

# **AQUA-5: Aquatic Animals and their Habitats**

[Jim Herrig](#) and Peggy Shute

Southern Region, USDA Forest Service and Tennessee Valley Authority respectively

What are the history, status, and likely future of aquatic habitats and species in the South?

## **1 Key Findings**

- Sediments, introduced into aquatic systems above natural, background levels, have adverse impacts on animal species in all seven taxonomic groups considered in this Assessment
- The aquatic communities of southeastern United States are globally significant. Many are very narrow endemics and subject to extinction from relatively minor habitat losses.
- Habitat barriers created by dams on major rivers have produced isolated populations of many southern aquatic animals. Some species occupy so little of their former range that they are vulnerable to extinction as described for the narrowly endemic species. Some others, mainly larger river animals, have become extinct because of habitat alterations. Current programs have improved conditions in some of the tailwaters.
- In some areas aquatic habitats have improved and reintroduction or augmentation supported by captive breeding programs may improve the recovery potential for some species.
- Some groundwater systems are being dewatered, threatening unique aquatic communities. Careful aquifer management will be necessary for these aquatic communities.
- Certain aquatic species (for example, the flatwoods salamander) require ephemeral ponds to complete their life cycles. Restoration and protection of ephemeral ponds is essential to the conservation of these animals.
- Gaps in our scientific knowledge about southern aquatic species are monumental. Research of many types is urgently needed.
- In the South, much of the habitat for rare aquatic species is not controlled by Federal or State governments. The burden for protecting these habitats falls mainly on private landowners.

## **2 Introduction**

Master and others (1998) ranked the United States as first in terms of diversity of known aquatic species worldwide. Native taxa include crayfish, freshwater mussels, freshwater snails, stoneflies, mayflies, caddisflies, and stygobites (cave-dwelling crustacean invertebrates). The Southeastern United States accounts for much of the globally significant diversity. For example, many of the approximately 340 species of the freshwater crustaceans (crayfish, shrimps, scuds, etc.) known from North America north of Mexico occur here (Hobbs 1981, Schuster 1997), and new species are still being discovered and described from the region (see Thoma 2000, for example). Crustaceans occur in all habitat types. They are cave dwellers and surface water dwellers, and some build burrows in damp areas. Crustaceans are important members of the food web as they process leaves and other organic matter, and they provide food for fish and other animals, including humans (Pfieger 1996).

Insects also contribute tremendously to the diversity of aquatic animals in the Southeast. Morse and others (1997) discussed four important groups of insects (mayflies, stoneflies, caddisflies, and dragonflies & damselflies). They made many of the same observations about the importance of the Southeast for these insects. Of the more than 11,000 species known from North America north of Mexico, nearly half are in the Southeast (Morse and others 1997). Like crayfish, mussels and snails, the aquatic stages of these insects are found in all types of aquatic habitats. Although some are predators (dragonflies), these aquatic insects are also important components of aquatic communities because they shred leaves and other organic matter and serve as important food sources for many fish. They are also useful indicators of water quality (Harris and others 1991).

Of the world's freshwater mussels, 91 percent occur in this region. In addition, more than half of the known fingernail clams and snails are found in the Southeastern United States (Neves and others 1997). Mollusks are found in a wide variety of habitats, but more occur in riverine systems than other habitat types (Neves and others 1997). Mussels have been described as important indicators of water quality because they are filter feeders and highly susceptible to poor water quality. They are also major food sources for many fish, reptiles, and some terrestrial animals. Mussels have also been important commercially, as the raw materials for the pearl button industry of the early 20<sup>th</sup> century and "blanks" for the Asian cultured pearl industry (Jenkinson and Todd 1997).

Of the approximately 850 species of freshwater mollusks in North America, 516 are snails, and more than half of these are found in the Southeastern United States (Neves and others 1997). Little is known of the taxonomy of this group of mollusks, with many species still being described. Little is known of the ecology and life history of most snails, and they are difficult to identify. Distributions (especially historical versus current) are poorly known. Therefore, it is difficult to accurately assign conservation status (Neves and others 1997). The list included here is probably only a representative sample of snails at risk in the Southern United States.

Of the over 800 freshwater fish known from North America north of Mexico, the Southeastern United States is home to about half, many of which are found nowhere else in the world (Warren and others 1997, Warren and others 2000, Sheldon 1988). In comparison with the invertebrates briefly mentioned above, much more documentation exists about North American freshwater fish. Even so, new species are still being discovered and described in the scientific literature (see Skelton 2001). Obviously, fish are important to humans for food. Their existence in the aquatic assemblage is

important to freshwater mussels, as specific fish hosts are needed for the mussel to complete its larval stage and disperse (Neves and others 1997, and references therein). In addition, madtom catfish, many of which are found only in the Southeastern United States, could also be indicators of water quality. They rely on “tasting” the water to know what’s around them. Their intolerance of even minute amounts of pollutants is a suggested explanation of why these small catfish are not found in areas where they were historically known (Etnier and Jenkins 1980).

In comparison with the aquatic animals mentioned above, fewer southeastern amphibian species are known (147 species). Even so, more species are found in the Southeast than anywhere else in the United States, including several salamanders that are found nowhere else in the world (Dodd 1997). Like the other animal groups mentioned, amphibians are found in a diversity of aquatic habitat types. More studies that detail their life histories may result in these secretive animals being recognized as indicators of water quality and other factors, such as the integrity of the ozone layer, and the amount of ultraviolet radiation reaching earth.

About a fourth of the approximately 200 aquatic reptiles known from North America, north of Mexico are found in the Southeastern United States (Buhlmann and Gibbons 1997). The Southeast is especially known for its diversity of aquatic turtles, many of which are commercially important as food or for the pet trade (Buhlmann and Gibbons 1997).

Unfortunately, the globally important southeastern aquatic fauna described above is under extreme threats because of past and present human activities in the water and on land (Stein and others 2000, Benz and Collins 1997). In fact, Ricciardi and Rasmussen (1999) projected extinction rates for North American freshwater animals at about five times that of North American terrestrial animals, and within the range of that estimated for tropical rainforests. Richter and others (1997) summarized a survey of experts on freshwater fauna in the United States, which included the same animal groups we include in this Assessment (except reptiles, which we include and they did not). They showed variation in stressors among the groups of aquatic animals considered; differences between the top listed stressors in the Eastern and Western United States; and differences between historic threats and those currently threatening these animals. In the East, sediment from agricultural nonpoint pollution was listed as the major stressor affecting the ability of aquatic animals to recover from declines. Wilcove and Bean (1994) made several recommendations for aquatic animal conservation. Master and others (1998) and Wilcove and Bean (1994) provided several case studies of cooperative projects in watersheds critically important to preserve aquatic diversity.

### **3 Methods and Data Sources**

#### **3.1 Aquatic Habitats**

For this Assessment, fresh-water habitats important to rare aquatic animals were classified as groundwater habitats or surface water habitats. Groundwater includes those in caves, and also springs and seeps. Surface water habitats include standing water (lakes, ponds, oxbows, beaver ponds, swamps, bogs, and some wetland areas) and flowing water (rivers and streams). These two divisions are, obviously, generalizations of

the immense diversity of aquatic habitats that exist in the South, and grade from one to another (see, for example, discussions by Vannote and others 1980 and Mishall and others 1983). Aquatic systems are not only connected but are also completely intergraded between what is typically referred to as an aquifer to a lake or a river. By defining these broad categories and attempting to determine a primary habitat and in some cases a secondary habitat for each species considered in this Assessment, we were able to more thoroughly discuss the biological significance of these habitats and the factors threatening the species found there.

Because they are generally threatened by the same factors, permanently flooded ponds were not distinguished from ephemeral ponds in this discussion. Rivers were defined as flowing waters exclusive of headwater tributaries. Headwater tributaries include both perennial and intermittent streams.

### 3.2 Aquatic Species

Several agencies and conservation organizations track the distribution and conservation status of species in the United States. The U.S. Fish and Wildlife Service (USFWS) maintains a list of species that have officially been proposed or listed threatened or endangered under the Endangered Species Act of 1976, as amended. They also track species, called candidates, for which insufficient information exists to warrant formal listing. Before species are added to the list, their present and historic status must be thoroughly evaluated and the public must be given the opportunity to provide input about proposed listings. For this reason, years often go by from the time the species is petitioned or proposed for listing until it is officially listed in the Federal Register as threatened or endangered. These procedural requirements may delay or even prevent some species from being listed.

Another ranking is managed by the Association for Biodiversity Information (ABI). The ABI is a nonprofit organization founded by The Nature Conservancy and the Natural Heritage Network (Stein and others 2000, NatureServe 2000a). The list managed by ABI is more inclusive, and uses standardized criteria in an attempt to objectively rank individual species across their native ranges. This global ranking, or G rank ascribes a degree of vulnerability to extinction throughout the entire range of the species. [Table 1](#) gives the definitions used by ABI for the G ranks. Because this Assessment is concerned with range-wide sustainability, only species with ranks of G3 and lower (including GX and GH,) were included ([Table 2](#) and [Figure 1](#)). Species ranked G4 or higher are “apparently secure” throughout their native ranges at present. ABI updates its list three times a year, and experts review the status of all listed species and potential new entries. The USFWS draws upon ABI information and on many of the same experts for updates to its list. The ABI source was used for this Assessment to produce the list of potentially imperiled aquatic species because it is generally more current and comprehensive than the USFWS list. This list was supplemented by six fish and three crayfish from American Fisheries Society expert committees on the status of crayfish, mussels, and fish (Taylor and others 1996, Williams and others 1993, and Williams and others 1989).

Additionally, only species that spend a portion of their life cycle in a freshwater environment, including crustaceans, insects, snails, mussels, fish amphibians, and reptiles were included in this Chapter. Finally, we needed adequate information to evaluate species distributions and life histories. Species with a “?” or “Q” following their G rank were not included in the lists produced for this Assessment. [Table 2](#) displays the

percentage of each taxonomic group that had inadequate information. While these latter species were omitted from this Assessment, their importance should not be overlooked. Many of these animals, in fact, may be extremely imperiled. The lack of distributional, taxonomic, and ecological information on these species represents a major data gap for aquatic species in the South.

The ABI database was searched for seven groups of aquatic animals – crustaceans, insects, snails, mussels, fish, amphibians, and reptiles. Search dates were May 15, 16, and 17, 2000 for all seven groups. A major update to the database was incorporated by ABI several months later. Second searches were conducted on July 15, 2001, for mussels and August 17, 2001 for insects. The results of these searches were used in this Assessment. [Table 2](#) lists the taxonomic groupings and [Figure 1](#) displays relative proportion of the 864 rare aquatic species selected by the criteria listed above. The lists of crayfish, mussels, and fish were compared to lists of vulnerable species published by the American Fisheries Society (AFS) (Williams and others 1993, Warren and others 2000, and Taylor and others 1996). The AFS lists excluded the Rio Grande watershed. The only other differences between the AFS and ABI lists were six fish and three crayfish, which were added to the ABI list and considered in this Assessment. The mussel lists were in complete agreement.

With the exception of insects, the number of species ranked G1-G5 (includes G?, GU, GQ, GX and GH) displayed in [Table 2](#) represents a close approximation of the number of described species in each of the taxonomic groups in the South.

## 4 Discussion

The [Aquatic Habitats section \(4.1\)](#) discusses the potential physical and chemical impacts of human activities on the broad categories of aquatic habitats discussed here. The distributions and biological effects of human activities on the distributions of aquatic animals included in this Assessment are summarized in the [Aquatic Species \(4.2\) section](#).

### 4.1 Aquatic Habitats

The number of species in each taxonomic group dependent on the five aquatic habitats is shown in [Table 3](#). If appropriate, primary and secondary habitats were evaluated for aquatic animals that are not restricted to one habitat type. For example, some species migrate between different habitats for different parts of their life cycles. In the study area, lakes and ponds contained fewer rare aquatic species than rivers and streams, subterranean waters or springs.

#### 4.1.1 Groundwater habitats

Subterranean aquatic systems are widely dispersed across the South. Caves and springs are widely distributed in the Southeastern United States (Hobbs 1992). Although the distribution of many cave-dwelling animals is not well known (Hobbs 1992, Peck 1998), we do know that aquifers and springs in Texas support rare crayfish, beetles, salamanders, and fish. North Carolina and Virginia caves are home to rare shrimp, aquatic sow bugs, scuds, and crayfish. The springs of Florida and South Carolina provide habitats for unique snails and fish. Tennessee, Alabama, Kentucky, and Arkansas are

known for their cave salamanders, as well as cavefish, crayfish, and shrimp (NatureServe 2000a, NatureServe 2000b, Hobbs 1989).

Larger springs may have a unique assemblage of spring-adapted animals. The spring run flowing from it then may have its own unique assemblage (Hubbs 1995) and share some species with the spring habitat.

Many of the species restricted to subterranean aquatic systems are narrow endemics, occurring only in a few isolated localities (NatureServe 2000a, NatureServe 2000b, Hubbs 1995, Hobbs 1989, Burr and Warren 1986). Several characteristics that allow animals restricted to these habitats to be extremely efficient at using the available, often limited, resources could result in declines. These include small body size, late maturity, and infrequent reproduction, which result in low reproductive rates and small population size (Hobbs 1992).

#### **4.1.2 Physical and chemical threats to groundwater habitats**

Chemical and physical conditions of waters in caves and springs are relatively stable (Hobbs 1992, Hubbs 1995). The rare animals adapted to subterranean areas are threatened by activities that alter these stable conditions. Subterranean systems are being affected by rapid agricultural and urban growth, which can dewater aquifers and change water chemistry (Hobbs 1992). Groundwater can be contaminated by domestic, municipal, agricultural, and industrial wastes. Changes in the vegetative cover of the drainage basin can alter runoff patterns. Flooding from manmade lakes, pesticides, and sedimentation associated with deforestation and urbanization in the watersheds can also affect groundwater habitats (Petranka 1998, Hobbs 1992).

Recharge areas for springs and caves can be of considerable size (Hubbs 1995). Thus, water quality and quantity can be affected by activities throughout the recharge area, often long distances away from a cave or spring. However, the recharge areas for many important spring or cave systems are not known. Even if the recharge area is known, the potential effects of human activities in these areas are not well documented. Hobbs (1992) suggested that over-extraction of groundwater may slowly concentrate metals or other pollutants to the point that they ultimately become lethal to specialized aquatic cave-dwelling animals.

Because of the value of a reliable clean, clear water supply, springs are often modified so they can be used as water sources. Aquatic vegetation, which can be very important to spring-adapted animals, is often removed. Etnier and Starnes (1991) noted that Tennessee's spring-adapted fish are jeopardized more frequently than would be expected in comparison with fish adapted to other aquatic habitat types. They concluded that the habitats themselves are jeopardized. The same factors that can affect water chemistry in the recharge areas for cave habitats can affect springs. In particular, withdrawal of groundwater can affect the quality and quantity of spring water by concentrating dissolved chemicals and reducing flow (Hobbs 1992). Hubbs (1995) described this condition as an "artificial drought". Hobbs (1992) commented on the need for more States to adopt cave protection laws, and suggested that purchasing important areas for preserves, restricting entry into caves, and public education are necessary means of conserving cave and spring-adapted animals.

### **4.1.3 Lakes**

Natural lakes are rare in the South. Some of the most important natural lakes include the Carolina bay lakes, cypress ponds, and lakes formed in the floodplains of large rivers (Crisman 1992). Florida and the coastal plain of North Carolina have the most natural lakes. Comparatively fewer rare aquatic animals are dependent on lake habitats than other aquatic habitat types in the South. Construction of dams on the larger rivers in the South has created many reservoirs, which have characteristics similar to natural lakes. However, these artificial habitats do not benefit these rare species.

### **4.1.4 Physical and chemical threats to lake habitats**

Lake habitats are threatened by increased sedimentation and eutrophication. These non-point pollution sources are discussed in detail in [Aqua 1 Chapter](#). The most significant threat to natural lake habitats is urban development along the shores, which increases eutrophication (NatureServe 2000a). Guidelines for septic tank drainage need to be implemented and enforced to protect this habitat type.

### **4.1.5 Ponds**

Permanent and ephemeral ponds are widely dispersed and numerous in the South. Many low-gradient streams have associated oxbows, beaver ponds, and swamps. Rare species from every taxonomic group except mussels depend on ponds. Crustaceans are among the most rare species associated with these habitats. Many amphibian species use only ephemeral ponds for spawning, thus avoiding predation on their eggs and tadpoles by species that require permanent ponds. Some fish (slackwater and trispot darters, for example) use seasonally flooded wetland areas for spawning (McGregor and Shephard 1995, Ryon 1986).

### **4.1.6 Physical and chemical threats to pond habitats**

The quality and quantity of these habitats have been reduced by channel straightening, beaver trapping, and drainage systems. Urban development and intensive agricultural and silvicultural activities that drain or fill wetlands are detrimental to permanent and ephemeral ponds (Petranka 1998, Palis 1996, and Vickers and others 1985).

The removal of beaver during the past 400 years has reduced the number of wetlands in the South (White and Wilds 1997). Beaver have recovered in many areas but populations in the Southern Appalachian Mountains have been slow in returning. Absence of this “keystone” species contributes to the isolation of many amphibian populations (Herrig and Bass 1998).

In some areas, fire suppression has allowed shading to develop resulting in colder temperatures in the ponds and extension of the maturation time for tadpoles (NatureServe 2000a)

Pesticides and accidental chemical spills may threaten species dependent on pond habitats because of the small volume and isolated nature of these waters.

#### 4.1.7 Rivers

Rare mussels, snails, and fish have the greatest dependency on riverine habitats ([Table 3](#)). While the numbers of rare insects and reptiles that rely on this habitat type are small, riverine habitats support about half the rare species in each of these groups. None of the rare crustaceans or amphibians included in this Assessment is known to depend exclusively on river habitats

#### 4.1.8 Physical and chemical threats to river habitats

At least one-sixth of all river miles in the United States are now impounded (Abell and others 2000, Benke 1990). Dams have created barriers to dispersal that have genetically isolated populations of many aquatic animals, inhibited movement, or created unsuitable habitats for the fish that are hosts to the mussel's larvae. Dams have blocked migration routes for herrings, suckers and sturgeons.

Flow releases from dams rarely emulate natural, daily, or seasonal discharges; the results are marginal to unsuitable habitats for the native aquatic species living in these tailwaters. In extreme cases, unsuitable conditions may extend for up to 125 miles downstream (Abell and others 2000).

Dams can convert shallow, flowing, oxygenated streams into deep, still, stagnant pools. In North America, at least 36 species of snails from the Mobile River system have become extinct since the beginning of European settlement (USDI Fish and Wildlife Service 2000). A series of dams on the Coosa River is believed to have caused the immediate extinction of 20 snail species (Lydeard and Mayden 1995, USDI Fish and Wildlife Service 2000). Reservoirs have flooded much of the flowing water habitats needed for stream-dwelling or spring animals (NatureServe 2000a). For example, the Amistad gambusia went extinct when Amistad Reservoir flooded its only known location (NatureServe 2000b). Dams collect sediment, degrading the habitat for mussels and their fish hosts (Parmalee and Bogan 1998).

Channelization and commercial sand and gravel dredging operations decrease river habitat diversity, directly remove mussels from their beds, and create "motionless pools alternating with unbroken stretches where silt and sand constantly scud along the bottom" (Hart and Fuller 1974).

Petroleum spills, urban and agricultural pesticides, chemical, manufacturing, and wood product wastes are among the most insidious pollutants (Hart and Fuller 1974, Abell and others 2000). The impacts from these pollutants are often both immediate and persistent.

Sediment contributes to river degradation (NatureServe 2000b). Sediment sources are discussed in detail in [Aqua 1 Chapter](#). The turbidity associated with sediment runoff can interfere with feeding for both sight and filter feeders and can shade out aquatic vegetation or erode away attached algae. Once the sediment settles into the river, it may bury slow-moving benthic organisms and eggs, clog interstitial spaces, and armor the stream bottom.

Conant and Collins (1998) reported that egg-laying reptiles whose nests are on sandbars or banks of rivers could be affected by various human activities. The habitats required

for nesting could be covered by impoundments or affected by channel maintenance dredging (Dodd, 1997). Eggs, which often remain buried for several months, may also be destroyed by off-road vehicles; agricultural, silvicultural, and mining activities; road construction; and residential or industrial construction.

#### **4.1.9 Streams**

Both perennial and intermittent streams are important to aquatic species. Individuals from all of the rare aquatic groups considered in this Assessment depend on stream habitats. Stream habitats and the composition and diversity of aquatic animals change in a predictable way as stream order (size) increases (Sheldon 1988). More rare crustacean species are associated with intermittent streams than any other aquatic species group. Further studies of aquatic insects, however, may reveal an even stronger dependency by this group on intermittent streams. Wallace and others (1992) suggest that headwater streams of the Southern Appalachians probably contain a greater diversity of aquatic insects than any other region of North America, and that fish and salamander diversity is also relatively high there.

#### **4.1.10 Physical and chemical threats to stream habitats**

Removal of riparian vegetation along streams (Petranka 1998) and intensive ground disturbance within riparian areas may adversely alter stream habitats, especially for crustaceans and amphibians (Petranka and others 1994, Petranka 1998).

Because they have less volume of water, small streams may be exposed to higher concentrations of pollutants, including sediments, than rivers. Petroleum spills; urban and agricultural pesticides; and industrial wastes are particularly damaging to streams (Hart and Fuller 1974, Abell and others 2000) and can affect individuals from all taxonomic groups. Water withdrawals for rural and urban uses may excessively reduce base flow of small streams, further shrinking available habitat (Abell and others 2000).

Indirect impacts of pollutants or habitat alterations may occur through a reduction in food organisms for the animals discussed (NatureServe 2000b). Other examples of more direct effects of human activities include disturbances to the nests of egg-laying reptiles (Conant and Collins 1998). Etnier and Starnes (1991) reported a disproportionately high number of Tennessee's rare fish are in medium-sized rivers. They hypothesize that impoundments on medium rivers produce habitat changes that are not as well tolerated by animals adapted to streams of this size, relative to those adapted to larger river habitats. They concluded that the habitats themselves are threatened.

### **4.2 Aquatic Species**

Southeastern aquatic animal diversity is globally significant. A recurring theme in the chapters edited by Benz and Collins (1997) is that, although the importance of the aquatic diversity of the Southeastern United States is well known to biologists, there is still much that we don't know. Although the worldwide biodiversity crisis is well publicized, very little is known about aquatic systems, especially the exceptional diversity indigenous to North America. The lists of rare aquatic animals included in this Assessment should be considered as indicators of the groups as a whole, and not inclusive lists. Lydeard and Mayden (1995) suggested that protecting habitats important

to a majority of southeastern aquatic animals would result in conservation of a high proportion (more than 80 percent) of North American aquatic biodiversity. Below, we focus on what is known of geographical distribution patterns and biological characteristics that make these rare species vulnerable.

Important life history characteristics, including feeding, reproduction, and escape mechanisms, are reviewed for each taxonomic group. These characteristics govern the sensitivity of organisms to ecological stressors, especially sediment, during the most critical stages in their life histories. Fish are too diverse in their life histories to include in a single group, and have been split into families for analysis.

#### **4.2.1 Crustaceans**

The 159 rare crustaceans included in this Assessment ([Table 4](#)) belong to three orders: decapods (containing shrimp and crayfishes), isopods (sowbugs), and amphipods (sideswimmers, or scuds) (Pennak 1989, NatureServe 2000a) ([Figure 2](#)). Although Shuster (1997) commented that there isn't enough known about many crustacean groups to make a determination about conservation status, we include species in this Assessment for which there are enough available data to indicate their rarity. All of these rare crustaceans are scavengers feeding on dead or dying animals and plants. The females of these three orders protect their eggs and young by retaining them in a marsupial pouch until they reach their first instar.

Habitats used by crustaceans include four broad aquatic habitat types: caves and subterranean streams, ponds, burrows in stream or pond banks or in wet meadows, and streams. [Figure 3](#) displays the proportion of species associated with each habitat type.

Some crayfish excavate burrows, which provide protection from dehydration during dry periods (Hobbs 1976, 1989, Pflieger 1996). Burrowing crayfish are often found along stream or pond edges, but they may occur at great distances from open water in moist pastures or lawns (Pennak 1989, Pflieger 1996). The pond and stream-dwelling crayfish include burrowers and nonburrowers (Hobbs 1989), but even stream-dwelling crayfish that normally don't burrow can excavate burrows if their stream dries out. The stream dwelling crayfish spend daylight hours hidden under rocks or organic debris in the stream channel, emerging at night to forage (Hobbs 1989). The isopods, amphipods considered here, and 24 of the crayfish are restricted to caves and springs.

Available data indicate that these rare species are not geographically clustered but are evenly distributed around the South ([Figure 4](#)), except in western Texas and Oklahoma, which are devoid of rare crustaceans. Crustaceans in general, as well as the southeastern species included in this Assessment, are among the most narrowly endemic organisms known (Taylor and others 1996). For example, of the 159 species discussed in this Assessment, 144 are known from relatively small geographical areas ([Figure 5](#)).

#### **4.2.2 Threats to crustaceans**

The extremely restricted ranges of many crustaceans amplify the effects of even relatively small-scale impacts. Taylor and others (1996) noted, "Taxa restricted in range to an area of 100 square miles or less are particularly vulnerable to habitat destruction or degradation..." Any degradation severe enough to cause extirpation could also cause total extinction.

For example, three of the four-pond dwelling crayfish listed in [Table 4](#) are known from a single locality, while the range of the fourth is restricted to only a slightly larger area. However, these crayfish may tolerate periodic desiccation of the ponds they live in because they can burrow if the ponds dry (Hobbs 1989).

In addition to pollution and habitat alteration, threats to stream-dwelling crayfish include over-collecting for bait or food, competition from exotic crayfish, and predation from introduced (stocked) fish, (NatureServe 2000a, Taylor and others 1996). Another non-native pest species, the zebra mussel can attach so densely to crayfish' carapaces that they are unable to shed and grow (Schuster 1997)

The rare groundwater-inhabiting species of isopods, amphipods, and crayfish are being impacted by dewatering of aquifers, pollution, and sedimentation.

#### **4.2.3 Future for crustaceans**

Regardless of the preferred habitat, the viability of many of the rare crustaceans is most threatened because of their small ranges. Impacts to habitats that would reduce or extirpate local populations of other taxonomic groups might result in extinction of some crustaceans (Taylor and others 1996). Crayfish are somewhat tolerant of desiccation, but permanent conversion of wetlands to pasture or urban uses could eliminate populations and lead to extinctions. Best management practices directed at the protection of wetlands and riparian areas will increase the potential viability of these species.

Areas that contain non-native crayfish associated with “bait-bucket” introductions could see the natives continue to decline (Taylor and others 1996).

#### **4.2.4 Insects**

The 176 rare aquatic insects ([Table 5](#)) addressed in this Assessment include organisms from five separate orders: Plecoptera (stoneflies – 64 species), Ephemeroptera (mayflies – 15 species), Odonata (dragonflies – 31 species and damselflies – 4 species), Trichoptera (caddisflies – 60 species), and Coleoptera (aquatic beetles – 2 species) (Meritt and Cummins 1984) ([Figure 6](#)). They use all five habitat types but are predominately found in rivers and streams ([Figure 7](#)). With the exception of the two beetle species, all of the adult insects considered in this Assessment are terrestrial, returning to the aquatic environment only to deposit eggs.

The stoneflies are most often associated with flowing water where they seek hiding cover among rocks, algae, and organic debris. They are very sensitive to low oxygen levels. Eggs are released into the water column or attached to underwater structures. Once the nymphs hatch, they spend from 1 to 3 years in the water. Most nymphs are carnivorous, feeding on aquatic insects; however, some species feed on algae, bacteria, and vegetable detritus (Pennak 1989).

Mayflies are very similar to stoneflies in their habitats and preferred habitats. Most species in this group, however, are herbivorous. Some species are carnivorous while others feed on organic detritus (Pennak 1989).

Dragonflies and damselflies are similar to each other in many of their habitat needs (Meritt and Cummins 1984). They are sight feeders, feeding on insects, worms, small

crustaceans, and mollusks, and cannot feed adequately in turbid water. Depending on the species and water temperature, nymphs may spend a few months to several years in the water (Pennak 1989).

The caddisflies typically produce one or two generations per year. In most species, the adult female enters the water and swims to the bottom to attach eggs to the substrate. Many nymphs build elaborate cases to provide protection and attachment. Feeding strategies include grazers and scrapers that feed on algae and detritus attached to rocks; strainers and net filters that collect suspended organic matter from the water column; and carnivores that feed on insect, worms, and small crustaceans (Pennak 1989).

The aquatic larvae life stage of the two beetle species listed in [Table 5](#) are restricted to springs and subterranean flows associated with Edward's aquifer in central Texas (NatureServe 2001b). These larvae crawl along the bottom feeding on algae and plant detritus. In addition, since neither species is capable of flight, the adults are also closely linked to these aquatic habitats, and dispersal is limited to water movement through the aquifer (Pennak 1989).

Morse and others (1997) noted that insects are generally small, cryptic, little known animals. Few biologists are expert in their identification or ecological requirements. In their discussion of rare southeastern insects, Morse and others included a list of dragonflies and damselflies, mayflies, stoneflies, and caddisflies. These groups are apparently better known than some other groups of aquatic insects (Wiggins 1977, Harris and others 1991, for example).

With the exception of the narrow endemics, whose geographic ranges are relatively small, the insects are wide-ranging, with their distributions often including several States. However, these large ranges frequently include vast areas of unoccupied habitats; the areas currently occupied by these insects are often highly localized. Because the adults can be far ranging and more mobile than many of the other aquatic animals discussed in this Assessment, they are likely to reoccupy areas where they have been previously extirpated (NatureServe 2001b). County occurrence data are not available for most of these species; consequently, no distribution map could be produced.

#### **4.2.5 Threats to insects**

Because of restricted geographic ranges, or highly localized populations of wide-ranging species, the insects are subject to extinction from any factors that alter their habitats severely enough to extirpate single populations. In addition to water pollution, or other factors that affect food organisms, runoff that results in increased turbidity could interfere with sight-feeding ability and adversely affect these predatory insects.

Sediment can also affect filter feeding caddisflies, some of which require stable stream bottoms with spaces among rocks for attachment of filter nets. Many caddisflies, stoneflies, mayflies, and other insect larvae require sediment-free surfaces for grazing and prey production.

Although biological threats are not listed for the beetles, the U.S. Fish and Wildlife Service (U.S. Federal Register 1997) stated, "The primary factor threatening the long-

term survival of these species is availability of a sufficient quantity of water to maintain essential characteristics of their habitat.”

