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

Chapter 23: Aquatic Animals and their Habitats

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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 ground-water 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.

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 and 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 20th 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 (Sheldon 1988; Warren and others 1997, 2000). 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 one-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 earlier are under extreme threats because of past and present human activities in the water and on land (Benz and Collins 1997, Stein and others 2000). 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.

Methods and Data Sources

Aquatic Habitats

For this Assessment, freshwater habitats important to rare aquatic animals were classified as groundwater habitats or surface-water habitats. Ground water 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, 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.

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 (NatureServe

2000, Stein and others 2000). 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 23.1 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 23.2) (fig. 23.1). 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

Table 23.1—Definitions for various levels of imperilment given for individual species by the Association for Biodiversity Information used in this Assessment

Rank	Definition
GX	**Presumed extinct** (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. Eliminated (ecological communities)—Eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.
GH	**Possibly extinct** (species)—Known from only historical occurrences but may nevertheless still be extant; further searching needed. Presumed 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	**Critically imperiled**—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	**Imperiled**—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	**Vulnerable**—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	**Apparently secure**—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#	**Infraspecific 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.

Source: The Association for Biodiversity Information (ABI) maintains an electronic database (NatureServe 2000).

Table 23.2—Aquatic species in seven taxonomic groups selected for evaluation of their vulnerability to extinction based on global ranking received from the Association of Biodiversity Information[a]

Taxonomic group	Date of database query	Global rank G1-G5	Species eliminated[b]	Rare aquatic species[c]	Group with inadequate data
					Percent
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
Total		3,491	2,627	864	

[a] Global rankings are based on queries of the database (NatureServe 2000) on the dates indicated.
[b] 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.
[c] The remaining species evaluated included those with global ranks of G1-G3, T1-T3, GH, and GX.

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 (AFS) expert committees on the status of crayfish, mussels, and fish (Taylor and others 1996; Williams and others 1989, 1993).

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 23.2 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 23.2 lists the taxonomic groupings, and figure 23.1 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 AFS (Taylor and others 1996, Warren and others 2000, Williams and others 1993). 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 to G5 displayed in table 23.2 represents a close approximation of the number of described species in each of the taxonomic groups in the South.

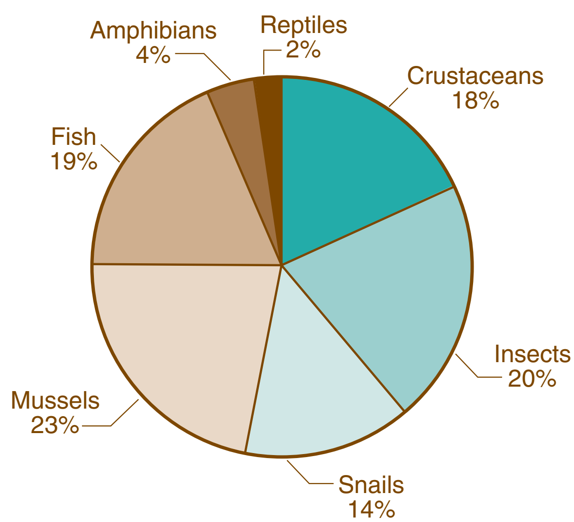

Figure 23.1—The 864 rare aquatic species evaluated are distributed among 7 major taxonomic groups.

Discussion

The "Aquatic Habitats" section, which follows, 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" section.

Aquatic Habitats

The number of species in each taxonomic group dependent on the five aquatic habitats is shown in table 23.3. 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.

Ground-water 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 (Hobbs 1989, NatureServe 2000).

Larger springs may have a unique assemblage of spring-adapted animals. The spring runs flowing from them then may have their own unique assemblages (Hubbs 1995) and share some species with the spring habitats.

Many of the species restricted to subterranean aquatic systems are narrow endemics, occurring only in a few isolated localities (Burr and Warren 1986, Hobbs 1989, Hubbs 1995, NatureServe 2000). 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).

Physical and chemical threats to ground-water 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). Ground water 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 artificial lakes, pesticides, and sedimentation associated with deforestation and urbanization in the watersheds can also affect ground-water habitats (Hobbs 1992, Petranka 1998).

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 ground water 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

Table 23.3—Habitat preferences for rare aquatic species[a]

Taxonomic group	Ground water		Lakes		Ponds		Rivers		Streams	
	Prim.	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
Total	126	117	3	2	68	26	389	393	281	323

Primary and secondary habitat types.

Prim. = primary; Sec. = secondary. These designations do not necessarily imply a consistent order or ranking of importance to the taxonomic group.
[a] Five general habitat categories are evaluated in the Assessment; only habitats that are significantly used are considered.

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 ground water 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.

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.

Physical and chemical threats to lake habitats—Lake habitats are threatened by increased sedimentation and eutrophication. These nonpoint-pollution sources are discussed in detail in chapter 19. The most significant threat to natural lake habitats is urban development along the shores, which increases eutrophication (NatureServe 2000). Guidelines for septic tank drainage need to be implemented and enforced to protect this habitat type.

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).

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 (Palis 1996, Petranka 1998, 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 2000).

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

Rivers—Rare mussels, snails, and fish have the greatest dependency on riverine habitats (table 23.3). 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.

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 mussels' 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 (U.S. Department of the Interior, 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, U.S. Department of the Interior, Fish and Wildlife Service 2000). Reservoirs have flooded much of the flowing water habitats needed for stream-dwelling or spring animals (NatureServe 2000). For example, the Amistad gambusia went extinct when Amistad Reservoir flooded its only known location (NatureServe 2000). 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; and chemical, manufacturing, and wood product wastes are among the most insidious pollutants (Abell and others 2000, Hart and Fuller 1974). The impacts from these pollutants are often both immediate and persistent.

Sediment contributes to river degradation (NatureServe 2000). Sediment sources are discussed in detail in chapter 19. 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.

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.

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 1998, Petranka and others 1994).

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 (Abell and others 2000, Hart and Fuller 1974) 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 2000). 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.

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 do not 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 as 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. Next, 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.

Crustaceans—The 159 rare crustaceans included in this Assessment (table 23.4) belong to three orders: (1) decapods (containing shrimp and crayfishes), (2) isopods (sowbugs), and (3) amphipods (sideswimmers, or scuds) (NatureServe 2000, Pennak 1989) (fig. 23.2). Although Shuster (1997) commented that there is not 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: (1) caves and subterranean streams, (2) ponds, (3) burrows

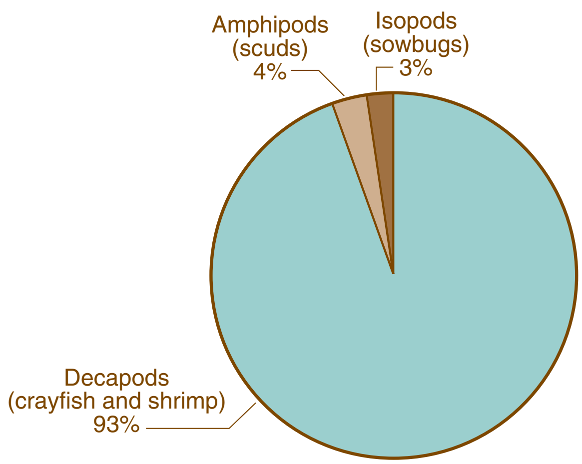

Figure 23.2—The 159 rare aquatic crustacean species evaluated belong to 3 orders.

Table 23.4—The rare aquatic crustaceans evaluated included 159 species, of which 9 are federally listed as threatened or endangered

Scientific name	Common name	Federal status[a]	ABI global rank	Primary habitat[b]	Secondary habitat[b]
Antrolana lira	Madison cave isopod	LT	G1		Ground water
Bouchardina robisoni	A crayfish		G1	Streams	Streams
Caecidotea sp. 7	A cave isopod (Lee County)		G1	Ground water	Ground water
Cambarellus blacki	Cypress crayfish		G1	Ponds	Ponds
Cambarellus diminutus	Least crayfish		G3	Streams	Streams
Cambarellus lesliei	A crayfish		G3	Streams	Streams
Cambarellus ninae	A crayfish		G3	Streams	Streams
Cambarellus schmitti	A crayfish		G3	Streams	Streams
Cambarus aculabrum	A crayfish	LE	G1	Ground water	Ground water
Cambarus angularis	A crayfish		G3	Streams	Streams
Cambarus batchi	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	Ground water	Ground water
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	Ground water	Ground water
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	Ground water	Ground water
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	Ground water	Ground water
Cambarus tartarus	Oklahoma cave crayfish		G1	Ground water	Ground water
Cambarus truncatus	Oconee burrowing crayfish		G1	Ponds	Streams
Cambarus unestami	A crayfish		G2	Streams	Streams
Cambarus zophonastes	Hell Creek cave crayfish	LE	G1	Ground water	Ground water
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

continued

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Table 23.4—The rare aquatic crustaceans evaluated included 159 species, of which 9 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank	Primary habitat[b]	Secondary habitat[b]
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	Ground water	Ground water
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	Ground water	Ground water
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	Ground water	Ground water
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	Ground water	Ground water
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	Ground water	Ground water
Palaemonias alabamae	Alabama cave shrimp	LE	G1G3	Ground water	Ground water
Palaemonias ganteri	Mammoth cave shrimp	LE	G1	Ground water	Ground water
Procambarus acherontis	Orlando cave crayfish		G1	Ground water	Ground water
Procambarus apalachicolae	A crayfish		G2	Ponds	Streams
Procambarus attiguus	Silver Glen Springs crayfish		G1	Ground water	Ground water
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	Ground water	Ground water
Procambarus echinatus	Edisto crayfish		G3	Streams	Streams

continued

AQUATIC

Table 23.4—The rare aquatic crustaceans evaluated included 159 species, of which 9 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank	Primary habitat[b]	Secondary habitat[b]
Procambarus econfinae	Panama City crayfish		G1G2	Ponds	Streams
Procambarus epicyrtus	A crayfish		G3	Streams	Streams
Procambarus erythrops	Santa Fe cave crayfish		G1	Ground water	Ground water
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	Ground water	Ground water
Procambarus gibbus	A crayfish		G3	Streams	Streams
Procambarus hagenianus vesticeps	A crayfish		G4G5T3	Ponds	Streams
Procambarus horsti	Big Blue Springs cave crayfish		G1	Ground water	Ground water
Procambarus kensleyi	A crayfish		G3	Ponds	Streams
Procambarus lagniappe	Lagniappe crayfish		G2	Streams	Streams
Procambarus latipleurum	A crayfish		G2	Ponds	Streams
Procambarus leitheuseri	Coastal lowland cave crayfish		G2	Ground water	Ground water
Procambarus lucifugus	Florida cave crayfish		G2G3	Ground water	Ground water
Procambarus lucifugus alachua	A crayfish		G2G3T2	Ground water	Ground water
Procambarus lucifugus lucifugus	A crayfish		G2G3T1	Ground water	Ground water
Procambarus lylei	Shutispear crayfish		G2	Streams	Streams
Procambarus marthae	A crayfish		G3	Streams	Streams
Procambarus medialis	Tar River crayfish		G2	Streams	Streams
Procambarus milleri	Miami cave crayfish		G1	Ground water	Ground water
Procambarus morrisi	A crayfish		G1	Ground water	Ground water
Procambarus nechesae	A crayfish		G1G2	Ponds	Streams
Procambarus nigrocinctus	A crayfish		G1G2	Streams	Streams
Procambarus nueces	A crayfish		G1	Streams	Streams
Procambarus orcinus	Woodville karst cave crayfish		G1	Ground water	Ground water
Procambarus pallidus	Pallid cave crayfish		G2G3	Ground water	Ground water
Procambarus pecki	Phantom cave crayfish		G2	Ground water	Ground water
Procambarus penni	Pearl blackwater crayfish		G3	Streams	Streams
Procambarus petersi	A crayfish		G3	Streams	Streams
Procambarus pictus	Spotted royal crayfish		G2	Streams	Streams
Procambarus pogum	Bearded red crayfish		G1	Ponds	Streams
Procambarus pubischelae deficiens	A crayfish		G5T3Q	Streams	Streams
Procambarus rathbunae	A crayfish		G2	Ponds	Streams
Procambarus regalis	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	Ground water	Ground water
Stygobromus pecki	Peck's cave amphipod	LE	G1	Ground water	Ground water

continued

AQUATIC

Table 23.4—The rare aquatic crustaceans evaluated included 159 species, of which 9 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank	Primary habitat[b]	Secondary habitat[b]
Stygobromus sp. 10	A cave amphipod (Botetourt County)		G1	Ground water	Ground water
Stygobromus sp. 11	A ground water amphipod (Nelson County)		G1	Ground water	Ground water
Stygobromus sp. 12	A ground water amphipod (Rockbridge County)		G1	Ground water	Ground water
Stygobromus sp. 13	A ground water amphipod (Patrick County)		G1	Ground water	Ground water
Stygobromus sp. 9	A cave amphipod (Shenandoah County)		G1	Ground water	Ground water
Troglocambarus maclanei	Spider cave crayfish		G2	Ground water	Ground water
Troglocambarus sp. 1	A crayfish		G1	Ground water	Ground water

ABI = Association for Biodiversity Information.
[a] 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.
[b] Primary and secondary habitat do not necessarily imply a consistent order or ranking of importance to the taxonomic group.
Source: NatureServe 2000a.

in stream or pond banks or in wet meadows, and (4) streams. Figure 23.3 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, the 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 (fig. 23.4), 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 (fig. 23.5).

