Know Your Forest, Know Your Water

Educational Workbook Topics:

www.ncforestservice.gov

Cover Photo: Pond at Jordan Lake Educational State Forest

Healthy Forests = Clean Water

North Carolina has abundant and diverse forests: pines, oaks, cypress, gums, hickories, maples, and many more. There are approximately 34.4 million acres of land in North Carolina, with almost 18 million of those acres being forests. That's enough forest to cover almost 13.5 million football fields!

Forests provide many things: wood, paper, cardboard boxes, charcoal, food, and fuel, among other products. Forests also provide many benefits such as cleaning the air & water, nests for birds, homes for animals, and recreation places.

Most of the forests are privately-owned. This includes farmers, families, investors, hunters, and people who just enjoy the outdoors. Foresters help woodland owners by giving advice on how to manage their forest, how to sustainably harvest trees, improve wildlife habitat, and re-grow the next generation of forest.

Proper management allows forests to provide the things we all need, and also keep the water clean. When working in the woods, foresters and loggers use Best Management Practices (abbreviated as 'BMPs'), to protect soil, water, wetlands, and wildlife. The N.C. Forest Service routinely monitors logging jobs to make sure they comply with the water quality rules.

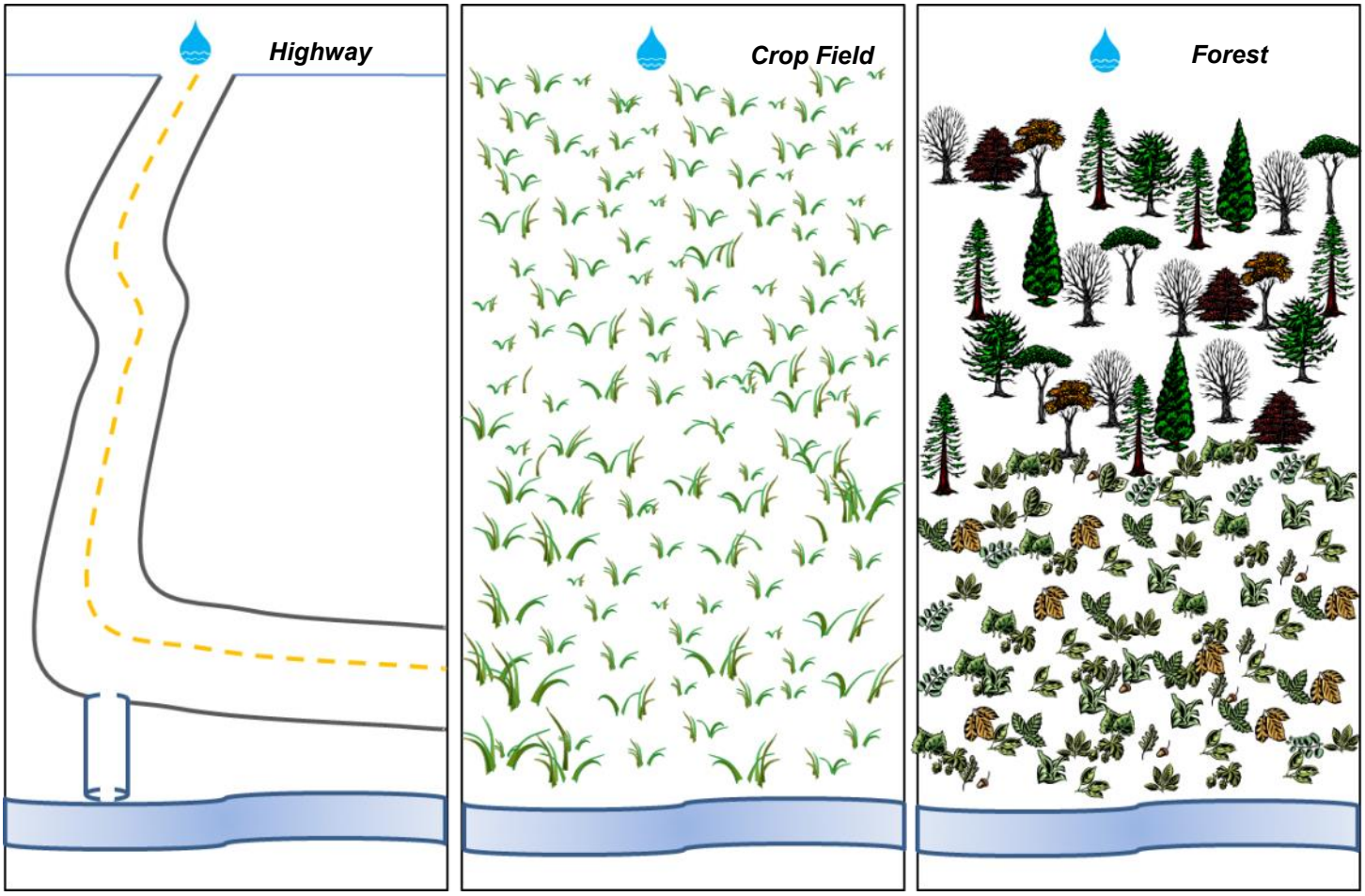
The water you drink may have flowed through a forest!

Many lakes where drinking water is taken from are surrounded by forests, and the streams that feed those lakes are in forests, too. More than 45% of North Carolina's surface drinking water gets it start in a forest!

QUIZ 1: What percent of North Carolina's total land area is covered in forestland?

How Water Flows

Let's a play a game! Each box has a drop of water at the top that needs to flow downhill to the stream, at the bottom. Draw a line for each water drop to follow, without touching your line to any objects in the box. Keep track of how much time it takes to draw each line.



