elusive (e.g., in deep water habitats), hampers our ability to conclude that species have been extirpated from a particular reach or river system. The strongest evidence of species extirpation consists of records of past occurrence along with failure to collect a species over a prolonged period of sampling; the hypothesis of extirpation is further strengthened if the species' habitat has been severely altered or otherwise made inaccessible. Nonetheless, we recognize that rarity and difficulty in sampling can result in "rediscovery" of fishes presumed extinct or extirpated for decades (Mayden and Kuhajda 1996), and so our conclusions must be tempered with the possibility of future discoveries. For diadromous species, we presumed extirpation from those portions of the range made inaccessible by downstream dams that lack provisions for fish passage. For other species, we presumed extirpation if the species had not been observed in at least two decades. We counted a limited number of species as extirpated from flow-regulated reaches for which we lack historical records but hypothesize that the species likely occurred on the basis of habitat characteristics and proximity to areas with known occurrences.

We assessed the condition of fish assemblages in flow-regulated segments by examining evidence of species persistence for three taxonomic groups that commonly occur in wadeable habitats: sunfishes and basses (Centrarchidae), minnows (Cyprinidae), and darters (Percidae: Etheostomatini). Focusing on these three groups allowed us to include a large portion of the native fish diversity in the Alabama River system (Appendix A), while avoiding biases attributable to inefficient sampling in deep water. Examining extant diversity of these three groups also allowed us to compare persistence of habitat-generalists species that are tolerant of lotic and lentic conditions (i.e., sunfishes and basses) with that of fishes primarily adapted to flowing-water habitats (i.e., the darters and the majority of the native riverine minnows; Etnier and Starnes 1993; Jenkins and Burkhead 1994). We estimated expected native richness for these taxonomic groups in the flow-regulated reaches on the basis of known species occurrences either within the reach or in similar mainstem or large tributary habitats within the subsystem.

We used information from 11 studies (Table 2), collected over varying time periods and by different researchers, to estimate the numbers of native sunfish and basses, minnows, and darters persisting in each flow-regulated segment. In four of the flow-regulated reaches, prepositioned area electrofishers (PAEs: 1.5 × 6 m in size; Bain et al. 1985) have been used to sample fishes in wadeable habitats using similar effort on multiple occasions (i.e., over 2 to 5 years; Table 2). We used presence-absence data from PAE samples from sequential years to estimate native species detectability and richness for each site and taxonomic group, to examine the possibility that low observed species richness in some reaches resulted from low detectability. Detectability and species richness estimates were made using the jackknife estimator for closed-populations with heterogeneous detectabilities among species (model M_h), computed using program CAPTURE (Williams et al. 2002). Additional species occurrence data for flow-regulated reaches were obtained by boat electrofishing, backpack electrofishing and seining, and collection with rotenone (Table 2). Taken together, these studies provided data on species persistence for those faunal groups that were vulnerable to at least one of the sampling methods employed in each flow-regulated reach. For comparison, we estimated percent of native species persisting in the unregulated portions of the Conasauga, Etowah, and Tallapoosa systems based on Walters (1997) and our unpublished collection records.

Last, to understand how impoundments and other navigation-related changes to the Alabama River main stem have altered the fish assemblages, we summarized the results of previous studies (Buckley 1995; Buckley and Bart 1996), which used data from a long-term, fish-monitoring survey conducted by Royal D. Suttkus and the late Gerald E. Gunning to examine trends in fish species richness and abundance over time in the impounded reach of the river. Suttkus and Gunning initiated a semiannual, fish-monitoring survey of eight stations, and an annual survey at 10 stations, along a 100 km stretch of the Alabama River in 1967, continuing through the 1990s. The start of the Alabama River Fish Monitoring Survey roughly coincides with the period of intensive modification of the Alabama River for navigation. Work on the two dams that encompasses most of the Suttkus and Gunning survey area (Miller's Ferry Lock and Dam and Claiborne Lock and Dam) was initiated in 1965 and completed in 1972. Dredging of the river for maintenance of the navigation channel occurred periodically throughout the survey.

Specimens and data from the Alabama River Fish Survey are archived in the Royal D. Suttkus Fish Collection in the Tulane University Museum of Natural History. In summarizing the data, Buckley (1995) and Buckley and Bart (1996) used records from the museum database as well as information from the personal field notes of R. D. Suttkus. Sampling gear remained constant during the survey, consisting of 3.3 × 2 m, 0.5-cm mesh seines and (rarely) trammel nets. Initially, sampling was conducted at night, but changed to mostly daylight hours starting in 1983. Early collection efforts generally lasted for 45 min to 1 h, whereas later collections (after 1985) were from 15 to 30 min.

The overall species richness trend is based on pooled data for all collections within a given year.

Table 2.—Studies used to assess species occurrences in flow-regulated main-stem reaches of the Alabama River system, showing years over which studies were conducted, methods, and references.

Segment	Year(s)	Methods	Reference(s)
Coosawattee and Oostanaula rivers below Carter's Dam and rereg dam	1993–1998	Backpack or boat electrofished 14 sites; also compiled historical records (pre-dam, 1936–1962: 6 sites; post-dam, 1977–1984: 18 sites, including 1 rotenone sample).	Freeman 1998
Etowah River below Allatoona Dam	1992–1998	Backpack or boat electrofished 16 sites; also compiled historical data (pre-dam, 1949, 1 site; post-dam, 1959–1979: 4 sites).	Burkhead et al. 1997; Freeman 1998
Coosa River bypass below Weiss Dam	1999–2000	Boat and backpack electrofishing collections at 12 sites distributed throughout reach, in 5 seasons.	Stewig 2001
	1999–2000	260 pre-positioned area electrofisher (PAE) samples at 2 sites in upper third of reach, 3 seasons.	Irwin et al. 2001
Coosa River below Jordan Dam	1992–1997	PAE samples collected in a shoal complex in upper half of reach, monthly (1992–1996, 833 samples) or annually (1997–1999, 300 samples).	Peyton and Irwin 1997; E.R. Irwin, unpublished data
Tallapoosa River below Harris Dam	1990–1992, 1994–1997	Samples at 3 sites by seasonal boat electrofishing (1990–1992) and PAE sampling in spring and summer, (1990–1992: 307 samples, and 1994–1997: 791 samples).	Travnichek and Maceina 1994; Bowen et al. 1998; Freeman et al. 2001
Tallapoosa River below Thurlow Dam	1990–1992, 1994–1995, 1997	Samples at 2 sites in upper half of reach by seasonal boat electrofishing (1990–1992); PAE sampling in spring and summer, (1990–1992: 177 samples, and 1994–1995: 400 samples); rotenone (1990, 1992, 1997).	Travnichek and Maceina 1994; Travnichek et al. 1995; Bowen et al. 1998; Alabama Game and Fish Division, unpublished data

Species abundance trends are based on sampling time-adjusted data (minutes of sampling effort) and thus account for the decrease in sampling effort of collections after 1985. The data are summarized in 6-year time blocks.

Results

The Alabama River system contains at least 184 native fish species (Appendix A), counting all described and known but undescribed fishes of which we are aware. Uncertainty in the total number of fish taxa stems from the occurrence of cryptic species, some of which have been recognized (i.e., four undescribed species related to the holiday darter, Appendix A) and likely others that have not. The fauna includes at least 33 species that are endemic to the Alabama River system, approximately 18% of the native fauna. Despite the high level of endemism, many fishes are widespread within the system; for example, at least 96 species (52%) natively occurred in each of the Coosa, Tallapoosa, and Alabama sub-systems.

Alien species compose approximately 10% of the fish fauna in the Alabama River system, numbering about 19 species that may be established (Appendix A). Five species (threadfin shad, common carp, grass carp, fathead minnow, and redbreast sunfish) are widespread in the system. The redbreast sunfish occurs so commonly that the species' status as alien is questionable. Other alien species generally are restricted to narrower ranges within the basin (Appendix A), occurring as a result of local introductions that were either accidental (e.g., from bait buckets or aquaculture facilities) or to support sport fisheries (e.g., three salmonid species, restricted to cool headwaters). The red shiner is an exception, occurring widely in the upper Coosa system (Appendix A). The red shiner has been present in the upper Coosa since at least the early 1970s, and presently is one of the few cyprinids persisting in the bypassed Coosa River channel below Weiss Dam (Irwin et al. 2001). Through the 1990s, red shiners have spread up the Coosa system and threaten to reduce populations of the three native *Cyprinella* species (including the federally threatened blue shiner) through displacement and hybridization (N. M. Burkhead, unpublished data).

