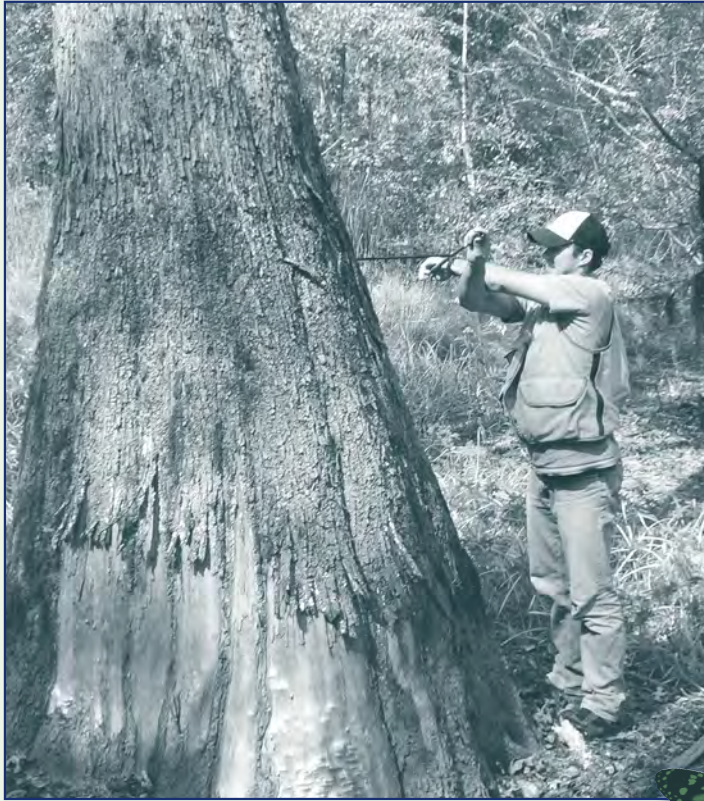


Mussel Mania!

***How Streamflow Affects
Freshwater Mussels
Over Long Time Periods***

Photo courtesy of Dr. Andrew Rypel

Meet the Scientists



◀ **Dr. Andrew Rypel**, Applied Aquatic Ecologist: My favorite science experience is finding something totally unexpected that other people can't believe, but also can't argue with, because the data are so clear!

In this photo, I am using an increment (in krə mən) borer to take a tree core. For more information on tree coring, see the sidebar on page 82.



▶ **Dr. Wendell Haag**, Fisheries Biologist: When I was a kid, I loved to roam the fields, woods, creeks, and even my backyard, catching salamanders and crayfish and looking at plants and birds. In high school, I was lucky to have some great biology teachers who told me that I might actually be able to make a living doing these things. Now I think I have the best job in the world because I get to work with cool creatures every day, learn about how they live, and maybe even help to protect them.

Another great part of my job is working with other people who love animals and plants. People can be so generous and helpful when they're doing something they love. That tells me they must be pretty happy, and I know that being a biologist certainly makes me happy.



Glossary words are **bold** and are defined on page 85.

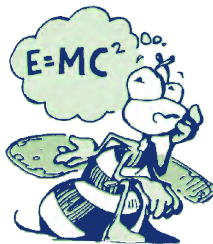
What Kinds of Scientists Did This Research?

applied aquatic ecologist: This scientist studies the effects of man-made change on aquatic ecosystems.

fisheries biologist: This scientist studies fish and other aquatic organisms living in the wild, including what they eat, their habitat, and how they interact with their environment.

Thinking About Science

When scientists identify a problem they must sometimes find new methods to study the problem. Sometimes scientists come up with a new method based on some other method they know about or have used before. One new field of study is called **sclerochronology** (skler ə krə nə lə jē). This new field of study is based on **dendrochronology**.



What's in a Word?

Large words can be broken down into smaller words. Breaking larger words into smaller words helps to illustrate how the words were created and to understand why they are used. Sclerochronology is the study of chemical and physical changes in the gradual increase in hard tissue of organisms. Break down the word “sclerochronology:”

sclero: hard, hardened, or hardening

chronos: time

logos: science

By piecing these smaller words together, you can see that the word sclerochronology comes from the science of how things harden over time, such as shells and bones.

Dendrochronology is a field of study in which scientists learn about trees by studying the tree's growth rings (**figure 1**). The field of sclerochronology similarly enables scientists to learn about any organism that leaves growth rings in hard tissues like bones or shells. Some scientists examine fish scales and mussel shells to learn more about the animal (**figure 2**). The growth rings in mussel shells can provide information about how fast the animal grew, how old it is, and how growth changes with changes in climate.



Figure 1. A tree's growth rings can show times of fire, drought, and other events that the tree experienced. The rings also tell the age of the tree. Photo courtesy of Jessica Nickelsen.



Figure 2. A mussel has a hard exterior shell, and the animal deposits a ring of hard tissue each winter when its growth slows. Photo courtesy of Dr. Andrew Rypel.

Thinking About the Environment

Bottomland hardwood forests are unique **ecosystems** (figure 3). These ecosystems have a lot of **diversity** and are highly **endangered**.



Bottomland hardwood forests are river swamps. These forests are found along rivers and streams and typically include large **floodplains**. The way in which water moves and flows through these rivers and forests has an effect on the entire ecosystem. Hydrology is the study of how water moves and flows. Changes to the hydrology of the rivers and streams may cause problems for the entire ecosystem.



Figure 3. Bottomland hardwood forests are river swamps. These forests are found along rivers and streams and typically include large floodplains. Photo courtesy of the U.S. Fish and Wildlife Service.

In earlier studies, scientists learned that periods of flooding are important to this ecosystem. One reason these periods of flooding are important is because **carbon** deposits from the land, in the form of leaves and other **organic matter**, are transferred into the river during these periods. Carbon is important for the plants and animals in and along the river. The scientists in this study wondered if flooding provides other benefits for this ecosystem.