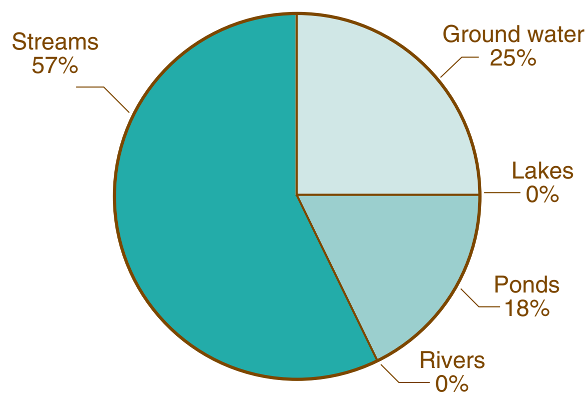

Figure 23.3—The 159 rare aquatic crustaceans are found in ground water, streams, and ponds. They are absent from large bodies of water (rivers and lakes).

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 23.4 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 overcollecting for bait or food, competition from exotic crayfish, and predation from introduced (stocked) fish (NatureServe 2000, Taylor and others 1996). Another nonnative pest species, the zebra mussel, can attach so densely to crayfish that the crayfish are unable to shed their carapaces and grow (Schuster 1997).

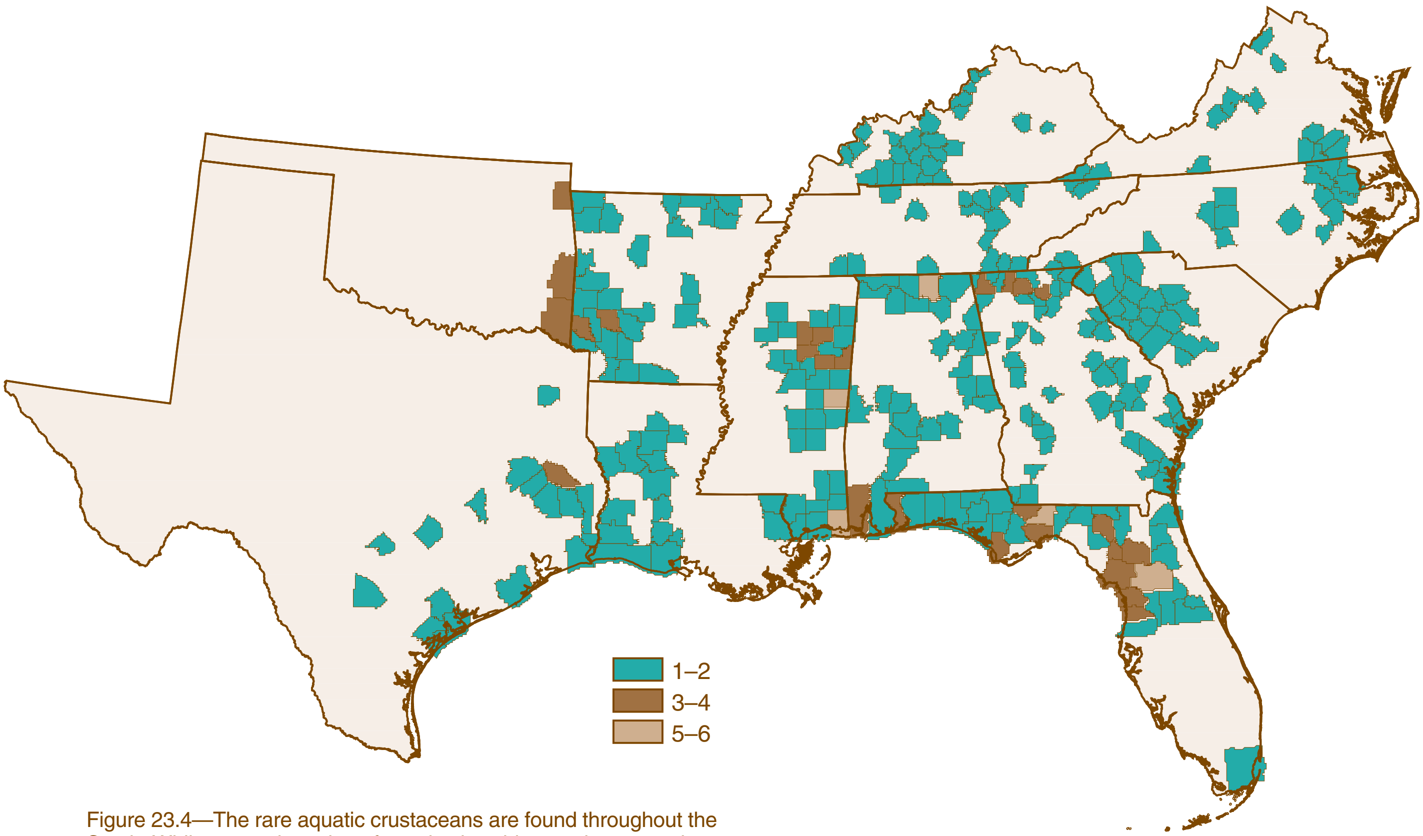

Figure 23.4—The rare aquatic crustaceans are found throughout the South. While some clustering of species is evident and rare species are absent from western Texas and Oklahoma, distribution is surprisingly uniform.

Figure 23.5—Endemism is extremely high in crustaceans. Over 90 percent of the rare aquatic crustaceans have native ranges smaller than five counties and over one-third are restricted to a single county.

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

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 nonnative crayfish associated with “bait-bucket” introductions could see the natives continue to decline (Taylor and others 1996).

Insects—The 176 rare aquatic insects (table 23.5) addressed in this Assessment include organisms from five separate orders: (1) Plecoptera

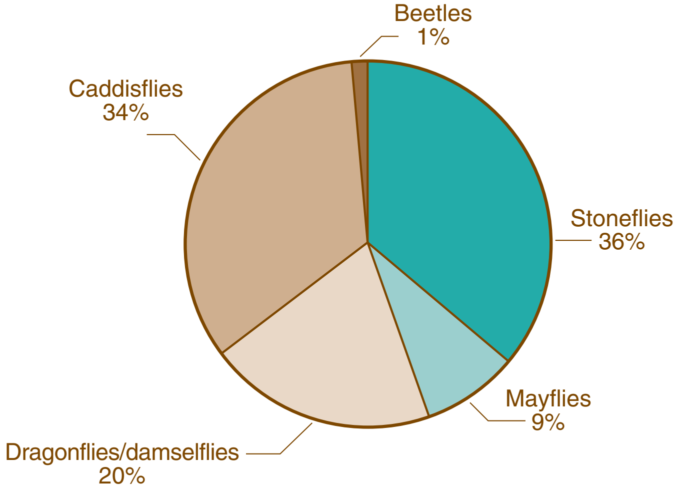

Figure 23.6—The 176 rare aquatic insect species evaluated belong to 5 orders.

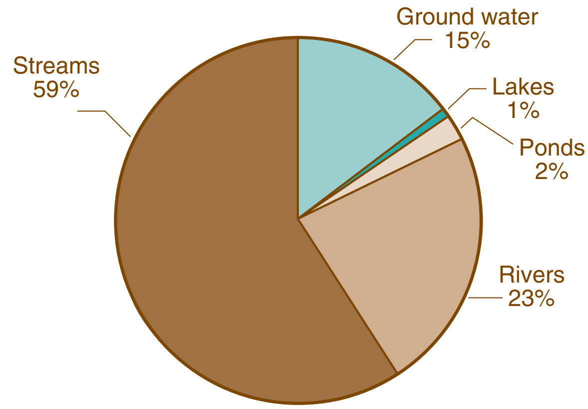

Figure 23.7—The 176 rare aquatic insects are found in all 5 habitat types. Rivers support more than one-half of these species. Still-water habitats (lakes and ponds) provide habitat for the fewest rare insect species.

(stoneflies, 64 species), (2) Ephemeraoptera (mayflies, 15 species), (3) Odonata (dragonflies, 31 species, and damselflies, 4 species), (4) Trichoptera (caddisflies, 60 species), and (5) Coleoptera (aquatic beetles, 2 species) (Meritt and Cummins 1984) (fig. 23.6). These organisms use all five habitat types but are predominately found in rivers and streams (fig. 23.7). 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 23.5 are restricted to springs and subterranean flows associated with Edward's aquifer in central Texas (NatureServe 2001). 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 (Harris and others 1991, Wiggins 1977, 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 2001). County occurrence data are not available for most of these species; consequently, no distribution map could be produced.

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.

Table 23.5—The rare aquatic insects evaluated included 176 species, of which 2 are federally listed as threatened or endangered

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]
Agarodes libalis	Spring-loving psiloneuran caddisfly		G1G2	Ground water	Ground water
Cheumatopsyche comis	Flint's net-spinning caddisfly		G3	Ground water	Ground water
Cheumatopsyche morsei	A common netspinning caddisfly		G1	Ground water	Ground water
Chimarra holzenthali	A caddisfly		G1	Ground water	Ground water
Glyphopsyche sequatchie	Sequatchie caddisfly	C	G1	Ground water	Ground water
Heterelmis comalensis	Comal Springs riffle beetle	LE	G1	Ground water	Ground water
Hydroptila ouachita	A purse casemaker caddisfly		G1	Ground water	Ground water
Hydroptila wakulla	Wakulla springs vari-colored microcaddis		GH	Ground water	Ground water
Isoperla szczytkoi	A stonefly		G1	Ground water	Ground water
Megaleuctra flinti	A stonefly		G2	Ground water	Ground water
Megaleuctra williamsae	Williams' rare winter stonefly		G2	Ground water	Ground water
Oconoperla innubila	A stonefly		G2	Ground water	Ground water
Ostrocerca prolongata	A stonefly		G3	Ground water	Ground water
Stygoparnus comalensis	Comal Springs dryopid beetle	LE	G1	Ground water	Ground water
Viehoperla ada	A stonefly		G3	Ground water	Ground water
Zapada chila	A stonefly		G2	Ground water	Ground water
Agarodes ziczac	Zigzag blackwater caddisfly		G1	Streams	Ground water
Argia leonorae	Leonora's damselfly		G3	Streams	Ground water
Austrotinodes texensis	Texas austrotinodes caddisfly		G2	Streams	Ground water
Ceratopsyche etnieri	Buffalo Springs caddisfly		G1G3	Streams	Ground water
Chimarra florida	Floridain finger-net caddisfly		G1G2	Streams	Ground water
Cordulegaster sayi	Say's spiketail		G2	Streams	Ground water
Gomphus consanguis	Cherokee clubtail		G2G3	Streams	Ground water
Lepidostoma morsei	Morse's little plain brown sedge		G1G2	Streams	Ground water
Leuctra mitchellensis	A stonefly		G3	Streams	Ground water
Leuctra szczytkoi	Schoolhouse Springs leuctran stonefly		G2	Streams	Ground water
Ochrotrichia okaloosa	A caddisfly		G1	Streams	Ground water
Ochrotrichia provosti	Provost's ochrotrichian caddisfly		G1	Streams	Ground water
Libellula jesseana	Purple skimmer		G2	Lakes	Lakes
Libellula composita	Bleached skimmer		G3	Ground water	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
Allocapnia jeanae	A winter stonefly		G2	Rivers	Rivers
Alloperla ouachita	A stonefly		G2	Rivers	Rivers
Anepeorus simplex	Wallace's deepwater mayfly		G2	Rivers	Rivers
Diploperla kanawholensis	Little kanawha perlodid stonefly		G3	Rivers	Rivers
Gomphus crassus	Handsome clubtail		G3	Rivers	Rivers
Gomphus gonzalezi	Tamaulipan clubtail		G2	Rivers	Rivers
Gomphus modestus	Gulf Coast clubtail		G3	Rivers	Rivers
Gomphus ventricosus	Skillet clubtail		G3	Rivers	Rivers
Gomphus viridifrons	Green-faced clubtail		G3	Rivers	Rivers
Gomphus westfalli	Westfall's clubtail		G1G2	Rivers	Rivers
Helopicus nalatus	A stonefly		G3	Rivers	Rivers
Heterocloeon berneri	Berner's two-winged mayfly		G1	Rivers	Rivers
Homoeoneuria cahabensis	Cahaba sand-filtering mayfly		G2	Rivers	Rivers
Homoeoneuria dolani	Blue sand-river mayfly		G2	Rivers	Rivers