Extensive physical and hydrologic alteration has contributed to a relatively high level of imperilment of fishes of the Alabama River system. Ten fish species are federally listed under the Endangered Species Act, and 28 additional species are considered imperiled (i.e., 3 endangered, 9 threatened, and 16 vulnerable; Appendix A). Periodic assessments of conservation status show a steady increase in fishes considered endangered and vulnerable, with the pattern for the Alabama River system fauna largely paralleling that for the southeastern United States (Figure 2). Faunal imperilment in the Alabama River system reflects three of the major effects of multiple main-stem dams: (1) decline of diadromous and migratory species; (2) species loss in flow-modified riverine fragments downstream from dams; and (3) population isolation in tributary river systems, where populations are subject to habitat degradation (e.g., from urban development). We present evidence for each of these effects below.

Diadromous and migratory fauna.—Dams have substantially restricted the ranges of three of the four diadromous fishes native to the Alabama River system. The American eel persists in the Alabama and Cahaba rivers (Pierson et al. 1989; Mettee et al. 1996), and commonly occurs in the tailwater shoals of the downstream-most dams on the Coosa and Tallapoosa rivers (Mettee et al. 1996). Jordan (1877) reported the presence of eels in the upper Coosa system in north Georgia, prior to construction of the first hydropower dams on the Coosa and Tallapoosa (in 1914 and 1924, respectively). In systems with unobstructed passage, the American eel commonly migrates inland thousands of kilometers and inhabits a wide range of stream sizes and habitats (Helfman et al. 1997). Thus, although we lack additional predam survey data, we hypothesize that eels likely migrated throughout the Alabama River system prior to large dam construction.

The dams on the Alabama River main stem have restricted Gulf sturgeon to the portion of the river downstream from Claiborne Lock and Dam (USFWS and GSMFC 1995). Historically, the species migrated from the Gulf of Mexico upstream to the fall line in the Cahaba River (Pierson et al. 1989). Alabama shad similarly migrated from the Gulf to and above the fall line in the Coosa and Cahaba

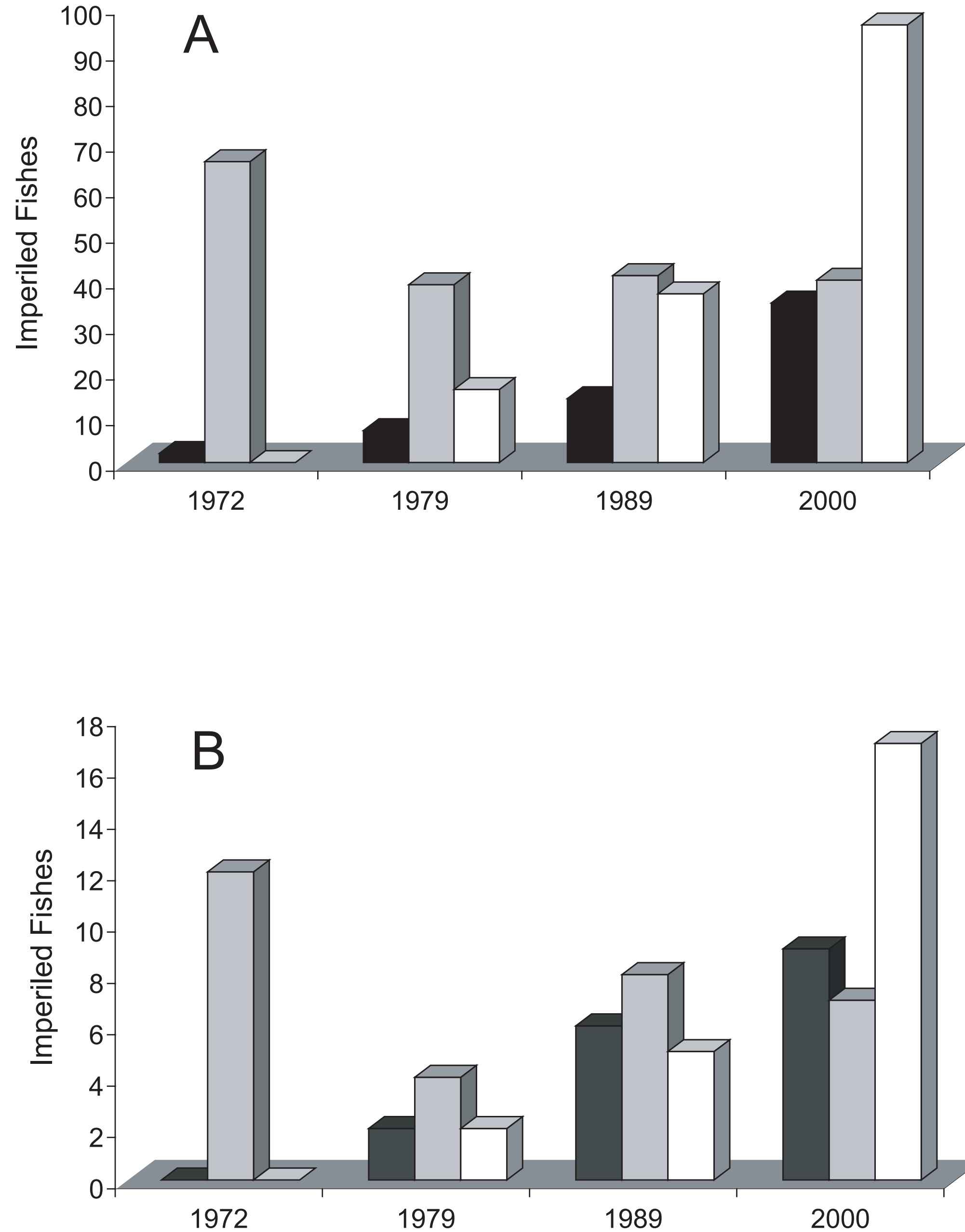

Figure 2.—Comparison of conservation statuses (black is endangered, gray is threatened, and white is vulnerable) based on classification by the American Fisheries Society for the A: southeastern United States and B: Alabama River system (derived from Miller 1972; Deacon et al. 1979; Williams et al. 1989; and Warren et al. 2000).

rivers, respectively, prior to lock and dam construction on the Alabama River (Mettee et al. 1996). This anadromous species is likely extirpated from the Cahaba River (Pierson et al. 1989), and Mettee and O'Neil (2003) report only five individuals collected from the Alabama River in the last 25 years, all downstream from Claiborne and Millers Ferry lock and dams. We hypothesize that the Gulf sturgeon and Alabama shad are extirpated from the lower, flow-regulated reaches of the Coosa and Tallapoosa rivers. Although we know of no records for Alabama shad in the upstream portions of the Coosa or Tallapoosa systems, Burkhead et al. (1997) hypothesized that the Alabama shad also is extirpated from the upper Coosa system in north Georgia. Their hypothesis is based on the observation that in Atlantic Slope drainages (e.g., the James River), the American shad migrated as far inland as the Blue Ridge province.

The Gulf striped bass, the fourth diadromous fish native to the Alabama River system, remains widespread although dams have altered migrations and population sustainability. Historically, striped bass migrated from the Gulf upstream at least to the fall line and supported popular sport fisheries in the tailwaters of the downstream-most dams on the Coosa and Tallapoosa rivers (Anonymous 1950; J. Hornsby, Alabama Department of Conservation and Natural Resources, personal communication). We lack predam records of striped bass in the more upstream portions of the Coosa and Tallapoosa systems, and thus we do not know how far upstream of the fall line native striped bass may have migrated. In any case, the main-stem dams on the Alabama River (completed between 1963 and 1972) largely blocked striped bass migration from the Gulf. The species presently occurs widely in the system; however, as a result of stocking into impoundments. Stocked populations have been of both Gulf and Atlantic origin. Lack of sufficient riverine conditions inhibits natural reproduction by populations in most of the Coosa impoundments, although stocked striped bass are known to spawn in the free-flowing portions of the Oostanaula river system upstream from Weiss Reservoir (W. Davin, Berry College, Rome Georgia, personal communication). Thus, the range of the striped bass may have increased in the Alabama River system compared to the historical range; however, most populations likely are not self-sustaining and may represent a mixture of subspecies.