Which path was the fastest and straightest? Which was the slowest and longest?

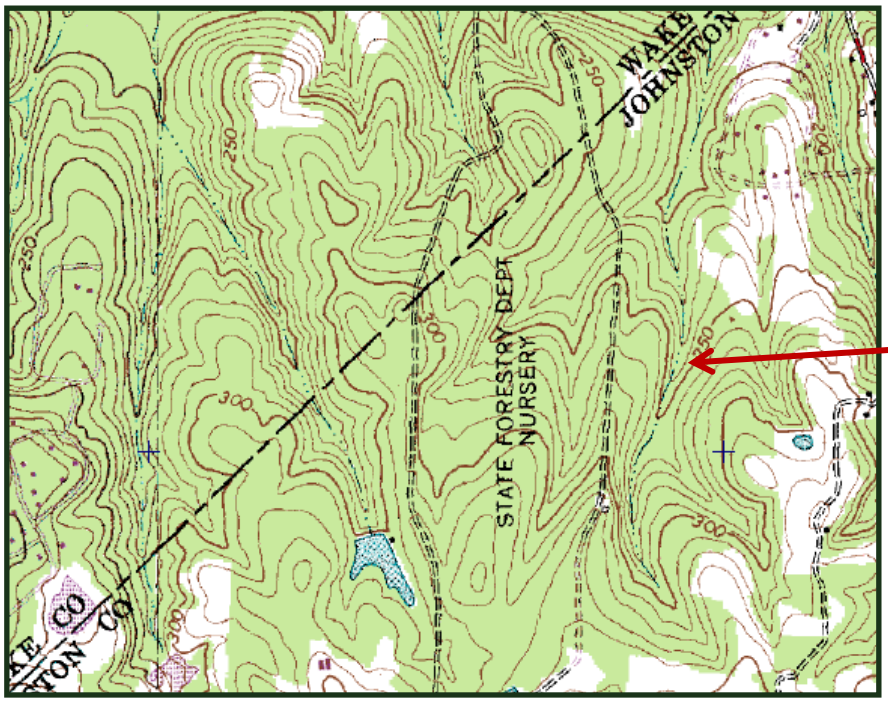
- Water that flows on pavement cannot slow down before entering a stream. It can wash oil, dirt, trash, and other pollution into the stream. *Never pour waste fluids into the street gutter*.
- Water that flows across a crop field, pasture, or grassy area goes a little slower. The soil and roots of plants absorb water like a sponge, and the leftover water either flows slowly across the ground or it gets filtered into the stream.
- **Water that flows through a forest takes a long time!** The seedlings, roots, leaves, and pine needles slow the water, letting dirt settle out, and giving time for the water to soak deep into the ground. This groundwater helps trees grow, maintains stream flow, and replenishes wells.

QUIZ 2: If you have a bare spot of land that is not being used, what could you do to slow down the water?

Reading the Landscape

There are many types of maps that can help you find streams and read the lay-of-the-land. But, not all streams are shown on these maps. To know for sure, you need to get out into the woods and examine. *(Make sure you get permission from the landowner before exploring!)*

The type of map shown here is called a topographic map. It shows the steepness of the land, using brown curving lines called “contour lines”. Streams are shown in blue color with solid lines, or dashed & dotted lines. Forest areas are shown as green shading, and farm fields or open areas are shown as white shading. Other things shown include roads, trails, and ponds.



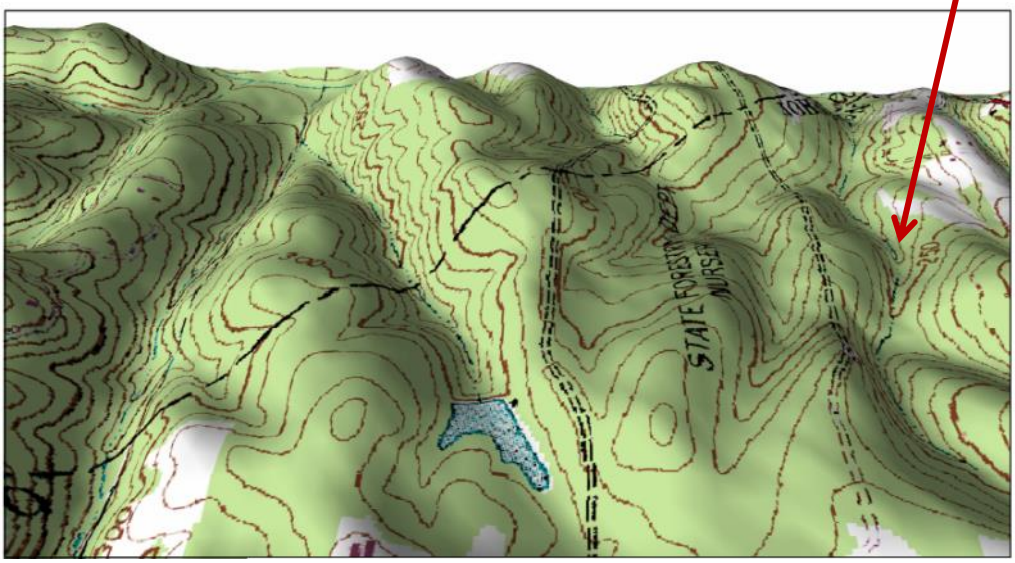
The map at the bottom is the same as the map on top, except it is tilted to show a 3-D view of the hills and valleys.

<u>Some things to notice:</u>

Streams are down in the bottom of the valleys.

