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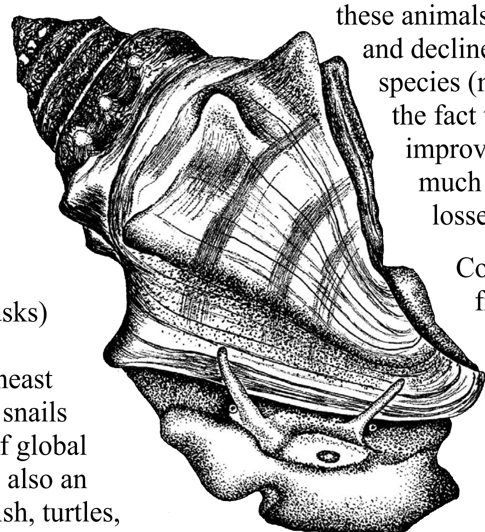
Sustaining America's Aquatic Biodiversity
Freshwater Snail Biodiversity and Conservation

Authored by Paul D. Johnson, Research scientist, Tennessee Aquarium Research Institute, Cohutta, Ga.

Introduction

More than seven hundred different species of snails are distributed across the streams, rivers, and lakes of North America. There are unique species associated with every type of aquatic habitat from the Canadian Arctic to the Everglades of Florida. However, the greatest species richness is associated with flowing waters (streams and rivers). The number of North American freshwater gastropods (one or no-shell mollusks) is the richest in the world, rivaled only by the river systems of Southeast Asia. North American freshwater snails represent a rich natural heritage of global importance. Freshwater snails are also an important food source for many fish, turtles, and other species of wildlife. Finally, because of their sensitivity to certain chemicals, many species are excellent water-quality indicators.



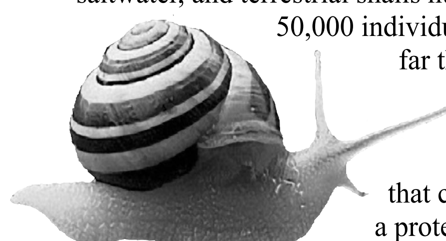
Unfortunately, freshwater snails are threatened like many other river species across North America. The abundance and variety of snails have dramatically declined over the last century, especially those species that inhabit streams and rivers. Approximately 67 species of freshwater snails are presumed extinct, 380 are threatened or endangered, and another 73 are considered vulnerable. In other words, 10 percent of all freshwater snails are extinct and 64 percent are conservation targets. This rate of imperilment exceeds that of most other major animal groups in North America.

The decline of freshwater snails began in the early twentieth century. Dam construction and other channel modifications, siltation, and industrial and agricultural pollution have all degraded the river habitats on which most species depend. As a result, the species richness and the abundance of freshwater snails have declined dramatically. This decline has been especially pronounced in the Southeastern United States where these animals are most diverse. The continued loss and decline of freshwater snails and other river species (mussels, fish, crayfish) are testament to the fact that despite significant water-quality improvements made in the last few decades, much work remains if we are to halt species losses.

Conservation and recovery efforts for freshwater snails include artificial culture, water pollution control, and most importantly, habitat protection and restoration. Cleaning waterways not only improves the habitat for snails and other aquatic life, but it also improves the quality and supply of water for human consumption. Your help is required to assist conservation and recovery efforts aimed at rivers and streams, and the animals that inhabit them. Adopt a stream, become involved with a local river conservation group, or assist your state natural resource agency with water-quality measurements.

What Is a Snail?

Freshwater snails belong to a larger group of shelled animals called mollusks. Together, freshwater, saltwater, and terrestrial snails number well over 50,000 individual species, by far the largest group of mollusks. Snails are soft-bodied animals that carry with them a protective shell. This shell is composed primarily



of calcium and other minerals the snail has eaten and hardened into a well-formed shell. The soft-bodied animal is permanently connected to the shell by a strong ligament and other soft tissues. The snail's shell is used for protection from environmental threats and predators.

Most species of freshwater snails originally evolved from saltwater habitats, although several species evolved from terrestrial habitats to freshwater. Snails usually play a dominant role in the ecology of freshwaters by providing food for many other animals and by grazing on vast amounts of algae and detritus (debris). They are critical to normal ecological processes in rivers. Their unusual common names such as: banded mysterysnail, applesnail, pagoda slitsnail, knob mudalia, rough hornsnail, interrupted rocksnail, among many others often belie their importance as a food source to other aquatic animals and as indicators of water quality.