Factors that can affect aquatic insects in general include runoff, including sediment and chemicals from agricultural, silvicultural, and urban activities. Other threats include water-quality degradation from fish farms, and exotic pests that affect trees on stream-sides. Forest harvests also can produce other changes that could affect stream-dwelling insects. For example, a change in plant community composition may reduce the amount of large woody debris in streams, a change in the processing rate of organic matter, or lowered quality of food (leaves) that falls into the stream to be “processed” by insects (Morse and others 1997). These changes could affect the entire food web.

#### **4.2.6 Future for insects**

The riverine insects have lost a considerable amount of habitat as a result of dams and reservoirs. The remaining populations are often isolated from each other by great distances, making dispersal and genetic exchange difficult or impossible. Some intervening habitats, which may be suitable, are unoccupied for unknown reasons. Three odonate species are restricted to single populations and the loss of any of these populations would amount to extinction of the species. Better information about the distribution of all rare odonates is needed. To ensure long-term viability of all stream-dwelling insects, measures that improve and maintain water and habitat quality are needed.

The insects restricted to springs and other ground-water habitats are threatened by water withdrawal that dewateres the aquifers, by pollutants (that can become concentrated as ground water is lowered), and by other activities that directly affect spring habitats.

#### **4.2.7 Snails**

The 123 freshwater snails ([Table 6](#) and [Figure 8](#)) included in this Assessment are classified into two groups: Pulmonata (7 species) and Prosobranchia (116 species) (Hart and Fuller 1974). Members of the Order Pulmonata are related to terrestrial snails and are capable of breathing air, which allows them to exist in water containing low levels of oxygen (Hart and Fuller 1974). Five of these, including one lake-dweller and two stream dwellers, are presumed to be extinct. The two remaining species are known from swift-flowing water (Hart and Fuller 1974).

Members of the Order Prosobranchia are related to marine snails and have internal gills that help them obtain oxygen from the water (Hart and Fuller 1974). All 22 of the spring or cave species and 94 of the stream-dwelling snails belong to this group. [Figure 9](#) displays the habitats utilized by rare snail species.

Snails feed on algae and detritus, which are scraped from rocks, vegetation, and other substrates (Pennak 1989). Life cycles typically range from 1 to 3 years; most species have annual life cycles (Pennak 1989). Reproduction varies among species. The majority of species are egg layers, but some are livebearers (Hart and Fuller 1974).

The distribution of rare aquatic snails is highly localized; most of the stream-dwelling snails are indigenous to the Tennessee or Mobile River systems ([Figure 10](#)). One rare

species is found in lakes in Virginia. Others are known from springs and caves -- 14 species in Florida, 3 in Texas, 2 in Kentucky, and 1 each in Arkansas, Virginia, and Alabama.

#### **4.2.8 Threats to snails**

Threats to the viability of these rare snails are associated with impacts to their preferred habitats. For example, the Piedmont pondsnail was known from only one pond. It apparently became extinct because cattle were allowed access to the pond for watering (NatureServe 2000a).

Many of the 100 stream-dependent snail species are historically known from small geographic areas, even single riffles, and therefore have been threatened by dams. For example, a series of dams on the Coosa River is believed to have caused the immediate extinction of at least 20 snail species (Lydeard and Mayden 1995). Any existing populations of these stream-dwelling snails are physically isolated by reservoirs (USDI Fish and Wildlife Service 2000). At least 89 of the 100 rare snails that prefer streams are concentrated in the Tennessee and Mobile River systems ([Figure 10](#)). In North America, at least 36 species of snails are thought to have become extinct since European settlement began; all are from the Mobile River system (Lydeard and Mayden 1995). Exotic species, including zebra mussels, are threats to the remaining stream-dwelling populations of rare snails (Hart and Fuller 1974).

A major threat is sedimentation. It can inhibit growth of algae on which snails graze (Neves and others 1997), accelerate erosion of snail shells, and affect survival of eggs (Hart and Fuller 1974). Although scant information on toxicity is available, other pollution events, such as chemical spills are potential threats to aquatic gastropods (Hart and Fuller 1974, Neves and others 1997).

#### **4.2.9 Future for snails**

The single lake-dwelling snail species listed in this Assessment is considered extinct. The narrowly endemic Piedmont pondsnail was apparently formerly restricted to a single lake. It appears to have been destroyed by cattle (NatureServe 2000a), but water pollution, sedimentation, or an accidental spill could have produced the same result.

Fourteen of the 22 rare snails associated with springs and caves are found in Florida. All of these species are narrow endemics, often restricted to a single spring (NatureServe 2000a). In Florida, the major threats to spring and cave systems are sewage seepage and sedimentation (Petranka 1998). Presently, aquifer drawdown is apparently not a significant threat to the Florida spring systems, but in Texas, it may be the single most important threat (NatureServe 2000a). As with all narrow endemics, the magnitude of potential threats to a single population needs to be respected.

#### **4.2.10 Mussels**

The 191 rare mussels ([Table 7](#)) evaluated are not divided into subgroups based on taxonomy. They use only river and stream habitats ([Figure 11](#)). The primary and secondary habitats of each mussel were determined from distribution records and specific references (Parmalee and Bogan 1998, NatureServe 2001a, USDI Fish and Wildlife Service 1992, Dennis 1985, USDI Fish and Wildlife Service 2000, Williams and

others 1993). No rare mussels were found to be dependent on groundwater habitats, lakes, or ponds.

Freshwater mussels respire and feed by siphoning water across their gills; food consists of microorganisms and organic particles (Parmalee and Bogan 1998).

Reproduction is extraordinarily complex. Males release sperm into the stream; sperm are siphoned out and fertilization occurs within the females. The eggs mature into larvae known as glochidia which are released into the water and become encysted on a fish host that is often very specific. Varieties of mechanisms have been developed to ensure that the glochidia reach the appropriate host (Parmalee and Bogan 1998). While parasitizing the fish host, the glochidia transforms into a juvenile mussel. After detaching from the fish, the juvenile mussels take up residence in the stream bottom.

The rare mussels are distributed among 11 major watersheds or groups of watersheds spread across the South ([Figure 12](#)). This grouping is based on the unionid faunal provinces summarized in Parmalee and Bogan (1998). Almost 80 percent (148 of 191 species) of these rare mussels are endemic to single watersheds.

The Cumberland watershed is home to 60 of the 191 rare mussels evaluated in this Assessment. Historically, the Tennessee and Cumberland River systems had the most diverse mussel fauna in the South (Parmalee and Bogan 1998, Hughes and Parmalee 1999). Although inhabitants of shallow shoals in larger rivers have probably declined the most (Neves and others 1997), some species remain in scattered localities where riverine habitat remains, but they are isolated by dams and reservoirs (Parmalee and Bogan 1998).

Another important area for mussels is the Mobile River basin, which ranks among the top 10 river basins in the world in terms of historical diversity of freshwater mussels (Lydeard and Mayden 1995, USDI Fish and Wildlife Service 2000). Today these imperiled species are found in relatively clean river reaches isolated by degraded reaches or reservoirs (USDI Fish and Wildlife Service 2000).

Other important areas for mussels include the Mississippi watershed; the Apalachicola, Ochlockonee, and Suwannee River watersheds; and the South Atlantic Rivers ([Figure 12](#)).

#### **4.2.11 Threats to mussels**

The threats to viability of freshwater mussels are many and compounding in their impacts. Parmalee and Bogan (1998) stated, "The greatest overall detrimental impact on mussel populations probably can be attributed, directly or indirectly, to dam construction -- especially those built in the 1930's, 1940's and 1950's." Numerous recovery plans published by the USDI Fish and Wildlife Service (Ahlstedt 1983, USDI Fish and Wildlife Service 2000) also identify dams as the most important factor in the decline of mussels.

The most direct effect of dams on mussels is the immediate loss of flowing water upstream of the dam site. Once their habitat is inundated by a reservoir, the mussels living there are unable to move to suitable riverine habitat. In addition, reproduction

will not occur if the fish host is similarly adapted to riverine environments. Bogan (1993) described mussels stranded in reservoirs as “...functionally extinct when the host fish is no longer present.” Although, historically, subpopulations of the same species may have been separated by several miles in a river, their dispersal schemes (glochidia attached to more mobile fish), allowed the flow of genes between the cohorts. Currently, subpopulations that are separated by a few miles are often genetically isolated by dams.

The plight of these mussels is aggravated by the accumulation of sediment that would normally move through the system. Because flow is often restricted in reservoirs, sediment can settle and accumulate.

To adequately consider the habitat needs of freshwater mussels, it is important to include the needs of their fish hosts. Freshwater mussels spend some time as a parasitic larva (glochidia) attached to the gills or fins of various fish species. The fish hosts for many of the rare mussels are unknown (Ahlstedt 1983); however, this aspect of freshwater mussel ecology is being actively researched (Neves and others 1997). Turbid water may inhibit the sight-feeding fish hosts, which must find the glochidia (NatureServe 2001a). Therefore, for riverine fauna to remain viable, measures to reduce the amount of sediment that reaches the bottom habitats in streams are necessary.

Transportation and accumulation of sediment occur in all river habitats. The principal sources of sediment to rivers and their relative level of significance are discussed in detail in the [Aqua 1 Chapter](#).

Sediment can clog gills of mussels, reducing feeding efficiency, and interfering with mussel and host fish interactions. Heavy sediment loads can also potentially smother individual mussels. Sediments result from agricultural, silvicultural, mining, urban development, road construction, and other activities on the land (Neves and others 1997). According to Neves and others (1997), agriculture is the most widely reported source of pollutants. Streamside buffer strips can significantly reduce soil and nutrient concentrations in surface runoff.

In addition to this sediment threat in the Southeastern United States, excessive nutrients and pesticides from intensive agriculture or silviculture could affect mussels. Although mussels can close their valves to avoid short-term exposure to pollutants, the effects of chronic exposures are mostly unknown. Neves and others (1997) emphasized the need to set water quality criteria by using early life history stages for toxicity testing. Other pollutants potentially affecting mussels include petroleum spills, industrial discharges, and highway salts (Hart and Fuller 1974, Neves and others 1997, Abell and others 2000). Coal mining can produce sediment runoff and alter water chemistry with acid drainage and heavy metals (Neves and others 1997).

On many large and medium-sized rivers, continual dredging is often necessary to maintain an appropriate channel for barge traffic (Abell and others 2000). Dredging can make the river substrate unstable and unsuitable for mussels (Hart and Fuller 1974). On smaller streams, relocating or straightening channels can reduce habitat diversity and stability of the bottom substrates. Dredging can also remove mussels from their beds. Commercial sand and gravel dredging operations can have similar effects (Neves and others 1997).

Water withdrawals can sometimes compound these threats, especially, in small streams. Because they have less volume of water, small streams often are exposed to higher concentrations of pollutants than larger streams. Water withdrawals for rural and urban uses may also reduce base flows of small streams, shrinking available mussel habitat (Abell and others 2000).

Two exotic mussel species, Asian clams and zebra mussels, directly compete with native mussels for food and space, especially in reservoirs and large rivers (Bogan 1993). Zebra mussels may attach to native mussels in large enough numbers to weaken or kill the natives. Zebra mussels (living and dead) may also accumulate in such densities that they significantly alter the physical characteristics of the substrate as well as the water quality.

#### **4.2.12 Future for mussels**

The way in which mussel habitats are affected by human activities vary little between watersheds; consequently, this Assessment focuses on stream size without emphasis on drainage unit.

The long-term status of many river mussels is undetermined at present. Neves and others (1997) stated: “Because mussels are thought to be the longest lived freshwater invertebrates, with a longevity of more than 100 years for some species, population declines may continue for decades. Thus, the extirpation of species is a prolonged event, lagging decades behind the directly responsible factors of attrition of the fauna.”

The system of dams along the 650 miles of the Tennessee River from Knoxville, Tennessee, to Paducah, Kentucky, was designed so that even at the lowest operating pool level, the water behind one dam backed up to the next (Ungate 1990), essentially eliminating any free-flowing water. Flow of the Cumberland and Mobile Rivers is similarly restricted (USDI Fish and Wildlife Service 2000). However, there are still some relatively riverine sections of these systems. The methods of operating the dams can improve downstream water and habitat quality, providing additional habitat (Yeager 1993).

In free-flowing segments of rivers, mussel communities may be wholly or partially intact, but the populations probably have become genetically isolated from other populations of the same species. Chance events probably also take a toll on these isolated populations, which have no natural means of being augmented and little habitat suitable for expansion. Many rare mussel species that depend on river habitats may not be able to sustain themselves. However, recent advances in technology have stimulated proposals for augmenting or reintroducing captively propagated individuals (U.S. Federal Register 2001b) in some of these large river habitats.

Rare mussels that are typically found in stream habitats are subject to the same environmental impacts as mussels in the rivers but they could be affected more severely by changes in water quality and quantity. For example, streams are more often affected by road and railroad crossings, and roads that parallel their courses. That the likelihood for accidental spills from trucks or trains is high. Chemical spills pose a serious threat to many isolated mussels populations. Fish hosts and mussel glochidia may be more susceptible to acute toxicity than adult mussels (Rand and Petrocelli 1985), but adult mussels may be more susceptible to chronic exposures, especially those from materials that accumulate in their bodies (Fridell 1996).

Urban and agricultural pesticides enter river systems either directly as they are sprayed onto the body of water; or indirectly as residues attached to soil particles that wash into the stream following a storm (USDA Forest Service 1989). Some of these pesticides, such as 2,4-D, are known to be extremely toxic to fish and many invertebrates (Johnson and Finley 1980, Mayer and Ellersieck 1986). Yet, the potential toxicity of these chemicals to the majority of mussel or fish (host) species is unknown. However, recent advances in technology that improve captive production of mussels may allow for toxicity testing to more accurately set water quality standards (Neves and others 1997). The effects of agricultural chemicals on the reproductive success of mussels also need to be researched. Miniscule amounts of pesticide may mimic natural hormones (Neves and others 1997). This threat is difficult to recognize because adult mussels may remain in the river for years without reproducing.

Mining, chemical, manufacturing, and wood product wastes entering rivers from point sources are subject to environmental reviews for permitting and monitoring (Fridell 1996). However, water-quality standards used in this permitting usually are not based on toxicity testing of rare species. Mussels and their fish hosts may be more sensitive than the organisms tested to establish the standards. Therefore, permitted activities may indeed affect the rare mussels and fish. Threats to water quality can also arise when retention ponds are overwhelmed by a storm. The chemical wastes associated with these activities could have direct and immediate effects on the fish and mussels, and some of these toxicants may persist for months or even years. As suggested above, the ability to captively produce enough individuals of the more sensitive aquatic species to use in setting water quality standards could improve this situation.

Water withdrawals for domestic, agricultural, or industrial uses diminish the wetted stream bottom and could reduce available habitat for mussels and their host fishes. Although typically, there are limits on individual withdrawals and minimum flow requirements, demands for water are increasing in the South.

#### **4.2.13 Fish**

Like most of the other aquatic animal groups discussed here, the Southeastern United States is well known by biologists for its high diversity of freshwater fish (Warren and others 1997, 2000). Nearly half of the North American fish fauna is found in this region (Warren and others 2000). Etnier (1994) noted that only two southern fish (hairlip sucker, *Moxostoma lacerum*, and whiteline topminnow, *Fundulus albolineatus*) are known to be extinct. Two others (Scioto madtom, *Noturus trautmani*, and Maryland darter, *Etheostoma sellare*) are also believed to be probably extinct. The Southeast also contains a high proportion of fish currently considered jeopardized. Warren and others (2000) listed 28 percent of the 662 native freshwater or diadromous southern fish as jeopardized. They noted this was a 75 percent increase in the proportion of jeopardized fish since 1989, and 125 percent since 1979. Although there are still gaps in knowledge, freshwater fish are better known than many other aquatic animals discussed in this Assessment. Etnier (1994) pointed out that, even though we have relatively more data on Southeastern freshwater fish than some other groups, our knowledge is still inadequate to accurately assess the status of many, possibly declining fish. He recommended more long-term monitoring efforts.

The 165 rare fish assessed ([Table 8](#)) belong to 14 families ([Figure 13](#)). Rivers, streams, and groundwater habitats are the major habitats where they occur most often ([Figure 14](#)).

Etnier and Starnes (1991) noted that darters and madtom catfish are more likely to be jeopardized than would be expected, based on their representation in the fauna. These groups of fish have highly specialized reproductive requirements, which probably also contribute to their sensitivity. Angermeier (1995) also noted that ecological specialists are more extinction-prone than are generalists. These animals normally have life history requirements that include the use of crevices beneath or between rocks and a clean stream bottom. Darters (63 of the fishes discussed here) occupy a wide variety of habitats ranging from small springs to fast-flowing riffles in large rivers to backwater areas in swamps (Etnier and Starnes 1993, Jenkins and Burkhead 1993, Smith-Vaniz 1968, Pflieger 1975, Burr and Warren 1986). Many darters are considered clean-water species (Etnier and Starnes 1993) that are sensitive to sedimentation. Most are sight feeders and many species care for their eggs and young. Like many other groups previously discussed, some darter species are restricted to relatively small geographical areas, often a single watershed (Jenkins and Burkhead 1993, Etnier and Starnes 1993, Warren and others 2000).

Minnows (46 species discussed here) are generally sight feeders, taking microorganisms and organic matter from the water column. Reproductive activities range from spawning in association with nests built by a larger minnow, placing eggs in crevices in rocks or logs, and attaching eggs to submerged plants or gravel (Etnier and Starnes 1993). Although some minnows protect their nests, many eggs are scattered or attached, and left alone. Some rare minnows are geographically restricted to small watersheds.

The 16 rare catfish included in this Assessment are predominately madtoms. Spawning occurs beneath rocks or other objects on or near the substrate. Eggs and young are guarded by the males and are well protected (Burr and Stoeckel 1999, Etnier and Starnes 1993). Most catfish are nocturnal feeders, relying on their highly sensitive barbels to detect aquatic insects. They also apparently rely heavily on “taste” or “smell” to find mates or make other observations about what goes on in their waters (Todd 1973). The rare madtoms, headwater catfish, and spotted bullhead are found in small to medium-sized streams; many species have highly localized populations. The two cave catfish included here are found in groundwater systems restricted to Edward’s Aquifer in Texas. All of these catfish are endemic with highly localized populations (Burr and Stoeckel 1999).

Seven suckers are included in this Assessment. These fish use small to large streams. They feed on invertebrates that they stir up by nudging their heads into gravel and cobble streambeds (Etnier and Starnes 1993). Therefore, a loose substrate is essential for their foraging. Spawning occurs in similar areas; eggs are buried beneath the gravel and cobbles, which are disturbed by the tail movements of the fish. Some species build rough nests, but no parental protection is provided for the eggs or fry (Etnier and Starnes 1993).

The sturgeons included in this Assessment (six species) are all relatively long-lived fish that can reach a large size. They are prized for their flesh and eggs (Etnier and Starnes 1993), although the Federal protection status of most of the species listed in this Assessment does not allow for legal harvest. Sturgeons are bottom feeders, using their

barbels to find food organisms, which include crayfish, mussels, snails, and insects (Jenkins and Burkhead 1993). Spawning migrations may cover more than a hundred miles; individual fish do not spawn every year and sexual maturity may not be reached until the fish is 14 to 30 years old (Jenkins and Burkhead 1993). Spawning occurs in shallow water, and no parental care is provided to the eggs or fry (Etnier and Starnes 1993). Several of these characteristics, including late maturity and infrequency of spawning, render all the sturgeon species exceptionally vulnerable.

The five species of live-bearers included in this Assessment are restricted to warm-water springs and spring runs in Texas (NatureServe 2000b). Two of these species are believed to be nearing extinction, if they aren't already extinct (Williams and others 1989). These fish are all midwater feeders, taking insects, amphipods, filamentous algae, and young fish (Lee and others 1980). Spawning can take place year-round. In comparison with most other fishes, which hatch from eggs, possess a large yolk-sac, and are relatively helpless for a while, live-bearer young are born fully developed (Lee and others 1980).

Four rare species of topminnows and studfish are included in this Assessment. All of these species prefer small streams, springs, or the margins of rivers and are closely associated with cover (Etnier and Starnes 1993). They feed near the surface on invertebrates. All spawn over a substrate of rock or attach their eggs among vegetation; no parental care to the eggs or fry is provided (Etnier and Starnes 1993).

The four pygmy sunfish included in the Assessment prefer springs, spring runs, or blackwater swamps where they feed on crustaceans (NatureServe 2000b, Etnier and Starnes 1993). The life spans of most pygmy sunfish species are probably not much longer than 1 year (Etnier and Starnes 1993). The distributions of several species are geographically isolated, and some are found in only a few localities (Rohde and Arndt 1987).

The four sculpin evaluated in this Assessment are restricted to small, cold-water streams or springs. Three are found in headwaters of the Tennessee River drainage in Virginia and one is found in a single spring in the Mobile River basin in Alabama (Jenkins and Burkhead 1993, Mettee and others 1996). All four are narrow endemics occupying very small geographic areas. Sculpins are predators. They feed on aquatic insect larvae, crayfish and fish, usually ambushing their prey at night from beneath the cover of rocks (Jenkins and Burkhead 1993). Spawning takes place in cavities under rocks excavated by males (Jenkins and Burkhead 1993). The males care for the eggs until they hatch (Etnier and Starnes 1993).

The bass and sunfish evaluated in this Assessment include three black bass and one rockbass. These all prefer small- to medium-sized streams (Lee and others 1980), where they feed on crayfish, other invertebrates, and small fish (Jenkins and Burkhead 1993). Males construct nests and provide protection for their eggs and fry (Lee and others 1980). All of these species are considered sport fish.

Two of the three pupfish evaluated are restricted to springs; the others occur in streams (NatureServe 2000b). All three are endemic to Texas. These small fish may exist in loose gravel when no surface water is present. They spawn over gravel; the male defends a territory but does not provide any protection for the eggs. Food includes microscopic benthic organisms (NatureServe 2000b).

The three cavefish are all narrow endemics restricted to cave systems in the Mississippi, Cumberland, and Ozark watersheds. They feed on copepods, crayfish, salamanders, and their young (Pflieger 1975). Spawning activity has not been documented; however, Etnier and Starnes (1993) speculate that they may be mouth brooders.

The Waccamaw silverside is the only silverside included in this Assessment. This species probably only lives for about 1 year (Shute 1997). Silversides are upper-water residents that school in large numbers. They feed on small, planktonic invertebrates and are believed to spawn in open water, providing no protection for the eggs or young (NatureServe 2000b). This fish is especially vulnerable because of its short lifespan, and because it is a narrow endemic, being restricted to a single lake in North Carolina.

The distribution of rare fish across the South ([Figure 15](#)) is remarkably similar to the rare mussel distribution. In fact, the three watersheds (Cumberland, Mississippi, and Mobile) with the highest number of rare mussel and rare fish are the same. The South Atlantic and Apalachicola are also high for both species groups. The Rio Grande is a significant watershed for rare fish.

#### **4.2.14 Threats to fish**

Threats to fish are many, cumulative, and interactive. The most frequent explanation for declines in southern fish is habitat alteration, which has affected all habitat types (Etnier 1997, Warren and others 1997, Williams and others 1989). Physical habitat alteration resulting from impoundment, channelization, dredging, sedimentation, ditch cleaning, and other changes that result from land treatments could affect darters, minnows, catfish, bass, pygmy sunfish, and sculpins, for example (Warren and others 2000).

Many of the fish (excluding the wider-ranging minnows, herrings, suckers and sturgeons) considered in this Assessment have apparently always been narrow endemics (Warren and others 2000). Others currently exist in fragmented populations because of habitat alterations. Consequently, the small, isolated populations that remain are subject to extinction from a few or even a single natural chance or accidental event.

Reservoirs have flooded much of the preferred habitats for fish in at least six of the family groups discussed here. For example, the Amistad gambusia went extinct when Amistad Reservoir flooded its only known location (NatureServe 2000b). However, in spite of the many reservoirs found throughout the South, many populations of sensitive fishes still exist (Etnier 1994). Populations remaining are often widely separated, and therefore much more vulnerable to single catastrophic events (Angermeier 1995, Warren and others 2000). Dams have also blocked migration routes for suckers, herrings, and sturgeons.

Chronic buildup of sediments and prolonged periods of turbidity can adversely affect feeding, spawning, and cover availability. Sight feeders, such as the rare Conasauga logperch, forage by flipping rocks over with their snouts and feeding on the aquatic insects found on the bottom of the rock, they've just flipped. Rocks imbedded in silt are not easily moved, and they support fewer aquatic invertebrates for darters and other fishes that feed similarly (Etnier and Starnes 1993). Since most darters and madtoms, and some of the other fishes included here (suckers, and some minnows), deposit their eggs on or near the substrate, sediment buildup impacts their spawning success. Many

darters also seek cover from predators in the spaces between rocks. Sediment fills these spaces and eliminates the essential cover.

In addition, many other sensitive fish discussed in this Assessment are especially vulnerable to impacts of human activities simply because of their life histories. For example, some sturgeons do not become sexually mature until they are 15 to 30 years old (Etnier and Starnes 1993), and then they only reproduce periodically, exposing themselves to years of habitat alterations and pollution, and potential harvest by humans before they're even able to produce offspring. Conversely, some other fishes are extremely short-lived. For example, the pygmy sunfish and the Waccamaw silverside seldom live for more than 1 year (Shute 1997, Rohde and Arndt 1987, Jenkins and Burkhead 1993). If some factor results in poor reproductive success during a single spawning season, the entire population could be lost.

Pollution and sediment threats from mining, industrial, and agricultural activities, accidental spills, and urban expansion have already, or potentially could, impact most of the fish family groups or their food resources (Warren and others 2000). Sediment reduces available food organisms and may inhibit maturation of eggs, especially for crevice spawning minnows or species with bottom-dwelling larvae and young, like madtoms, darters, and some minnows. For other animal groups, developing water-quality standards based on toxicity testing of more sensitive fish species could improve this situation.

Water withdrawal resulting in aquifer draw down and contamination of groundwater is potentially a serious threat to spring and cave-adapted species (Etnier and Starnes 1991, Hubbs 1995, Etnier 1997, Elliott 2000, Warren and others 2000). These sensitive fish include some of the topminnows, pupfish, livebearers, and cavefish. Animals living in these habitats are more vulnerable to pollution and sedimentation, because of their inability to adapt to water quality and habitat changes in their relatively stable environments.

While not as obvious in the Southeast as in the Western United States, introductions of non-native fishes can result from stocking, bait bucket releases, and interbasin connections (Sheldon 1988, Nico and Fuller 1999). Competition from introduced species threatens some topminnows, pupfish, bass, and livebearers; hybridization is a potential threat to some darters, minnows, topminnows, pupfish, and bass. Predation from introduced species threatens darters, suckers, madtom catfishes, and silversides (NatureServe 2000b). The San Marcos gambusia, a livebearer, apparently was forced into extinction from a combination of events including competition and hybridization (NatureServe 2000b).

Over-harvesting and collecting for bait or aquarium trade are affecting or have affected suckers, bass, pygmy sunfish, sturgeon, topminnows, pupfish, and cavefish (NatureServe 2000b).

#### **4.2.15 Future for fish**

Many of the rare darters included here are narrowly endemic species subject to catastrophic losses from relatively minor accidents or chance events. A single spill of toxic chemicals could drastically reduce or eliminate a population. Therefore, protecting important stream-bottom habitats and water quality by preventing runoff and spills is

important to ensure their continued existence. Because these populations are geographically isolated and reinvasions are not likely because of habitat barriers, augmentation or reintroduction may be necessary to ensure existence of some species.

In comparison with many fish discussed above, distributions of most of the rare minnows considered in this Assessment are somewhat broader, but their populations have often been fragmented. For many minnow species, so little is known about requirements for various life stages that real threats and reasons for rarity are speculative. Dams, reservoirs, and other unknown factors have adversely altered habitat or water quality, resulting in isolated populations of some minnows, like the spotfin chub and blue shiner. Population augmentation or reintroduction may be necessary to improve the probability of long-term existence for some species.

Etnier and Starnes (1991) concluded that, although the madtoms are a disproportionately jeopardized part of Tennessee's fish, they are not largely confined to habitats that are more jeopardized than any others. Their specialized reproductive requirements and their probable sensitivity to trace chemicals ("olfactory noise", see Etnier and Jenkins 1980) are likely major factors in their vulnerability. In addition, many of the madtoms included here, as well as the headwater catfish and the spotted bullhead, are narrow endemics, or currently exist as fragmented populations that are only portions of formerly more widespread geographic distributions. This habitat fragmentation also increases their vulnerability (Angermeier 1995). As with all species that have very limited ranges, any losses could be catastrophic, and could result from relatively minor accidents or events.

Sediment and pollutants that reduce the amount of available food or interfere with chemical communication could be detrimental to these catfish. In addition, although males protect eggs and young, chronic sedimentation can lead to heavy imbeddedness of the stream bottom, and greatly reduce the amount of suitable spawning sites. Measures that protect and improve habitat and water quality in streams where these fish are known to occur would increase the likelihood of their continued existence. Frequent, regular monitoring should be conducted, and population augmentation or reintroduction has been recommended for some species (Shute and others 1997, Rakes and others 1999).

Most of the rare sucker species included here are relatively large in comparison with the other groups of fishes discussed. The large number of individuals concentrated together during spawning runs and the noted quality of their flesh have made suckers a valuable food item for hundreds of years. Intensive harvesting by Native Americans and later by generations of Americans, however, apparently did not greatly reduce sucker populations. Only after the dams blocked their migration routes and altered flowing-river habitats did some sucker species experience declines. Post-impoundment declines may have resulted from over-harvest because of the suckers being concentrated below the dams.

Suckers need an unconsolidated substrate for foraging. Chronic sedimentation causes stream bottoms to become imbedded with silt, making foraging more difficult, and successful spawning less likely. In addition non-native predators, especially the flathead and blue catfish, decrease the survival of young suckers (NatureServe 2000b). Measures to control sedimentation, careful management of non-native fish, and, where

appropriate, measures to assist in fish passage could insure long-term survival of rare suckers.

The rare sturgeons are all large, long-lived fish. The very long period before reaching reproductive maturity and dams that block migration routes have led to declines. Most of the species discussed in this Assessment currently receive some form of Federal protection, either listing or candidate for listing, and they are not legally harvestable, although all sturgeons have historically been considered sport fish. Their continued survival will be contingent on re-establishing spawning runs and protecting immature fish. Like many large river mussels, these long-lived, big river fish may continue to exist, but if their habitats and migration routes have been destroyed, they may not persist without human intervention. In areas where appropriate habitats exist or are restored, reintroduction or population augmentation may be important management techniques for ensuring the long-term viability of these fishes.

