Virginia 4-H Marine/Aquatic Education Program

What Do You Know About Water Quality?

Issued in furtherance of Cooperative Extension work, Virginia Polytechnic Institute and State University, Virginia State University, and the U.S. Department of Agriculture cooperating. Mark McCann, Director, Virginia Cooperative Extension, Virginia Tech, Blacksburg; Alma Hobbs, Administrator, 1890 Extension Program, Virginia State, Petersburg.

Welcome to ***What Do You Know About Water Quality?*** **This is an interactive program that will help you learn about Virginia's water resources, how water quality is measured and what the indicators mean.**

First, review the Program Guide and Game Instructions. Then explore the Water Quality Indicator and Virginia's Watershed sections.

A **Glossary** is provided for vocabulary review. **Topics** of interest are also presented separately. The **Games** are presented in a "Jeopardy" format. In addition, the **Personal Action** section will help you learn how to be a better steward for our water resources.

We hope you enjoy this program. Any comments and suggestions may be sent to:
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(804-524-5848, bfox@vsu.edu).

Navigation Page

Program Guide

Game Instructions

Introduction

Glossary

Water Quality Indicators

Watershed Tour

Virginia's Watersheds

Game Preparation

Topic Information

Play Game

Personal Action

Credits

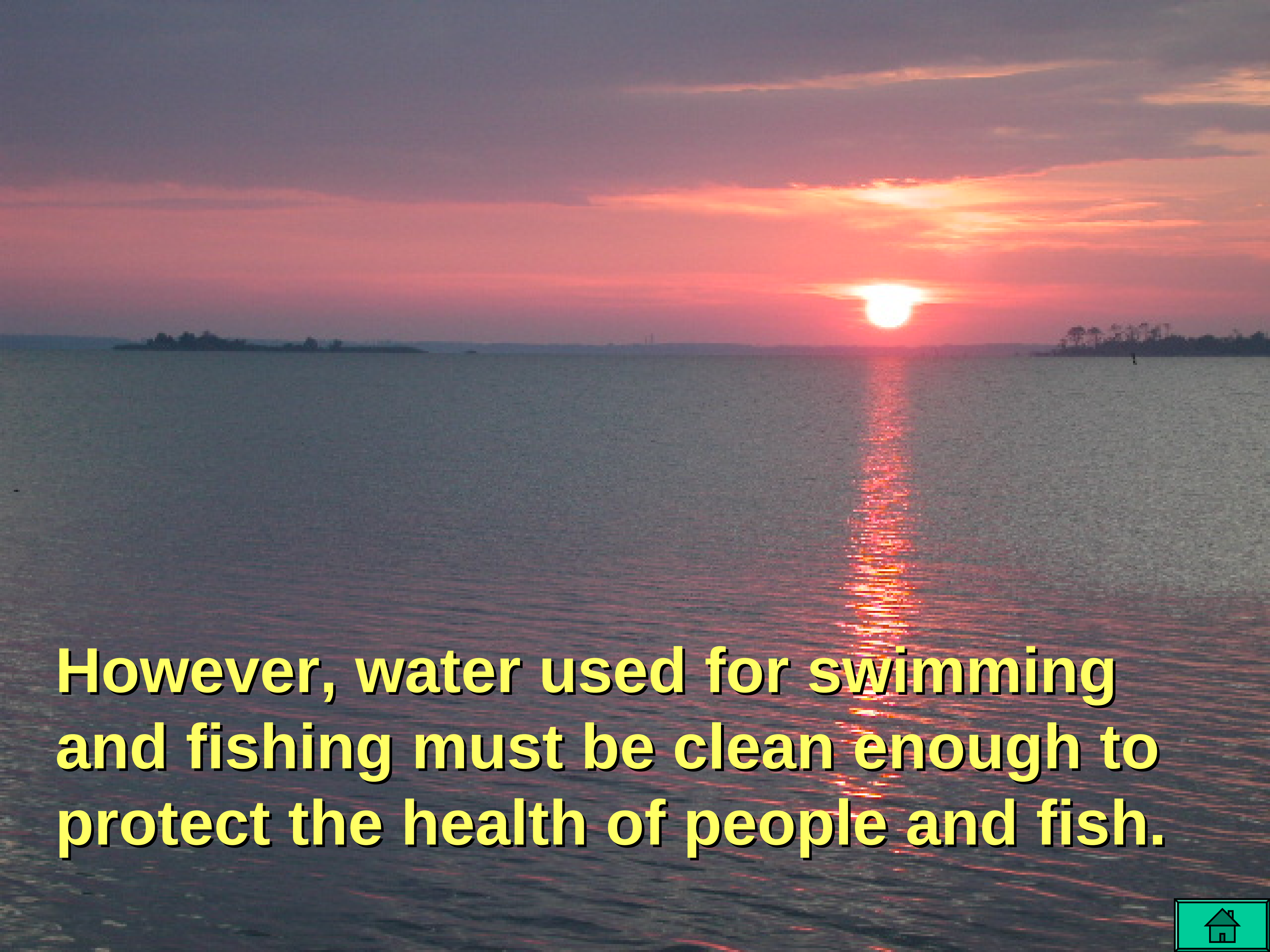
INTRODUCTION

We all need clean water. We need it not only for personal use, but also for:

and many other uses.


Water quality refers to the condition of the water. How water is used determines what the condition needs to be.

Drinking water must be in better condition (cleaner) than water used for swimming and fishing.

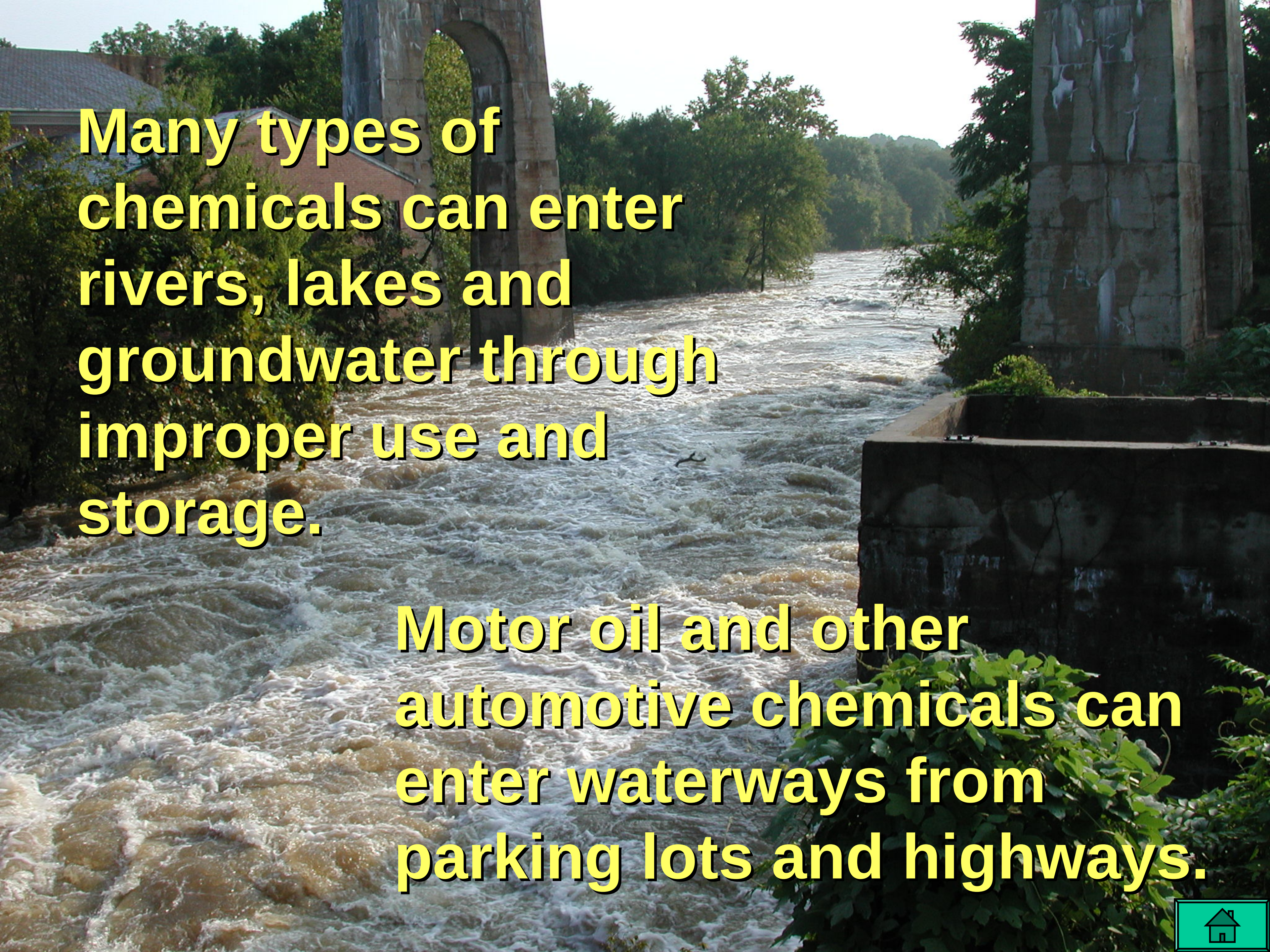

However, water used for swimming and fishing must be clean enough to protect the health of people and fish.

Regardless of how water is used, good water quality is a must. However, nearly everything we do affects the quality of water.

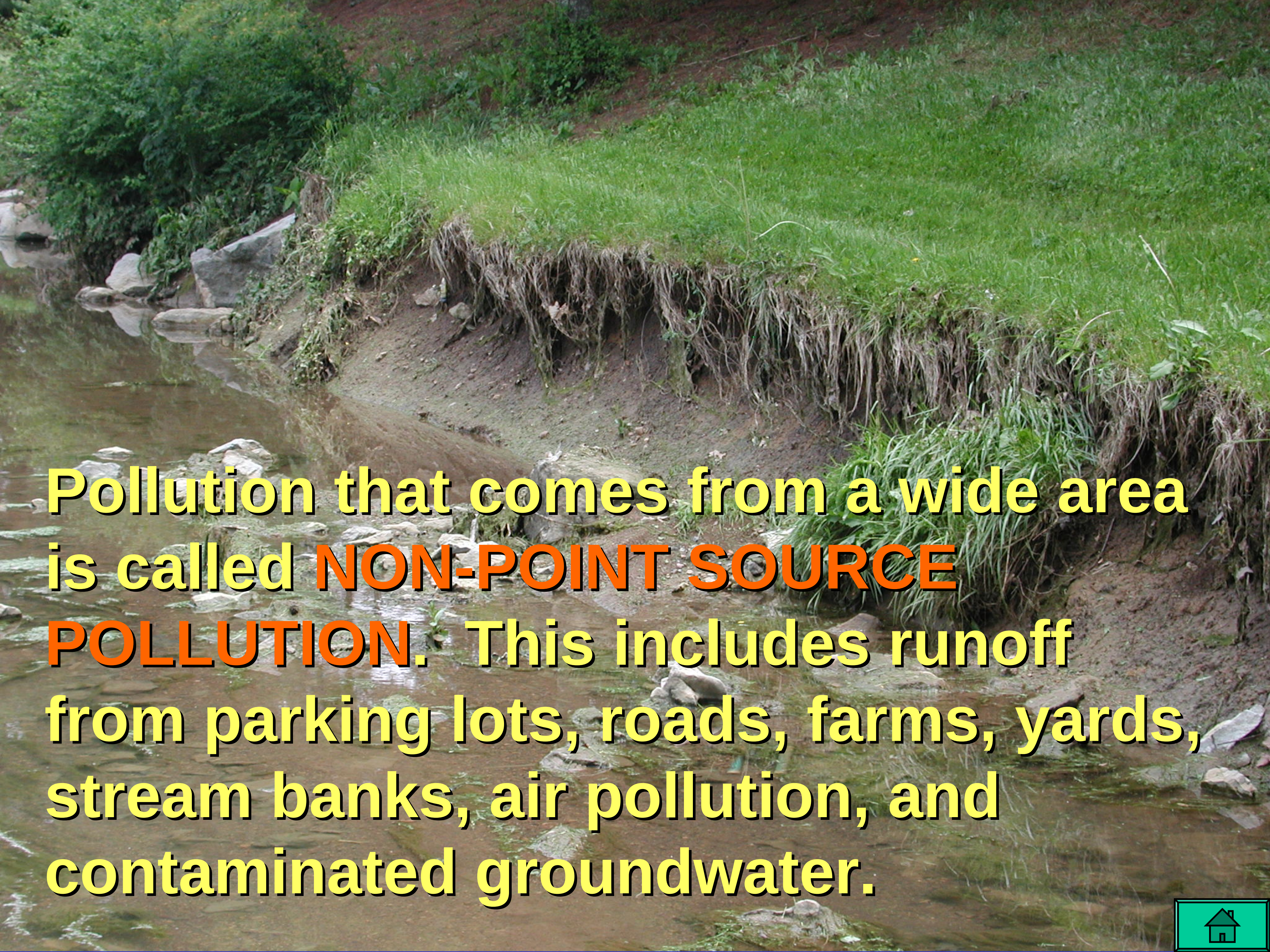
Vehicles, industry and natural events create air-borne particles and gases that enter waterways with dust, rain and snow.

Sewage treatment adds nutrients and other pollutants to waterways.

Agriculture and yard care produces sediment, nutrient and pesticide pollution.


Many types of chemicals can enter rivers, lakes and groundwater through improper use and storage.
Motor oil and other automotive chemicals can enter waterways from parking lots and highways.

There are many sources of water pollution. Pollution that originates from a specific place is called **POINT SOURCE POLLUTION**. This includes outflows from sewage plants, factories, landfills, feed lots and underground storage tanks.


Pollution that comes from a wide area is called NON-POINT SOURCE POLLUTION. This includes runoff from parking lots, roads, farms, yards, stream banks, air pollution, and contaminated groundwater.

Water pollution can also originate from natural sources. Mineral-rich soils, natural oil seepage, coastal saltwater, wildlife and natural disasters can all affect water quality.

There are many types of water pollution. Some of these include:

- Petroleum Products
- Nutrients
- Sewage
- Solid Wastes
- Pesticides
- Toxic Wastes
- Bacteria
- Sediments
- Heated Water

and others.

The most widespread types of pollution are **sediment, nutrients** and **bacteria**.

Erosion moves soil into waterways. The soil creates suspended **sediment** that blocks sunlight, smothers aquatic life and adds contaminants.

Primary plant nutrients include nitrogen, phosphorus and other elements. Excess nutrients increase algal growth. The algae die and the resulting decay consumes oxygen.


In addition, partially treated sewage, farm runoff and animal wastes are major sources of nutrients and bacteria.

Bacterial contamination is becoming a chronic problem in many waterways. The most prevalent sources are poorly treated sewage, and wildlife, pet or livestock waste.

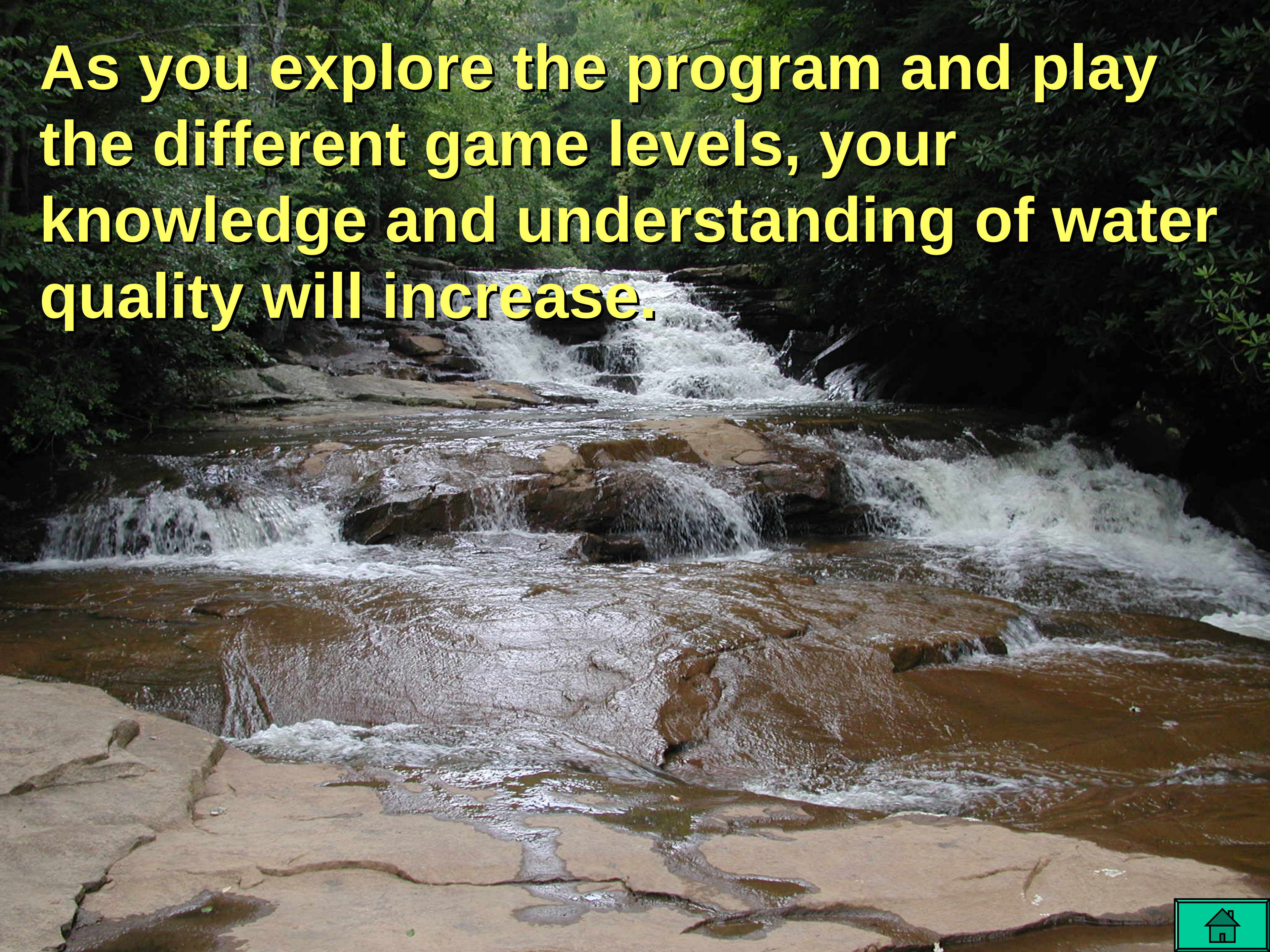
Virginia Beach water quality monitoring sites.

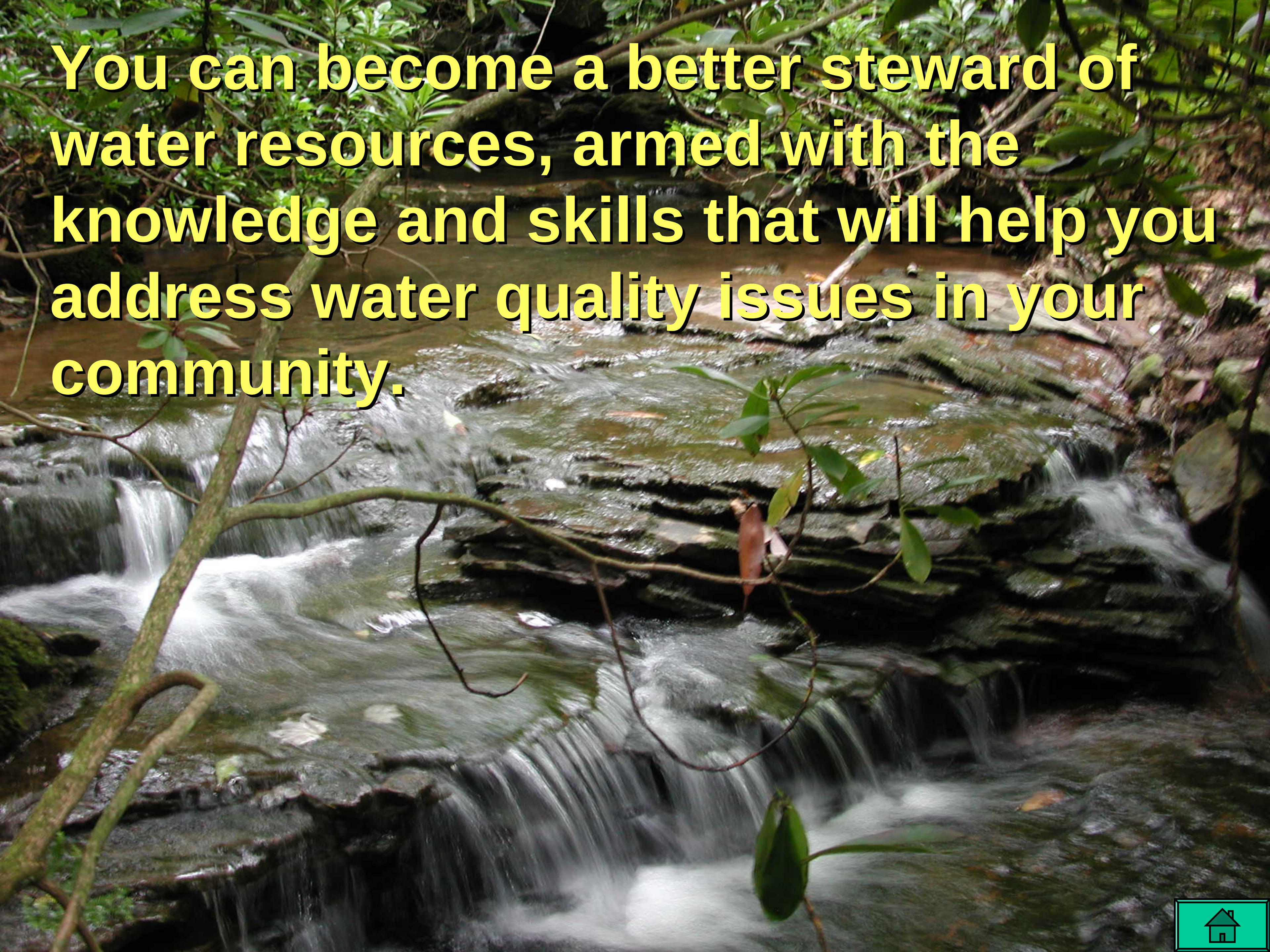

Petroleum products, farm and garden chemicals, heavy metals and other toxic substances can severely affect water quality.

An important concern is the long-term exposure to low levels of these pollutants. Cancer is a possible risk. However, these substances may also affect hormone and immune systems.

There are many chemical measures used to determine water quality. This program will help you learn about important water quality indicators.

As you explore the program and play the different game levels, your knowledge and understanding of water quality will increase.




You can become a better steward of water resources, armed with the knowledge and skills that will help you address water quality issues in your community.

WATER QUALITY INDICATORS

Select a water quality indicator to learn more about it.

Alkalinity

Ammonia

Bacteria

Conductivity

Dissolved Oxygen

Hardness

Nitrate

Pesticides

Parts Per Million

More Indicators

WATER QUALITY INDICATORS

pH

Phosphate

Salinity

Sediment

Temperature

Toxic Chemicals

Total Dissolved and Suspended Solids

Turbidity

Puzzle Games

Valuable Water Quality Web Sites

USDA Water Quality Information Center

U.S. Environmental Protection Agency

U.S. Geological Service

Chesapeake Bay Program

Return to Preparation

ALKALINITY

Alkalinity refers to the water's ability to neutralize acids.

Alkalinity is produced by minerals such as limestone.

Limestone is a type of ocean sediment composed of calcium carbonate.

Limestone bedrock areas often have caves and sinkholes, known as Karst.

Powell River Limestone Spring

Water with high alkalinity is basic while low alkalinity is usually acidic.

AMMONIA

Ammonia is produced by the decay of protein matter and animal waste.

Ammonia is toxic to most aquatic life, especially at high pH.

Bacteria readily convert ammonia to nitrate (a plant nutrient).

Ammonia is a form of nitrogen and part of the Nitrogen Cycle .

BACTERIA

Most bacteria are important in nutrient and other biological cycles.