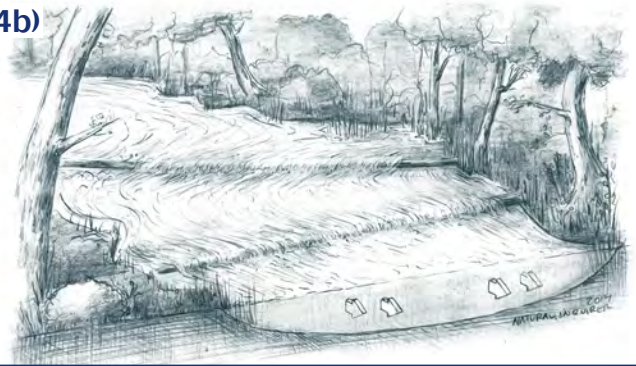
One way to study flooding is to look at the amount of water in a stream or river at different

times. The amount of water and the **velocity**, or speed, of water in a stream or river is called streamflow (**figures 4a, 4b, and 4c**). You will learn more about streamflow in the “Introduction” section. The scientists were particularly interested in how freshwater mussels responded to changes in streamflow.

(4a)



(4b)



Figures 4a and 4b. Note the differences between the two illustrations. Which illustration has a high streamflow? How do you know? Illustrations by Stephanie Pfeiffer.



Figure 4c. This river currently has a low streamflow. Photo courtesy of Dr. Wendell Haag.

Introduction

An ecosystem is a community of plant and animal species interacting with one another and the nonliving environment. Ecosystems may change over time. Ecosystem changes are recorded in unique ways. For example, a tree's growth rings show scientists which years of the tree's life included drought and fire. Similarly, the shell of a mussel can show scientists the age and growth rate of the animal. In this study, the scientists wanted to use information from the mussels' shells to help them better understand the environment in which the mussels lived.

The scientists in this study were interested in studying mussels in bottomland hardwood forest ecosystems. Streamflow is an important factor in bottomland hardwood forest ecosystems. Streamflow is the volume of water flowing through a stream at any particular place. The scientists wanted to figure out how streamflow affected mussels and plants near and in the rivers in these ecosystems. The scientists also wanted to compare streamflow with cypress trees along the river to see if streamflow affected mussels and trees the same way (**figure 5**).

North America has the highest diversity of freshwater mussels in the world (**figure 6**). Mussels are **mollusks**. They have two shells that are joined by a ligament (**figure 7**). Mussels have two small **siphons** used to draw in and expel water. This siphoning action helps to filter water of bacteria, algae, and other small particles, and it makes this material available to



Figure 5. Bald cypress trees are found in bottomland hardwood forests because they are able to survive in areas that are seasonally flooded or that are covered in water a majority of the time. These bald cypress trees are found in Okefenokee National Wildlife Refuge. Photo courtesy of Babs McDonald.

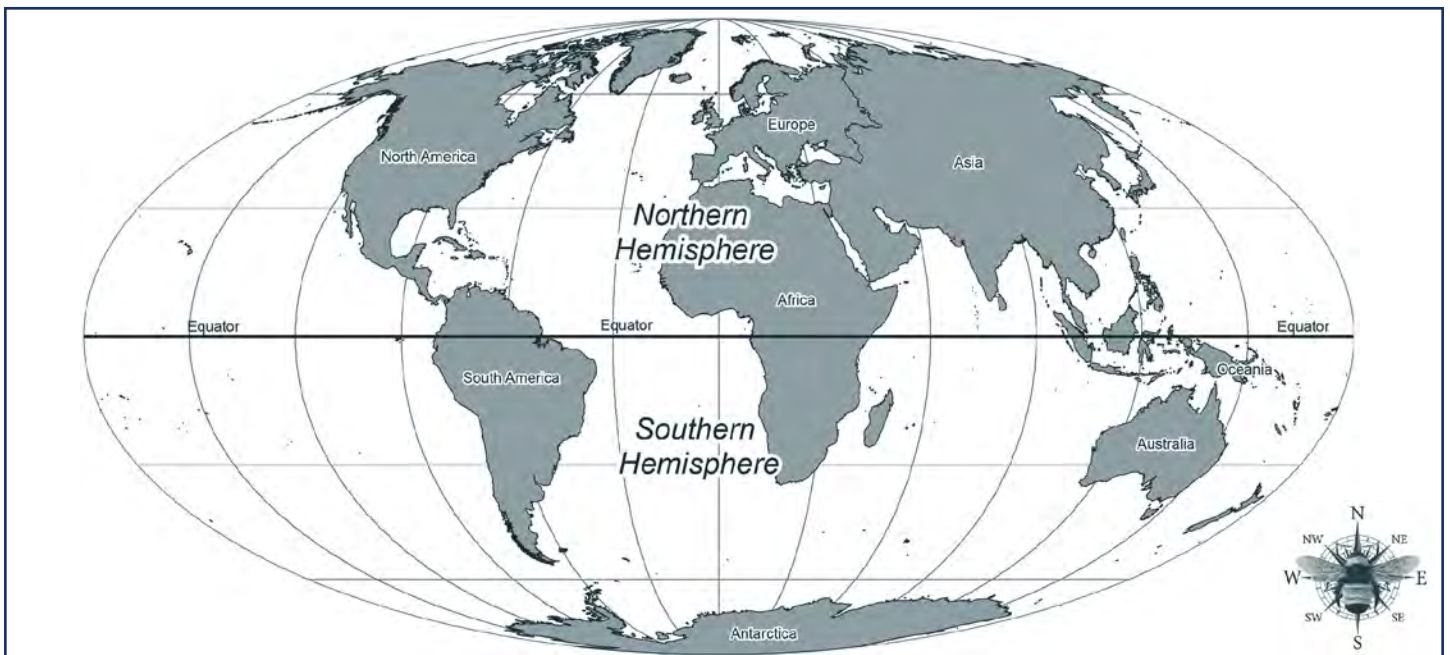


Figure 6. North America is located in the Northern Hemisphere. Map by Carey Burda.

other organisms that live on the bottom. Mussels, therefore, help improve water quality.

The outer shell of a living mussel is a home to some organisms. Mussels are also a source of food for many animals. Some animals that eat mussels are muskrats, raccoons, otters, turtles, and fish (**figure 8**). In addition, the empty shells become homes for animals after the mussels are no longer living.