Structure and appearance

Freshwater snails generally are dull colored, especially in comparison to their marine and terrestrial cousins. Their color generally varies from yellow-brown to black, but some species have stripes and other distinctive markings.

The shell is composed primarily of calcium carbonate (similar to chalk) and other minerals extracted from the snail's diet. The shell is coated with a horny epidermal (outer) covering called the periostracum (pair-i-ahs´-truh-kum). This covering is what gives the shell its color.

Freshwater snails come in a variety of shapes and sizes. Some snails are almost completely round in shape, but most species are generally conical. Adults of some species are smaller than the head of a pin and others larger than a baseball.

Along with size, shape, and coloring, structural shapes such as large tubercles, spiny projections, folds, sharp ridges, and fine lines on their elaborately sculptured shells are what give some individual species their distinctive forms. These ornate shell structures are formed while the snail is building its shell. They add strength to the shell to resist crushing by predators (i.e., fishes and crayfishes). In contrast, the pearly inside of the shell (nacre) is very smooth and is usually a translucent white to light pink or even blue. The interior's smoothness cushions the hard shell against the snail's soft body. Many species have internal striping on the nacre, which usually is also visible on the outside of the shell.

The snail's soft body is divided into three distinct sections (Figure 1). A well-defined head is connected to a large muscular foot. The foot is the most visible external feature of the snail's body and is the animal's mode of locomotion. A snail propels itself with this single foot, which is controlled by hydrostatic action inside the snail's body. Additionally, the foot surface is covered with tiny projections (cilia) that assist the gliding motion. Snails feed along the bottom as they move, partially clearing a path for the foot. As the foot passes over the substrate, it leaves a "trail" behind the snail. These trails are commonly visible in soft sediments or across hard surfaces such as rocks or submerged trees.

The third distinctive section, the internal organs, is concealed inside the shell. The internal organs of a snail include a heart for circulating "blood;" a complete digestive system with a distinct mouth, stomach, and intestine; a reproductive system; and a gill or other respiratory surface used for oxygen exchange. When a snail is threatened by a predator, the head is retracted into the shell first, followed by the foot; thus the entire body can retreat inside the shell. Some snails even have a hard "lid" on their tails called an operculum (oh-pûr´-ky-lum) that is made of protein. The hard operculum covers most soft tissue of the foot exposed to a predator when the snail has retracted into its shell.

Freshwater snails with an operculum are descended from marine ancestors and extract oxygen from the water with a single gill. These operculate snails are the most diverse group, comprising about 70 percent of all North American freshwater snails. They have separate sexes and a short reproductive season. In general, these species are slow-growing, longer-lived, and very sensitive to environmental changes. These species are distinctly distributed about separate river systems and most major drainages have their own unique species.

In contrast, snails that lack an operculum evolved from terrestrial ancestors and breathe with a modified "lung." These species are hermaphroditic, that is each snail possesses both male and female reproductive organs, and have an extended breeding season. They are fast-growing, short-lived, and often less sensitive to their environment. Unlike operculate snails, these species are generally not limited by river drainages, and most species are found across distinct drainage basins.

Distribution and Diversity

Freshwater snails can be found living at the bottoms of our largest lakes and rivers as well as the smallest streams and ponds. Some species have been recorded at depths of over 100 feet. The more than 700 species in North America are found from deep, interior Canada near the Arctic Circle to the subtropical regions of South Florida and Mexico. North America is the Earth's center of freshwater snail diversity. Only the rivers of Southeast Asia appear to contain nearly as many species. Additionally, new species of freshwater snails are discovered each year. In the United States, the abundance of species diversity lies in the river systems of the Southeast.

The Mobile River Basin

The rivers and streams of the Mobile River Basin (streams in Alabama, Georgia, Eastern Mississippi, and Southeast Tennessee) contain the greatest species richness of freshwater snails in North America. The Alabama, Black Warrior, Coosa, Cahaba, and Tombigbee river drainages together comprise the Mobile River Basin. Although the Mobile River Basin is about 3.5 percent the size of the Mississippi River basin, it contains 120 different species of snails. In other words, over 18 percent of the species found in all of North America are located in a basin with only about 1.5 percent of the nation's surface area.