Hilltops are shown by brown contour lines drawn as a circle or oval.

When the brown contour lines are drawn closer together, that means the land is steep.



Even when streams are not shown on the topographic map, foresters will explore places where many contour lines come together in a V-shape on the map. Those areas often have a stream or waterway on the ground. Gravity pulls the water down-hill from the top of the hill into the streams and valleys.

QUIZ 3: How many streams can you find on the uppermost (top) map?

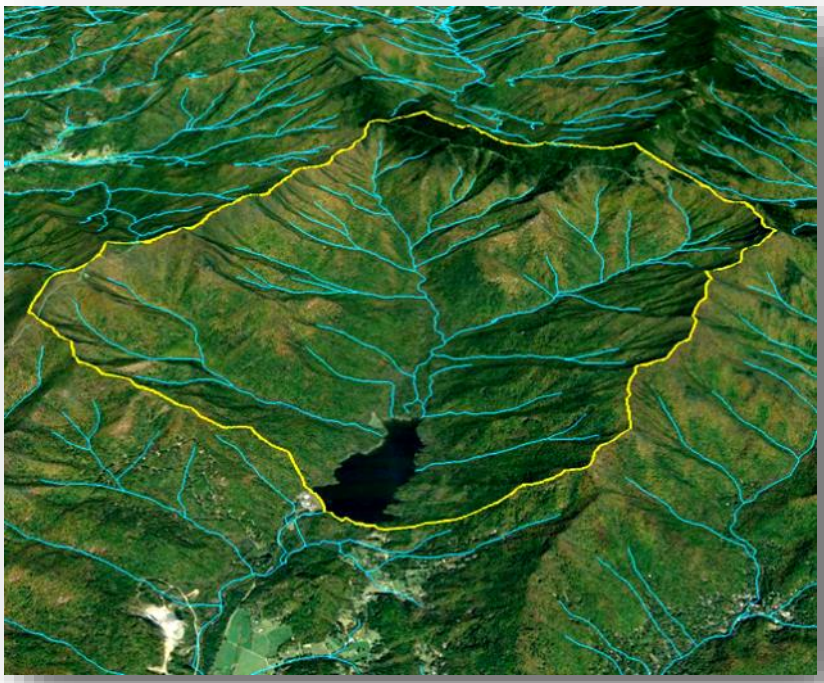
Watersheds

A watershed is an area of land where all of the water drains down into the same stream, river, pond, or lake. Some watersheds are small, perhaps like the campus of your school. And some are large, such as a river basin. North Carolina has 17 major river basins, and nearly all of them are at least half-covered by forests.

Because forests are the best way to keep water clean and to keep water flowing in streams all year round, many cities get their drinking water from watersheds that are mostly covered by forest.

This 3-D map (right) shows the 14,000 acre watershed area for Burnett Lake, which provides drinking water for Asheville, NC.

The watershed boundary is highlighted on the map by the yellow line, so you can see it here.



It is important to conserve and manage watershed forests to keep them healthy, vigorous, prevent wildfire, and avoid uncontrolled damage by insects, disease, or invasive/non-native species.

By using Forestry Best Management Practices (known as “BMPs”), foresters and loggers can harvest areas of trees once in a while, then establish new seedlings, manage the forest, and still keep the water clean.

Use BMPs to Keep the Water Clean!

QUIZ 4: Do you think it costs more or less money to clean the water to drink, when it comes from forests?

What Lives in the Stream?

The type of insects that live in a stream can give you a good idea of how healthy and clean that stream and its upstream watershed are. There are three categories of water insects:

Sensitive: *Cannot survive with pollution (needs clean water).*
Moderate: *Able to live with some pollution.*
Tolerant: *Able to survive in dirty, polluted waters.*

Sediment pollution is easy to see, and it is the most frequent type of pollution. Other things like bacteria, chemicals, too much nutrients, or too hot of water temperature can also cause problems and can be hard to see, but the insects know!

Studying aquatic insects is quicker and costs less money than taking water samples and analyzing them in a laboratory, and has shown to be a reliable method to get a snapshot of stream health.

The insects and animals shown on this chart are only a small sample of those most commonly found in streams.

Where to Look: Insects like to hide!

- Look under wet rocks, packs of leaves, twigs, or chunks of wood in the stream.
- Some insects build a hard tube sleeve and stay inside that tube. So, you have to search for their tube sleeve, which can look like a small hollow twig, about 1" long, or less.
- And they move fast, too, so watch for something moving around.

Sensitive	Moderate	Tolerant
Caddisfly	Clams	Aquatic Worm
Dobsonfly	Crane Fly	Blackfly (larvae)
Mayfly	Crayfish	Leech
Riffle Beetle	Damselfly	Midges (larvae)
Stonefly	Dragon Fly	Snails
Water Penny	Scud	
	Sowbug	

Above: A Caddisfly inside its tube, stuck onto a small twig.

Streams in the forests support insects, birds, amphibians, and other wildlife.

QUIZ 5: Most insects you find in streams are in a larval, nymph or pupa stage. What is that process called?

