Freshwater Ecology Unit

A RESOURCE FOR EDUCATORS and STUDENTS

Handouts and activities to accompany your field trip or program

STROUD™
WATER RESEARCH CENTER

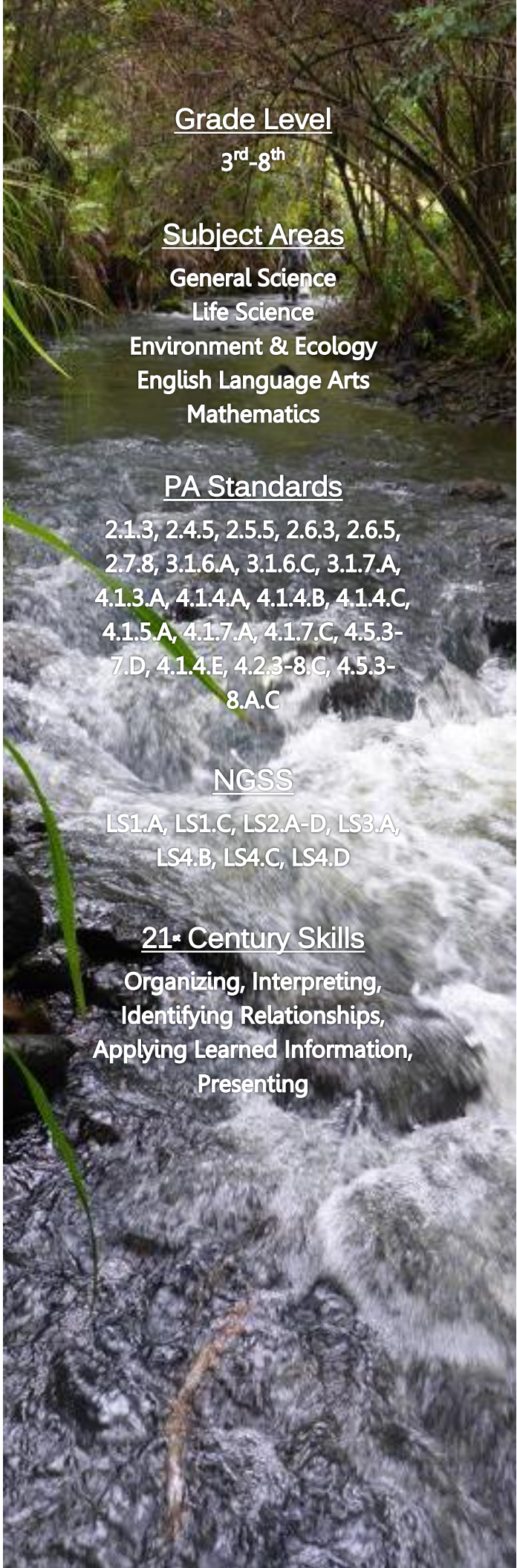
A Note to the Reader:

Thank you for choosing Stroud Water Research Center for your students. As you follow along with this Freshwater Ecology Unit, you will find an assortment of student handouts and activities designed to help your students understand the complex ecosystem of freshwater streams. Though curated in a specific order, feel free to choose what lessons work best for your school's curriculum. The Freshwater Ecology Unit works well as a stand-alone curriculum, but is even more enriching when used as a pre-visit introduction before your Stroud field trip or post-visit to help new material sink in. It is also great when partnered with Trout Grow on Trees, Trout in the Classroom, Tree Monitoring, Stream Monitoring, Leaf Pack Network, or other similar programs.

Primary Objectives

At the end of the program, students will:

- Be able to state reasons why trees are important for healthy streams.
- Understand how trout, leaves, aquatic insects, and trees are interconnected.
- Describe what trout need in order to survive in the wild.
- Comprehend food web systems that lead to trout "growing on" trees, including energy transfer between producers and consumers.
- Have a greater understanding of what makes up an ecosystem.



Grade Level

3rd-8th

Subject Areas

General Science
Life Science
Environment & Ecology
English Language Arts
Mathematics

PA Standards

2.1.3, 2.4.5, 2.5.5, 2.6.3, 2.6.5, 2.7.8, 3.1.6.A, 3.1.6.C, 3.1.7.A, 4.1.3.A, 4.1.4.A, 4.1.4.B, 4.1.4.C, 4.1.5.A, 4.1.7.A, 4.1.7.C, 4.5.3-7.D, 4.1.4.E, 4.2.3-8.C, 4.5.3-8.A.C

NGSS

LS1.A, LS1.C, LS2.A-D, LS3.A, LS4.B, LS4.C, LS4.D

21st Century Skills

Organizing, Interpreting, Identifying Relationships, Applying Learned Information, Presenting

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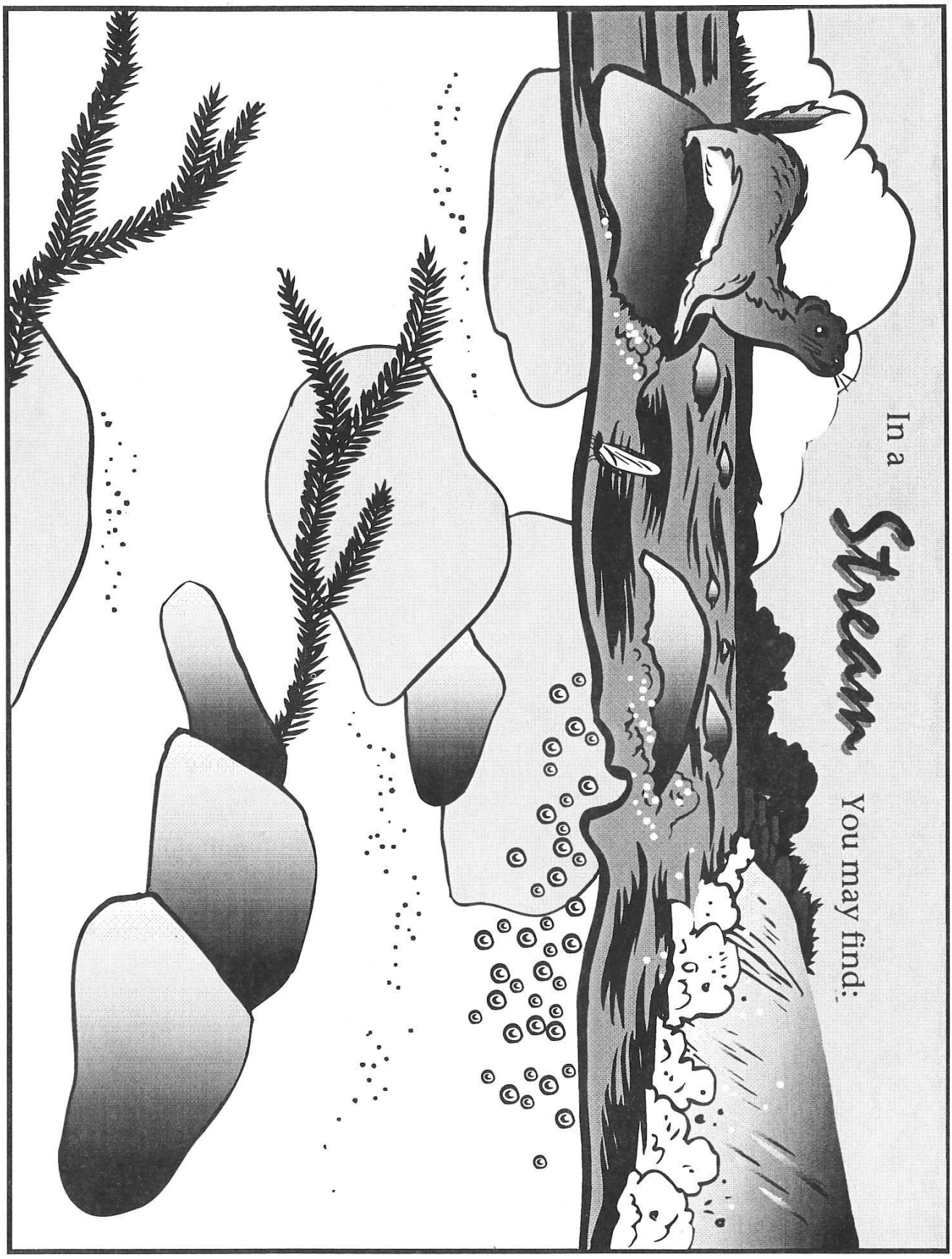
Fill in the rest of this picture. What other plants and animals can be found inside and outside a healthy stream?



Name: _____ Class: _____
Grade: _____ Teacher: _____ School: _____

Freshwater Ecology Unit

Topic	Before Program	I have a question	After Program
How can you tell whether a creek is healthy?			
What is an example of a Macroinvertebrate?			
Why are trees important alongside streams (3 reasons)?			
Can you give an example of a Food Chain in a stream?			
What is something that is negatively affecting our native Trout?			
What is a watershed?			
What is a Lateral Line and how is it used?			

What's a Watershed?