River system fragmentation has also curtailed migration by resident large-river fishes, resulting in declines in at least three native species. The southeastern blue sucker is only common within the Alabama River system in the lower Alabama River, where Mettee et al. (1996) report spawning aggregations at the base of Millers Ferry Dam and postspawning movements downstream past Claiborne Dam. We hypothesize that this species historically occurred widely in larger rivers of the Alabama River system. A single record from the upper Coosa River (Scott 1950) documents occurrence above the fall line, and a number of records exist for the lower portions of the Cahaba and Tallapoosa rivers (Pierson et al. 1989; Mettee et al. 1996). Similarly, the Alabama sturgeon, which is endemic to the Mobile River drainage, historically occurred in the main channels of the Alabama, lower Cahaba, and lower Tallapoosa rivers (Burke and Ramsey 1995). An 1898 report by the U.S. Commission of Fish and Fisheries documents a large (19,000 kg, about 20,000 fish), if brief, commercial catch of Alabama sturgeon (Mayden and Kuhajda 1996). The species has continued to be encountered by fishermen in the lower portion of the Alabama River, but with decreasing frequency from the 1980s to present (Burke and Ramsey 1995; USFWS 2000). The Alabama sturgeon was federally listed as endangered in 2000, having essentially disappeared in most of its range (USFWS 2000). Overfishing and loss and fragmentation of riverine habitat as a result of dam construction are the primary suspected causes of the sturgeon's decline (Williams and Clemmer 1991; Burke and Ramsey 1995; Mayden and Kuhajda 1996; USFWS 2000). The Alabama sturgeon presently is known to persist in the Alabama River main stem downstream from Millers Ferry and Claiborne lock and dams, and in the Cahaba River (B. Kuhajda, University of Alabama, personal communication).

Finally, the lake sturgeon historically occurred in the upper Coosa River system (Scott 1950; Burke and Ramsey 1995), representing a disjunct population from those in the Mississippi, Great Lakes, and Hudson Bay drainages. Older residents of north Georgia report catching large sturgeon in the Etowah and Coosa rivers from the 1930s to 1970s, including an 86-lb individual taken with a pitchfork at the base of a low-head dam on the Etowah main stem in 1948. The last known record dates to 1980, when an individual was taken from a periodically flooded pond adjacent to the Oostanaula River. The lake sturgeon is now presumed extirpated from the Alabama River system by the Georgia Department of Natural Resources (GDNR), which has initiated a reintroduction program using individuals of Wisconsin origin.

Fish Assemblages in Flow-Modified River Segments.—The segments of the Alabama River system regulated by upstream hydropower dams all have experienced species losses and assemblage simplification. Most of the flow-regulated sections lack records for 30% or more of the minnow and/or darter species presumed native to these reaches (Figure 3). Sunfish and bass species generally show less evidence of faunal loss in flow-regulated segments (Figure 3). An exception is the short reach of the Coosa River that remains unimpounded downstream from Jordan Dam, where all three groups exhibit low percentages of native species (Figure 3). The percent of native minnow and darter species persisting in the regulated portions of the Tallapoosa appear higher than in the Coosa system; however, this variation is not obviously related to length of the segment, length of time regulated, or flow regime characteristics. The two regulated Tallapoosa segments include the most recent and among the earliest segments to be regulated, and the lowest and highest base flow provisions (Table 1).

Applying the jackknife estimator of species richness to presence-absence data from replicated PAE samples for four reaches (Coosa below Jordan Dam, Coosa below Weiss Dam, Tallapoosa below Harris Dam and Tallapoosa below Thurlow Dam) did not suggest that low species richness observations in these reaches resulted from low species detectability. Ratio of observed to estimated species richness exceeded 83% for all species groups at all sites except for centrarchid richness in the Tallapoosa downstream from Harris Dam (4 years of repeated samples; observed: estimated richness = 57%). Additionally, in all cases except the Coosa below Jordan, other sampling efforts (Table 2) obtained records for as many or more additional species as were indicated as unobserved in PAE sampling. For the Coosa below Jordan (where our richness estimates are entirely based on PAE sampling), the jackknife estimates suggest presence of only two additional minnow species (9% of native richness) and one additional centrarchid (8% of native richness). It is impossible to estimate the presence of species that are not vulnerable to any sampling. However, the fact that most of the native sunfish and bass, minnow, and darter fauna have been recorded in at least three of the unregulated portions of these systems (Figure 3), coupled with failure of replicated samples to suggest low species detectability in total sampling efforts, supported the hypothesis that fish assemblages in flow-regulated reaches have experienced species losses, particularly of river-dependent species.

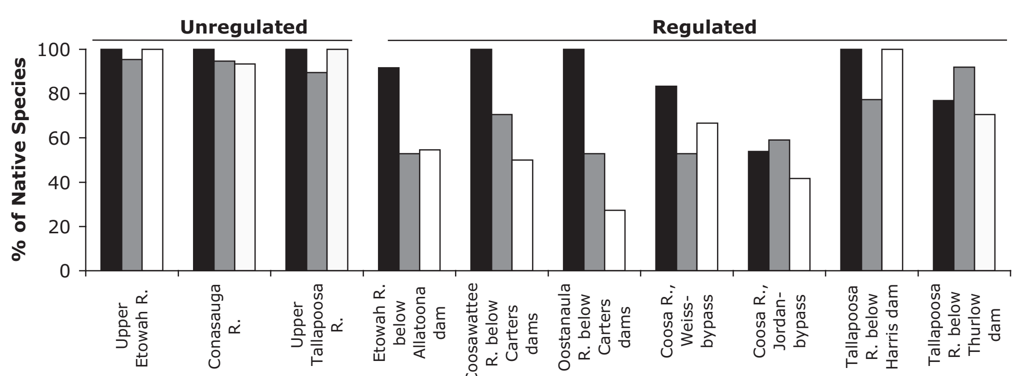

Figure 3.—Estimated percentages of native species persisting in three unregulated and seven flow-regulated segments of the Alabama River system, for three families: Centrarchidae (black bars), Cyprinidae (gray bars), and Percidae (white bars). Identities of species with known occurrences in the flow-regulated reaches are indicated in Appendix A.

Analysis of Suttkus and Gunning's long-term fish survey data suggested that the main stem of the Alabama River has also experienced dramatic changes in fish assemblage richness and composition. Species richness in collections, pooled for all sites, declined significantly over the survey period, from a high of 96 species in 1964 to a low of 34 species in 2000 (Figure 4). This decline preceded, and continued after, the change in 1983 from nighttime to daytime sampling. Groups accounting for most of the decline were percids (mostly darters), catfishes, minnows such as the "Pine Hills chub" *Macrhybopsis* sp. *cf. aestivalis,* and fluvial shiner and a group of diadromous and euryhaline species, including the Alabama shad, bay anchovy, American eel, striped mullet, southern flounder, and the hogchoker (Figure 5). Among darters, the crystal darter exhibited the strongest decline. Other darters showing marked declines were the naked sand darter, the river darter, and the saddleback darter.