Guide to Macroinvertebrate Taxa Groups and Aquatic Pollution Tolerance

Group 1 : SENSITIVE ORGANISMS

POLLUTION-SENSITIVE OR INTOLERANT ORGANISMS, Their dominance indicates Good Water Quality

Mayfly (nymph)
Insecta : Ephemeroptera
plate-like or feathery gills on sides of lower body; three (sometimes 2) long, hair-like tails

Stonefly (nymph)
Insecta: Plecoptera
two hair-like tails; six jointed legs with two hooked tips each; big antennae; no gills on lower half of body

Caddisfly:
Insecta: Trichoptera
six jointed, hooked legs just behind head; 2 hooks at back end; may be in a case made of stones, leaves or sticks; non-netspinning caddisflies have no bushy gills along bottom

Freshwater Mussels (adult)
Molluska: Bivalvia
two hinged, calcareous shells

Water Penny (larva)
Insecta: Coleoptera
shaped like a tiny, grey, oblong frisbee; 6 tiny legs on bottom; slow crawler

Fishfly (larvae)
Insecta: Megaloptera
resemble Hellgrammites, but are smaller and have no gill tuffs

Dobsonfly larva (aka Hellgrammite)
Insecta: Megaloptera
dark body; six jointed legs; large, pinching jaws; many pointed feelers along edge of body; two small hooks at back end; feathery tufts of gills along side of body

Gilled Snail (adult)
Molluska: Gastropoda
shell opens on the right and is covered by a hard shield-like operculum

Riffle Beetle (adult)
Insecta: Coleoptera
oval body covered in tiny hairs, does not swim or surface

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Group 2 : MODERATELY-SENSITIVE ORGANISMS

MODERATELY POLLUTION TOLERANT ORGANISMS, found in wide range of water quality conditions

CraneFly (larvae)
Insecta: Diptera
4 finger-like lobes at back end; milky green to light brown; caterpillar-like segmented body

Damselfly (nymph)
Insecta: Odonata
body ending in 3 oblong fan-like plates (tracheal gills); 6 thin, hooked legs; smooth tapered sides of body

Dragonfly: Order *Odonata*
Insecta: Odonata
large eyes; wide oval to round abdomen; 6 hooked legs

Scud (adult)
Crustacea: Amphipoda
body higher than wide; shrimp-like apperance; white to gray in color; swims laying on its side; more than 6 legs

Crayfish (adult)
Crustacea: Decapoda
lobster-like; 8 walking legs and 2 pinching claws

Water Beetle larvae
Insecta: Coleoptera
light-colored; 6 legs on upper 1/2 of body; strong jaws; short antennae; body smooth or with hair-like projections or knobs

Sowbug (adult)
Crustacea: Isopoda
oblong body, wider than high; gray in color; more than 6 legs; long antennae

Fingernail Clam (adult)
Molluska: Bivalvia
2 hinged, $CaCO_3$ shells that are thin & fragile; adults 2.5 cm or smaller; hinge near middle

Whirligig Beetle (adult)
Insecta: Coleoptera
short, fan-shaped middle and hind lergs; frong legs long & slender; floats on surface

Water Strider (adult)
Insecta: Hemiptera
slender, long-legged bug; surface film dweller

Water Scorpion (adult)
Insecta: Hemiptera
slender, long-legged bug; 2 long groved filaments for breathing underwater

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Group 3 : TOLERANT ORGANISMS

HIGHLY POLLUTION TOLERANT ORGANISMS, can be found in any quality of water, their dominance usually indicated poor water quality

Midge fly (larva)
Insecta: Diptera
dark head; warm-like segmented body; 2 tiny legs on each side

Black fly (larva)
Insecta: Diptera
one end of body wider; black head; suction pad on end

Horse fly (larva)
Insecta: Diptera
robust and worm-like; 1" in length or longer; tapered at both ends

Drone fly (larva) (aka rat-tailed maggot)
Insecta: Diptera
distinctive tube at end through which it breaths; tube up to 1" long

Pouch Snail (adult)
Molluska: Gastropoda
no operculum; breaths air; shell typically opens to left, but some species open to right

Leech (adult)
Annelida: Hirudinea
brown, grey or patterned body; body ends with suction pad; flattened, segmented worm; carnivores or parasites; moves like inch worm by contracting/extending body

Oligochaete worms
Annelida: Oligochaeta
segmented body with thin bristles (setae); round cross-section, like thin earth worms; red-pink to dark color; moves by contracting/extending or by wriggling; burrowing scavengers; tubifex common genus; head in mud, tail waving

Roundworms
Nematoda: Nematodes
slender, pale color; pointed at both ends, moves by wriggling (doesn not contract); no segments or bristles; scavengers or parasites; most less than 1 cm

Flatworms
Platyhelminthes: Turbellaria
flat body, blunt head; no segments or bristles; gray-brown to pale color; glides smoothly (does not wriggle); carnivores or scavengers

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Qualities of Water, Part 1

TEMPERATURE

Fish, insects, frogs, and other animals that live in streams need the water temperature to stay comfortable and not get too hot. Many animals can handle cold temperatures, by burrowing into the ground, hibernating, or basking in sunlight. But when the water temperature gets too hot, it causes problems. On a hot sunny summer day, you enjoy being in the tree shade, right? Well, so do the fish!

North Carolina has rules against raising the maximum temperature in streams:

- For trout streams, maximum allowable temperature is 68°F
- For other streams in the mountains or upper piedmont, the maximum allowable temperature is 84.2°F
- For streams in the lower piedmont or coastal plain, the maximum allowable temperature is 89.6°F

Exercise: Using a thermometer, take temperature readings in the stream. If possible take multiple readings then average them. Hold the thermometer in the stream for 2 minutes. Wait 10 minutes between taking the next reading. Take different readings in sunny spots, and then again in shady spots.

Sun Spot 1: _____ Sun Spot 2: _____ Sun Spot 3: _____ Average:_____

Shade Spot 1: _____ Shade Spot 2: _____ Shade Spot 3: _____ Average: _____

Now, average your two final answers, to get the overall stream temperature: _____

Does the temperature of your stream fall under the maximum allowed degrees?