When you hear the word "**watershed**" what's the first thing that comes to mind? If it's a small building where bottles of water are stored, you're probably going to want to keep reading. A watershed is a large area of land that collects all of the rain water as it falls from the sky, and directs it down toward the lowest point, like a funnel. The lowest point of land is where you are likely to find a stream flowing, or even a river. Did you know, you're on a watershed right now?

Find your watershed address:

It's easy! Log on to www.wikiwatershed.org and use *Model My Watershed* to discover more about your local watershed from its name to its health. At Stroud Water Research Center, we are part of the Delaware River Watershed which drains the water from a land area of 14,119 square miles. That's 353 times bigger than Disney World! This watershed includes five states – New York, New Jersey, Pennsylvania, Delaware, and Maryland.

Why care about watersheds?

Whenever anything falls on the ground, it will eventually end up in a waterway even if there is no visible water nearby. This is because we are all part of a watershed. The **water cycle** is in constant motion, pulling fresh water into the atmosphere through **evaporation** and **transpiration** where it **condenses** into clouds, and then releasing that water back onto the earth through **precipitation**. Once that water collects on the ground, the ground becomes **saturated**, and much of that water begins to run along the surface, pulling debris along with it. This debris can be anything from candy wrappers and plastic bottles to fertilizer and spilled oil. That water and debris will make its way closer and closer to a creek where it will meet up with a river which will eventually meet up with a bay, and finally will meet up with the ocean. Having clean watersheds means having clean drinking water, clean places to swim in rivers and at the beach, plenty of healthy fish and other aquatic life, and beautiful waterways.

Make your own watershed map

Materials:

- Different sized sports balls (bouncy balls, soccer balls, tennis balls, etc.)
- a large cotton drop cloth
- Blue ribbon and/or blue fabric strips
- Four weights or rocks
- A large open area on the ground
- Black sharpies or washable markers

Procedure:

- Put the balls on the ground in a random pattern
- Place the drop cloth over the balls
- Place the four weights on the corners
- Begin pushing down between the hills on the cloth to make valleys
- Place the blue ribbon/fabric wherever water would be on this watershed
- Think about a **Topographical Map**, it has many circles drawn together to show how high the **terrain** is. Draw circles around the hills that get smaller at the top to make a Topographical Map.
- Remove the drop cloth from the ground and lay it flat. Point to where the largest hills were, smallest hills, and the waterways based on the lines drawn.

What's a Watershed?

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous page, and then answer the following questions based on what you read using complete sentences.

1. What is a watershed?

_____

_____

2. What are the five states that are part of the Delaware River Watershed?

_____

_____

3. What are the steps of the water cycle?

_____

_____

4. Please describe how the actions of someone in New York could affect our drinking water or a day at the beach. Please be specific.

_____

_____

5. How can you help keep waterways healthy?

_____

_____

6. What is a topographical map?

_____

_____

What are Living Things?

All of the **living things**, called **organisms**, combined with all of the **nonliving things** of a specific area are called an **ecosystem**. How can you tell if something is living or nonliving? If something has died, is it now nonliving? Most living things require five **basic needs** for survival: Food, Water, Shelter, Air, and other organisms of the same kind. So if it is an organism that requires (or required) five basic needs, it is a living thing. Even if it has died, it is still a living thing, it is just no longer alive. The place that meets these basic needs for survival is called its **habitat**. Freshwater ecosystems include streams, rivers, ponds, and lakes. The types of organisms that might be found in each ecosystem will be different based on the kind of habitat you are looking in; there may be frogs in ponds, trout in streams, otters in rivers, and ducks in lakes, but these animals will not be found in the others' habitats. This is because different plants and animals like different kinds of **abiotic factors** in their habitats. These are the nonliving parts of their ecosystem, things like temperature, water flow, how clear the water is, and how much oxygen is available are just some of the abiotic factors. The living parts of the ecosystem are called **biotic factors**; these are the plants and animals in and around the water. Having a lot of different kinds of habitats available so that many types of plants and animals can survive means the area can support high **biodiversity**.

Organism → Species → Population → Community → Ecosystem

A single type of organism is known as a **species**, this would be all of the Brook Trout in a stream, for example. Species are defined by organisms that can reproduce with each other and have young that can also reproduce and have young. Every member of a species in one area, for example, across a section of a stream, are known as a **population**, and if we were to take all of the populations of different species from the stream and look at them together, that would be a **community**. The last step is the ecosystem, which looks at not just the living things (or biotic), but combines the nonliving (or abiotic) parts into the mix.

Trout Basic Needs for Survival Game

Procedure:

- Get a big group of people together (20+), you will also need a paper & pencil or small whiteboard and marker
- Have half of the group stand on one side of a field or room, and the other stand opposite – in a line, shoulder to shoulder
- Begin with group facing each other, one person must stand out as the game facilitator
- Facilitator will make half of the group Brook Trout, the other half will be Basic Needs for Survival
- When told to do so, they will all turn so they can't see each other and will hold up a hand signal showing one of the basic needs (Both hands up together for shelter, Rub tummy for food, Hand to mouth for water, One arm up for air, Both hands over ears for Trout), then they all turn and face each other when their facilitator says so while showing their hand signals.
- If a person on Trout side matches a Basic Need, they pull that person to the Trout side. If a Trout can't find a Basic Need, they join the Basic Needs side.
- Facilitator counts and graphs the number of Trout each "season" (round), and discusses the numbers with the group after the game compared to real-world population changes and the causes (due to abiotic changes in the habitat).

What are Living Things?

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous page, and then answer the following questions based on what you read using complete sentences.

1. How can you know whether something is a living or nonliving thing?

_____

_____

2. Why are different organisms found in different habitats?

_____

_____

3. Can you name four different types of Freshwater Ecosystems and give one example of an organism that could be found in each one?

_____

_____

4. What are some examples of the abiotic factors in a Freshwater Ecosystem?

_____

_____

5. What is the correct order of the following words: Population, Ecosystem, Community, Species? Can you use specific examples of animals found in freshwater environments to fit with each word?

_____

_____

6. What do you think would happen if there were two different species of Trout competing for the same food in a stream? Can you give two possible outcomes?

_____

_____

What's a Food Web?

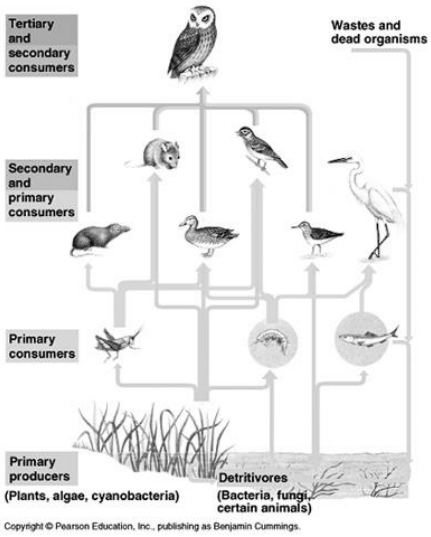
Food Chains

As animals eat food, they are passing energy from one organism to another. This passing of energy between different species as they are eaten is shown simply with a **food chain**. The first organism in a food chain is a **producer**; this is usually a type of plant that gets its energy from the sun through **photosynthesis**. The second organism, a **primary consumer**, eats the producer. Because it is eating a plant, this animal will be either an **herbivore** or an **omnivore**. The next organism in a food chain is the **secondary consumer** that eats the primary consumer, and after that would be a **tertiary consumer**, and so on. If these organisms eat only other animals, they will be **carnivores**. The top consumer which has no other predators is known as an **apex predator**, they are extremely important to an ecosystem because they help to keep a balance to the system; examples of apex predators include wolves, sharks, bears, eagles, and humans. When drawing a food chain, the arrows follow the flow of energy up from producer to top consumer. In a freshwater stream, an example of a food chain could be shown as:

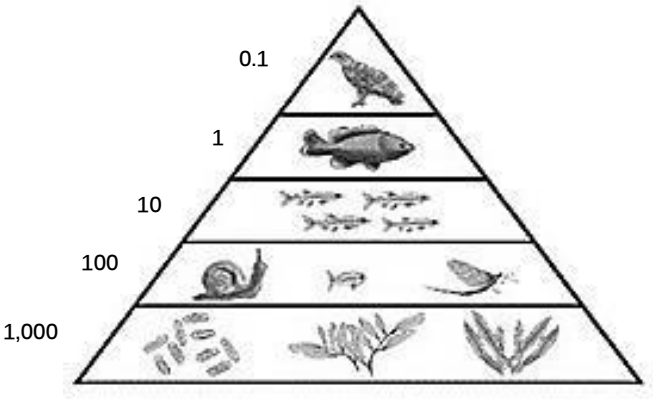
Tree Leaves → Stonefly → Brook Trout → Great Blue Heron
(primary producer) (primary consumer) (secondary consumer) (tertiary consumer)

Food Webs

Because food chains don't tell the whole story in an ecosystem, showing how energy is moving along many paths as animals are eating and being eaten by a variety of other animals, Ecologists use a **food web** to better show how energy flows through many food chains at once. For example, you don't ever eat only one food item during the course of one day alone, you eat many different foods that give you the energy you need to move and grow. For other animals it is the same, they prefer a variety of foods because some give them more energy, some taste better, and some are easier to catch. A food web in a freshwater stream might be shown like the one pictured to the right. Note how the food web includes **decomposers** like bacteria and fungi. They help give nutrients back to the primary producers.