The five livebearers listed here are all narrowly endemic to warm-water springs. Two are either believed to be already extinct, and three are federally listed, and in eminent danger of extinction. One was eliminated by the construction of a reservoir over its spring. The other was lost to herbicide pollution, competition, and eventual hybridization (NatureServe 2000b). The other three livebearers are currently facing these same threats, in addition to draw-down of the aquifers where they exist. The long-term survival of these species in the wild depends on managing the entire aquifers where the livebearers occur, with careful consideration for the needs of these endemic fish.

The topminnows and studfish are also narrow endemics associated with a series of springs, or short stream sections. Groundwater drawdown has significantly impacted some of these fish, especially the Barrens topminnow. Collection for bait or aquarium trade may have also reduced the numbers of some populations, but was probably only a significant factor when droughts caused them to be concentrated in small areas. Captive breeding programs and long-term plans for water supply and use in the areas affecting these fishes would help to ensure their long-term survival.

The pygmy sunfish listed here are found in heavily vegetated springs, swamps, roadside ditches, and small streams. They are most vulnerable because of their short lifespan. Removing vegetation from the areas where they occur also threatens their continued existence.

The sculpins listed here are all narrow endemics found in small headwater streams or cold springs. Although the pygmy sculpin, found in a single spring, is potentially threatened by groundwater contamination and aquifer draw down, the spring is used as a town water supply, and the fish is currently carefully monitored. However, because it is restricted to such a small geographic area, it is vulnerable.

The headwater sculpin species are threatened by commercial and residential development. Chronic sedimentation could reduce their food supply or interfere with reproduction. Although populations of these fish exist in small geographic areas, they are relatively abundant where they are found. Activities that improve or maintain habitat and water quality would help ensure their continued existence.

The bass are all narrow endemics. They are potentially threatened with hybridization or competition, to a lesser extent, with non-native fish. Fishing pressure could affect these species.

The pupfish listed here are all narrow endemics. The three pupfish are endemic to small geographically isolated areas in Texas; two are restricted to springs where impoundments and aquifer drawdown have had significant adverse impacts (NatureServe 2000a, Elliott 2000). Sheepshead minnows, not native to the areas where the pupfish are found have been introduced, and compete with or hybridize with all three species. Water pollution has also affected the Pecos pupfish. Potential for long-term survival of the two spring-inhabiting species of pupfish in the wild is low.

The cavefish are all narrow endemics. In addition to their endemism, the cavefish are threatened by life histories that result in extremely low population numbers (Hobbs 1992).

Chemical, non-point source water pollution associated with agriculture and urban development could contribute to declines in these sensitive fish. Surface aquifer recharge areas may contribute chemicals that disrupt the essential chemoreception in blind cavefishes.

The Waccamaw silverside is restricted to Lake Waccamaw. Its short lifespan, just over 1 year, vulnerable to unsuccessful spawning in a single season. The water quality in this lake is affected by nutrient loading from shoreline homes, agriculture, and intensive timber harvesting in the swamps surrounding the lake (Shute 1997). The recent, natural invasion of the native brook silverside into Lake Waccamaw may pose a threat from competition to the Waccamaw silverside, but the likelihood of this is unknown at present (J.R. Shute Pers. Comm.).

The Alabama shad is a marine species that migrates into major rivers to spawn. Dams have blocked many of rivers, preventing extensive spawning runs.

#### **4.2.16 Amphibians**

Dodd (1997) noted that, although some amphibian populations are known to fluctuate substantially from year to year, few long-term data sets exist to document whether this is a natural occurrence. As mentioned for other groups of aquatic animals, assessing conservation status is difficult without this information. Therefore, until better information is available, the list of rare amphibians included in this discussion should be considered only a representative sample of threatened species.

The 31 rare amphibians ([Table 9](#)) include: 2 frogs, 1 toad, and 28 salamanders ([Figure 16](#)). Two species (the toad and one salamander) are terrestrial as adults but lay their eggs in ephemeral ponds. The other 29 species use the aquatic environment year round, including the breeding season. The primary habitats where these amphibians are found are shown in [Figure 17](#). Rivers and lakes are not frequently used by any of the rare amphibians included here. Sixteen of the nineteen salamanders discussed are associated with subterranean streams and springs of the Edward's Aquifer in central Texas.

Most amphibians are predators feeding primarily on invertebrates as adults and larvae (tadpoles) (Petranka 1998). Female salamanders of some species protect their eggs. The frogs and toad lay their eggs in ponds and abandon them. The flatwoods salamander lays its eggs in areas that are likely to be temporarily flooded after heavy rains (Petranka 1998).

The rare amphibians included in this Assessment are not distributed uniformly across the South. [Figure 18](#) shows three significant clusters of amphibian occurrences. The first cluster is in Central Texas, principally the Edward's Aquifer, where groundwater habitats support a variety of species. A second cluster along the Appalachian Mountains is the result of several geographically restricted salamander species associated with flowing streams and streamside habitats. A third concentration of rare amphibian occurrences extends across the Florida panhandle, where salamanders, newts, and an amphiuma are the species of concern. Dodd (1997) noted the same areas of importance, and included the Edwards Plateau and the Interior Highlands as important areas for amphibian diversity.

#### **4.2.17 Threats to amphibians**

Amphibians are subject to a variety of direct and indirect threats to survival, including bait collecting (USDA Forest Service 2001, Benz and Collins 1997), removal of mature hardwood trees along streams (Petranka 1998), intensive ground-disturbing activities associated with timber extraction (Petranka and others 1994, Petranka 1998) and acid rain (Petranka 1998). Dodd (1997) suggested that the different life history stages (eggs, larvae, young, adults) might have different sensitivities to environmental perturbations.

Several rare amphibians primarily associated with perennial streams and streamside habitats are especially vulnerable because of their geographically restricted distributions (Petranka 1998). In addition, removing beaver has reduced the number of southern wetland habitats (White and Wilds 1997, Herrig and Bass 1998), further isolating many amphibian populations. Dodd (1997) also noted that if populations fluctuations reported for some amphibians are natural, small, isolated populations might be especially at risk.

Subterranean species are sensitive to sedimentation, and seepage of even small quantities of chemicals or nutrients into the aquifers (Petranka 1998, Elliott 2000).

Amphibians associated with perennial streams and streamside are affected by the removal of riparian vegetation, thus they would benefit from the careful management of appropriately sized buffer strips.

Amphibians associated with ephemeral ponds on the Atlantic and Gulf Coastal Plains are threatened by changes in hydrology brought on by intensively forest management, agricultural, or urban development. In these areas, wetlands used by these amphibians are often altered, by deliberately draining land with perched water tables (Segal and others 1987, Miwa and others 1999) or through indirect effects of other intensive land management activities (Petranka 1998, Palis 1996, and Vickers and others 1985). Herbicides used in conjunction with timber harvests may also affect amphibians, but as with many other groups discussed here, sensitivity of amphibians to chemicals is largely unknown (Dodd 1997). Dodd (1997) noted that forest community changes associated with silvicultural activities such as, conversion of deciduous forests to pine forests could result in reduced amphibian diversity.

Other factors that may affect rare amphibians include water quality changes because of mining, acid precipitation, or runoff from road cuts. Changes in pH may have adverse effects, especially on eggs and larval stages, and can inhibit growth and feeding (Dodd 1997). Other chemical pollutants are known to mimic hormones, and thus may interfere with reproductive success (Dodd 1997). Ultraviolet light (UVB) is also known to affect larval hatching success. This effect is compounded by low pH (Dodd 1997).

Roads can have several adverse effects, including acting as barriers that prevent adults from migrating between nonbreeding and breeding habitats. Noise and light associated with roads may also interfere with the ability of frogs and toads to hear calls or to see and catch prey (Dodd 1997). Many rare amphibians use terrestrial habitats; they are discussed in [TERRA 1 Chapter](#) and [TERRA 5 Chapter](#).

#### **4.2.18 Future for amphibians**

Sixteen of the nineteen salamanders included here are associated with subterranean streams and springs. These species are dependent on the Edward's Aquifer in central Texas and are affected by rapid agricultural and urban growth in this area. Although the only known location for the Valdina Farms sinkhole salamander has been flooded by a reservoir, and the species may no longer exist (NatureServe 2000b), the more common threat to the salamanders in this region is water withdrawal from Edward's Aquifer.

Three additional subterranean or spring-associated salamanders are included in this Assessment. One is known from northern Oklahoma and Arkansas, another from southern Tennessee and northern Alabama, and the third from southwestern Georgia and northern Florida. All three of these species are apparently far less threatened than are their Texas counterparts. However, like other subterranean species, seepage of even small quantities of chemicals or nutrients into the aquifers, and sedimentation could pose significant threats to their continued existence (Petranka 1998).

The amphibians associated with perennial streams and stream sides include six salamanders restricted to small geographic areas in the Southern Appalachian Mountains, two salamanders and a frog restricted to the Gulf Coastal Plain, and a salamander from the Atlantic Coastal Plain in North Carolina. Because of their restricted ranges, these amphibians are all vulnerable to relatively small disturbances, which may further isolate populations. Perturbations could result from intensive ground disturbing activities associated with timber harvesting, altering wetlands, and stream sedimentation (Petranka 1998).

Herrig and Bass (1998) demonstrated the importance of the dispersal mechanism that beaver ponds provided to amphibians, prior to the beaver's extirpation in the 1700's. Because of the greatly diminished riparian habitat provided by beavers, gene dispersal between salamander populations is restricted in some areas. Another threat is the collection of salamanders for bait (Petranka 1998), which often happens with little regard to species. Acid precipitation and sedimentation in streams may also contribute to the decline of some salamanders in this region. All six of these stream-dwelling salamanders are located primarily on land administered by the National Park Service and the Forest Service.

Three rare salamanders and a frog are associated with perennial streams and streamsides near the Gulf and Atlantic Coasts. They are most affected by the removal of

riparian vegetation. In addition, as discussed above, the small number of beaver ponds present in these areas restricts gene flow between populations. Maintenance of streamside buffers would increase the likelihood of long-term existence of these amphibians.

The final group of amphibians includes four salamanders, a frog, and a toad, all of which are associated with ephemeral ponds. Land management activities that result in rapid runoff instead of retention of standing pools of water are detrimental to these species. For example, the flatwoods salamander and Houston toad have suffered significant range reductions brought on by certain land management activities, including land clearing, ditching, draining and filling of wetlands, and hydrological alteration brought on by mechanical disturbance of the soil (Jensen 1999, Petranka 1998, and NatureServe 2000b). Restoring and protecting important ephemeral ponds may be necessary to ensure the continued existence of the flatwoods salamander (US Federal Register: April 1, 1999). Land uses that alter habitats required by the flatwoods salamander threaten the species.

The Texas Parks and Wildlife Department now manages two preserves for the recovery of the Houston toad (Fostey 2001), which should ensure the survival of this species, at least for the short-term. The other four remaining species of ephemeral pond-dwelling amphibians (three salamanders and one frog) have apparently not been affected as severely as those discussed above.

#### 4.2.19 Reptiles

Although Buhlmann and Gibbons (1997) reported that historical information needed to accurately determine the status of many North American aquatic reptiles is lacking, they concluded that more than half of the southeastern aquatic reptile fauna is jeopardized. Because of this lack of information, the list included in this Assessment should probably be considered as only an indicator of the trends in southeastern aquatic reptile status. However, Buhlmann and Gibbons (1997) noted that the Southeast contains North America's greatest diversity of freshwater turtles.

The 19 rare reptiles ([Table 10](#)) discussed here include 1 crocodile, 4 snakes, and 14 turtles ([Figure 19](#)). These reptiles are typically found in flowing rivers or calm waters of swamps and bogs ([Figure 20](#)); none are known depend on groundwater habitats or lake habitats. Most of these reptiles require basking sites such as logs or boulders that protrude from the water. Except for the live-bearing snakes of the genus *Nerodia*, all of these reptiles require undisturbed gravel bars or soft banks for egg laying (Wilson 1995). Most of these rare reptiles are long-lived and require several years to reach sexual maturity (White and Wilds 1997). Invertebrates, fish, and amphibians are their main food items. An exception is the Alabama redbelly turtle, an herbivore that feeds on aquatic plants (NatureServe 2000b, USDI Fish and Wildlife Service 2000, Wilson 1995).

Two areas in the South are known to have concentrations of rare reptiles ([Figure 21](#)). One area in west Texas includes the Rio Grande and Pecos River systems, and another extends from central and southern Mississippi into the panhandle of Florida ([Figure 21](#)) (NatureServe 2000b). Other rare reptile occurrences are scattered throughout southern Florida, the Southern Appalachian Mountains, western Tennessee and Kentucky, and central Texas (Wilson 1995).

#### **4.2.20 Threats to reptiles**

Many rare reptiles are long-lived, narrow endemics (Wilson 1995, Palmer and Braswell 1995) and are subject to extinction from natural chance events or even localized human activities. Seemingly inconsequential activities, such as riding an off-road vehicle on a stream bank, collecting a few turtle eggs for the pet trade, or “plinking” at basking turtles, may in fact be devastating to species whose populations are isolated, and who may have already experienced severe population declines. However, in comparison with the other aquatic animals included in this Assessment, these reptiles may be relatively resilient to, or capable of adapting to habitat changes (NatureServe 2000b). Buhlmann and Gibbons (1997) emphasized the lack of ecological knowledge about many aquatic reptiles; they could be more vulnerable than we know. Certain aspects of their life histories could be easily disrupted, resulting in population declines. Two species that are not narrowly endemic are the copperbelly water snake and bog turtle, which both have relatively widespread but spotty distributions. Thus, they are also subject to extinction from natural chance events or localized human activities.

The illegal pet trade also could have a significant impact on some of these reptile populations (Buhlmann and Gibbons 1997), especially those small turtles. Overharvest for food (largely for Asian markets) could have significant impacts on some turtles. Some harvest is apparently legal, but poorly regulated (Buhlmann and Gibbons 1997). Target practice results in the death or injury of many rare turtles and snakes (NatureServe 2000b).

Pollution and sediment may impact all of these species directly or indirectly through a reduction in their food organisms (NatureServe 2000b). The 16 egg-laying species are potentially affected by direct disturbances to their nests (Conant and Collins 1998). Most nests are close to water; the eggs often remain buried for months. Off-road vehicle riding, trampling, or other human activities could destroy these nests (NatureServe 2000b).

The reptiles that prefer flowing water have been impacted by dams, channelization, and dredging (NatureServe 2000b). These activities often remove logs which are essential basking sites that extend out of the water. The Texas species have also been impacted by water withdrawal (NatureServe 2000b).

The species that prefer standing water in bogs or swamps have lost habitat because of wetland alterations, removal of basking logs, and loss of beaver ponds (NatureServe 2000b, Herrig and Bass 1998).

#### **4.2.21 Future for reptiles**

The loss of beaver and the wetlands they create has greatly reduced the available habitat for bog turtles and copperbelly water snakes. Natural range expansion and genetic dispersal for these species requires an interconnection of suitable aquatic habitats (Herrig and Bass 1998). However, since beaver are increasing in the South, these situations may improve.

Removing water for irrigation, industrial, and urban uses; lowering of stream flows; and pollution resulting from agricultural practices have contributed to the decline of rare aquatic reptiles in Texas (NatureServe 2000b). Development and implementation of

management plans to provide appropriate amounts and quality of water would increase the long-term survival potential for these species.

Identification and protection of important nesting areas along waterways would improve the future prospects of these long-lived reptiles.

## 5 Summary Conclusions

Presently, the major threats to our southern aquatic animals include population fragmentation resulting from impoundments and other habitat alterations, sedimentation, and other pollutants. Other threats include homogenization of the aquatic communities, resulting from species introductions, and interbasin connections. Grumbine (1990) noted difficulties in conserving rare species: “Providing for viable populations of native species on Federal lands will require some unprecedented combinations of administrative and legal reform.” Grumbine considered restoring natural fire cycles, reintroducing extirpated and endangered species, closing roads, and reforestation as important components of this reform.

The extraordinary diversity of aquatic animals in the Southeastern United States still exists today in spite of the many threats to their environments. Sustaining these animals and their habitats will require surmounting many difficult challenges.

## 6 Needs for Additional Research

Benz and Collins (1997) summarized *Southeastern Aquatic Fauna in Peril: the southeastern perspective*, and noted several recurrent themes for all groups of southeastern aquatic animals. These themes were discussed in this Assessment, and summarized by Shute and others (1997). For example, distributional information is relatively well documented for most southern fish, but there are still gaps in our knowledge. Even less is known about the other aquatic animal groups included here. Baseline information is necessary to document declines, or to predict extirpations and extinctions.

General distribution information, and long-term population data are not presently available for any aquatic animal groups. These data would help in predicting extinctions (Etnier 1994, Angermeier 1995, Lydeard and Mayden 1995). Grumbine (1990) also noted insufficient knowledge of population dynamics.

Life history and habitat preferences are critically needed for all life stages of all the aquatic animal groups discussed here, and especially the aquatic insects. Several authors have emphasized that different life stages (eggs, larvae, juveniles) may have different habitat requirements that could explain their vulnerability. Rakes and others (1999) provided some examples of previously unknown habitat requirements and life history habits of larval boulder darters and spotfin chubs that could explain their sensitivity. O’Dee and Watters (2000) commented that proper identification of host fish species for rare mussels would provide information needed by resource agencies to manage for preservation or conservation of rare mussels.

Other authors (Dodd 1997, Neves and others 1997, Shute and others 1997) suggested that early life history stages of mussels, amphibians, and fishes might be more sensitive to various pollutants than adults are. To ensure that water-quality standards are adequate to protect the more sensitive animals, toxicity testing of rare animals or their surrogates has been recommended by these authors.

Etnier and Starnes (1991) noted that fish found in springs and medium-sized rivers were disproportionately jeopardized. They suggested that this conclusion be documented by studying other groups of aquatic animals found in these habitat types.

The information recommended above will be of little use, if it is not made available to those who should use it. Grumbine (1990) recommended constructing a regional database of species of concern that would include information on habitat requirements, reserves, connectivity, zoning, buffers, and ecological restoration. Some of this information already exists in various places (NatureServe, and Natural Heritage programs for example), but appropriately interpreted versions could be made available for various types of users. This Assessment is intended to be a step in that direction.

Finally, captive propagation techniques need to be developed for some mussels (Neves and others 1997) and fish (Rakes and others 1999). Reintroductions and population augmentation may help to restore or manage populations of declining animals. For example, mussels are being reintroduced into main stem riverine habitats in the Tennessee River, U.S. Federal Register 2001b). Similar proposals are underway for fish (U.S. Federal Register 2001a). In some situations, reintroductions may be appropriate for sensitive species that cannot invade these restored or improved areas (Dunn and others 2000).

## 7 Literature Cited

Abell, Robin A.; Olson, David M.; Dinerstein, Eric [and others]. 2000. Freshwater ecoregions of North America a conservation assessment. Washington, DC: Island Press. 319p.

Ahlstedt, Steve. 1983. Recovery plan for the green-blossom pearly mussel *Epioblasma (=Dysnomia) torulosa gubernaculum* (Reeve, 1865). Atlanta, GA: U.S. Department of the Interior, Fish and Wildlife Service. 50 p.

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

Benke, A.C. 1990. A perspective on America's vanishing streams. *Journal of the North American Benthological Society*. 9:77-88.

Benz, G. W.; Collins, D.E. 1997. Aquatic fauna in peril: the southeastern perspective. Decatur, GA.: Southeast Aquatic Research Institute, Lenz Design and Communications. Special Publication 1. 554 p.

Bogan, Arther E. 1993. Freshwater bivalve extinctions (Mollusca: Unionoida): A search for causes. *American Zool.* 33: 599-609.

Buhlmann, K. A.; Gibbons, J. W. 1997. Imperiled aquatic reptiles of the southeastern United States: historical review and current conservation status. Pp. 201-232 In: Benz, G.W.; Collins, D.E., eds. Aquatic Fauna in Peril: the southeastern perspective: Special Publication Southeastern Aquatic Research Institute. Lenz Design and Communications, Decatur, GA, 554 p.

Burr, Brooks M.; Warren, Melvin L., Jr. 1986. A distributional atlas of Kentucky fishes. Frankfort, KY.: Kentucky Nature Preserves Commission. 398 p.

Burr, B. M.; Stoeckel, J. N. 1999. The natural history of madtoms (genus *Noturus*), North America's diminutive catfishes. American Fisheries Society Symposium 24:51-101.

Coats, R. N.; Miller, T.O. 1981. Cumulative silvicultural impacts on watersheds: a hydrologic and regulatory dilemma. Environmental Management 5:147-160.

Conant, Roger; Collins, Joseph T. 1998. A field guide to reptiles and amphibians; Eastern and Central North American. Boston: Houghton Mifflin Co. 616 p.

Crisman, T.C. 1992. Natural lakes of the southeastern United States: origin, structure, and function. In: Hackney, C.T.; Adams, S.M.; Martin, W.H., eds. Biodiversity of the Southeastern United States, Aquatic Communities. New York: John Wiley & Sons, Inc.: 475-538.

Davis, J.; Hurst, R.; Goranflo, M. Jr.; Whitlock, A. 2001. A river runs through it. Forum for Applied Research and Public Policy 16:103-108.

Dennis, Sally D. 1985. Distributional analysis of the freshwater mussel fauna of the Tennessee River System, with special reference to possible limiting factors of siltation. Nashville, TN.: Tennessee Wildlife Resources Agency. 85(2): 171.

Dodd, C. K., Jr. 1997. Imperiled amphibians, a historical perspective. Pp. 165-200 In: Benz, G.W.; Collins, D.E., eds. Aquatic Fauna in Peril: the southeastern perspective: Special Publication Southeastern Aquatic Research Institute. Lenz Design and Communications, Decatur, GA, 554 p.

Dunn, H.L.; Sietman, B.E.; Kelner, D. E. 2000. Evaluation of recent unionid (*Bivalvia*) relocations and suggestions for future relocations and reintroductions. Pp 169-189. In: R. A. Tankersley, D. I Warmolts, G. T. Watters, B. J. Armitage, P. D. Johnson, and R. S. Butler (eds.) Freshwater Mollusk Symposium Proceedings. Ohio Biological Survey, Columbus, Ohio. 274 pp.

Elliott, W. R. 2000. Conservation of the North American cave and karst biota. In: H. Wilkens, D. C. Culver, and W. F. Humphreys (editors) Subterranean Ecosystems.

Etnier, D.A. 1994. Our southeastern fishes--what have we lost and what are we likely to lose. Southeastern Fishes Council Proceedings 29: 5-9.

Etnier, D. A. 1997. Jeopardized southeastern freshwater fishes: a search for causes. Pp. 87-104 In: Benz, G.W.; Collins, D.E., eds. Aquatic Fauna in Peril: the southeastern

perspective: Special Publication Southeastern Aquatic Research Institute. Lenz Design and Communications, Decatur, GA, 554 p.

Etnier, D.A.; Jenkins, R. E. 1980. *Noturus stanauli*, a new madtom catfish (Ictaluridae) from the Clinch and Duck rivers, Tennessee. Bulletin of the Alabama Museum of Natural History 5:17-22.

Etnier, D.A.; Starnes, W. C. 1991. An analysis of Tennessee's jeopardized fish taxa. Journal of the Tennessee Academy of Science 66:129-133.

Etnier, D.A.; Starnes W. C. 1993. The fishes of Tennessee. Knoxville, TN.: The University of Tennessee Press. 681 p.

Fostey, Nathan. 2001. *Bufo houstonensis* Houston toad. Lansing, MI.: University of Michigan Press. 23 p.

Fridell, John A. 1996. Recovery plan for Appalachian elktoe (*Alasmidonta ravelinana*) Lea. Atlanta, GA.: U.S. Department of the Interior, Fish and Wildlife Service. 48 p.

Grumbine, E. 1990. Viable populations, reserve size, and federal lands management: a critique. Conservation Biology 4:127-134.

Harris, S.C.; O'Neil, P.E.; Lago, P.K. 1991. Caddisflies of Alabama. 1991. Bulletin 145. Geological Survey of Alabama, Tuscaloosa, Alabama. 442 p.

Hart, C.W., Jr.; Fuller, Samuel L.H. 1974. Pollution ecology of freshwater invertebrates. New York: Academic Press. 312 p.

Herrig, Jim; Bass, Quentin. 1998. Beaver: The light in the forest. In: SAMAB, Ninth Annual Conference. 1998 November 4-6; Gatlinburg, TN.

Hobbs, H. H., Jr. 1976. Crayfishes (Astacidae) of North and Middle America. U.S. Environmental Protection Agency Water Pollution Control Research Series 18050 ELDO5/72 (Second Printing). Cincinnati, OH. 173 pp.

Hobbs, H. H., Jr. 1981. The crayfishes of Georgia. Smithsonian Contributions to Zoology 318: 1-549.

Hobbs, Horton H., Jr. 1989. An illustrated checklist of the American crayfishes (Decapoda: Astacidae, Cambaridae and Parastacidae). Washington, DC: Smithsonian Contributions to Zoology. 480: 236 p.

Hobbs, H. H. III. 1992. Caves and springs. In: Biodiversity of the Southeastern United States, Aquatic Communities. New York: John Wiley & Sons, Inc.: 59-131

Hubbs, C. 1995. Springs and spring runs as unique aquatic systems. Copeia 1995:989-991.

Hughes, M.H.; Parmalee, P.W. 1999. Prehistoric and modern freshwater mussel (Mollusca: Bivalvia: Unionidae) faunas of the Tennessee River: Alabama, Kentucky, and Tennessee. *Regulated Rivers: Research & Management*. 15:25-42.

Jenkins, Robert E.; Burkhead, Noel M. 1993. *Freshwater fishes of Virginia*. Bethesda, MA.: American Fisheries Society. 1079 p.

Jenkinson, J. J.; Todd, R. M. 1997. Management of native mollusk resources. Pp. 283-305 In: Benz, G.W.; Collins, D.E., eds. *Aquatic Fauna in Peril: the southeastern perspective: Special Publication Southeastern Aquatic Research Institute*. Lenz Design and Communications, Decatur, GA, 554 p.

Jensen, J.B. 1999. Flatwoods salamander. Pp. 92-93 In: *Protected animals of Georgia*. Georgia Department of Natural Resources, Social Circle, GA. 247 pp.

Johnson, Waynon W.; Finley, Mack T. 1980. *Handbook of acute toxicity of chemicals to fish and aquatic invertebrates*. Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service. Resource Publication 137. 93 p.

Layzer, J.B.; Gordon, M.E.; Anderson, R.M. 1993. Mussels: the forgotten fauna of regulated rivers. A case study of the Caney Fork River. *Regulated Rivers* 8:63-71.

Lee, David S.; Gilbert, C.R.; Hocutt, C.H. (and others). 1980. *Atlas of North American freshwater fishes*. Raleigh, N.C.: North Carolina State Museum of Natural History. 854 p.

Lydeard, C.; Mayden, R.L. 1995. A diverse and endangered aquatic ecosystem of the southeastern United States. *Conservation Biology* 9:800-805.

Master, L.L.; Flack, S.R.; Stein, B.A. 1998. *Rivers of life: critical watersheds for protecting freshwater biodiversity*. The Nature Conservancy, Arlington, VA. 71 pp.

Mayer, Foster L., Jr.; Ellersick, Mark R. 1986. *Manual of aquatic toxicology: interpretation and data base for 410 chemicals and 66 species of freshwater animals*. Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service. Resource Publication 160. 579 p.

McGregor, S. W.; Shepard, T. E. 1995. Investigations of slackwater darter, *Etheostoma boschungii*, populations, 1992-1994. Circular 184. Tuscaloosa, AL: Geological Survey of Alabama. 33 p.

Meritt, R.W.; Cummins, K.W. 1984. *An introduction to the aquatic insects of North America*, 2<sup>nd</sup> edition. Kendall Hunt, Dubuque, Iowa.

Mettee, M.F.; O'Neil, P.E.; Pierson, J.M. 1996. *Fishes of Alabama and the Mobile Basin*. Birmingham, AL: Oxmoor House. 820 p.

Mishall, G.W.; Petersen, R.C.; Cummings, K.W. [and others]. 1983. Interbiome comparison of stream ecosystem dynamics. *Ecological Monographs* 53:1-25.

Miwa, Masato; Aust, W. Michael; Burger, James A.; and others. 1999. Harvesting and site preparation effects on the hydroperiods of wet pine plantations. Tenth Biennial Southern Silvicultural Research Conference. Shreveport, LA February 16-18, 1999. 293-297.

Morse, J.C.; Stark, B.P.; McCafferty, W.P.; Tennessen, K.J. 1997. Southern Appalachian and other southeastern streams at risk: implications for mayflies, dragonflies and damselflies, stoneflies, and caddisflies. Pp. 17-42 In: Benz, G.W.; Collins, D.E., eds. Aquatic Fauna in Peril: the southeastern perspective: Special Publication Southeastern Aquatic Research Institute. Lenz Design and Communications, Decatur, GA, 554 p.

NatureServe. 2000a. An online encyclopedia of life. [database]. Version 1.1. Arlington, Virginia, USA: Association for Biodiversity Information. <http://www.natureserve.org/>. (May 16).

NatureServe. 2000b. An online encyclopedia of life. [database]. Version 1.1. Arlington, Virginia, USA: Association for Biodiversity Information. <http://www.natureserve.org/>. (May 17).

NatureServe. 2001a. An online encyclopedia of life. [database]. Version 1.5. Arlington, Virginia, USA: Association for Biodiversity Information. <http://www.natureserve.org/>. (July 15).

NatureServe. 2001b. An online encyclopedia of life. [database]. Version 1.5. Arlington, Virginia, USA: Association for Biodiversity Information. <http://www.natureserve.org/>. (August 17).

Neves, R.J.; Bogan, A.E.; Williams, J.D. (and others). 1997. Status of aquatic mollusks in the Southeastern United States: A downward spiral of diversity. In: Aquatic fauna in peril: The Southeastern perspective. Special Publication 1. Decatur, GA.: Southeast Aquatic Research Institute, Lenz Design and Communications.

Nico, L.G.; Fuller, P.L. 1999. Spatial and temporal patterns of nonindigenous fish introductions in the United States. *Fisheries* 24:16-27.

O'Dee, S. H., and G. T. Watters. 2000. New or confirmed host identifications for ten freshwater mussels. Pp. 77-82 IN: R. A. Tankersley, D. I Warmolts, G. T. Watters, B. J. Armitage, P. D. Johnson, and R. S. Butler (eds.) Freshwater Mollusk Symposium Proceedings. Ohio Biological Survey, Columbus, Ohio. 274 pp.

Palis, J.G. 1996. Flatwoods Salamander (*Ambystoma cingulatum* Cope). Element Stewardship Abstract. *Natural Areas Journal*. 16: 49-54.