Unfortunately, some 38 species of snails in the basin are now thought to be extinct. The construction of several large hydroelectric dams on the Coosa River were responsible for driving most of these species to extinction. In addition, seven species of freshwater mussels have been lost from the Mobile River Basin in the past 80 years. The loss of 44 species of freshwater mollusks from the Coosa River Basin is widely considered to be the single largest recent extinction event in the United States.

However, at specific localities in the Mobile River Basin, snail diversity can exceed 12 different species. Species diversity at these selected sites in the basin is probably greater than at any other location in the country. Additionally, snail densities can exceed more than 50 per square foot of river bottom at certain locations. Yet, even this density can be exceeded at certain locations within the Ohio River Basin.

The Ohio River Basin

The rivers and streams of the Ohio River Basin are located across Northern Alabama, Illinois, Indiana, Georgia, Kentucky, Mississippi, New York, North Carolina, Ohio, Pennsylvania, Tennessee, and Virginia. These rivers and streams are home to the second most diverse assemblage of freshwater gastropods in North America. The Ohio River Basin supports more than 10 percent of all North American species. This includes about five species that are now considered to be extinct. Once widespread and with populations numbering in the billions, many remaining river species are limited to small ranges. In fact, range reductions greater than 80 percent are common for many operculate species.

The major rivers of the Ohio River Basin include the Allegheny, Big Sandy, Cumberland, Green, Kanawha, Kentucky, Monongalia, Muskingum, Tennessee, and Wabash, which drain portions of many states. The Tennessee Basin alone drains streams from seven states (Alabama, Georgia, Kentucky, Mississippi, North Carolina, Tennessee, and Virginia) and contains the largest species richness of any Ohio River Basin tributary. Species richness in several tributaries of the Tennessee River is exceptionally high. These tributaries

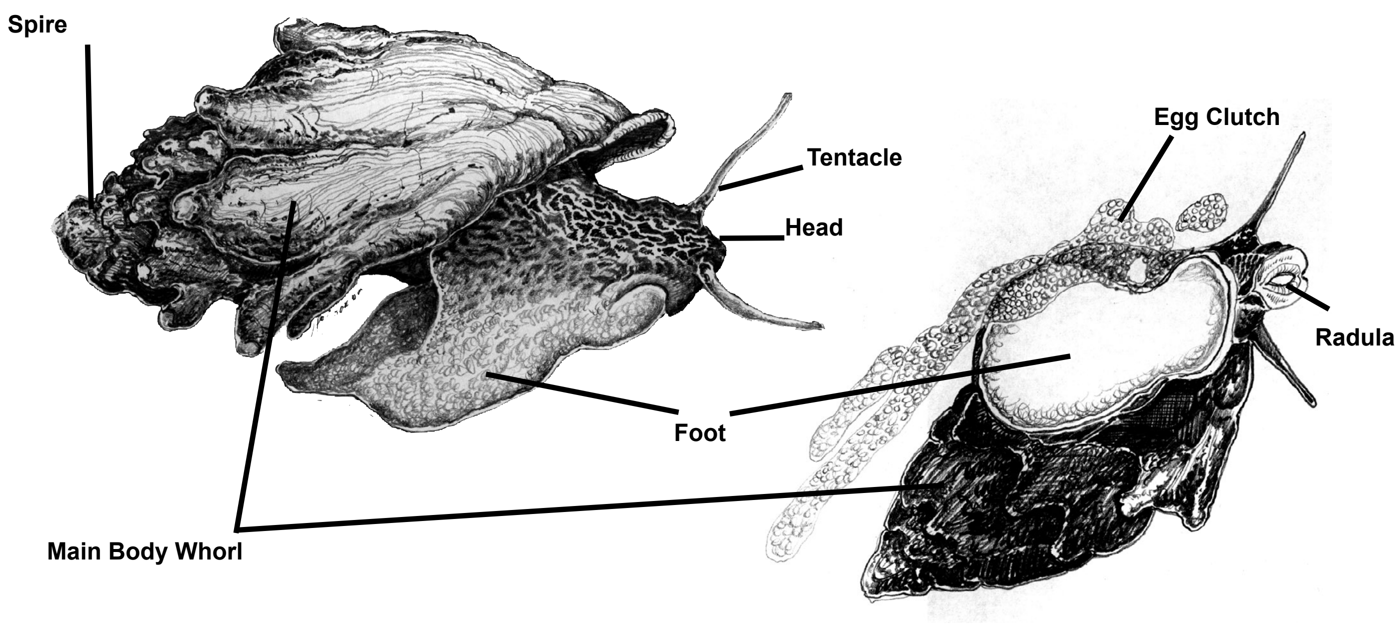


Figure 1. Major anatomical features of the spiny river snail (*Io fluvialis*).

include Limestone Creek in North Central Alabama and the Duck River Basin of Central Tennessee. Snail densities in these systems can easily exceed 100 individuals per square foot of river bottom.