Energy Pyramids



To follow the amount of energy being transferred from one species to another, Ecologists use an **energy pyramid**. The producers are at the bottom of the pyramid and are the most abundant since they have the most available energy. As you travel up to the top of the pyramid, where the top consumer is found, there is less energy available and fewer of those animals. This is because at each **trophic level** of the pyramid, only 10% of the energy from the level below it is passed on. These units of energy are measured in Joules.

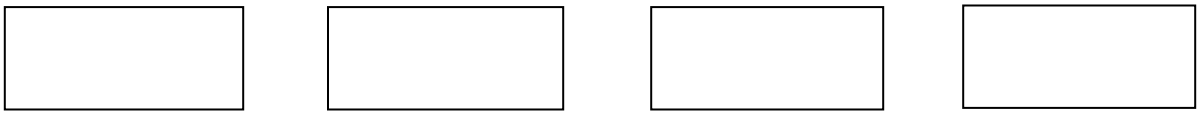
What's a Food Web?

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous page, and then answer the following questions based on what you read using complete sentences.

1. Please make your own food chain using the provided boxes. Make sure the arrows are pointing in the correct direction for energy transfer.



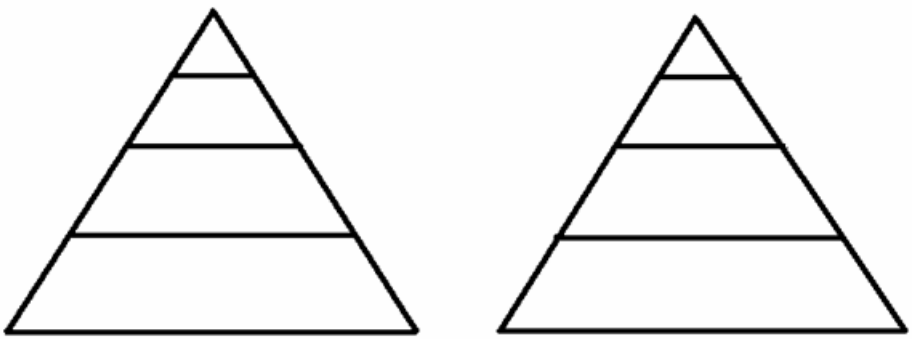
2. In the food chain you created, please list which organism was the primary producer, primary consumer, secondary consumer, and tertiary consumer. Did you have an apex predator?

_____

_____

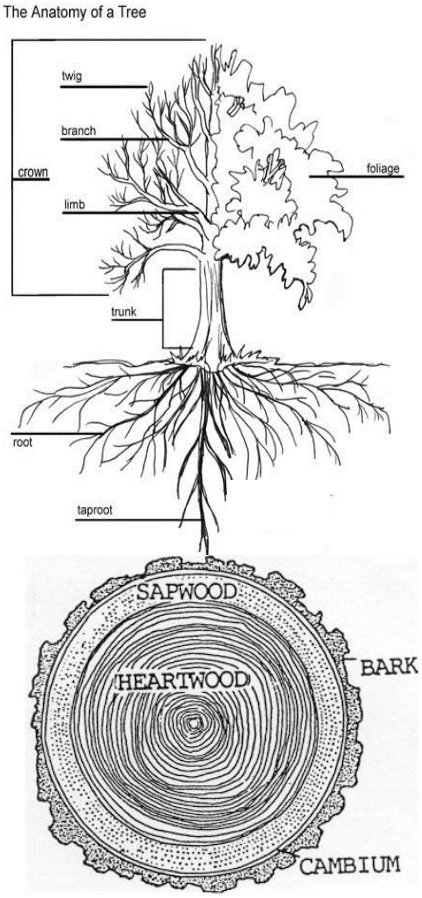
3. In the space provided, please draw a food web by adding to the food chain you created and including more organisms.

4. Using the provided energy pyramids, fill in your food chain starting at the bottom. Then, show how energy is lost between higher trophic levels starting with 1,000 Joules.



Anatomy of a Tree

There's no denying that trees are amazing. They're enormous! How can they get so tall without falling over, anyway? They breathe in the Carbon Dioxide that we breathe out, and breathe out the Oxygen that we and all other animals breathe in. Thanks, trees! They give us cooling shade on hot days, delicious fruit to eat, and provide homes for so much wildlife. Trees help prevent floods with their roots, are a food source to animals, and clean the water we drink. And on top of that, they can be made into useful things like paper, lumber to build homes, firewood to keep us warm, and even wooden boats. So let's take a closer look at what makes trees so great.



Trees have many parts to their structure, but if we were to cut the trunk of a tree across, we would see many rings. By counting these **tree rings**, we can discover how old the tree was; every wide ring is a Spring growing season, and the narrow ring next to it is the Summer growing season. So the following wide ring would be a new year. This type of tree aging is done on trees that have fallen or have been cut down, or may also be done on a tree branch, though that would only show how old the branch is, not the whole tree. Looking more closely at this cut **cross-section**, we can see that aside from the tree rings, the circles on it are different colors. The outer-most ring is the **bark**, this section is similar to our skin and protects the tree from diseases and insects that could harm it on the outside, and keeps moisture trapped on the inside. The next layer below the bark is the **phloem**, also called the inner bark, this layer is a pipeline that carries **sap** with water, sugar, and nutrients (liquid energy!) from the leaves down to the rest of the tree. After the phloem is the **cambium**, this layer is very thin, but has a very important job. It is made up of special cells that can become anything the tree needs; when needed, the cells of the cambium can multiply into branches, roots, phloem, bark, or sapwood. Next is the **sapwood** which works in reverse of the phloem, carrying water and nutrients from the roots up to the leaves. It's also known as the **xylem** and is made up of the youngest layers of wood the cambium creates each year. The last layer on the inside of the tree is called the **heartwood**, this is the most dense part of the tree and is not able to transport sap or water. The heartwood is dead wood and is old xylem that has its transport vessels filled with **resin**. When builders use trees for their construction materials, they prefer to use the heartwood because it is less likely to rot than the softer, living sapwood.

How do trees grow so tall?

All plants contain a material in their cell walls called **Lignin**. Lignin is what helps grasses stand up straight, helps rose stems stay upright when a flower is blooming, and is what keeps trees from falling over. Different plants have different amounts of lignin in their cells, and it's no surprise that trees have the most lignin of any other plant. Some trees have more lignin than others, which is why trees like Redwoods are able to grow so straight and tall. Wooden boatbuilders use the fact that lignin is a fat to their advantage; they heat and steam wood planks to melt the lignin, bend their plank into its shape, and when it cools the lignin will permanently harden the plank into the curved form.

Anatomy of a Tree

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous page, and then answer the following questions based on what you read using complete sentences.