Catfishes showed an abrupt change in abundance and occurrence from high during the first half of the survey (1964–1984) to low during the second half of the survey (1985–2000). Coincident with this change was the change in sampling time from evening to daylight hours. Since most catfishes are nocturnal, the most parsimonious explanation for the decline is that they were underrepresented in daylight samples due to inactivity. However, among the catfishes were five species of madtoms (the black madtom, tadpole madtom, speckled madtom, frecklebelly madtom, and freckled madtom), which were collected in the first few years of the survey (12 years prior to the start of daytime

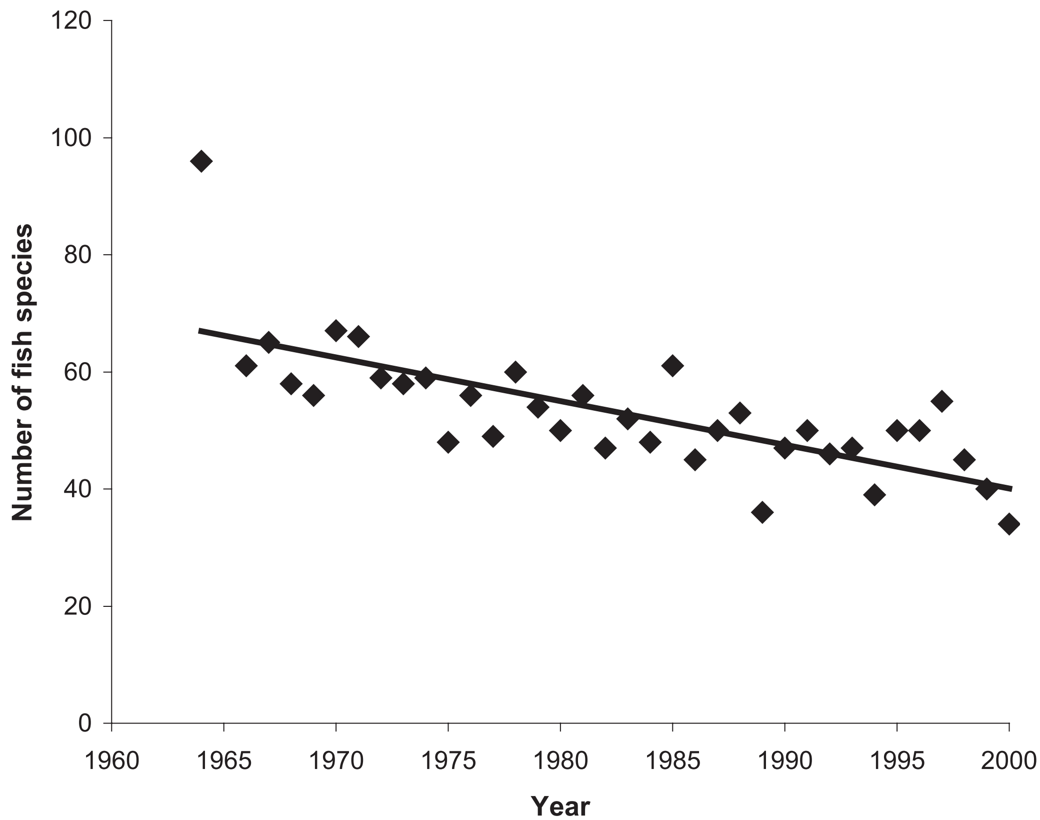

Figure 4.—Decline in total number of species collected across years in the long-term fish monitoring survey of the Alabama River main stem by R. D. Suttkus and G. E. Gunning. The coefficient of determination (r^2) for the plotted trend is 0.64.

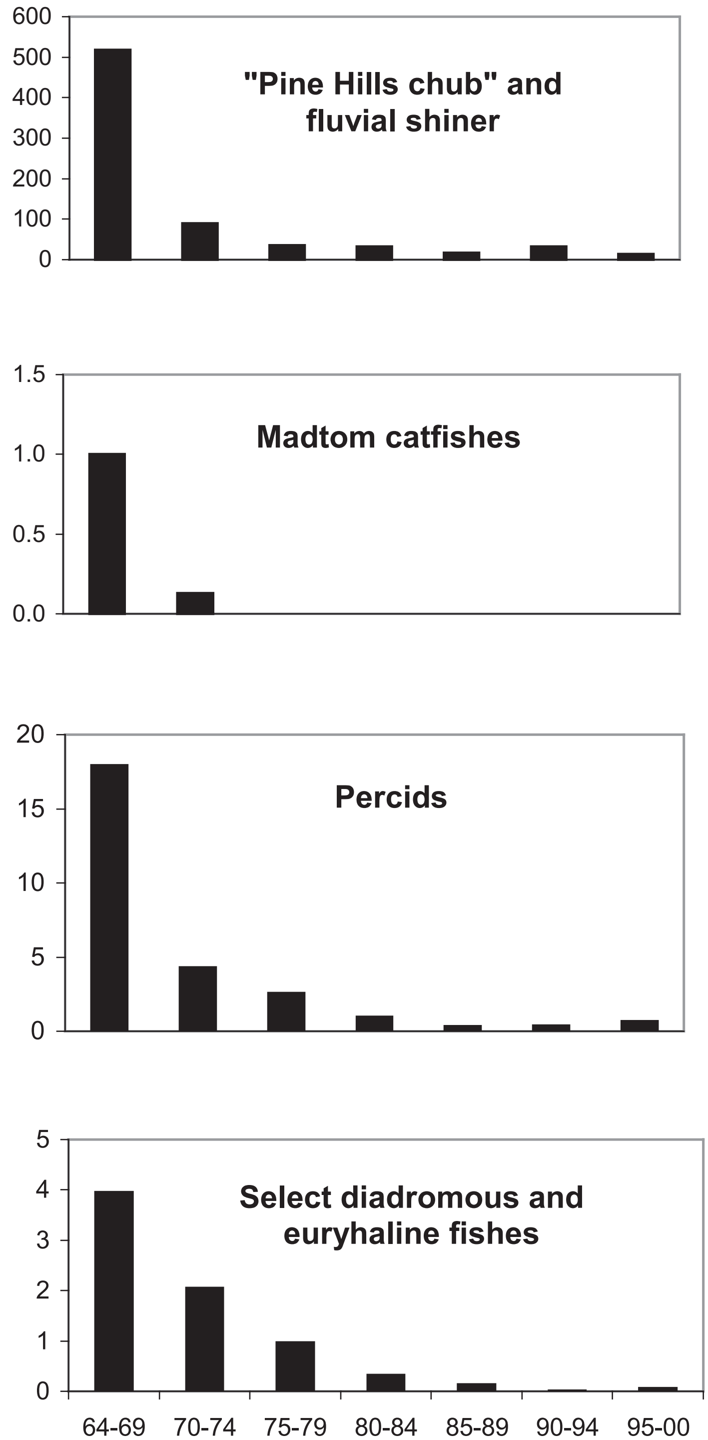

Figure 5.—Trends in sampling-time-adjusted abundance across 6-year time blocks for "Pine Hills chub" and fluvial shiner, madtom catfishes, percids, and select diadromous and euryhaline fishes collected in the long-term fish monitoring survey of the Alabama River main stem by R. D. Suttkus and G. E. Gunning.

collecting), but not after this time (Figure 5). Declines in species such as the speckled chub, fluvial shiner, frecklebelly madtom, crystal darter, and saddleback darter are attributed to the reduction in gravel bars and change from lotic to more lentic conditions in impounded portions of the survey area.

Fauna of major tributaries.—The free-flowing and unregulated portions of the ACT harbor the remaining populations of 8 of the 10 federally listed species in the system (i.e., excepting only the two listed sturgeon species) along with a large portion of the native fish fauna. For example, the Conasauga River system retains at least 71 of 77 native fishes (Walters 1997), and the upper Etowah River system holds at least 68 of 74 native fishes. Together, these two Coosa River headwater systems contain four darter species and one minnow species that are federally listed, with the remaining small-bodied protected fishes occurring in the Coosawattee system, the Cahaba system, and in the case of the pygmy sculpin, a single spring in the Coosa system (Williams 1968; Appendix A).

At least five of the federally listed darters and minnows have had their ranges restricted and fragmented as a result of main-stem impoundments. The amber darter persists in disjunct populations in the upper Conasauga and Etowah rivers, separated by Allatoona Reservoir and the flow-regulated segments of the Etowah and Oostanaula rivers (Figure 6). The goldline darter persists in populations in the upper Coosawattee and Cahaba rivers, separated by eight main-stem dams (Figure 6). The blue shiner similarly persists in fragmented populations separated by main-stem impoundments and sections of flow-regulated rivers in the upper Coosa (USFWS 1992; Figure 6). Allatoona Reservoir on the Etowah River has inundated and fragmented tributary habitats occupied by the Cherokee darter (Bauer et al. 1995) and truncated the downstream range of the Etowah darter. All of these species are hypothesized or known to have occurred more widely in main-stem shoals (or downstream portions of tributaries) before these were impounded or subjected to the effects of flow-regulation.