Palmer, William M.; Braswell, Alvin L. 1995. Reptiles of North Carolina. Chapel Hill, NC: The University of North Carolina Press. 412 p.

Parmalee, Paul W.; Bogan, Author E. 1998. The freshwater mussels of Tennessee. Knoxville, TN.: The University of TN Press. 328 p.

Peck, S.B. 1998. A summary of diversity and distribution of the obligate cave-inhabiting faunas of the United States and Canada. *Journal of Cave and Karst Studies* 60:18-26.

Pennak, Robert W. 1989. *Freshwater invertebrates of the United States*, 3d ed. New York: John Wiley and Sons, Inc. 628 p.

Petranka, James W. 1998. *Salamanders of the United States and Canada*. Washington and London: Smithsonian Institution Press. 587 p.

Petranka, J.W.; Brannon, M.P.; Hopey, M.E. [and others]. 1994. Effects of timber harvesting on low elevation populations of Southern Appalachian salamanders. *Forest Ecology and Management*. 67: 135-147.

Pflieger, William L. 1975. *The Fishes of Missouri*. Jefferson City, MO.: Missouri Department of Conservation. 343 p.

Pflieger, William L. 1996. *The Crayfishes of Missouri*. Jefferson City, MO.: Missouri Department of Conservation. 152 p.

Rand, Gary M.; Petrocelli, S.R. 1985. *Fundamentals of aquatic toxicology*. New York: Hemisphere Publishing Corp. 666 p.

Rakes, P.L.; Shute, J.R.; Shute, P.W. 1999. Reproductive behavior, captive breeding, and restoration ecology of endangered fishes. *Environmental Biology of Fishes*. 55:31-42.

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

Richter, B.D.; Braum, D.P.; Mendelson, M.A. [and others]. 1997. Threats to imperiled freshwater fauna. *Conservation Biology*. 11: 1081-1093.

Rohde, F.C.; Arndt, R.G. 1987. Two new species of pygmy sunfishes (Elassomatidae, *Elassoma*) from the Carolinas. *Proceedings of the Academy of Natural Sciences Philadelphia* 139:65-85.

Ryon, M.G. 1986. The life history and ecology of *Etheostoma trisella* (Pisces: Percidae). *American Midland Naturalist* 115: 73-86.

Schuster, G.A. 1997. Resource management of freshwater crustaceans in the southeastern United States. Pp. 269-282 In: Benz, G.W.; Collins, D.E., eds. *Aquatic Fauna in Peril: the southeastern perspective*: Special Publication Southeastern Aquatic Research Institute. Lenz Design and Communications, Decatur, GA, 554 p.

Segal, D.S.; Neary, D.G.; Best, G.R.; Michael, J.L. 1987. Effect of ditching, fertilizing, and herbicide application on groundwater levels and groundwater quality in a flatwood spodosol. In: *Proceedings soil and crop science society of Florida*. Florida agricultural Experiment Station Journal Series No. 7942. 46:107-112.

Sheldon, A.E. 1988. Conservation of stream fishes: patterns of diversity, rarity, and risk. *Conservation Biology* 2:149-156.

Shelton, Douglas N. 2000. A systematic list of mollusks in the northern Gulf of Mexico off the coast of Alabama [web application].

<http://home.hiwaay.net/~dwills/alaview.html> (August 24).

Shelton, Douglas N. 2000. A systematic list of terrestrial mollusks from the state of Alabama. [web application]. <http://home.hiwaay.net/~dwills/alaview.html> (August 24).

Shute, J.R. 1997. Waccamaw silverside *Menidia extensa* Hubbs and Raney. P. 11 In: Endangered, threatened, and rare fauna of North Carolina Part IV. A reevaluation of the freshwater fishes. Occasional papers of the North Carolina State Museum of Natural Sciences and the North Carolina Biological Survey. 11: 106 p.

Shute, P.W.; Biggins, R.G.; Butler, R.S. 1997. Management and conservaton of aquatic resources: a historical perspective and recommendations for incorporating ecosystem management. Pp. 445-466 In: Benz, G.W.; Collins, D.E., eds. Aquatic Fauna in Peril: the southeastern perspective: Special Publication Southeastern Aquatic Research Institute. Lenz Design and Communications, Decatur, GA, 554 p.

Skelton, C.E. 2001. New dace of the genus *Phoxinus* (Cyprinidae: Cypriniformes) from the Tennessee River Drainage, Tennessee. *Copeia* 2001:118-128.

Smith-Vaniz, William F. 1968. Freshwater fishes of Alabama. Auburn, AL.: Auburn University. 211 p.

Stein, B.A.; Kutner, L.S.; Adams, J.S. 2000. Precious heritage the status of biodiversity in the United States. New York: Oxford University Press. 399 p.

Taylor, C.A.; Warren, M.L., Jr.; Fitzpatrick, J.F., Jr. [and others]. 1996. Conservation status of crayfishes of the United States and Canada. *Fisheries*. 21(4): 25-38.

Thoma, R.F. 2000. *Cambaraus (Jugicambarus) jezerinaci* (Crustacea: Decapoda: Cambaridae), a new species of crayfish from the Powell River drainage of Tennessee and Virginia. *Proceedings of the Biological Society of Washington* 113:731-738.

Thompson, Fred G. 2000. Field guide to the freshwater snails of Florida [web application]. <http://www.flmnh.ufl.edu/natsci/malacology/fl-snail/snails7.htm> (August 24).

Todd, J.H. 1973. The chemical language of fishes. *Scientific American* 224:99-108.

Ungate, Christopher D. 1990. Final environmental impact statement Tennessee River and reservoir system operation and planning review. Knoxville, TN.: TVA/RDG/Eqs-91/1. 198 p.

U.S. Department of Agriculture, Forest Service. 1989. Final environmental impact statement vegetation management in the Appalachian Mountains. Atlanta, GA.: U.S. Department of Agriculture, Forest Service, Southern Region. 331 p.

U.S. Department of the Interior, Fish and Wildlife Service. 1992. Endangered and threatened species of the southeastern United States (The Red Book). Atlanta, GA.: U.S. Department of the Interior, Fish and Wildlife Service. [Not paged].

U.S. Department of the Interior, Fish and Wildlife Service. 2000. Mobile River basin aquatic ecosystem recovery plan. Atlanta, GA.: U.S. Department of the Interior, Fish and Wildlife Service. 128 p.

U.S. Federal Register: December 18, 1997. Final rule to list three aquatic invertebrates in Comal and Hays Counties, TX as endangered. Washington: U.S. Department of the Interior, Fish and Wildlife Service: 62(243): 66295-66304.

U.S. Federal Register: April 1, 1999. Final rule on listing the flatwoods salamander. Washington: U.S. Department of the Interior, Fish and Wildlife Service. 64(62): 15691-15704.

U.S. Federal Register. 2001a. Endangered and threatened wildlife and plants; proposed establishment of nonessential experimental population status for 4 fishes into the Tellico River, from the backwaters of Tellico Reservoir upstream to Tellico River mile 33 in Monroe County, Tennessee. Washington: U.S. Department of the Interior, Fish and Wildlife Service. 66(111): 30853-30860.

U.S. Federal Register. 2001b. Endangered and threatened wildlife and plants; establishment of nonessential experimental population status for 16 freshwater mussels and 1 freshwater snail (Anthony's riversnail) in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL. Federal Register 66:32250-32264.

Vannote, R.L.; Minshall, G.W.; Cummings, K.W. [and others]. 1980. The river continuum concept. *Canada Journal of Fisheries & Aquatic Sciences* 37:130-137.

Vickers, C.R.; Harris, L.D.; Swindel, B.F. 1985. Changes in herpetofauna results from ditching of cypress ponds in coastal plains flatwoods. *Forest Ecology and Management*. 11:17-29.

Wallace, J.T.; Webster, J.R.; Lowe, R.L. 1992. High gradient streams of the Appalachians. Pp. 133-191 In: *Biodiversity of the southeastern United States, aquatic communities*. New York: John Wiley & Sons, Inc. 779 pp.

Warren, Melvin L., Jr.; Burr, B.M.; Walsh, S.J. [and others]. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southeastern United States. *Fisheries* 25(10): 7-29.

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: Benz, G.W.; Collins, D.E., eds. *Aquatic Fauna in Peril: the southeastern perspective: Special Publication Southeastern Aquatic Research Institute*. Lenz Design and Communications, Decatur, GA, 554 p.

Welch, Paul S. 1952. *Limnology*. New York: McGraw-Hill Book Company 538 p.

White, P.S.; Wilds, S.P. 1997. Status and trends of the Nation's biological diversity. Fort Collins, CO: U.S. Department of the Interior, Geological Survey. 1:255-313.

Wiggins, B.G. 1977. Larvae of the North American caddisfly genera (Trichoptera). University of Toronto Press, Toronto. 457p.

Wilcove, D.S.; Bean, M.J. 1994. Editors. The big kill: declining biodiversity in America's lakes and rivers. Environmental Defense Fund, Washington, D.C. 276 pp.

Williams, G.P.; Miller, M.G. 1984. Downstream effects of dams on alluvial rivers. U.S. Geological Survey Professional Paper 1286. 83 p.

Williams, J.D.; Warren, M.L., Jr.; Cummings, K.S. [and others]. 1993. Conservation status of freshwater mussels of the United States and Canada. *Fisheries*. 18(9): 6-22.

Williams, J.E.; Johnson, J.E.; Hendrickson, D.A. [and others]. 1989. Fishes of North America endangered, threatened, or of special concern: *Fisheries* 14: 2-20.

Wilson, Lawrence A. 1995. Land manager's guide to the amphibians and reptiles of the South. Chapel Hill, NC: The Nature Conservancy, Southeastern Region. 324 p.

Yeager, Bruce L. 1993. Impacts of reservoirs on the aquatic environment of regulated rivers. Norris, TN: The Tennessee Valley Authority – River Basin Operations Water Resources. 112 p.

## **8 Tables and Figures**

**Table 1--The Association for Biodiversity Information (ABI) maintains an electronic database (NatureServe 2000). The definitions for various levels of imperilment given for individual species by ABI are used in this Assessment**

Rank	Definition
GX	<b>Presumed Extinct</b> (species)—Believed to be extinct throughout its range. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered. <span style="float: right;">Eliminated</span> (ecological communities)—Eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.
GH	<b>Possibly Extinct</b> (species)—Known from only historical occurrences, but may nevertheless still be extant; further searching needed. <span style="float: right;">Presumed</span> Eliminated (Historic, ecological communities)—Presumed eliminated throughout its range, with no or virtually no likelihood that it will be rediscovered, but with the potential for restoration, for example, American Chestnut (Forest).
G1	<b>Critically Imperiled</b> —Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1,000) or acres (<2,000) or linear miles (<10).
G2	<b>Imperiled</b> —Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction or elimination. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000) or acres (2,000 to 10,000) or linear miles (10 to 50).
G3	<b>Vulnerable</b> —Vulnerable globally either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction or elimination. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals.
G4	<b>Apparently Secure</b> —Uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern. Typically more than 100

occurrences and more than 10,000 individuals.

- G5      **Secure**—Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals.
- T#      **Intraspecific Taxon** (trinomial)—The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank. Rules for assigning T-ranks follow the same principles outlined above. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1. A T subrank cannot imply the subspecies or variety is more abundant than the species, for example, a G1T2 subrank should not occur. A vertebrate animal population (e.g., listed under the U.S. Endangered Species Act or assigned candidate status) may be tracked as an infraspecific taxon and given a T rank; in such cases a Q is used after the T-rank to denote the taxon's informal taxonomic status.
- ?      **Inexact Numeric Rank**—Denotes inexact numeric rank
- Q      **Questionable taxonomy that may reduce conservation priority**—Distinctiveness of this entity as a taxon at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or inclusion of this taxon in another taxon, with the resulting taxon having a lower-priority (numerically higher) conservation status rank.

[Return to first reference in text](#)

**Table 2--Aquatic species in seven taxonomic groups were selected for evaluation of their vulnerability to extinction based on the Global Ranking they received from ABI. Global Rankings are based on queries of the database (NatureServe 2000) on the dates indicated**

Taxonomic group	Date of database query	Global rank G1 - G5	<sup>a</sup> Species eliminated	<sup>b</sup> Rare aquatic species	Percentage of group with inadequate data
Crustaceans	5/16/00	335	176	159	5%
Insects	8/17/01	1170	994	176	37%
Snails	5/16/00	277	154	123	9%
Mussels	7/15/01	312	121	191	2%
Fish	5/17/00	810	645	165	8%
Amphibians	5/17/00	218	187	31	0%
Reptiles	5/17/00	369	350	19	1%
Totals		3491	2627	864	

<sup>a</sup>Species were eliminated from further consideration because their Global ranking exceeded G3, they were terrestrial or marine, their taxonomy was undetermined, or their distribution was unknown.

<sup>b</sup>The remaining species evaluated included those with Global ranks of G1 - G3, T1 - T3, GH, and GX

[Return to first reference in text](#)

[Return to second reference in text](#)

[Return to third reference in text](#)

[Return to forth reference in text](#)

**Table 3--Habitat preferences for the rare aquatic species are displayed. Five general habitat categories are evaluated in the Assessment; only habitats that are significantly used are considered**

Primary and secondary habitat types

Taxonomic group	Groundwater		Lakes		Ponds		Rivers		Streams	
	<sup>a</sup> Prim.	<sup>a</sup> Sec.	Prim.	Sec.	Prim.	Sec.	Prim.	Sec.	Prim.	Sec.
Crustaceans	40	40	0	0	52	4	0	0	67	115
Insects	24	28	2	1	2	5	40	43	108	99
Snails	27	18	0	0	2	2	81	77	13	26
Mussels	0	0	0	0	0	0	185	185	6	6
Fish	18	14	1	1	1	2	76	79	69	69
Amphibians	17	17	0	0	6	6	0	0	8	8
Reptiles	0	0	0	0	5	7	7	9	10	0
Totals	126	117	3	2	68	26	389	393	281	323

<sup>a</sup> Prim. = Primary; Sec. = Secondary. These designations do not necessarily imply a constant order or ranking of importance to the taxonomic group

[Return to first reference in text](#)

[Return to second reference in text](#)

**Table 4--The rare aquatic crustaceans evaluated included 159, species of which 9 are Federally listed as threatened or endangered (NatureServe 2000a)**

Scientific name	Common name	<sup>a</sup> Federal status	ABI global rank	<sup>b</sup> Primary habitat	<sup>b</sup> Secondary habitat
<i>Antrolana lira</i>	Madison Cave Isopod	LT	G1	Groundwater	Groundwater
<i>Bouchardina robisoni</i>	A Crayfish		G1	Streams	Streams
<i>Caecidotea</i> sp. 7	A Cave Isopod (Lee County)		G1	Groundwater	Groundwater
<i>Cambarellus blacki</i>	Cypress Crayfish		G1	Ponds	Ponds
<i>Cambarellus diminutus</i>	Least Crayfish		G3	Streams	Streams
<i>Cambarellus lesliei</i>	A Crayfish		G3	Streams	Streams
<i>Cambarellus ninae</i>	A Crayfish		G3	Streams	Streams
<i>Cambarellus schmitti</i>	A Crayfish		G3	Streams	Streams
<i>Cambarus aculabrum</i>	A Crayfish	LE	G1	Groundwater	Groundwater
<i>Cambarus angularis</i>	A Crayfish		G3	Streams	Streams
<i>Cambarus batchi</i>	Bluegrass Crayfish		G3	Ponds	Streams

Cambarus bouchardi	Big South Fork Crayfish	G2G3	Streams	Streams
Cambarus catagius	Greensboro Burrowing Crayfish	G3	Ponds	Streams
Cambarus causeyi	A Crayfish	G1	Streams	Streams
Cambarus chaugaensis	A Crayfish	G2	Streams	Streams
Cambarus conasaugaensis	A Crayfish	G3	Streams	Streams
Cambarus coosawattae	A Crayfish	G1	Streams	Streams
Cambarus cracens	A Crayfish	G1	Streams	Streams
Cambarus cryptodytes	Dougherty Plain Cave Crayfish	G2	Groundwater	Groundwater
Cambarus cymatilis	A Crayfish	G1	Ponds	Streams
Cambarus englishi	A Crayfish	G3	Streams	Streams
Cambarus extraneus	Chickamauga Crayfish	G2	Streams	Streams
Cambarus fasciatus	A Crayfish	G2	Streams	Streams
Cambarus georgiae	Little Tennessee Crayfish	G1	Streams	Streams
Cambarus harti	Piedmont Blue Burrower	G1	Ponds	Streams

Cambarus howardi	Chattahoochee Crayfish	G3	Streams	Streams
Cambarus jonesi	Alabama Cave Crayfish	G3	Groundwater	Groundwater
Cambarus miltus	Rusty Grave Digger	G2	Ponds	Streams
Cambarus obeyensis	Obey Crayfish	G2	Streams	Streams
Cambarus ornatus	A Crayfish	G3	Streams	Streams
Cambarus parrishi	A Crayfish	G1	Streams	Streams
Cambarus pristinus	A Crayfish	G1	Streams	Streams
Cambarus pyronotus	Fire-Back Crayfish	G2	Ponds	Streams
Cambarus scotti	A Crayfish	G3	Streams	Streams
Cambarus sp. 3	(Shelta Cave, Madison Co., Al) (Aviticambarus, Sp B)	G1	Groundwater	Groundwater
Cambarus speciosus	A Crayfish	G2	Streams	Streams
Cambarus spicatus	A Crayfish	G3	Streams	Streams
Cambarus strigosus	A Crayfish	G2	Ponds	Streams
Cambarus subterraneus	A Crayfish	G1	Groundwater	Groundwater

Cambarus tartarus	Oklahoma Cave Crayfish		G1	Groundwater	Groundwater
Cambarus truncatus	Oconee Burrowing Crayfish		G1	Ponds	Streams
Cambarus unestami	A Crayfish		G2	Streams	Streams
Cambarus zophonastes	Hell Creek Cave Crayfish	LE	G1	Groundwater	Groundwater
Distocambarus carlsoni	Mimic Crayfish		G3	Ponds	Streams
Distocambarus crockeri	A Crayfish		G3	Ponds	Streams
Distocambarus devexus	A Crayfish		G1	Ponds	Streams
Distocambarus youngineri	A Crayfish		G1	Ponds	Streams
Fallicambarus burrisi	A Crayfish		G3	Ponds	Streams
Fallicambarus danielae	Speckled Burrowing Crayfish		G2	Ponds	Streams
Fallicambarus devastator	Texas Prairie Crayfish		G3	Ponds	Streams
Fallicambarus gilpini	A Crayfish		G1	Ponds	Streams
Fallicambarus gordoni	A Crayfish		G1	Ponds	Streams
Fallicambarus harpi	A Crayfish		G1	Ponds	Streams
Fallicambarus hortoni	Hatchie Burrowing Crayfish		G1	Ponds	Streams

Fallicambarus jeanae	A Crayfish		G2	Ponds	Streams
Fallicambarus macneesei	A Crayfish		G3	Ponds	Streams
Fallicambarus petilicarpus	A Crayfish		G1	Ponds	Streams
Fallicambarus strawni	A Crayfish		G1G2	Ponds	Streams
Faxonella blairi	A Crayfish		G2	Ponds	Ponds
Faxonella creaseri	A Crayfish		G2	Ponds	Ponds
Hobbseus attenuatus	Pearl Riverlet Crayfish		G2	Streams	Streams
Hobbseus cristatus	A Crayfish		G3	Ponds	Streams
Hobbseus orconectoides	Oktibbeha Riverlet Crayfish		G3	Ponds	Streams
Hobbseus petilus	Tombigbee Riverlet Crayfish		G2	Streams	Streams
Hobbseus valleculus	Choctaw Riverlet Crayfish		G1	Streams	Streams
Hobbseus yalobushensis	A Crayfish		G3	Streams	Streams
Lirceus usdagalun	Lee County Cave Isopod	LE	G1	Groundwater	Groundwater
Orconectes bisectus	Crittenden Crayfish		G2	Streams	Streams
Orconectes blacki	A Crayfish		G2	Streams	Streams

Orconectes carolinensis	North Carolina Spiny Crayfish	G3	Streams	Streams
Orconectes cooperi	A Crayfish	G1	Streams	Streams
Orconectes eupunctus	Coldwater Crayfish	G3	Streams	Streams
Orconectes hartfieldi	A Crayfish	G2	Streams	Streams
Orconectes hathawayi	A Crayfish	G3	Streams	Streams
Orconectes holti	A Crayfish	G3	Streams	Streams
Orconectes incomptus	Tennessee Cave Crayfish	G1	Groundwater	Groundwater
Orconectes jeffersoni	Louisville Crayfish	G1	Streams	Streams
Orconectes jonesi	A Crayfish	G3	Streams	Streams
Orconectes kentuckiensis	A Crayfish	G2	Streams	Streams
Orconectes maletae	A Crayfish	G2	Streams	Streams
Orconectes marchandi	Mammoth Spring Crayfish	G2	Streams	Streams
Orconectes menae	A Crayfish	G3	Streams	Streams
Orconectes mississippiensis	A Crayfish	G2G3	Streams	Streams
Orconectes nana	A Crayfish	G3	Streams	Streams

Orconectes neglectus chaenodactylus	Ringed Crayfish		G5T2	Streams	Streams
Orconectes pellucidus	Eyeless Crayfish		G3	Groundwater	Groundwater
Orconectes rafinesquei	A Crayfish		G2	Streams	Streams
Orconectes ronaldi	A Crayfish		G3	Streams	Streams
Orconectes saxatilis	Kiamichi Crayfish		G1	Streams	Streams
Orconectes sheltae	Shelta Cave Crayfish		G1	Groundwater	Groundwater
Orconectes shoupi	Nashville Crayfish	LE	G1	Streams	Streams
Orconectes virginiensis	Chowanoke Crayfish		G3	Streams	Streams
Orconectes williamsi	A Crayfish		G2	Streams	Streams
Orconectes wrighti	A Crayfish		G1	Streams	Streams
Palaemonetes cummingi	Squirrel Chimney Cave Shrimp	LT	G1	Groundwater	Groundwater
Palaemonias alabamae	Alabama Cave Shrimp	LE	G1G3	Groundwater	Groundwater
Palaemonias ganteri	Mammoth Cave Shrimp	LE	G1	Groundwater	Groundwater
Procambarus acherontis	Orlando Cave Crayfish		G1	Groundwater	Groundwater

Procambarus apalachicolae	A Crayfish	G2	Ponds	Streams
Procambarus attiguus	Silver Glen Springs Crayfish	G1	Groundwater	Groundwater
Procambarus barbiger	Jackson Prairie Crayfish	G2	Ponds	Streams
Procambarus brazoriensis	Brazoria crayfish	G1	Ponds	Streams
Procambarus cometes	Mississippi Flatwoods Crayfish	G1	Ponds	Streams
Procambarus connus	Carrollton Crayfish	GH	Ponds	Streams
Procambarus delicatus	Bigcheek Cave Crayfish	G1	Groundwater	Groundwater
Procambarus echinatus	Edisto Crayfish	G3	Streams	Streams
Procambarus econfinae	Panama City Crayfish	G1G2	Ponds	Streams
Procambarus epicyrtus	A Crayfish	G3	Streams	Streams
Procambarus erythropros	Santa Fe Cave Crayfish	G1	Groundwater	Groundwater
Procambarus escambiensis	A Crayfish	G2	Ponds	Streams
Procambarus ferrugineus	A Crayfish	G1	Ponds	Streams
Procambarus fitzpatricki	Spinytail Crayfish	G2	Ponds	Streams
Procambarus franzi	Orange Lake Cave Crayfish	G1	Groundwater	Groundwater

<i>Procambarus gibbus</i>	A Crayfish	G3	Streams	Streams
<i>Procambarus hagenianus vesticeps</i>	A Crayfish	G4G5T3	Ponds	Streams
<i>Procambarus horsti</i>	Big Blue Springs Cave Crayfish	G1	Groundwater	Groundwater
<i>Procambarus kensleyi</i>	A Crayfish	G3	Ponds	Streams
<i>Procambarus lagniappe</i>	Lagniappe Crayfish	G2	Streams	Streams
<i>Procambarus latipleurum</i>	A Crayfish	G2	Ponds	Streams
<i>Procambarus leitheuseri</i>	Coastal Lowland Cave Crayfish	G2	Groundwater	Groundwater
<i>Procambarus lucifugus</i>	Florida Cave Crayfish	G2G3	Groundwater	Groundwater
<i>Procambarus lucifugus alachua</i>	A Crayfish	G2G3T2	Groundwater	Groundwater
<i>Procambarus lucifugus lucifugus</i>	A Crayfish	G2G3T1	Groundwater	Groundwater
<i>Procambarus lylei</i>	Shutispear Crayfish	G2	Streams	Streams
<i>Procambarus marthae</i>	A Crayfish	G3	Streams	Streams
<i>Procambarus medialis</i>	Tar River Crayfish	G2	Streams	Streams
<i>Procambarus milleri</i>	Miami Cave Crayfish	G1	Groundwater	Groundwater

<i>Procambarus morrиси</i>	A Crayfish	G1	Groundwater	Groundwater
<i>Procambarus nechesae</i>	A Crayfish	G1G2	Ponds	Streams
<i>Procambarus nigrocinctus</i>	A Crayfish	G1G2	Streams	Streams
<i>Procambarus nueces</i>	A Crayfish	G1	Streams	Streams
<i>Procambarus orcinus</i>	Woodville Karst Cave Crayfish	G1	Groundwater	Groundwater
<i>Procambarus pallidus</i>	Pallid Cave Crayfish	G2G3	Groundwater	Groundwater
<i>Procambarus pecki</i>	Phantom Cave Crayfish	G2	Groundwater	Groundwater
<i>Procambarus penни</i>	Pearl Blackwater Crayfish	G3	Streams	Streams
<i>Procambarus petersi</i>	A Crayfish	G3	Streams	Streams
<i>Procambarus pictus</i>	Spotted Royal Crayfish	G2	Streams	Streams
<i>Procambarus pogum</i>	Bearded Red Crayfish	G1	Ponds	Streams
<i>Procambarus pubischelae deficiens</i>	A Crayfish	G5T3Q	Streams	Streams
<i>Procambarus rathbunae</i>	A Crayfish	G2	Ponds	Streams
<i>Procambarus regalis</i>	A Crayfish	G2G3	Ponds	Streams

Procambarus reimeri	A Crayfish		G1	Ponds	Streams
Procambarus rogersi campestris	A Crayfish		G4T2T3	Ponds	Streams
Procambarus rogersi expletus	A Crayfish		G4T1	Ponds	Streams
Procambarus rogersi ochlocknensis	A Crayfish		G4T2T3	Ponds	Streams
Procambarus rogersi rogersi	A Crayfish		G4T1	Ponds	Streams
Procambarus tenuis	A Crayfish		G3	Ponds	Streams
Procambarus texanus	A Crayfish		G1	Ponds	Ponds
Procambarus truculentus	A Crayfish		G3	Ponds	Streams
Procambarus youngi	Florida Longbeak Crayfish		G2	Streams	Streams
Remasellus parvus	An Isopod (From Fl)		G1	Groundwater	Groundwater
Stygobromus pecki	Peck's Cave Amphipod	LE	G1	Groundwater	Groundwater
Stygobromus sp. 10	A Cave Amphipod (Botetourt County)		G1	Groundwater	Groundwater
Stygobromus sp. 11	A Groundwater Amphipod (Nelson County)		G1	Groundwater	Groundwater
Stygobromus sp. 12	A Groundwater Amphipod (Rockbridge County)		G1	Groundwater	Groundwater

	County)			
Stygobromus sp. 13	A Groundwater Amphipod (Patrick County)	G1	Groundwater	Groundwater
Stygobromus sp. 9	A Cave Amphipod (Shenandoah County)	G1	Groundwater	Groundwater
Troglocambarus maclanei	Spider Cave Crayfish	G2	Groundwater	Groundwater
Troglocambarus sp. 1	A Crayfish	G1	Groundwater	Groundwater

<sup>a</sup>Federal status: LE = Listed as endangered; LT = Listed as threatened; PE = Proposed for listing as endangered; PT = Proposed for listing as threatened; C = Candidate for listing

<sup>b</sup>Primary and secondary habitat do not necessarily imply a consistent order or ranking of importance to the taxonomic group

[Return to first reference in text](#)

[Return to second reference in text](#)

**Table 5--The rare aquatic insects evaluated included 176 species, of which 2 are Federally listed as threatened or endangered (NatureServe 2001b)**

Scientific name	Common name	ABI global rank	<sup>a</sup> Federal status	<sup>b</sup> Primary habitat	<sup>b</sup> Secondary habitat
<i>Agarodes libalis</i>	spring-loving Psiloneuran caddisfly	G1G2		Groundwater	Groundwater
<i>Cheumatopsyche comis</i>	Flint's net-spinning caddisfly	G3		Groundwater	Groundwater
<i>Cheumatopsyche morsei</i>	a common net-spinning caddisfly	G1		Groundwater	Groundwater
<i>Chimarra holzenthali</i>	a caddisfly	G1		Groundwater	Groundwater
<i>Glyphopsyche sequatchie</i>	Sequatchie caddisfly	G1	C	Groundwater	Groundwater
<i>Heterelmis comalensis</i>	Comal Springs Riffle Beetle	G1	LE	Groundwater	Groundwater
<i>Hydroptila ouachita</i>	a purse casemaker caddisfly	G1		Groundwater	Groundwater
<i>Hydroptila wakulla</i>	Wakulla springs vari-colored microcaddis	GH		Groundwater	Groundwater
<i>Isoperla szczytkoi</i>	a stonefly	G1		Groundwater	Groundwater
<i>Megaleuctra flinti</i>	a stonefly	G2		Groundwater	Groundwater

Megaleuctra williamsae	Williams' rare winter stonefly	G2		Groundwater	Groundwater
Oconoperla innubila	a stonefly	G2		Groundwater	Groundwater
Ostrocerca prolongata	a stonefly	G3		Groundwater	Groundwater
Stygoparnus comalensis	Comal Springs Dryopid Beetle	G1	LE	Groundwater	Groundwater
Viehopera ada	a stonefly	G3		Groundwater	Groundwater
Zapada chila	a stonefly	G2		Groundwater	Groundwater
Agarodes ziczac	zigzag blackwater caddisfly	G1		Streams	Groundwater
Argia leonora	Leonora's Damselfly	G3		Streams	Groundwater
Austrotinodes texensis	Texas Austrotinodes caddisfly	G2		Streams	Groundwater
Ceratopsyche etnieri	Buffalo Springs caddisfly	G1G3		Streams	Groundwater
Chimarra florida	Floridain finger-net caddisfly	G1G2		Streams	Groundwater
Cordulegaster sayi	Say's Spiketail	G2		Streams	Groundwater
Gomphus consanguis	Cherokee Clubtail	G2G3		Streams	Groundwater
Lepidostoma morsei	Morse's little plain brown sedge	G1G2		Streams	Groundwater