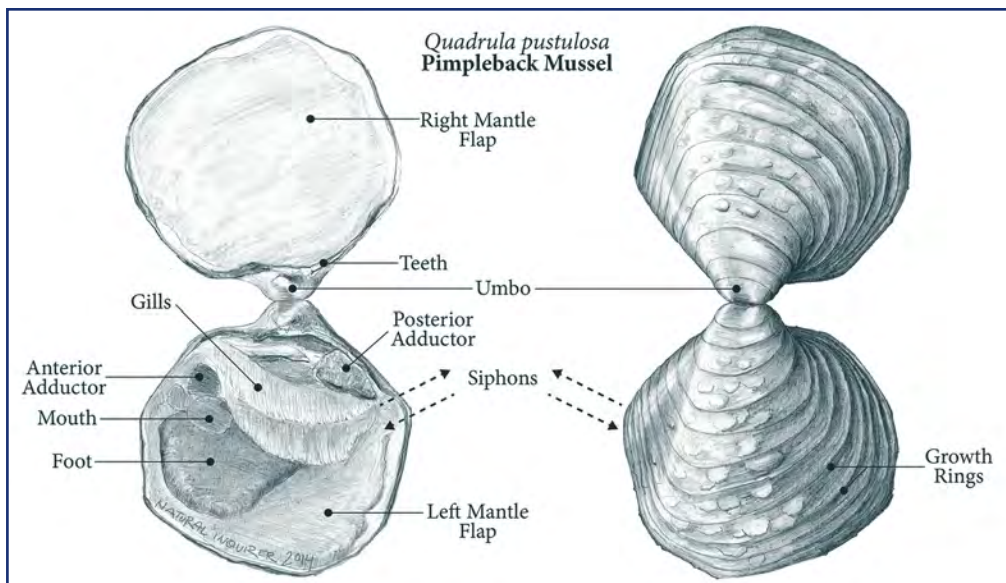


Figure 7. A mussel has many interesting features, such as a foot, a mouth, and teeth that help lock the shell together. Illustration by Stephanie Pfeiffer.



Figure 8. Raccoons and other animals use mussels as a source of food. Photo courtesy of Babs McDonald.

Mussels are very sensitive to changes in rivers or lakes, and this sensitivity makes them good indicators of the health of aquatic ecosystems. Mussels are also interesting because they have a unique reproductive cycle (see sidebar on page 80). Due to the importance of mussels in the ecosystem, the scientists wanted to know how streamflow in the bottomland hardwood forest ecosystems affected the mussels. The scientists wanted to know specifically how streamflow affected mussel growth.

Reflection Section

- 🍁 State in your own words and in the form of questions what the scientists wanted to learn.
- 🍁 Mussels are important to the ecosystem. Name three ways mussels are important and why each function is important to the ecosystem.



Why Is the Mussel Reproductive Cycle Important?

Male mussels release sperm into the water, and the current carries the sperm to female mussels. After the eggs are fertilized, they hatch into tiny **larvae** inside the female's gills. The females then release the larvae into the water where they must attach to a fish. The larvae are parasites that need nutrition from a fish to grow into young mussels. Different mussel species need different kinds of fish. The female mussel must somehow make sure her larvae find the right kind of fish.

Mussels have different ways of attracting fish depending on what kind of fish their larvae need. For example, mussels whose larvae need big predators like bass have large lures that look like minnows. In this case, lures are something that attracts a fish. Other mussels whose larvae need smaller fishes have tiny lures that look like insects or snails. When a fish tries to attack the lure, the larvae attach to the fish and remain for several weeks. After they have developed into young mussels, they

drop off, leaving the fish unharmed. Due to this interesting reproductive cycle, healthy mussel communities are dependent on a healthy and diverse fish community (**figure 9**).

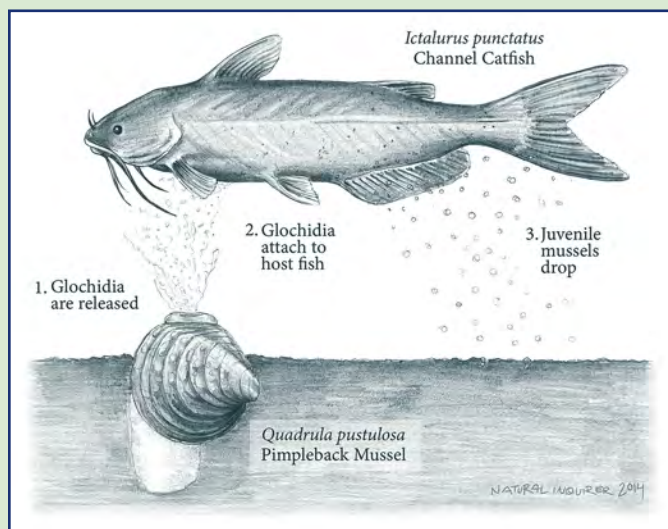


Figure 9. A simplified version of mussel reproduction illustrates some of the interesting features of the reproductive cycle. Illustration by Stephanie Pfeiffer.

Methods

The scientists studied 13 mussel species. The scientists collected the mussels from Alabama, Arkansas, and Mississippi (**figure 10**). They collected mussels from two sites in Alabama on the Sipsey River, one site on the St. Francis River in Arkansas, and one site on the Little Tallahatchie River in Mississippi (**figure 11**).

The rivers that the scientists collected from were different from each other in several important ways. Some of the rivers were regulated and some were unregulated. A regulated river is a river whose water is