1. How old is this tree?

2. List the main tree layers in a trunk cross section and their functions:

Tree Layer	Function

3. Explain how trees are able to grow so tall.

_____

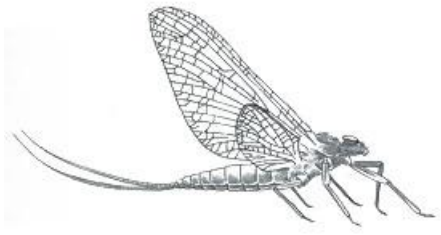
_____

4. What are some of the ways trees help the planet?

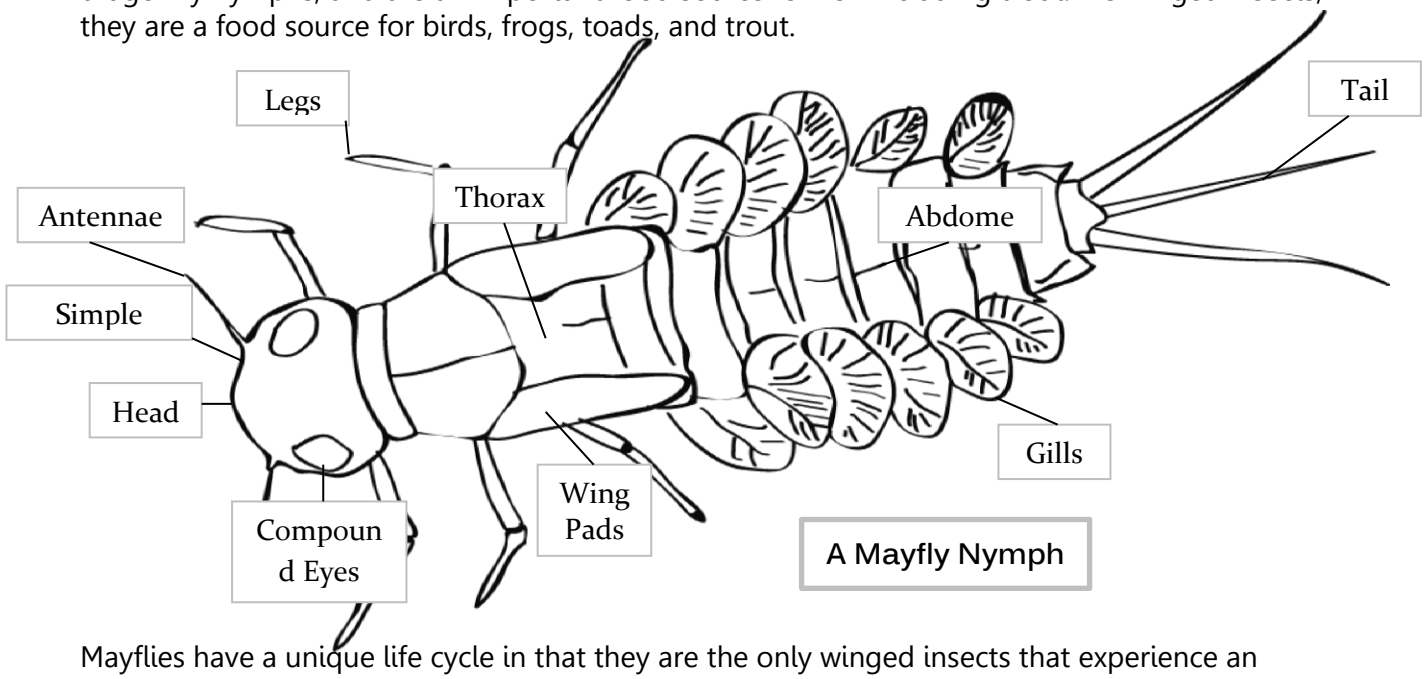
_____

_____

Anatomy of a Mayfly



One of the most sensitive **macroinvertebrates** is the mayfly. These insects are used as **bioindicators** in streams by Freshwater Ecologists to help them understand how healthy a stream is because they can only survive in the cleanest waters. There are over 3,000 different species of mayflies known throughout the world, 630 of which are in North America. They are also an example of a living fossil because Mayflies have been on earth for over 350 million years; that's even before the dinosaurs! Mayflies are short-lived, and spend most of their lives in the water. For about the first two years of their lives, mayflies live underwater in the stream's riffles as **nymphs**, clinging to rocks using their six legs, and breathing in the water's Dissolved Oxygen with the gills on their **abdomen**. Because they will one day emerge from the water as flying insects, these young mayflies have wing pads on their **thorax**. On their heads, they have two **compound eyes** that help them to see the world around them, and two **simple eyes** that help them to see shadows like when a fish is swimming overhead in search of a meal. Mayflies are **herbivores** and **detritivores**, they eat algae, diatoms, and decaying leaves found around the rocks on the stream bed. They have several predators in the stream including other insects like dragonfly nymphs, and are an important food source for fish including trout. As winged insects, they are a food source for birds, frogs, toads, and trout.



Mayflies have a unique life cycle in that they are the only winged insects that experience an additional molt after they go through the stage of getting their wings. This middle stage between the nymph stage and the final adult stage, or **imago**, is called a **subimago**. The time that a mayfly spends out of the water is used only to reproduce and lay eggs; they do not eat any food while they are flying insects. Mayflies have had a long time to perfect the timing of when they emerge from the water, so that they can all become flying insects together and reproduce; this causes an event known as a swarm. Once the mayflies have had a chance to lay their eggs in streams, rivers, and lakes, they die. Mayflies have a very short life in their winged form, only surviving between 1-3 days. This is where they get their scientific **order** name **Ephemeroptera**, which comes from the word "ephemeral" meaning something that lasts for a very short time. Threats to mayflies include water pollution and light pollution since reflective surfaces can confuse females trying to lay their eggs in water and send them off-course.

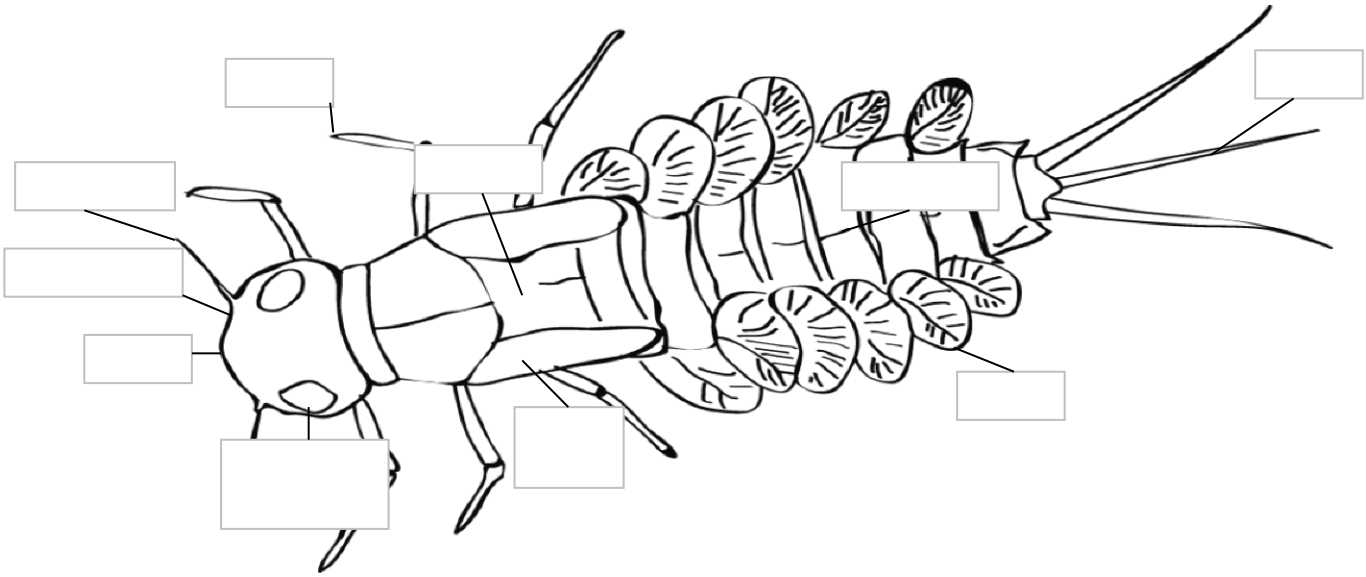
Anatomy of a Mayfly

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous page, and then answer the following questions based on what you read using complete sentences.

1. Label the parts of the mayfly:



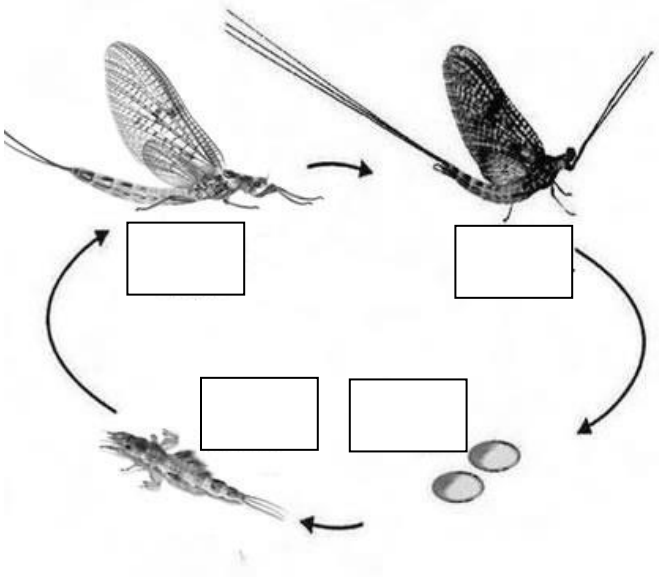
2. Why are mayflies such an important part of freshwater ecosystems?