Leuctra mitchellensis	a stonefly	G3	Streams	Groundwater
Leuctra szczytkoi	Schoolhouse Springs Leuctran stonefly	G2	Streams	Groundwater
Ochrotrichia okaloosa	a caddisfly	G1	Streams	Groundwater
Ochrotrichia provosti	Provost's Ochrotrichian caddisfly	G1	Streams	Groundwater
Libellula jesseana	Purple Skimmer	G2	Lakes	Lakes
Libellula composita	Bleached Skimmer	G3	Groundwater	Ponds
Nehalennia pallidula	Everglades Sprite	G3	Ponds	Ponds
Gomphus diminutus	Diminutive Clubtail	G3	Streams	Ponds
Somatochlora calverti	Calvert's Emerald	G3	Streams	Ponds
Somatochlora margarita	Texas Emerald	G2	Streams	Ponds
Oxyethira kingi	King's cream and brown mottled microcaddis	G1	Lakes	Rivers
Acanthametropus pecatonica	Pecatonica River Mayfly	G2	Rivers	Rivers
Acroneuria petersi	a stonefly	G3	Rivers	Rivers

<i>Allocapnia jeanae</i>	a winter stonefly	G2	Rivers	Rivers
<i>Alloperla ouachita</i>	a stonefly	G2	Rivers	Rivers
<i>Anepeorus simplex</i>	Wallace's deepwater mayfly	G2	Rivers	Rivers
<i>Diploperla kanawholensis</i>	Little Kanawha Perlodid stonefly	G3	Rivers	Rivers
<i>Gomphus crassus</i>	Handsome Clubtail	G3	Rivers	Rivers
<i>Gomphus gonzalezi</i>	Tamaulipan clubtail	G2	Rivers	Rivers
<i>Gomphus modestus</i>	Gulf Coast Clubtail	G3	Rivers	Rivers
<i>Gomphus ventricosus</i>	Skillet Clubtail	G3	Rivers	Rivers
<i>Gomphus viridifrons</i>	Green-Faced Clubtail	G3	Rivers	Rivers
<i>Gomphus westfalli</i>	Westfall's Clubtail	G1G2	Rivers	Rivers
<i>Helopicus nalatus</i>	a stonefly	G3	Rivers	Rivers
<i>Heterocloeon bernerri</i>	Berner's two-winged mayfly	G1	Rivers	Rivers
<i>Homoeoneuria cahabensis</i>	Cahaba sand-filtering mayfly	G2	Rivers	Rivers
<i>Homoeoneuria dolani</i>	blue sand-river mayfly	G2	Rivers	Rivers

Hydroperla fugitans	a spring stonefly	G3	Rivers	Rivers
Hydroperla phormidia	a stonefly	G3	Rivers	Rivers
Macromia margarita	Mountain River Cruiser	G3	Rivers	Rivers
Ophiogomphus acuminatus	Acuminate Snaketail	G2	Rivers	Rivers
Ophiogomphus edmundo	Edmund's Snaketail	G1	Rivers	Rivers
Ophiogomphus howei	Pygmy Snaketail	G3	Rivers	Rivers
Ophiogomphus incurvatus	Appalachian Snaketail	G3	Rivers	Rivers
Ophiogomphus incurvatus incurvatus		G3T3	Rivers	Rivers
Ophiogomphus westfalli	Westfall's Snaketail	G2	Rivers	Rivers
Orthotrichia dentata	dentate Orthotrichian microcaddis	G1G2	Rivers	Rivers
Pentagenia robusta	robust Pentagenian burrowing mayfly	GX	Rivers	Rivers
Proptila arca	San Marcos saddle-case caddisfly	G1	Rivers	Rivers
Pteronarcys comstocki	a stonefly	G3	Rivers	Rivers
Remenus duffieldi	a stonefly	G2	Rivers	Rivers

<i>Somatochlora ozarkensis</i>	Ozark Emerald	G3	Rivers	Rivers
<i>Stylurus notatus</i>	Elusive Clubtail	G3	Rivers	Rivers
<i>Stylurus potulentus</i>	Yellow-Sided Clubtail	G2	Rivers	Rivers
<i>Stylurus townesi</i>	Townes' Clubtail	G3	Rivers	Rivers
<i>Taeniopteryx robinae</i>	a stonefly	G1	Rivers	Rivers
<i>Taeniopteryx starki</i>	Leoan River winter stonefly	G1	Rivers	Rivers
<i>Traverella lewisi</i>	a mayfly	G2	Rivers	Rivers
<i>Erpetogomphus heterodon</i>	dashed ringtail	G3	Streams	Rivers
<i>Gomphus hodgesi</i>	Hodges' Clubtail	G3	Streams	Rivers
<i>Oecetis morsei</i>	Morse's long-horn sedge	G2	Streams	Rivers
<i>Ophiogomphus australis</i>	southern snaketail	G2	Streams	Rivers
<i>Stylurus potulentus</i>	yellow-sided clubtail	G2	Streams	Rivers
<i>Hansonoperla cheaha</i>	a stonefly	G2	Groundwater	Streams
<i>Hydroptila chelops</i>	a caddisfly	G1	Groundwater	Streams

Hydroptila decia	Knoxville Hydroptilan micro caddisfly	G1G3	Groundwater	Streams
Hydroptila lagoi	a caddisfly	G1	Groundwater	Streams
Leuctra nephophila	a stonefly	G3	Groundwater	Streams
Prostoia hallasi	Hallas' broadback spring stonefly	G3	Groundwater	Streams
Remenus kirchneri	a stonefly	G2	Groundwater	Streams
Progomphus bellei	Belle's Sanddragon	G3	Ponds	Streams
Isonychia berneri	a mayfly	G3	Rivers	Streams
Orthotrichia instabilis	changeable Orthotrichian microcaddis	G1G3	Rivers	Streams
Perlesta browni	a stonefly	G3	Rivers	Streams
Acroneuria flinti	Flint's common stonefly	GH	Streams	Streams
Acroneuria hitchcocki	a stonefly	G3	Streams	Streams
Acroneuria ozarkensis	a perlid stonefly	G2	Streams	Streams
Agarodes alabamensis	a caddisfly	G1	Streams	Streams
Allocapnia fumosa	a stonefly	G2	Streams	Streams

<i>Allopnia illinoensis</i>	a stonefly	G3	Streams	Streams
<i>Allopnia oribata</i>	a stonefly	G1	Streams	Streams
<i>Allopnia ozarkana</i>	a winter stonefly	G2	Streams	Streams
<i>Allopnia peltoides</i>	a stonefly	G3	Streams	Streams
<i>Allopnia perplexa</i>	a stonefly	G1	Streams	Streams
<i>Allopnia stannardi</i>	a stonefly	G3	Streams	Streams
<i>Allopnia tennesa</i>	a stonefly	G3	Streams	Streams
<i>Allopnia warreni</i>	a winter stonefly	GH	Streams	Streams
<i>Alloperla biserrata</i>	a stonefly	G3	Streams	Streams
<i>Alloperla caddo</i>	a stonefly	G2	Streams	Streams
<i>Alloperla furcula</i>	a stonefly	G2	Streams	Streams
<i>Alloperla natchez</i>	Natchez stonefly	G2	Streams	Streams
<i>Amphinemura mockfordi</i>	a stonefly	G2	Streams	Streams
<i>Argia pima</i>	Pima Dancer	G1G3	Streams	Streams

Argia rhoadsi	Golden-Winged Dancer	G3	Streams	Streams
Baetisca becki	a mayfly	G2	Streams	Streams
Beloneuria georgiana	Georgia Beloneurian stonefly	G2	Streams	Streams
Beloneuria jamesae	Cheaha Beloneurian stonefly	G1	Streams	Streams
Beloneuria stewarti	Cheaha Beloneurian stonefly	G3	Streams	Streams
Ceraclea alabamae	a caddisfly	G1	Streams	Streams
Cheumatopsyche bibbensis	a caddisfly	G1	Streams	Streams
Cheumatopsyche cahaba	a caddisfly	G1	Streams	Streams
Cheumatopsyche gordonae	Gordon's little sister sedge	G1	Streams	Streams
Cheumatopsyche helma	Helma's net-spinning caddisfly	G1G3	Streams	Streams
Cheumatopsyche petersi	Peters' Cheumatopsyche caddisfly	G2	Streams	Streams
Diploperla morgani	a stonefly	G2	Streams	Streams
Gomphus geminatus	Twin-Striped Clubtail	G3	Streams	Streams
Gomphus sandrius	Tennessee Clubtail	G1	Streams	Streams

Habrophlebiodes annulata	a mayfly	G2	Streams	Streams
Hansonoperla appalachia	Hanson's Appalachian stonefly	G3	Streams	Streams
Hansonoperla hokolesqua	a stonefly	G2	Streams	Streams
Haploperla chukcho	Chukcho stonefly	G2	Streams	Streams
Helopicus bogaloosa	a stonefly	G3	Streams	Streams
Hydroperla rickeri	a stonefly	G2	Streams	Streams
Hydropsyche alabama	a caddisfly	G1	Streams	Streams
Hydroptila berneri	Berner's microcaddisfly	G1	Streams	Streams
Hydroptila cheaha	a caddisfly	G1	Streams	Streams
Hydroptila chocolocco	a caddisfly	G1	Streams	Streams
Hydroptila fuscina	a caddisfly	G1	Streams	Streams
Hydroptila lloganae	Llogan's varicolored microcaddisfly	G1G3	Streams	Streams
Hydroptila metteei	a caddisfly	G1	Streams	Streams
Hydroptila micropotamis	a caddisfly	G1	Streams	Streams

Hydroptila molsonae	Molson's microcaddisfly	G2G3	Streams	Streams
Hydroptila paralatosa	a caddisfly	G2	Streams	Streams
Hydroptila patriciae	a caddisfly	G1	Streams	Streams
Hydroptila scheiringi	a caddisfly	G1	Streams	Streams
Hydroptila setigera	a caddisfly	G1	Streams	Streams
Hydroptila wetumpka	a caddisfly	G1	Streams	Streams
Isoperla distincta	a stonefly	G3	Streams	Streams
Isoperla ouachita	a stonefly	G3	Streams	Streams
Leuctra moha	a stonefly	G3	Streams	Streams
Leuctra paleo	a stonefly	G2	Streams	Streams
Macdunnoa brunnea	a mayfly	G3	Streams	Streams
Neochoroterpes kossi	a mayfly	G2	Streams	Streams
Neoperla harrisi	Perlid stonfly	G2	Streams	Streams
Nyctiophylax morsei	Morse's dinky light summer sedge	G1G2	Streams	Streams

Ochrotrichia elongiralla	a caddisfly	G1	Streams	Streams
Oecetis daytona	a caddisfly	G2	Streams	Streams
Oecetis parva	Little Oecetis longhorn caddisfly	GH	Streams	Streams
Oxyethira kellyi	Kelly's cream and brown mottled microcaddis	G1G2	Streams	Streams
Oxyethira lumipollex	a caddisfly	G2	Streams	Streams
Oxyethira novasota	Novaaota Oxyethiran microcaddisfly	G2	Streams	Streams
Perlesta baumanni	a stonefly	G2	Streams	Streams
Perlesta bolukta	a stonefly	G2	Streams	Streams
Perlesta frisoni	a stonefly	G3	Streams	Streams
Phylocentropus harrisi	a caddisfly	G1	Streams	Streams
Polycentropus carlsoni	Carlson's Polycentropus caddisfly	G1G3	Streams	Streams
Polycentropus floridensis	Florida brown checkered summer sedge	G2	Streams	Streams
Protoptila cahabensis	Cahaba saddle-case caddisfly	G1	Streams	Streams

Rhyacophila alabama	a caddisfly	G1	Streams	Streams
Rhyacophila carolae	a caddisfly	G1	Streams	Streams
Serratella frisoni	Frison's Serratellan mayfly	G3	Streams	Streams
Serratella spiculosa	spiculose Serratellan mayfly	G2	Streams	Streams
Siphloplecton brunneum	a mayfly	G1	Streams	Streams
Stactobiella cahaba	a caddisfly	G1	Streams	Streams
Taeniopteryx nelsoni	Nelson's early black stonefly	G1	Streams	Streams
Tallaperla elisa	a stonefly	G3	Streams	Streams
Tallaperla lobata	lobed roach-like stonefly	G2	Streams	Streams
Theliopsyche tallapoosa	a caddisfly	G1	Streams	Streams
Triaenodes helo	marsh triaenode caddisfly	G2G3	Streams	Streams
Triaenodes tridonta	Three-toothed Triaenodes caddisfly	GH	Streams	Streams
Zealeuctra arnoldi	a stonefly	G3	Streams	Streams
Zealeuctra wachita	a stonefly	G2	Streams	Streams

<sup>a</sup>Federal status: LE = Listed as endangered; LT = Listed as threatened; PE = Proposed for listing as endangered; PT = Proposed for listing as threatened; C = Candidate for listing.

<sup>b</sup>Primary and secondary habitat do not necessarily imply a consistent order or ranking of importance to the taxonomic group

[Return to first reference in text](#)

[Return to second reference in text](#)

**Table 6--The rare aquatic snails evaluated included 123 species, of which 11 are Federally listed as threatened or endangered (NatureServe 2000a)**

Scientific name	Common name	ABI		<sup>b</sup> Primary habitat	<sup>b</sup> Secondary habitat	Subclass
		<sup>a</sup> Federal status	global rank			
<i>Amnicola cora</i>	Foushee Cavesnail		G1	Groundwater	Groundwater	Prosobranchia
<i>Antroselatus spiralis</i>	Shaggy Cavesnail		G2G3	Groundwater	Groundwater	Prosobranchia
<i>Aphaostracon asthenes</i>	Blue Spring Hydrobe		G1	Groundwater	Groundwater	Prosobranchia
<i>Aphaostracon chalarogyrus</i>	Freemouth Hydrobe		G1	Groundwater	Groundwater	Prosobranchia
<i>Aphaostracon monas</i>	Wekiwa Hydrobe		G1	Groundwater	Rivers	Prosobranchia
<i>Aphaostracon pycnus</i>	Dense Hydrobe		G1	Groundwater	Groundwater	Prosobranchia
<i>Aphaostracon theiocrenetus</i>	Clifton Spring Hydrobe		G1	Groundwater	Groundwater	Prosobranchia
<i>Aphaostracon xynoelictus</i>	Fenney Spring Hydrobe		G1	Groundwater	Groundwater	Prosobranchia
<i>Campeloma decampi</i>	Slender Campeloma	LE	G1	Streams	Streams	Prosobranchia
<i>Cincinnatia helicogyra</i>	Crystal Siltsnail		G1	Groundwater	Groundwater	Prosobranchia

<i>Cincinnatia integra</i>	Midland Siltsnail	G3	Rivers	Rivers	Prosobranchia
<i>Cincinnatia mica</i>	Ichetucknee Siltsnail	G1	Groundwater	Groundwater	Prosobranchia
<i>Cincinnatia monroensis</i>	Enterprise Siltsnail	G1	Groundwater	Streams	Prosobranchia
<i>Cincinnatia parva</i>	Pygmy Siltsnail	GX	Groundwater	Groundwater	Prosobranchia
<i>Cincinnatia ponderosa</i>	Ponderous Siltsnail	G1	Groundwater	Groundwater	Prosobranchia
<i>Cincinnatia vanhyningi</i>	Seminole Siltsnail	G1	Groundwater	Groundwater	Prosobranchia
<i>Cincinnatia wekiwae</i>	Wekiwa Siltsnail	G1	Groundwater	Groundwater	Prosobranchia
<i>Clappia cahabensis</i>	Cahaba Pebblesnail	GH	Rivers	Rivers	Prosobranchia
<i>Clappia umbilicata</i>	Umbilicate Pebblesnail	GH	Rivers	Rivers	Prosobranchia
<i>Dasyscias franzi</i>	Shaggy Ghostsnail	G1	Groundwater	Groundwater	Prosobranchia
<i>Elimia acuta</i>	Acute Elimia	G1	Rivers	Rivers	Prosobranchia
<i>Elimia alabamensis</i>	Mud Elimia	G1	Rivers	Streams	Prosobranchia
<i>Elimia ampla</i>	Ample Elimia	G1	Rivers	Rivers	Prosobranchia
<i>Elimia aterina</i>	Coal Elimia	G1	Streams	Streams	Prosobranchia

Elimia bellacrenata	Princess Elimia		G1	Groundwater	Streams	Prosobranchia
Elimia bellula	Walnut Elimia		G1	Rivers	Streams	Prosobranchia
Elimia bentoniensis	Rusty Elimia		G1	Streams	Streams	Prosobranchia
Elimia brevis	Short-Spire Elimia		GH	Rivers	Rivers	Prosobranchia
Elimia cahawbensis	Cahaba Elimia		G3	Streams	Streams	Prosobranchia
Elimia capillaris	Spindle Elimia		G1	Rivers	Rivers	Prosobranchia
Elimia chiltonensis	Prune Elimia		G1	Streams	Streams	Prosobranchia
Elimia clara	Riffle Elimia		G3	Rivers	Rivers	Prosobranchia
Elimia clausa	Closed Elimia		GH	Rivers	Rivers	Prosobranchia
Elimia clenchi	Slackwater Elimia		G1G2	Rivers	Rivers	Prosobranchia
Elimia cochilaris	Cockle Elimia		G1	Groundwater	Streams	Prosobranchia
Elimia crenatella	Lacey Elimia	LT	G1	Rivers	Streams	Prosobranchia
Elimia cylindracea	Cylinder Elimia		G1	Rivers	Rivers	Prosobranchia
Elimia fusiformis	Fusiform Elimia		GH	Rivers	Rivers	Prosobranchia

Elimia gibbera		GH	Rivers	Rivers	Prosobranchia
Elimia hartmaniana	High-Spired Elimia	GH	Rivers	Rivers	Prosobranchia
Elimia haysiana	Silt Elimia	G1	Rivers	Rivers	Prosobranchia
Elimia hydei	Gladiator Elimia	G2	Rivers	Rivers	Prosobranchia
Elimia impressa	Constricted Elimia	GH	Rivers	Rivers	Prosobranchia
Elimia jonesi	Hearty Elimia	GH	Rivers	Rivers	Prosobranchia
Elimia lachryma	Nodulose Coosa River Snail (Al)	GH	Rivers	Rivers	Prosobranchia
Elimia laeta	Ribbed Elimia	GH	Rivers	Rivers	Prosobranchia
Elimia macglameriana	Macglamery's Coosa River Snail (Al)	GH	Rivers	Rivers	Prosobranchia
Elimia pilsbryi	Rough-Lined Elimia	GH	Rivers	Rivers	Prosobranchia
Elimia pupaeformis	Pupa Elimia	GH	Rivers	Rivers	Prosobranchia
Elimia vanuxemiana	Cobble Elimia	GH	Rivers	Rivers	Prosobranchia
Fontigens orolibas	Blue Ridge Springsnail	G2G3	Groundwater	Groundwater	Prosobranchia

<i>Gyrotoma excisa</i>	Excised Slitshell		GX	Rivers	Rivers	Prosobranchia
<i>Gyrotoma lewisii</i>	Striate Slitshell		GX	Rivers	Rivers	Prosobranchia
<i>Gyrotoma pagoda</i>	Pagoda Slitshell		GX	Rivers	Rivers	Prosobranchia
<i>Gyrotoma pumila</i>	Ribbed Slitshell		GX	Rivers	Rivers	Prosobranchia
<i>Gyrotoma pyramidata</i>	Pyramid Slitshell		GX	Rivers	Rivers	Prosobranchia
<i>Gyrotoma walkeri</i>	Round Slitshell		GX	Rivers	Rivers	Prosobranchia
<i>Io fluvialis</i>	Spiny Riversnail		G2	Rivers	Rivers	Prosobranchia
<i>Leptoxis ampla</i>	Round Rocksnail	LT	G1G2	Rivers	Rivers	Prosobranchia
<i>Leptoxis clipeata</i>	Agate Rocksnail		GH	Rivers	Rivers	Prosobranchia
<i>Leptoxis compacta</i>	Oblong Rocksnail		GH	Rivers	Streams	Prosobranchia
<i>Leptoxis crassa</i>	Boulder Snail		GH	Rivers	Rivers	Prosobranchia
<i>Leptoxis crassa anthonyi</i>	Anthony's River Snail	LE	G1T1	Rivers	Rivers	Prosobranchia
<i>Leptoxis formanii</i>	Interrupted Rocksnail		G1	Rivers	Rivers	Prosobranchia
<i>Leptoxis formosa</i>	Maiden Rocksnail		GH	Streams	Streams	Prosobranchia

Leptoxis ligata	Rotund Rocksnail		GH	Rivers	Rivers	Prosobranchia
Leptoxis lirata	Lirate Rocksnail		GH	Rivers	Rivers	Prosobranchia
Leptoxis melanoidus	Black Mudalia		G2	Rivers	Rivers	Prosobranchia
Leptoxis occultata	Bigmouth Rocksnail		GH	Rivers	Rivers	Prosobranchia
Leptoxis picta	Spotted Rocksnail		G1	Rivers	Rivers	Prosobranchia
Leptoxis plicata	Plicate Rocksnail	LE	G1	Streams	Rivers	Prosobranchia
Leptoxis showalterii	Coosa Rocksnail		GH	Rivers	Rivers	Prosobranchia
Leptoxis taeniata	Painted Rocksnail	LT	G1	Rivers	Rivers	Prosobranchia
Leptoxis umbilicata	Umbilicate Rocksnail		G1	Rivers	Rivers	Prosobranchia
Leptoxis virgata	Smooth Mudalia		G2	Rivers	Rivers	Prosobranchia
Leptoxis vittata	Striped Rocksnail		GH	Rivers	Rivers	Prosobranchia
Lepyrium showalteri	Flat Pebblesnail	LE	G1	Rivers	Rivers	Prosobranchia
Lioplax cyclostomaformis	Cylindrical Lioplax	LE	G1	Rivers	Rivers	Prosobranchia
Lithasia duttoniana	Helmet Rocksnail		G2	Rivers	Streams	Prosobranchia

Lithasia jayana	Rugose Rocksnail	G2	Rivers	Rivers	Prosobranchia
Lithasia lima	Warty Rocksnail	G2	Rivers	Rivers	Prosobranchia
Phreatodrobia imitata	Mimic Cavesnail	G1	Groundwater	Groundwater	Prosobranchia
Pleurocera annulifera	Ringed Hornsnail	G1	Rivers	Streams	Prosobranchia
Pleurocera brumbyi	Spiral Hornsnail	G1	Groundwater	Streams	Prosobranchia
Pleurocera corpulenta	Corpulent Hornsnail	G1	Rivers	Rivers	Prosobranchia
Pleurocera curta	Shortspire Hornsnail	G2	Rivers	Rivers	Prosobranchia
Pleurocera postelli	Broken Hornsnail	G2	Streams	Streams	Prosobranchia
Pleurocera pyrenella	Skirted Hornsnail	G2	Rivers	Rivers	Prosobranchia
Pleurocera trochiformis	Sulcate Hornsnail	G2	Rivers	Rivers	Prosobranchia
Pyrgulopsis agarhecta	Ocmulgee Marstonia	G1	Streams	Streams	Prosobranchia
Pyrgulopsis castor	Beaverpond Marstonia	G1	Streams	Streams	Prosobranchia
Pyrgulopsis davisi	Limpia Creek Springsnail	G1	Groundwater	Streams	Prosobranchia
Pyrgulopsis metcalfi	Naegele Springsnail	G1	Groundwater	Groundwater	Prosobranchia

<i>Pyrgulopsis ogmorhappe</i>	Royal Marstonia	LE	G1	Groundwater	Streams	Prosobranchia
<i>Pyrgulopsis olivacea</i>	Olive Marstonia		GH	Streams	Groundwater	Prosobranchia
<i>Pyrgulopsis ozarkensis</i>	Ozark Pyrg		G1	Rivers	Rivers	Prosobranchia
<i>Pyrgulopsis pachyta</i>	Armored Marstonia	LE	G1	Streams	Streams	Prosobranchia
<i>Pyrgulopsis scalariformis</i>	Moss Pyrg		G1	Rivers	Rivers	Prosobranchia
<i>Somatogyrus amnicoloides</i>	Ouachita Pebblesnail		GX	Rivers	Rivers	Prosobranchia
<i>Somatogyrus biangulatus</i>	Angular Pebblesnail		GH	Rivers	Rivers	Prosobranchia
<i>Somatogyrus crassilabris</i>	Thicklipped Pebblesnail		GX	Rivers	Rivers	Prosobranchia
<i>Somatogyrus currierianus</i>	Tennessee Pebblesnail		GH	Rivers	Rivers	Prosobranchia
<i>Somatogyrus excavatus</i>	Ovate Pebblesnail		GH	Rivers	Rivers	Prosobranchia
<i>Somatogyrus humerosus</i>	Atlas Pebblesnail		GH	Rivers	Rivers	Prosobranchia
<i>Somatogyrus quadratus</i>	Quadrate Pebblesnail		GH	Rivers	Rivers	Prosobranchia
<i>Somatogyrus strengi</i>	Rolling Pebblesnail		GH	Rivers	Rivers	Prosobranchia
<i>Somatogyrus substriatus</i>	Choctaw Pebblesnail		GH	Rivers	Rivers	Prosobranchia

Somatogyrus tenax	Savannah Pebblesnail		G2G3	Rivers	Rivers	Prosobranchia
Somatogyrus tennesseensis	Opaque Pebblesnail		G1	Rivers	Rivers	Prosobranchia
Somatogyrus virginicus	Panhandle Pebblesnail		G1G2	Rivers	Rivers	Prosobranchia
Somatogyrus wheeleri	Channelled Pebblesnail		GX	Rivers	Rivers	Prosobranchia
Stiobia nana	Sculpin Snail		G3	Groundwater	Streams	Prosobranchia
Tryonia adamantina	Diamond Y Spring Snail	C	G1	Groundwater	Streams	Prosobranchia
Tryonia brunei	Brune Spring Snail		G1	Groundwater	Streams	Prosobranchia
Tryonia cheatumi	Phantom Lake Tryonia		G1	Streams	Streams	Prosobranchia
Tulotoma magnifica	Tulotoma	LE	G1	Rivers	Rivers	Prosobranchia
Amphigyra alabamensis	Shoal Sprite		GH	Rivers	Rivers	Pulmonata
Neoplanorbis smithi	Classification Uncertain		GX	Rivers	Rivers	Pulmonata
Neoplanorbis tantillus	Classification Uncertain		GX	Rivers	Rivers	Pulmonata
Neoplanorbis umbilicatus	Classification Uncertain		GX	Rivers	Rivers	Pulmonata
Planorbella magnifica	Magnificent Rams-Horn		G1	Ponds	Ponds	Pulmonata

Rhodacme elatior	Domed Ancyloid	G1	Rivers	Rivers	Pulmonata
Stagnicola neopalustris	Piedmont Pondsnaail	GX	Ponds	Ponds	Pulmonata

<sup>a</sup>Federal status: LE = Listed as endangered; LT = Listed as threatened; PE = Proposed for listing as endangered; PT = Proposed for listing as threatened; C = Candidate for listing.

<sup>b</sup>Primary and secondary habitat do not necessarily imply a consistent order or ranking of importance to the taxonomic group.