Keeping forests along streams will keep shade over the water, and help control water temperatures.

DISSOLVED OXYGEN (D.O.)

Fish and other animals that live in streams need oxygen, just like you.
But unlike people, those animals extract dissolved oxygen from the water.

High D.O. is found in: cool temperature waters, rapids or riffles (where water churns or bubbles).
Low D.O. can occur because of: warmer water temperatures that come from warmer air, shallow water, too much plant life or bacteria in the water, and stagnant water.

So, if forests provide shade to streams,
...and shaded streams are usually cooler,
...and cooler streams contain more D.O.,
then that's why streams in the forest often have more aquatic life, because all the right qualities come together. **This is an example of a beneficial ecosystem service produced by forests.**

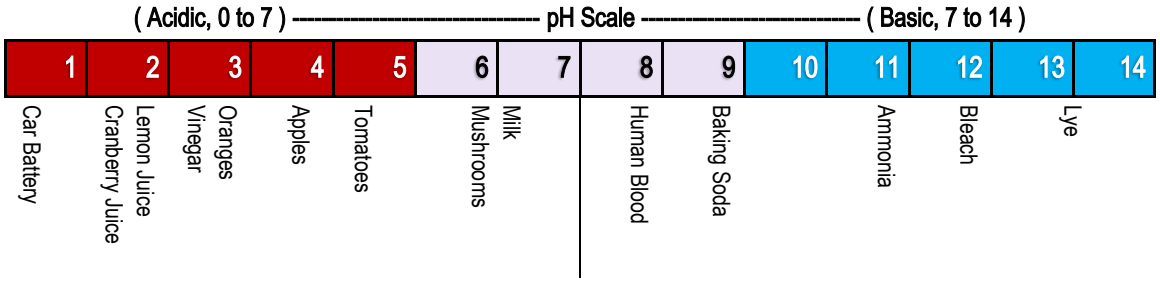
In the photo, the N.C. Forest Service's hydrologist measures the D.O. and temperature of a stream that was restored at DuPont State Recreational Forest, to see how well the work improved trout fish habitat.

QUIZ 6: What kinds of actions might worsen temperature or dissolved oxygen levels in a stream?

Qualities of Water, Part 2

ACIDITY (pH)

Acidity is natural in water, soil and air. But too much, or too little, can cause bad chemical reactions, burns, and permanent injury. The unit of measurement to determine acidity is the pH scale. The pH scale goes from 0 to 14. The pH levels for some common items are shown in the chart below for comparison.



North Carolina has rules for the pH level of water and streams:

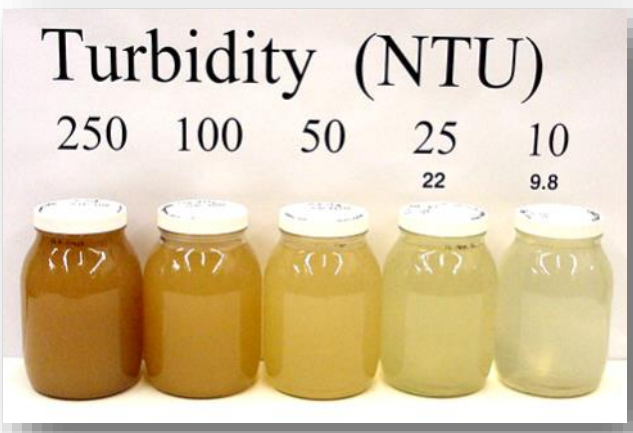
- pH should be between 6.0 and 9.0; this is the optimum level for fish, wildlife, and insects.
- pH in swamps may be lower, with the minimum allowed to be between 4.0 and 5.0.

The pH of water is strongly effected by the type of geology (bedrock and soil) and the amount of certain airborne substances deposited through rainfall (such as nitrogen, sulfur or phosphorus).

Forests can help to stabilize the pH levels in streams that flow through them, due to the chemical reactions within trees that occur as they absorb & release many different elements.

TURBIDITY

Photograph courtesy of N.C. Division of Water Resources



Turbidity occurs when microscopic sediment particles are suspended in water, causing the water to look cloudy, muddy, or murky. It may take hours or days for these particles to settle out. Have you noticed after a heavy rain, the water in many streams turns brownish or reddish color? That is turbidity! It is measured in units of NTU's. North Carolina has rules that set limits on Turbidity:

- No more than 50 NTUs for streams.
- No more than 25 NTUs for lakes and reservoirs.
- No more than 10 NTUs for Trout waters.

Too much turbidity can cause problems, by:

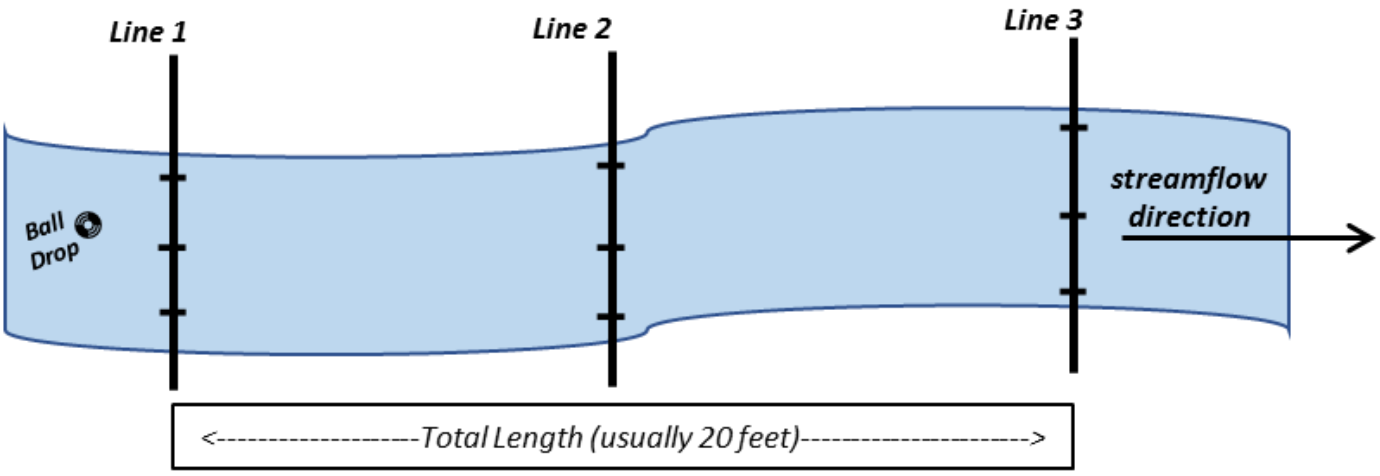
...blocking sunlight from reaching down into the water, which can limit aquatic life productivity.
...smothering clams, snails, and other aquatic life that live on stream bottoms and cannot escape.
...clogging filters for drinking water, making it more expensive and difficult to treat before use.

Forests naturally filter-out sediment, which also helps to reduce turbidity. But when timber is harvested or other work is done in the forest, care must be taken to limit soil disturbance by using Forestry Best Management Practices ("BMPs").

QUIZ 7: In a healthy forest ecosystem, plants & animals rely upon each other by an _____ relationship.

How Much Water Is That?

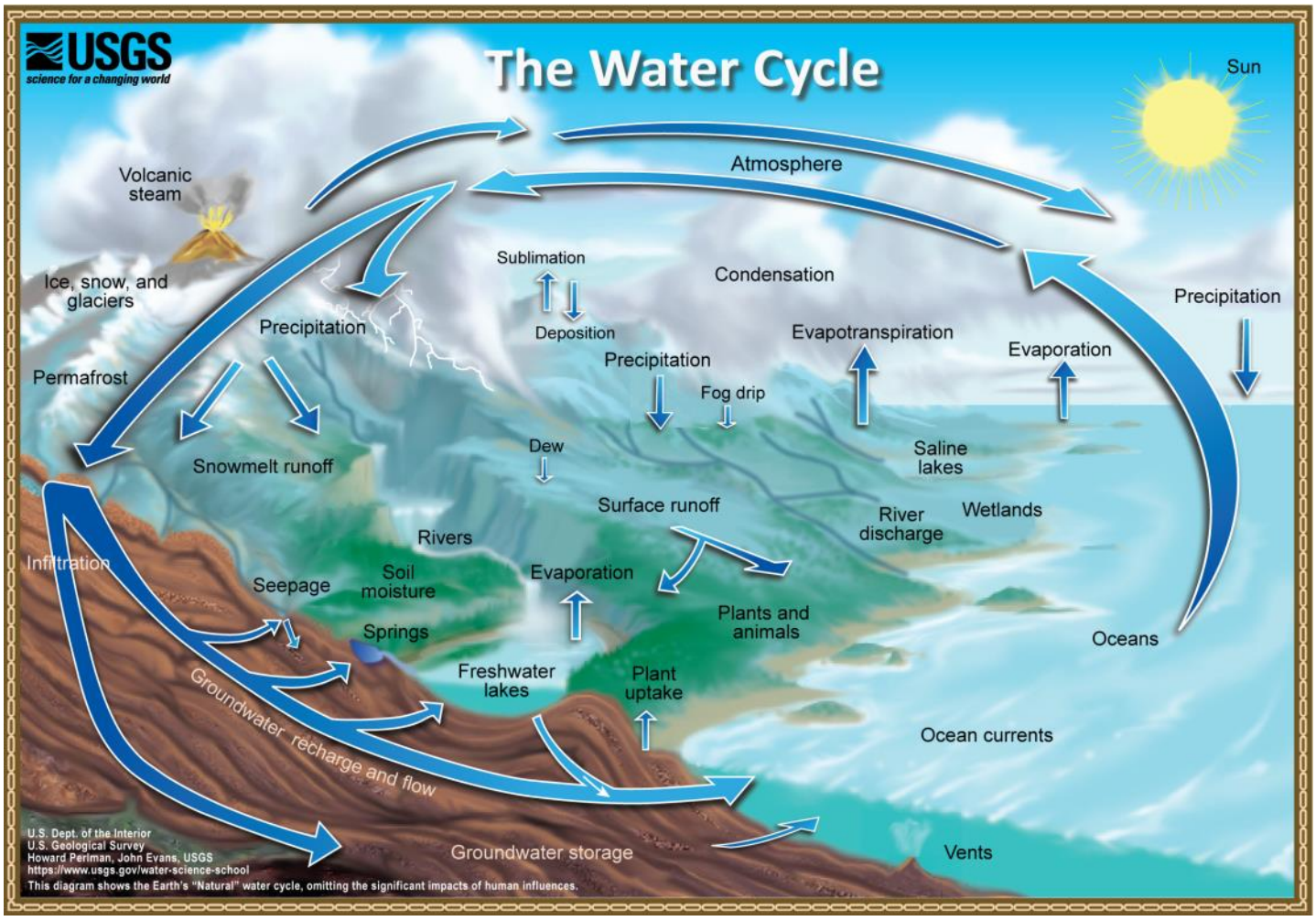
Use the worksheet below to estimate how much water is flowing in your stream. You will need: ping pong ball, 3 pieces of string or rope, measuring tapes, stopwatch timer, and calculator.