Discussion

The Alabama River system contains one of the most diverse temperate fish assemblages known, the full extent of which remains under discovery. Intensive faunal study continues to uncover cryptic species that have diverged from and are similar to known species and that often are narrowly distributed (Burkhead and Jelks 2000). Although the lake sturgeon has disappeared from the system, there are no recorded extinctions of Alabama River system fishes. This contrasts with the state of the system's large-river molluscan fauna; at least 32 species and 4 genera of freshwater snails are extinct as a result of the damming of the Coosa River shoals (Bogan et al. 1995; Neves et al. 1997). Of course, it is possible that fish species not discovered by science have gone extinct with the damming and fragmentation of the system. Further, if the lake sturgeon of the upper Coosa represents a unique, endemic taxon, following the pattern of other Mobile River system endemics (e.g., Alabama sturgeon) that have diverged from sister taxa in the Mississippi system, then the loss of the lake sturgeon from the Alabama River system is an extinction. Preventing future extinctions will require managing the system differently than has occurred over the last century, with direct intent to protect and restore the ecological integrity of the river system.

Conserving the fish fauna of the Alabama River system will require addressing the detrimental effects of 16 main-stem dams on native aquatic biota, preventing the spread of alien species to the greatest extent practicable, and managing future land use changes to minimize stream and river degradation. The large river main stems have been transformed from a heterogeneous continuum of flowing water habitats, to a series of slowly flowing, deep-water impoundments interspersed with fragments of unimpounded river having altered flow regimes. The major free-flowing tributary systems retain much of the system's fish fauna, but are isolated from each other and subject to effects of human population growth and increasing societal demands for water supply. In this context, the actions most essential to long-term species conservation are restoring large river habitat for fishes, including migratory species, and protecting hydrologic regimes and water quality in the free-flowing tributary systems.

Substantial potential for restoring populations of migratory, large-river fishes such as Alabama stur-

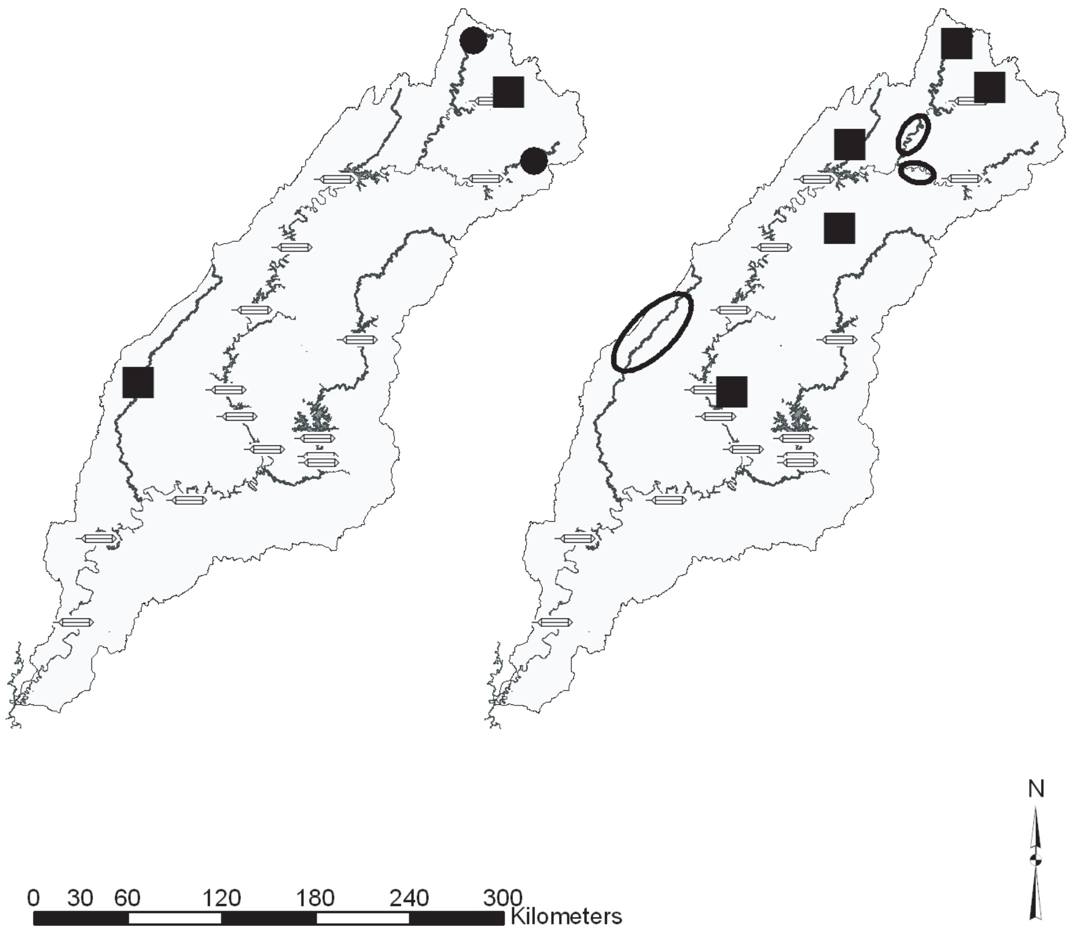

Figure 6.—Locations of extant populations of three federally protected fishes in the Alabama River system: amber darter (solid circles, left map), the goldline darter (solid squares, left map), and the blue shiner (solid squares, right map). Ovals on right map indicate reaches historically containing blue shiners. Open bars represent main-stem dams.

geon, Gulf sturgeon, Alabama shad, and southeastern blue sucker entails modifying the two downstream-most dams on the Alabama River. Enhancing fish passage at Claiborne and Millers Ferry lock and dams could restore connectivity between the lower Alabama River and the Cahaba River, encompassing over 400 km of riverine habitat from the Gulf to the fall line. Some passage occurs under present conditions; for example, southeastern blue suckers are able to swim upstream past Claiborne Dam when the dam is periodically inundated during high flows (M. F. Mettee, Alabama Geological Survey, unpublished data and personal communication). However, this represents a narrow opportunity for passage, and the success or frequency of migration by other fishes (e.g. through the locks), is unknown. Regulatory agencies and conservation groups are interested in improving fish migration success. The USACE has partnered with the World Wildlife Fund, the U.S. Fish and Wildlife Service (USFWS), and Alabama Department of Conservation and Natural Resources (ADCNR), under Section 1135 of the Water Resources Development Act, to explore options for facilitating fish passage at Claiborne Lock and Dam. Feasibility level designs have identified options, including construction of a fish lift or a vertical slot fishway to facilitate passage; funding for implementation has not been identified (M. J. Eubanks, USACE, Mobile District, personal communication). Modifying lock operations to facilitate fish passage at Millers Ferry is also being explored by the USACE and USFWS (Carl Couret, USFWS, Daphne, Alabama, and M. J. Eubanks, personal communications). Because little is known concerning the movements of most migratory fishes in the lower Alabama River system, efforts to enhance passage at dams should be accompanied by research to estimate migratory patterns and population responses of target fishes. Restoring continuous, free-flowing riverine habitat by removing the two downstream-most dams in the system may ultimately be necessary for population recovery of fishes that evolved in and require flowing-water habitat, including the diverse small-bodied fish assemblages native to the Alabama River main stem.

Present conservation efforts for two of the system's large-river fishes, Alabama sturgeon and lake sturgeon, are focused on captive propagation and fish reintroduction. Efforts by ADCNR and USFWS to propagate the Alabama sturgeon have been limited by the species' rarity; only five fish had been captured between 1997 and 2000 to use as broodstock, three of which have died in captivity (USFWS 2000). Recovery of this species obviously remains highly tentative unless the factors limiting natural reproduction and survival of Alabama sturgeon can be identified and addressed, most likely through restoration of large river habitat. The GDNR has initiated a reintroduction of lake sturgeon in the Coosa River system in Georgia, beginning with the release (in 2002) of 1,100 fingerlings produced from Wisconsin stock. The success of this program will not be known for years, but clearly depends on the availability of suitable habitat for sturgeon spawning, feeding, and overwintering, and of adequate water quality. The upper Coosa River system (upstream from Weiss Reservoir) could provide 190 km of interconnected, unimpounded riverine habitat to sturgeon and other riverine fishes, but only if the flow-regulated sections below Allatoona Dam and Carters Dam can be managed to support riverine biota.