[Return to first reference in text](#)

**Table 7--The rare mussels evaluated included 191 species, of which 71 are Federally listed as threatened or endangered (NatureServe 2001a)**

Scientific name	Common name	<sup>a</sup> Federal status	ABI	<sup>b</sup> Primary habitat	<sup>b</sup> Secondary habitat	<sup>c</sup> Watersheds
			global rank			
<i>Alasmidonta arcula</i>	Altamaha arc mussel		G2	Rivers	Rivers	SA
<i>Alasmidonta atropurpurea</i>	Cumberland Elktoe	LE	G1G2	Rivers	Rivers	Cu
<i>Alasmidonta heterodon</i>	Dwarf Wedgemussel	LE	G1G2	Rivers	Rivers	NA,SA
<i>Alasmidonta mccordi</i>	Coosa elktoe		GX	Rivers	Rivers	Mo
<i>Alasmidonta raveneliana</i>	Appalachian Elktoe	LE	G1	Rivers	Rivers	Cu
<i>Alasmidonta robusta</i>	Carolina elktoe		GX	Rivers	Rivers	SA
<i>Alasmidonta varicosa</i>	Brook Floater		G3	Rivers	Rivers	NA,SA
<i>Alasmidonta wrightiana</i>	Ochloskonee arc mussel		GH	Rivers	Rivers	Ap
<i>Amblema elliottii</i>	Coosa fiveridge		G3	Rivers	Rivers	Mo
<i>Amblema neislerii</i>	Fat Threeridge	LE	G1	Rivers	Rivers	Ap

Anodonta heardi	Apalachicola Floater		G1	Rivers	Rivers	Ap
Anodontoides denigratus	Cumberland Papershell		G1	Rivers	Rivers	Cu
Anodontoides radiatus	Rayed creekshell		G3	Rivers	Rivers	Ap,Mo
Arkansia wheeleri	Ouachita Rock Pocketbook	LE	G1	Rivers	Rivers	Mi,Oz
Cumberlandia monodonta	Spectaclecase		G2G3	Rivers	Rivers	Cu
Cyprogenia aberti	Western fanshell		G2	Rivers	Rivers	Oz
Cyprogenia stegaria	Fanshell	LE	G1	Rivers	Rivers	Cu,Mi
Disconaias salinasensis	Salina mucket		G1	Rivers	Rivers	RG
Dromus dromas	Dromedary Pearlymussel	LE	G1	Rivers	Rivers	Cu
Elliptio ahenea	Southern lance		G3	Rivers	Rivers	Fl
Elliptio chipolaensis	Chipola Slabshell	LT	G1	Rivers	Rivers	Ap
Elliptio dariensis	Georgia elephantear		G3	Rivers	Rivers	Fl,SA
Elliptio downiei	Satilla elephantear		G3	Rivers	Rivers	SA

Elliptio fraterna	Brother spile		G1	Rivers	Rivers	Ap
Elliptio hepatica	Brown elliptio		G2G3	Rivers	Rivers	SA
Elliptio hopetonensis	Altamaha slabshell		G3	Rivers	Rivers	SA
Elliptio lanceolata	Yellow lance		G2G3	Rivers	Rivers	Ap,NA,SA
Elliptio mcmichaeli	Fluted elephantear		G3	Rivers	Rivers	Ap,Mo
Elliptio monroensis	St. John's elephantear		G2G3	Rivers	Rivers	Fl
Elliptio nigella	Winged spike		GH	Rivers	Rivers	Ap
Elliptio purpurella	Inflated spike		G3	Rivers	Rivers	Ap
Elliptio roanokensis	Roanoke slabshell		G2G3	Rivers	Rivers	SA
Elliptio spinosa	Altamaha spinymussel		G1G2	Rivers	Rivers	SA
Elliptio steinstansana	Tar River Spinymussel	LE	G1	Rivers	Rivers	SA
Elliptoideus sloatianus	Purple Bankclimber	LT	G2	Rivers	Rivers	Ap
Epioblasma arcaeformis	Sugarspoon		GX	Rivers	Rivers	Cu
Epioblasma biemarginata	Angled riffleshell		GX	Rivers	Rivers	Cu

Epioblasma brevidens	Cumberlandian Combshell	LE	G1	Rivers	Rivers	Cu
Epioblasma capsaeformis	Oyster Mussel	LE	G1	Rivers	Rivers	Cu
Epioblasma cincinnatiensis	A freshwater mussel		GX	Rivers	Rivers	Mi
Epioblasma flexuosa	Leafshell		GX	Rivers	Rivers	Mi
Epioblasma florentina	Yellow Blossom	LE	G1	Rivers	Rivers	Cu
Epioblasma florentina curtisi	Curtis Pearlymussel	LE	G1T1	Rivers	Rivers	Cu
Epioblasma florentina florentina	Yellow Blossom	LE	G1TX	Rivers	Rivers	Cu
Epioblasma haysiana	Acornshell		GX	Rivers	Rivers	Cu
Epioblasma lenoir	Narrow catspaw		GX	Rivers	Rivers	Cu
Epioblasma lewisii	Forkshell		GX	Rivers	Rivers	Cu
Epioblasma metastriata	Upland Combshell	LE	GH	Rivers	Rivers	Mo
Epioblasma obliquata	Catspaw	LE	G1	Rivers	Rivers	Mi
Epioblasma obliquata obliquata	Catspaw	LE	G1T1	Rivers	Rivers	Cu,Mi

Epioblasma obliquata perobliqua	White Catspaw	LE	G1T1	Rivers	Rivers	Mi
Epioblasma penita	Southern Combshell	LE	G1	Rivers	Rivers	Mo
Epioblasma personata	Round combshell		GX	Rivers	Rivers	Mi
Epioblasma propingua	Tennessee riffleshell		GX	Rivers	Rivers	Cu
Epioblasma sampsonii	Wabash Riffleshell	LE	G1	Rivers	Rivers	Mi
Epioblasma stewardsoni	Cumberland leafshell		GX	Rivers	Rivers	Cu
Epioblasma torulosa	Tubercled Blossom	LE	G2	Rivers	Rivers	Mi
Epioblasma torulosa gubernaculums	Green Blossom	LE	G2TX	Rivers	Rivers	Mi
Epioblasma torulosa rangiana	Northern Riffleshell	LE	G2T2	Rivers	Rivers	Mi
Epioblasma torulosa torulosa	Tubercled Blossom	LE	G2TX	Rivers	Rivers	Mi
Epioblasma triquetra	Snuffbox		G3	Rivers	Rivers	Cu,Mi
Epioblasma turgidula	Turgid Blossom	LE	GH	Rivers	Rivers	Cu
Fusconaia apalachicola	Apalachicola ebonyshell		GX	Rivers	Rivers	Ap
Fusconaia askewi	Texas pigtoe		G2	Rivers	Rivers	Mi,Sab

Fusconaia cor	Shiny Pigtoe	LE	G1	Rivers	Rivers	Mo
Fusconaia cuneolus	Finerayed Pigtoe	LE	G1	Rivers	Rivers	Cu
Fusconaia escambia	Narrow pigtoe		G2	Rivers	Rivers	Ap
Fusconaia masoni	Atlantic pigtoe		G2	Rivers	Rivers	SA
Fusconaia ozarkensis	Ozark pigtoe		G3	Rivers	Rivers	Mi
Fusconaia subrotunda	Longsolid		G3	Rivers	Rivers	Cu,Mi
Fusconaia subrotunda subrotunda	Longsolid		G3T3	Rivers	Rivers	Cu,Mi
Fusconaia succissa	Purple pigtoe		G3	Rivers	Rivers	Ap
Hemistena lata	Cracking Pearlymussel	LE	G1	Rivers	Rivers	Cu,Mi
Lampsilis abrupta	Pink Mucket	LE	G2	Rivers	Rivers	Cu,Mi
Lampsilis altilis	Finelined Pocketbook	LT	G2	Rivers	Rivers	Mo
Lampsilis australis	Southern sandshell		G2	Rivers	Rivers	Ap
Lampsilis binominata	Lined pocketbook		GH	Rivers	Rivers	Ap
Lampsilis bracteata	Texas fatmucket		G1	Rivers	Rivers	CT

Lampsilis dolabraeformis	Altamaha pocketbook		G3	Rivers	Rivers	SA
Lampsilis higginsii	Higgins Eye	LE	G1	Rivers	Rivers	Mi
Lampsilis perovalis	Orangenacre Mucket	LT	G2	Rivers	Rivers	Mo
Lampsilis powellii	Arkansas Fatmucket	LT	G1G2	Rivers	Rivers	Mi
Lampsilis rafinesqueana	Neosho mucket		G2	Rivers	Rivers	Oz
Lampsilis reeviana	Arkansas brokenray		G3	Rivers	Rivers	Oz
Lampsilis reeviana brevuclula	Ozark brokenray		G3T2	Rivers	Rivers	Oz
Lampsilis reeviana reeviana	Arkansas brokenray		G3T1T2	Rivers	Rivers	Oz
Lampsilis satura	Sandbank pocketbook		G2	Rivers	Rivers	Mi
Lampsilis sp.2	A freshwater mussel		G1	Rivers	Rivers	SA
Lampsilis splendida	Rayed pink fatmucket		G3	Rivers	Rivers	SA
Lampsilis straminea straminea	Rough fatmucket		G5T3	Rivers	Rivers	Mo
Lampsilis subangulata	Shinyrayed pocketbook	LE	G2	Rivers	Rivers	Ap
Lampsilis virescens	Alabama Lampmussel	LE	G1	Rivers	Rivers	Cu

Lasmigona complanata alabamensis	Alabama heelsplitter		G5T2T3	Rivers	Rivers	Mo
Lasmigona decorata	Carolina Heelsplitter	LE	G1	Rivers	Rivers	SA
Lasmigona subviridis	Green floater		G3	Rivers	Rivers	NA,SA
Lemiox rimosus	Birdwing Pearlymussel	LE	G1	Rivers	Rivers	Cu
Leptodea leptodon	Scaleshell	PE	G1	Rivers	Rivers	Cu,Mi
Lexingtonia dolabelloides	Slabside pearlymussel		G2	Rivers	Rivers	Cu
Margaritifera hembeli	Louisiana Pearlshell	LT	G1	Rivers	Rivers	Mi,Mo
Margaritifera marrianae	Alabama pearlshell	C	G1	Rivers	Rivers	Mo
Medionidus acutissimus	Alabama Moccasinshell	LT	G1	Rivers	Rivers	Mo
Medionidus parvulus	Coosa moccasinshell	LE	G1	Rivers	Rivers	Mo
Medionidus penicillatus	Gulf moccasinshell	LE	G1	Rivers	Rivers	Ap,Fl
Medionidus simpsonianus	Ochlockonee moccasinshell	LE	G1	Rivers	Rivers	Ap
Medionidus walkeri	Suwannee moccasinshell		G1	Rivers	Rivers	Fl

Obovaria jacksoniana	Southern hickorynut		G1G2	Rivers	Rivers	Mi
Obovaria retusa	Ring pink	LE	G1	Rivers	Rivers	Cu,Mi
Obovaria rotulata	Round ebonyshell		G1	Rivers	Rivers	Ap
Obovaria unicolor	Alabama hickorynut		G3	Rivers	Rivers	Ap,Mi
Pegias fabula	Littlewing pearlymussel	LE	G1	Rivers	Rivers	Cu
Plethobasus cicatricosus	White wartyback	LE	G1	Rivers	Rivers	Cu,Mi
Plethobasus cooperianus	Orangefoot pimpleback	LE	G1	Rivers	Rivers	Cu,Mi
Plethobasus cyphus	Sheepnose		G3	Rivers	Rivers	Cu,Mi
Pleurobema altum	Highnut		GH	Rivers	Rivers	Mo
Pleurobema avellanum	Hazel pigtoe		GH	Rivers	Rivers	Mo
Pleurobema beadleianum	Mississippi pigtoe		G2G3	Rivers	Rivers	Mi
Pleurobema chattanoogaense	Painted clubshell		G1	Rivers	Rivers	Mo
Pleurobema clava	Clubshell	LE	G2	Rivers	Rivers	Cu,Mi
Pleurobema collina	James spinymussel	LE	G1	Rivers	Rivers	SA

Pleurobema cordatum	Ohio pigtoe		G3	Rivers	Rivers	Mi
Pleurobema curtum	Black clubshell	LE	G1	Rivers	Rivers	Mo
Pleurobema decisum	Southern clubshell	LE	G1G2	Rivers	Rivers	Mo
Pleurobema furvum	Dark pigtoe	LE	G1	Rivers	Rivers	Mo
Pleurobema georgianum	Southern pigtoe	LE	G1	Rivers	Rivers	Mo
Pleurobema gibberum	Cumberland pigtoe	LE	G1	Rivers	Rivers	Cu
Pleurobema hagleri	Brown pigtoe		G1	Rivers	Rivers	Mo
Pleurobema hanleyianum	Georgia pigtoe		G1	Rivers	Rivers	Mo
Pleurobema johannis	Alabama pigtoe		GH	Rivers	Rivers	Mo
Pleurobema marshalli	Flat Pigtoe	LE	GH	Rivers	Rivers	Mo
Pleurobema murrayense	Coosa pigtoe		GH	Rivers	Rivers	Mo
Pleurobema nucleopsis	Longnut		GH	Rivers	Rivers	Mo
Pleurobema perovatum	Ovate clubshell	LE	G1	Rivers	Rivers	Mo
Pleurobema plenum	Rough pigtoe	LE	G1	Rivers	Rivers	Cu,Mi

<i>Pleurobema pyriforme</i>	Oval pigtoe	LE	G2	Rivers	Rivers	Ap,Fl
<i>Pleurobema riddellii</i>	Louisiana pigtoe		G1G2	Rivers	Rivers	Mi,Sab
<i>Pleurobema rubellum</i>	Warrior pigtoe		GH	Rivers	Rivers	Mo
<i>Pleurobema rubrum</i>	Pyramid pigtoe		G2	Rivers	Rivers	Cu,Mi
<i>Pleurobema strodeanum</i>	Fuzzy pigtoe		G2G3	Rivers	Rivers	Ap,Mo
<i>Pleurobema taitianum</i>	Heavy Pigtoe	LE	G1	Rivers	Rivers	Mo
<i>Pleurobema troschelianum</i>	Alabama clubshell	C	G1	Rivers	Rivers	Mo
<i>Pleurobema verum</i>	True pigtoe		GH	Rivers	Rivers	Mo
<i>Popenaias popeii</i>	Texas Hornshell		G1	Rivers	Rivers	RG
<i>Potamilus amphichaenus</i>	Texas heelsplitter		G1	Rivers	Rivers	Sab
<i>Potamilus capax</i>	Fat Pocketbook	LE	G1	Rivers	Rivers	Mi
<i>Potamilus inflatus</i>	Alabama Heelsplitter	LT	G1	Rivers	Rivers	Mi,Mo
<i>Ptychobranchnus greenii</i>	Triangular Kidneyshell	LE	G1	Rivers	Rivers	Mo
<i>Ptychobranchnus jonesi</i>	Southern kidneyshell		G1	Rivers	Rivers	Ap,Mo

Quadrula aurea	Golden orb		G1	Rivers	Rivers	CT
Quadrula couchiana	Rio Grande Monkeyface		GH	Rivers	Rivers	RG
Quadrula cylindrica	Rabbitsfoot		G3	Rivers	Rivers	Cu,Mi
Quadrula cylindrica cylindrica	Rabbitsfoot		G3T3	Rivers	Rivers	Cu,Mi
Quadrula cylindrica strigillata	Rough Rabbitsfoot	LE	G3T2T3	Rivers	Rivers	Cu,Mi
Quadrula fragosa	Winged Mapleleaf	LE	G1	Rivers	Rivers	Cu,Mi
Quadrula houstonensis	Smooth pimpleback		G2	Rivers	Rivers	CT
Quadrula intermedia	Cumberland Monkeyface	LE	G1	Rivers	Rivers	Cu
Quadrula petrina	Texas pimpleback		G2	Rivers	Rivers	CT
Quadrula rumphiana	Ridged mapleleaf		G3	Rivers	Rivers	Mo
Quadrula sparsa	Appalachian Monkeyface	LE	G1	Rivers	Rivers	Cu
Quadrula stapes	Stirrupshell	LE	GH	Rivers	Rivers	Mo
Quadrula tuberosa	Rough rockshell		GX	Rivers	Rivers	Cu
Quincuncina burkei	Tapered pigtoe		G2G3	Rivers	Rivers	Ap

Quincuncina mitchelli	False spike		GH	Rivers	Rivers	CT,RG
Simpsonaias ambigua	Salamander mussel		G3	Rivers	Rivers	Mi
Strophitus connasaugaensis	Alabama creekshell		G3	Rivers	Rivers	Mo
Strophitus subvexus	Southern creekmussel		G3	Rivers	Rivers	Ap,Mi,Mo
Toxolasma corvunculus	Southern purple lilliput		GH	Rivers	Rivers	Mo
Toxolasma cylindrellus	Pale lilliput	LE	G1	Rivers	Rivers	Cu
Toxolasma lividus	Purple lilliput		G2	Rivers	Rivers	Cu,Mi
Toxolasma lividus lividus			G2T1	Rivers	Rivers	Cu
Toxolasma pullus	Savannah lilliput		G2	Rivers	Rivers	SA
Truncilla cognata	Mexican fawnsfoot		GH	Rivers	Rivers	RG
Truncilla macrodon	Texas fawnsfoot		G2	Rivers	Rivers	Mi
Utterbackia peggyae	Florida floater		G3	Rivers	Rivers	Ap
Utterbackia peninsularis	Pennisular floater		G3	Rivers	Rivers	Fl
Villosa amygdala	Florida rainbow		G3	Rivers	Rivers	Fl

Villosa arkansasensis	Ouachita creekshell		G2	Rivers	Rivers	Oz
Villosa choctawensis	Chocta bean		G2	Rivers	Rivers	Ap
Villosa constricta	Notched rainbow		G3	Rivers	Rivers	SA
Villosa fabalis	Rayed bean		G1G2	Rivers	Rivers	Cu,Mi
Villosa nebulosa	Alabama rainbow		G3	Rivers	Rivers	Ap,Cu Mi
Villosa ortmanni	Kentucky creekshell		G2	Rivers	Rivers	Cu
Villosa perpurpurea	Purple bean	LE	G1	Rivers	Rivers	Cu
Villosa trabalis	Cumberland bean	LE	G1	Rivers	Rivers	Cu
Villosa vaughaniana	Carolina creekshell		G2	Rivers	Rivers	SA
Villosa villosa	Downy rainbow		G3	Rivers	Rivers	Ap,Fl
Epioblasma florentina walkeri	Tan Riffleshell	LE	G1T1	Streams	Streams	Cu
Fusconaia barnesiana	Tennessee pigtoe		G2G3	Streams	Streams	Cu
Lasmigona holstonia	Tennessee heelsplitter		G3	Streams	Streams	Cu,Mo
Pleurobema oviforme	Tennessee clubshell		G3	Streams	Streams	Cu

Ptychobranchnus subtentum	Fluted kidneyshell	G2G3	Streams	Streams	Cu
Villosa vanuxemensis umbrans	Coosa creekshell	G4T2	Streams	Streams	Cu

<sup>a</sup>Federal status: LE = Listed as endangered; LT = Listed as threatened; PE = Proposed for listing as endangered; PT = Proposed for listing as threatened; C = Candidate for listing.

<sup>b</sup>Primary and secondary habitat do not necessarily imply a consistent order or ranking of importance to the taxonomic group.

<sup>c</sup>Watersheds: Ap = Apalachicola, CT = Central Texas, Cu = Cumberland, Fl = Florida, Mo = Mobile, Ms = Mississippi, NA = North Atlantic, Oz = Ozark, RG = Rio Grande, SA = South Atlantic, Sab = Sabine.

[Return to first reference in text](#)

**Table 8--The rare fish evaluated included 165 species, of which 45 are Federally listed as threatened or endangered (NatureServe 2000b)**

Scientific name	Common name	<sup>a</sup> Federal status	ABI	<sup>b</sup> Primary habitat	<sup>b</sup> Secondary habitat	<sup>c</sup> Watersheds
			global rank			
<i>Acipenser brevirostrum</i>	Shortnose Sturgeon	LE	G3	Rivers	Rivers	NA,SA,Fl
<i>Acipenser fulvescens</i>	Lake Sturgeon		G3	Rivers	Rivers	Mo,Mi,Cu
<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	LT, C	G3	Rivers	Rivers	NA,SA,Fl
<i>Acipenser oxyrinchus desotoi</i>	Gulf Sturgeon	LT	G3T2	Rivers	Rivers	Fl,Ap,Mo,Mi
<i>Alosa alabamae</i>	Alabama Shad	C	G3	Rivers	Rivers	Fl,Ap,Mo,Mi, Cu,Oz
<i>Ambloplites cavifrons</i>	Roanoke Bass		G3	Streams	Streams	SA
<i>Amblyopsis rosae</i>	Ozark Cavefish	LT	G2	Groundwater	Groundwater	Oz
<i>Amblyopsis spelaea</i>	Northern Cavefish		G3	Groundwater	Groundwater	Mi
<i>Ameiurus serracanthus</i>	Spotted Bullhead		G3	Streams	Streams	Fl,Ap
<i>Ammocrypta clara</i>	Western Sand Darter		G3	Rivers	Rivers	Mi,Cu,Oz,Sab

<i>Ammocrypta pellucida</i>	Eastern Sand Darter		G3	Rivers	Rivers	Cu,Mi
<i>Campostoma ornatum</i>	Mexican Stoneroller		G3	Rivers	Streams	RG
<i>Cottus paulus</i>	Pygmy Sculpin	LT	G1	Groundwater	Groundwater	Mo
<i>Cottus sp. 1</i>	Bluestone Sculpin		G2	Streams	Streams	Ms
<i>Cottus sp. 4</i>	Clinch Sculpin		G1G2	Streams	Streams	Cu
<i>Cottus sp. 5</i>	Holston Sculpin		G2	Streams	Streams	Cu
<i>Crystallaria asprella</i>	Crystal Darter		G3	Rivers	Rivers	Mi
<i>Cyprinella caerulea</i>	Blue Shiner	LT	G2	Rivers	Rivers	Mo
<i>Cyprinella callisema</i>	Ocmulgee Shiner		G3	Rivers	Rivers	SA
<i>Cyprinella callitaenia</i>	Bluestripe Shiner		G2	Rivers	Rivers	Ap
<i>Cyprinella lepida</i>	Plateau Shiner		G1G2	Streams	Streams	CT
<i>Cyprinella monacha</i>	Spotfin Chub	LT	G2	Rivers	Rivers	Cu
<i>Cyprinella proserpina</i>	Proserpine Shiner		G3	Rivers	Rivers	RG
<i>Cyprinella xaenura</i>	Altamaha Shiner		G1G2	Rivers	Rivers	SA

Cyprinodon bovinus	Leon Springs Pupfish	LE	G1	Groundwater	Groundwater	RG
Cyprinodon elegans	Comanche Springs Pupfish	LE	G1	Groundwater	Groundwater	RG
Cyprinodon pecosensis	Pecos Pupfish	C	G1	Streams	Streams	RG
Dionda argentosa	Manantial Roundnose Minnow		G2	Streams	Rivers	RG
Dionda diaboli	Devil's River Minnow	C	G1	Streams	Rivers	RG
Dionda serena	Nueces Roundnose Minnow		G2	Streams	Rivers	CT
Elassoma alabamae	Spring Pygmy Sunfish		G1	Streams	Streams	Cu
Elassoma boehlkei	Carolina Pygmy Sunfish		G2	Streams	Streams	SA
Elassoma okatie	Bluebarred Pygmy Sunfish		G2G3	Streams	Streams	SA
Elassoma sp. 3	Jewel Pygmy Sunfish		G1	Streams	Streams	SA
Erimystax cahni	Slender Chub	LT	G1G2	Rivers	Rivers	Cu
Etheostoma acuticeps	Sharphead Darter		G2G3	Rivers	Rivers	Cu

<i>Etheostoma aquali</i>	Coppercheek Darter		G2	Rivers	Rivers	Cu
<i>Etheostoma bellator</i>	Warrior Darter		G2	Rivers	Rivers	Mo
<i>Etheostoma boschungii</i>	Slackwater Darter	LT	G1	Streams	Streams	Cu
<i>Etheostoma brevirostrum</i>	Holiday Darter		G2	Rivers	Rivers	Mo
<i>Etheostoma chermocki</i>	Vermilion Darter	PE	G1	Streams	Streams	Mo
<i>Etheostoma chienense</i>	Relict Darter	LE	G1	Streams	Streams	Ms
<i>Etheostoma chuckwachatte</i>	Lipstick Darter		G2G3	Streams	Rivers	Mo
<i>Etheostoma cinereum</i>	Ashy Darter		G2	Streams	Streams	Cu
<i>Etheostoma collis</i>	Carolina Darter		G3	Streams	Streams	SA
<i>Etheostoma corona</i>	Crown Darter		G1G2	Streams	Streams	Cu
<i>Etheostoma cragini</i>	Arkansas Darter	C	G3	Streams	Streams	Oz
<i>Etheostoma denoncourti</i>	Golden Darter		G2	Streams	Rivers	Cu
<i>Etheostoma ditrema</i>	Coldwater Darter		G1G2	Groundwater	Streams	Mo
<i>Etheostoma douglasi</i>	Tuskaloosa Darter		G2	Streams	Rivers	Mo

<i>Etheostoma etowahae</i>	Etowah Darter	LE	G1	Streams	Rivers	Mo
<i>Etheostoma fonticola</i>	Fountain Darter	LE	G1	Groundwater	Streams	CT
<i>Etheostoma forbesi</i>	Barrens Darter		G1G2	Streams	Streams	Cu
<i>Etheostoma grahami</i>	Rio Grande Darter		G3	Rivers	Rivers	RG
<i>Etheostoma maculatum</i>	Spotted Darter		G2	Rivers	Rivers	Mi
<i>Etheostoma mariae</i>	Pinewoods Darter		G3	Streams	Streams	SA
<i>Etheostoma microlepidum</i>	Smallscale Darter		G2G3	Rivers	Rivers	Cu
<i>Etheostoma moorei</i>	Yellowcheek Darter		G1	Streams	Streams	Oz
<i>Etheostoma neopteron</i>	Lollipop Darter		G1G2	Streams	Streams	Cu
<i>Etheostoma nuchale</i>	Watercress Darter	LE	G1	Groundwater	Streams	Mo
<i>Etheostoma okaloosae</i>	Okaloosa Darter	LE	G1	Streams	Streams	Ap
<i>Etheostoma olivaceum</i>	Sooty Darter		G3	Streams	Streams	Cu
<i>Etheostoma osburni</i>	Candy Darter		G3	Streams	Streams	Mi
<i>Etheostoma pallididorsum</i>	Paleback Darter		G2	Streams	Streams	Mi

<i>Etheostoma percnurum</i>	Duskytail Darter	LE	G1	Rivers	Rivers	Cu
<i>Etheostoma phytophilum</i>	Rush Darter		G1	Streams	Streams	Mo
<i>Etheostoma pseudovulatum</i>	Egg-Mimic Darter		G1	Streams	Streams	Cu
<i>Etheostoma pyrrhogaster</i>	Firebelly Darter		G2	Streams	Streams	Ms
<i>Etheostoma raneyi</i>	Yazoo Darter		G2	Streams	Streams	Ms
<i>Etheostoma rubrum</i>	Bayou Darter	LT	G1	Streams	Streams	Ms
<i>Etheostoma scotti</i>	Cherokee Darter	LT	G2	Streams	Streams	Mo
<i>Etheostoma sp. d</i>	Bluemask (Jewel) Darter	LE	G1	Streams	Rivers	Cu
<i>Etheostoma striatulum</i>	Striated Darter		G1	Streams	Streams	Cu
<i>Etheostoma susanae</i>	Cumberland Johnny Darter	C	G2	Streams	Streams	Cu
<i>Etheostoma tecumsehi</i>	Shawnee Darter		G1	Streams	Streams	Ms
<i>Etheostoma tippecanoe</i>	Tippecanoe Darter		G3	Rivers	Rivers	Cu,Ms
<i>Etheostoma trisella</i>	Trispot Darter		G1	Rivers	Streams	Mo

Etheostoma tuscumbia	Tuscumbia Darter		G2	Groundwater	Groundwater	Cu
Etheostoma vulneratum	Wounded Darter		G3	Rivers	Rivers	Cu
Etheostoma wapiti	Boulder Darter	LE	G1	Rivers	Rivers	Cu
Fundulus albolineatus	Whiteline Topminnow		GX	Groundwater	Groundwater	Cu
Fundulus bifax	Stippled Studfish		G2G3	Streams	Rivers	Mo
Fundulus euryzonus	Broadstripe Topminnow		G2	Rivers	Rivers	Mi
Fundulus julisia	Barrens Topminnow		G1	Groundwater	Groundwater	Cu
Gambusia amistadensis	Amistad Gambusia		GX	Groundwater	Streams	RG
Gambusia gaigei	Big Bend Gambusia	LE	G1	Groundwater	Ponds	RG
Gambusia georgei	San Marcos Gambusia	LE	GX	Rivers	Groundwater	RG
Gambusia heterochir	Clear Creek Gambusia	LE	G1	Streams	Streams	CT
Gambusia nobilis	Pecos Gambusia	LE	G2	Groundwater	Streams	RG
Gila pandora	Rio Grande Chub		G3	Streams	Streams	RG
Hemitremia flammea	Flame Chub		G3	Groundwater	Groundwater	Mo,Cu

Hybognathus amarus	Rio Grande Silvery Minnow	LE	G1G2	Streams	Streams	RG
Hybopsis lineapunctata	Lined Chub		G3	Streams	Streams	Mo
Ictalurus lupus	Headwater Catfish		G3	Streams	Rivers	CT
Lythrurus matutinus	Pinewoods Shiner		G2G3	Streams	Streams	SA
Lythrurus snelsoni	Ouachita Shiner		G2	Streams	Streams	Mi
Macrhybopsis gelida	Sturgeon Chub	C	G2	Rivers	Rivers	Mi
Macrhybopsis meeki	Sicklefin Chub	C	G3	Rivers	Rivers	Mi
Macrhybopsis sp. 2	Florida Chub		G3	Rivers	Rivers	Ap
Menidia extensa	Waccamaw Silverside	LT	G1	Lakes	Lakes	SA
Micropterus cataractae	Shoal Bass		G3	Rivers	Streams	Ap
Micropterus notius	Suwannee Bass		G2G3	Rivers	Streams	Fl
Micropterus treculi	Guadalupe Bass		G3	Rivers	Streams	CT
Moxostoma lacerum	Harelip Sucker		GX	Rivers	Rivers	Cu,Mi

Moxostoma robustum	Robust Redhorse		G1	Rivers	Rivers	SA
Moxostoma sp. 1	Apalachicola Redhorse		G3	Rivers	Rivers	Ap
Moxostoma valenciennesi	Greater Redhorse		G3	Rivers	Rivers	Mi
Notropis albizonatus	Palezone Shiner	LE	G2	Rivers	Streams	Cu
Notropis ariommus	Popeye Shiner		G3	Streams	Rivers	Cu,Ms
Notropis cahabae	Cahaba Shiner	LE	G2	Rivers	Rivers	Mo
Notropis chihuahua	Chihuahua Shiner		G3	Streams	Groundwater	RG
Notropis girardi	Arkansas River Shiner	LT	G2	Rivers	Rivers	Oz
Notropis hypsilepis	Highscale Shiner		G3	Streams	Streams	Ap
Notropis jemezianus	Rio Grande Shiner		G3	Rivers	Rivers	RG
Notropis mekistocholas	Cape Fear Shiner	LE	G1	Rivers	Streams	SA
Notropis melanostomus	Blackmouth Shiner		G2	Ponds	Rivers	Ap,Mi
Notropis ortenburgeri	Kiamichi Shiner		G3	Streams	Streams	Oz,Mi
Notropis oxyrhynchus	Sharpnose Shiner		G3	Rivers	Rivers	CT

<i>Notropis ozarcanus</i>	Ozark Shiner		G3	Rivers	Streams	Mi,Oz
<i>Notropis perpallidus</i>	Peppered Shiner		G3	Rivers	Rivers	Mi
<i>Notropis rupestris</i>	Bedrock Shiner		G2	Streams	Streams	Cu
<i>Notropis semperasper</i>	Roughhead Shiner		G2G3	Rivers	Rivers	SA
<i>Notropis simus</i>	Bluntnose Shiner	LT	G2	Rivers	Rivers	RG
<i>Notropis suttkusi</i>	Rocky Shiner		G3	Rivers	Rivers	Mi
<i>Notropis uranoscopus</i>	Skygazer Shiner		G2	Rivers	Rivers	Mo
<i>Noturus baileyi</i>	Smoky Madtom	LE	G1	Rivers	Rivers	Cu
<i>Noturus flavipinnis</i>	Yellowfin Madtom	LT	G1	Rivers	Rivers	Cu
<i>Noturus furiosus</i>	Carolina Madtom		G3	Streams	Streams	SA
<i>Noturus gilberti</i>	Orangefin Madtom		G2	Rivers	Streams	SA
<i>Noturus lachneri</i>	Ouachita Madtom		G2	Streams	Streams	Mi
<i>Noturus munitus</i>	Frecklebelly Madtom		G3	Rivers	Rivers	Mo
<i>Noturus placidus</i>	Neosho Madtom	LT	G2	Rivers	Rivers	Oz

Noturus sp. 2	Broadtail Madtom		G2	Rivers	Rivers	SA
Noturus sp. 4	Chucky Madtom		G1	Streams	Streams	Cu
Noturus stanauli	Pygmy Madtom	LE	G1	Rivers	Rivers	Cu
Noturus stigmosus	Northern Madtom		G3	Rivers	Rivers	Mi
Noturus taylori	Caddo Madtom		G1	Rivers	Rivers	Mi
Percina antesella	Amber Darter	LE	G2	Rivers	Rivers	Mo
Percina aurolineata	Goldline Darter	LT	G2	Rivers	Rivers	Mo
Percina aurora	Pearl Darter	C	G1	Rivers	Rivers	Ms
Percina austroperca	Southern Logperch		G3	Rivers	Rivers	Ap
Percina breviceauda	Coal Darter		G2	Rivers	Rivers	Mo
Percina burtoni	Blotchside Darter		G2	Rivers	Rivers	Cu
Percina jenkinsi	Conasauga Logperch	LE	G1	Rivers	Rivers	Mo
Percina lenticula	Freckled Darter		G2	Rivers	Rivers	Mo.Mi
Percina macrocephala	Longhead Darter		G3	Rivers	Rivers	Cu,Ms

<i>Percina nasuta</i>	Longnose Darter		G3	Streams	Rivers	Mi,Oz
<i>Percina pantherina</i>	Leopard Darter	LT	G1	Streams	Streams	Mi
<i>Percina rex</i>	Roanoke Logperch	LE	G2	Rivers	Rivers	SA
<i>Percina squamata</i>	Olive Darter		G2	Rivers	Rivers	Cu
<i>Percina tanasi</i>	Snail Darter	LT	G2	Rivers	Rivers	Cu
<i>Percina uranidea</i>	Stargazing Darter		G3	Rivers	Rivers	Mi,Oz
<i>Phoxinus cumberlandensis</i>	Blackside Dace	LT	G2	Streams	Streams	Cu
<i>Phoxinus tennesseensis</i>	Tennessee Dace		G2G3	Streams	Streams	Cu
<i>Pteronotropis euryzonus</i>	Broadstripe Shiner		G3	Streams	Streams	Ap
<i>Pteronotropis hubbsi</i>	Bluehead Shiner		G3	Streams	Ponds	Ap
<i>Satan eurystomus</i>	Widemouth Blindcat		G1	Groundwater	Groundwater	CT
<i>Scaphirhynchus albus</i>	Pallid Sturgeon	LE	G1G2	Rivers	Rivers	Mi
<i>Scaphirhynchus suttkusi</i>	Alabama Sturgeon	C	G1	Rivers	Rivers	Mo
<i>Scartomyzon austrinus</i>	West Mexican Redhorse		G3	Streams	Rivers	RG

<i>Semotilus lumbee</i>	Sandhills Chub		G3	Streams	Streams	SA
<i>Speoplatyrhinus poulsoni</i>	Alabama Cavefish	LE	G1	Groundwater	Groundwater	Cu
<i>Thoburnia atripinnis</i>	Blackfin Sucker		G2	Streams	Streams	Mi
<i>Thoburnia hamiltoni</i>	Rustyside Sucker		G2	Streams	Streams	SA
<i>Trogloglanis pattersoni</i>	Toothless Blindcat		G1	Groundwater	Groundwater	CT

<sup>a</sup>Federal status: LE = Listed as endangered; LT = Listed as threatened; PE = Proposed for listing as endangered; PT = Proposed for listing as threatened; C = Candidate for listing.