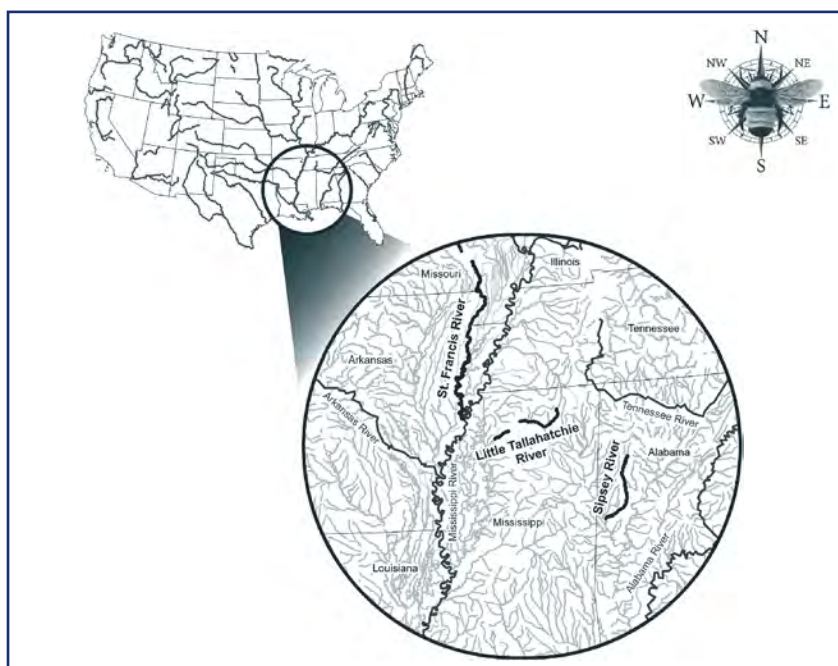


Figure 10. The mussels were collected in three States: Alabama, Arkansas, and Mississippi. Map by Lindsay Gnann.

controlled by dams or other water storage methods (**figure 12a**). An unregulated river does not have any dams or other water storage methods (**figure 12b**). Unregulated rivers are free flowing.

Streamflow can be different for regulated and unregulated rivers. For example, a dam can be opened to release more water, which causes higher streamflow, or it can be closed, reducing the amount of water in the river. Changes in streamflow at certain times of year can have negative impacts on aquatic organisms.



Figure 11. The Sipsey River in Alabama goes through part of the Sipsey Wilderness, and 61 miles of the river have been designated Wild and Scenic. For more information, visit <http://www.wilderness.net>. Photo courtesy of Dr. Andrew Rypel.

The scientists wanted to see if the difference between regulated and unregulated streams affected the mussels (**figure 13**).



Figure 12a. This river is regulated by a dam. Illustration by Stephanie Pfeiffer.



Figure 12b. This river is unregulated. Illustration by Stephanie Pfeiffer.

Name of River	Regulated or Unregulated	Description of River
Sipsey River	Unregulated	The watershed is mostly forested. Water quality is high, and the river has one of the most complete aquatic communities in this region.
St. Francis River	Mostly Unregulated	This river was mostly unregulated at the study site and has a high diversity of mussels; however, much of the watershed is affected by large-scale agriculture and water diversion projects.
Little Tallahatchie River	Regulated	The study site was just below a major storage reservoir , and another small dam is downstream of the study site.

Figure 13. The description of each river includes whether it is regulated or unregulated.

In order to understand how streamflow affected the mussels, the scientists had to collect a variety of **data**. The scientists used microscopes to examine thin sections of mussel shells (**figures 14 and 15**). The scientists took pictures of these shell sections with a digital



Figure 14. Ms. Cram, a Forest Service scientist, uses a microscope to study very small things. Ms. Cram is studying different types of fungi with this microscope. Look at the “Meet the Scientists” section on page 75. You will see Dr. Haag is using a microscope to study mussel shells. Photo courtesy of Jessica Nickelsen.



Figure 15. This thin piece of mussel shell provides the scientists with a lot of information. For example, the number of rings in the shell tells how old the mussel is, and the width of a particular ring tells how fast the mussel grew in that year. Photo courtesy of Dr. Andrew Rypel.

camera, which allowed them to measure how fast the mussels grew in different years. They also took cores from cypress trees to measure how fast the trees grew.

The scientists gathered streamflow data for each of the rivers they studied. The scientists were able to obtain streamflow data for each day over several decades from data collected by the U.S. Geological Survey and other government agencies. They put all of this information into a computer program to help them analyze the data.

What Is Tree Coring?

Obtaining a tree core is a way of getting information about a tree without cutting it down. Scientists, like the one pictured, use a tool called an increment borer to obtain the core.

The core looks like a long pencil with rings. Tree cores help scientists learn the age of the tree and how it grew over time.

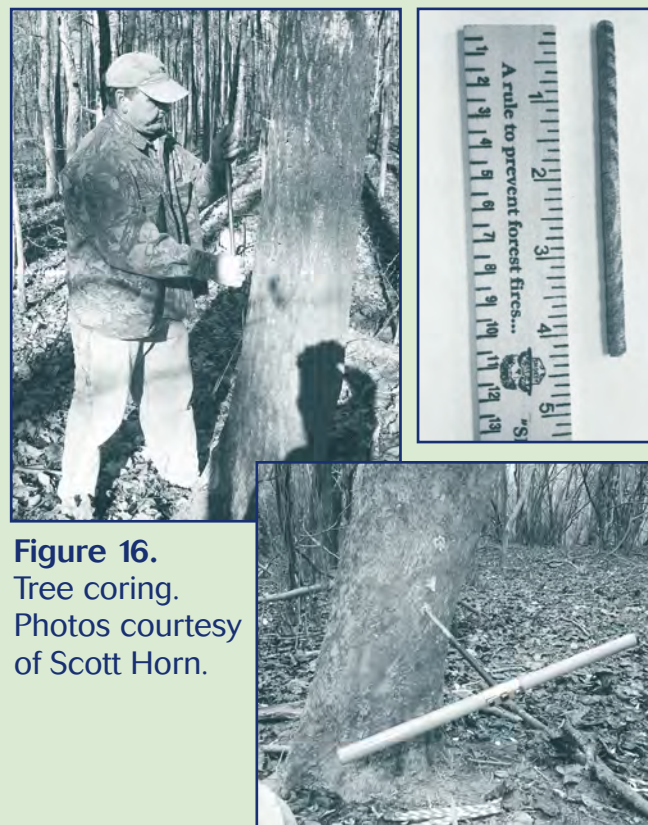


Figure 16. Tree coring. Photos courtesy of Scott Horn.

Reflection Section



- ✦ The scientists collected data from three different rivers. Do you think it is a good idea to collect data from different areas? Why or why not?
- ✦ The scientists included a description of each river in the study (see figure 13). Why do you think this information is useful?

Findings

In the unregulated Sipsey River, mussels grew faster during times of low streamflow and slower during times of high streamflow (**figure 17**). Some mussel species in the St. Francis River also

showed this relationship. The strongest and most consistent trend in the St. Francis River was a strong, positive relationship between mussel growth and **hydrologic** reversals.