Excess nutrients cause algal blooms. As algae die and decay, the high bacterial load rapidly consumes dissolved oxygen.

Fish kill due to low dissolved oxygen.

Certain types of bacteria indicate animal and human waste pollution.

Escherichia coli are **coliform bacteria** found in the intestines of warm-blooded organisms. Most strains are harmless but one *E. coli* strain can cause severe diarrhea and kidney damage.

Testing water for bacteria.

CONDUCTIVITY

Conductivity measures the water's ability to conduct an electrical current.

Pure water is a poor conductor.

The addition of dissolved solids, especially salts, increases the conductivity of water.

Salts and other compounds form ions (charged particles) in water.

The electrical current is measured using a conductivity meter.

Conductivity is measured in **micromhos** (µmhos/cm) or **microsiemens** (µs/cm) per centimeter.

Healthy freshwater lakes and streams have a conductivity of 150 – 500 µs/cm.

DISSOLVED OXYGEN

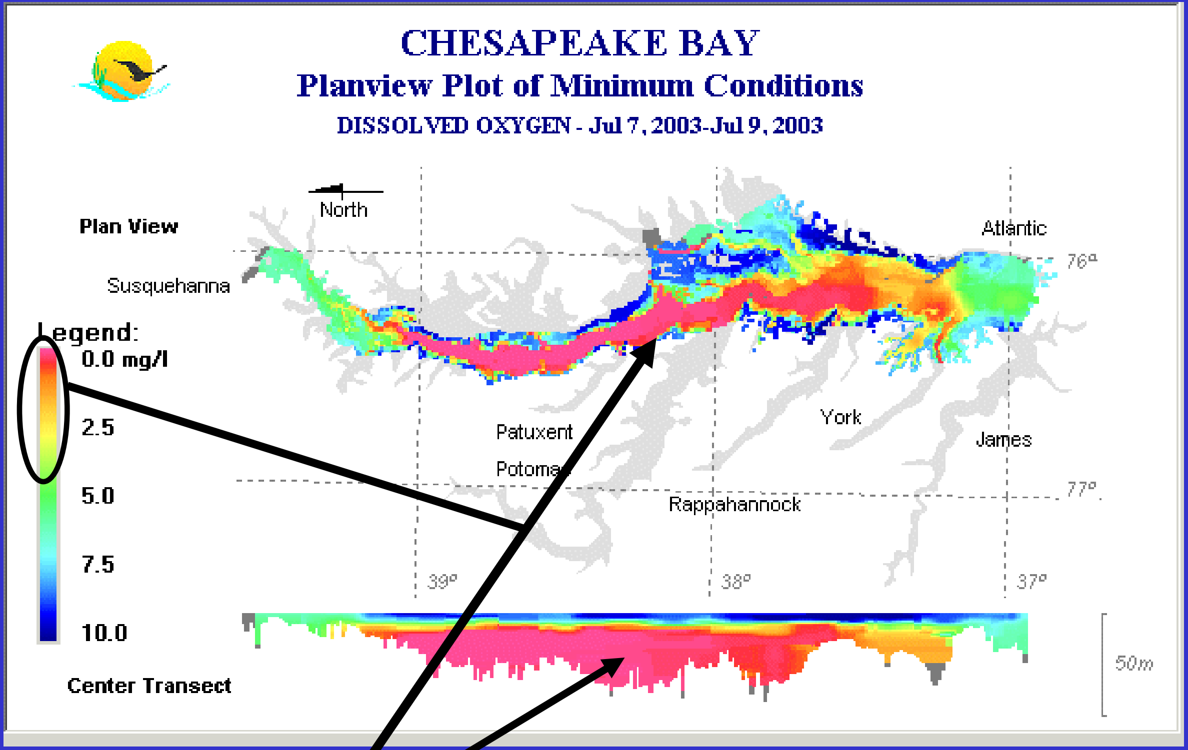
Dissolved oxygen is a product of photosynthesis and diffusion.

The warmer the water, the less oxygen it can hold.

Water does not hold much oxygen, up to about 15 ppm.

Suspended sediment and dissolved substances reduce the amount of oxygen water can carry.

Oxygen is needed for biological and chemical processes in water.



A large part of the Chesapeake Bay has low dissolved oxygen.

HARDNESS

Hardness refers to the concentration of calcium and magnesium in water.

Hard water has high concentrations of these elements. Soft water has low concentrations.

Water hardness often originates from limestone and other soluble minerals.

River and lake basins with quartz or granite rocks usually have soft water.

Areas of the U.S. with limestone bedrock have hard water.

Hard Water

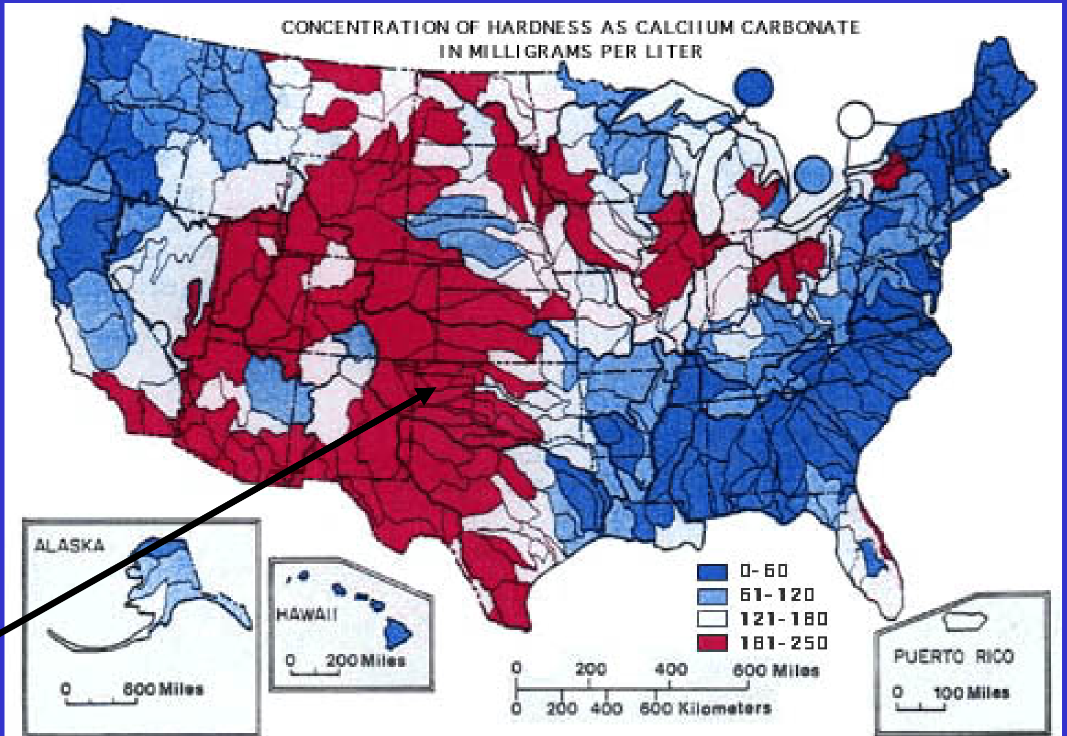


Figure 5.--Mean hardness as calcium carbonate at NASQAN stations during 1975 water year. Map at bottom is colored to show station data representing flow from the accounting unit.

Excessive hardness causes several water quality problems.

NITRATE

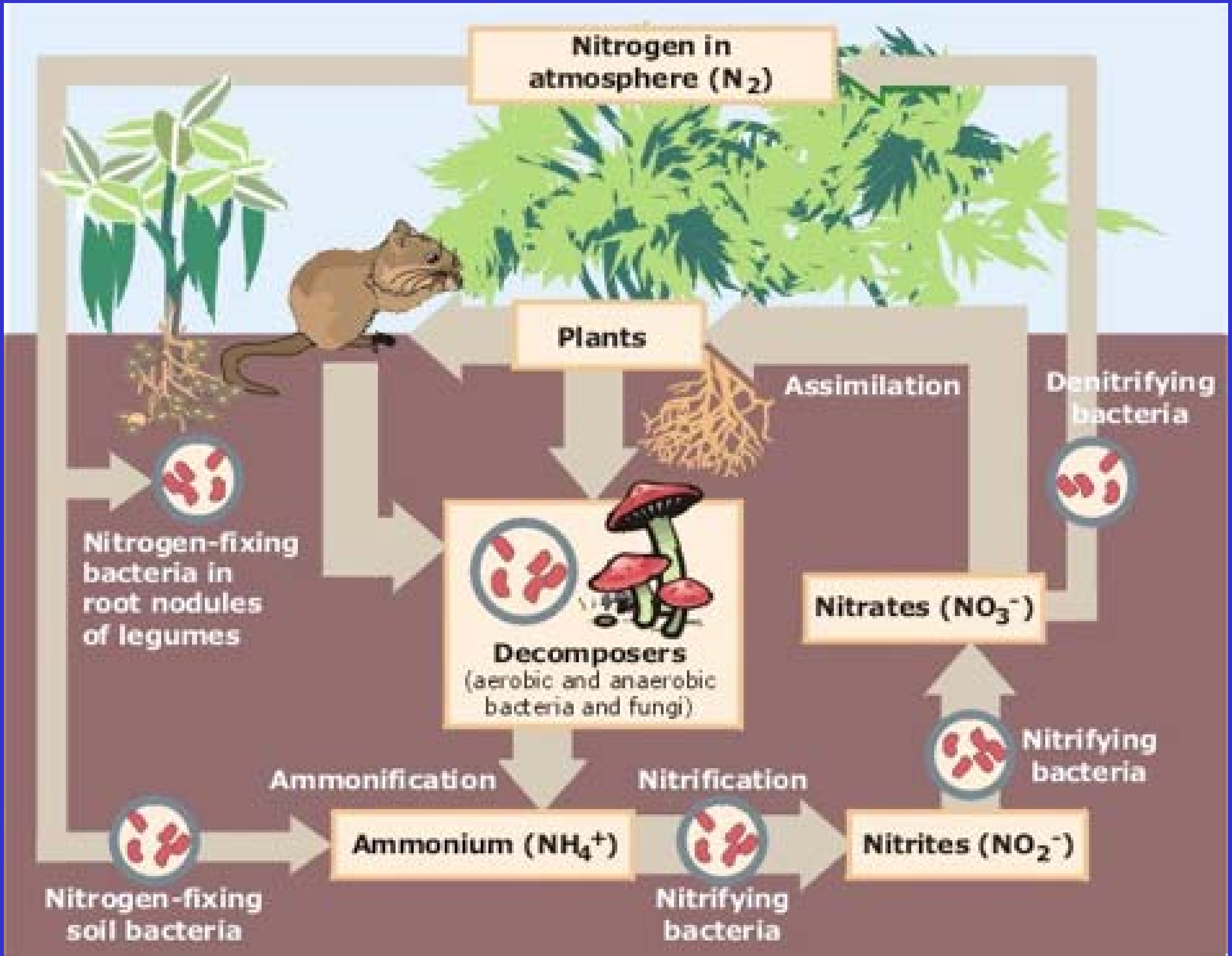
Nitrogen makes up 80% of the atmosphere.

Nitrate is a primary plant nutrient.

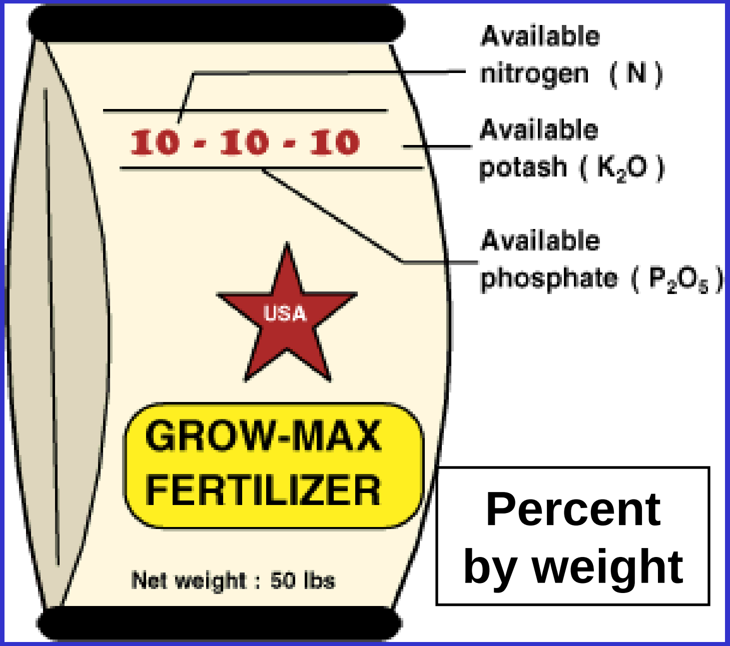
Nitrate is water soluble and moves easily from surface to groundwater.

Excess nitrate causes algal blooms that reduce water quality.

Nitrogen is changed to different forms through the nitrogen cycle.



Nitrate is the first nutrient listed in a fertilizer.

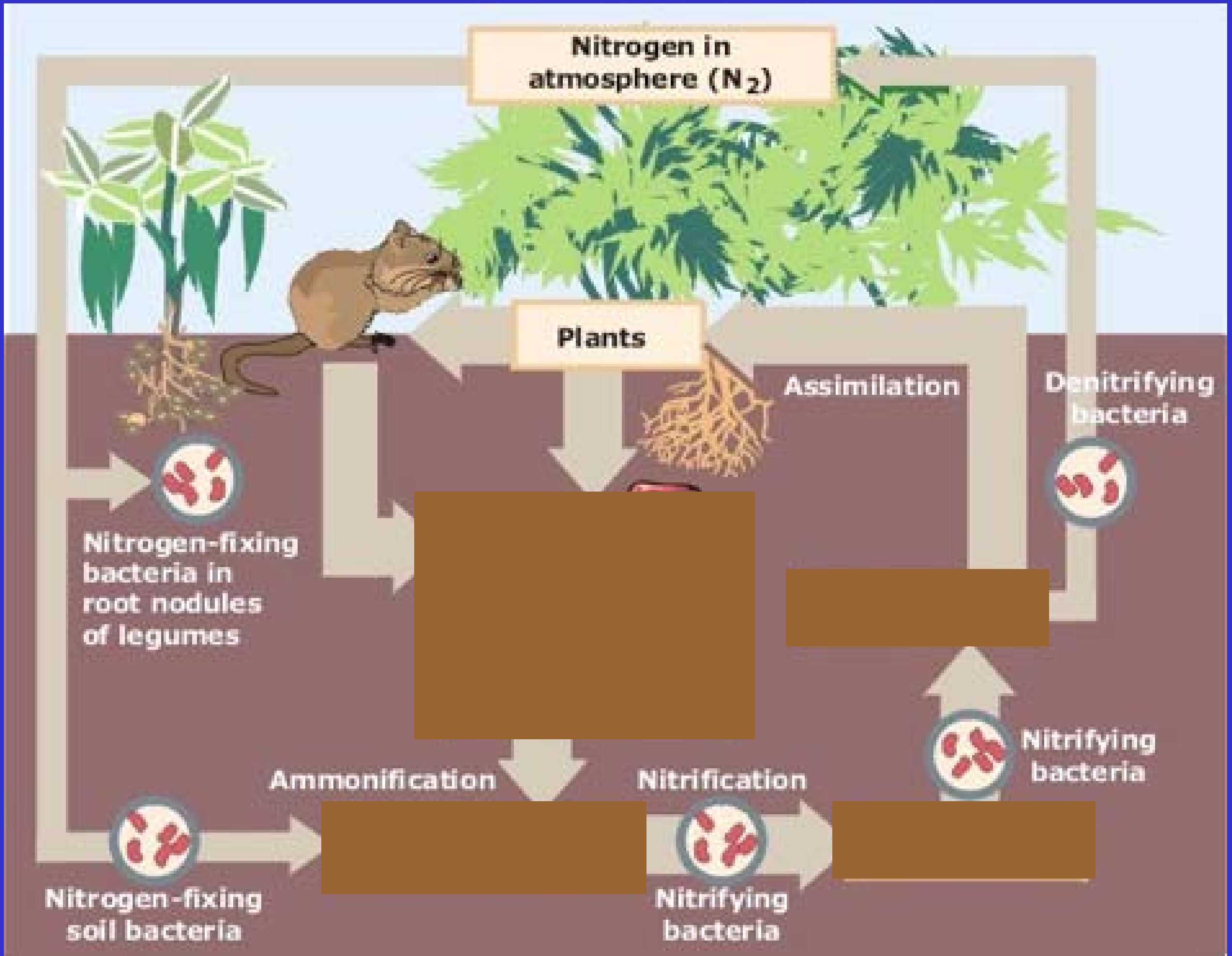


Learn more about the Nitrogen Cycle.

Learn more about soil nutrients.

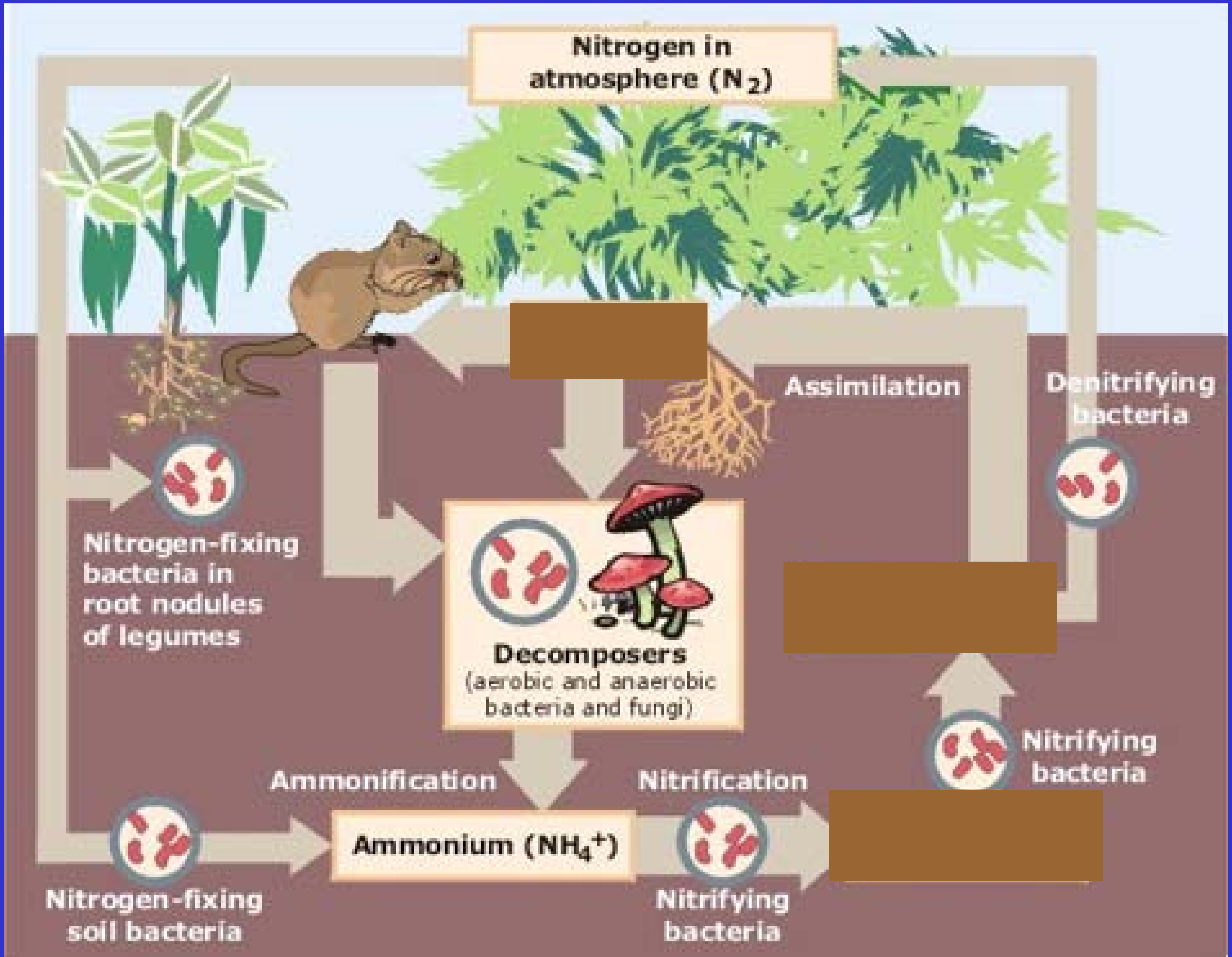
Nitrogen Cycle

Nitrogen exists as protein, ammonia, nitrite, nitrate and as free nitrogen gas. As animal and plant proteins decay, ammonia is released.



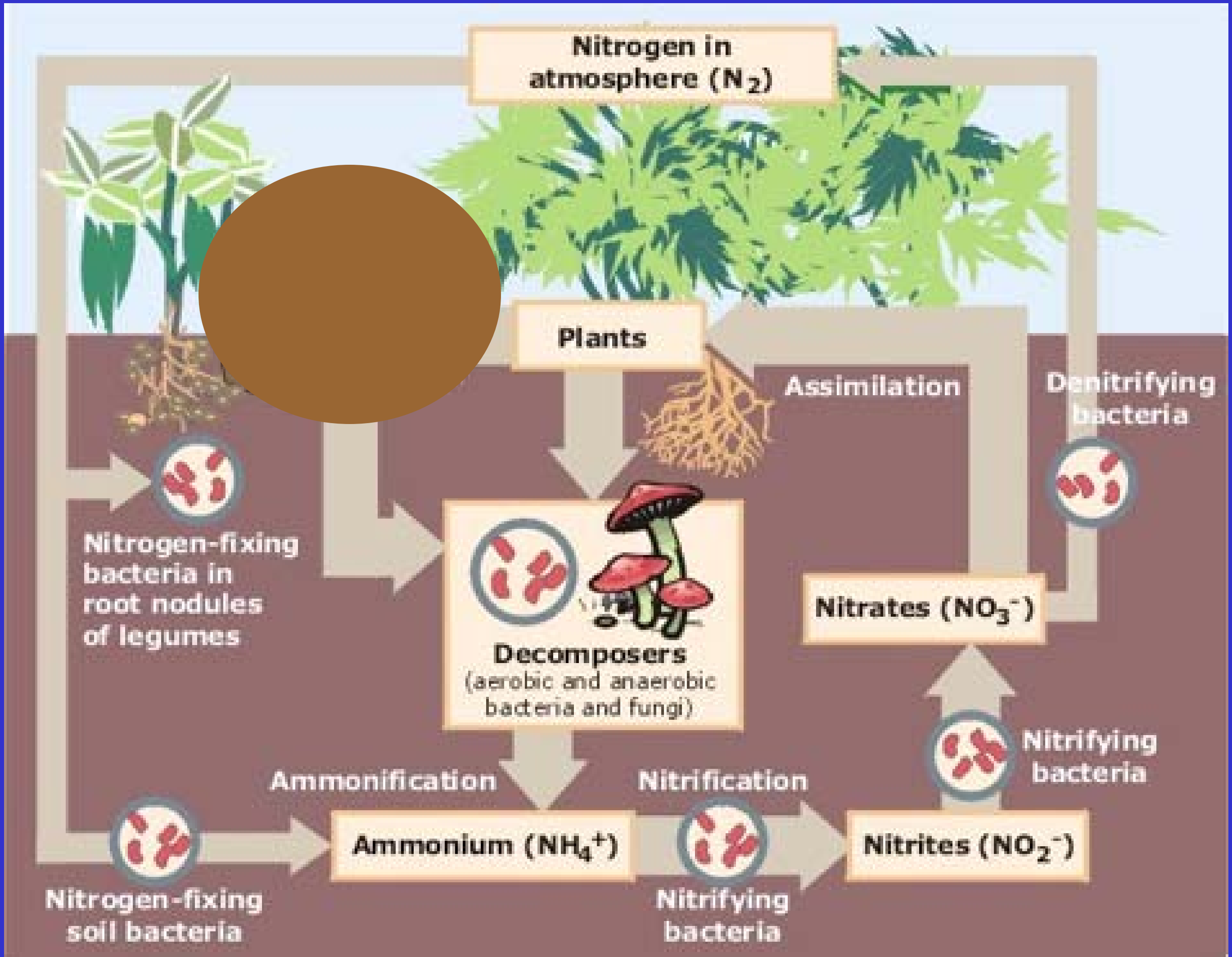
Nitrogen Cycle

Ammonia is converted to nitrite and then nitrate by nitrifying bacteria. Nitrate is utilized by plants as a primary nutrient.