continued

Table 23.5—The rare aquatic insects evaluated included 176 species, of which 2 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]
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
Protoptila arca	San Marcos saddle-case caddisfly		G1	Rivers	Rivers
Pteronarcys comstocki	A stonefly		G3	Rivers	Rivers
Remenus duffieldi	A stonefly		G2	Rivers	Rivers
Somatochlora ozarkensis	Ozark emerald		G3	Rivers	Rivers
Stylurus notatus	Elusive clubtail		G3	Rivers	Rivers
Stylurus potulentus	Yellow-sided clubtail		G2	Rivers	Rivers
Stylurus townesi	Townes' clubtail		G3	Rivers	Rivers
Taeniopteryx robinae	A stonefly		G1	Rivers	Rivers
Taeniopteryx starki	Leoan River winter stonefly		G1	Rivers	Rivers
Traverella lewisi	A mayfly		G2	Rivers	Rivers
Erpetogomphus heterodon	Dashed ringtail		G3	Streams	Rivers
Gomphus hodgesi	Hodges' clubtail		G3	Streams	Rivers
Oecetis morsei	Morse's long-horn sedge		G2	Streams	Rivers
Ophiogomphus australis	Southern snaketail		G2	Streams	Rivers
Stylurus potulentus	Yellow-sided clubtail		G2	Streams	Rivers
Hansonoperla cheaha	A stonefly		G2	Ground water	Streams
Hydroptila chelops	A caddisfly		G1	Ground water	Streams
Hydroptila decia	Knoxville hydroptilan micro caddisfly		G1G3	Ground water	Streams
Hydroptila lagoi	A caddisfly		G1	Ground water	Streams
Leuctra nephophila	A stonefly		G3	Ground water	Streams
Prostoia hallasi	Hallas' broadback spring stonefly		G3	Ground water	Streams
Remenus kirchneri	A stonefly		G2	Ground water	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
Allocapnia illinoensis	A stonefly		G3	Streams	Streams
Allocapnia oribata	A stonefly		G1	Streams	Streams
Allocapnia ozarkana	A winter stonefly		G2	Streams	Streams
Allocapnia peltoides	A stonefly		G3	Streams	Streams
Allocapnia perplexa	A stonefly		G1	Streams	Streams
Allocapnia stannardi	A stonefly		G3	Streams	Streams
Allocapnia tennessa	A stonefly		G3	Streams	Streams
Allocapnia warreni	A winter stonefly		GH	Streams	Streams

continued

Table 23.5—The rare aquatic insects evaluated included 176 species, of which 2 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]
Alloperla biserrata	A stonefly		G3	Streams	Streams
Alloperla caddo	A stonefly		G2	Streams	Streams
Alloperla furcula	A stonefly		G2	Streams	Streams
Alloperla natchez	Natchez stonefly		G2	Streams	Streams
Amphinemura mockfordi	A stonefly		G2	Streams	Streams
Argia pima	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 choccolocco	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

continued

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Table 23.5—The rare aquatic insects evaluated included 176 species, of which 2 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]
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

ABI = Association for Biodiversity Information.
[a] Federal status: LE = listed as endangered; C = candidate for listing.
[b] See table 23.1 for definitions of ABI rankings.
[c] Primary and secondary habitat do not necessarily imply a consistant order or ranking of importance to the taxonomic group.
Source: NatureServe 2001b.

Although biological threats are not listed for the beetles, the USFWS (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 streamsides. 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.

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 dewaters the aquifers, by pollutants (that can become concentrated as ground water is lowered), and by other activities that directly affect spring habitats.

Snails—The 123 freshwater snails (table 23.6) (fig. 23.8) 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).

Table 23.6—The rare aquatic snails evaluated included 123 species, of which 11 are federally listed as threatened or endangered

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]	Subclass
Amnicola cora	Foushee cavesnail		G1	Ground water	Ground water	Prosobranchia
Antroselatus spiralis	Shaggy cavesnail		G2G3	Ground water	Ground water	Prosobranchia
Aphaostracon asthenes	Blue spring hydrobe		G1	Ground water	Ground water	Prosobranchia
Aphaostracon chalarogyrus	Freemouth hydrobe		G1	Ground water	Ground water	Prosobranchia
Aphaostracon monas	Wekiwa hydrobe		G1	Ground water	Rivers	Prosobranchia
Aphaostracon pycnus	Dense hydrobe		G1	Ground water	Ground water	Prosobranchia
Aphaostracon theiocrenetus	Clifton spring hydrobe		G1	Ground water	Ground water	Prosobranchia
Aphaostracon xynoelictus	Fenney spring hydrobe		G1	Ground water	Ground water	Prosobranchia
Campeloma decampi	Slender campeloma	LE	G1	Streams	Streams	Prosobranchia
Cincinnatia helicogyra	Crystal siltsnail		G1	Ground water	Ground water	Prosobranchia
Cincinnatia integra	Midland siltsnail		G3	Rivers	Rivers	Prosobranchia
Cincinnatia mica	Ichetucknee siltsnail		G1	Ground water	Ground water	Prosobranchia
Cincinnatia monroensis	Enterprise siltsnail		G1	Ground water	Streams	Prosobranchia
Cincinnatia parva	Pygmy siltsnail		GX	Ground water	Ground water	Prosobranchia
Cincinnatia ponderosa	Ponderous siltsnail		G1	Ground water	Ground water	Prosobranchia
Cincinnatia vanhyningi	Seminole siltsnail		G1	Ground water	Ground water	Prosobranchia
Cincinnatia wekiwae	Wekiwa siltsnail		G1	Ground water	Ground water	Prosobranchia
Clappia cahabensis	Cahaba pebblesnail		GH	Rivers	Rivers	Prosobranchia
Clappia umbilicata	Umbilicate pebblesnail		GH	Rivers	Rivers	Prosobranchia
Dasyscias franzi	Shaggy ghostsnail		G1	Ground water	Ground water	Prosobranchia
Elimia acuta	Acute elimia		G1	Rivers	Rivers	Prosobranchia
Elimia alabamensis	Mud elimia		G1	Rivers	Streams	Prosobranchia
Elimia ampla	Ample elimia		G1	Rivers	Rivers	Prosobranchia
Elimia aterina	Coal elimia		G1	Streams	Streams	Prosobranchia
Elimia bellacrenata	Princess elimia		G1	Ground water	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	Ground water	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	Ground water	Ground water	Prosobranchia
Gyrotoma excisa	Excised slitshell		GX	Rivers	Rivers	Prosobranchia
Gyrotoma lewisii	Striate slitshell		GX	Rivers	Rivers	Prosobranchia
Gyrotoma pagoda	Pagoda slitshell		GX	Rivers	Rivers	Prosobranchia
Gyrotoma pumila	Ribbed slitshell		GX	Rivers	Rivers	Prosobranchia
Gyrotoma pyramidata	Pyramid slitshell		GX	Rivers	Rivers	Prosobranchia
Gyrotoma walkeri	Round slitshell		GX	Rivers	Rivers	Prosobranchia
Io fluvialis	Spiny riversnail		G2	Rivers	Rivers	Prosobranchia
Leptoxis ampla	Round rocksnail	LT	G1G2	Rivers	Rivers	Prosobranchia
Leptoxis clipeata	Agate rocksnail		GH	Rivers	Rivers	Prosobranchia
Leptoxis compacta	Oblong rocksnail		GH	Rivers	Streams	Prosobranchia
Leptoxis crassa	Boulder snail		GH	Rivers	Rivers	Prosobranchia
Leptoxis crassa anthonyi	Anthony's river snail	LE	G1T1	Rivers	Rivers	Prosobranchia
Leptoxis formanii	Interrupted rocksnail		G1	Rivers	Rivers	Prosobranchia

continued

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Table 23.6—The rare aquatic snails evaluated included 123 species, of which 11 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]	Subclass
Leptoxis formosa	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	Ground water	Ground water	Prosobranchia
Pleurocera annulifera	Ringed hornsnail		G1	Rivers	Streams	Prosobranchia
Pleurocera brumbyi	Spiral hornsnail		G1	Ground water	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	Ground water	Streams	Prosobranchia
Pyrgulopsis metcalfi	Naegele springsnail		G1	Ground water	Ground water	Prosobranchia
Pyrgulopsis ogmorhaphe	Royal marstonia	LE	G1	Ground water	Streams	Prosobranchia
Pyrgulopsis olivacea	Olive marstonia		GH	Streams	Ground water	Prosobranchia
Pyrgulopsis ozarkensis	Ozark pyrg		G1	Rivers	Rivers	Prosobranchia
Pyrgulopsis pachyta	Armored marstonia	LE	G1	Streams	Streams	Prosobranchia
Pyrgulopsis scalariformis	Moss pyrg		G1	Rivers	Rivers	Prosobranchia
Somatogyrus amnicoloides	Ouachita pebblesnail		GX	Rivers	Rivers	Prosobranchia
Somatogyrus biangulatus	Angular pebblesnail		GH	Rivers	Rivers	Prosobranchia
Somatogyrus crassilabris	Thicklipped pebblesnail		GX	Rivers	Rivers	Prosobranchia
Somatogyrus currierianus	Tennessee pebblesnail		GH	Rivers	Rivers	Prosobranchia
Somatogyrus excavatus	Ovate pebblesnail		GH	Rivers	Rivers	Prosobranchia
Somatogyrus humerosus	Atlas pebblesnail		GH	Rivers	Rivers	Prosobranchia
Somatogyrus quadratus	Quadrate pebblesnail		GH	Rivers	Rivers	Prosobranchia
Somatogyrus strengi	Rolling pebblesnail		GH	Rivers	Rivers	Prosobranchia
Somatogyrus substriatus	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	Ground water	Streams	Prosobranchia
Tryonia adamantina	Diamond Y spring snail	C	G1	Ground water	Streams	Prosobranchia
Tryonia brunei	Brune spring snail		G1	Ground water	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 ancylid		G1	Rivers	Rivers	Pulmonata
Stagnicola neopalustris	Piedmont pondsnail		GX	Ponds	Ponds	Pulmonata

ABI = Association for Biodiversity Information.
[a] Federal status: LE = listed as endangered; LT = listed as threatened; C = candidate for listing.
[b] See table 23.1 for definitions of ABI rankings.
[c] Primary and secondary habitat do not necessarily imply a consistent order or ranking of importance to the taxonomic group.
Source: NatureServe 2000a.