A hydrologic reversal is when the river changes from a rising river to a falling river or from a falling river to a rising river. A greater number of reversals can mean that the water falling on the land winds up in the river and flows downstream very quickly. This rapid movement of water often happens in an **agricultural** landscape like the St. Francis River because much of the forest is gone. In a forested landscape like the Sipsey River, the water is absorbed by the forest and enters the river more slowly. This absorption of water influences things like the frequency and severity of floods.




River Name, Mussel Species Name, and Common Name	Low Streamflow	High Streamflow	Number of Hydrologic Reversals
Sipsey River Mussels			
<i>Elliptio arca</i> (Alabama spike)	+	–	No change
<i>Elliptio crassidens</i> (Elephant ear)	+	–	No change
<i>Fusconaia cerina</i> (Gulf pigtoe)	+	–	No change
<i>Fusconaia ebena</i> (Ebonyshell)	+	–	No change
<i>Lampsilis ornata</i> (Southern pocketbook)	+	–	No change
<i>Pleurobema decisum</i> (Southern clubshell)	+	–	No change
<i>Quadrula asperata</i> (Alabama orb)	+	–	No change
<i>Quadrula verrucosa</i> (Pistolgrip)	No change	No change	No change
<i>Obovaria unicolor</i> (Alabama hickorynut)	+	–	No change
St. Francis River Mussels			
<i>Lampsilis teres</i> (Yellow sandshell)	No change	No change	A change
<i>Potamilus purpuratus</i> (Bleufer)	No change	–	A change
<i>Quadrula quadrula</i> (Mapleleaf)	No change	No change	A change
Little Tallahatchie River Mussels			
<i>Quadrula pustulosa</i> (Pimpleback)	No change	No change	No change

Figure 17. Mussel growth each year compared with low and high streamflow and number of hydrologic reversals. A plus sign means that growth was faster and a minus sign means growth was slower. What do you notice about the periods of low streamflow and high streamflow? You can see from the figure that mussels have very colorful names!

Unlike in the other rivers, mussel growth in the regulated Little Tallahatchie River was not significantly related to any streamflow measurements. This finding suggests that regulation of streamflow can disrupt the normal cycles of mussel growth found in unregulated streams. Interestingly, cypress trees behaved exactly the opposite from mussels. Cypress trees grew faster in high-streamflow years but slower in low-streamflow years.

Reflection Section



-  How does mussel growth change in times of high and low streamflow? How do you know based on the data in figure 17?
-  What did the scientists find out about the relationship between regulated and unregulated rivers and mussel growth? (Hint: Review figures 13 and 17.)
-  Read the descriptions of the rivers in figure 13. Do you think any of these river characteristics could influence mussel growth? What do you think the scientists might suggest as the next steps to take after this research?

Discussion

The scientists found that in unregulated streams, mussels showed higher growth in low-streamflow conditions. Low-streamflow conditions enable the growth of microbes and algae in the water, which make up much of an adult mussel's diet. During periods of high streamflow, mussel growth slows.

The scientists think that the mussels' growth pattern may be a result of several factors. One factor is that during times of high streamflow, mussels may require more energy to maintain their position in the riverbed. Another factor



is that high streamflow might make it more difficult for mussels to process their food. This difficulty is because the water is **turbid** and carries a lot of sediment that mussels must separate from edible material like algae and microbes. Finally, high water may dilute the food particles that mussels need to grow. The scientists would need to conduct additional studies to find out exactly why mussel growth is related to streamflow.

Even though the mussels experience lower growth during high streamflows, higher streamflows are needed periodically. Higher streamflows help keep the mussel habitat in good condition by removing fine **sediment** from the streambed. For some species of mussel, too much fine sediment may impact growth, feeding, and survival of young mussels. The different response of cypress trees also shows that a wide range of streamflows is necessary for the best growth for different organisms in the ecosystem.

The scientists found no relationship between streamflow and mussel growth in regulated streams. This finding suggests that dams or other forms of regulation disrupt the normal cycles of mussel growth. The scientists said that the potential relationships found between mussels and streamflow should be studied in other landscapes and rivers. This additional research is necessary so that the scientists will know if these relationships occur in many different places or only in the rivers they studied.

Reflection Section



-  Do you think it is important to study the impact of streamflow on mussels? Why or why not?
-  What are the advantages and disadvantages of dams on our rivers? Discuss with your classmates.

Glossary

agricultural (ə gri kəl ch(ə) rəl): Of, relating to, or used in farming or agriculture.

aquatic (ə kwä tik): (1) Living or found in, on, or near water; (2) of or relating to the animals or plants that live in, on, or near water.

carbon (kär bən): A chemical element that forms diamonds and coal and that is found in petroleum and in all living plants and animals.

data (dā tə): (1) Factual information used as a basis for reasoning, discussion, or calculation; (2) Facts or figures studied to make a conclusion.

dendrochronology (den drō krə nä lä jē): The science of dating events and variations in an environment in former periods by the study of growth rings in trees and aged wood.

diversion (də vər zhən): The act of changing the direction or use of something.

diversity (də vər sə tē): A measure of the differences between the types and numbers of living things in a natural area.

drought (draut): A period of dry weather with little or no rain.

ecosystem (ē kə sis təm): Community of plant and animal species interacting with one another and with the nonliving environment.

endangered (in dān jər ed): Being in danger or peril.

floodplain (fləd plān): Flat land area next to a stream or river.

hydrologic (hī drə lä jik): Of or relating to the science dealing with the properties, distribution, and circulation of water on and below Earth's surface and in the atmosphere.

larvae (lär vē): Wormlike feeding form that hatches from the egg of some animals.

mollusks (mä ləks): Any one of a large group of animals (such as snails and clams) that have a soft body without a backbone and that usually live in a shell.

organic matter (ör ga nik ma tər): Substance which breaks down naturally and which comes from either plants or animals.

reservoir (re zə vwär): Place where water is collected and stored for use.

sclerochronology (skler ə krə nä lä jē): The study of chemical and physical changes in the gradual increase in hard tissue of organisms.

sediment (se də mən): Soil particles carried along in streams and rivers, some of which may settle to the bottom.

siphon (sī fən): Tube-like organ in animals and especially mollusks or arthropods used for drawing in or ejecting fluids.

turbid (tər bəd): Not clear; foul or muddy.

velocity (vē lä sə tē): Speed of movement.

watershed (wä tər shed): The area that drains to a common waterway, such as a stream, lake, estuary, wetland, aquifer, or even the ocean.