_____

_____

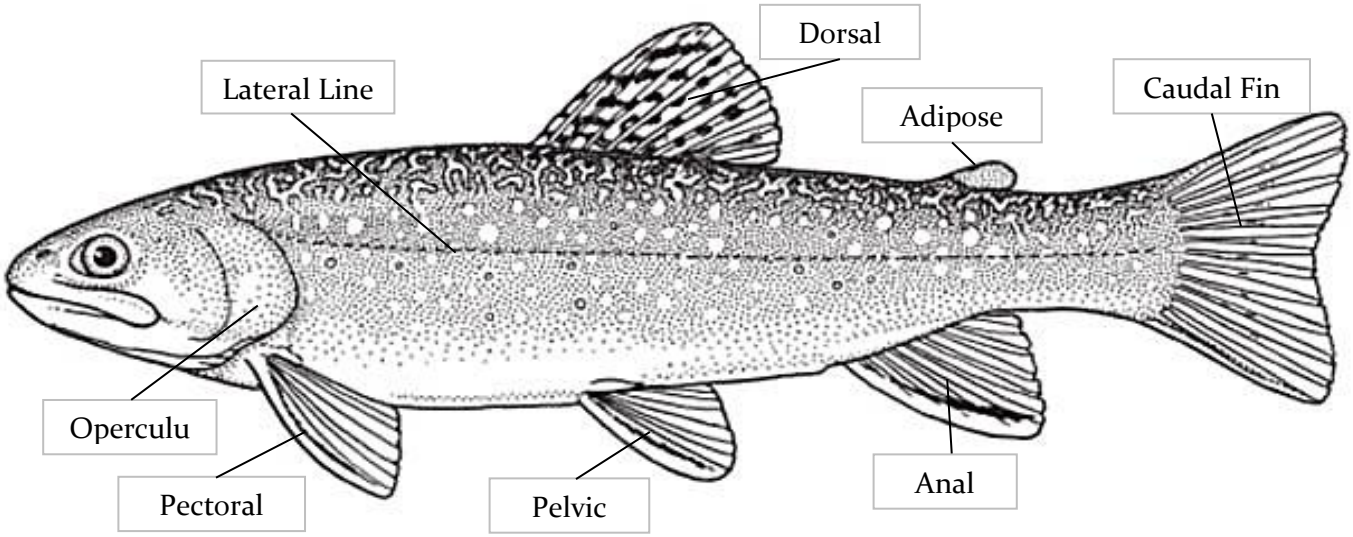
_____

3. Fill in this diagram of the mayfly life cycle:



Anatomy of a Trout

Because different fish have different body shapes, numbers and types of fins, let's take a closer look at the Brook Trout's body features. Brook Trout are **bony fish** that have a varied pattern of wiggles over dark green across their back, or **dorsal side**, that copies the ripples on the water's surface. This coloring that allows it to blend in with its surroundings is its **camouflage** and is a special **adaptation** that Brook Trout have developed over thousands of years of living in the same type of environment. This camouflage helps to protect them from predators that would hunt them from the air, like Great Blue Herons and Bald Eagles. After many generations, the fish best adapted to survive predators continued to have new offspring, and their young **inherited** the things that made it possible for those trout to survive; this is called **natural selection**. The wiggles become outlined spots along the sides, or **lateral side**, of the body, and change into a bright orange on the belly, called the **ventral side**. This lighter orange coloring contrasted with the darker green back is known as **counter shading** and makes it so that the trout's prey in the water below them can't see them coming since the trout will blend in with the fall leaves above. Many animals have counter shading both in the water and on land; can you think of some?



Trout have six types of fins, and each serve a specific purpose to help the fish move through the water. The **dorsal fin** is on the back closest to the head and helps the fish to stay upright. In trout, there is an additional fin on the dorsal side called an **adipose fin** which helps the fish to feel changes in the water around it through movement and sound. On the lateral side behind the **operculum** (the gill covering), there is a pair of **pectoral fins** that help to lift the fish in the water, much like airplane wings in the air. Behind the pectoral fins on the ventral side, there are two more types of fins, one pair of **pelvic fins** which also provide lift and help the fish to make sharp turns and stop quickly, and also a single **anal fin** which helps the fish swim straight in the same way as the dorsal fin. The last fin is the one located farthest to the back, this is the fish's tail called the **caudal fin** which helps the fish push itself through the water. Caudal fins come in a wide variety of shapes and sizes, and learning how to read them can tell you a lot about a fish including how fast of a swimmer they are, whether they are a distance swimmer or sprinter, and even the types of food they might eat. The Brook Trout's homocercal truncate-shaped caudal fin helps it dart quickly after prey. Trout are able to move up and down in the water using a special balloon full of gas in their bellies called a **swim bladder**. When they need to sink, the Brookie burps the air out of its swim bladder. Brook Trout can "talk" to each other using their **lateral line**. This jelly filled tube on their lateral side lets them feel other fish swimming around them, to help locate **prey**, and also lets them know whether there is danger nearby.

Anatomy of a Trout

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous pages, and then answer the following questions based on what you read using complete sentences.

1. Explain how a fish blends in with its surroundings. How does an animal develop this ability?

_____

_____

_____

2. What is counter shading? Name three different animals that have counter shading.

_____

_____

3. List the 6 types of fins of the Brook Trout and their functions (you do not have to use complete sentences):

a) _____

b) _____

c) _____

d) _____

e) _____

f) _____

4. What is a lateral line?

_____

_____

5. What is the purpose of a swim bladder?

_____

_____

Where are the trout?

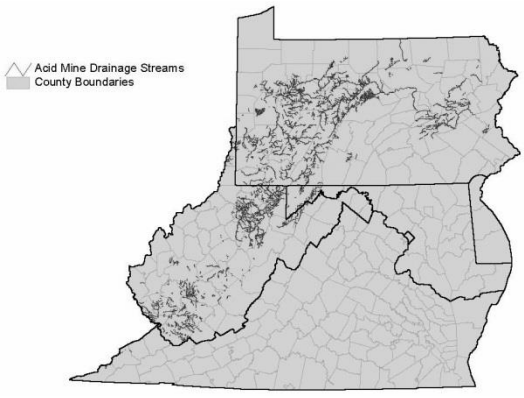
Once upon a time, Brook Trout could be found in every stream and river in eastern North America ranging from Georgia up through Maine to Northern Canada. Today, the native Brook Trout has a spotty distribution. This drop in the Brook Trout's numbers has happened for a number of reasons.

Deforestation

Since about 1900, logging for harvesting timber has destroyed much of the Brook Trout's habitat since the trees provided much needed shade along stream banks, and removing them meant that the waters' temperatures became too warm for the trout living there. This is because trout need to live in water cooler than 70°F, and if the water is too warm it can't hold enough oxygen for the trout to breathe. Another thing the trees did was held the soil in place when it rained; without the trees along the stream banks, the streams became too clogged with dirt, and the trout didn't have their clear waters anymore. The trees also provided a habitat for the fish to hide in the form of logs, and their leaves provided a food source for primary consumers, like insects, which the trout fed on as secondary consumers. Without the trees, the trout could no longer live in the once beautiful streams of the Southern Appalachian area. Today, efforts are being made to rebuild the forests that were once clear cut through watershed restoration so that the native Brook Trout can come home.

Acid Mine Drainage

One of the worst disasters to Brook Trout habitat is **acid mine drainage**. This happens when the coal mines, once an important industry in Pennsylvania, closed down. Because the mines are underground, they are below the water level, this means they needed to constantly have the water pumped out of them so they wouldn't flood. When the coal was removed, a layer of pyrite (or "fool's gold") was left behind; when the water flooded the mines, it reacted with the pyrite creating acid mine drainage, or AMD. This new material is very acidic, about as acidic as a lemon or vinegar; it can have a pH as low as 3 or 4 and can contain metals like iron, aluminum, and manganese. Acidic water is deadly to fish; they need a pH between 6.5-8 in order to live and have their young. The metals, which look like an orange coating, settle on the bottom and kill all of the insects that fish eat, making it so there is no food. Some of the metals, like aluminum, are poison to all life in the water. It is because of acid mine drainage that there is limited habitat for Brook Trout throughout much of Western Pennsylvania and West Virginia. But there is hope, many organizations are working to restore streams affected by acid mine drainage in the United States and Canada in order to save the Brook Trout's habitat.



Where are the trout?

(Continued)

Competition

Wild Brook Trout – Bright orange belly and olive back. Rimmed speckles on side and worm-like

Stocked Rainbow Trout – Pale colors, Pink on cheek is faded & no pink on side, speckles dim. Short fins. Fish looks over fed.

Wild Tiger Trout – Bright striped pattern with orange belly

For a long time people became used to fishing for Brook Trout (or Brookies) in the streams along the Appalachian Mountains, but after years of misuse of natural resources, their habitat had been destroyed and their population dropped too much for fishing. The US government came up with a temporary solution in 1886 when they decided to begin a stocking program to raise and release Brown Trout which are not native to the eastern United States, but are from northern Europe. Then in 1888 they released Rainbow Trout from northern California, a species that is native to the western United States and parts of Asia and Russia. Why release non-native Rainbow Trout and Brown Trout instead of the native Brook Trout? It was decided that Rainbow and Brown Trout were easier to raise in tanks and they also grew much faster than Brook Trout. The problem with introducing a new species to an ecosystem is competition. When the new trout are placed into the Brook Trout's habitat, they eat their food and they take their homes; they are larger than the Brook Trout so they can take over their space. The stocking program was supposed to be a short plan while they figured out how to fix a much bigger problem, however people got used to the excitement of trout stocking season, and the releases are still happening to this day, over 100 years later! Most of the stocked trout are not as healthy as wild Brook Trout and don't survive past the stocking season, they haven't learned how to avoid predators or find food on their own. Stocked trout are made to not be able to reproduce, but sometimes they do. When a female Brown Trout has baby fish with a male Brook Trout, their offspring are called "Tiger Trout", but they are very rare. You can tell a stocked fish from a wild fish because wild fish have much brighter colors and are usually slimmer with fins that are the right size and shape for their body. Look at the fish to the right, you can see the differences between the native and wild Brook Trout with its brightly colored body compared to the dull colors and overweight body of the stocked Rainbow Trout. Pictured at the bottom is the **hybrid** Tiger Trout which is a mixture of a wild Brook Trout and a stocked Brown Trout. An animal that is born from two different species cannot have young of its own. Sometimes the very thing done to help save a species or ecosystem can also cause harm.