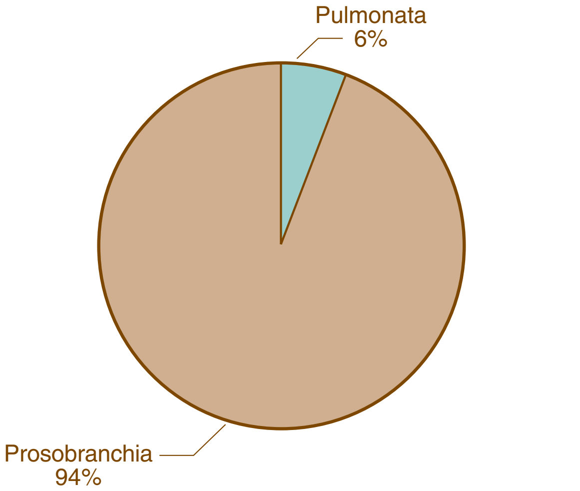

Figure 23.8—The 123 rare aquatic snail species are separated into 2 groups based on their mode of respiration. The Pulmonata have a "lung" and are able to breathe air while the Prosobranchia have gills.

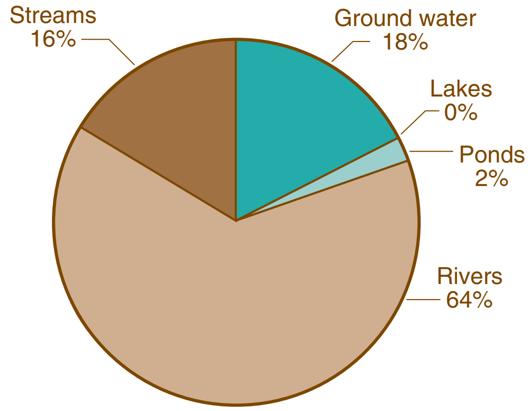

Figure 23.9—The 123 rare snails are found in 4 of the 5 aquatic habitats evaluated. Lakes are not used at all and ponds are a minor habitat.

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 23.9 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 live-bearers (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 (fig. 23.10). 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.

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 2000).

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 (U.S. Department of the Interior, 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 (fig. 23.10). 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).

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 2000), 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 2000). 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 2000). As with all narrow endemics, the magnitude of potential threats to a single population needs to be respected.

Mussels—The 191 rare mussels (table 23.7) evaluated are not divided into subgroups based on taxonomy. They use only river and stream habitats (fig. 23.11). The primary and secondary habitats of each mussel were determined from distribution records and specific references (Dennis 1985; NatureServe 2001; Parmalee and Bogan 1998; U.S. Department of the Interior, Fish and Wildlife Service 1992, 2000; Williams and others 1993). No rare mussels were found to be dependent on ground-water 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

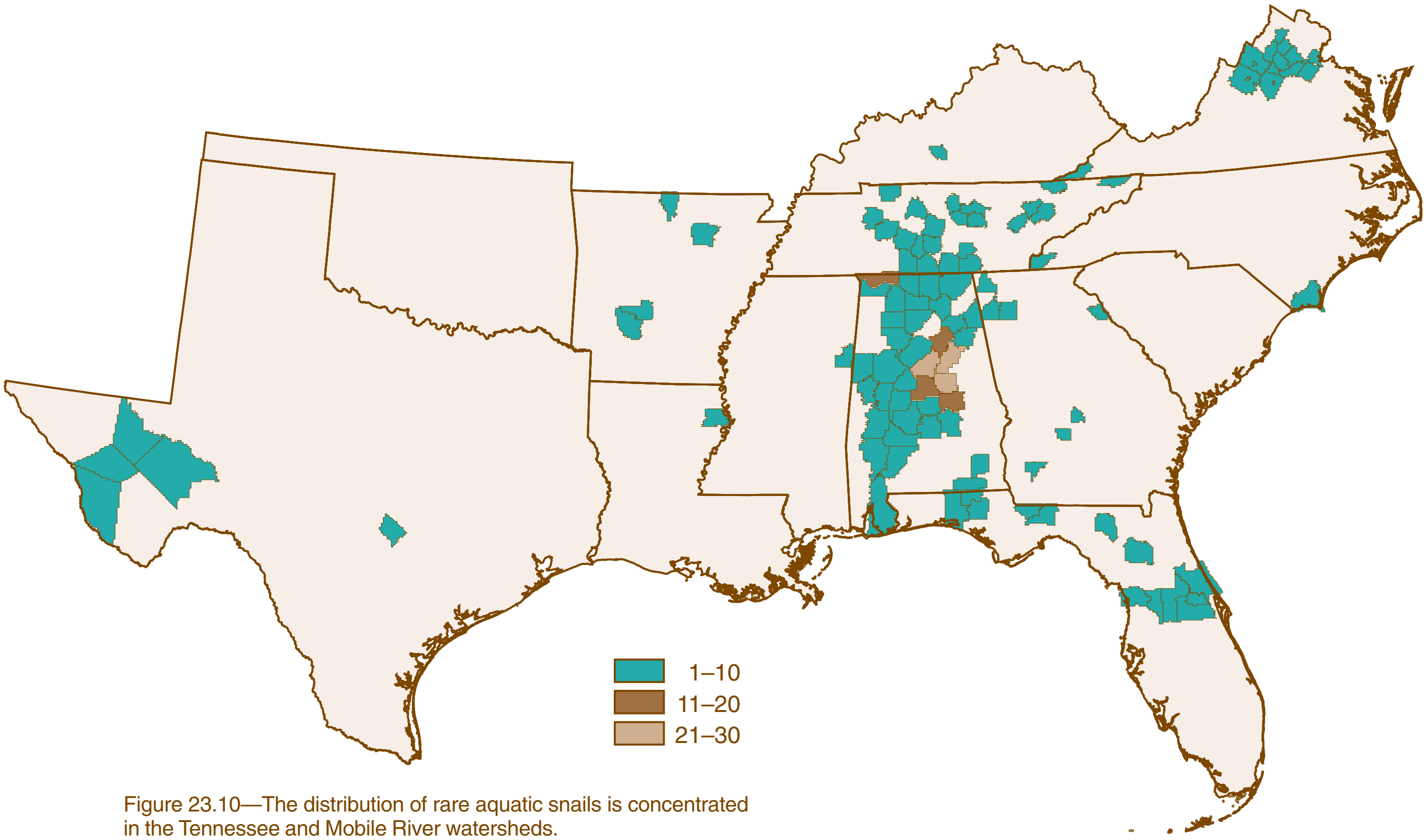

Figure 23.10—The distribution of rare aquatic snails is concentrated in the Tennessee and Mobile River watersheds.

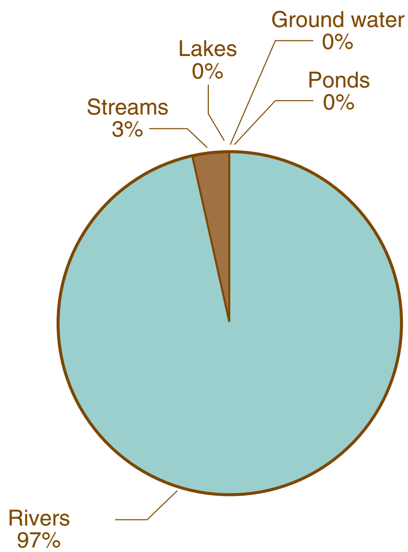

Figure 23.11—The 191 rare mussels are almost completely restricted to rivers. A few are found in streams, but none are dependent on ground water, lakes, or pond systems.

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 glochidium 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 (fig. 23.12). 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 (Hughes and Parmalee 1999, Parmalee and Bogan 1998). 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, U.S. Department of the Interior, Fish and Wildlife Service 2000). Today these imperiled species are found in relatively clean river reaches isolated by degraded reaches or reservoirs (U.S. Department of the Interior, Fish and Wildlife Service 2000).

Table 23.7—The rare mussels evaluated included 191 species, of which 71 are federally listed as threatened or endangered

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]	Watersheds[d]
Alasmidonta arcula	Cumberland elktoe		G2	Rivers	Rivers	SA
Alasmidonta atropurpurea	Cumberland elktoe	LE	G1G2	Rivers	Rivers	Cu
Alasmidonta heterodon	Dwarf wedgemussel	LE	G1G2	Rivers	Rivers	NA,SA
Alasmidonta mccordi	Coosa elktoe		GX	Rivers	Rivers	Mo
Alasmidonta raveneliana	Appalachian elktoe	LE	G1	Rivers	Rivers	Cu
Alasmidonta robusta	Carolina elktoe		GX	Rivers	Rivers	SA
Alasmidonta varicosa	Brook floater		G3	Rivers	Rivers	NA,SA
Alasmidonta wrightiana	Ochloskonee arcmussel		GH	Rivers	Rivers	Ap
Amblema elliottii	Coosa fiveridge		G3	Rivers	Rivers	Mo
Amblema neislerii	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	Ms,Oz
Cumberlandia monodonta	Spectaclecase		G2G3	Rivers	Rivers	Cu
Cyprogenia aberti	Western fanshell		G2	Rivers	Rivers	Oz
Cyprogenia stegaria	Fanshell	LE	G1	Rivers	Rivers	Cu,Ms
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	Ms
Epioblasma flexuosa	Leafshell		GX	Rivers	Rivers	Ms
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	Ms
Epioblasma obliquata obliquata	Catspaw	LE	G1T1	Rivers	Rivers	Cu,Ms
Epioblasma obliquata perobliqua	White catspaw	LE	G1T1	Rivers	Rivers	Ms
Epioblasma penita	Southern combshell	LE	G1	Rivers	Rivers	Mo
Epioblasma personata	Round combshell		GX	Rivers	Rivers	Ms
Epioblasma propingua	Tennessee riffleshell		GX	Rivers	Rivers	Cu
Epioblasma sampsonii	Wabash riffleshell	LE	G1	Rivers	Rivers	Ms
Epioblasma stewardsoni	Cumberland leafshell		GX	Rivers	Rivers	Cu
Epioblasma torulosa	Tubercled blossom	LE	G2	Rivers	Rivers	Ms
Epioblasma torulosa gubernaculums	Green blossom	LE	G2TX	Rivers	Rivers	Ms

continued

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Table 23.7—The rare mussels evaluated included 191 species, of which 71 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]	Watersheds[d]
Epioblasma torulosa rangiana	Northern riffleshell	LE	G2T2	Rivers	Rivers	Ms
Epioblasma torulosa torulosa	Tubercled blossom	LE	G2TX	Rivers	Rivers	Ms
Epioblasma triquetra	Snuffbox		G3	Rivers	Rivers	Cu,Ms
Epioblasma turgidula	Turgid blossom	LE	GH	Rivers	Rivers	Cu
Fusconaia apalachicola	Apalachicola ebonyshell		GX	Rivers	Rivers	Ap
Fusconaia askewi	Tesas pigtoe		G2	Rivers	Rivers	Ms,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	Ms
Fusconaia subrotunda	Longsolid		G3	Rivers	Rivers	Cu,Ms
Fusconaia subrotunda subrotunda	Longsolid		G3T3	Rivers	Rivers	Cu,Ms
Fusconaia succissa	Purple pigtoe		G3	Rivers	Rivers	Ap
Hemistena lata	Cracking pearlymussel	LE	G1	Rivers	Rivers	Cu,Ms
Lampsilis abrupta	Pink mucket	LE	G2	Rivers	Rivers	Cu,Ms
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	Ms
Lampsilis perovalis	Orangenacre mucket	LT	G2	Rivers	Rivers	Mo
Lampsilis powellii	Arkansas fatmucket	LT	G1G2	Rivers	Rivers	Ms
Lampsilis rafinesqueana	Neosho mucket		G2	Rivers	Rivers	Oz
Lampsilis reeviana	Arkansas brokenray		G3	Rivers	Rivers	Oz
Lampsilis reeviana brevucula	Ozark brokenray		G3T2	Rivers	Rivers	Oz
Lampsilis reeviana reeviana	Arkansas brokenray		G3T1T2	Rivers	Rivers	Oz
Lampsilis satura	Sandbank pocketbook		G2	Rivers	Rivers	Ms
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,Ms
Lexingtonia dolabelloides	Slabside pearlymussel		G2	Rivers	Rivers	Cu
Margaritifera hembeli	Louisiana pearlshell	LT	G1	Rivers	Rivers	Ms,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 jachsoniana	Southern hickorynut		G1G2	Rivers	Rivers	Ms
Obovaria retusa	Ring pink	LE	G1	Rivers	Rivers	Cu,Ms
Obovaria rotulata	Round ebonyshell		G1	Rivers	Rivers	Ap
Obovaria unicolor	Alabama hickorynut		G3	Rivers	Rivers	Ap,Ms
Pegias fabula	Littlewing pearlymussel	LE	G1	Rivers	Rivers	Cu
Plethobasus cicatricosus	White wartyback	LE	G1	Rivers	Rivers	Cu,Ms
Plethobasus cooperianus	Orangefoot pimpleback	LE	G1	Rivers	Rivers	Cu,Ms
Plethobasus cyphyus	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	Ms
Pleurobema chattanoogaense	Painted clubshell		G1	Rivers	Rivers	Mo
Pleurobema clava	Clubshell	LE	G2	Rivers	Rivers	Cu,Ms