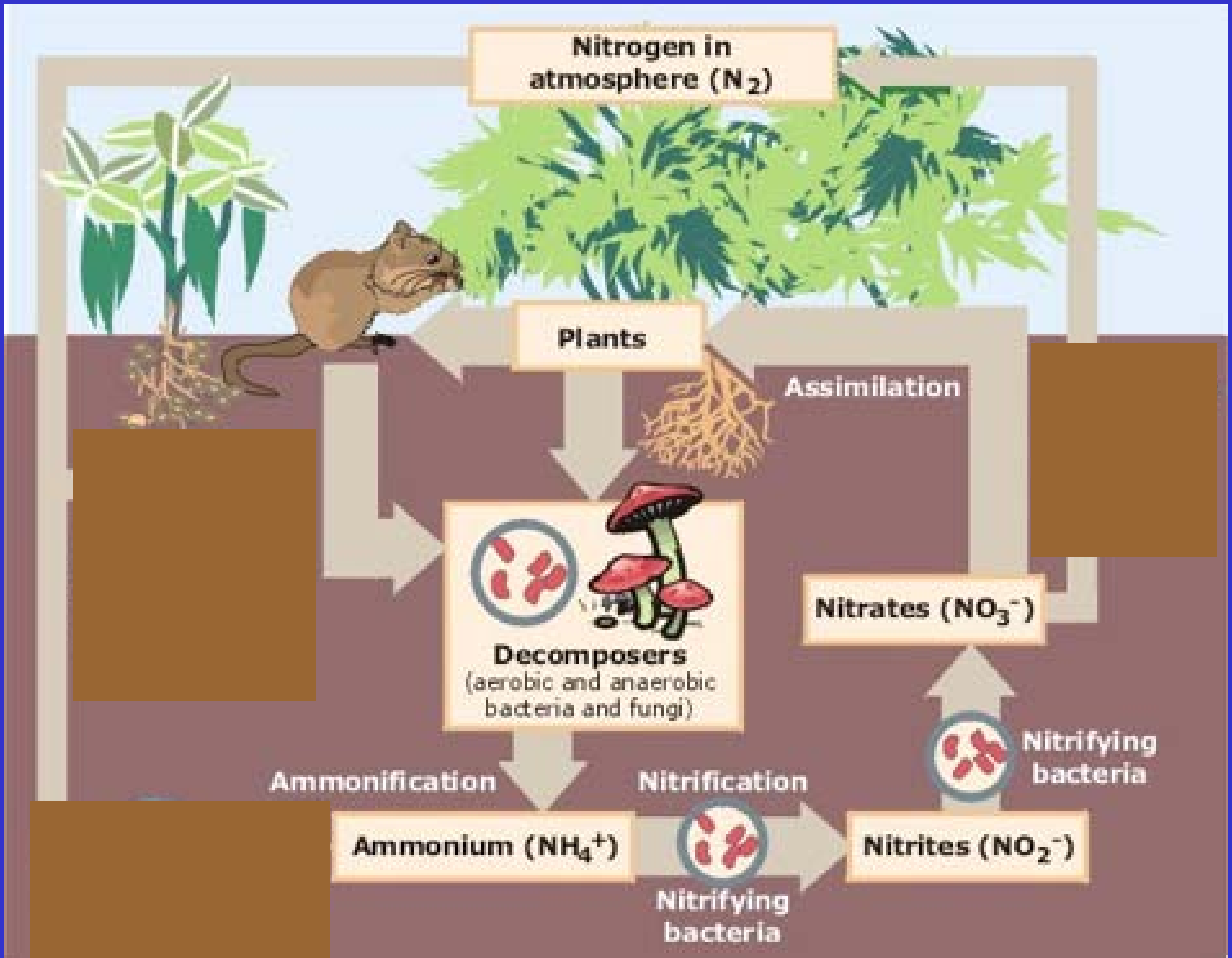
Nitrogen Cycle

Animals consume plants and other animals and use amino acids to build their proteins.



Nitrogen Cycle

Free nitrogen is produced by bacteria or lightning and converted to nitrate by nitrogen fixing plants.



Nitrogen Cycle

Return to Topics

Under normal conditions, the nitrogen cycle keeps the amount of available nitrogen in balance with the demands. However, excessive use of fertilizers and nutrient-rich sewage release have created a surplus of nitrate in waterways. The result has been eutrophication from excess algae and bacteria with reduced dissolved oxygen.

ALLIANCE FOR THE CHESAPEAKE BAY
BAY JOURNAL

Bay's water quality lives up - or down - to scientists' predictions

By Karl Blankenship (September 2005)

Chesapeake Bay water quality this summer fared the way scientists had expected it to: It was poor. In early August, about 41 percent of the main stem of the Chesapeake was suffering from low-oxygen conditions, and almost 10 percent had virtually no oxygen at all—creating a true biological "dead zone."

PARTS PER MILLION

Most dissolved substances found in water are measured in parts per million (ppm) or even smaller amounts. This means that for every one million parts (units) total there is a certain number of parts of the substance.

It is also expressed as milligrams per liter. There are 1000 milliliters in a liter and 1000 milligrams in a gram. For example, a dissolved oxygen reading of 8 ppm means there are 8 milligrams of oxygen for every 1000 milliliters of water.

8/1000 gram ÷ 1000 milliliters =

8/1,000,000 (8 parts per million)

Concentrations of certain substances are also measured in parts per billion, parts per trillion and so on. These are very small amounts but certain substances can be harmful even at these very low concentrations.

PESTICIDES

These chemicals are very complex.
They are rated by a number of factors:

- How well they adhere to soil.
- How water soluble they are.
- How long they last in the environment.
- How they affect organisms.

and other factors.

Some types of pesticides include:

Herbicides

Insecticides

Fungicides

Algicides

Miticides

Rodenticides

There are four main groups of chemical pesticides that use more than 120 active ingredients.

All pesticides should be handled safely and according to instructions.

Take a look at Atrazine.

Learn more about pesticides

A look at one herbicide - Atrazine

Trade Names: Aatrex, Actinite PK, Akticon, Argezin, Atazinax, Atranex, Atrataf, Atred, Candex, Cekuzina-T, Chromozin, Crisatrina, Cyazin, Fenamin, Fenatrol, Gesaprim, Griffex, Hungazin, Inakor, Pitezin, Primatol, Radazin, Strazine, Vectal, Weedex A, Wonuk, Zeapos, Zeazine

Persistence – Moderate to very

Long-term effects on mammals – Cancer, immune and hormone effects

Effects on other organisms – Moderately to highly toxic to bees, molluscs, aquatic insects, amphibians and fish.

Pounds used each year in the U.S. – 70 – 80 million

The decay of Atrazine is a complex cycle. It may persist from one week to one year, depending on soil conditions.

Little is known about the effects of the various Atrazine metabolites (by-products) on organisms.

Atrazine is currently being studied for its suspected effects on amphibians and other organisms.

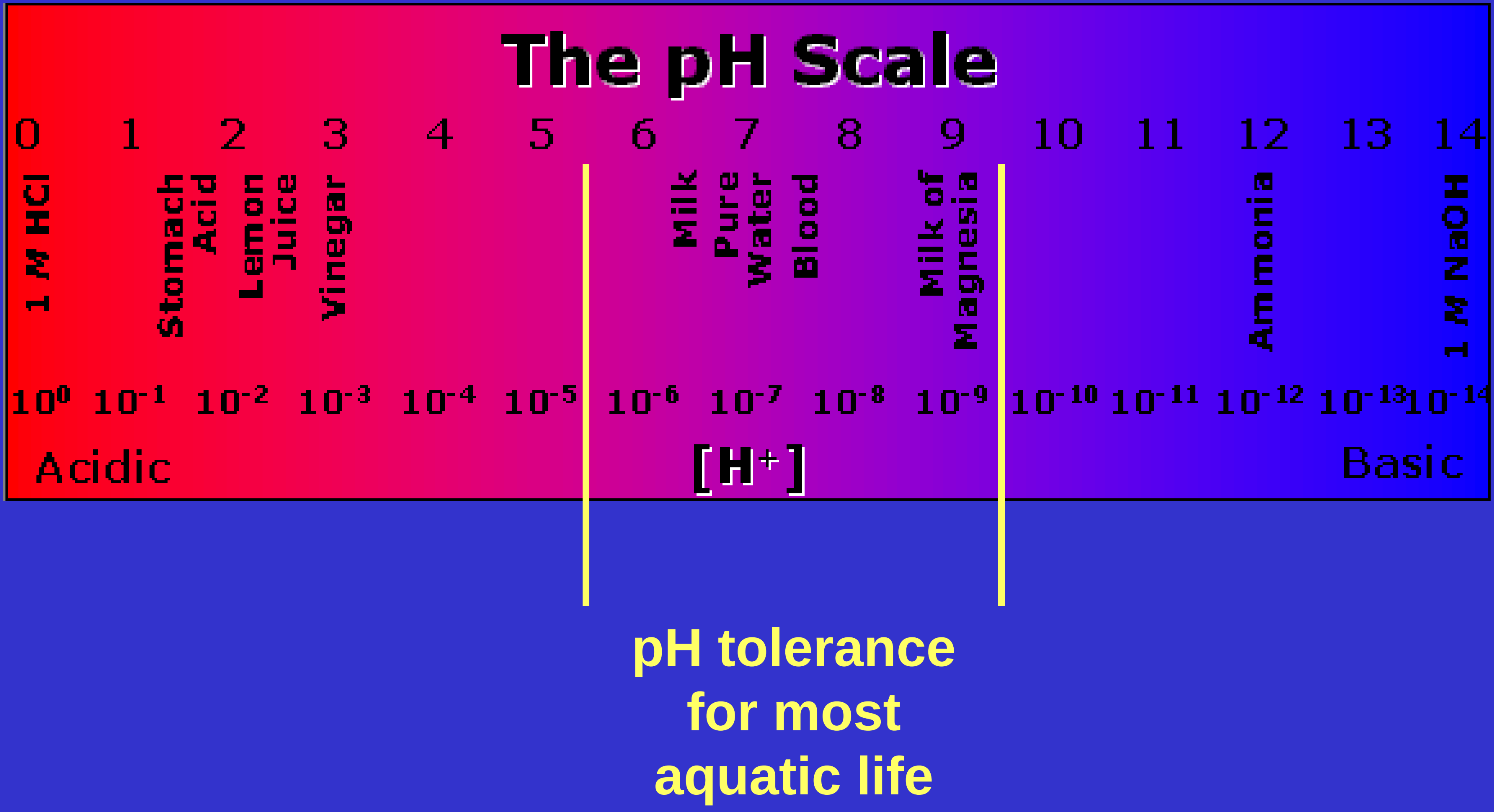
pH

pH is the measure of the hydrogen ion (H^+) concentration.

The pH scale is zero to 14. Seven is neutral, below seven is acidic, and above seven is basic (or alkaline).

Most aquatic organisms exist within a pH range of 5.5 to 9.5.

Carbon dioxide reacts with water to form a weak acid called carbonic acid.



PHOSPHATE

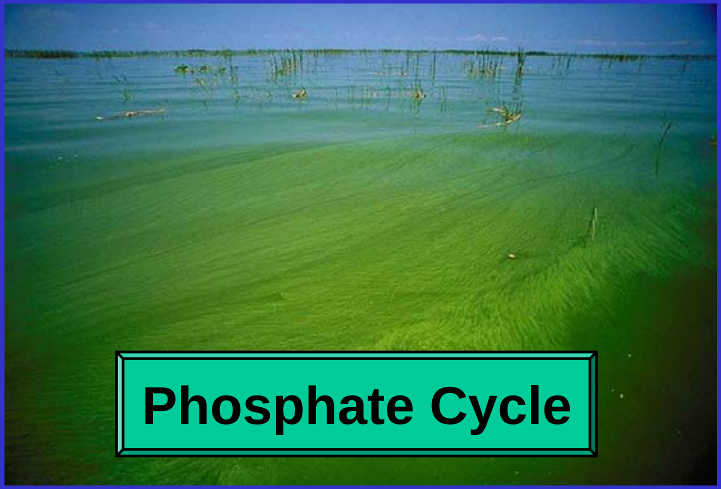
Phosphate is an important plant nutrient used for root growth.

Phosphate binds to soil particles and is not usually water soluble.

Most phosphorus mineral is obtained from mining.

Phosphate exists in both organic and inorganic forms.

Excess phosphate can cause algal blooms and reduce water quality.



Chicken and swine production are major sources of phosphate pollution.

SALINITY

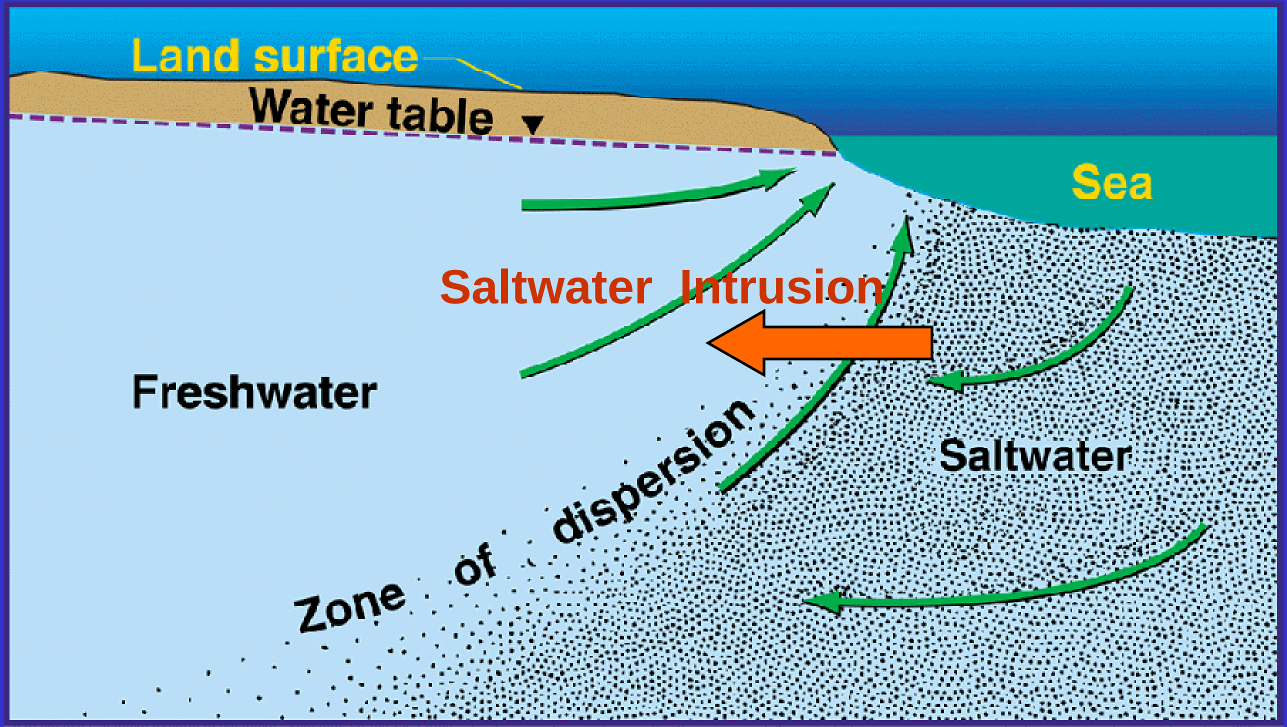
Salinity refers to the salt concentration in water, mostly sodium chloride.

Salinity is measured in parts per thousand (ppt) or grams per liter.

Ocean water has a salinity of about 35 ppt.

Brackish water has less than 20 ppt salinity.

Saltwater can cause problems when it replaces fresh groundwater in coastal areas.



SEDIMENT

Erosion causes loose soil to enter waterways.

Heavier sediment particles quickly settle out of the water.

Suspended sediment blocks sunlight and reduces dissolved oxygen.

As suspended sediments settle, they can smother bottom (benthic) organisms.

Sediments can carry many types of man-made chemicals.

TEMPERATURE

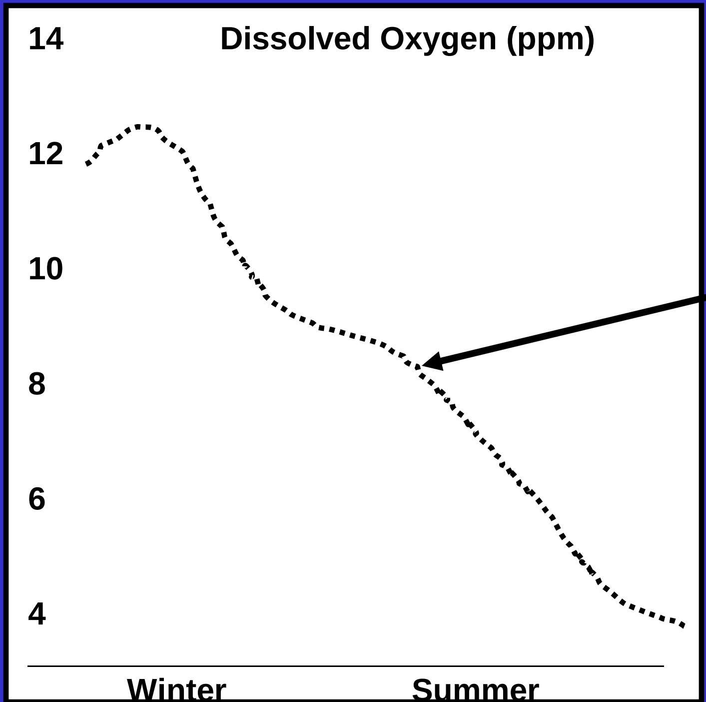
Temperature is measured in Fahrenheit and Celsius degrees.

Temperature can be measured using field thermometers but digital probes are much more accurate.

Most aquatic organisms live within a temperature range of +32º F (+0º C) to 90º F (32º C).

Rapid temperature change and temperature extremes can stress aquatic organisms.

Temperature affects the oxygen-carrying capacity of water.



As the water warms, the amount of dissolved oxygen decreases.

TOTAL DISSOLVED SOLIDS (TDS)

TDS is the measure of the material dissolved in water.

This measure is related to hardness, salinity and conductivity.

Hard water has more TDS than soft water.

TOTAL SUSPENDED SOLIDS (TSS)

TSS is the measure of the sediment suspended in the water.

TSS is related to turbidity.

Water with high TSS usually has high Total Dissolved Solids (TDS) as well.

TOXIC CHEMICALS

Toxic chemicals usually come from industry and energy production.

The effects are often not known until years after they have entered the environment.

Toxic chemicals include heavy metals (lead, mercury), organic compounds (DDT, PCB), inorganic substances (arsenic) and others.

Many common household chemicals are toxic to aquatic life (cleaning fluids, paints, thinners, polishes, etc.)

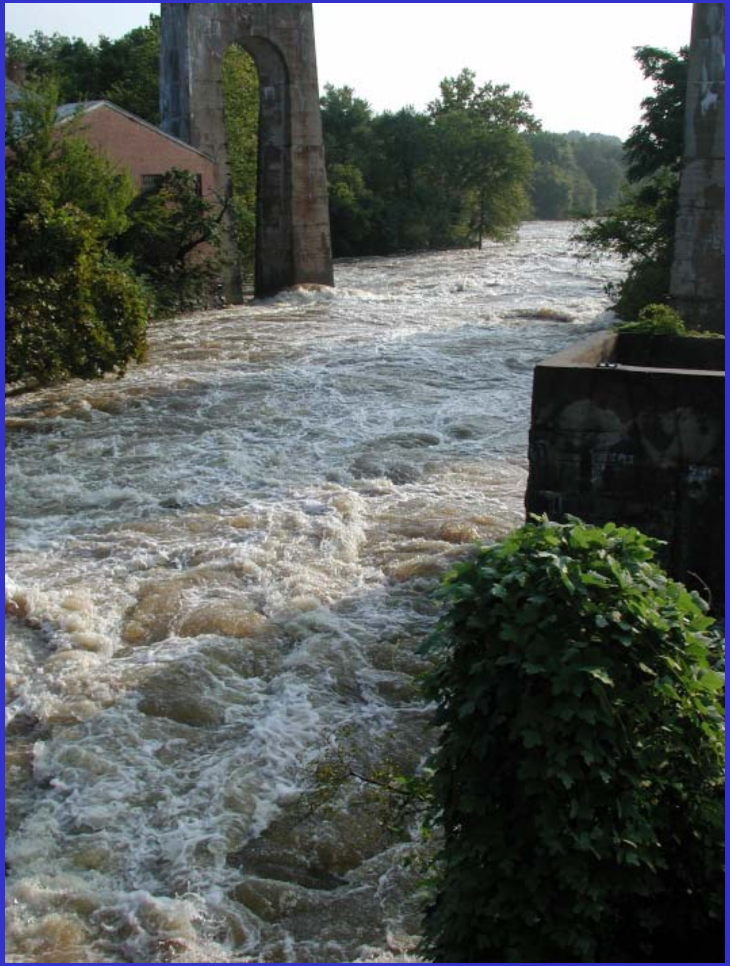
A description of some of the “Toxics of Concern” is available at this link (Toxics).

TURBIDITY

Turbidity refers to water clarity.

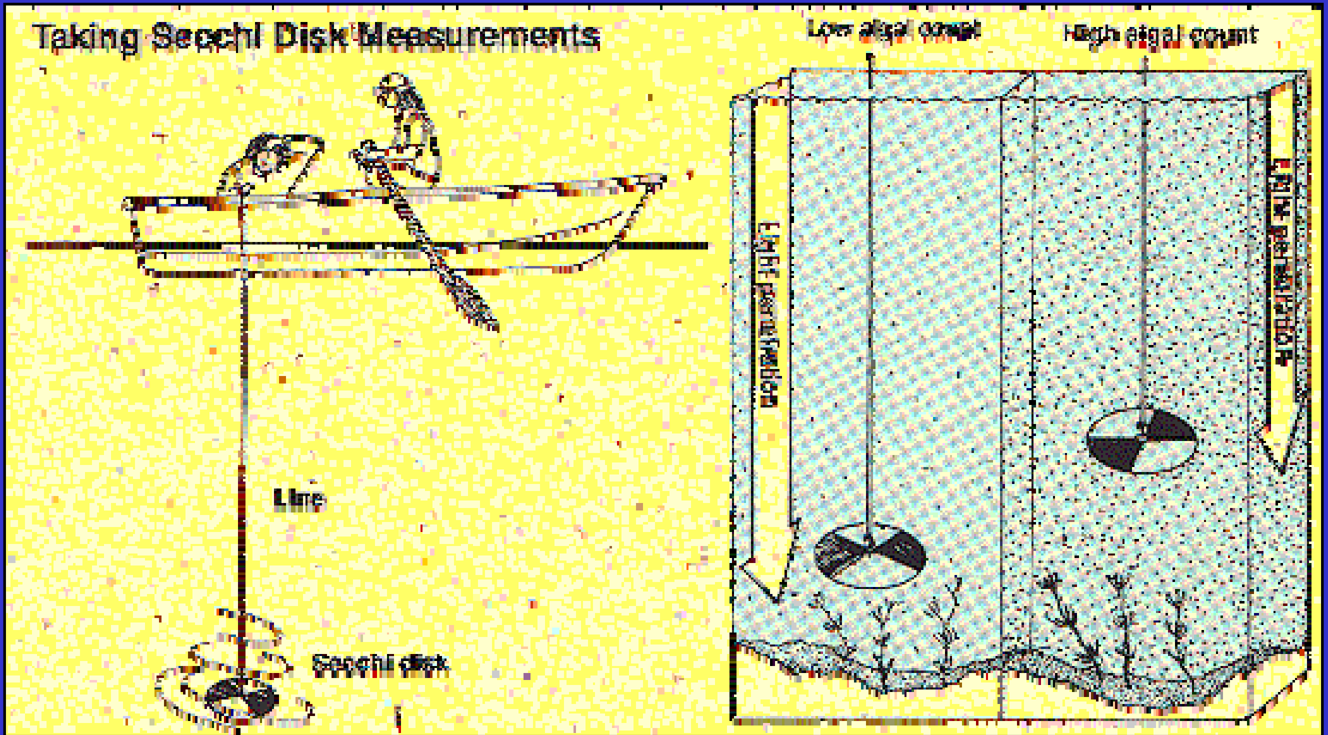
Sediments suspended in the water increase turbidity.