<sup>b</sup>Primary and secondary habitat do not necessarily imply a consistent order or ranking of importance to the taxonomic group.

<sup>c</sup>Watersheds: Ap = Apalachicola, CT = Central Texas, Cu = Cumberland, Fl = Florida, Mo = Mobile, Ms = Mississippi, NA = North Atlantic, Oz = Ozark, RG = Rio Grande, SA = South Atlantic, Sab = Sabine.

[Return to first reference in text](#)

**Table 9--The rare aquatic amphibians evaluated included 31 species, of which 5 are Federally listed as threatened or endangered (NatureServe 2000b)**

Scientific name	Common name	<sup>a</sup> Federal status	ABI global rank	<sup>b</sup> Primary habitat	<sup>b</sup> Secondary habitat
<i>Ambystoma cingulatum</i>	Flatwoods Salamander	LT	G2G3	Ponds	Ponds
<i>Amphiuma pholeter</i>	One-Toed Amphiuma		G3	Ponds	Ponds
<i>Bufo houstonensis</i>	Houston Toad	LE	G1	Ponds	Ponds
<i>Desmognathus apalachicola</i>	Apalachicola Dusky Salamander		G3	Streams	Streams
<i>Desmognathus carolinensis</i>	Carolina Mountain Dusky Salamander		G2	Streams	Streams
<i>Desmognathus imitator</i>	Imitator Salamander		G3	Streams	Streams
<i>Desmognathus ocoee</i>	Ocoee Salamander		G2G3	Streams	Streams
<i>Desmognathus orestes</i>	Blue Ridge Dusky Salamander		G2	Streams	Streams
<i>Eurycea latitans</i>	Cascade Caverns Salamander		G3	Groundwater	Groundwater
<i>Eurycea nana</i>	San Marcos Salamander	LT	G1	Groundwater	Groundwater
<i>Eurycea neotenes</i>	Texas Salamander		G1	Groundwater	Groundwater

Eurycea pterophila	Dwarf Salamander		G2	Groundwater	Groundwater
Eurycea rathbuni	Texas Blind Salamander	LE	G1	Groundwater	Groundwater
Eurycea robusta	Blanco Blind Salamander		G1	Groundwater	Groundwater
Eurycea sosorum	Barton Springs Salamander	LE	G1	Groundwater	Groundwater
Eurycea sp. 1	Plateau Salamander		G1	Groundwater	Groundwater
Eurycea sp. 2	Salado Springs Salamander		G1	Groundwater	Groundwater
Eurycea sp. 4	Buttercup Creek Caves Salamander		G1	Groundwater	Groundwater
Eurycea sp. 5	Georgetown Salamander		G1	Groundwater	Groundwater
Eurycea sp. 6	River Spring Salamander		G1	Groundwater	Groundwater
Eurycea tridentifera	Comal Blind Salamander		G1	Groundwater	Groundwater
Eurycea troglodytes	Valdina Farms Sinkhole Salamander		GH	Groundwater	Groundwater
Eurycea tynerensis	Oklahoma Salamander		G3	Groundwater	Groundwater
Gyrinophilus palleucus	Tennessee Cave Salamander		G2	Groundwater	Groundwater
Haideotriton wallacei	Georgia Blind Salamander		G2	Groundwater	Groundwater

Necturus alabamensis	Black Warrior Waterdog	G2	Streams	Streams
Necturus lewisi	Neuse River Waterdog	G3	Streams	Streams
Notophthalmus meridionalis	Black-Spotted Newt	G1	Ponds	Ponds
Notophthalmus perstriatus	Striped Newt	G2G3	Ponds	Ponds
Pseudacris streckeri illinoensis	Illinois Chorus Frog	G5T3	Ponds	Ponds
Rana okaloosae	Florida Bog Frog	G2	Streams	Streams

<sup>a</sup>Federal status: LE = Listed as endangered; LT = Listed as threatened; PE = Proposed for listing as endangered; PT = Proposed for listing as threatened; C = Candidate for listing.

<sup>b</sup>Primary and secondary habitat do not necessarily imply a consistent order or ranking of importance to the taxonomic group.

[Return to first reference in text](#)

**Table 10--The rare aquatic reptiles evaluated included 19 species, of which 8 are Federally listed as threatened or endangered (NatureServe 2000b)**

Scientific name	Common name	<sup>a</sup> Federal status	ABI global rank	<sup>b</sup> Primary habitat	<sup>b</sup> Secondary habitat
<i>Clemmys muhlenbergii</i>	Bog Turtle	LT	G3	Ponds	Ponds
<i>Crocodylus acutus</i>	American Crocodile	LE	G2	Ponds	Rivers
<i>Farancia erythrogramma seminola</i>	South Florida Rainbow Snake		G5T1	Streams	Ponds
<i>Graptemys barbouri</i>	Barbour's Map Turtle		G2	Streams	Rivers
<i>Graptemys caglei</i>	Cagle's Map Turtle	C	G3	Streams	Rivers
<i>Graptemys ernsti</i>	Escambia Map Turtle		G2	Rivers	Ponds
<i>Graptemys flavimaculata</i>	Yellow-Blotched Map Turtle	LT	G2	Rivers	Ponds
<i>Graptemys nigrinoda</i>	Black-Knobbed Map Turtle		G3	Streams	Rivers
<i>Graptemys nigrinoda delticola</i>	Delta Map Turtle		G3T2	Streams	Rivers
<i>Graptemys nigrinoda nigrinoda</i>	Black-Knobbed Map Turtle		G3T3	Streams	Rivers
<i>Graptemys oculifera</i>	Ringed Map Turtle	LT	G2	Rivers	Rivers

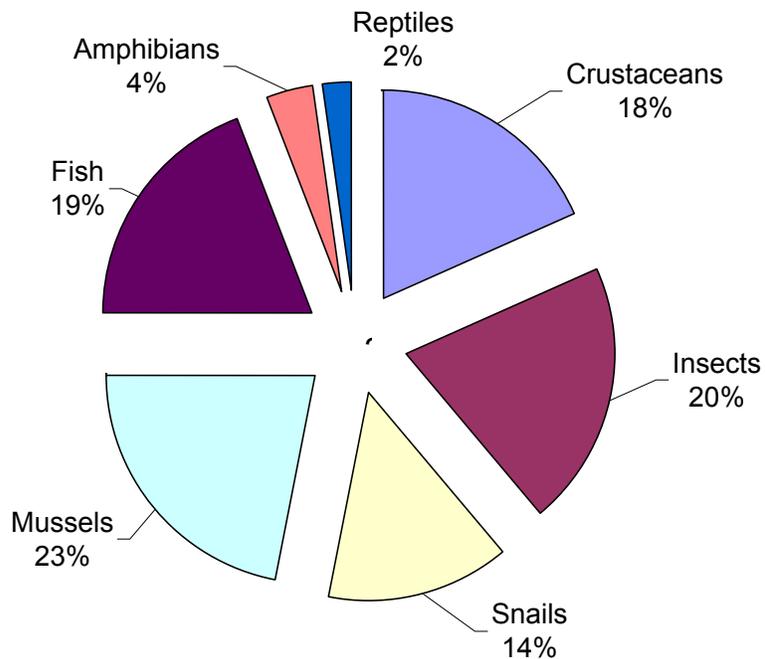
Kinosternon hirtipes	Mexican Mud Turtle		G3	Rivers	Ponds
Kinosternon hirtipes murrayi	Big Bend Mud Turtle		G3T3	Rivers	Ponds
Nerodia erythrogaster neglecta	Copperbelly Water Snake	LT	G5T2T3	Streams	Ponds
Nerodia harteri	Brazos Water Snake		G2	Streams	Ponds
Nerodia paucimaculata	Concho Water Snake	LT	G2	Streams	Ponds
Pseudemys alabamensis	Alabama Redbelly Turtle	LE	G1	Rivers	Rivers
Sternotherus depressus	Flattened Musk Turtle	LT	G2	Streams	Rivers
Trachemys gaigeae	Big Bend Slider		G3	Rivers	Rivers

<sup>a</sup>Federal status: LE = Listed as endangered; LT = Listed as threatened; PE = Proposed for listing as endangered; PT = Proposed for listing as threatened; C = Candidate for listing.

<sup>b</sup>Primary and secondary habitat do not necessarily imply a consistent order or ranking of importance to the taxonomic group.

[Return to first reference in text](#)

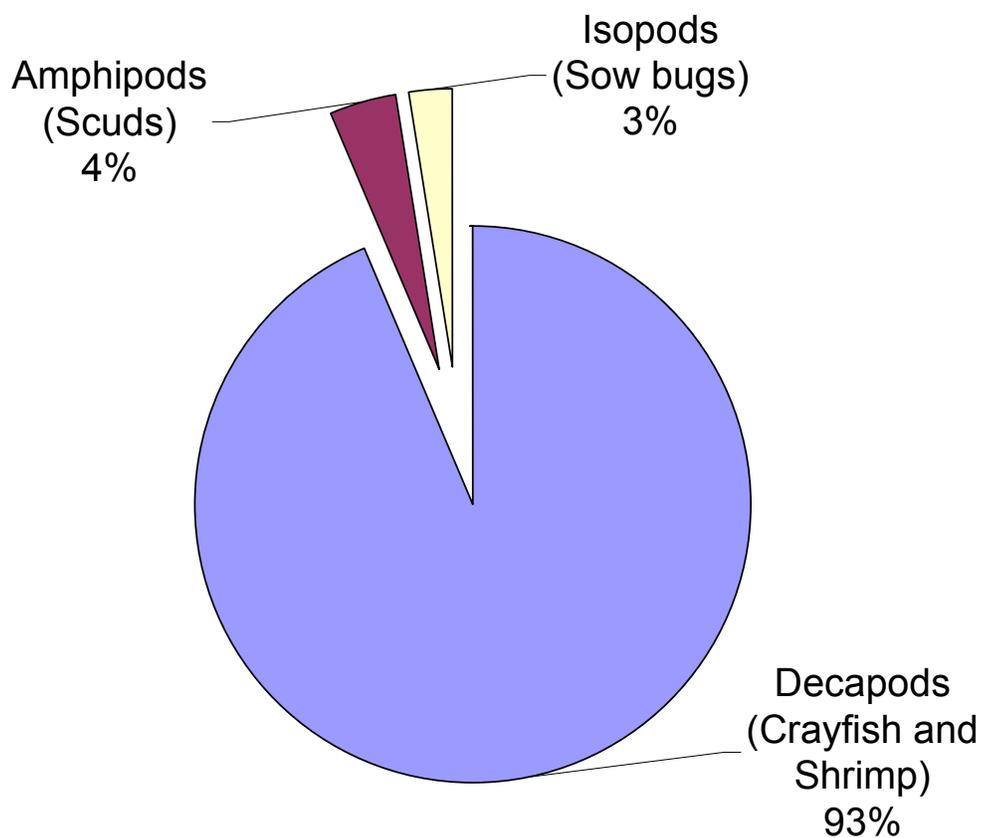
**Figure 1--The 864 rare aquatic species evaluated are distributed among seven major taxonomic groups.**



[Return to first reference in text](#)

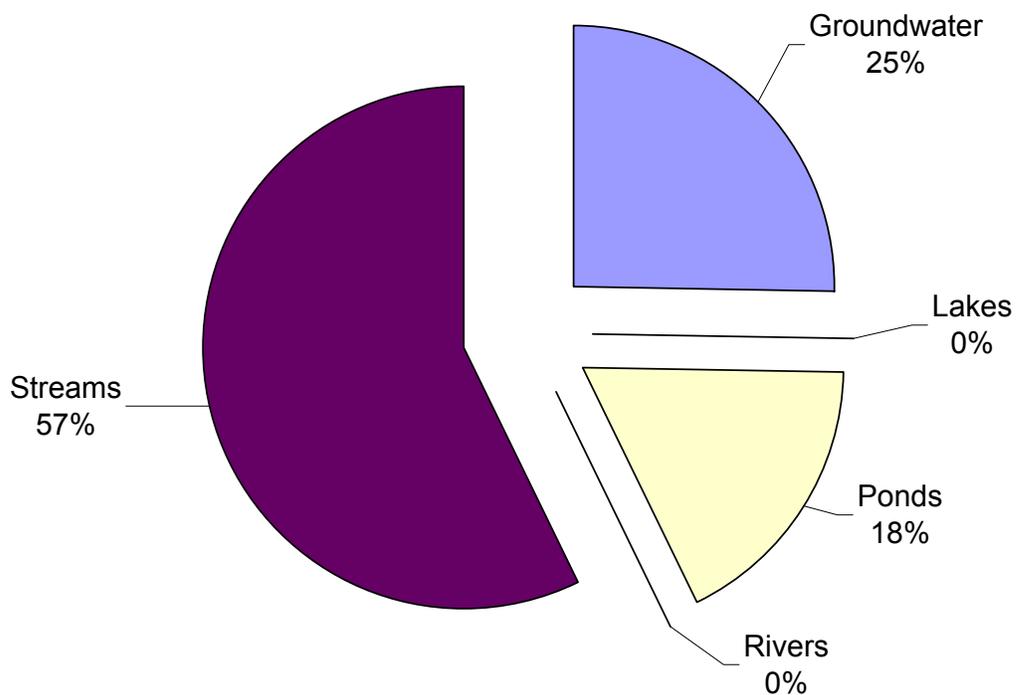
[Return to second reference in text](#)

**Figure 2--The 159 rare aquatic crustacean species evaluated belong to three Orders.**



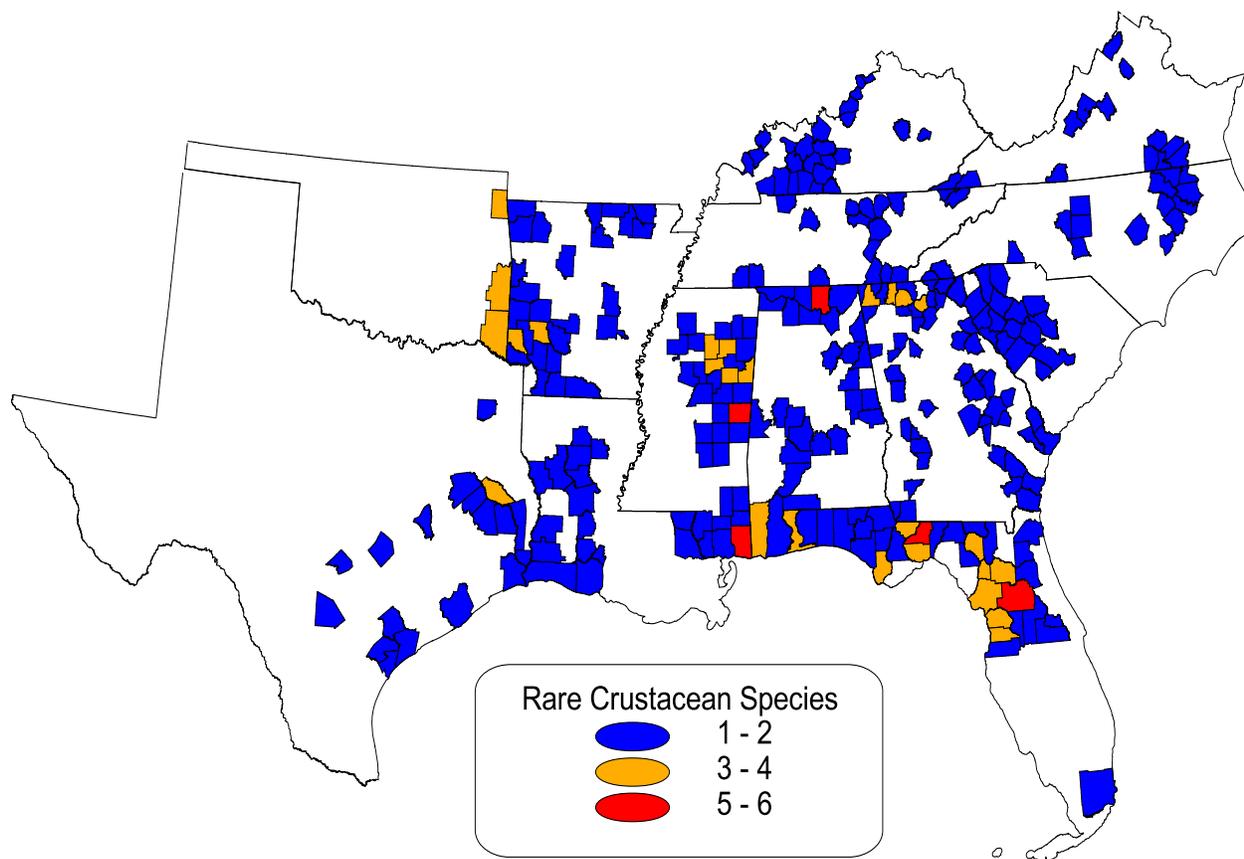
[Return to first reference in text](#)

**Figure 3--The 159 rare aquatic crustaceans are found in groundwater, streams, and ponds. They are absent from large bodies of water (rivers and lakes).**



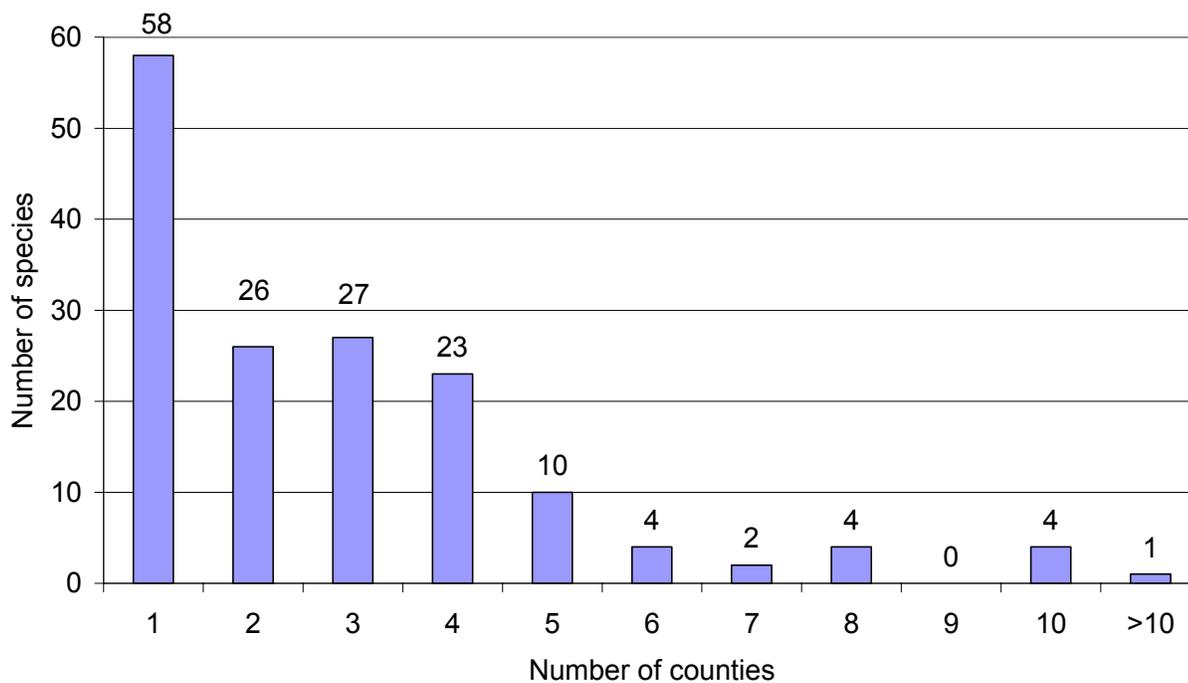
[Return to first reference in text](#)

**Figure 4--The rare aquatic crustaceans are found throughout the South. While some clustering of species is evident and rare species are absent from western Texas and Oklahoma, distribution is surprisingly uniform.**



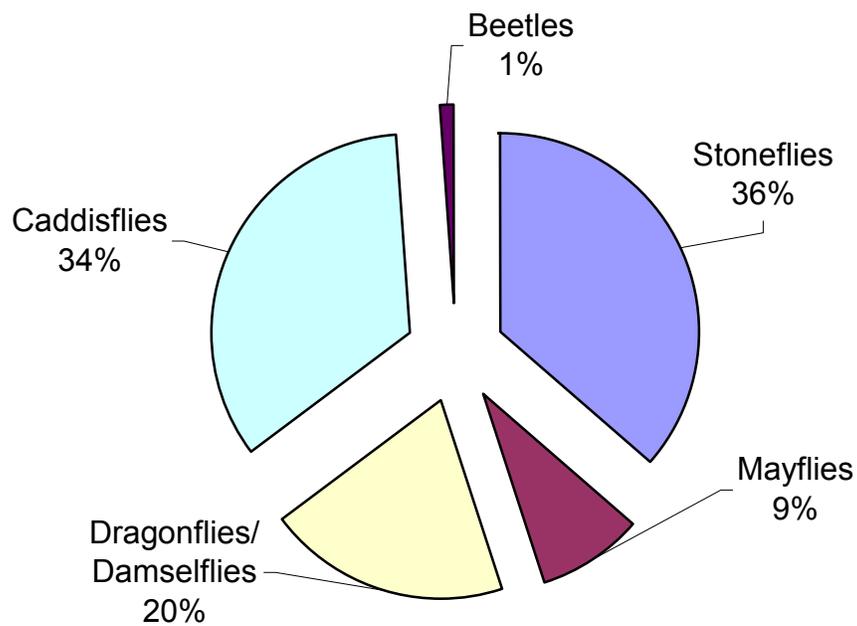
[Return to first reference in text](#)

**Figure 5--Endemism is extremely high in crustaceans. Over 90 percent of the rare aquatic crustaceans have native ranges smaller than five counties and over a third are restricted to a single county.**



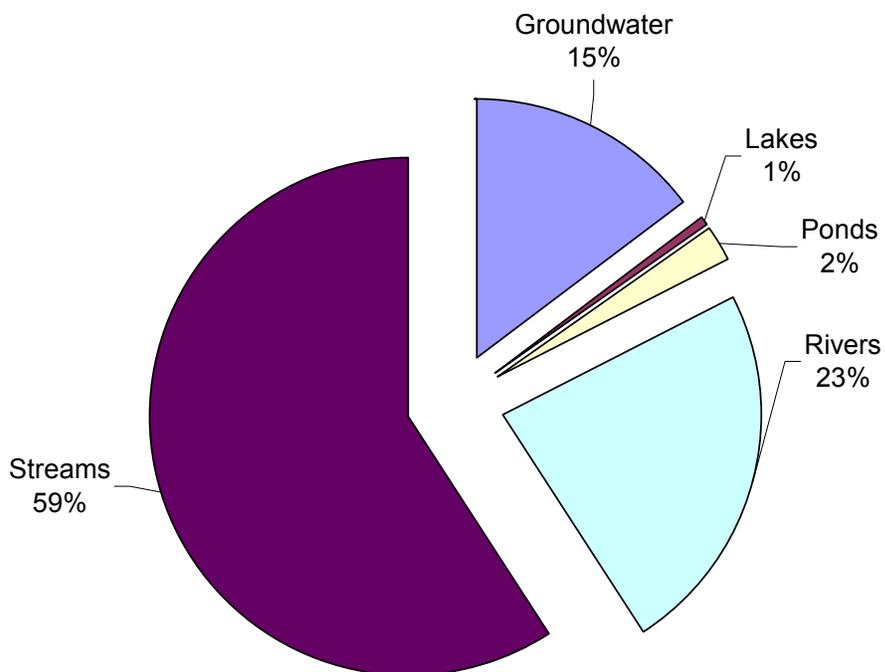
[Return to first reference in text](#)

**Figure 6--The 176 rare aquatic insect species evaluated belong to five Orders.**



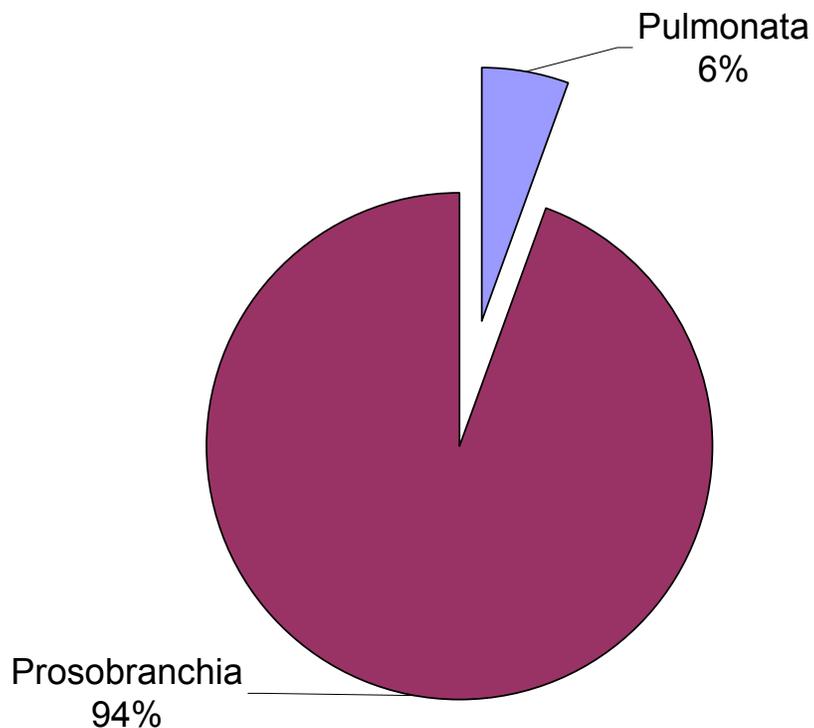
[Return to first reference in text](#)

**Figure 7--The 176 rare aquatic insects are found in all five habitat types. Rivers support more than half of these species. Still water habitats (lakes and ponds) provide habitat for the fewest rare insect species.**



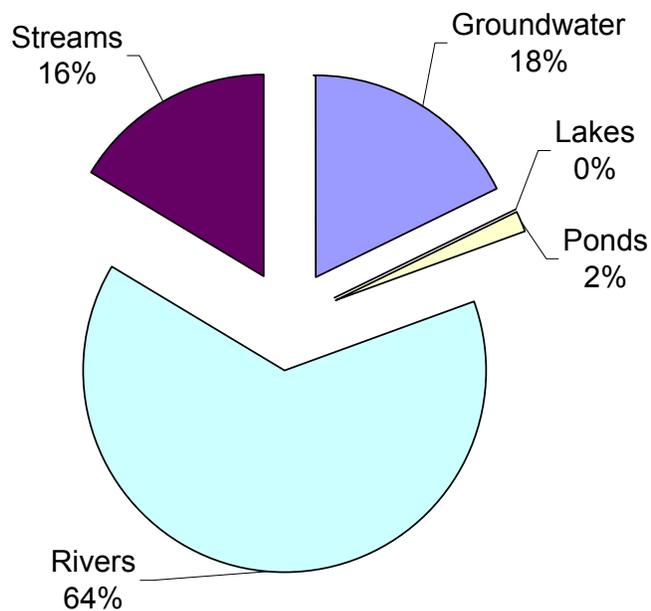
[Return to first reference in text](#)

**Figure 8--The 123 rare aquatic snail species are separated into two groups based on their mode of respiration. The Pulmonata have a “lung” and are able to breathe air while the Prosobranchia have gills.**