For comparison, Niagara Falls flows on average annually at nearly 85,000CFS! When there are lots of forests in a watershed, streamflows are usually more consistent and reliable, even during a drought. Forests can help to reduce flooding by slowing runoff before it reaches the stream.

QUIZ 8: When a stream has steady water flow all year, would you expect to see more or less aquatic life?

Forests and the Water Cycle



Sometimes you will hear people call trees 'nature's drinking straws'. That's because the trees will draw water up & out from the soil, use some, and then release the leftover water into the atmosphere. The processes listed below are how trees are involved in the Water Cycle:

Interception: Trees catch some rain, softening its impact onto the soil and reducing soil erosion.

Throughfall: Some rain trickles down the tree trunk and drips off the leaves. Some of this water runs off, and some soaks into the soil becoming Groundwater.

Absorption: Tree roots take-in water from the soil, for carrying nutrients up & down the tree.

Recharge: Un-used Groundwater that drains into a stream, lake, swamp or ditch.

Evapotranspiration: A word that foresters use, combining the following two processes:

> Evaporation: Water on leaves or needles that turns into a vapor by the sun's energy.
>
> Transpiration: Water vapor released into the air through small pores in a leaf or needle (called Stomata). This water vapor is leftover after the tree uses it for photosynthesis and respiration.

Some tree species use water more rapidly than others:

Tree species that cycle more water include pine, maple, yellow-poplar, willow and gum.
Tree species that cycle less water include oak and hickory.

QUIZ 9: After a forest area is harvested, will the streamflow in that area often increase or decrease?

Soil & Water

When you think about streams and water, you also need to think about the soil.

Soil contains lots of microscopic pores that hold water droplets for tree roots -- that's good!

But, if soil is compressed tightly (see picture at right, this is called compaction), there is no room to hold water and tree roots will dry out -- that's bad! Also, when soil is compacted, rain will quickly runoff and not soak into the ground. Fast runoff causes un-natural erosion. Forests help to control erosion by soaking in rainfall and slowing runoff.

Over a long time, water causes soil to change its color:

When there is persistent water on the surface or contained in the soil, the soil's color is gray, blue-ish, or black. This is because of the reducing chemical reaction that occurs due to a lack of oxygen in the soil, (known as anaerobic conditions).

When soil remains dry for most of the year, the soil's color is brown, red, orange, or yellow-ish. This is because of the oxidizing chemical reaction that occurs when there is lots of oxygen in the soil (known as aerobic conditions), similar to how metal rusts when it gets wet, and then is exposed to the air.

Time to Get Your Hands Dirty!

Step 1: Dig a shallow hole (8 to 12 inches deep) using a soil auger or narrow shovel.
Step 2: As you remove the soil, neatly lay it out from top-to-bottom, to examine it.
Step 3: Take a small handful, and rub it between your fingers.

- Does it feel gritty (sand), or squishy/sticky (clay), or slick/greasy (silt-loam or organic-muck)....or a mixture of these?
- What color is the soil? (sand is usually white or yellow, clay is red or orange, and silt-loam is brown, black or gray).
- Does the soil feel moist or dry? (sand is usually dry or damp, clay is moist or wet, and silt-loam is wet).
- Does the feel, the color, or the wetness of the soil change as the soil gets deeper? Why is that?
- How far down do you see fine roots? (most small roots are in the top 12 to 24 inches of soil). If soil is compacted do you think there would more roots, or less roots?

Soil forms in layers, like a sandwich. These layers are called horizons. Usually the topsoil horizon is darker because it has decomposed leaves, pine needles, and wood. North Carolina has many types of soils. Forest soils hold water, retain carbon, and provide habitat for beneficial worms, insects, and other micro-organisms that are important for growing healthy trees. Protecting the soil is important to sustain good forests.

A + B: Two different sandy loams. See how the color changes, as you go from top to bottom. Soil "B" has more clay in the bottom (the small orange-colored clumps).

C: This is red clay, with shades of yellow and orange.

D: This soil is from a stream channel, next to the water's edge. See the different soil color, when compared with the others?

QUIZ 10: Which type of soil will water drain through fastest? Why?

Stream Buffers

Stream buffers are the last line of defense to keep out pollution.

Trees, shrubs, and other plants along both sides of the stream can act like a coffee filter, and catch soil. Sedimentation is the #1 pollution problem for streams and lakes.

Trees also cast shade over the stream that keeps the water cool for fish and wildlife. Cooler water usually has more dissolved oxygen, which supports better conditions for aquatic life.

Deep roots of trees, shrubs, and native grass help to prevent soil erosion and also anchor the streambank to keep it from washing away when the water runs high after a rain storm.

What can you do to help a stream buffer?

Leave a stream buffer strip at least 20 feet wide, on each side.

Allow native trees, shrubs, vines, and plants to grow alongside the stream.

Do not mow the grass all-of-the-way down to the stream's edge.