Clay and silt particles produce most of the turbidity.



High turbidity prevents light from reaching submerged aquatic vegetation (underwater plants).

A secchi disk is one type of instrument used to measure turbidity.



Return to Preparation

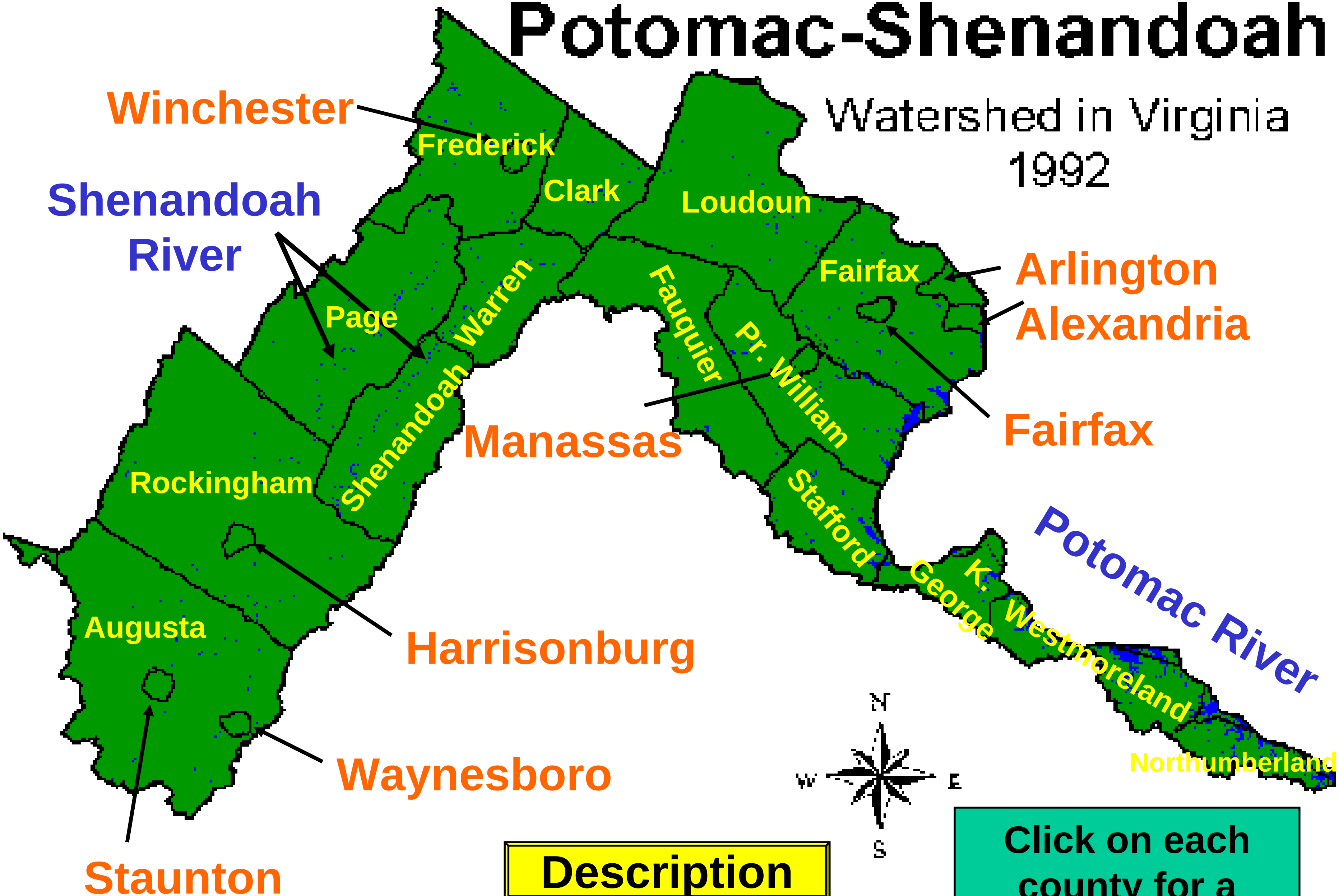
Virginia's Principal Watersheds

Click on the watershed names to learn more about them.

For more information about Virginia's watersheds, visit: http://www.wm.edu/geology/virginia/rivers/rivers.html and http://www.cnr.vt.edu/PLT/watersheds.html.

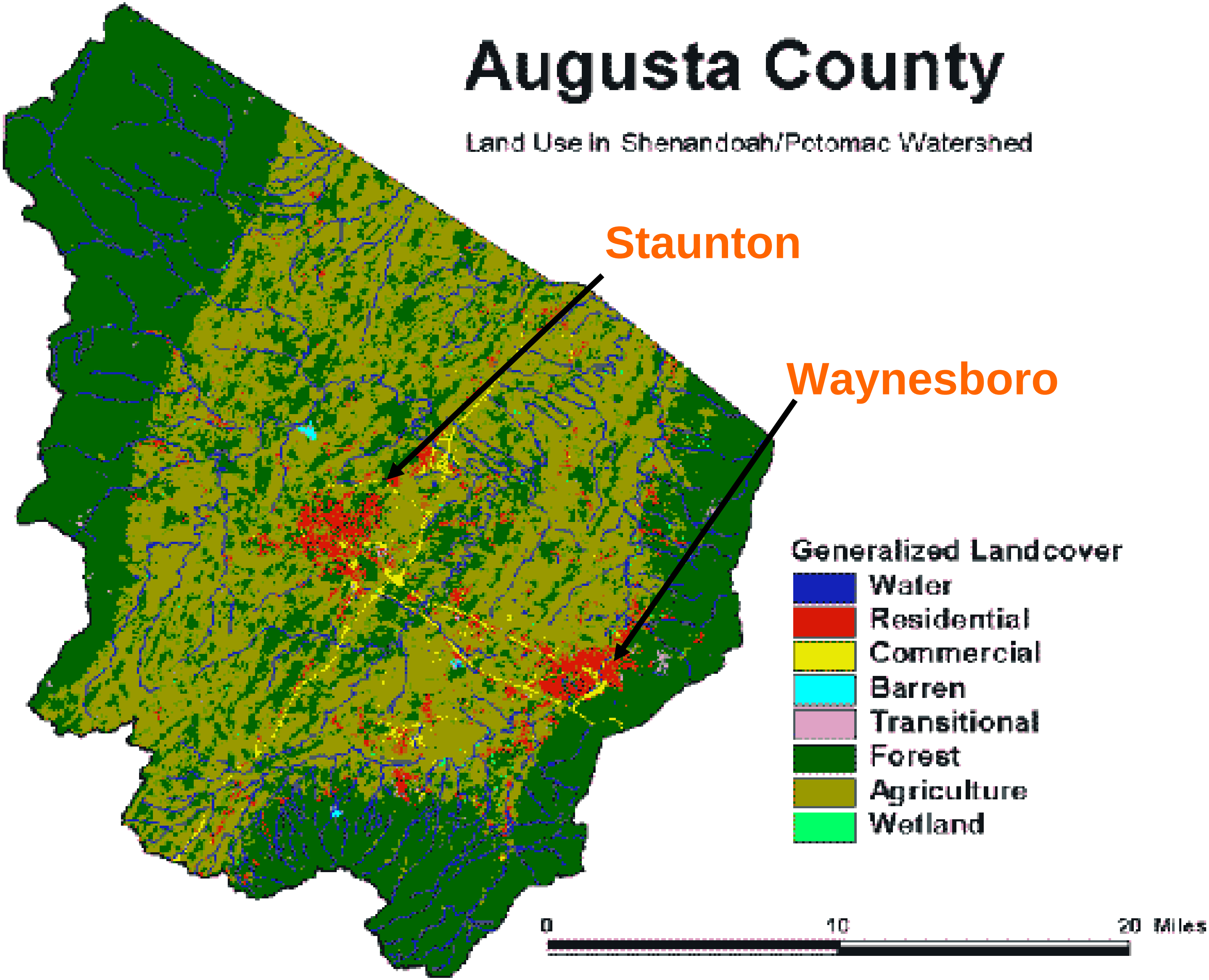
Potomac-Shenandoah

Watershed in Virginia 1992



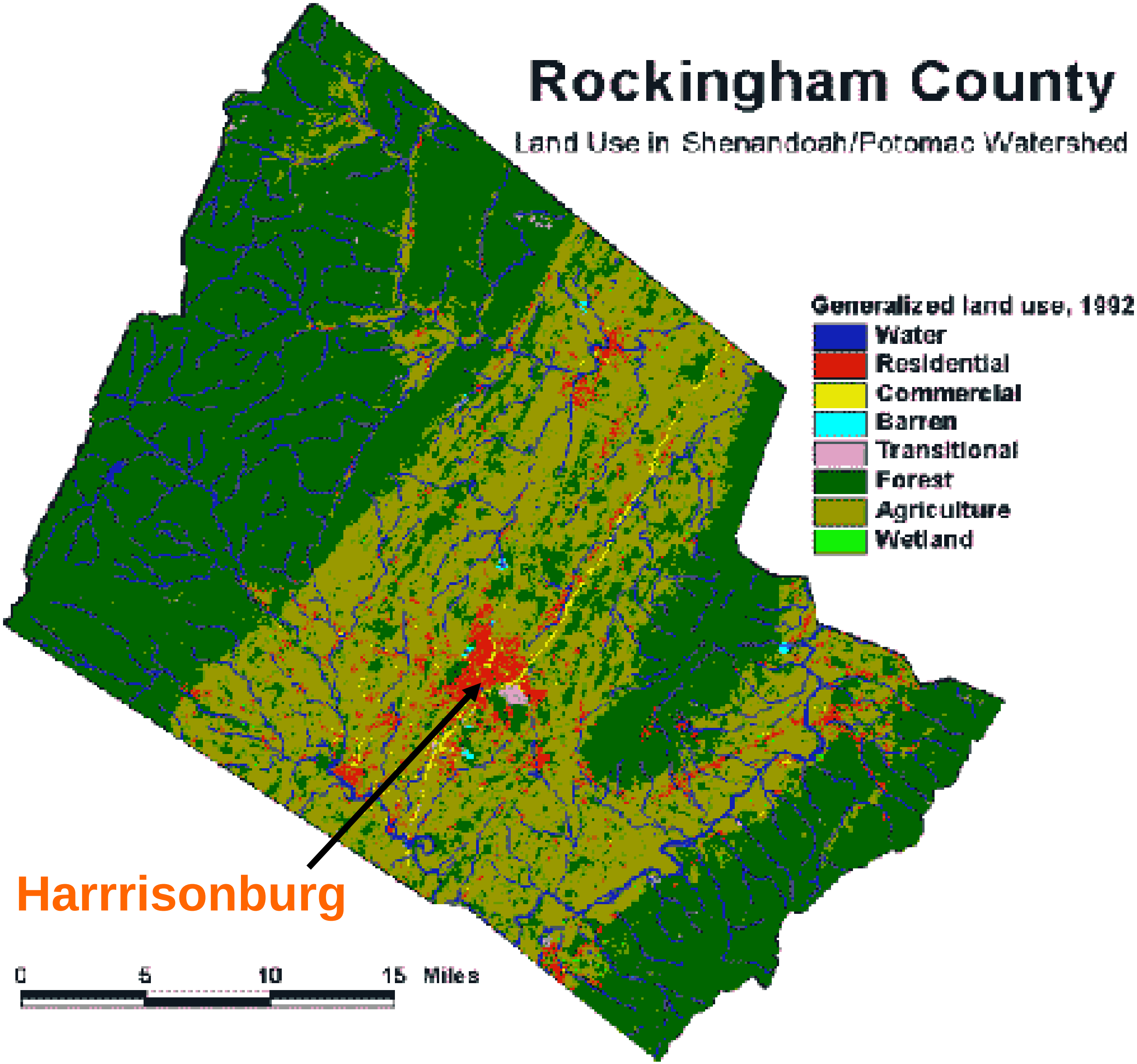
Description

Click on each county for a close-up view.

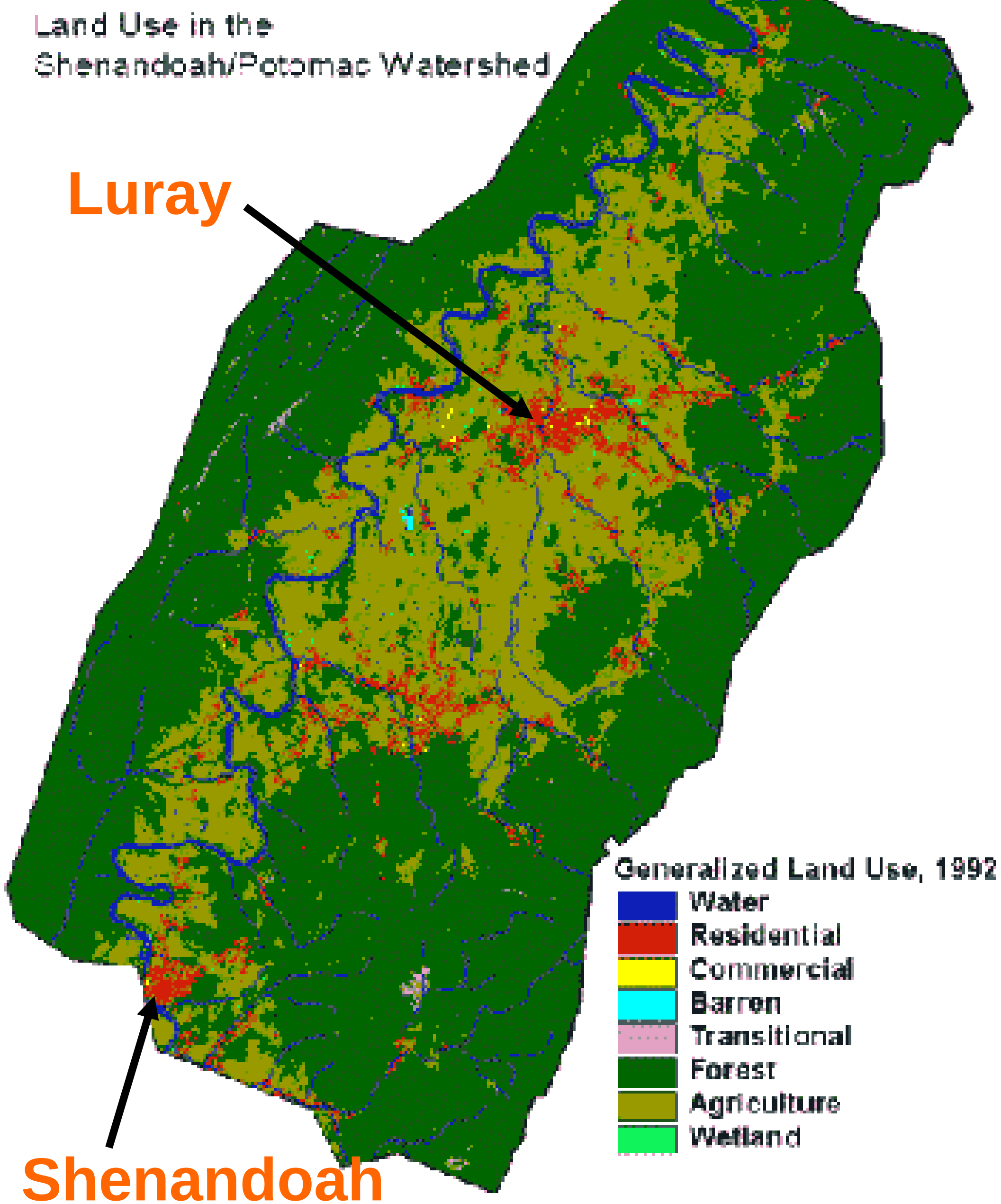

Augusta County
Land Use in Shenandoah/Potomac Watershed
Staunton
Waynesboro
Generalized Landcover
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland
0
10
20 Miles

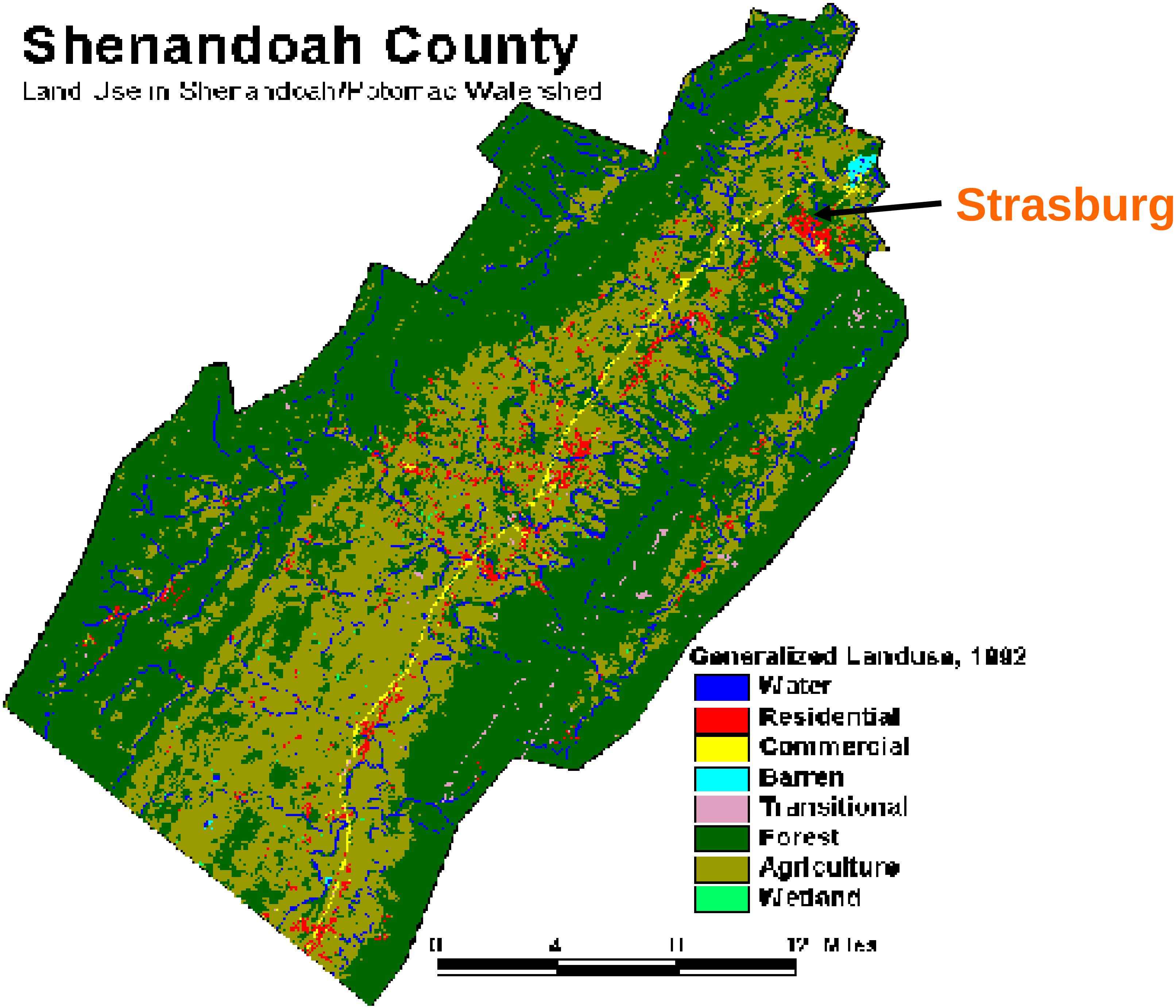
Rockingham County

Land Use in Shenandoah/Potomac Watershed



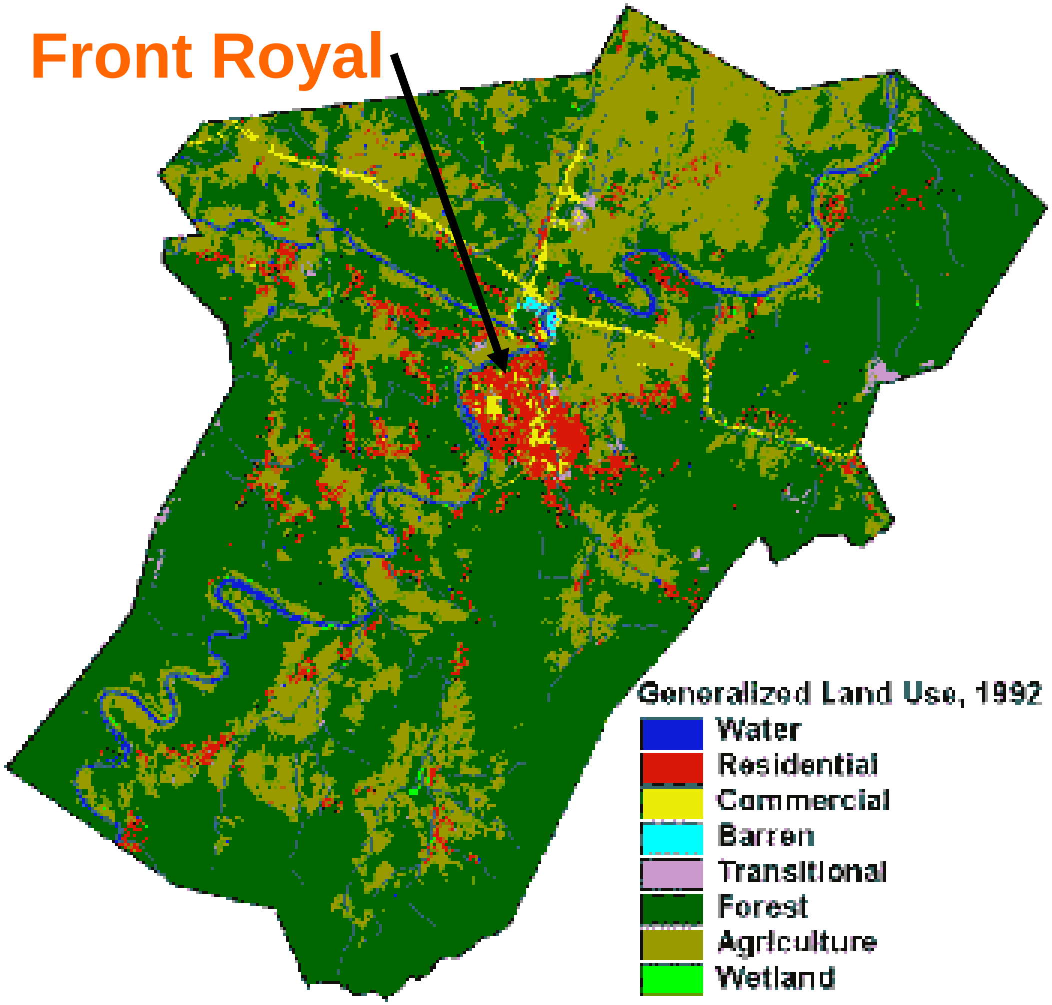
Page County


Land Use in the
Shenandoah/Potomac Watershed
Luray
Shenandoah
Generalized Land Use, 1992
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland

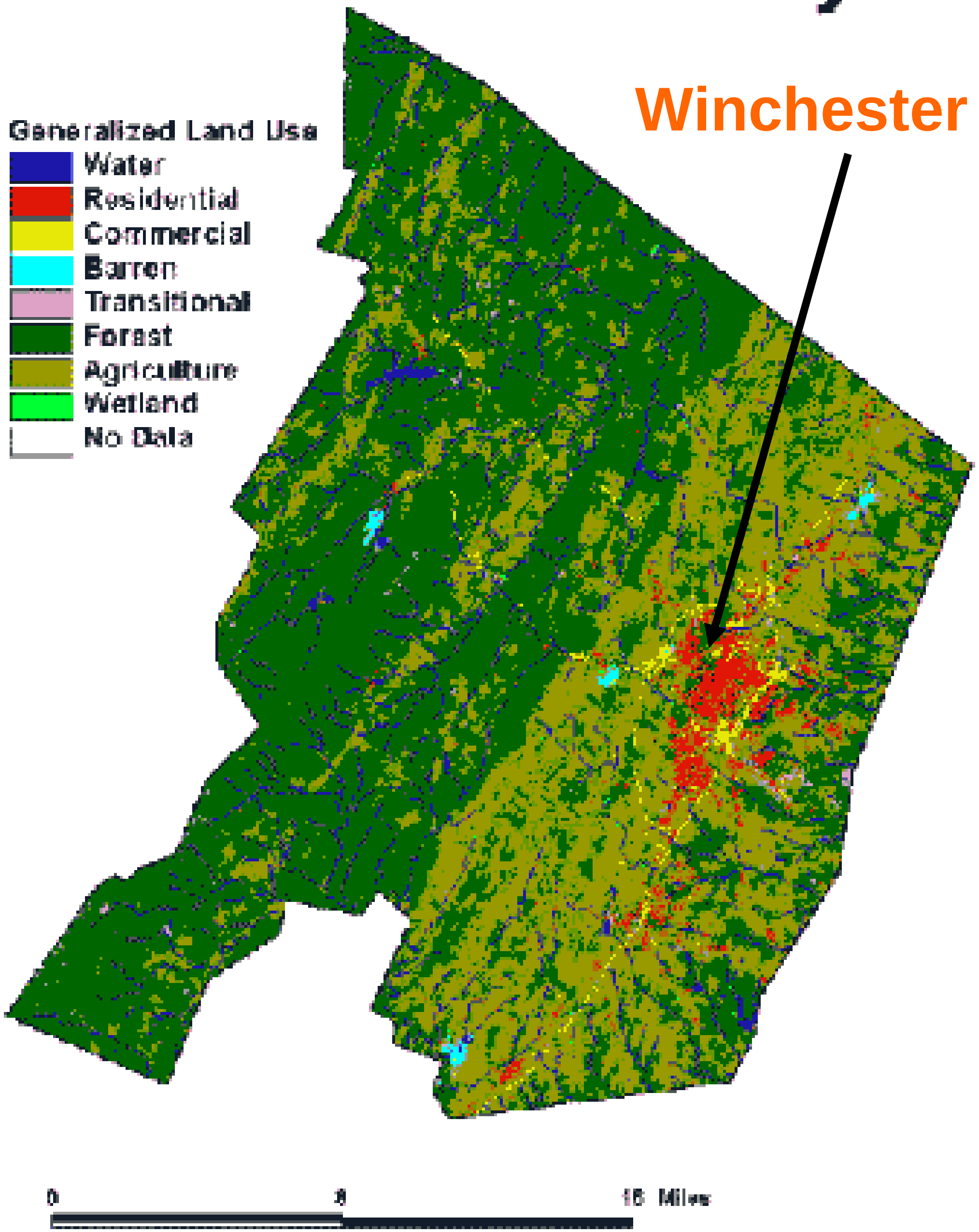

Shenandoah County
Land Use in Shenandoah/Potomac Watershed
Strasburg
Generalized Landuse, 1992
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland
0
12 Miles

Warren County

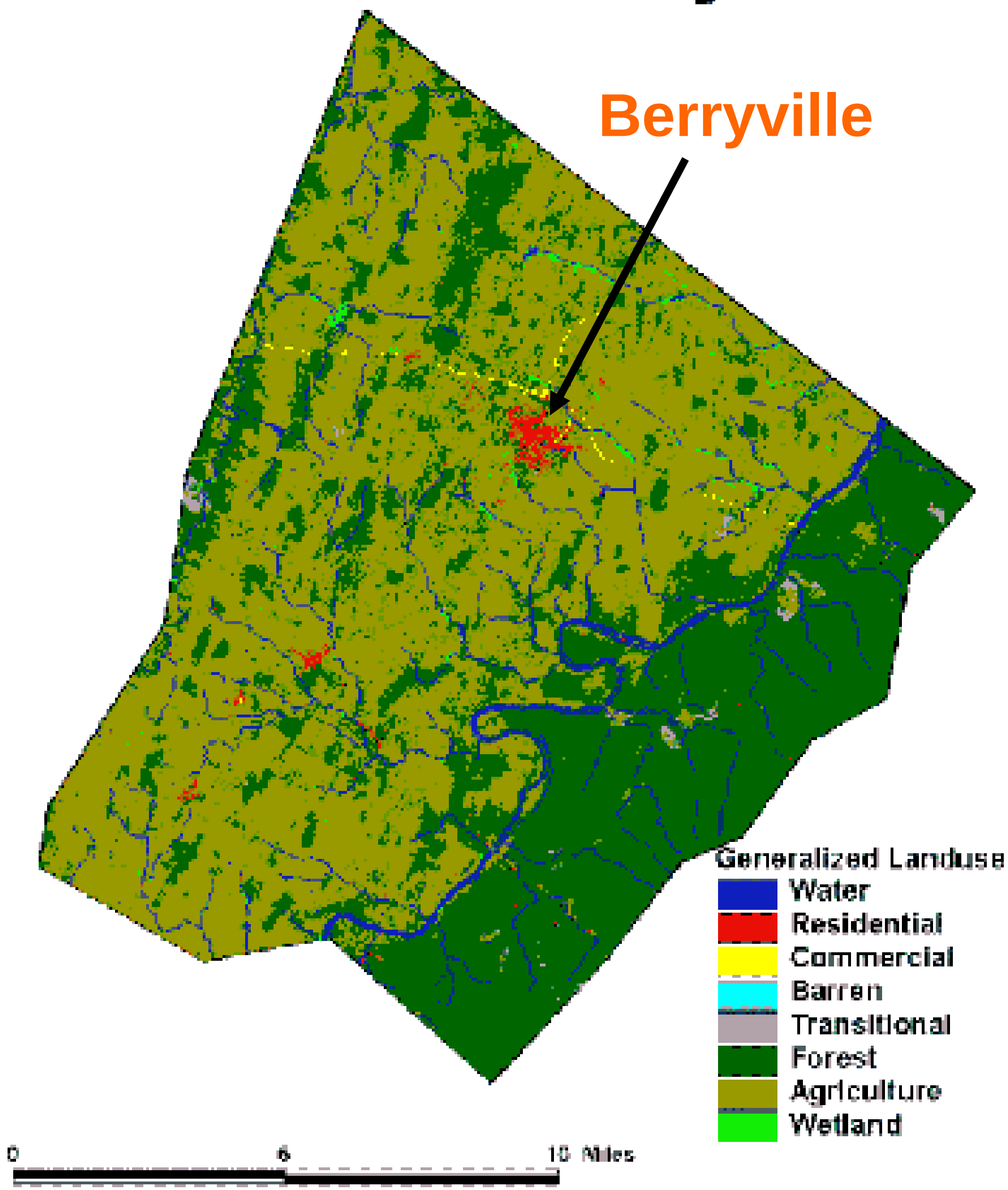
Land Use in the Shenandoah/Potomac Watershed

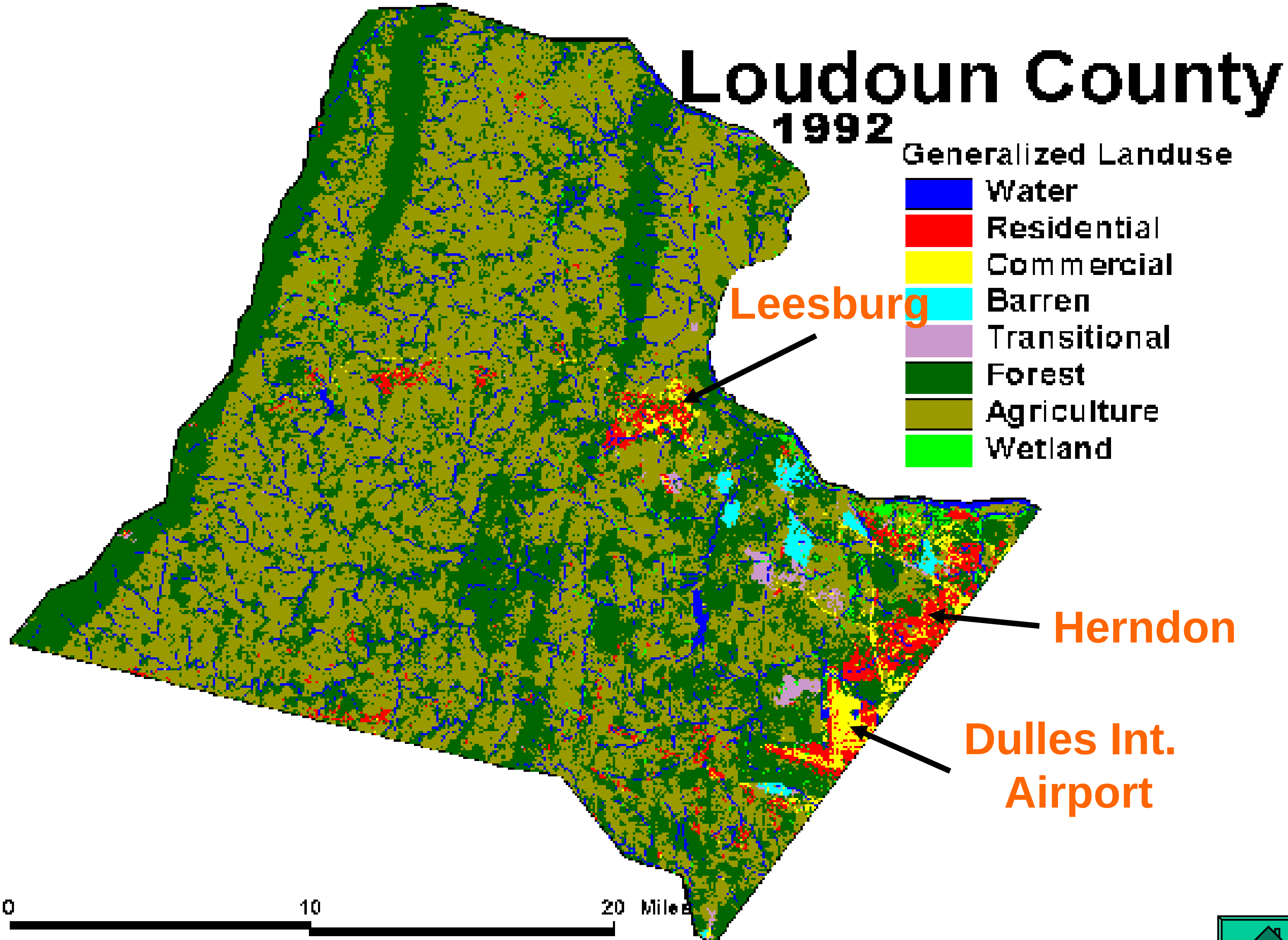


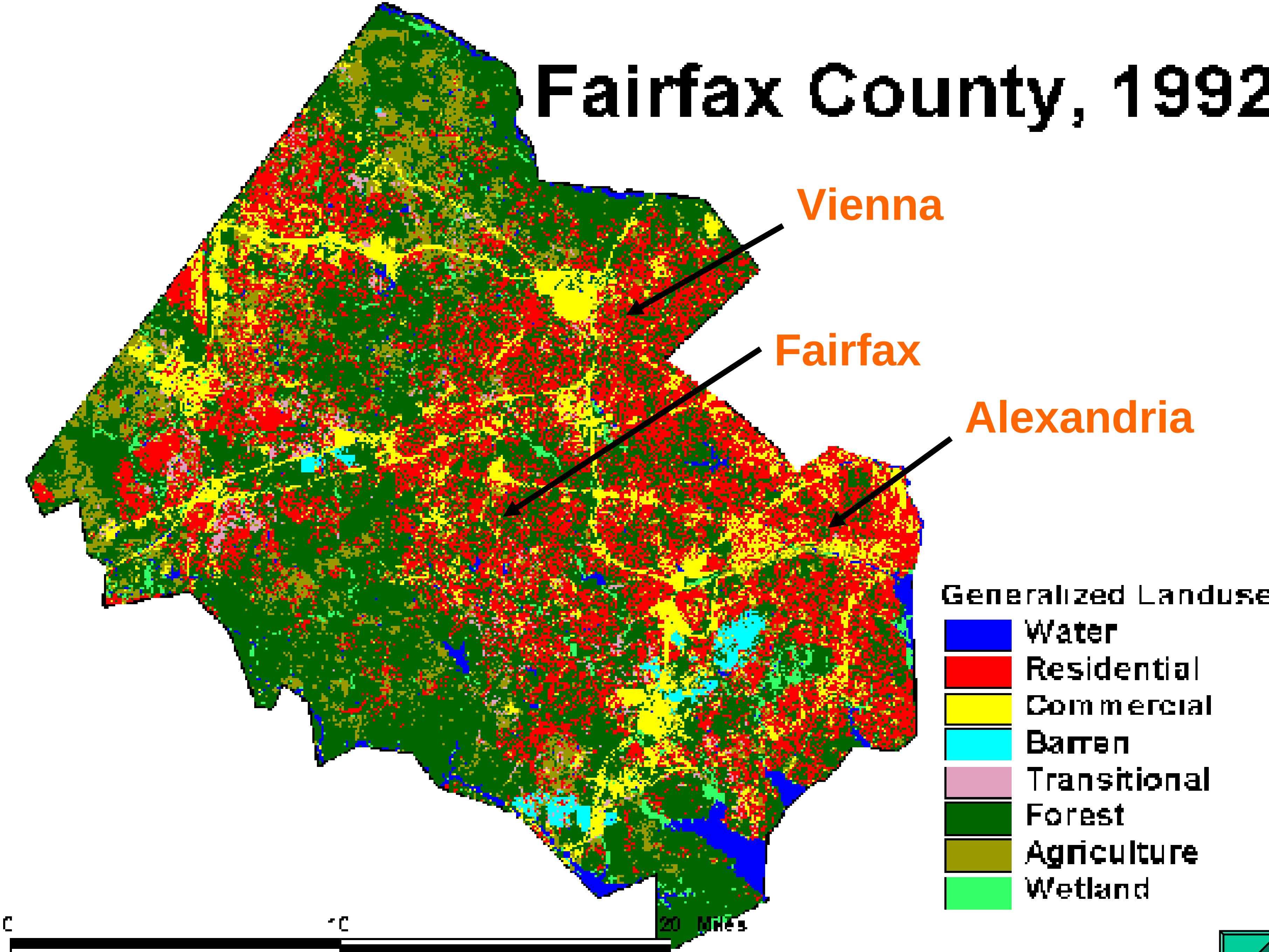
Frederick County



Clarke County

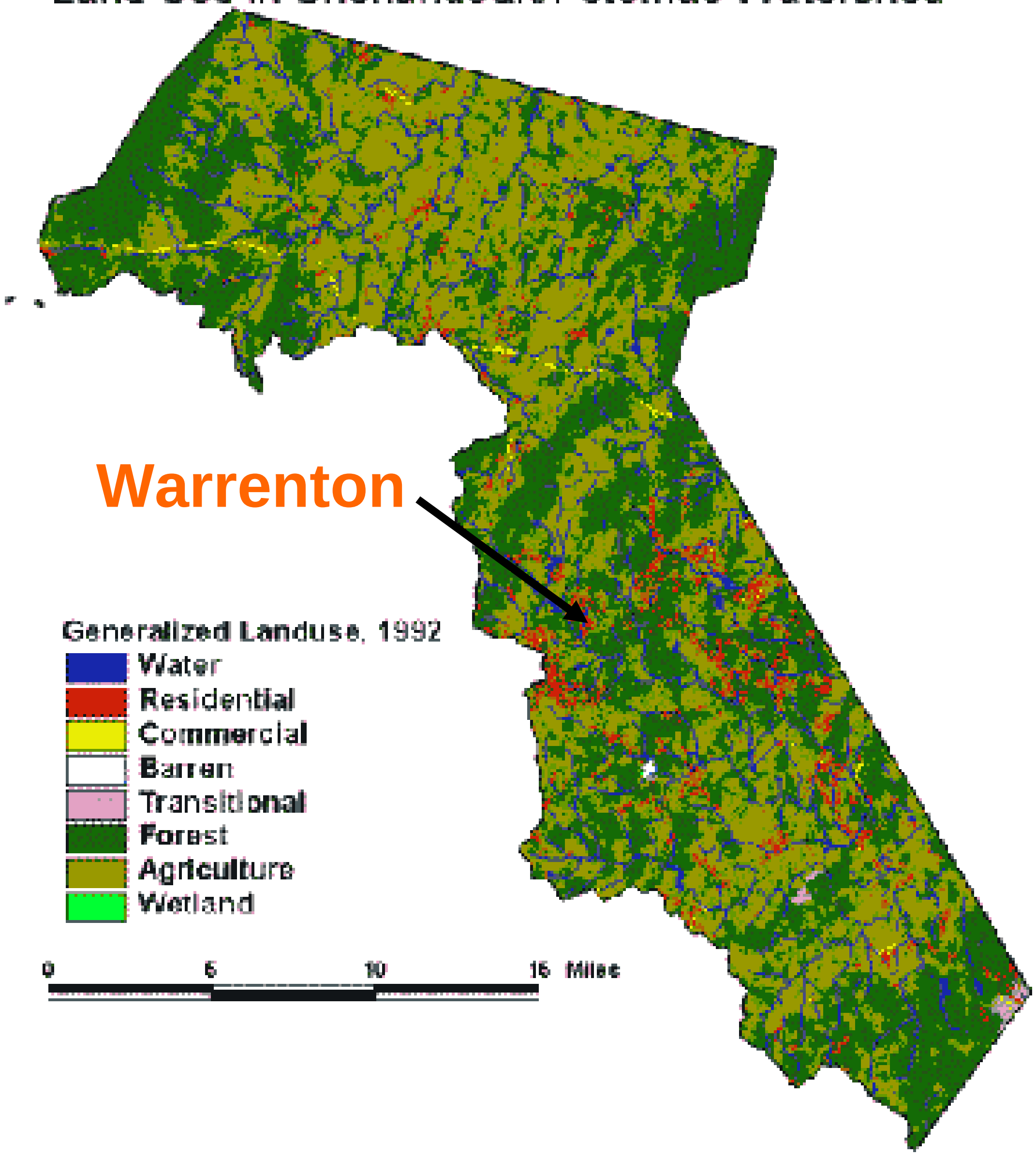


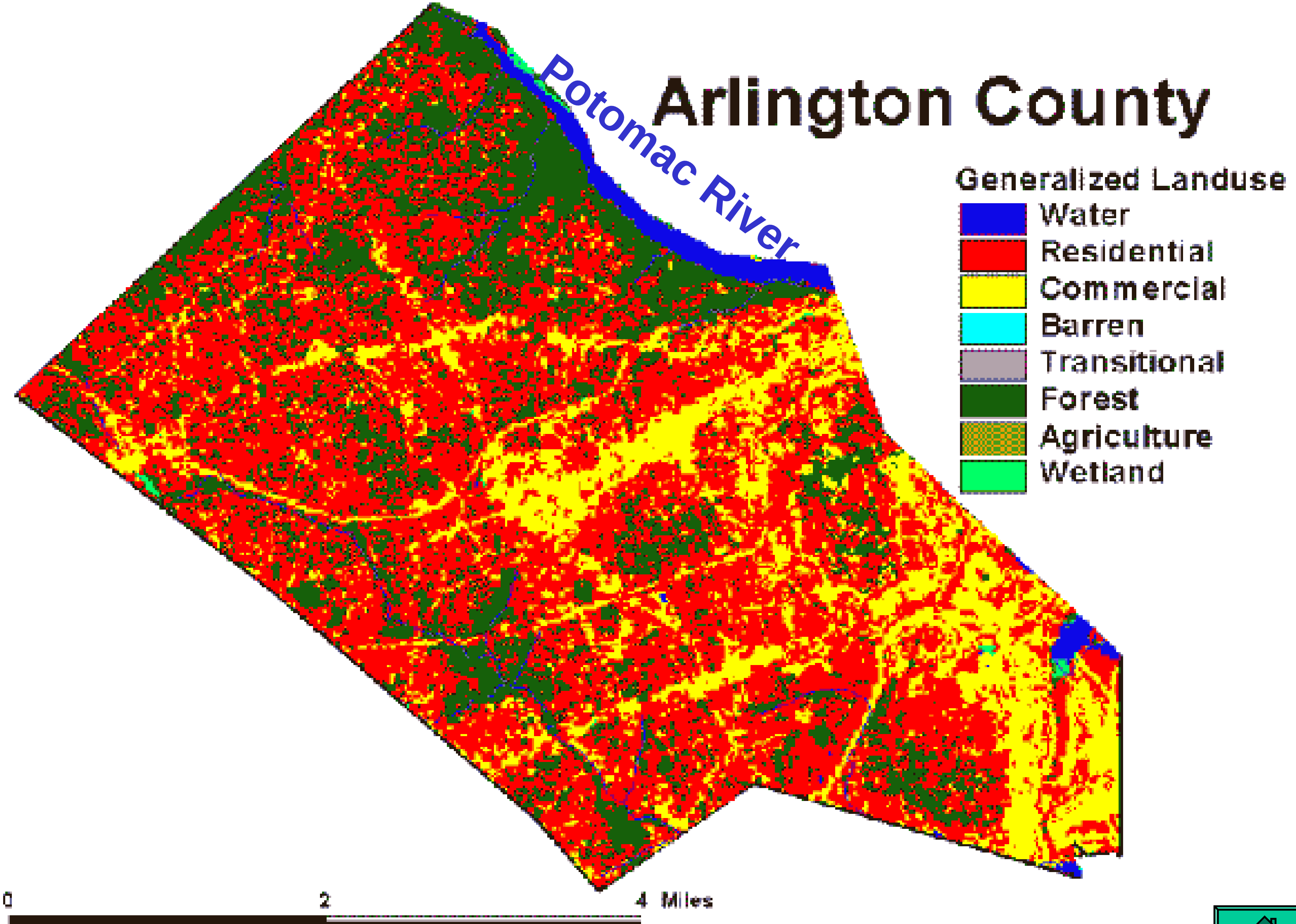

Loudoun County
1992
Generalized Landuse
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland
Leesburg
Herndon
Dulles Int.
Airport
0
10
20 Miles