continued

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Table 23.7—The rare mussels evaluated included 191 species, of which 71 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]	Watersheds[d]
Pleurobema collina	James spinymussel	LE	G1	Rivers	Rivers	SA
Pleurobema cordatum	Ohio pigtoe		G3	Rivers	Rivers	Ms
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,Ms
Pleurobema pyriforme	Oval pigtoe	LE	G2	Rivers	Rivers	Ap,Fl
Pleurobema riddellii	Louisiana pigtoe		G1G2	Rivers	Rivers	Ms,Sab
Pleurobema rubellum	Warrior pigtoe		GH	Rivers	Rivers	Mo
Pleurobema rubrum	Pyramid pigtoe		G2	Rivers	Rivers	Cu,Ms
Pleurobema strodeanum	Fuzzy pigtoe		G2G3	Rivers	Rivers	Ap,Mo
Pleurobema taitianum	Heavy pigtoe	LE	G1	Rivers	Rivers	Mo
Pleurobema troschelianum	Alabama clubshell	C	G1	Rivers	Rivers	Mo
Pleurobema verum	True pigtoe		GH	Rivers	Rivers	Mo
Popenaias popeii	Texas hornshell		G1	Rivers	Rivers	RG
Potamilus amphichaenus	Texas heelsplitter		G1	Rivers	Rivers	Sab
Potamilus capax	Fat pocketbook	LE	G1	Rivers	Rivers	Ms
Potamilus inflatus	Alabama heelsplitter	LT	G1	Rivers	Rivers	Ms,Mo
Ptychobranchus greenii	Triangular kidneyshell	LE	G1	Rivers	Rivers	Mo
Ptychobranchus jonesi	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,Ms
Quadrula cylindrica cylindrica	Rabbitsfoot		G3T3	Rivers	Rivers	Cu,Ms
Quadrula cylindrica strigillata	Rough rabbitsfoot	LE	G3T2T3	Rivers	Rivers	Cu,Ms
Quadrula fragosa	Winged mapleleaf	LE	G1	Rivers	Rivers	Cu,Ms
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	Ms
Strophitus connasaugaensis	Alabama creekshell		G3	Rivers	Rivers	Mo
Strophitus subvexus	Southern creekmussel		G3	Rivers	Rivers	Ap,Ms,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,Ms
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	Ms
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,Ms
Villosa nebulosa	Alabama rainbow		G3	Rivers	Rivers	Ap,Cu Ms
Villosa ortmanni	Kentucky creekshell		G2	Rivers	Rivers	Cu

continued

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Table 23.7—The rare mussels evaluated included 191 species, of which 71 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]	Watersheds[d]
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
Ptychobranchus subtentum	Fluted kidneyshell		G2G3	Streams	Streams	Cu
Villosa vanuxemensis umbrans	Coosa crekshell		G4T2	Streams	Streams	Cu

ABI = Association for Biodiversity Information.
[a] Federal status: LE = listed as endangered; LT = listed as threatened; PE = proposed for listing as endangered; C = candidate for listing.
[b] See table 23.1 for definitions of ABI rankings.
[c] Primary and secondary habitat do not necessarily imply a consistent order or ranking of importance to the taxonomic group.
[d] 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.
Source: NatureServe 2001a.

Other important areas for mussels include the Mississippi watershed; the Apalachicola, Ochlockonee, and Suwannee River watersheds; and the South Atlantic Rivers (fig. 23.12).

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 1930s, 1940s and 1950s." Numerous recovery plans published by the U.S. Department of the Interior, Fish and Wildlife Service (Ahlstedt 1983, U.S. Department of the Interior, 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

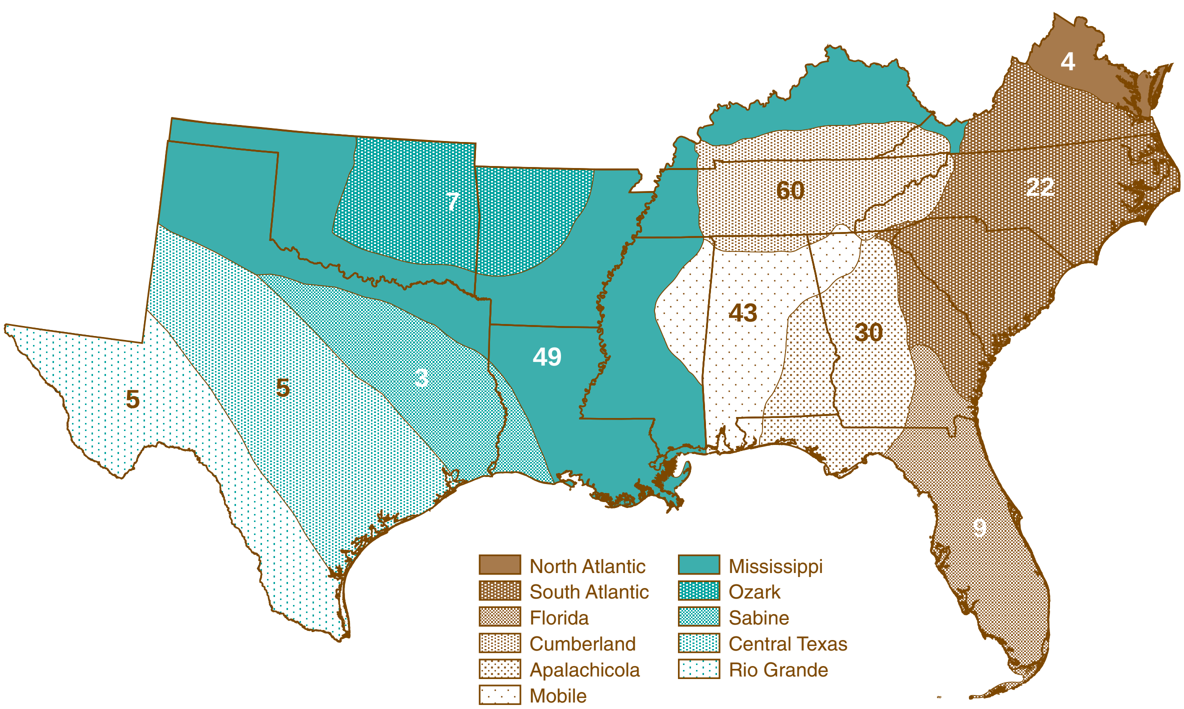

Figure 23.12—Rare mussels occur in all 11 of the aquatic fauna provinces described by Parmalee and Bogan (1998). The Cumberland Province, including the Tennessee and Cumberland River systems, supports the greatest number of rare mussels.

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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 2001). 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 chapter 19.

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 (Abell and others 2000, Hart and Fuller 1974, Neves and others 1997). 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.

Future for mussels—The ways 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, TN, to Paducah, KY, 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 (U.S. Department of the Interior, 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 2001a) 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. The likelihood for accidental spills from trucks or trains is high. Chemical spills pose a serious threat to many isolated mussel 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 (U.S. Department of Agriculture, 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. Minuscule 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.

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 others2000). 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 23.8) belong to 14 families (fig. 23.13). Rivers, streams, and ground water habitats are the major habitats where they occur most often (fig. 23.14).

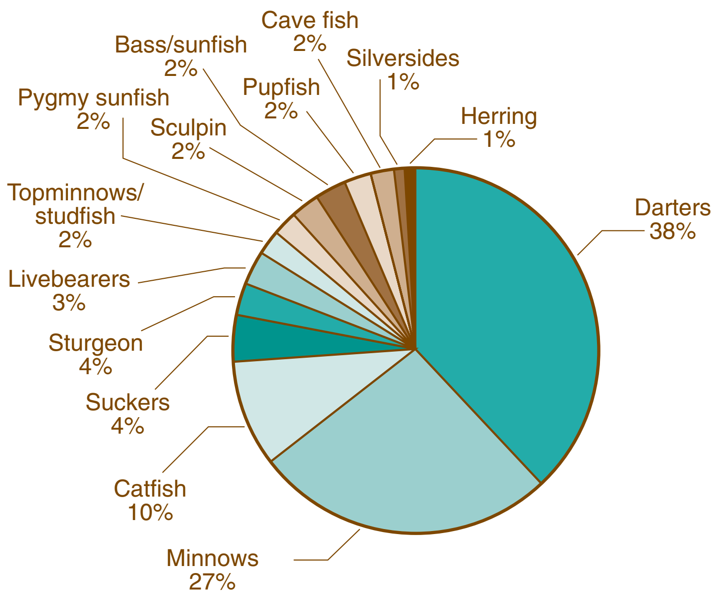

Figure 23.13—The 165 rare fish species are divided among 14 families. The darter, minnow, and catfish families contain 75 percent of the species considered in this Assessment.

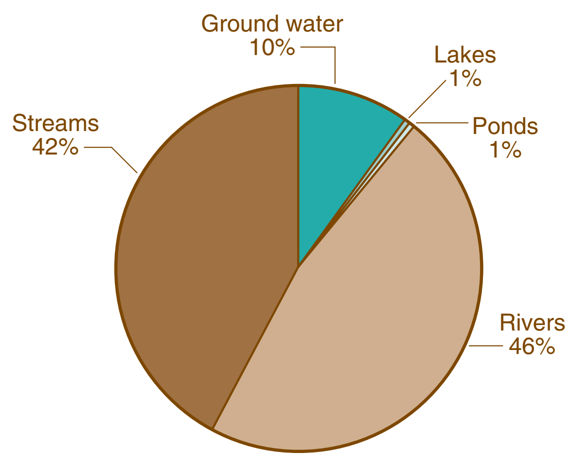

Figure 23.14—The 165 rare fish evaluated use all 5 aquatic habitats. Lakes and ponds combined support only about 2 percent of the species.