Restoring faunal integrity in the flow-regulated river segments of the Alabama River system depends in part on changing hydropower dam operations to ameliorate detrimental effects on biota. These sections retain natural instream habitat structure (e.g., alternating shoals and pools), but are subjected to the unnatural flow regimes imposed by the upstream dams. The Federal Energy Regulatory Commission licenses operation of the nonfederal dams and requires periodic license renewal (typically at 30–50 year intervals). Although an infrequent occurrence, relicensing provides opportunities to make scientifically based changes in dam operations to enhance conditions for downstream aquatic biota. Most commonly, operational changes involve providing higher base flows to sustain aquatic habitats during periods of nongeneration, which can benefit riverine fauna. For example, increasing base flows at Jordan Dam on the Coosa River has resulted in higher fish species richness (Peyton and Irwin 1997) and higher abundances of the endangered snail *Tulatoma magnifica* (Christman et al. 1995). Similarly, increasing the base flow at Thurlow Dam on the Tallapoosa River to about 25% of mean annual flow has been followed by increases in riverine-dependent fishes downstream from the dam (Travnichek et al. 1995).

Low flows are not the only aspects of flow regimes below dams that limit biota downstream (Poff et al. 1997; Richter et al. 1997). Hydropeaking fluctuations (Cushman 1985; Bain et al. 1988; Freeman et al. 2001) and alteration of flood levels and seasonality, and of thermal and sediment regimes, also degrade habitat quality for native river biota (Sparks 1995; Collier et al. 1996; Stanford et al. 1996). Restoration of multiple aspects of natural flow regimes will be necessary to restore ecological integrity in flow-regulated rivers, but the interesting questions remain of how much and what types of restoration are necessary to conserve native biota. Clearly, full restoration of natural flow regimes in regulated rivers is not compatible with other management objectives such as hydropeaking and flood control. An adaptive management approach (Walters 1986) to modifying dam operations will thus be essential for evaluating the relative benefits to river biota of differing hydrologic changes (e.g., increasing base flows, dampening hydropeaking fluctuations, restoring seasonal flow differences; Irwin and Freeman 2002). The USACE dams, including Allatoona and Carters dams, are not subject to licensing but would also benefit from an adaptive approach to improving flow regimes. Alleviating flow-related limitations in the flow-regulated portions of the Etowah and Coosawattee rivers could substantially expand the habitat available to the imperiled riverine fauna (such as the blue shiner and amber darter), as well as the reintroduced lake sturgeon and striped bass.

Conserving the fishes of the Alabama River system will strongly depend on protecting populations in the remaining free-flowing and unregulated portions of the system that retain high proportions of the native fauna. The system has been, and continues to be, degraded by land-use activities that alter runoff and inputs of sediment, nutrients, and contaminants to the rivers. Water quality degradation in the Cahaba River as a result of wastewater discharge from multiple municipal treatment plants, and from surface mining, has been implicated in the extirpation of the blue shiner and in substantial range reductions of the goldline darter and Cahaba shiner (Mayden and Kuhajda 1989; USFWS 1990, 1992). Urban development in the Birmingham, Alabama area also has been linked to loss of fish species (Shepard et al. 1994) and reduced abundances of sensitive minnows and darters in the Cahaba River system (Onorato et al. 1998, 2000). In the Etowah River system, which is affected by development emanating from the Atlanta, Georgia area, the rapid conversion of farmland to urban and suburban developments are major threats to the amber darter, Cherokee darter, and Etowah darter (USFWS 1994; Burkhead et al. 1997) and is leading to loss of endemic fishes, minnows, darters, and sculpins in areas with urban land cover as low as 10% (Walters 2002).

Increasing demand for water supply is a direct consequence of human population growth and places additional strain on aquatic systems. Although not as disruptive of flow regimes as dams built for hydropower production, water supply reservoirs degrade and fragment habitat for stream-dependent fishes. New reservoirs are being planned for those portions of the system that yet maintain high water quality, also ensuring overlap with refugia for species eliminated from degraded streams. Quantifying how much water can be removed from a system for water supply, and how much fragmentation a stream system can sustain, without leading to losses of stream species, is critical to water resource development that conserves native aquatic biota.

The challenges of conserving the fish fauna of the Alabama River system are large, involving both societal and scientific questions, and reflect similar aquatic conservation and river management problems throughout the southeastern United States. The increase in proportion of the Alabama River system's fish fauna recognized as imperiled over the last 25 years mirrors fish imperilment for the region (Figure 2). Although the fauna has largely survived over a century of changes to the rivers and the watershed, a substantial portion of Alabama River system fishes (i.e., at least some 38 species) is now imperiled with extinction. Further, river and landscape alteration in the system, as regionally, have reached unprecedented levels of spatial extent and intensity. Whereas, in the past, many species likely had refugia in undeveloped or less disturbed portions of systems, the combination of damming and urban growth now leaves few subsystems unaffected. Unless future river and land use management strategies in the Alabama River system specifically address conservation and restoration of flowing water systems and their biota, fish species extinctions appear inevitable.

Acknowledgments

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Appendix A.—Conservation and indigenous status of the 203 fishes (freshwater, diadromous, and common marine invaders) currently known from the Alabama River system. The statuses of federally listed fishes are in boldface; other conservation designations are based on Warren et al. (2000): CS = currently stable, V = vulnerable, T = threatened, E = endangered. Occurrence symbols: native = N; native and presumably extirpated = Ext; endemic to the Alabama River system = N^E (or Ext^E); probably native = PN; marine invader = M; introduced = I; probably introduced = PI. River system abbreviations are Cona = Conasauga; Cosaw = Coosawattee; Etow = Etowah; Oost = Oostanaula; Coosa = Coosa; Talla = Tallapoosa; Cah = Cahaba; Ala = Alabama. Species occurring in flow-regulated, main-stem reaches are indicated by bold type (Figure 1, reaches 1, 2, 3, 4, 6) and/or are underlined (reaches 5 and 7). See text for data sources.

Binomen	Common name	Status	Cona	Cosaw	Etow	Oost	Coosa	Talla	Caha	Ala
Petromyzontidae	**Lampreys (3)**									
Ichthyomyzon castaneus	chestnut lamprey	CS	N	**N**	**N**	**N**	N	N	N	N
I. gagei	southern brook lamprey	CS	N	**N**	N	N	N	**N**	N	N
Lampetra aepyptera	least brook lamprey	CS	N	N	N	N	N	N	N	N
Acipenseridae	**Sturgeons (3)**									
Acipenser fulvescens	lake sturgeon	T			Ext	Ext	Ext			
A. oxyrinchus desotoi	Gulf sturgeon	**T**					Ext[a]	Ext[a]	Ext	N
Scaphirhynchus suttkusi	Alabama sturgeon	**E**					Ext[a]	Ext	N	N
Polyodontidae	**Paddlefishes (1)**									
Polyodon spathula	paddlefish	V					N	N	N	N
Lepisosteidae	**Gars (3)**									
Lepisosteus oculatus	spotted gar	CS					**N**	N	N	N
L. osseus	longnose gar	CS	N	**N**	**N**	**N**	**N**	N	N	N
Atractosteus spatula	alligator gar	V								N
Amiidae	**Bowfins (1)**									
Amia calva	bowfin	CS					N	N	N	N
Anguillidae	**Freshwater eels (1)**									
Anguilla rostrata	American eel	CS	Ext[a]	Ext[a]	Ext	Ext[a]	N	N	N	N
Engraulidae	**Anchovies (1)**									
Anchoa mitchilli	bay anchovy									M
Clupeidae	**Shads (4)**									
Alosa alabamae	Alabama shad	V					Ext	Ext[a]	Ext	N
A. chrysochloris	skipjack herring	CS			N	N	N	N	N	N
Dorosoma cepedianum	gizzard shad	CS	N	**N**	**N**	**N**	**N**	N	N	N
D. petenense	threadfin shad	CS		I	I	**I**	**I**	I	I	I
Hiodontidae	**Mooneyes (1)**									
Hiodon tergisus	mooneye	CS	N	**N**	**N**	N	N	N	N	N
Cyprinidae	**Minnows (59)**									
Campostoma oligolepis	largescale stoneroller	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
C. pauciradii	bluefin stoneroller	CS			N			N		

Appendix A.—Continued.