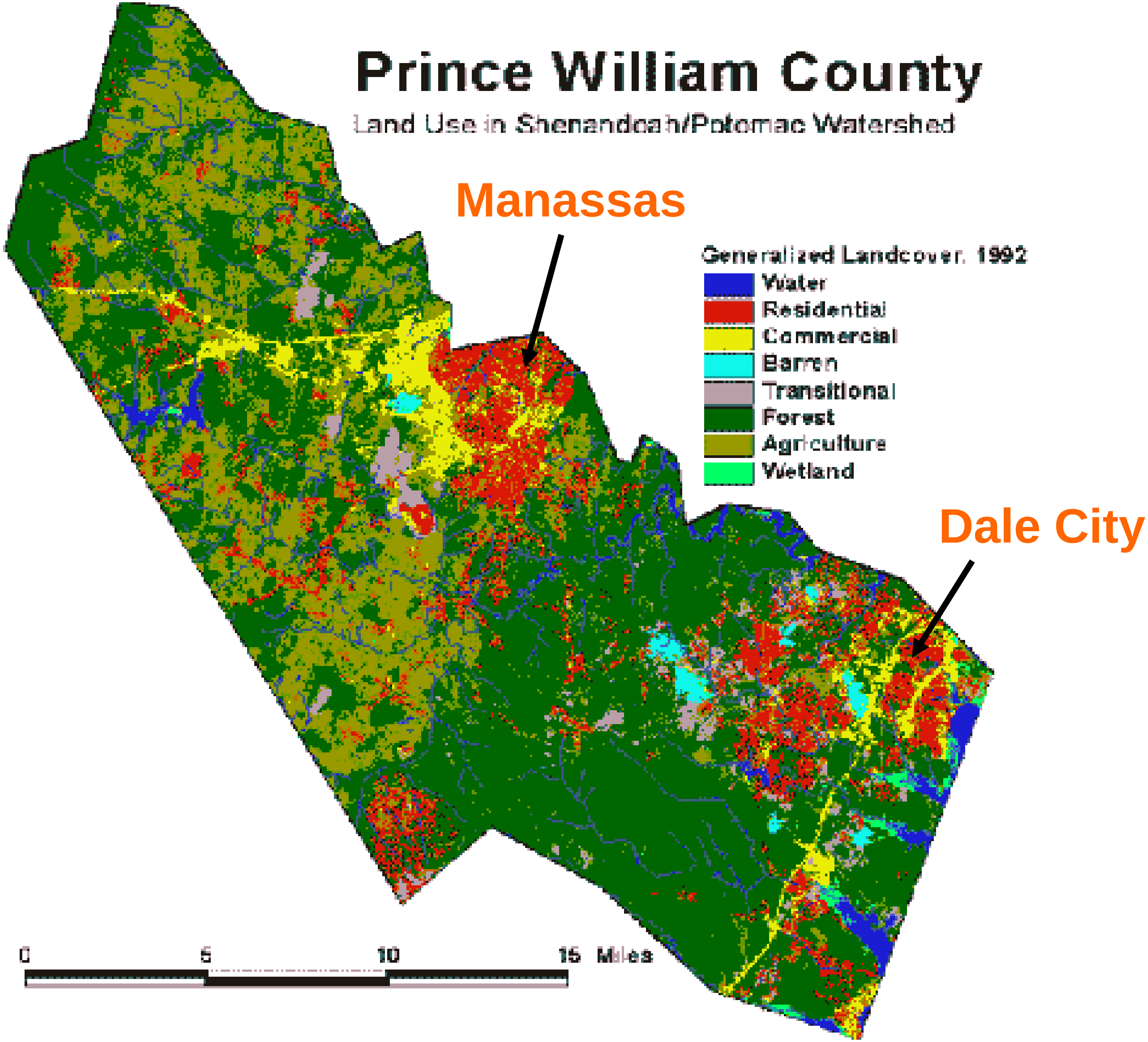

Fairfax County, 1992
Vienna
Fairfax
Alexandria
Generalized Landuse
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland
0
10
20 Miles

Fauquier County

Land Use in Shenandoah/Potomac Watershed

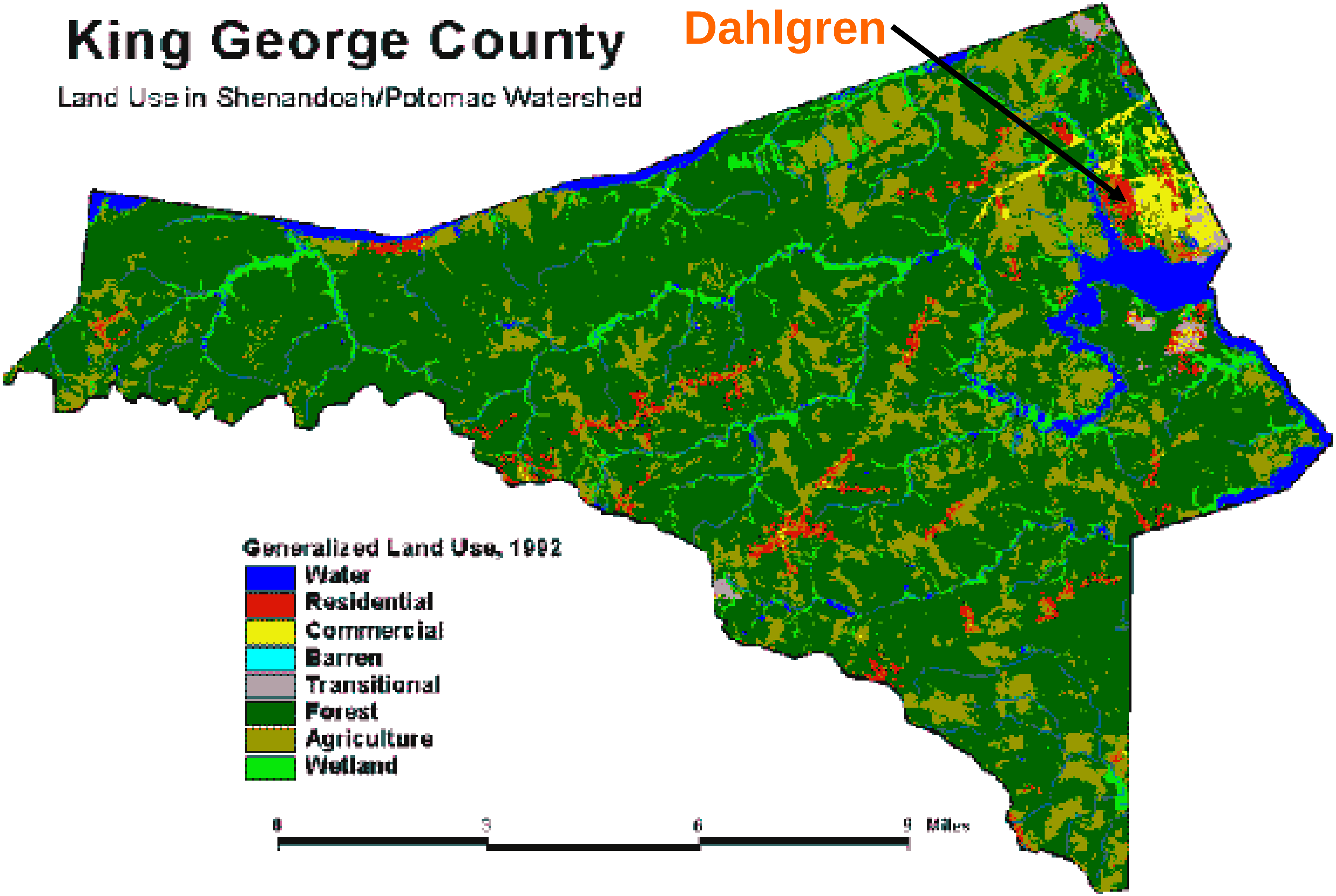


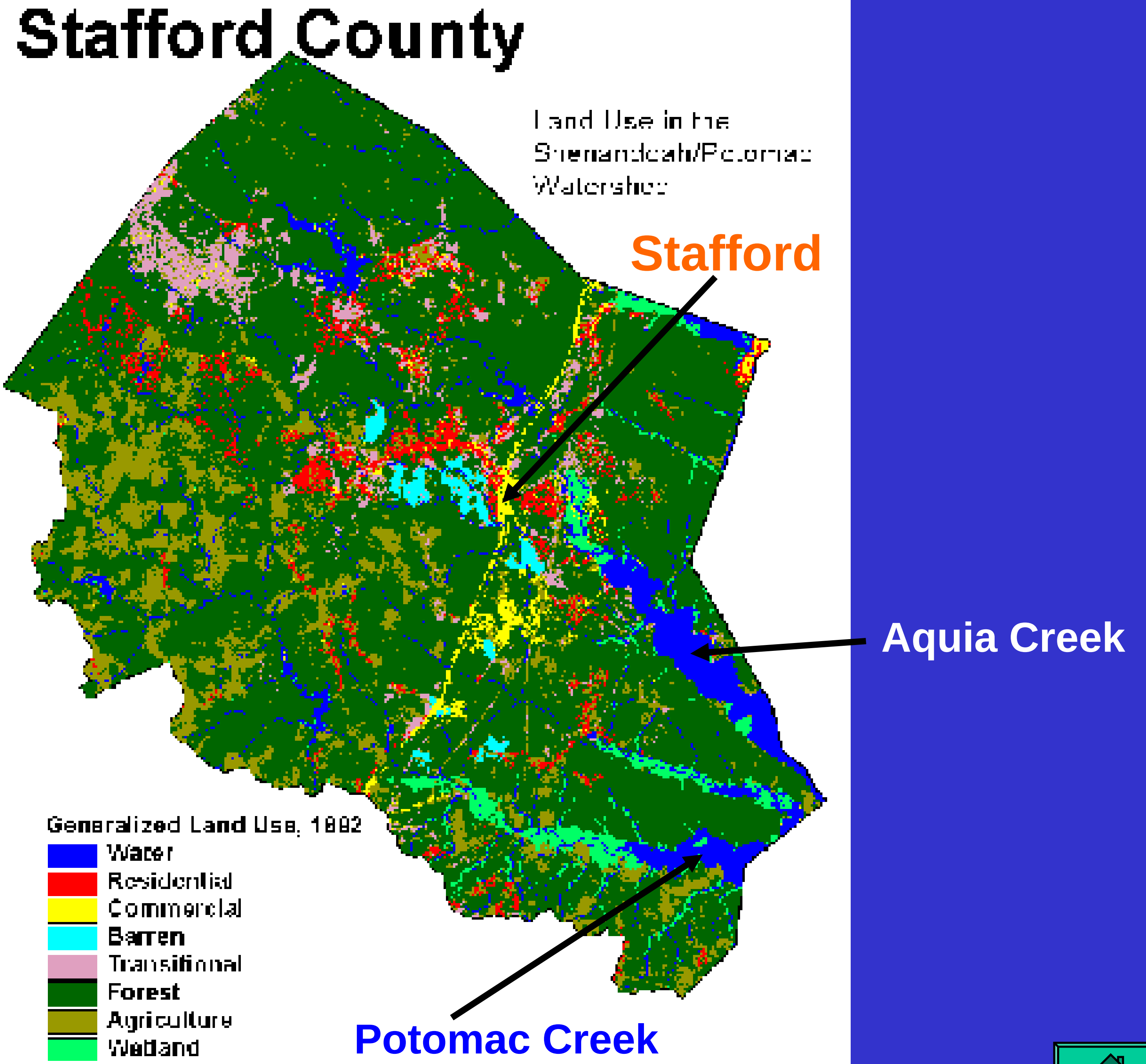

Arlington County
Potomac River
Generalized Landuse
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland
0
2
4 Miles

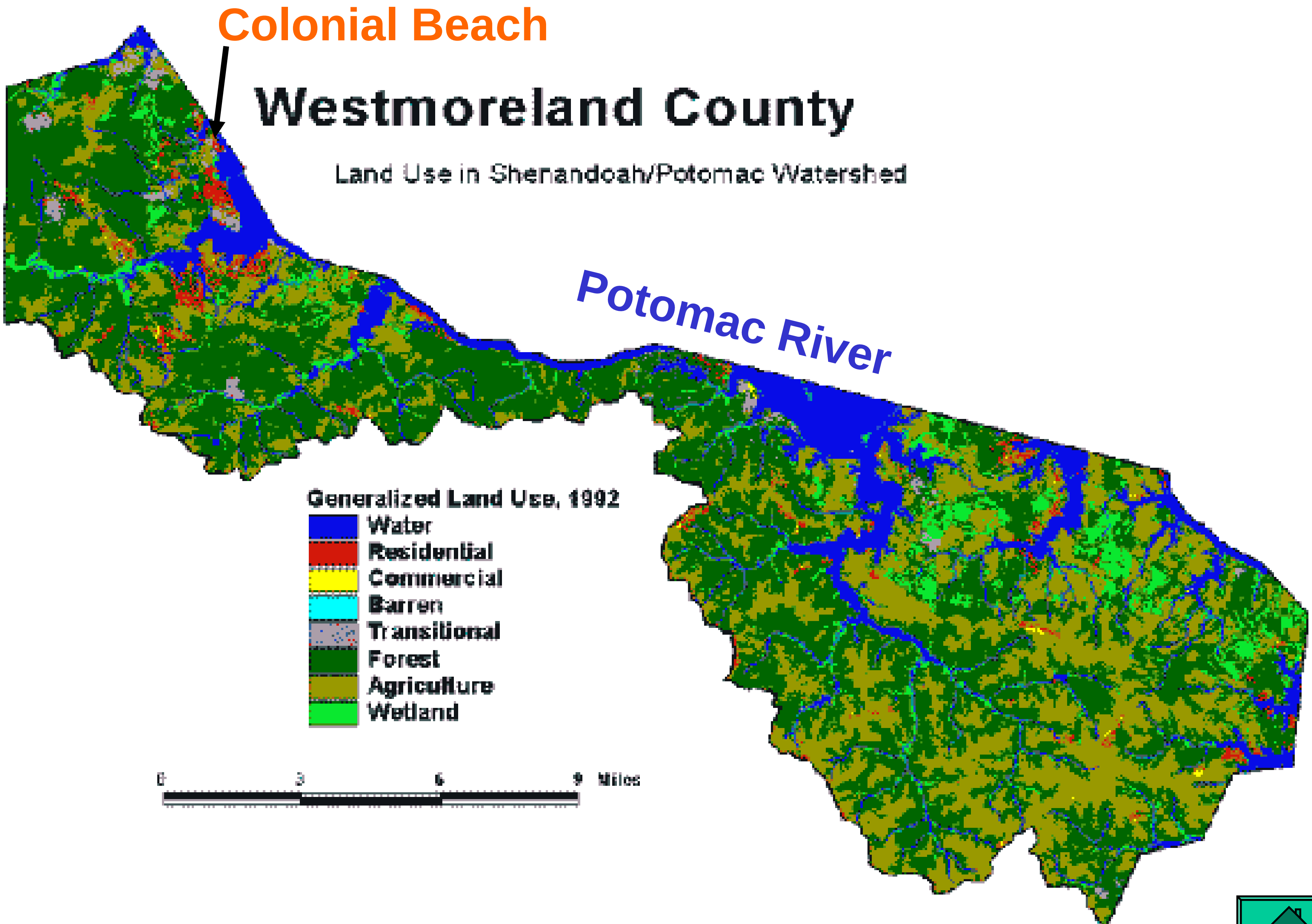

Prince William County
Land Use in Shenandoah/Potomac Watershed
Manassas
Generalized Landcover, 1992
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland
Dale City
0
5
10
15 Miles

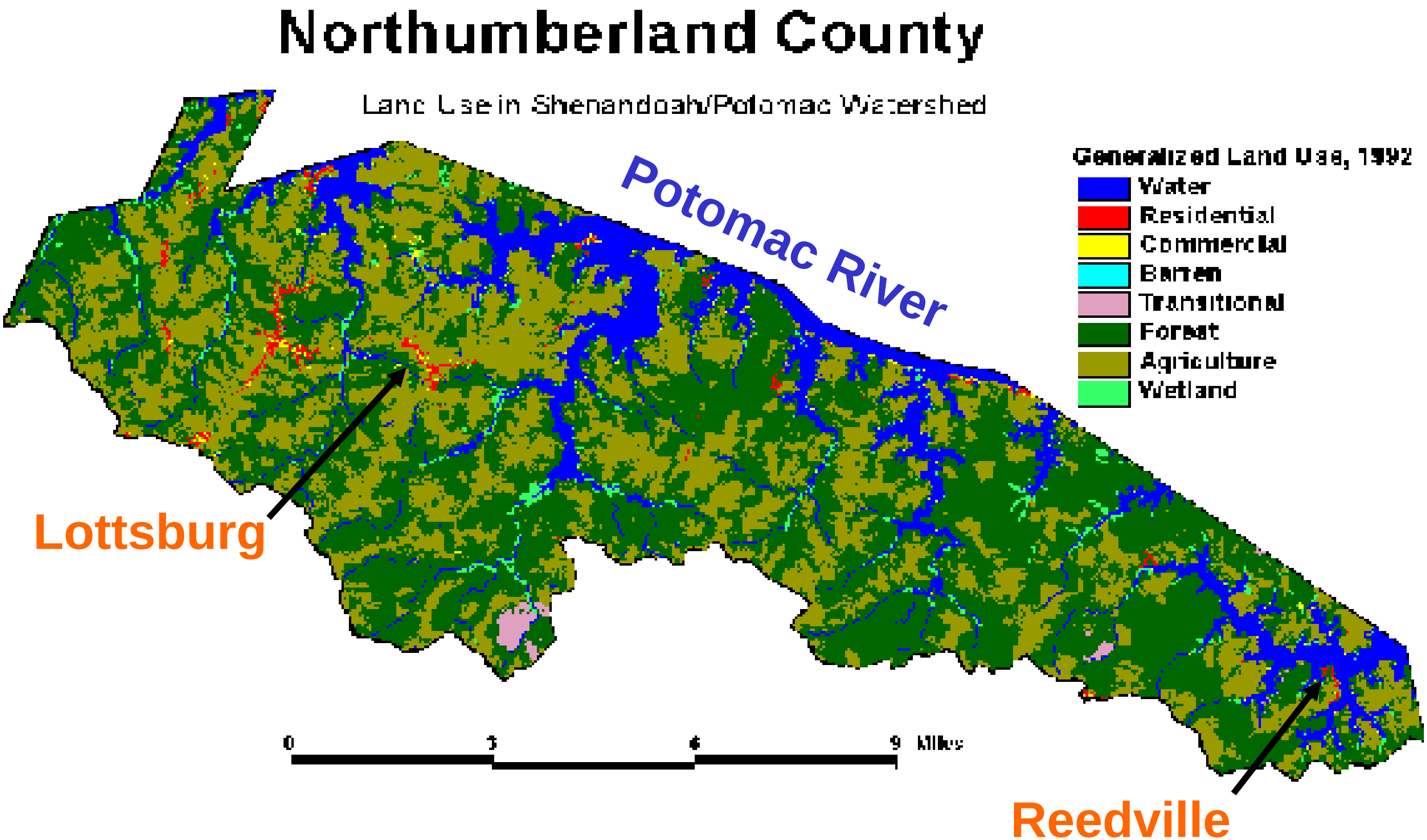
King George County

Land Use in Shenandoah/Potomac Watershed




Stafford County
Land Use in the
Shenandoah/Potomac
Watershed
Stafford
Aquia Creek
Potomac Creek
Generalized Land Use, 1992
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland


Colonial Beach
Westmoreland County
Land Use in Shenandoah/Potomac Watershed
Potomac River
Generalized Land Use, 1992
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland
0 3 6 9 Miles


Northumberland County
Land Use in Shenandoah/Potomac Watershed
Generalized Land Use, 1992
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland
Potomac River
Lottsburg
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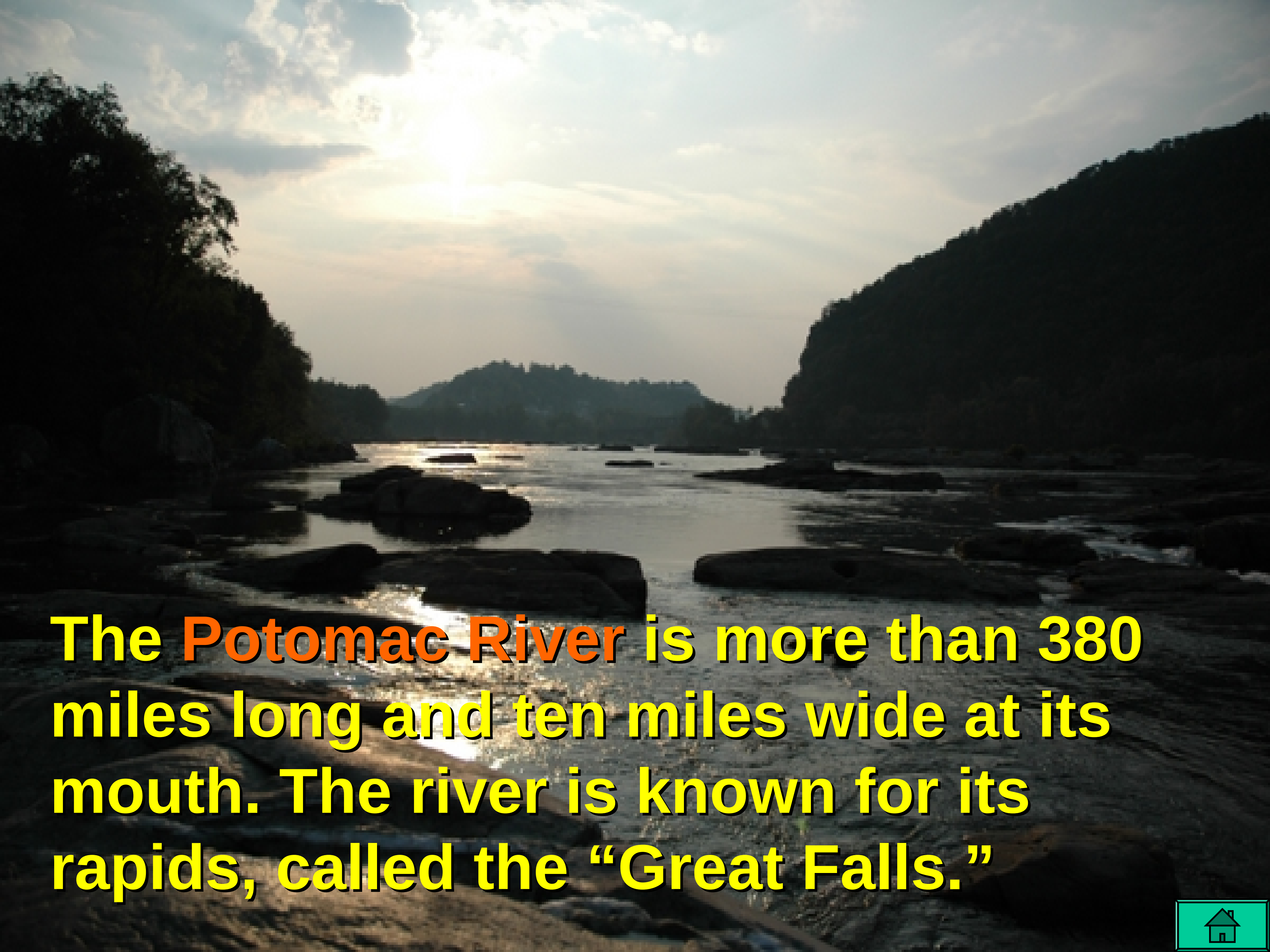
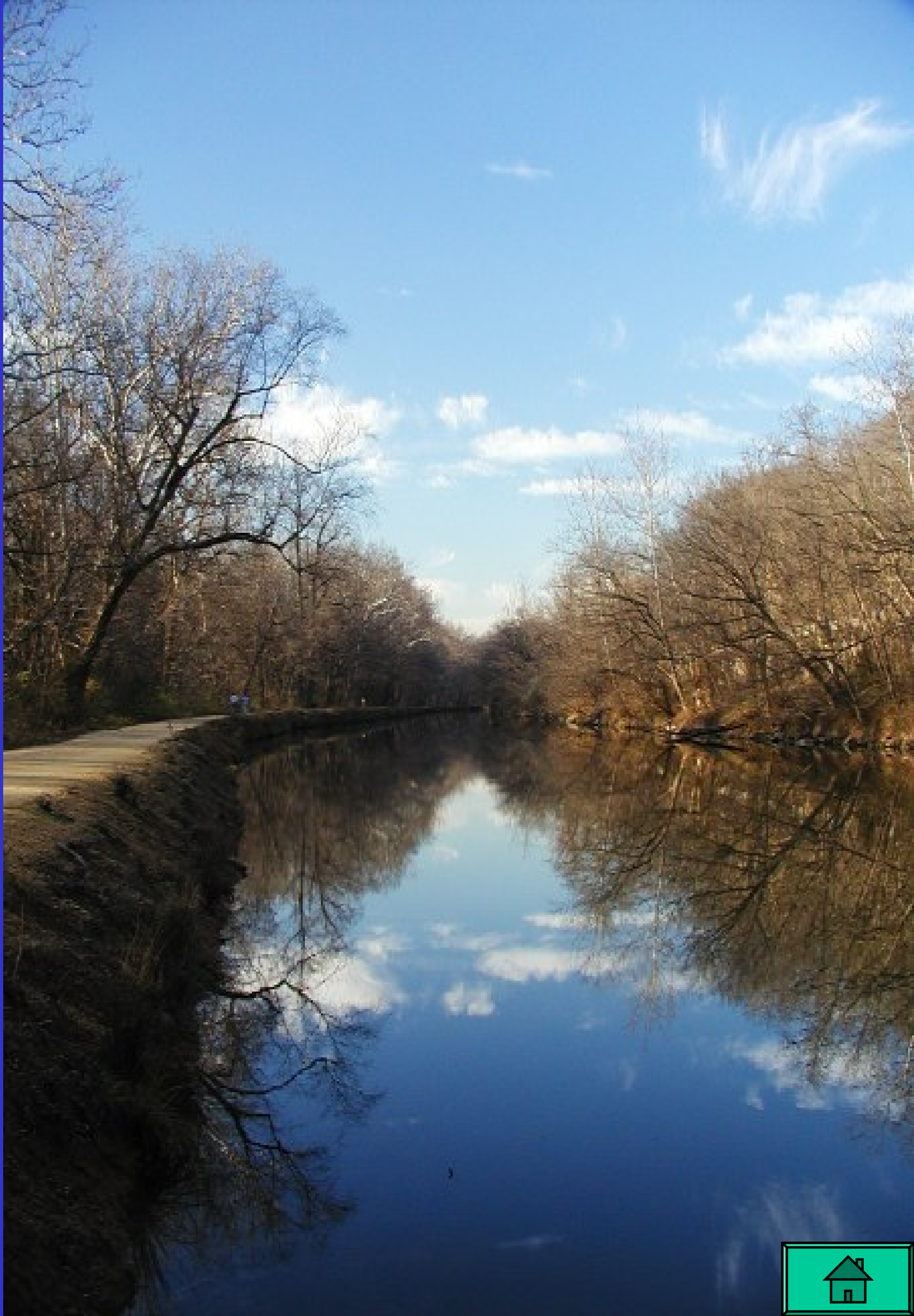
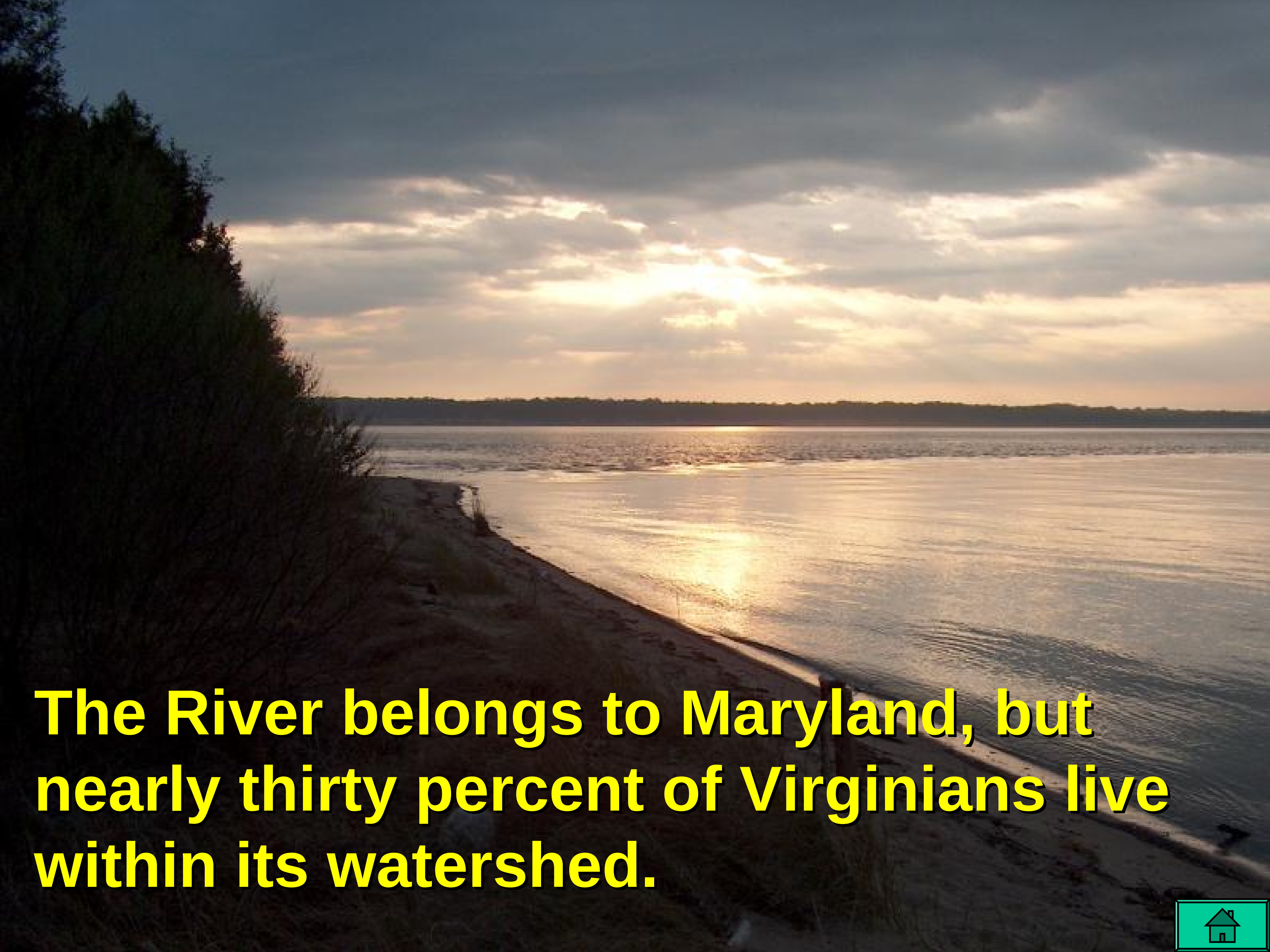
Miles