Table 23.8—The rare fish evaluated included 165 species, of which 45 are federally listed as threatened or endangered

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]	Watersheds[d]
Acipenser brevirostrum	Shortnose sturgeon	LE	G3	Rivers	Rivers	NA,SA,Fl
Acipenser fulvescens	Lake sturgeon		G3	Rivers	Rivers	Mo,Ms,Cu
Acipenser oxyrinchus	Atlantic sturgeon	LT, C	G3	Rivers	Rivers	NA,SA,Fl
Acipenser oxyrinchus desotoi	Gulf sturgeon	LT	G3T2	Rivers	Rivers	Fl,Ap,Mo,Ms
Alosa alabamae	Alabama shad	C	G3	Rivers	Rivers	Fl,Ap,Mo, Ms, Cu,Oz
Ambloplites cavifrons	Roanoke bass		G3	Streams	Streams	SA
Amblyopsis rosae	Ozark cavefish	LT	G2	Ground water	Ground water	Oz
Amblyopsis spelaea	Northern cavefish		G3	Ground water	Ground water	Ms
Ameiurus serracanthus	Spotted bullhead		G3	Streams	Streams	Fl,Ap
Ammocrypta clara	Western sand darter		G3	Rivers	Rivers	Ms,Cu,Oz,Sab
Ammocrypta pellucida	Eastern sand darter		G3	Rivers	Rivers	Cu,Ms
Campostoma ornatum	Mexican stoneroller		G3	Rivers	Streams	RG
Cottus paulus	Pygmy sculpin	LT	G1	Ground water	Ground water	Mo
Cottus sp. 1	Bluestone sculpin		G2	Streams	Streams	Ms
Cottus sp. 4	Clinch sculpin		G1G2	Streams	Streams	Cu
Cottus sp. 5	Holston sculpin		G2	Streams	Streams	Cu
Crystallaria asprella	Crystal darter		G3	Rivers	Rivers	Ms
Cyprinella caerulea	Blue shiner	LT	G2	Rivers	Rivers	Mo
Cyprinella callisema	Ocmulgee shiner		G3	Rivers	Rivers	SA
Cyprinella callitaenia	Bluestripe shiner		G2	Rivers	Rivers	Ap
Cyprinella lepida	Plateau shiner		G1G2	Streams	Streams	CT
Cyprinella monacha	Spotfin chub	LT	G2	Rivers	Rivers	Cu
Cyprinella proserpina	Proserpine shiner		G3	Rivers	Rivers	RG
Cyprinella xaenura	Altamaha shiner		G1G2	Rivers	Rivers	SA
Cyprinodon bovinus	Leon Springs pupfish	LE	G1	Ground water	Ground water	RG
Cyprinodon elegans	Comanche Springs pupfish	LE	G1	Ground water	Ground water	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
Etheostoma aquali	Coppercheek darter		G2	Rivers	Rivers	Cu
Etheostoma bellator	Warrior darter		G2	Rivers	Rivers	Mo
Etheostoma boschungi	Slackwater darter	LT	G1	Streams	Streams	Cu
Etheostoma brevirostrum	Holiday darter		G2	Rivers	Rivers	Mo
Etheostoma chermocki	Vermilion darter	PE	G1	Streams	Streams	Mo
Etheostoma chienense	Relict darter	LE	G1	Streams	Streams	Ms
Etheostoma chuckwachatte	Lipstick darter		G2G3	Streams	Rivers	Mo
Etheostoma cinereum	Ashy darter		G2	Streams	Streams	Cu
Etheostoma collis	Carolina darter		G3	Streams	Streams	SA
Etheostoma corona	Crown darter		G1G2	Streams	Streams	Cu
Etheostoma cragini	Arkansas darter	C	G3	Streams	Streams	Oz
Etheostoma denoncourti	Golden darter		G2	Streams	Rivers	Cu
Etheostoma ditrema	Coldwater darter		G1G2	Ground water	Streams	Mo
Etheostoma douglasi	Tuskaloosa darter		G2	Streams	Rivers	Mo
Etheostoma etowahae	Etowah darter	LE	G1	Streams	Rivers	Mo
Etheostoma fonticola	Fountain darter	LE	G1	Ground water	Streams	CT
Etheostoma forbesi	Barrens darter		G1G2	Streams	Streams	Cu
Etheostoma grahami	Rio Grande darter		G3	Rivers	Rivers	RG
Etheostoma maculatum	Spotted darter		G2	Rivers	Rivers	Ms
Etheostoma mariae	Pinewoods darter		G3	Streams	Streams	SA
Etheostoma microlepidum	Smallscale darter		G2G3	Rivers	Rivers	Cu
Etheostoma moorei	Yellowcheek darter		G1	Streams	Streams	Oz
Etheostoma neopterum	Lollipop darter		G1G2	Streams	Streams	Cu
Etheostoma nuchale	Watercress darter	LE	G1	Ground water	Streams	Mo
Etheostoma okaloosae	Okaloosa darter	LE	G1	Streams	Streams	Ap

continued

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Table 23.8—The rare fish evaluated included 165 species, of which 45 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]	Watersheds[d]
Etheostoma olivaceum	Sooty darter		G3	Streams	Streams	Cu
Etheostoma osburni	Candy darter		G3	Streams	Streams	Ms
Etheostoma pallididorsum	Paleback darter		G2	Streams	Streams	Ms
Etheostoma percnurum	Duskytail darter	LE	G1	Rivers	Rivers	Cu
Etheostoma phytophilum	Rush darter		G1	Streams	Streams	Mo
Etheostoma pseudovulatum	Egg-mimic darter		G1	Streams	Streams	Cu
Etheostoma pyrrhogaster	Firebelly darter		G2	Streams	Streams	Ms
Etheostoma raneyi	Yazoo darter		G2	Streams	Streams	Ms
Etheostoma rubrum	Bayou darter	LT	G1	Streams	Streams	Ms
Etheostoma scotti	Cherokee darter	LT	G2	Streams	Streams	Mo
Etheostoma sp. d	Bluemask (jewel) darter	LE	G1	Streams	Rivers	Cu
Etheostoma striatulum	Striated darter		G1	Streams	Streams	Cu
Etheostoma susanae	Cumberland johnny darter	C	G2	Streams	Streams	Cu
Etheostoma tecumsehi	Shawnee darter		G1	Streams	Streams	Ms
Etheostoma tippecanoe	Tippecanoe darter		G3	Rivers	Rivers	Cu,Ms
Etheostoma trisella	Trispot darter		G1	Rivers	Streams	Mo
Etheostoma tuscumbia	Tuscumbia darter		G2	Ground water	Ground water	Cu
Etheostoma vulneratum	Wounded darter		G3	Rivers	Rivers	Cu
Etheostoma wapiti	Boulder darter	LE	G1	Rivers	Rivers	Cu
Fundulus albolineatus	Whiteline topminnow		GX	Ground water	Ground water	Cu
Fundulus bifax	Stippled studfish		G2G3	Streams	Rivers	Mo
Fundulus euryzonus	Broadstripe topminnow		G2	Rivers	Rivers	Ms
Fundulus julisia	Barrens topminnow		G1	Ground water	Ground water	Cu
Gambusia amistadensis	Amistad gambusia		GX	Ground water	Streams	RG
Gambusia gaigei	Big Bend gambusia	LE	G1	Ground water	Ponds	RG
Gambusia georgei	San Marcos gambusia	LE	GX	Rivers	Ground water	RG
Gambusia heterochir	Clear Creek gambusia	LE	G1	Streams	Streams	CT
Gambusia nobilis	Pecos gambusia	LE	G2	Ground water	Streams	RG
Gila pandora	Rio Grande chub		G3	Streams	Streams	RG
Hemitremia flammea	Flame chub		G3	Ground water	Ground water	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	Ms
Macrhybopsis gelida	Sturgeon chub	C	G2	Rivers	Rivers	Ms
Macrhybopsis meeki	Sicklefin chub	C	G3	Rivers	Rivers	Ms
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,Ms
Moxostoma robustum	Robust redhorse		G1	Rivers	Rivers	SA
Moxostoma sp. 1	Apalachicola redhorse		G3	Rivers	Rivers	Ap
Moxostoma valenciennesi	Greater redhorse		G3	Rivers	Rivers	Ms
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	Ground water	RG
Notropis girardi	Arkansas River shiner	LT	G2	Rivers	Rivers	Oz
Notropis hypsilepis	Highscale shiner		G3	Streams	Streams	Ap
Notropis jemezanus	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,Ms
Notropis ortenburgeri	Kiamichi shiner		G3	Streams	Streams	Oz,Ms
Notropis oxyrhynchus	Sharpnose shiner		G3	Rivers	Rivers	CT
Notropis ozarcanus	Ozark shiner		G3	Rivers	Streams	Ms,Oz
Notropis perpallidus	Peppered shiner		G3	Rivers	Rivers	Ms
Notropis rupestris	Bedrock shiner		G2	Streams	Streams	Cu
Notropis semperasper	Roughhead shiner		G2G3	Rivers	Rivers	SA
Notropis simus	Bluntnose shiner	LT	G2	Rivers	Rivers	RG

continued

Table 23.8—The rare fish evaluated included 165 species, of which 45 are federally listed as threatened or endangered (continued)

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]	Watersheds[d]
Notropis suttkusi	Rocky shiner		G3	Rivers	Rivers	Ms
Notropis uranoscopus	Skygazer shiner		G2	Rivers	Rivers	Mo
Noturus baileyi	Smoky madtom	LE	G1	Rivers	Rivers	Cu
Noturus flavipinnis	Yellowfin madtom	LT	G1	Rivers	Rivers	Cu
Noturus furiosus	Carolina madtom		G3	Streams	Streams	SA
Noturus gilberti	Orangefin madtom		G2	Rivers	Streams	SA
Noturus lachneri	Ouachita madtom		G2	Streams	Streams	Ms
Noturus munitus	Frecklebelly madtom		G3	Rivers	Rivers	Mo
Noturus placidus	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	Ms
Noturus taylori	Caddo madtom		G1	Rivers	Rivers	Ms
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 brevicauda	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,Ms
Percina macrocephala	Longhead darter		G3	Rivers	Rivers	Cu,Ms
Percina nasuta	Longnose darter		G3	Streams	Rivers	Ms,Oz
Percina pantherina	Leopard darter	LT	G1	Streams	Streams	Ms
Percina rex	Roanoke logperch	LE	G2	Rivers	Rivers	SA
Percina squamata	Olive darter		G2	Rivers	Rivers	Cu
Percina tanasi	Snail darter	LT	G2	Rivers	Rivers	Cu
Percina uranidea	Stargazing darter		G3	Rivers	Rivers	Ms,Oz
Phoxinus cumberlandensis	Blackside dace	LT	G2	Streams	Streams	Cu
Phoxinus tennesseensis	Tennessee dace		G2G3	Streams	Streams	Cu
Pteronotropis euryzonus	Broadstripe shiner		G3	Streams	Streams	Ap
Pteronotropis hubbsi	Bluehead shiner		G3	Streams	Ponds	Ap
Satan eurystomus	Widemouth blindcat		G1	Ground water	Ground water	CT
Scaphirhynchus albus	Pallid sturgeon	LE	G1G2	Rivers	Rivers	Ms
Scaphirhynchus suttkusi	Alabama sturgeon	C	G1	Rivers	Rivers	Mo
Scartomyzon austrinus	West Mexican redhorse		G3	Streams	Rivers	RG
Semotilus lumbee	Sandhills chub		G3	Streams	Streams	SA
Speoplatyrhinus poulsoni	Alabama cavefish	LE	G1	Ground water	Ground water	Cu
Thoburnia atripinnis	Blackfin sucker		G2	Streams	Streams	Ms
Thoburnia hamiltoni	Rustyside sucker		G2	Streams	Streams	SA
Trogloglanis pattersoni	Toothless blindcat		G1	Ground water	Ground water	CT

ABI = Association for Biodiversity Information.
[a] Federal status: LE = listed as endangered; LT = listed as threatened; PE = proposed for listing as endangered; C = candidate for listing.
[b] See table 23.1 for definitions of ABI rankings.
[c] Primary and secondary habitat do not necessarily imply a constistent order or ranking of importance to the taxonomic group.
[d] 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.
Source: NatureServe 2000b.

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 (Burr and Warren 1986. Etnier and Starnes 1993, Jenkins and Burkhead 1993, Pflieger 1975, Smith-Vaniz 1968). 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 (Etnier and Starnes 1993, Jenkins and Burkhead 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 100 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 warmwater springs and spring runs in Texas (NatureServe 2000). 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 (Etnier and Starnes 1993, NatureServe 2000). 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, coldwater 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 2000). 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 2000).

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 2000). 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 (fig. 23.15) is remarkably similar to the rare mussel distribution. In fact, the three watersheds (Cumberland, Mississippi, and Mobile) with the highest number of rare mussels 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.