You Can Help Trout!

- You can help native fish by raising and releasing Brook Trout in a stream that can support them. Remember what Brook Trout need, cold clean water surrounded by trees, insects in the stream for food, and plenty of places to live and hide. Visit www.TroutintheClassroom.org for details.
- If you know of a place where trout like to live, make sure it's clean by picking up any trash nearby.
- Plant a tree near the stream to give the trout a nice shady spot as well as some food for the insects they like to eat.
- You can also enjoy trout by getting out and fishing! Being close to the water by participating in catch and release helps us to connect with the places and animals we want to protect.

Where are the trout?

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous pages, and then answer the following questions based on what you read using complete sentences.

1. What is the only species of trout that is native to eastern North America?

_____

2. What are three reasons the native trout in eastern North America has been disappearing?

_____

_____

3. In your opinion, should trout that are not native to an ecosystem be stocked there? Use data to support your answer.

_____

_____

4. What are some of the ways to identify a wild fish from a stocked fish?

_____

_____

5. What causes acid mine drainage?

_____

_____

6. How do trees help trout?

_____

_____

7. How can you help native trout?

_____

_____

Analyzing Data: Ichthyology

Through **Ichthyology**, or the study of fish, scientists are able to better understand how to protect native fish populations like the Brook Trout and many others. With the use of **electrofishing** equipment, researchers stun the fish temporarily so that they can discover what fish are in a certain waterway. Once they've collected their stunned fish samples, they can weigh them, measure their length, and even tag them so that they know later whether they have caught the same fish more than once. Fish can be tagged by injecting a brightly colored liquid under the skin, or by clipping a small tag onto one of their fins; sometimes their tag might have a GPS tracker on it so they can be found again. After the fish are marked and measured, they are safely returned to the same stream site where they were collected so that there is as little stress as possible on the test subjects. Occasionally, researchers may choose to do surveys of fish and observe them in their natural habitat with the use of underwater cameras. Knowing how well the fish are doing helps them understand the health of the whole stream ecosystem since fish need so many different abiotic factors to stay healthy. Scientists also collect data to understand how people interact with fish. The table below is from a report by the Pennsylvania Fish and Boat Commission after they did a survey of people fishing in Pennsylvania stocked trout streams to better understand how **anglers** viewed the waterways and the trout in them.

Data Table

Number of fish caught in stocked trout streams in Pennsylvania before and after opening weekend in one year.

Fish Type	Before or After	Number of Fish Caught
Brook Trout	Before	398,042
Brook Trout	After	1,345,908
Brown Trout	Before	350,480
Brown Trout	After	1,857,318
Rainbow Trout	Before	996,851
Rainbow Trout	After	1,821,494

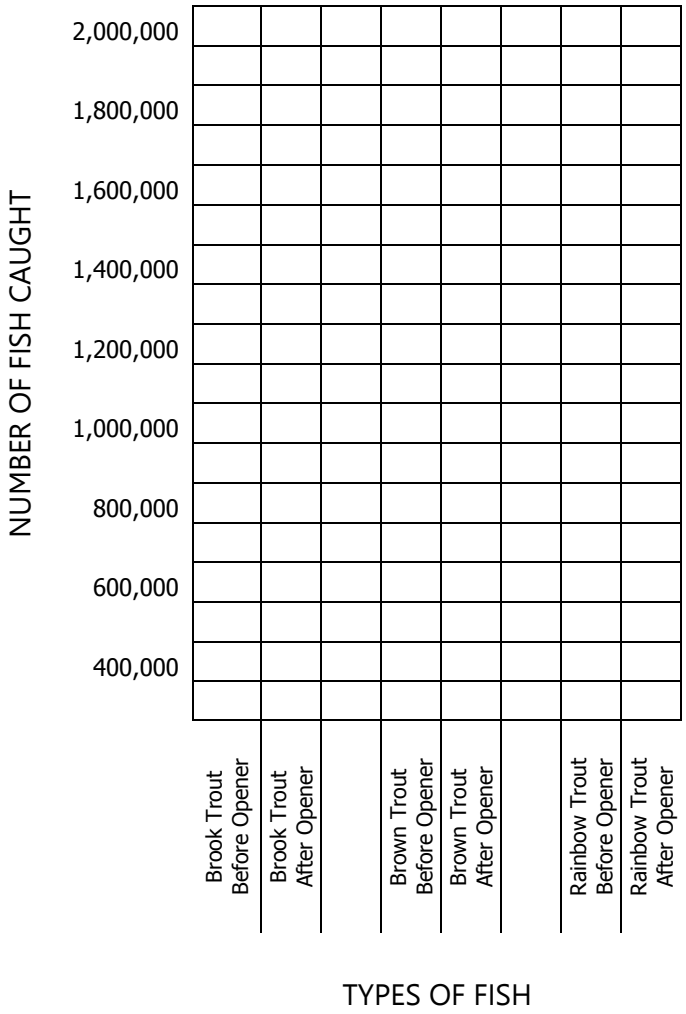
Analyzing Data: Ichthyology

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Using the data provided on the previous page, make a bar graph by coloring in the blocks to show the number of each type of trout caught in one year before and after the opening of the trout stocking season. Create a title for your bar graph.

Title: _____



Calculate Population

Using the numbers in the data table, add together then write the total number of each trout species collected during the year:

a) Brook Trout _____

b) Brown Trout _____

c) Rainbow Trout _____

d) Total Trout _____

Are these numbers a good representation of the total number of trout in Pennsylvania? Why or why not?

_____

_____

_____

_____

_____

Draw Conclusions

Using your graph, do you see any differences between the numbers of different kinds of fish? Did your data show that people fished more before or after opening weekend?

_____

_____

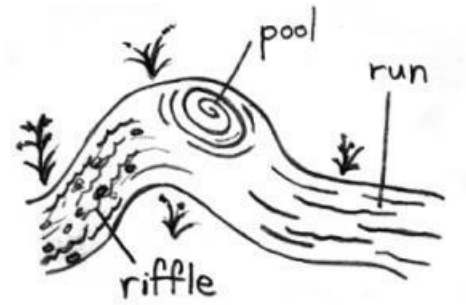
_____

Stream Health

When **field researchers** are trying to figure out whether a place is healthy or not, they need to look at the entire ecosystem to make sure they are seeing the big picture. These scientists are typically called **Ecologists** because they compare both the abiotic factors and the biotic factors of an environment, and how they work together to make the whole ecosystem. The people doing research in streams and rivers are known as **Freshwater Ecologists**, though each scientist usually focuses on a certain topic of interest.

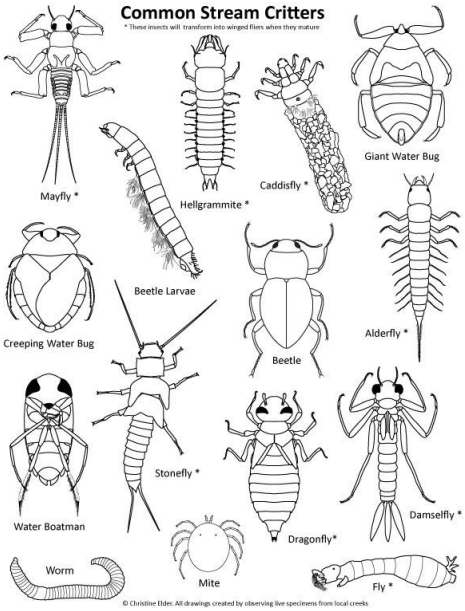
Figuring out if a stream is healthy is a bit like getting a check-up at the doctor's office. Scientists take the stream's **temperature** to make sure it's not running a fever. They find out its **pH** to make sure it's not too acidic or basic much the same as if you have an upset stomach. They make sure there is enough **Dissolved Oxygen** in the water so that the animals living there can breathe easy; if you've ever been out of breath or had an asthma attack, you know how important getting enough oxygen can be. And they even test the water for extra nutrients like **Nitrate** and **Phosphate** which are found in fertilizers from farms, and can come from waste water when humans don't treat the water properly before releasing it into the stream. Having these nutrients in the stream is similar to eating too much candy on Halloween, it tastes good but it is not good for you. When there are too many nutrients in the water, it can lead to plankton blooms and even cause fish to die! These methods of water testing are called a "**Chemical Assessment**". This means they are the nonliving components of a stream, or the abiotic factors that affect the living things in the stream. However, though testing these things are important since they make sure the water is clean and safe enough for animals to live in and for people to use as drinking water, they are not the whole story.