Accented syllables are in **bold**. Marks and definitions are from <http://www.merriam-webster.com>. Definitions are limited to the word's meaning in the article.

The definition for watershed is taken directly from the U.S. Environmental Protection Agency (<http://www.epa.gov>).

Adapted from Rypel, A.L.; Haag, W.R.; Findlay, R.H. 2009. Pervasive hydrologic effects on freshwater mussels and riparian trees in southeastern floodplain ecosystems. *Wetlands*. 29(2): 497–504. <http://www.treesearch.fs.fed.us/pubs/33529>.



Time Needed

One class period

Materials (Materials for each student or group of students)

- Three graphs on pages 86 and 87.
- Pencils

In this article, you learned about freshwater mussels and how they respond to streamflow. In this FACTivity, you will be the scientist and analyze real-time streamflow data from the three rivers that the scientists in this study studied.

The question you will answer in this FACTivity is: How do the three graphs of data from the rivers studied by the scientists compare with each other?

Look at the three graphs provided (figures 18, 19, and 20). Each graph represents the streamflow for each river during the same 8-day period. What is similar and different between the graphs? Look back at the findings about mussel growth and streamflow. Now, look at the three graphs. In which river or rivers do you think the mussels may grow the best during the 8-day period? Why? Do you think an 8-day period provides enough information about the streamflow in a river? Why or why not?

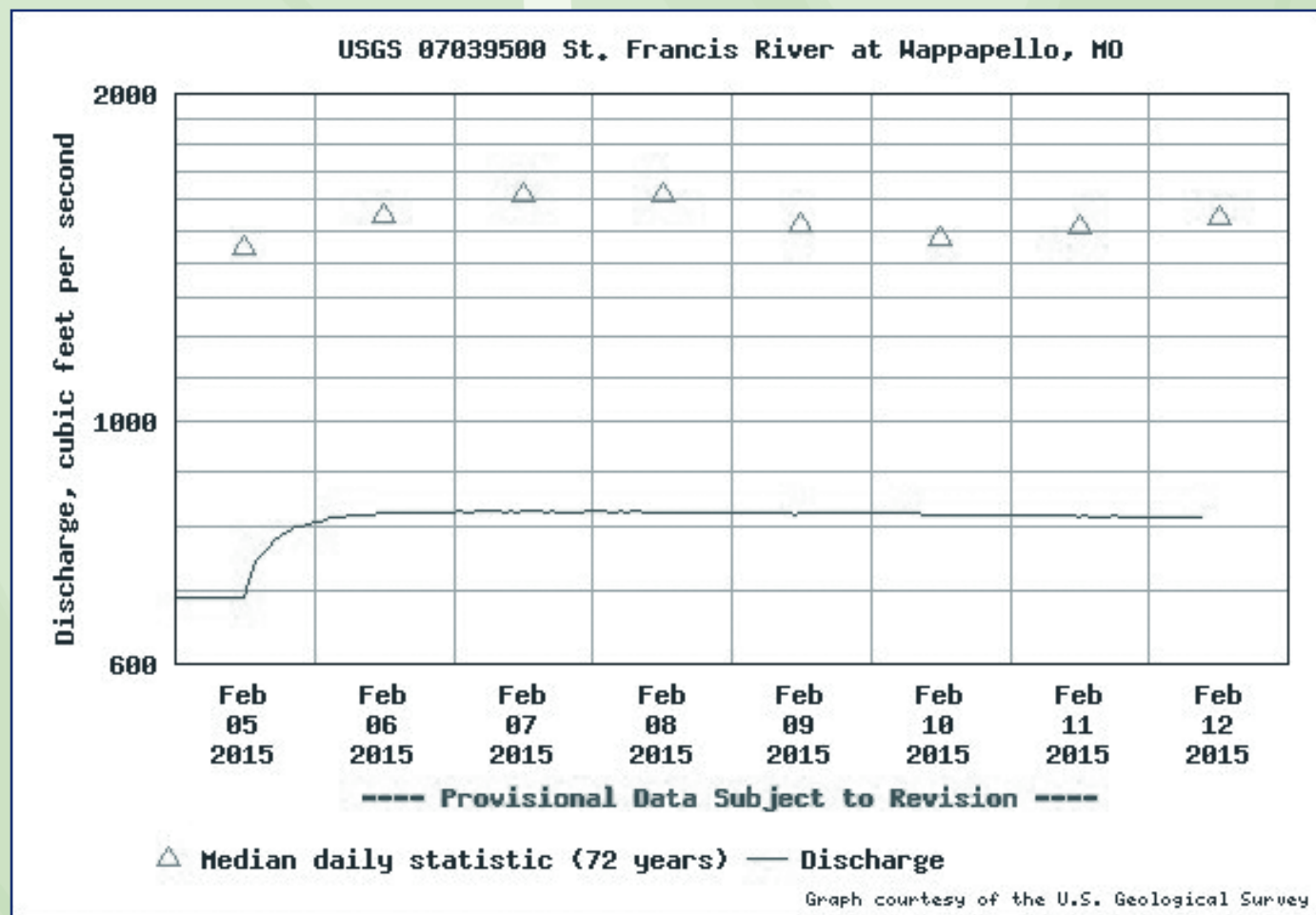


Figure 18. Graph of stream discharge for the St. Francis River at Wappapello, MO. Graph courtesy of the U.S. Geological Survey.