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 2000). 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 have just flipped. Rocks imbedded in silt are not easily moved, and they

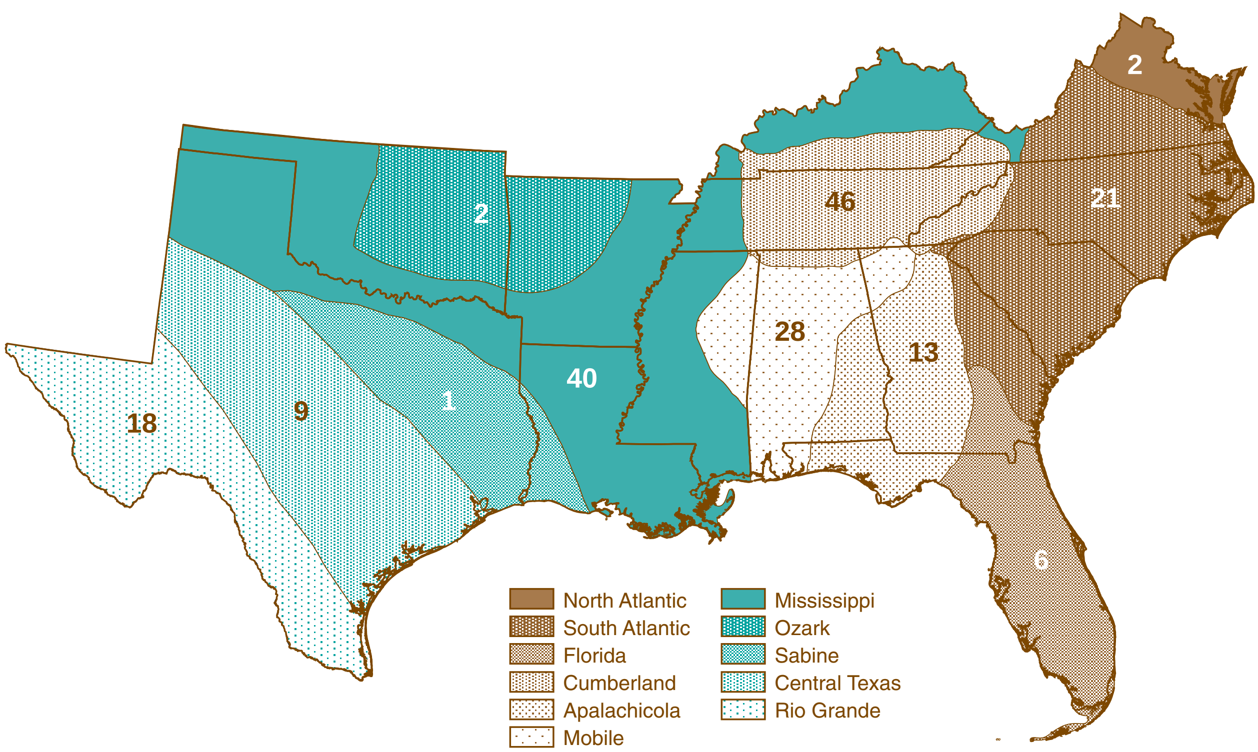

Figure 23.15—Rare fish occur in all 11 of the aquatic fauna provinces described by Parmalee and Bogan (1998). The Cumberland Province, including the Tennessee and Cumberland River systems, supports the greatest number of rare fish.

AQUATIC

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 are 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 (Jenkins and Burkhead 1993, Rohde and Arndt 1987, Shute 1997). 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 drawdown and contamination of ground water is potentially a serious threat to spring and cave-adapted species (Elliott 2000, Etnier 1997, Etnier and Starnes 1991, Hubbs 1995, Warren and others 2000). These sensitive fish include some of the topminnows, pupfish, live-bearers, 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 nonnative fishes can result from stocking, bait-bucket releases, and interbasin connections (Nico and Fuller 1999, Sheldon 1988). Competition from introduced species threatens some topminnows, pupfish, bass, and live-bearers; 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 2000). The San Marcos gambusia, a live-bearer, apparently was forced into extinction from a combination of events including competition and hybridization (NatureServe 2000).

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

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 (Rakes and others 1999, Shute and others 1997).

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. Postimpoundment declines may have resulted from overharvest 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, nonnative predators, especially the flathead and blue catfish, decrease the survival of young suckers (NatureServe 2000). Measures to control sedimentation, careful management of nonnative fish, and, where appropriate, measures to assist in fish passage could ensure 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 reestablishing 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 live-bearers listed here are all narrowly endemic to warmwater springs. Two are either believed to be already extinct, and three are federally listed and in imminent 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 2000). The other three live-bearers are currently facing these same threats, in addition to drawdown of the aquifers where they exist. The long-term survival of these species in the wild depends on managing the entire aquifers where the live-bearers 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. Ground-water 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 drawdown, 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 nonnative 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 (Elliott 2000, NatureServe 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, nonpoint-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, makes it 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 [Personal communication. J.R. Shute (no personal communication information available at this time)].

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

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 23.9) include 2 frogs, 1 toad, and 28 salamanders (fig. 23.16). Two species (the toad and one salamander) are terrestrial as adults but lay their eggs in ephemeral ponds. The other 29

Table 23.9—The rare aquatic amphibians evaluated included 31 species, of which 5 are federally listed as threatened or endangered

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]
Ambystoma cingulatum	Flatwoods salamander	LT	G2G3	Ponds	Ponds
Amphiuma pholeter	One-toed amphiuma		G3	Ponds	Ponds
Bufo houstonensis	Houston toad	LE	G1	Ponds	Ponds
Desmognathus apalachicolae	Apalachicola dusky salamander		G3	Streams	Streams
Desmognathus carolinensis	Carolina Mountain dusky salamander		G2	Streams	Streams
Desmognathus imitator	Imitator salamander		G3	Streams	Streams
Desmognathus ocoee	Ocoee salamander		G2G3	Streams	Streams
Desmognathus orestes	Blue Ridge dusky salamander		G2	Streams	Streams
Eurycea latitans	Cascade Caverns salamander		G3	Ground water	Ground water
Eurycea nana	San Marcos salamander	LT	G1	Ground water	Ground water
Eurycea neotenes	Texas salamander		G1	Ground water	Ground water
Eurycea pterophila	Dwarf salamander		G2	Ground water	Ground water
Eurycea rathbuni	Texas blind salamander	LE	G1	Ground water	Ground water
Eurycea robusta	Blanco blind salamander		G1	Ground water	Ground water
Eurycea sosorum	Barton Springs salamander	LE	G1	Ground water	Ground water
Eurycea sp. 1	Plateau salamander		G1	Ground water	Ground water
Eurycea sp. 2	Salado Springs salamander		G1	Ground water	Ground water
Eurycea sp. 4	Buttercup Creek Caves salamander		G1	Ground water	Ground water
Eurycea sp. 5	Georgetown salamander		G1	Ground water	Ground water
Eurycea sp. 6	River spring salamander		G1	Ground water	Ground water
Eurycea tridentifera	Comal blind salamander		G1	Ground water	Ground water
Eurycea troglodytes	Valdina Farms sinkhole salamander		GH	Ground water	Ground water
Eurycea tynerensis	Oklahoma salamander		G3	Ground water	Ground water
Gyrinophilus palleucus	Tennessee cave salamander		G2	Ground water	Ground water
Haideotriton wallacei	Georgia blind salamander		G2	Ground water	Ground water
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

ABI = Association for Biodiversity Information.
[a] Federal status: LE = listed as endangered; LT = listed as threatened.
[b] See table 23.1 for definitions of ABI rankings.
[c] Primary and secondary habitat do not necessarily imply a constistent order or ranking of importance to the taxonomic group.
Source: NatureServe 2000b.

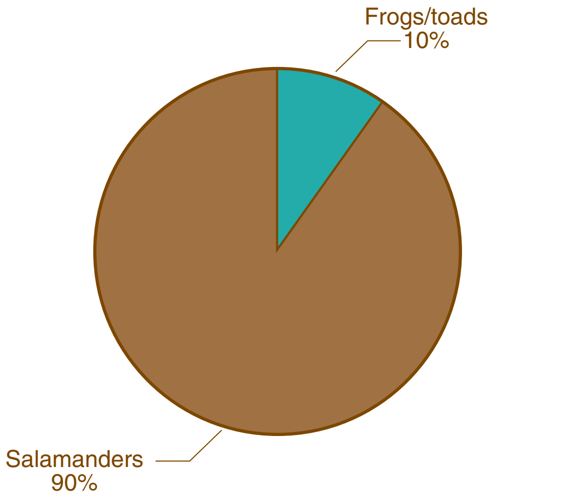

Figure 23.16—The 31 rare aquatic amphibians are dominated by salamanders; only 2 frogs and 1 toad are evaluated in this Assessment.

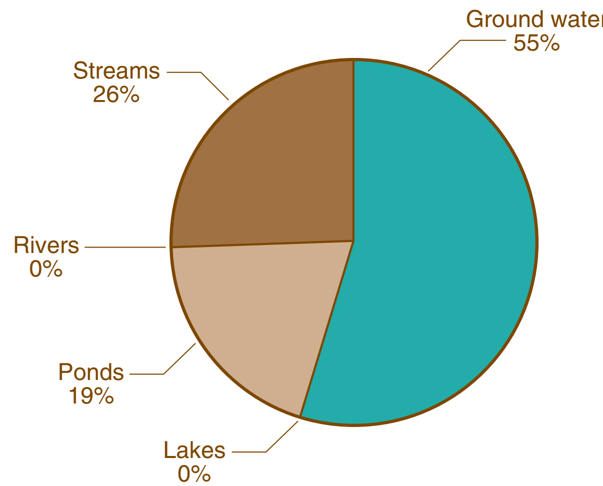

Figure 23.17—The 31 rare aquatic amphibians are reliant on 3 of the 5 habitats evaluated. No rare amphibians are dependent on river or lake habitats. Ground water systems support the most species.

species use the aquatic environment year round, including the breeding season. The primary habitats where these amphibians are found are shown in fig. 23.17. 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 23.18 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 Edward's Plateau and the Interior Highlands as important areas for amphibian diversity.

Threats to amphibians—Amphibians are subject to a variety of direct and indirect threats to survival, including bait collecting (Benz and Collins 1997, U.S. Department of Agriculture, Forest Service 2001), removal of mature hardwood trees along streams (Petranka 1998), intensive ground-disturbing activities associated with timber extraction (Petranka 1998, Petranka and others 1994), 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 (Herrig and Bass 1998, White and Wilds 1997), further isolating many amphibian populations. Dodd (1997) also noted that if population fluctuations reported for some amphibians are natural, small, isolated populations might be especially at risk.

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

Amphibians associated with perennial streams and streamsides 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 intensified forest management and agricultural or urban development. In these areas, wetlands used by these amphibians are often altered by deliberately draining land with perched water tables (Miwa and others 1999, Segal and others 1987) or through indirect effects of other intensive land management activities (Palis 1996, Petranka 1998, 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