Another method involves making sure there are plenty of **habitats** available for the animals living in the stream. The more different types of habitats there are, the greater the **biodiversity** will be throughout the stream because there will be a lot of different spaces available for many kinds of animals. A **riffle** is a shallow area flowing over small rocks that adds Dissolved Oxygen back into the stream. This is also where the smallest animals in the stream can be found, aquatic insects, snails, crayfish, worms, and salamanders are all experts at anchoring onto rocks and plants in the fast-moving current. These small animals are very good at breaking down plant matter, like dead leaves that fall into the stream, to return the nutrients back into the environment, and most of them are known as the Primary Consumers of the stream ecosystem. A **run** is a smoothly flowing section of the stream that also has a lot of oxygen in it that's flowing off of the riffle, but doesn't have as strong of a current. This is often where fish come to eat since its where bugs end up when they can't hold onto the rocks in the riffle. A **pool** is the deepest part of a stream and is where fish usually live, this is because the deep water makes it difficult for their predators, like Great Blue Herons, Hawks, and Bald Eagles, to catch them. However, the pool usually has the least amount of oxygen in the stream, so when temperatures rise in the summer, fish are usually found swimming in runs instead of pools so they can breathe easier. It's also important to look for other kinds of habitats throughout the stream like undercut banks where the water has cut away some of the dirt and left a roof of plant roots behind, fallen logs where many kinds of animals can find shelter, and a variety of stream bottom like rocks, plants, and logs that can provide hiding places. When scientists look for habitats in a stream, figure out how deep and fast the stream flows, and make sure the stream seems healthy based on its color and smell, they are doing a "**Physical Assessment**".

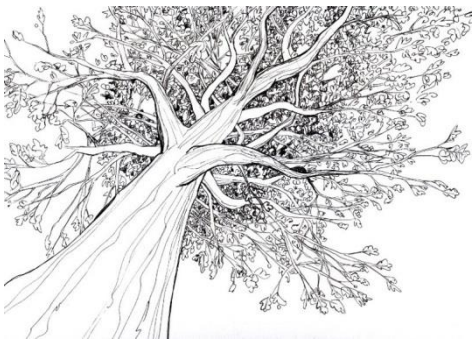


Stream Health

(continued)



The last of the three ways a stream is rated as healthy or not, is by looking at the biotic factors that are present; what sort of life exists in the stream that is using all of these habitats and the water that we tested? It's important to do the last measurement to understand the biodiversity of the stream, and to understand if there could be any hidden issues affecting the stream which could lead to future testing of the waterway. Sometimes, though a waterway might look healthy and test healthy at first on the Physical and Chemical Assessments, future tests could show that it has high levels of pesticides in it which are killing all of the bugs, for example. This is why doing all three tests are important for understanding the whole picture. When Stream Ecologists look at the "**Biological Assessment**" of a stream, they examine the biodiversity of the **macroinvertebrates** that live there. These are all of the animals that are the Primary Consumers and are at the base of the food web that are food for everything else in the stream. By understanding them, we can figure out whether there is food available for everything that is eating them. There are certain macroinvertebrates that are **bioindicators**; this means that they can show us how healthy a waterway is just by living in it. Certain macroinvertebrates, like **Mayflies**, **Caddisflies**, and **Stoneflies** are very sensitive to pollution or any changes in their environment; if their water is unhealthy, they can't survive. So if we see these sensitive macroinvertebrates, then we can assume the waterway is healthy now and has been for several months to several years. There are other macroinvertebrates that are somewhat tolerant to changes in their environment. This means that if there is just a little bit of pollution, they can still survive, but if it goes up any further, they will die. Many macroinvertebrates that live in waterways are tolerant to changes because they have evolved over a long time to live in a variety of environments. These are the ones you are most likely to see in any waterway. A lot of the macroinvertebrates that live in freshwater streams only spend part of their life in the water; these are the winged insects that you may see flying around in the summertime like Dragonflies, Mayflies, Stoneflies, Midges, Damselflies, Craneflies, and many others.



One of the most important things needed for a healthy stream is not even in the stream. Stroud Water Research Center scientists have discovered that trees are the most important thing keeping our waterways clean and healthy, and having a forest that is 100 feet wide on either side of a stream means that it will be well protected. Trees do so much to help streams. They clean the water by absorbing nutrient run-off coming from farms and fields before the nutrients can make it to the water. They help to hold the soil in place with their roots and prevent erosion. Trees shade the stream and keep it cool, and cooler streams mean they can hold more Dissolved Oxygen so animals can breathe. Their limbs provide a habitat for animals both out of the water and in the stream. Their leaves fall off in autumn and are an important food source for macroinvertebrates. Without trees, the stream would be dirty, full of nutrients and covered with slimy algae, it wouldn't have a lot of oxygen or habitats, there wouldn't be many macroinvertebrates, and there would be little to no fish.

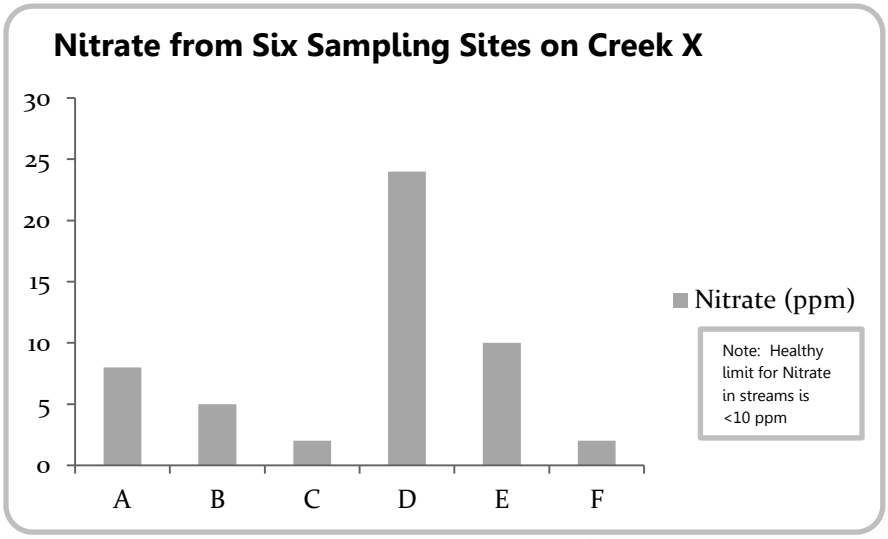
Stream Health

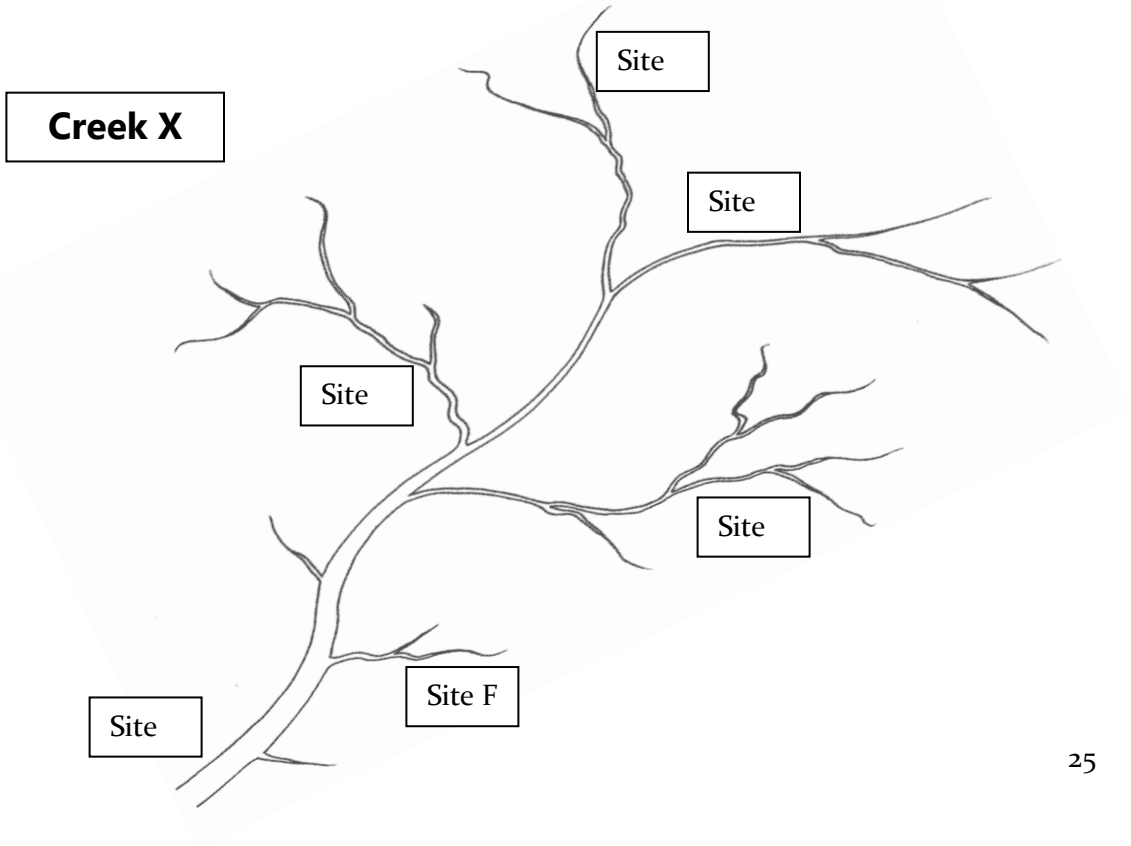
Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous pages, and then answer the following questions based on what you read using complete sentences, when possible.