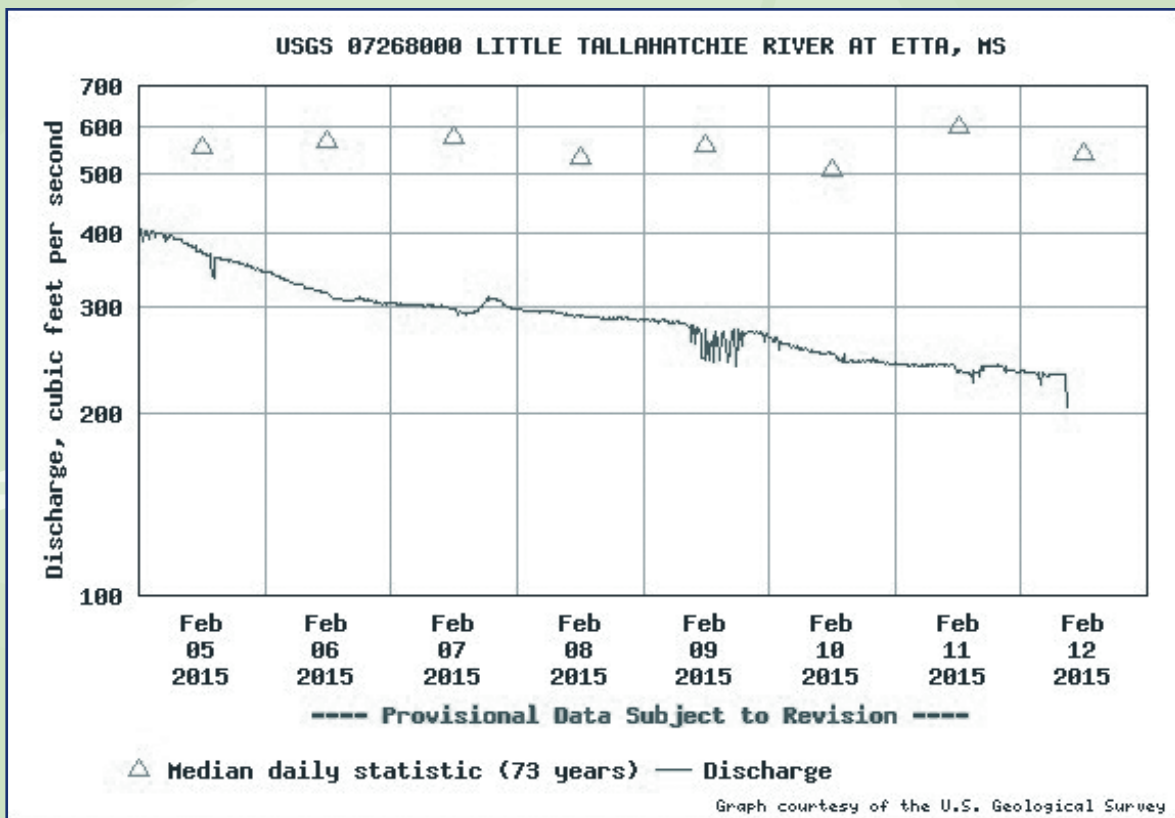


Figure 19. Graph of stream discharge for the Little Tallahatchie River at Etta, MS. Graph courtesy of the U.S. Geological Survey.

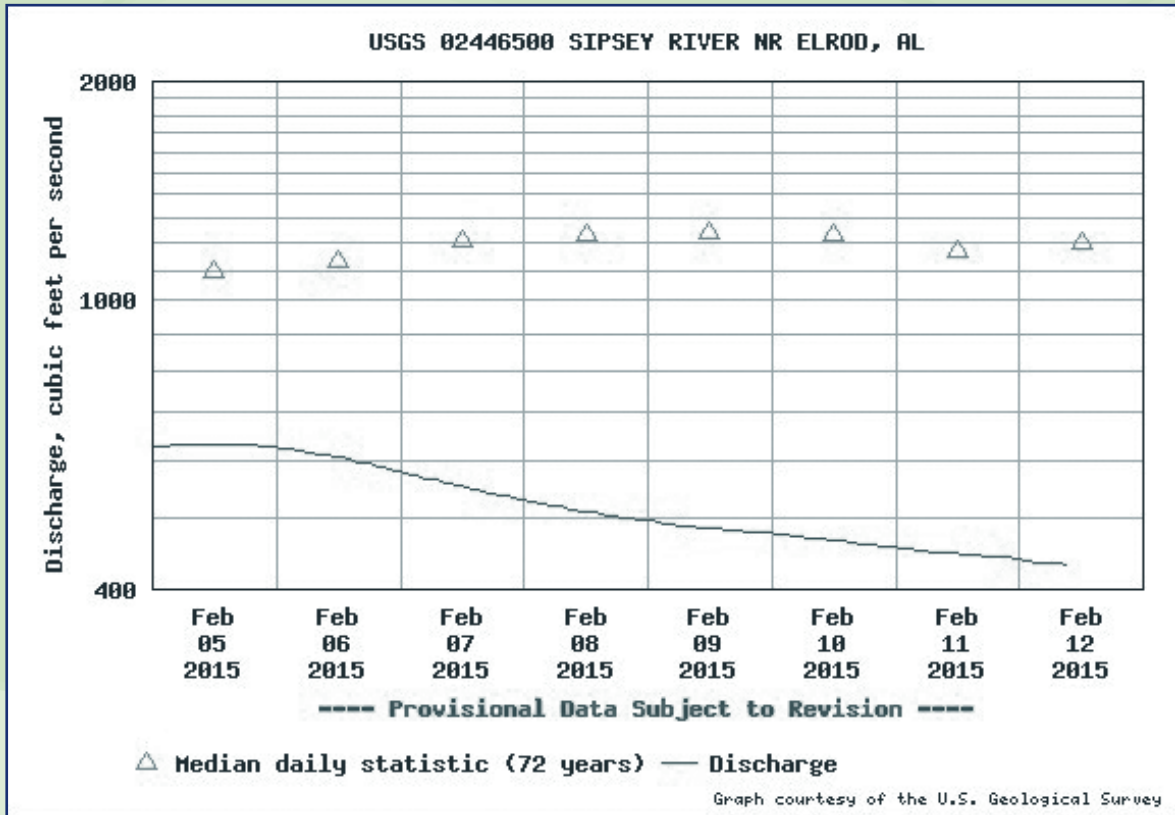


Figure 20. Graph of stream discharge for the Sipsey River near Elrod, AL. Graph courtesy of the U.S. Geological Survey.