The Potomac River is more than 380 miles long and ten miles wide at its mouth. The river is known for its rapids, called the "Great Falls."

The Chesapeake and Ohio Canal was built around the Great Falls in the 1800s. This made the Potomac an important shipping route. Today, this canal system is a national park.



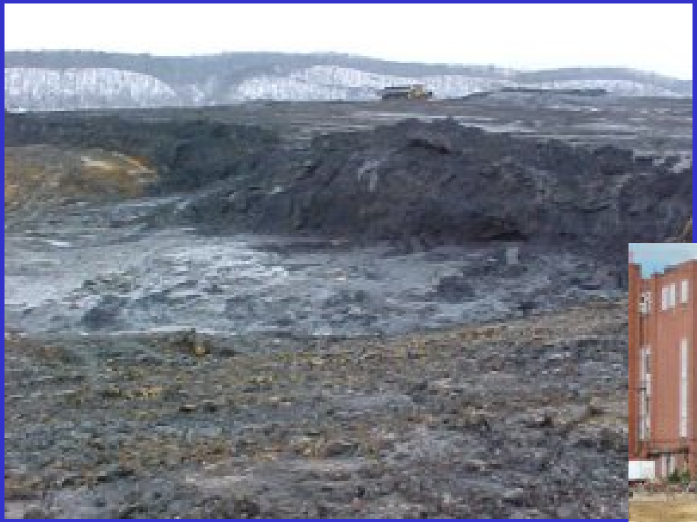

The River belongs to Maryland, but nearly thirty percent of Virginians live within its watershed.

The Shenandoah River is the Virginia tributary of the Potomac. The Shenandoah, which means “Daughter of the Stars,” is considered one of Virginia’s most beautiful rivers.


Despite its beauty, pollution has taken a heavy toll. Sediment and nutrient loading from livestock, agricultural and urban sources have affected water quality.

Both the North and South Forks of the Shenandoah are polluted with PCB. The Avtex Corporation, closed in 1989, was responsible for the pollution.

Reclaimed land becomes a soccer field



Fly ash storage area

Avtex Plant demolition

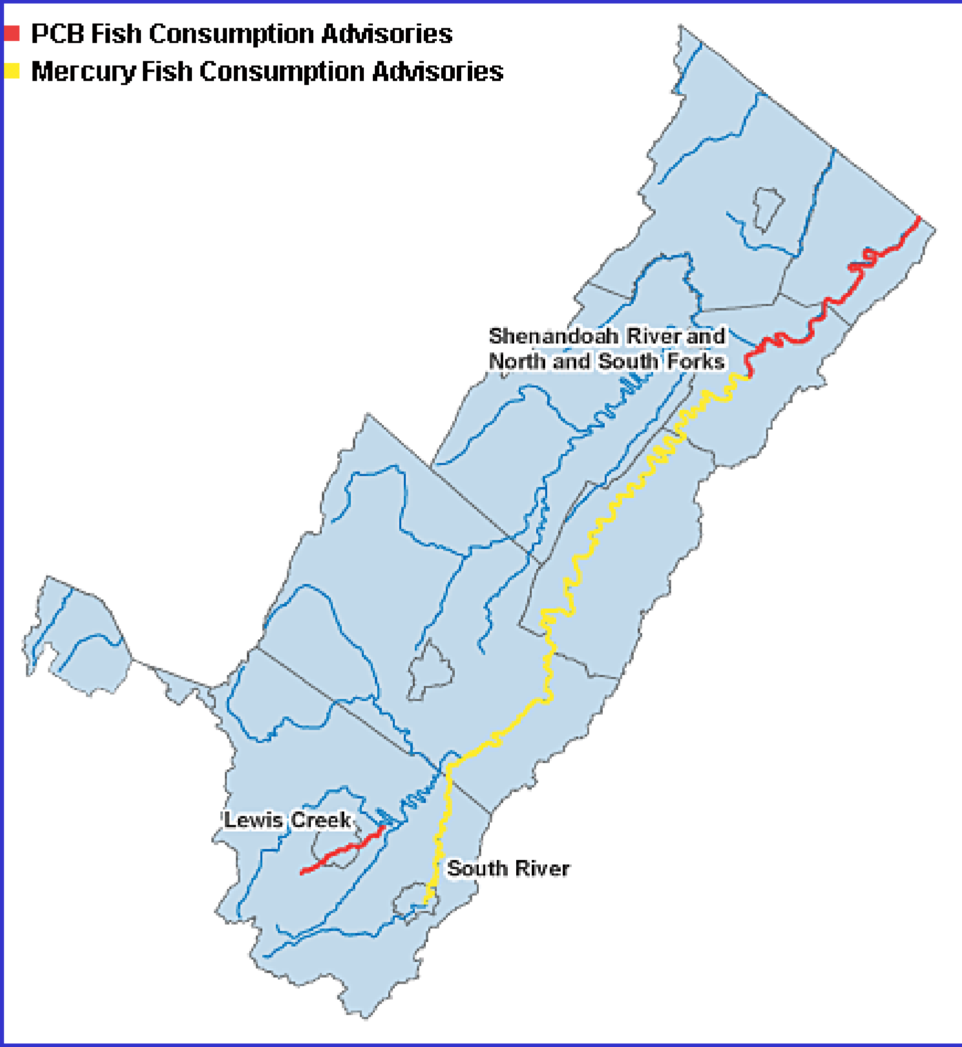
In addition, the former Dupont - Nemours factory released mercury into the South Fork from 1929 to 1950.

Dangerous Mercury Polluting Shenandoah River

Environmental Groups Plan to Sue DuPont to Force Cleanup

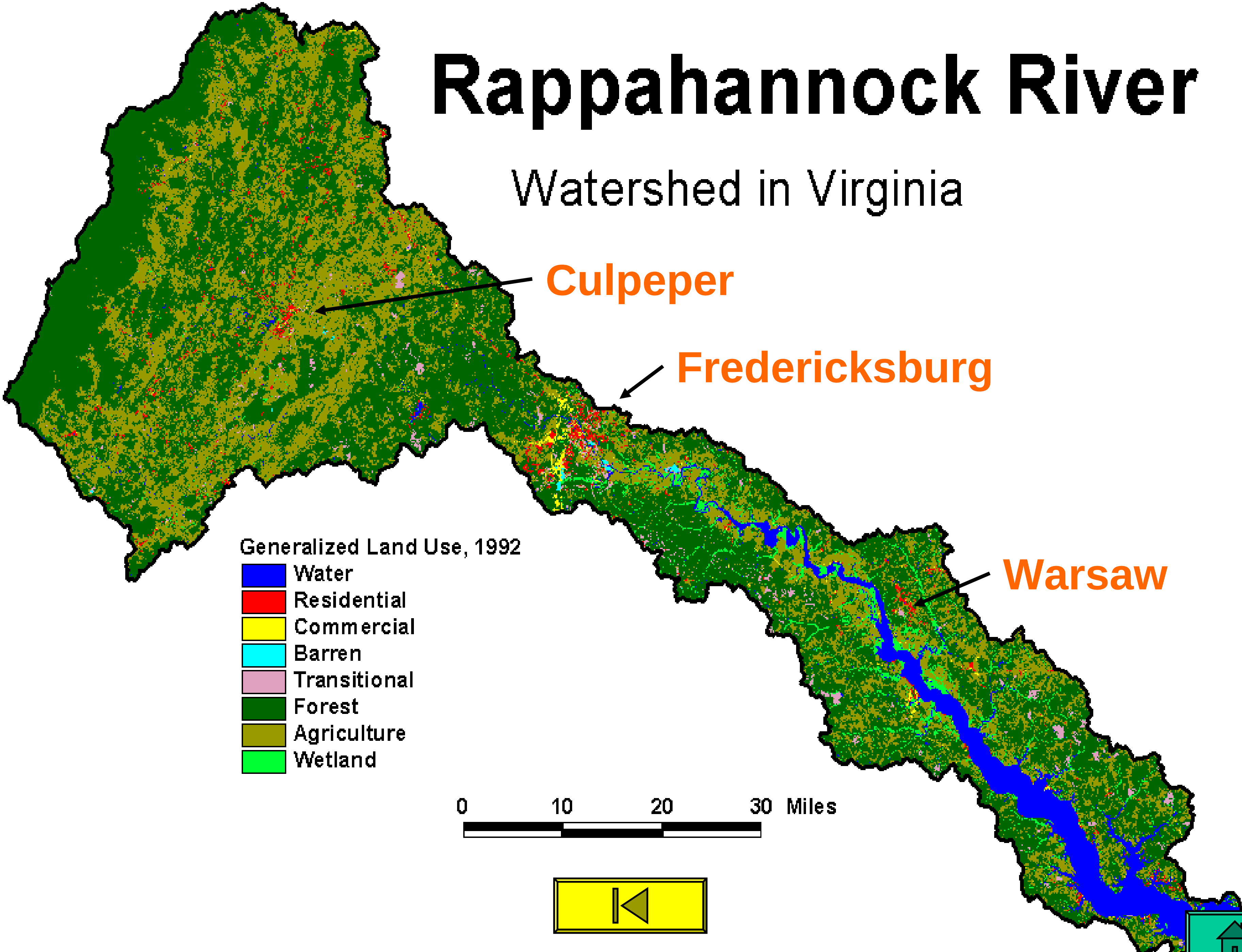
RICHMOND, Virginia (October 20, 2003) -- Two environmental groups will sue DuPont to force a cleanup of mercury from the South River and the South Fork of the Shenandoah River because of health risks for people who eat fish from those waters.

Fish advisories remain in effect today. State and local agencies are working to reduce pollution levels. However, this river will not see a clean bill of health for many years to come.



Rappahannock River

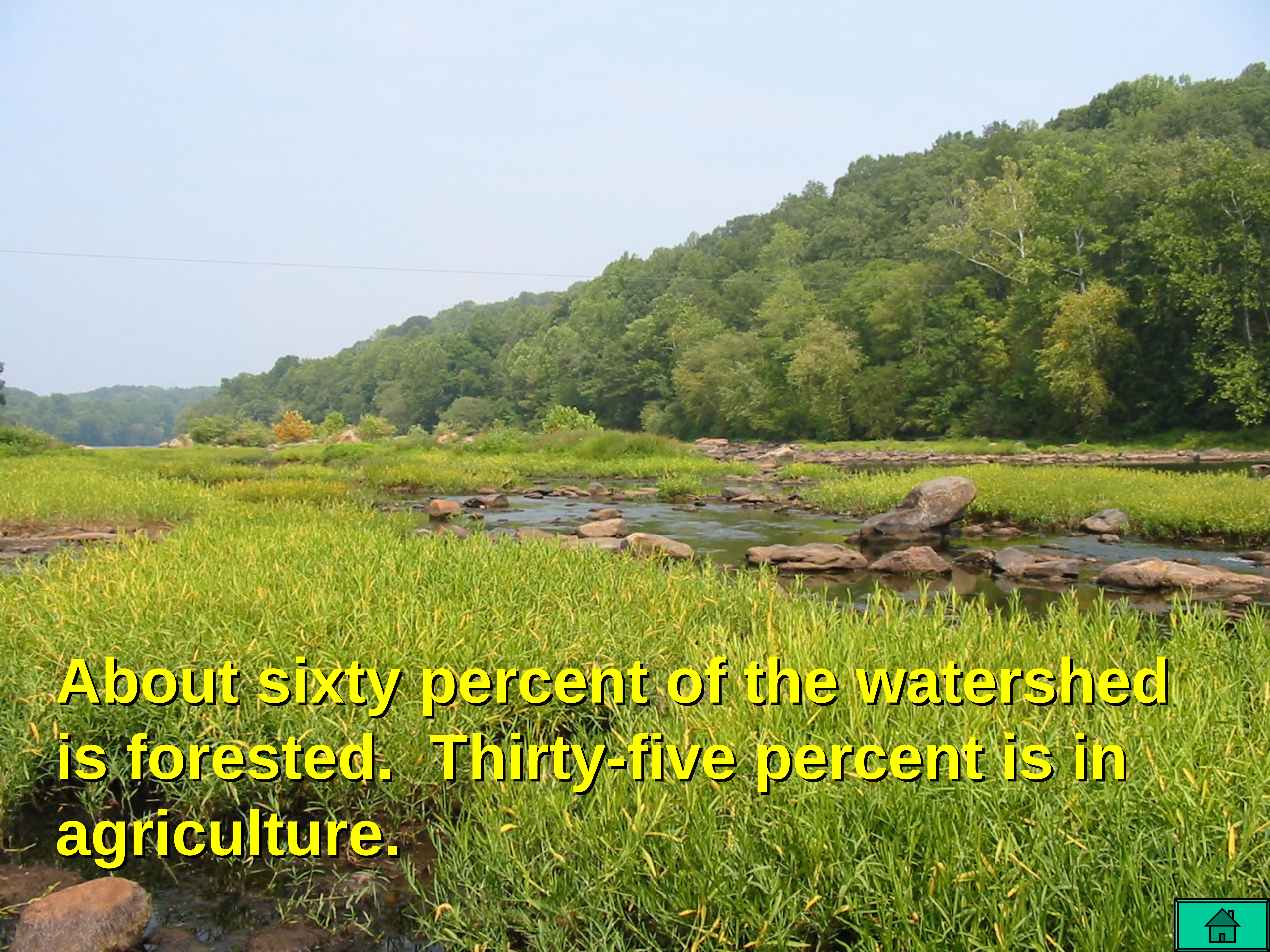
Watershed in Virginia

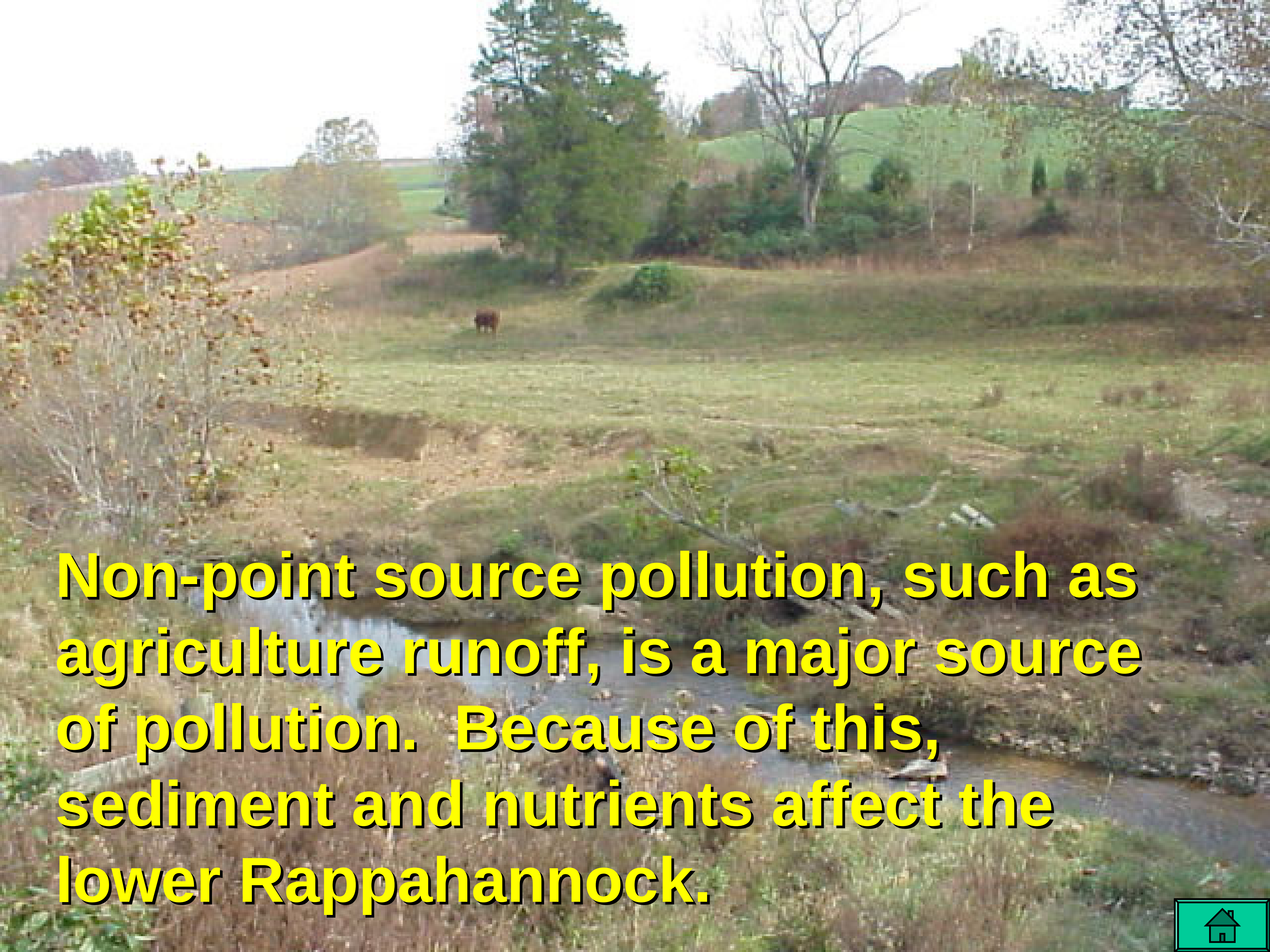


The Rappahannock River was named for the Native American Tribe who were called the "people of the alternating stream." This is because the river has strong tidal flows.

It is 184 miles long and one of the cleanest rivers on the East Coast. Its major tributary, the Rapidan, was originally called the Rapid Ann in honor of Queen Ann.