1. Use the data in the following graph to assist you in creating a picture of what the stream might look like where these samples were taken. What kinds of land uses do you think could be causing these results? Draw or write the answer next to the stream at each site location. (Remember to read the text for clues.)





Stream Health

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous pages, and then answer the following questions based on what you read using complete sentences, when possible.

2. What is a stream scientist called?

_____

_____

3. What are the three things scientists look at to measure a stream's health?

_____

_____

4. Using the sampling sites on the stream map from Question 1, which site(s) do you think might have the most kinds of macroinvertebrates? Why?

_____

_____

5. Compare and contrast three different streams. How would they look? How healthy might they be based on the three measurements for stream health? Think about the things that can affect a freshwater ecosystem both in the water and outside of it.

a) A stream surrounded by a forest

_____

_____

b) A stream that runs through farmland

_____

_____

c) A stream that borders a road in a city

_____

_____

6. Name 3 things **you** can do to help streams stay healthy. (Hint: The answer isn't written down, think about how you can help keep the water clean.)

_____ _____ _____

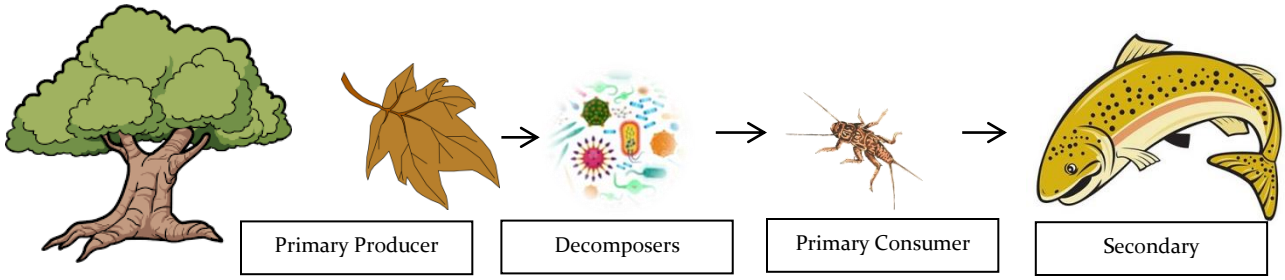
Trout Grow on Trees

Hearing that trout grow on trees can conjure up weird images of fish hanging from the branches of a trout tree, waiting to drop into the water. For those well versed in food webs, however, the term "trout grow on trees" is representative of the symbolic connection between producers and consumers in the complex stream ecosystem. So what does this phrase really mean?

Every autumn, the trees lining the banks of streams drop their leaves, and while most of these leaves fall onto the forest floor, some leaves fall directly into the stream or are washed in after rainstorms. Though they may not look like much, the dead leaves are holding something very valuable: **Nutrients**! As the leaves are broken down by **algae**, **fungus**, and **bacteria**, they begin to soften and become slimy. These slimy leaves are now ready to be chewed on by the **shredders** in the stream. These are the **aquatic macroinvertebrates** that use their chewing mouthparts to shred, cut, bite, or bore into the slimy, algae and fungus-covered leaves on the streambed. Some examples of shredders include certain species of **Mayflies, Stoneflies,** and **Caddisflies**, types of insects that can only survive in very healthy streams. After the shredders have had their feast, the **Brook Trout** and other fish living in the stream have theirs; macroinvertebrates that have become dislodged from the rocks they cling to in riffles are quickly eaten by fish lying in wait downstream in pools. The insects can become detached from their rocky riffle home because of flooding, an animal (including humans) walking through the stream or disturbing the rocks, or natural occurrences. Sometimes, they are able to reattach before leaving the riffle, but usually the swift current pushes them out into a run or a pool where there are no rocks to cling to and a lot of predators to hide from.

This is one example of a food chain in the stream. There are many other pieces of the story that make up the stream ecosystem's food web. For example, sometimes a macroinvertebrate won't get eaten by a trout, but will be eaten by a **Dragonfly Nymph** or a **Crayfish**. Are trout the end of the story? No, trout are not apex predators; there are other animals that eat them, like **Great Blue Herons** or **Bald Eagles**. But while it's important to look at the big picture, it's also necessary to understand and look closely at a small piece, to examine the connections and what lessons can be learned.

The most important lesson to understand about "trout grow on trees" is this: Trees are essential for all life in the stream. They are the foundation, the building block of life. The leaves provide the nutrients to the stream that starts the whole process. Aside from that, they provide the stream with shade to keep the temperature nice and cool and keep the Oxygen levels high, they keep harmful pollutants out of the stream by filtering rain water runoff, prevent erosion by anchoring soil with their roots, keep waters clear, and provide a habitat to wildlife both above and below water. Streams need trees.



Trout Grow on Trees

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous page, and then answer the following questions based on what you read using complete sentences.

1. Explain what Trout Grow on Trees means.

_____

_____

2. Draw the food chain for Trout Grow on Trees with an Apex Predator, or Tertiary Consumer, added in.

3. What is the most important lesson to learn from the story of Trout Grow on Trees?

_____

_____

4. What are five things trees do to help keep streams healthy?

_____

_____

5. Imagine a crystal clear stream in the middle of a forest with cool water, brimming with life. Now imagine that forest is completely cut down. What do you think are the ways that the stream would change?

_____

_____

Forest Restoration

Because trees are so important to healthy streams, **Watershed Restoration Ecologists** are working hard to replant forests that have been cut down in the past for logging, farming, or other reasons. By planting a buffer of baby trees, called **saplings**, alongside streams they can recreate the forests of the future that will help to lessen the impacts of farms, roads, housing developments, and other **land uses** on our waterways.

Protecting Saplings

There are a lot of problems that can happen when trying to rebuild a forest. The first problem to be addressed is how to protect the young trees from hungry **deer** and **voles** (a mouse-like rodent). Saplings are deer's favorite food, and voles like to **girdle** the young trees meaning they chew off all of the bark in a circle around the bottom so the tree can't pass sugars from the leaves down, or water and nutrients from the roots up. To help with this problem, the saplings are placed in **shelters** to protect them; each tree will stay in its shelter during its entire growth cycle, and when it is big enough the tree will split the seam with its trunk. The shelter will stay with the tree and will eventually break down in the environment from sunlight. There are many different kinds of shelters that are used for different kinds of trees and shrubs depending on the kind of sunlight they need, the environment where they are planted, and the way that they grow. Tree shelters also provide protection from wind, herbicides, and mowing.

Extra Protection

To add extra protection in areas with a lot of deer, **double fencing** is added that is 4 feet tall, with the first set of fencing close to the trees, and the second set of fencing 10 feet away from that. This double fence confuses the deer's depth perception so that it can't see exactly how tall or how far the fence really is, and it thinks it can't make the jump (even though it can), and leaves the trees alone. In places where there are a lot of voles, like alongside corn fields, **small rocks** are placed around the base of the tree to prevent them from burrowing under the shelters to get to the saplings inside, and the area around the trees is mowed so that **hawks** can see the voles and hunt them more easily.

Invasive Species

Another threat to forests is **invasive species**. These are plants and animals from other places that were brought either accidentally or on purpose many years ago, but now are growing out of control and killing **native** trees. An example of an invasive species is the **Emerald Ash Borer**, a beetle from Asia that burrows into Ash trees and kills them; this beetle is steadily destroying all of the Ash Trees in North America, and it is because of this bug that wood for camping must come from the same location as the campsite to help reduce the spread of the infestation. Another invasive species affecting forests is called **Oriental Bittersweet**, an **ornamental vine** with red berries that have a yellow casing from Eastern Asia; it was brought to the United States for flower arrangements and was accidentally introduced to forests through carelessness. Now, it is widespread along the entire East coast from Maine to Louisiana and as far West as the Rocky Mountains. Oriental Bittersweet is a vine that wraps around trees to climb up toward the top of the forest **canopy** for light, but because it wraps around the tree's trunk it ends up strangling the tree to death. Its roots also have the ability to pull **nutrients** in the soil away from other plants, so it can grow faster. The best way to deal with invasive species like Oriental Bittersweet is to cut them out of the forest so they can't cause harm to the trees.

Forest Restoration

Name _____ Date _____

CRITICAL THINKING QUESTIONS

DIRECTIONS: Read the text on the previous page, and then answer the following questions based on what you read using complete sentences.

1. Why would Watershed Restoration Ecologists want to replant forests?

_____

_____

2. What benefits does using a tree shelter provide saplings?

_____

_____

3. What do voles do to saplings? How do Watershed Restoration Ecologists prevent voles from attacking saplings?

_____

_____

4. What are two examples of invasive species that are affecting forests in North America?

_____

_____

5. What is the best way to remove invasive plants from the environment?

_____

_____

6. What reasons do you think invasive species were brought into this country? Think about how this country was founded as a “melting pot”.

_____

_____

7. Is there a place near your home or school that would benefit by planting some trees? You can help streams by planting one or more trees near a waterway, and by picking up litter. How will you help your local stream?

_____