Where Are They Found?

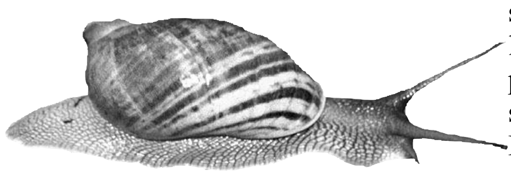
Freshwater snails occur across a variety of habitats, reflecting the wide-ranging biology of many different species. Many species spend their entire lives in a few square meters of habitat, making them extremely vulnerable to localized environmental habitat degradation. Although most species prefer clean, stable, and firm river bottoms, some prefer the soft substrates more common to ponds and lakes. A few wide-ranging snail species can easily survive in polluted habitats.

Snail species richness is greatest in large- to medium-size rivers. Within the Tennessee and Mobile River basins, it is not unusual for 10 or more species to be present at a single location. Locations with stable, clean river bottoms, clean water, high oxygen concentrations, and hard water usually support greater species richness and densities. Clean, clear water, free of sediments, is important to maintaining healthy snail populations. Snails can live in rivers at depths of more than 40 feet, as long as the water is clean enough to allow light penetration to that depth. Generally, only a few isolated locations in the Tennessee River contain snails at depths greater than 20 feet, because of the excessive nutrients and sediment.

How Do They Reproduce?

Because freshwater snails occur across a variety of freshwater habitats, they have adapted different reproductive strategies. There are basically three different modes of reproduction commonly used by freshwater snails.

Most species of snails are separately sexed, and males fertilize the female through direct copulation. Females attach their eggs directly to firm, clean substrates such as a rock, log, or aquatic plant, usually in shallow water. Egg clutches are commonly laid on the shells of other individuals. Egg clutches can contain two to over 300 eggs, depending on the species. Females can lay eggs in pairs, in a circular concentric pattern, or even in a large line several eggs across and several inches in length. A female snail can take several hours to deposit eggs for a single clutch.



For species that lay discrete clutches, the eggs are deposited over a period of one to three months, usually in the late winter and early spring. Larger, older females tend to lay more eggs per clutch. Warmer water temperature plays an important role in egg production, but day length also may be an important factor. Individual eggs are small, a little larger than 1/75 inch in diameter. The eggs may take one to five weeks to hatch depending on water temperatures. The warmer the water, the faster the eggs will hatch. A juvenile snail is about 1/100 inch at hatching, but rapidly grows its first year to several hundred times its birth size. Rapid juvenile growth in shell size to over 1/4 inch wide in the first year is not uncommon.

Another reproductive strategy of some operculate species is for females to birth live young. In reality, an egg hatches inside the female and the juvenile snail grazes in a special pouch inside the mother's body. After a few weeks of feeding, a juvenile snail about 1/4 inch in length crawls outside the mother's body. Female snails can produce several eggs simultaneously, and up to a dozen small juvenile snails can be inside the female during the summer and fall months. Like other operculate snails, these species have separate sexes and the male uses a modified tentacle as a penis. Juvenile snails emerge from the female fully functional and ready to feed.

Other species of freshwater snails have yet another mechanism for reproduction. For these species, each snail contains both male and female reproductive systems, and all individuals can lay eggs. However, individual snails do not self-fertilize, and sperm is exchanged between individuals. Eggs are laid in large, clear gelatinous clutches that can easily exceed 1/4 inch in diameter. Individual eggs and juveniles are generally larger than those of other snails at hatching. The total number of eggs is dependent on clutch size, but the clutches of some species contain over 50 individual eggs. As long as the food is abundant, these species generally produce eggs continuously from the late spring into the early fall. Not surprisingly, these species are widespread, commonly encountered, and rarely of conservation importance. However, these snails are a very important and abundant food for many crayfishes and fishes.