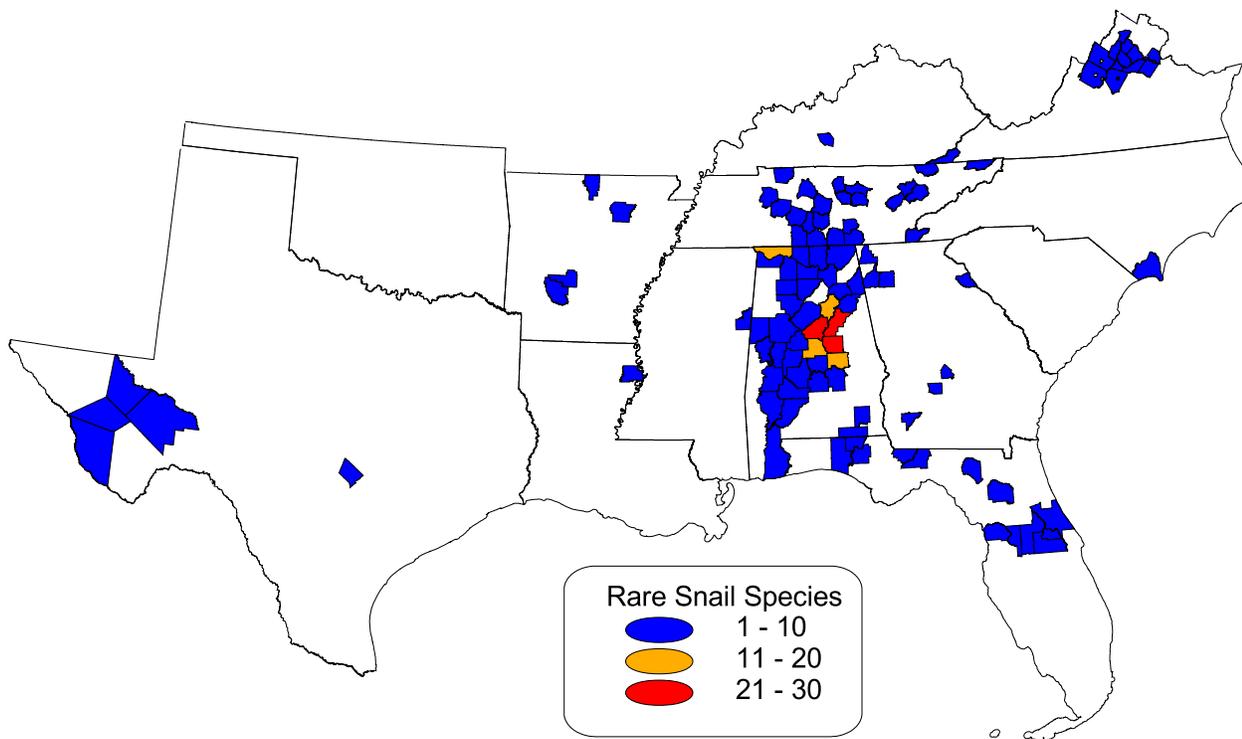
[Return to first reference in text](#)

**Figure 9--The 123 rare snails are found in four of the five aquatic habitats evaluated. Lakes are not used at all and ponds are a minor habitat.**



[Return to first reference in text](#)

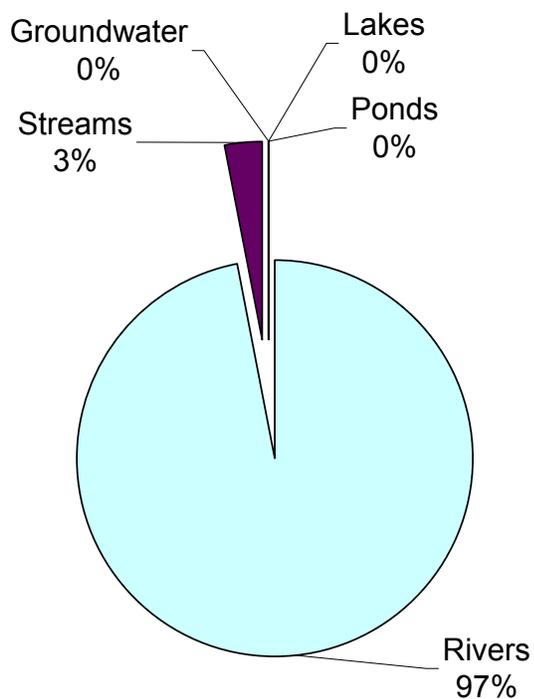
**Figure 10--The distribution of rare aquatic snails is concentrated in the Tennessee and Mobile watersheds.**



[Return to first reference in text](#)

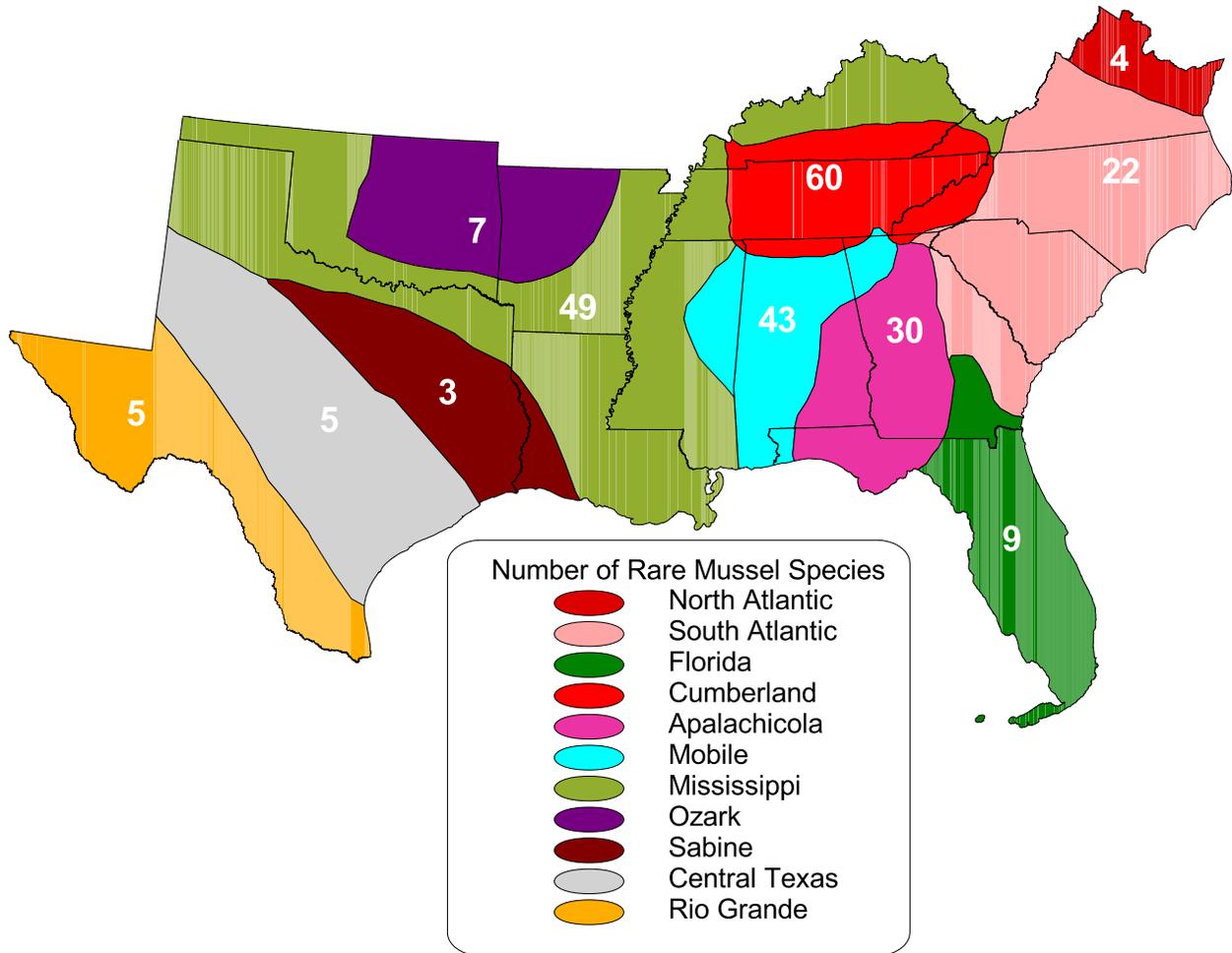
[Return to second reference in text](#)

**Figure 11--The 191 rare mussels are almost completely restricted to rivers. A few are found in streams, but none are dependent on groundwater, lakes, or pond systems.**



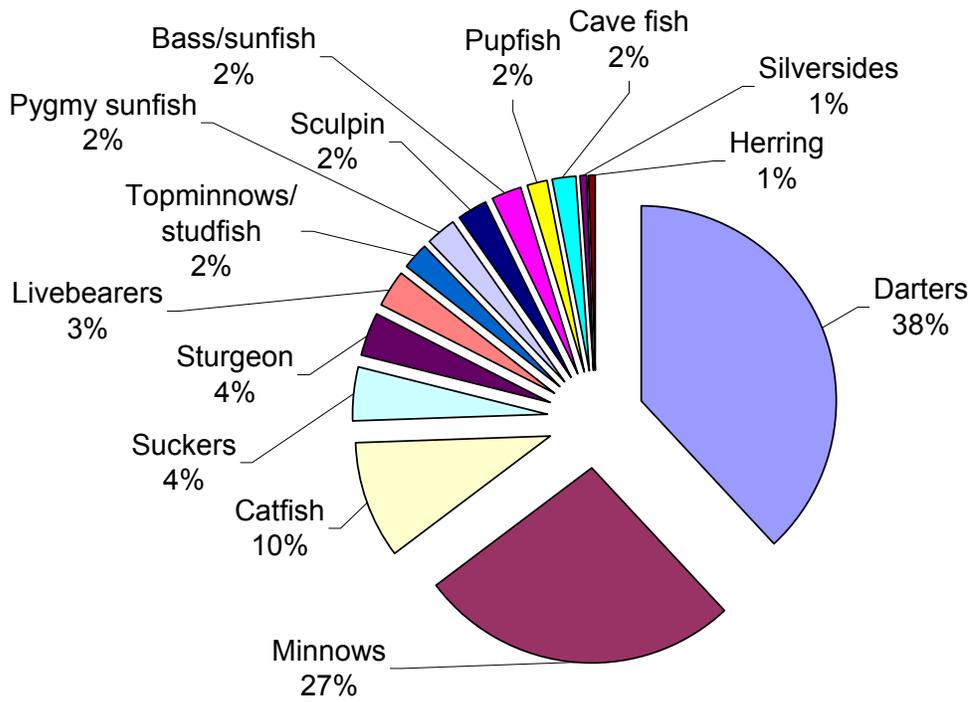
[Return to first reference in text](#)

**Figure 12--Rare mussels occur in all 11 of the aquatic fauna provinces described by Parmalee and Bogan (1998). The Cumberland Province, including the Tennessee and Cumberland River systems, supports the greatest number of rare mussels.**



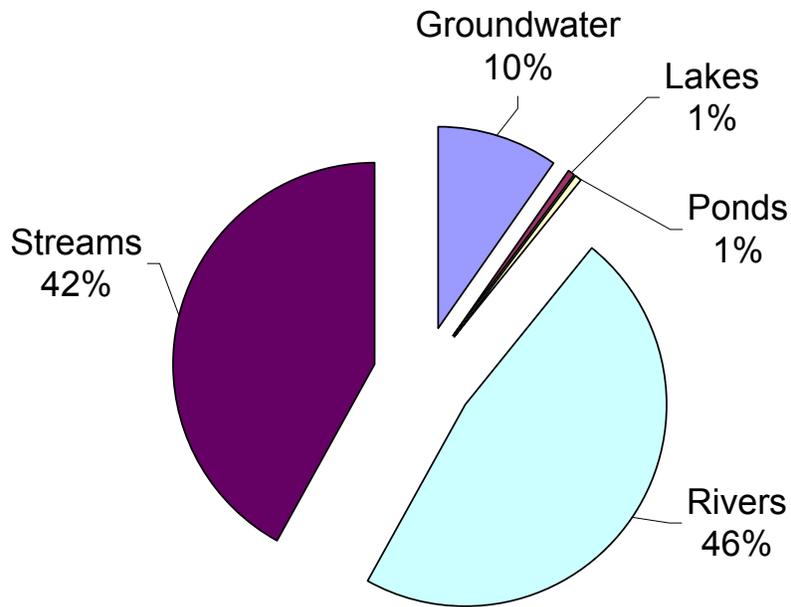
[Return to first reference in text](#)

**Figure 13--The 165 rare fish species are divided between 14 families. The darter, minnow, and catfish families contain 75 percent of the species considered in this Assessment.**



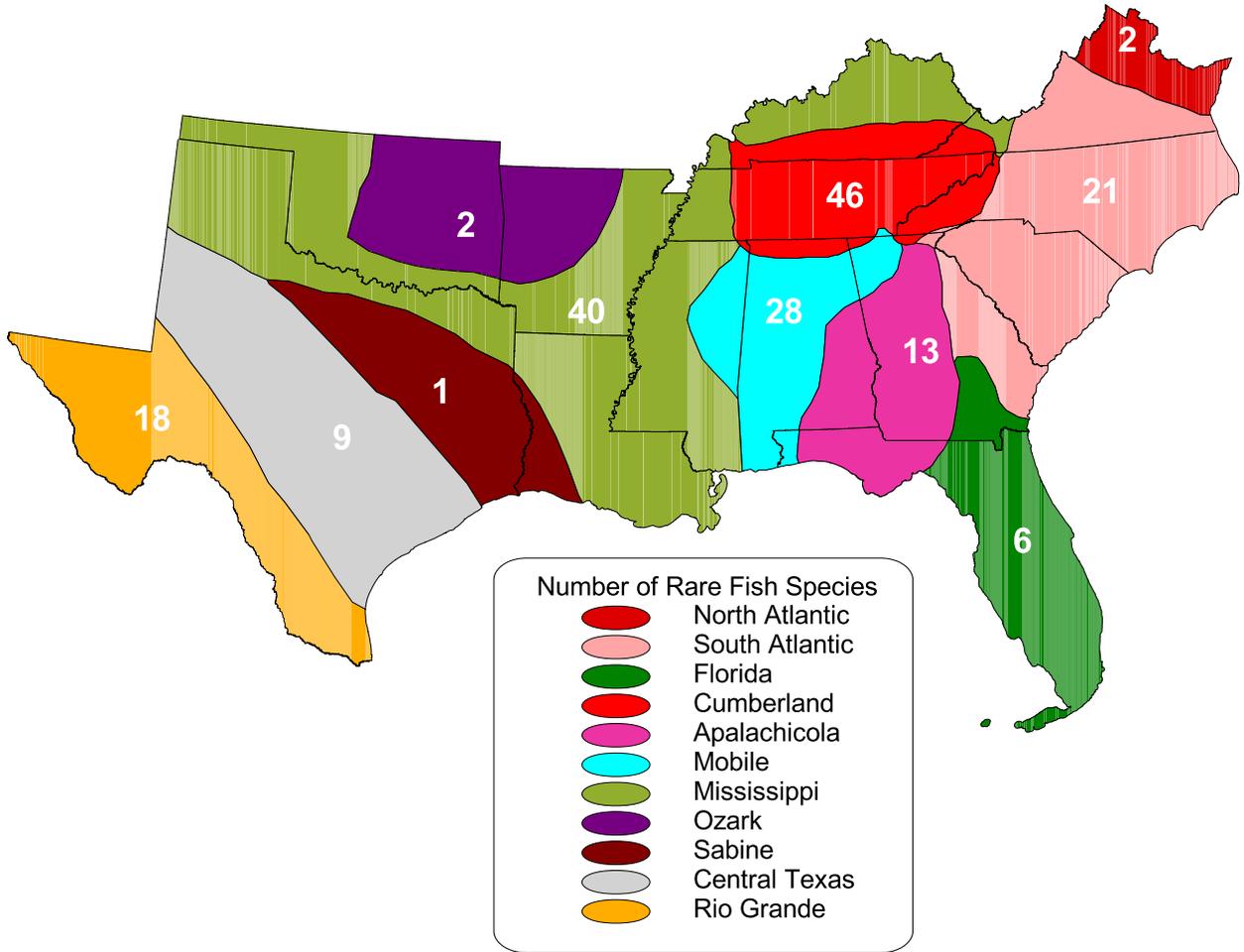
[Return to first reference in text](#)

**Figure 14--All five aquatic habitats are used by the 165 rare fish evaluated. Lakes and ponds combined support only about 2 percent of the species.**



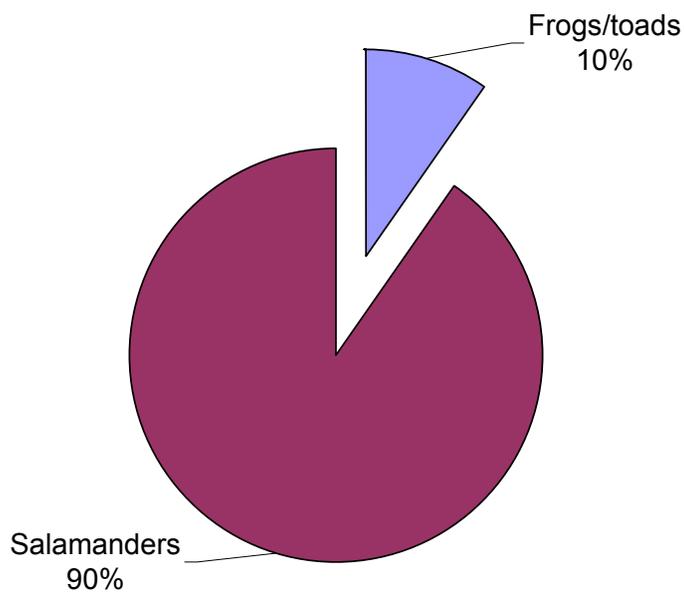
[Return to first reference in text](#)

**Figure 15--Rare fish occur in all 11 of the aquatic fauna provinces described by Parmalee and Bogan (1998). The Cumberland Province, including the Tennessee and Cumberland River systems, supports the greatest number of rare fish.**



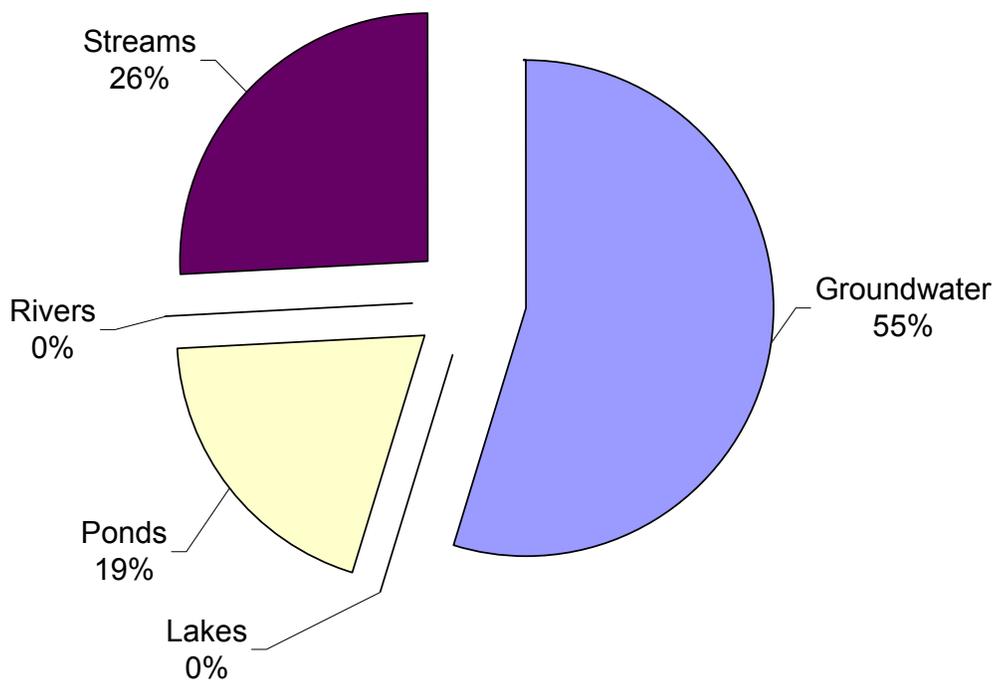
[Return to first reference in text](#)

**Figure 16--The 31 rare aquatic amphibians are dominated by salamanders; only two frogs and one toad are evaluated in this Assessment.**



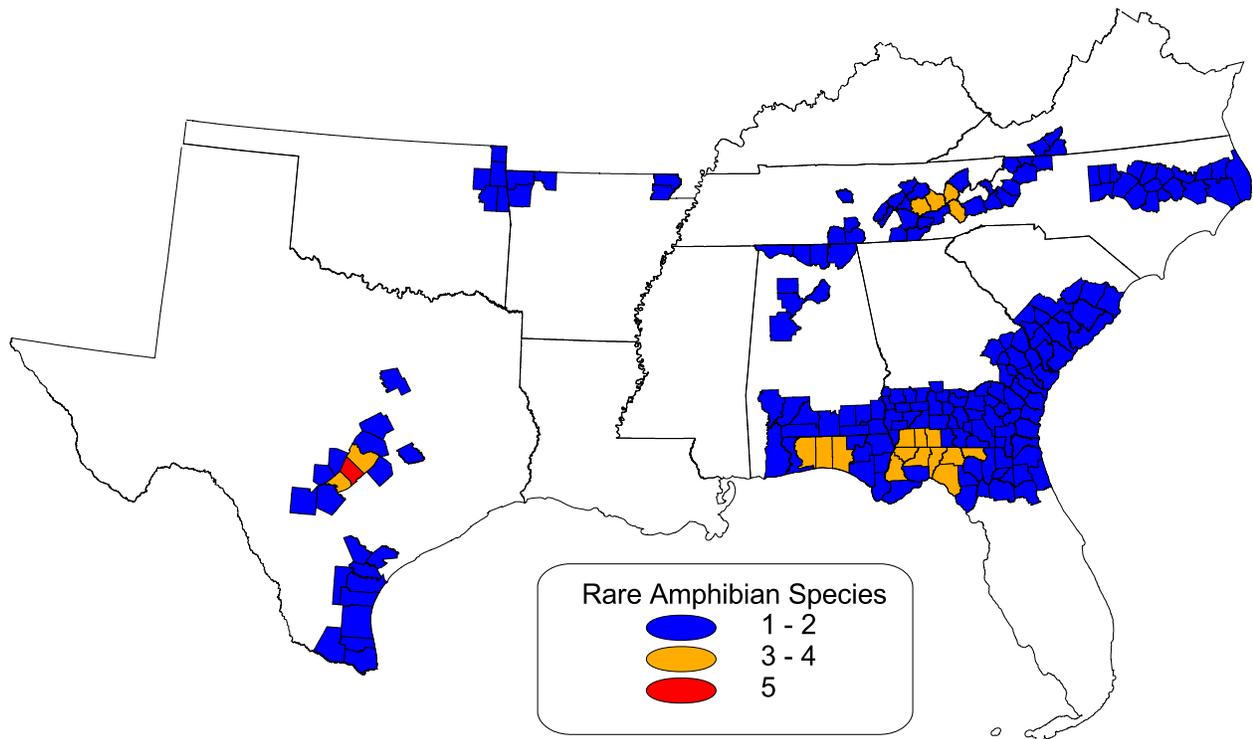
[Return to first reference in text](#)

**Figure 17--The 31 rare aquatic amphibians are reliant on three of the five habitats evaluated. No rare amphibians are dependent on river or lake habitats. Groundwater systems support the most species.**



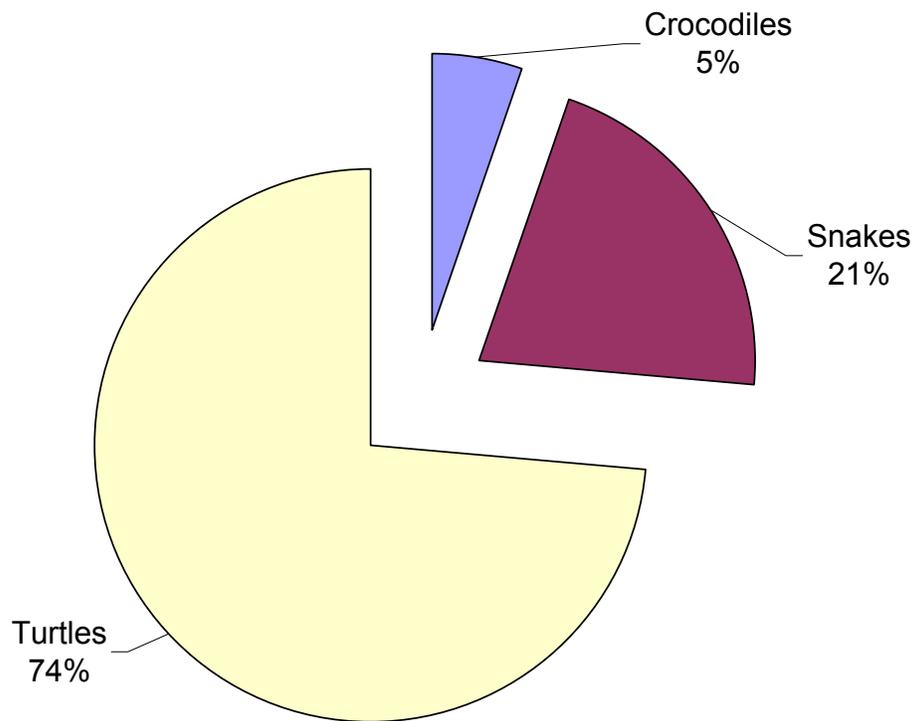
[Return to first reference in text](#)

**Figure 18--The rare aquatic amphibians have three areas of concentration in the South: central Texas, the southern Appalachian Mountains, and the Panhandle of Florida.**



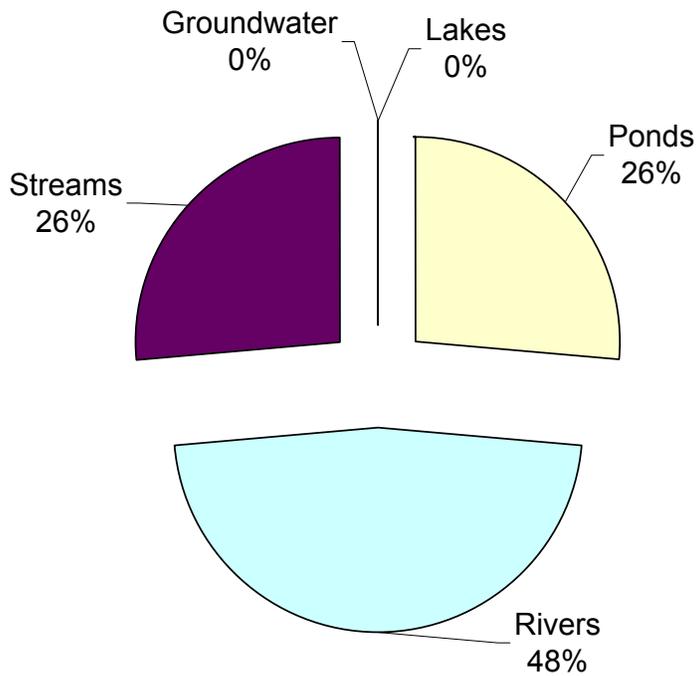
[Return to first reference in text](#)

**Figure 19--The 19 rare aquatic reptiles include 1 crocodile, 4 snakes, and 15 turtles.**



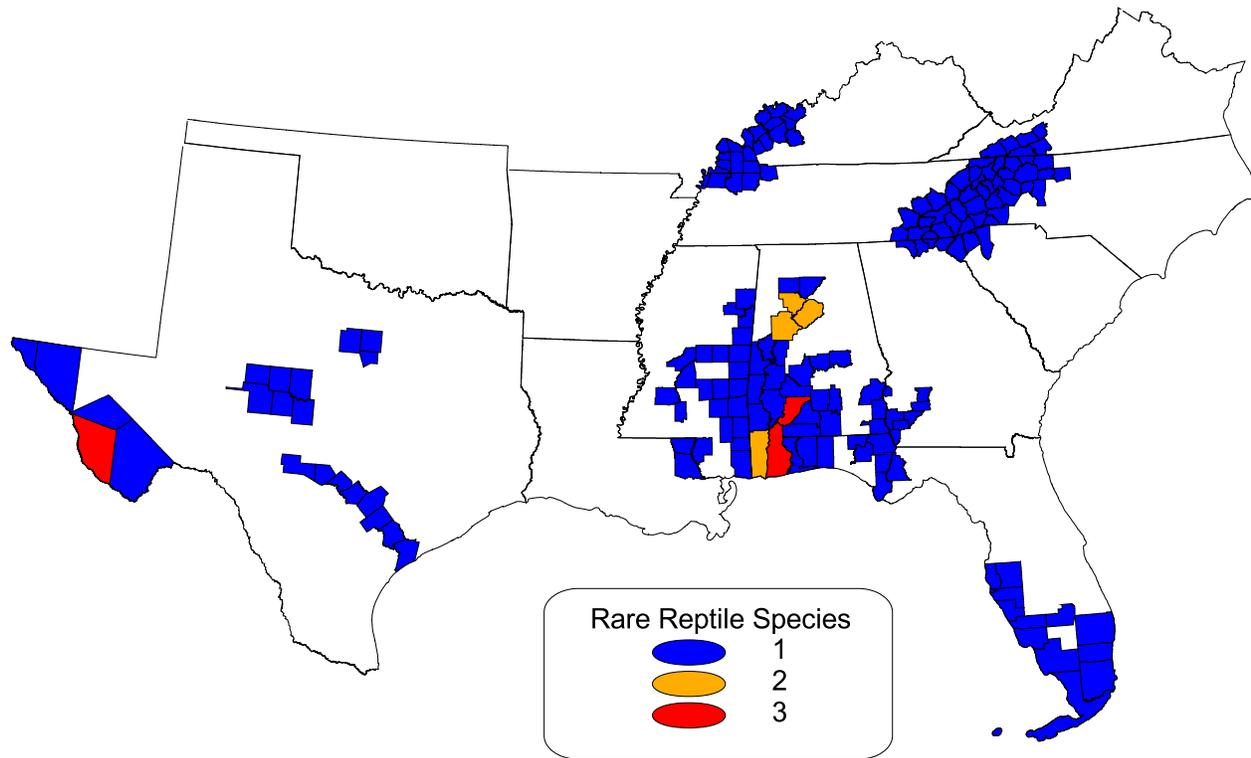
[Return to first reference in text](#)

**Figure 20-- Almost half of the 19 rare aquatic reptiles are associated with rivers. Streams and ponds provide habitat for the remaining species. No rare aquatic reptile species are dependent on groundwater and lake systems.**



[Return to first reference in text](#)

**Figure 21--Rare aquatic reptiles are very localized. Concentrations of species occur in the Pecos and Rio Grande River systems of Texas and in the Mobile and Mississippi River basins.**



[Return to first reference in text](#)

[Return to second reference in text](#)