Binomen	Common name	Status	Cona	Cosaw	Etow	Oost	Coosa	Talla	Caha	Ala
Carassius auratus	goldfish	CS	I	**I**			**I**	I		
Ctenopharyngodon idella	grass carp	CS	I		**I**	**I**	I	I	I	
Cyprinella caerulea	blue shiner	**T**	N[E]	Ext[E]	Ext[E]	Ext[E]	N[E]		Ext[E]	
C. callistia	Alabama shiner	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
C. gibbsi	Tallapoosa shiner	CS						**N**[E]		
C. lutrensis	red shiner	CS	I	**I**	**I**	**I**	**I**			
C. trichroistia	tricolor shiner	CS	N	**N**	N	N	**N**		N	N
C. venusta	blacktail shiner	CS	N	**N**	**N**	**N**	N	**N**	N	N
Cyprinus carpio	common carp	CS	I	**I**	**I**	**I**	**I**	**I**	I	I
Hemitremia flammea	flame chub	V					N			
Hybognathus hayi	cypress minnow	CS						N	N	N
H. nuchalis	Mississippi silvery minnow	CS						N	N	N
Hybopsis lineapunctata	lined chub	V	N[E]	N[E]	Ext[E]	Ext[E]	N[E]	**N**[E]		
H. winchelli	clear chub	CS					N	N	N	N
Hybopsis sp. cf. *winchelli*	"Etowah chub"	CS			N[E]					
Luxilus chrysocephalus	striped shiner	CS	N	**N**	N	**N**	N	**N**	N	N
L. zonistius	bandfin shiner	CS		N	N			**N**		
Lythrurus atrapiculus	blacktip shiner	CS						N		
L. bellus	pretty shiner	CS					N	N	N	N
L. lirus	mountain shiner	CS	N	N	**N**	N	**N**		N	
L. roseipinnis	cherryfin shiner	CS								N
Macrhybopsis sp. *cf. aestivalis*	"Fall line chub"	V	N[E]	**N**[E]	N[E]	Ext[E, a]	N[E]	**N**[E]	N[E]	
Macrhybopsis sp. *cf. aestivalis*	"Pine Hills chub"	CS						N	N	N
Macrhybopsis storeriana	silver chub	CS		**N**	**N**	**N**	N	N	N	N
Nocomis leptocephalus	bluehead chub	CS		N	N	Ext	N	**N**	N	N
N. micropogon	river chub	CS		N	N	Ext				
Notemigonus crysoleucas	golden shiner	CS	N	**N**	N	N	**N**	**N**	N	N
Notropis ammophilus	orangefin shiner	CS					N	N	N	N
N. asperifrons	burrhead shiner	CS	N	N	N	N	N	N	N	N
N. atherinoides	emerald shiner	CS			Ext	**N**	N	**N**	N	N
N. baileyi	rough shiner	CS					N	**N**	N	N
N. buccatus	silverjaw minnow	CS			PN		N	N	N	N
N. cahabae	Cahaba shiner	**E**							N	
N. candidus	silverside shiner	CS					N	N	N	N
N. chalybaeus	ironcolor shiner	V								N

Appendix A.—Continued.

Binomen	Common name	Status	Cona	Cosaw	Etow	Oost	Coosa	Talla	Caha	Ala
N. chrosomus	rainbow shiner	C	N	N	N	N	N		N	N
N. edwardraneyi	fluvial shiner	CS					N	N	N	N
N. longirostris	longnose shiner	CS			N					N
N. lutipinnis	yellowfin shiner	CS			PN		PN			
N. maculatus	taillight shiner	CS								N
N. petersoni	coastal shiner	CS								N
N. stilbius	silverstripe shiner	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
N. texanus	weed shiner	CS					N	**N**	N	N
N. uranoscopus	skygazer shiner	CS					N[E]	N[E]	N[E]	N[E]
N. volucellus	mimic shiner	CS	Ext				N	N	N	
N. xaenocephalus	Coosa shiner	CS					N	N	N	N
Opsopoeodus emiliae	pugnose minnow	CS	N[E]	**N[E]**	**N[E]**	N[E]	N[E]	N[E]		
Phenacobius catostomus	riffle minnow	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
Pimephales notatus	bluntnose minnow	CS					N	N	N	N
P. promelas	fathead minnow	CS	I	**I**	I	I	I	I	I	I
P. vigilax	bullhead minnow	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
Pteronotropis hypselopterus	sailfin shiner	CS								N
P. signipinnis	flagfin shiner	CS								N
P. welaka	bluenose shiner	V							N	N
Rhinichthys atratulus	eastern blacknose dace	CS	N	N	N	N	N			
Semotilus atromaculatus	creek chub	CS	N	N	N	N	N	N	N	N
S. thoreauianus	Dixie chub	CS					N	N	N	N
Catostomidae	**Suckers (16)**									
Carpiodes cyprinis	quillback	CS			**N**	Ext[a]	N	N	N	N
C. velifer	highfin carpsucker	CS				Ext[a]	N	N	N	N
Catostomus commersonii	white sucker	CS	PI							
Cycleptus meridionalis	southeastern blue sucker	V			Ext[a]	Ext[a]	N	N	N	N
Erimyzon oblongus	creek chubsucker	CS					N	N	N	N
E. sucetta	lake chubsucker	CS					N	N	N	N
E. tenuis	sharpfin chubsucker	CS					N	N	N	N
Hypentelium etowanum	Alabama hog sucker	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
H. nigricans	northern hog sucker	CS	PI							
Ictiobus bubalus	smallmouth buffalo	CS	N	**N**	**N**	**N**	**N**	N	N	N
I. cyprinellus	bigmouth buffalo	CS							I	
Minytrema melanops	spotted sucker	CS	N	**N**	N	**N**	**N**	N	N	N
Moxostoma carinatum	river redhorse	CS	N	**N**	Ext[a]	**N**	**N**	**N**	N	N

Appendix A.—Continued.

Binomen	Common name	Status	Cona	Cosaw	Etow	Oost	Coosa	Talla	Caha	Ala
M. duquesnei	black redhorse	CS	N	**N**	**N**	**N**	**<u>N</u>**	**N**	N	N
M. erythrurum	golden redhorse	CS	N	**N**	**N**	**N**	**N**	<u>N</u>	N	N
M. poecilurum	blacktail redhorse	CS	N	**N**	**N**	**N**	**<u>N</u>**	**<u>N</u>**	N	N
Ictaluridae	**Bullhead catfishes** (14)									
Ameiurus brunneus	snail bullhead	V			PN					
A. catus	white catfish	CS					I	I		
A. melas	black bullhead	CS	N	**N**	N	N	N	N	N	N
A. natalis	yellow bullhead	CS	N	N	N	N	N	<u>N</u>	N	N
A. nebulosus	brown bullhead	CS	N	N	N	N	**N**	N	N	N
Ictalurus furcatus	blue catfish	CS	N	N	**N**	**N**	**N**	<u>N</u>	N	N
I. punctatus	channel catfish	CS	N	**N**	**N**	**N**	**<u>N</u>**	**<u>N</u>**	N	N
Noturus funebris	black madtom	CS					N	N	N	N
N. gyrinus	tadpole madtom	CS					N	N	N	N
N. leptacanthus	speckled madtom	CS	N	**N**	N	N	N	**<u>N</u>**	N	N
N. munitus	frecklebelly madtom	T							N	N
Noturus sp. *cf. munitus*	"Coosa madtom"	T	N[E]		N[E]					
N. nocturnus	freckled madtom	CS			Ext	Ext[a]	Ext[a]	N	N	N
Pylodictis olivaris	flathead catfish	CS	N	**N**	**N**	N	**<u>N</u>**	**<u>N</u>**	N	N
Esocidae	**Pikes** (3)									
Esox americanus	redfin pickerel	CS					N	N	N	N
E. masquinongy	muskellunge	CS						I		
E. niger	chain pickerel	CS	N	Ext[a]	Ext	Ext[a]	N	<u>N</u>	N	N
Salmonidae	**Trouts and allies** (3)									
Oncorhynchus mykiss	rainbow trout	CS	I	I	I	I	I	I	I	
Salmo trutta	brown trout	CS	I	I	I	I	I			
Salvelinus fontinalis	brook trout	CS	I	I			I			
Aphredoderidae	**Pirate perch** (1)									
Aphredoderus sayanus	pirate perch	CS					N	N	N	N
Amblyopsidae	**Cavefishes** (1)									
Typhlichthys subterraneus	southern cavefish	V					N			
Belonidae	**Needlefish** (1)									
Strongylura marina	Atlantic needlefish	CS					M	M	M	M
Fundulidae	**Topminnows** (6)									
Fundulus bifax	stippled studfish	V					N[E]	N[E]		
F. dispar	starhead topminnow	CS							N	N
F. notatus	blackstripe topminnow	CS								N

Appendix A.—Continued.