First, you will need access to a computer to visit <http://waterdata.usgs.gov/nwis/rt>. This Web site is the U.S. Geological Survey's Web site for daily streamflow conditions across the United States (**figure 21**).

The three rivers that the scientists studied were the St. Francis, the Little Tallahatchie, and the Sipsey. Each of these rivers has a streamflow gage in it that records daily streamflow as well as other data.

1. Use the dropdown menu in the upper right hand corner to select a State. For each river, you will need to select the State. For example, for the St. Francis River, you would select Missouri (see bulleted list that follows).
2. After the Missouri Current Water Data page is displayed, then click on "Statewide Streamflow Table."
3. After the "Statewide Streamflow Table" is displayed, select the specific locations provided in the following list.
 - St. Francis at Wappapello, Missouri is 07039500

- Little Tallahatchie at Etta, Mississippi is 07268000
 - Sipsey River at Erod, Alabama is 02446500
4. Compare the data between the three rivers during different time periods and seasons. You might want to create graphs or charts to help you make your comparisons. What similarities and differences do you notice?
 5. Now, go back to the main page and click on your State. Explore some of the rivers around where you live. How do the data from these rivers compare to the three rivers in the study?
 6. Share what you found with your classmates. If you have time, create a poster about a river in your area. These posters can be hung up in the classroom or in the school to help others learn about streams and rivers in your area.

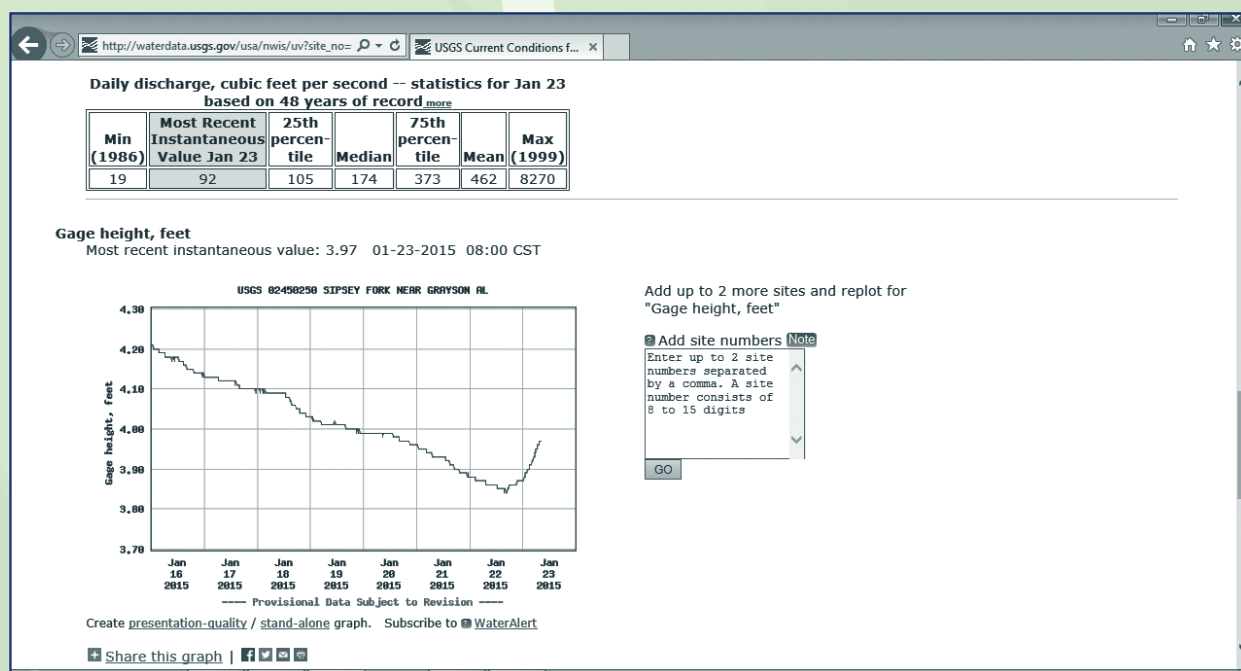


Figure 21. The U.S. Geological Survey Web site for daily streamflow conditions provides information about streams and rivers across the United States.

What's in a Word?

One of the many questions that people have asked from time to time is the spelling of the word “streamgage” versus spelling it with a “u” as in “streamgauge.” Page 50 of the U.S. Geological Survey report, *A History of the Water Resources Branch, U.S. Geological Survey: Volume I, From Predecessor Surveys to June 30, 1919* (<http://on.doi.gov/USGSWaterHistory>) includes a reference giving credit to the change in spelling to F.H. Newell around 1892. The author wrote:

At about this time, F.H. Newell adopted the spelling “gage” instead of “gauge.” As he informed the writer, “gage” was the Saxon spelling before the “u” was inserted as a result of Norman influence on the language.

Ever since then, the U.S. Geological Survey has spelled the word without the “u.”

Natural Inquirer Connections

You may want to reference these *Natural Inquirer* articles for additional information and FACTivities:

- For more on turbidity, sediment, and pollution in water, read “What’s the Nonpoint?” on page 25 or “Sedimental Journey” on page 58 in this *Natural Inquirer* edition.
- To learn about another impact of regulated streams, see the sidebar on page 100 of “Timed Travel” in this *Natural Inquirer* edition.
- For more on the connectivity of stream habitats, read “Swimming Upstream Without a Ladder” in the Tropical edition of *Natural Inquirer*.

These articles, along with others, can be found at: <http://www.naturalinquirer.org/all-issues.html>.

Web Resources

U.S. Geological Survey Water Data
<http://waterdata.usgs.gov/nwis/rt>

Bottomland Hardwood Forests
<http://water.epa.gov/type/wetlands/bottomland.cfm>

Fun With Freshwater Mussels!
<http://www.uvm.edu/~pass/tignor/mussels/>

America’s Mussels: Silent Sentinels
<http://www.fws.gov/midwest/endangered/clams/mussels.html>

Florida Museum of Natural History: Sclerochronology
<http://www.flmnh.ufl.edu/envarch/sclerochronology.htm>

Freshwater Mussel YouTube Video from Virginia Department of Game and Inland Fisheries
<https://www.youtube.com/watch?v=URHTTrAAkpr0>