What Do They Eat?

Whether they live in lakes, ponds, rivers, or streams, most snail species eat small bits of algae and organic debris found on the bottom and sides of the river channel or lake. Freshwater snails actively "graze" a variety of surfaces, scraping their food with a specially modified "tongue" called a radula. The radula is covered with tiny, hard, blade-like projections that scrape the surface. These tiny blades tear small bits of algae and organic material from these surfaces. Most snails graze on firm substrates, such as rocks, woody debris, root mats, and submerged plants. The ingested algae and organic matter is mixed with a steady stream of mucus as it enters the mouth. As their feet glide most easily across firm surfaces, the snails feed directly on top of the surface on which they are crawling.

Many snails are adapted to move and feed in soft sediments. They generally feed on tiny bits of organic debris that are imbedded in fine sediments. Snails will ingest sediment and organic material imbedded in a strand of mucus. This mucus stream flows directly into the mouth. In rivers with heavy amounts of suspended organic matter, snails may feed by lying on their shells and turning their foot up into the water column. Food collected on the bottom of a snail's foot is moved into the mouth through a strand of mucus. In this manner, snails can be suspension feeders, directly collecting food from the water column.

How Long Do They Live?

Freshwater snails can vary wildly in their longevity, which is dependent on the type of snail and the habitat in which it occurs. In general, snails that possess an operculum live longer than species without one. The maximum age of many species living in streams and rivers can exceed five years, whereas most species that prefer ponds and lakes live less than one and a half years. As a general rule, the more nutrients available to the snail, the faster it grows, and the shorter its lifespan. Snails living in nutrient-poor habitats on average tend to live longer.

Determining the age of a freshwater snail is difficult, and information about the maximum age for most species is lacking. River species usually live from two to six years. *Io*, the spiny river snail (see figure 1) may live well beyond 15 years, and is likely the longest-lived of all North American freshwater snails.

What Good Are They?

The value of freshwater snails lies in their ecological role in the aquatic food web and in maintaining water quality. In healthy river ecosystems throughout the Southeast, freshwater snails number in the millions and serve as an important source of food for other wildlife. Through sheer numbers, they contribute greatly to the nutrient exchange processes in these systems. Primarily by controlling algae growth, they also maintain water quality and clean substrates for other bottom-dwelling animals such as freshwater insects.

Snails are a common food item for many species of ducks, fishes, crayfishes, and turtles. In fact, one group of threatened turtles that lives in the rivers draining to the Gulf of Mexico relies heavily on snails as food. Freshwater snails also are the major food item for the snail darter, a small, endangered fish in the Tennessee River system. Whether they are eaten by turtles, fish, or dozens of other wildlife species, freshwater snails play an important role in the aquatic food web.

Snail Killers

The rapid decline in diversity and abundance of freshwater snails is attributed to a variety of human degradations of their natural habitats. The most prominent impacts include: (1) dams and impoundments, (2) channelization and dredging, (3) sedimentation and channel instability, and (4) water pollution, (5) climate change, and (6) invasive species.

Dams and impoundments

Dams turn rivers into reservoirs and modify aquatic habitat beyond the tolerance level of most river snails. Eliminating current flow and increasing water depth causes fine particles to settle on the reservoir bottom. Heavy layers of fine sediments literally smother snails. Floating algae and other suspended materials limit sunlight penetration to the lake bottom, reduce algae growth on bottom substrates, and eliminate the snails' primary food source. In deep reservoirs, the waters become "layered" with colder, oxygen-poor waters on the lake bottom, further reducing any chance of snail growth and reproduction. Many river species require flowing waters before females will even deposit their eggs. Dams also are effective barriers for snails moving up-river and fragment snail populations into small, isolated groups that are more vulnerable to adverse impacts. Dams don't just eliminate habitat for snails, they negatively impact river species of mussels, fishes, crayfishes, turtles, and salamanders.

Channelization and dredging

Channelization refers to the "straightening" of rivers and streams by removing the natural bends and meanders of a normal channel. This straightening process usually eliminates habitat for all but the hardiest of snail species. Channelization destroys the shallow-shoal habitats on which snails depend, and it can also increase water velocity, which can dislodge snails during flood events.