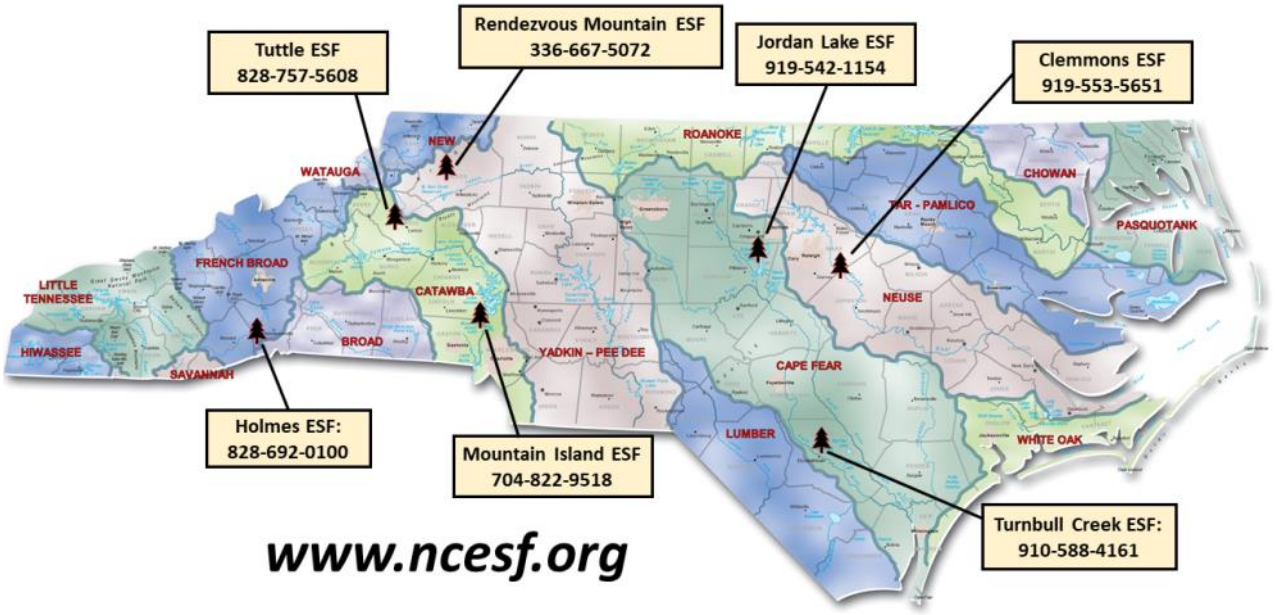
Plant native trees, shrubs or wildflowers in bare spots along the stream.

Do not pour any waste fluids or dump any trash into the stream buffer, or the stream.

Keep bicycles, ATVs, motorbikes and other vehicles out of the stream and its buffer.

QUIZ 11: Why is it important to keep ATVs, mowers, tractors and other vehicles out of the stream buffer?

North Carolina's Educational State Forests



Map adapted from original developed by NCDEQ Office of Environmental Education & Public Affairs, and the N.C. Wildlife Resources Commission.

QUIZ ANSWERS

Quiz 1: Approximately 52% (18 / 34.4)
Quiz 2: Plant trees! Or, allow new seedlings and shrubs to sprout up.
Quiz 3: At least 6 (or 7 counting the spur in the top-left corner).
Quiz 4: Less money, because the water is already pretty clean, so it does not need as much filtering to drink it.
Quiz 5: The process of changes in life stages is called "metamorphosis".
Quiz 6: Removing trees from along streams; Dumping lots of tree limbs, leaves, and pine needles into the water.
Quiz 7: "Interconnected" relationship. Plants and animals support each other in many phases of their life cycles.
Quiz 8: More life, because the constant flow provides a reliable source of dissolved oxygen. This type of stream is called Perennial.
Quiz 9: Usually streamflow increases, because the harvest temporarily interrupts a step in the water cycle. But as new trees re-grow, they will once again intercept rainfall, process water through evapotranspiration, and use groundwater. Research has shown that this effect only lasts 5-10 years after harvest.
Quiz 10: Sand, because it has larger gaps between soil particles.
Quiz 11: Prevent rutting, scraping, and compaction of the soil next to the stream. This reduces the risk of soil erosion.

POTENTIAL OPPORTUNITIES FOR CURRICULUM CORRELATION (North Carolina Standard Course of Study, ver.2021)
Healthy Forests = Clean Water: 1.G.2.2, 8.E.1.4.
How Water Flows: K.G.1.2.
Reading the Landscape: 1.G.1.1, 5.L.2.1.
Watersheds: K.G.1.1, 1.G.1.1, 1.G.2.2, 3.E.2.2, 4.L.1.3, 8.E.1.1.
What Lives in the Stream?: 2.L.1.2, 4.L.1.2, 4.L.1.4, 5.L.2.3, 6.L.2.3.
The Qualities of Water: 4.L.1.1, 5.L.2.3, 5.P.3.2, 5-RED.CR.2.1, 8.E.1.3, 8.E.1.4.
How Much Water is That?: 3.P.1.1, 5.P.1.1, 5.P.1.2, 5.P.1.3, 5-RED.CR.2.1, 7.P.1.1, 7.P.1.4.
Forests and the Water Cycle: 2.P.2.1, 3.E.2.1, 3.E.2.2, 3.P.2.3, 5.P.2.1, 6.L.1.2, 7.E.1.2.
Soil & Water: K.P.2.1, 1.E.2.1, 1.E.2.2, 3.L.2.2, 3.L.2.4, 4.E.2.3, 4.P.2.2, 6.E.2.3, 6.E.2.4, 8.P.1.3.
Stream Buffers : 1.L.1.3, 3.L.2.2, 4.L.1.1, 4.L.1.3, 5.L.2.1, 5.L.2.3, 6.E.2.4.

NORTH CAROLINA FOREST SERVICE NC

HEALTHY FORESTS = CLEAN WATER
Use Best Management Practices

Workbook compiled by Tom Gerow, Jr., with curriculum correlation by Amy Kinsella and Tom Gerow, Jr.

Commissioner of Agriculture, Steve Troxler