Binomen	Common name	Status	Cona	Cosaw	Etow	Oost	Coosa	Talla	Caha	Ala
F. nottii	bayou topminnow	CS								N
F. olivaceus	blackspotted topminnow	CS	N	**N**	N	N	**N**	**N**	N	N
F. stellifer	southern studfish	CS	N	**N**	**N**	**N**	**N**		Ext	N
Poeciliidae	**Livebearers (3)**									
Gambusia affinis	western mosquitofish	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
G. holbrooki	eastern mosquitofish	CS	I		PI					
Heterandria formosa	least killifish	CS								N
Atherinopsidae	**Silversides (2)**									
Labidesthes sicculus	brook silverside	CS						N	N	N
Menidia beryllina	inland silverside	CS								N
Cottidae	**Sculpins (5)**									
Cottus sp. *cf. bairdii*	"smokey sculpin"	CS	N	N	**N**	**N**	N			
Cottus sp.	Tallapoosa sculpin	CS						**N**[E]		
Cottus carolinae infernatus	Alabama banded sculpin	*CS*				**N**	**N**	N	N	N
C. carolinae zopherus	Coosa banded sculpin	CS	N[E]	**N**[E]	**N**[E]					
C. paulus	pygmy sculpin	**T**					N[E]			
Moronidae	**Temperate basses (3)**									
Morone chrysops	white bass	CS	I		I		**I**	I	I	I
M. mississippiensis	yellow bass	*CS*		I			**I**		I	
M. saxatilis	striped bass	CS	N	**N**	**N**	**N**	**N**	N	N	N
Elassomatidae	**Pygmy sunfishes (2)**									
Elassoma evergladei	Everglades pygmy sunfish	CS								N
E. zonatum	banded pygmy sunfish	CS					N	N	N	N
Centrarchidae	**Sunfishes (16)**									
Ambloplites ariommus	shadow bass	CS	N	**N**	N	**N**	N	**N**	N	N
Centrarchus macropterus	flier	CS					N	N	N	N
Lepomis auritus	redbreast sunfish	CS	PI	**PI**	**PI**	**PI**	**PI**	**PI**		
L. cyanellus	green sunfish	CS	N	**N**	**N**	N	**N**	**N**	N	N
L. gulosus	warmouth	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
L. humilis	orangespotted sunfish	*CS*					I	I		I
L. macrochirus	bluegill	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
L. marginatus	dollar sunfish	CS							N	N
L. megalotis	longear sunfish	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
L. microlophus	redear sunfish	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
L. miniatus	redspotted sunfish	CS	N	**N**	**N**	**N**	N	**N**	N	N

Appendix A.—Continued.

Binomen	Common name	Status	Cona	Cosaw	Etow	Oost	Coosa	Talla	Caha	Ala
Micropterus coosae	redeye bass	CS	N	**N**	**N**	**N**	**N**	**N**	N	
M. punctulatus	spotted bass	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
M. salmoides	largemouth bass	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
Pomoxis annularis	white crappie	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
P. nigromaculatus	black crappie	CS	N	**N**	**N**	**N**	**N**	**N**	N	N
Percidae	**Perches (46)**									
Ammocrypta beanii	naked sand darter	CS						N	N	N
A. meridiana	southern sand darter	CS						N	N	N
Crystallaria asprella	crystal darter	V					N	N	N	N
Etheostoma artesiae	redspot darter	CS					N	N	N	N
E. brevirostrum	holiday darter	T					N[E]			
E. sp. *cf. brevirostrum*	"Conasauga snubnose darter"	T	N[E]							
E. sp. *cf. brevirostrum*	"Coosawattee snubnose darter"	E		N[E]						
E. sp. *cf. brevirostrum*	"Amicalola snubnose darter"	T			N[E]					
E. sp. *cf. brevirostrum*	"Etowah snubnose darter"	E			N[E]					
E. chlorosoma	bluntnose darter	CS						N	N	N
E. chuckwachatte	lipstick darter	V						**N[E]**		
E. coosae	Coosa darter	CS	N[E]	N[E]	**N[E]**	N[E]	N[E]			
E. davisoni	Choctawhatchee darter	CS						N		
E. ditrema	coldwater darter (Nominal)	T	N[E]	Ext[E, a]	Ext[E]	Ext[E]	N[E]			
E. sp. *cf. ditrema*	Middle Coosa + Coldwater Spr.	T					N[E]			
E. etowahae	Etowah darter	**E**			N[E]					
E. fusiforme	swamp darter	CS								N
E. histrio	harlequin darter	CS						N	N	N
E. jordani	greenbreast darter	CS	N[E]	**N[E]**	**N[E]**	**N[E]**	**N[E]**	N[E]	N[E]	N[E]
E. nigrum	johnny darter	CS						N	N	N
E. parvipinne	goldstripe darter	CS					N	N	N	N
E. proeliare	cypress darter	CS								N
E. ramseyi	Alabama darter	CS					N[E]		N[E]	N[E]
E. rupestre	rock darter	CS	N	N	N	N	N	N	N	N
E. scotti	Cherokee darter	**T**			N[E]					
E. stigmaeum	speckled darter	CS	N	N	**N**	N	**N**	**N**	N	N
E. swaini	Gulf darter	CS					N	N	N	N

Appendix A.—Continued.

Binomen	Common name	Status	Cona	Cosaw	Etow	Oost	Coosa	Talla	Caha	Ala
E. tallapoosae	Tallapoosa darter	CS						**N^E**		
E. trisella	trispot darter	E	N^E	**N^E**	Ext^E	N^E	Ext^E			
E. zonifer	backwater darter	CS						N	N	N
Percina antesella	amber darter	**E**	N^E	Ext^{E,a}	N^E	Ext^{E,a}				
P. aurolineata	goldline darter	**T**		**N^E**					N	
P. brevicauda	coal darter	T			Ext^a	Ext^a	N	N	N	
P. jenkinsi	Conasauga logperch	**E**	N^E							
P. kathae	Mobile logperch	CS	N	**N**	**N**	**N**	**<u>N</u>**	**<u>N</u>**	N	N
P. lenticula	freckled darter	T	N	Ext^a	N	N	N	<u>N</u>	N	N
Percina sp.	Coosa bridled darter	V	N^E	Ext^E	N^E					
Percina sp.	muscadine darter	V						**N^E**		
P. maculata	blackside darter	CS						N	N	N
P. nigrofasciata	blackbanded darter	CS	N	**N**	**N**	**N**	**<u>N</u>**	<u>N</u>	N	N
P. palmaris	bronze darter	CS	N^E	**N^E**	**N^E**	N^E	**N^E**	**N^E**		
P. sciera	dusky darter	CS								N
P. shumardi	river darter	CS	N	Ext^a	Ext^a	N	**<u>N</u>**	<u>N</u>	N	N
P. vigil	saddleback darter	CS					Ext^a	<u>N</u>	N	N
P. suttkusi	Gulf logperch	CS								N
Sander vitreus	walleye	CS	**N**	**N**	**N**	**N**	**N**	<u>N</u>	N	N
Sciaenidae	**Drums** (1)									
Aplodinotus grunniens	freshwater drum	CS	N	**N**	**N**	**N**	N	<u>N</u>	N	N
Mugilidae	**Mullets** (1)									
Mugil cephalus	striped mullet	CS					M		M	M
Paralichthydae	**Lefteye flounders** (1)									
Paralichthys lethostigma	southern flounder	CS								M
Achiridae	**American soles** (1)									
Trinectes maculatus	hogchocker	CS								M
Total Alabama River system endemics			15	14	18	10	16	12	5	3
Total extirpated			2	7	12	14	5	3	4	0
Total native (N + N^E + Ext + Ext^E + M + PN)			77	79	95	83	125	125	125	137
Total introduced			13	10	10	8	14	11	8	5

[a] Status as native and extirpated is hypothesized based on occurrences in adjacent reaches and availability of appropriate habitat.