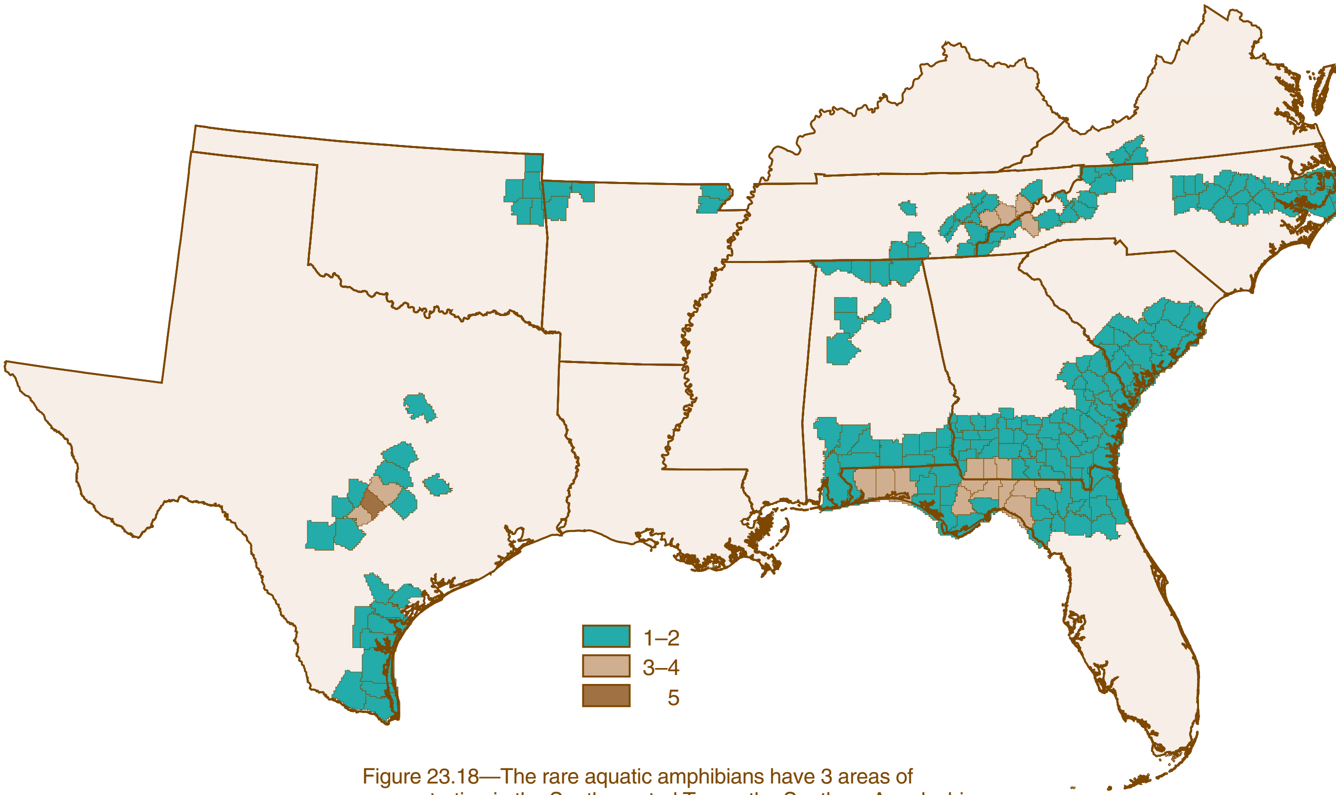

Figure 23.18—The rare aquatic amphibians have 3 areas of concentration in the South: central Texas, the Southern Appalachian Mountains, and the Panhandle of Florida.

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 chapters 1 and 5.

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 2000), 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, sedimentation and seepage of even small quantities of chemicals or nutrients into the aquifers could pose significant threats to their continued existence (Petranka 1998).

The amphibians associated with perennial streams and streamsides 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 1700s. 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 USDA 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 earlier, 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 the 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, NatureServe 2000, Petranka 1998). Restoring and protecting important ephemeral ponds may be necessary to ensure the continued existence of the flatwoods salamander (U.S. 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 earlier.

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 23.10) discussed here include 1 crocodile, 4 snakes, and 14 turtles (fig. 23.19). These reptiles are typically found in flowing rivers or calm waters of swamps and bogs (fig. 23.20); none are known to 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 2000, U.S. Department of the Interior, Fish and Wildlife Service 2000, Wilson 1995).

Two areas in the South are known to have concentrations of rare reptiles (fig. 23.21). One area in west Texas

Table 23.10—The rare aquatic reptiles evaluated included 19 species, of which 8 are federally listed as threatened or endangered

Scientific name	Common name	Federal status[a]	ABI global rank[b]	Primary habitat[c]	Secondary habitat[c]
Clemmys muhlenbergii	Bog turtle	LT	G3	Ponds	Ponds
Crocodylus acutus	American crocodile	LE	G2	Ponds	Rivers
Farancia erytrogramma seminola	South Florida rainbow snake		G5T1	Streams	Ponds
Graptemys barbouri	Barbour's map turtle		G2	Streams	Rivers
Graptemys caglei	Cagle's map turtle	C	G3	Streams	Rivers
Graptemys ernsti	Escambia map turtle		G2	Rivers	Ponds
Graptemys flavimaculata	Yellow-blotched map turtle	LT	G2	Rivers	Ponds
Graptemys nigrinoda	Black-knobbed map turtle		G3	Streams	Rivers
Graptemys nigrinoda delticola	Delta map turtle		G3T2	Streams	Rivers
Graptemys nigrinoda nigrinoda	Black-knobbed map turtle		G3T3	Streams	Rivers
Graptemys oculifera	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

ABI = Association for Biodiversity Information.
[a] Federal status: LE = listed as endangered; LT = listed as threatened; C = candidate for listing.
[b] See table 23.1 for definitions of ABI rankings.
[c] Primary and secondary habitat do not necessarily imply a constistent order or ranking of importance to the taxonomic group.
Source: NatureServe 2000b.

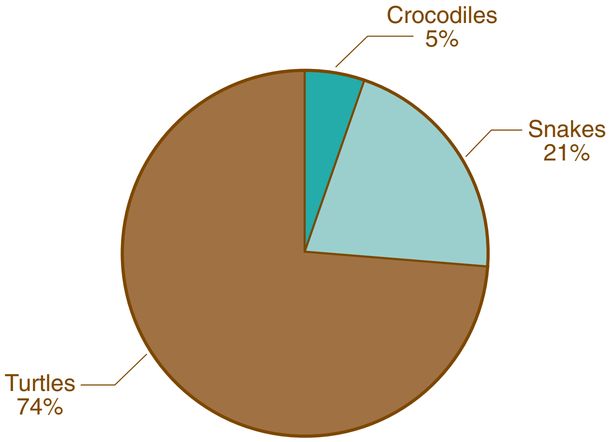

Figure 23.19—The 19 rare aquatic reptiles include 1 crocodile, 4 snakes, and 15 turtles.

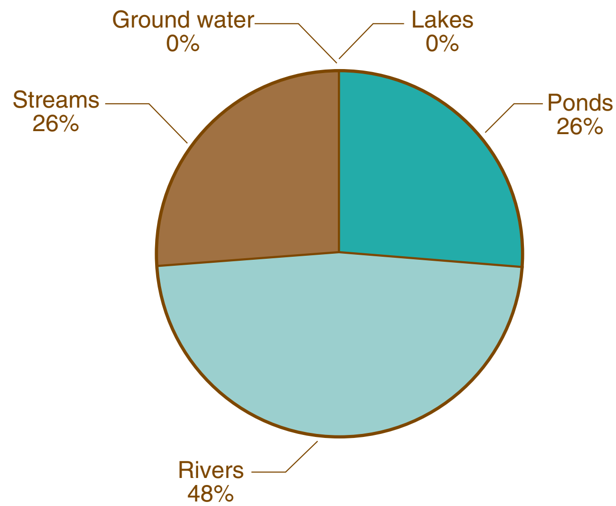

Figure 23.20—Almost one-half of the 19 rare aquatic reptiles are associated with rivers. Streams and ponds provide habitat for the remaining species. No rare aquatic reptile species are dependent on ground water and lake systems.

includes the Rio Grande and Pecos River systems, and another extends from central and southern Mississippi into the panhandle of Florida (fig. 23.21) (NatureServe 2000). Other rare reptile occurrences are scattered throughout southern Florida, the Southern Appalachian Mountains, western Tennessee and Kentucky, and central Texas (Wilson 1995).

Threats to reptiles—Many rare reptiles are long-lived, narrow endemics (Palmer and Braswell 1995, Wilson 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 which 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 2000). 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

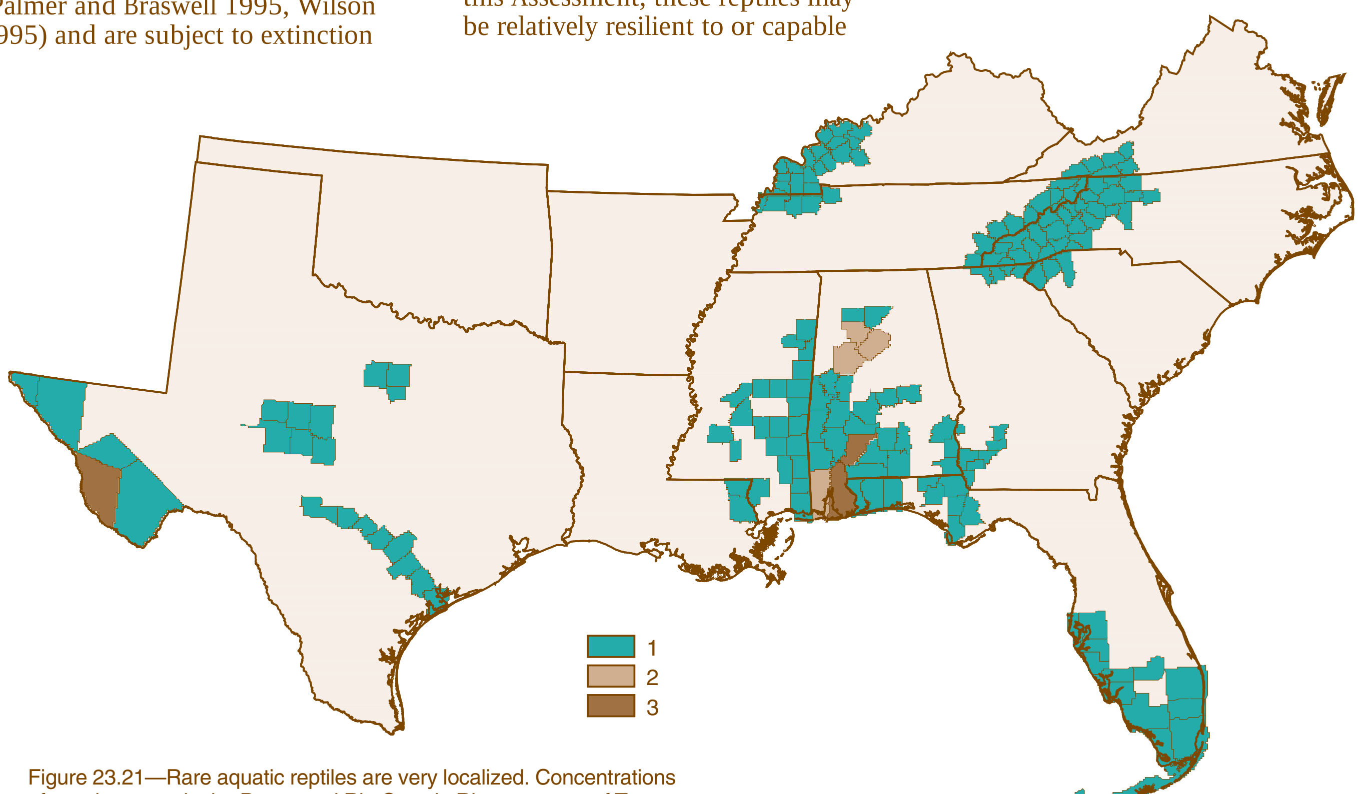

Figure 23.21—Rare aquatic reptiles are very localized. Concentrations of species occur in the Pecos and Rio Grande River systems of Texas and in the Mobile and Mississippi River basins.

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 of 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 2000).

Pollution and sediment may impact all of these species directly or indirectly through a reduction in their food organisms (NatureServe 2000). 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 2000).

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

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 (Herrig and Bass 1998, NatureServe 2000).

AQUATIC

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 stream flows; and pollution resulting from agricultural practices have contributed to the decline of rare aquatic reptiles in Texas (NatureServe 2000). 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.

Summary Conclusions

Presently, the major threats to our southern aquatic animals include population fragmentation resulting from impoundments and other habitat alterations, sedimentation, and 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.

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 are 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 and 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 (Angermeier 1995, Etnier 1994, 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, 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 here 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 2001a). Similar proposals are underway for fish (U.S. Federal Register 2001b). In some situations, reintroductions may be appropriate for sensitive species that cannot invade these restored or improved areas (Dunn and others 2000).

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The southern forest resource assessment provides a comprehensive analysis of the history, status, and likely future of forests in the Southern United States. Twenty-three chapters address questions regarding social/economic systems, terrestrial ecosystems, water and aquatic ecosystems, forest health, and timber management; 2 additional chapters provide a background on history and fire. Each chapter surveys pertinent literature and data, assesses conditions, identifies research needs, and examines the implications for southern forests and the benefits that they provide.

Keywords: Conservation, forest sustainability, integrated assessment.