Dredging refers to the physical removal of natural stream and river bottoms. Dredging removes gravel or sand in attempts to control localized flooding, or to deepen a river channel for boat navigation. Dredging physically removes prime shoal habitat and destabilizes upstream riverbanks. In other words, when you "dig-a-hole" in a river or stream, there is a natural tendency for that hole to fill with materials stripped from upstream banks. As a result, it is very common to see collapsed stream and riverbanks, with dozens of trees falling into the channel, upstream of recent dredging activity. Riverbank instability is most pervasive in small- and medium-size rivers, because larger rivers are more stable.

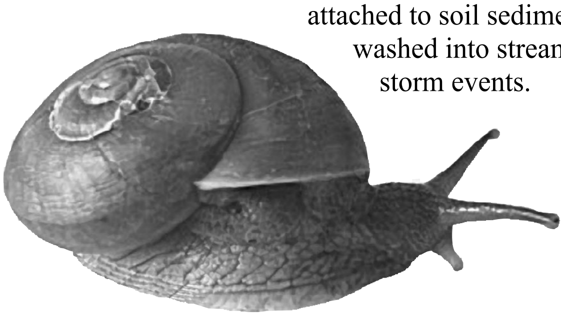
Many states consider stream and river bottoms to be state property, and it is illegal for anyone to build a dam or otherwise modify a stream or river channel without permits. Any damming, diverting, channel modification, wetland draining, gravel removal, or other direct habitat impact to a stream or river requires permits from the U.S. Army Corps of Engineers and other federal and state agencies.

Sedimentation and channel instability

As trees and other vegetation buffers are removed from stream and riverbanks, the bare sediments exposed become vulnerable to removal during flooding events. These exposed banks often wash away in large "chunks," depositing sediments in the river. If left uncorrected, the stream bottom next to an eroding bank also becomes very unstable, and readily "moves" during even minor flooding events. Shifting stream bottoms dislodge and bury adult snails, juveniles, and eggs and reduce snail habitat. Streams and rivers with high sediment loads are literally buried under layers of soft sediments and are devoid of aquatic species that require firm substrates to move, feed, and breathe.

Water pollution

The specific effects of toxic compounds on freshwater snails are poorly understood. However, the impacts of petroleum, certain metals, and agricultural fertilizers and pesticides on freshwater snails are well documented and can be lethal to snails in very small amounts. Frequently these toxic compounds are attached to soil sediments that are washed into streams during storm events.



What Can You Do?

Public involvement is critical to the protection of the aquatic systems on which freshwater snails and many other aquatic animals rely. Working to clean up and restore stream and river habitats has many benefits beyond wildlife conservation. Freshwater is a vital and limited resource, essential for all kinds of life, including our own. Less than one percent of all water on the planet is freshwater, so the degradation of our rivers and streams limits our own water supply. Polluted waters, which are still prevalent in some areas of the United States, result in increased water treatment costs to the taxpayer. Therefore, it is in everyone's interest to protect our aquatic resources and our water supply. Get involved with your local watershed conservation group. For information on the watershed group nearest you, check these sources:

U.S. Environmental Protection Agency's How's My Waterway tool, https://www.epa.gov/waterdata/hows-my-waterway.

National Water Quality Monitoring Council, https://www.epa.gov/awma/national-water-quality-monitoring-council.

Because many local and state water monitoring agencies are understaffed and overwhelmed, they need help monitoring rivers and streams. You should also be aware of changing land-use and water practices in your watershed. Land-use changes (agricultural, residential, urbanization, highway, mining, irrigation, industrial development, etc.) if not properly managed, can have profound impacts on local rivers and streams. Please report any suspected water pollution problems immediately to your state authorities. Any one of the following conditions could indicate a water-quality problem with your local stream or river.

1. Muddy or unusually cloudy water
2. Petroleum on the water surface
3. Large numbers of dead fish
4. Excessive algae growth
5. Unusual or pungent odors
6. Loss of water volume
7. Brown foam on the water surface
8. Large amounts of litter

By helping to keep rivers and streams clean, you will not only improve your local water quality, but you will also improve habitat for all kinds of freshwater wildlife, including snails. The future of our rivers depends on it. Remember nearly everyone lives downstream.

For more information about freshwater snails on the Internet, please visit any of the following websites:

Freshwater Mollusk Conservation Society: https://molluskconservation.org.

Freshwater Gastropods of North America: http://fwgna.org.

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