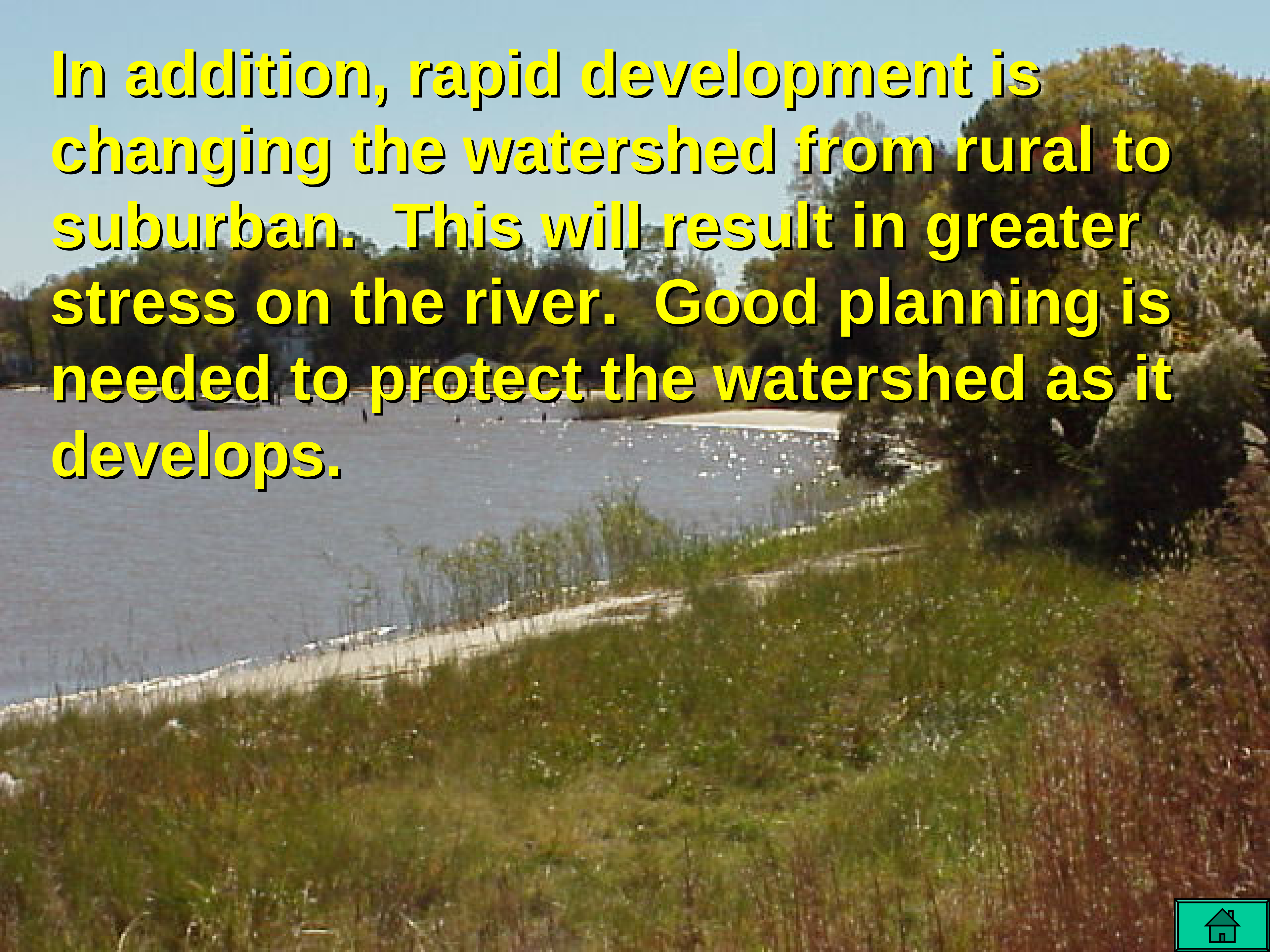
Fredericksburg is located along the River at the fall line. Canals were built during the 1700s and 1800s to move goods around the rapids of the river. Today, the rapids provide excellent whitewater recreation.

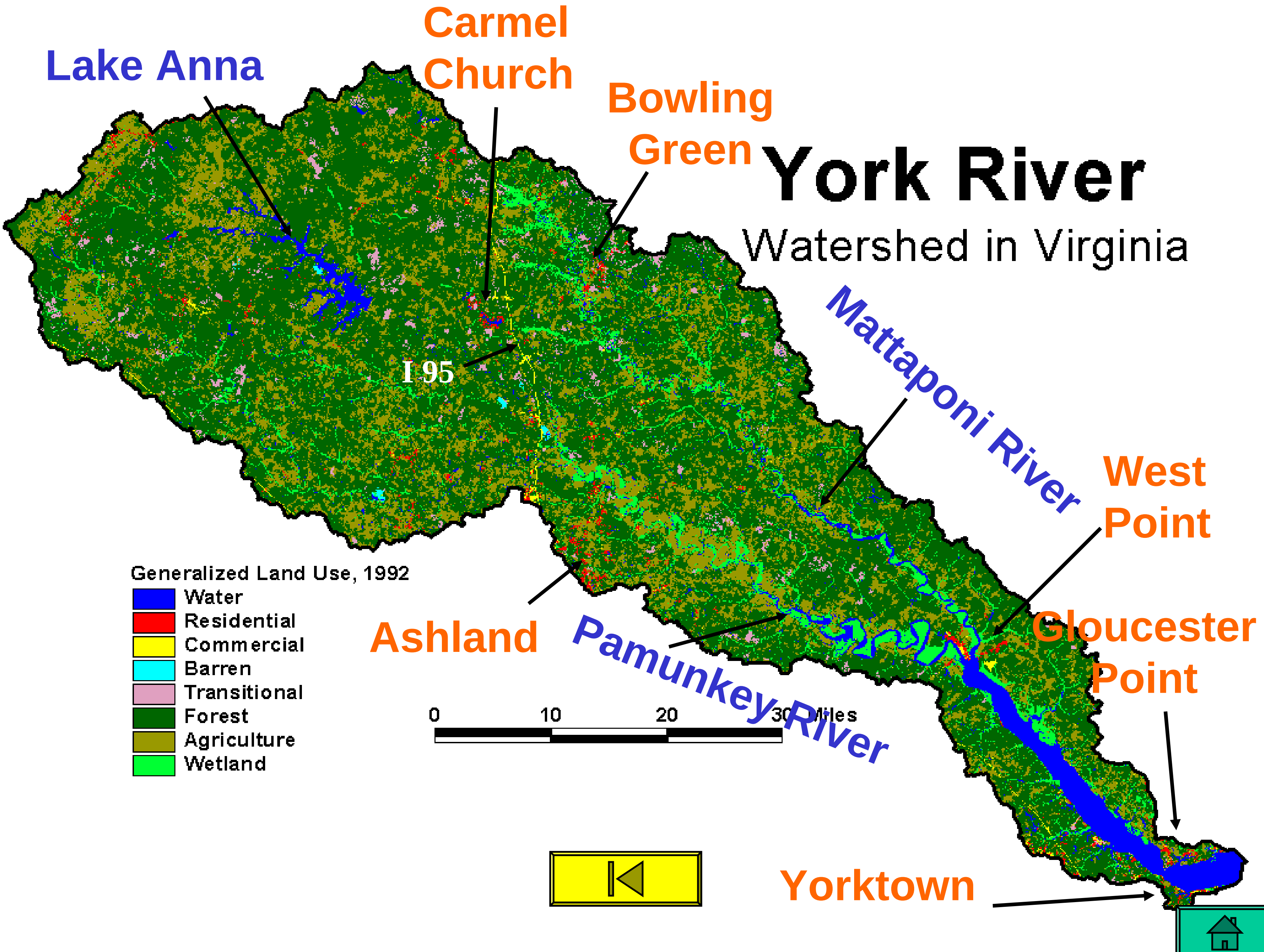

About sixty percent of the watershed
is forested. Thirty-five percent is in
agriculture.


Non-point source pollution, such as
agriculture runoff, is a major source
of pollution. Because of this,
sediment and nutrients affect the
lower Rappahannock.

Oyster and shad harvests have dwindled to a fraction of earlier times. Over-harvest and diseases have taken a toll. Dams reduced fish migrations.

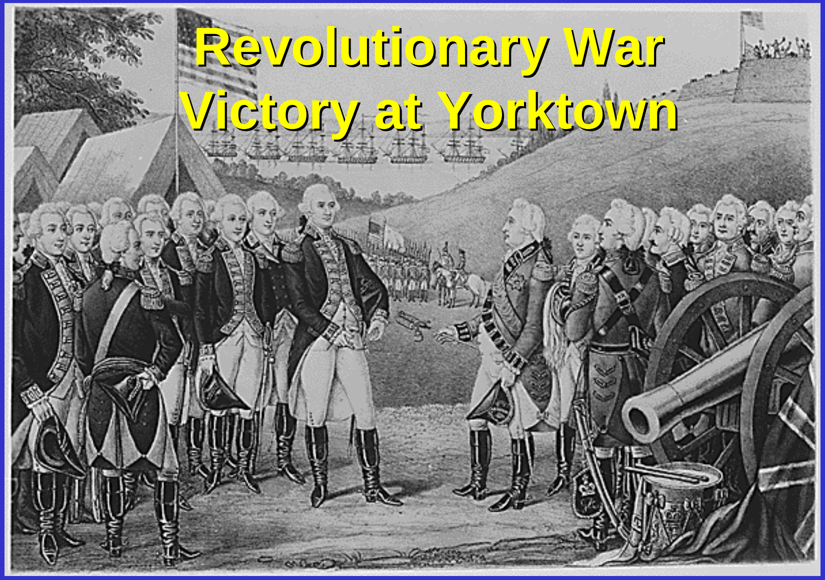
In addition, rapid development is changing the watershed from rural to suburban. This will result in greater stress on the river. Good planning is needed to protect the watershed as it develops.

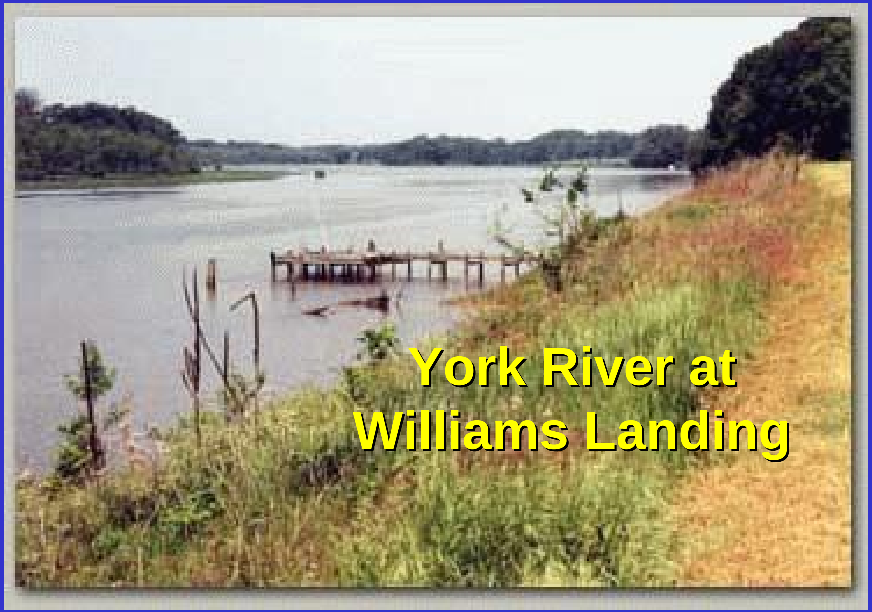


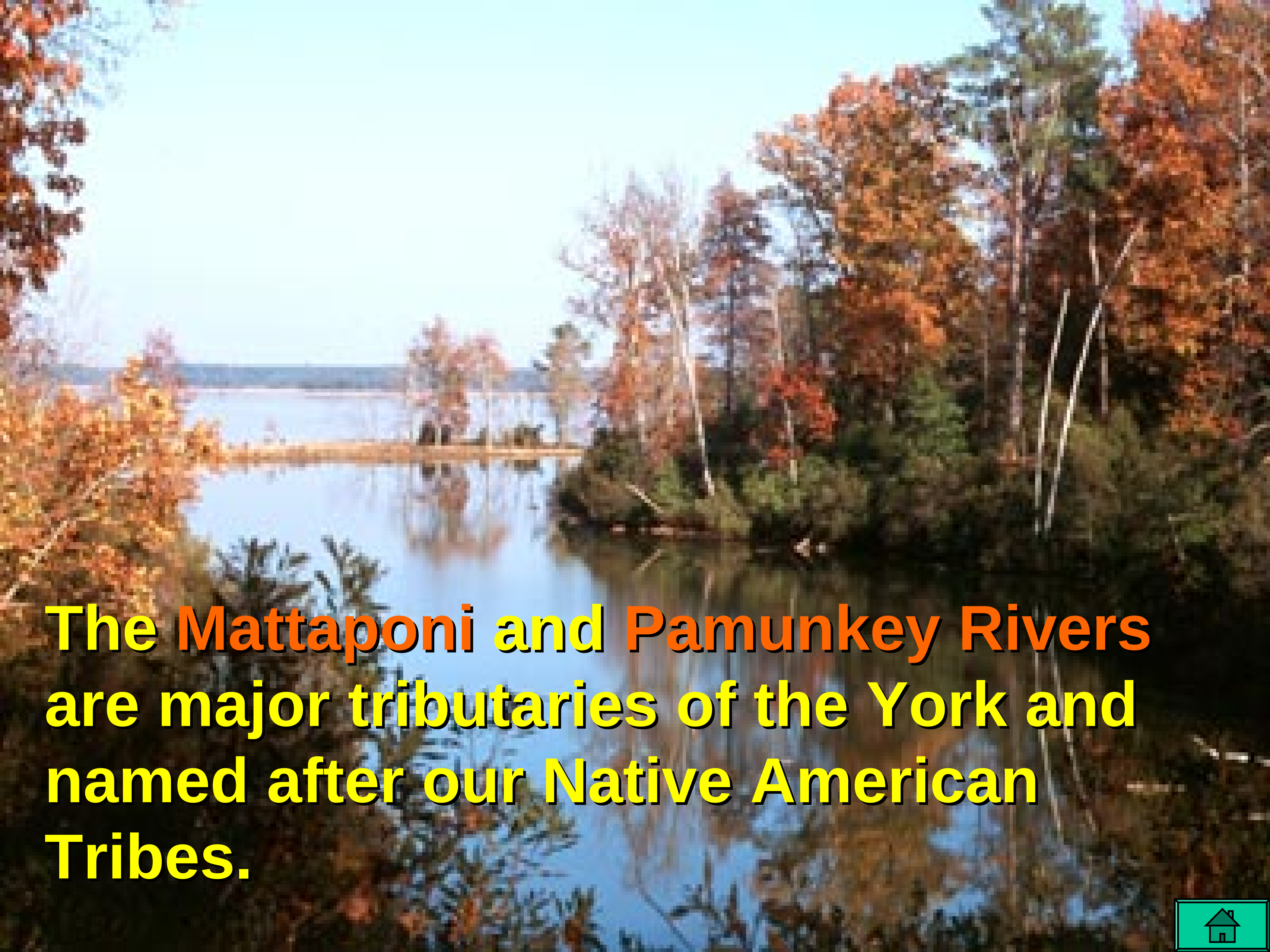

York River
Watershed in Virginia
Lake Anna
Carmel Church
Bowling Green
I 95
Mattaponi River
West Point
Gloucester Point
Ashland
Pamunkey River
Yorktown
Generalized Land Use, 1992
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland
0
10
20
30 Miles

English settlers changed the Indian name, Pamunkee River, to York in honor of Charles I, Duke of York.

The port of Yorktown was one of Virginia's best inland harbors in Colonial times. It was very important in the nation's early history.



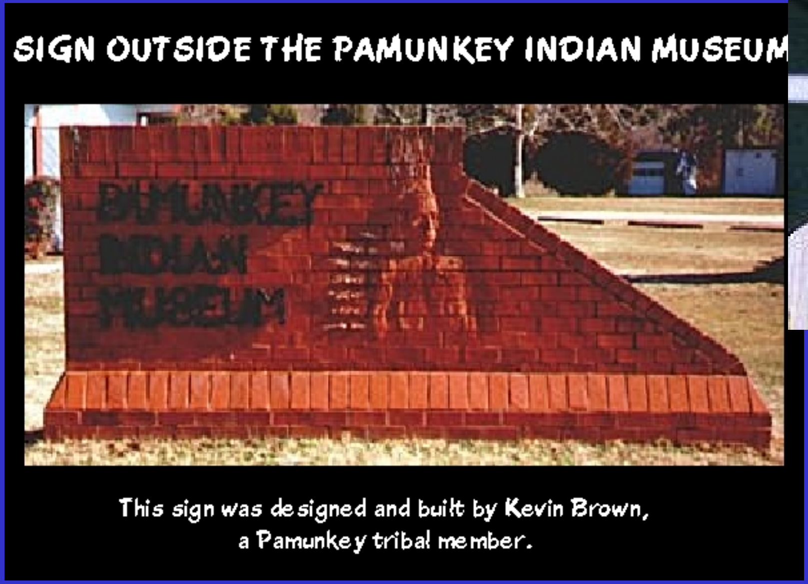




The Mattaponi and Pamunkey Rivers are major tributaries of the York and named after our Native American Tribes.

Their culture and community presence are an important part of Virginia’s living history.

Chief William P. Miles,
Pamunkey Tribal Government



Chief Webster “Little Eagle” Custalow, Mattaponi Tribal Government

Mattaponi Shad Hatchery

The Mattaponi has three branches, the Matta, the Po and the Ni. Tributaries of the Pamunkey include the North and South Anna Rivers. Virginia Power's North Anna Nuclear Power Plant is located here.

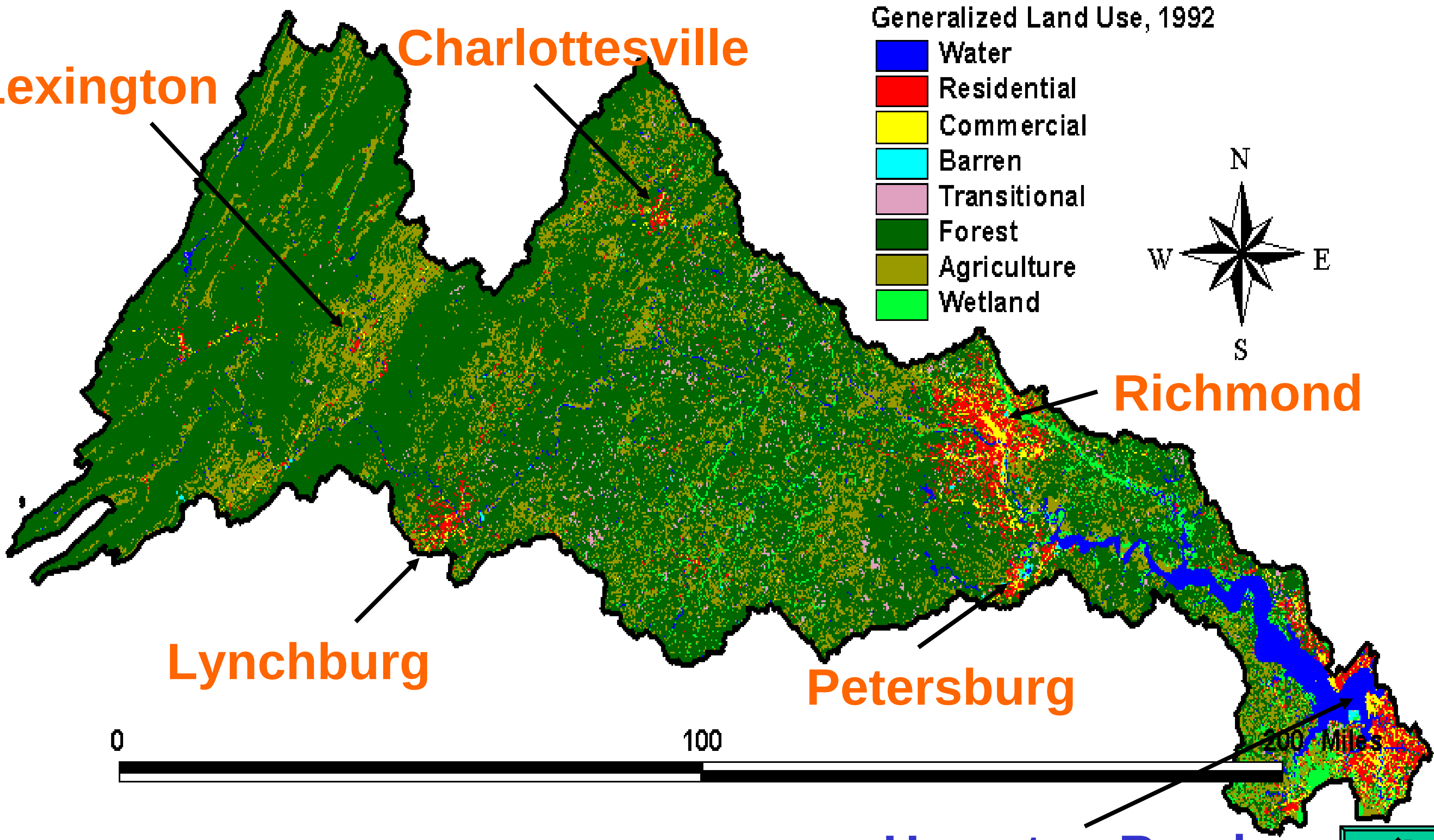
The York is 140 miles long. Its watershed covers about twelve percent of the state.

It is about seventy percent forested and has a low population density. However, it may see rapid growth as populations in northeast and southeast Virginia soar.

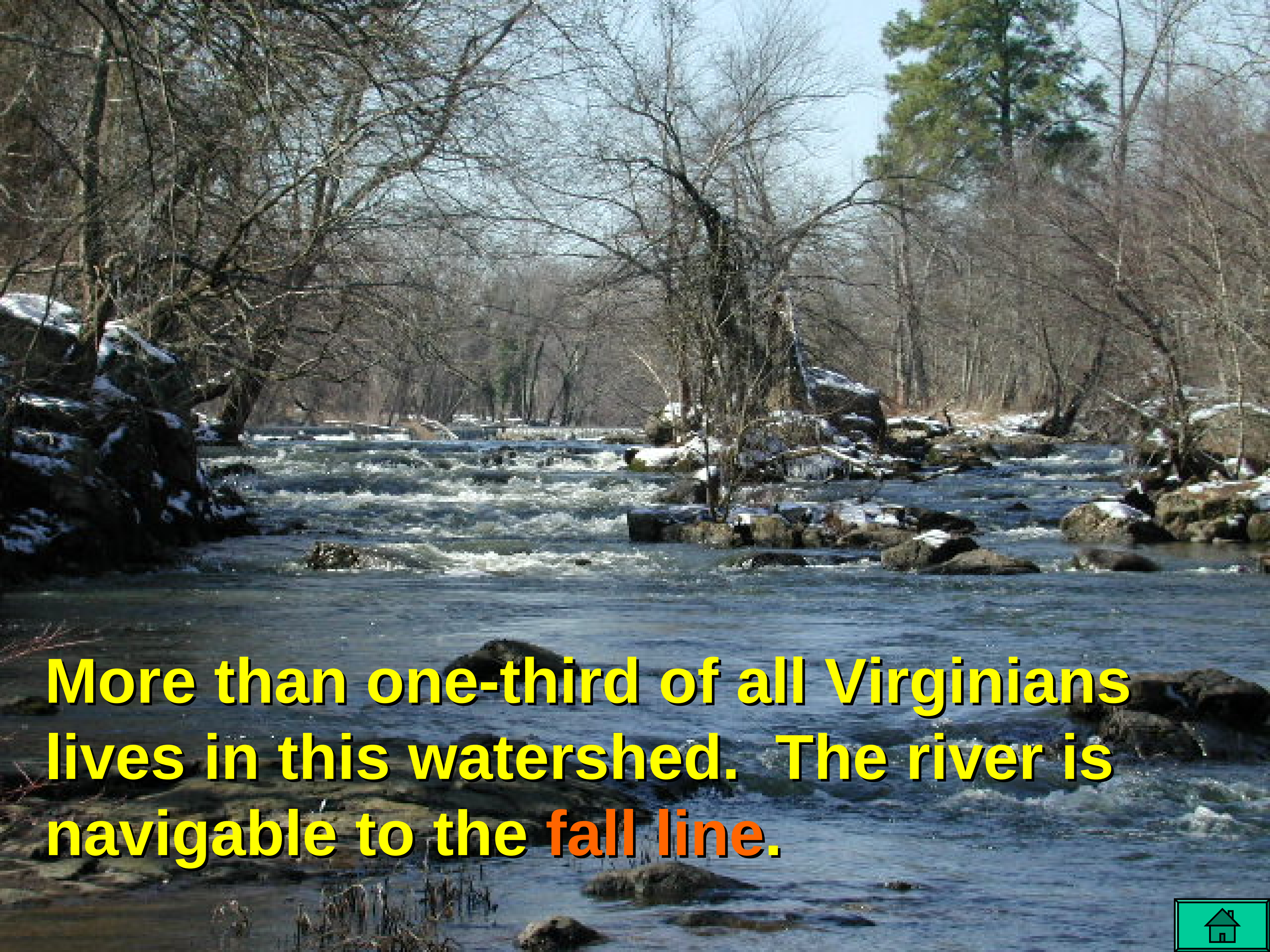
Much of the upper York has good water quality. However, the lower York has water quality problems similar to those of the James River – excess sediment and nutrients.

James River

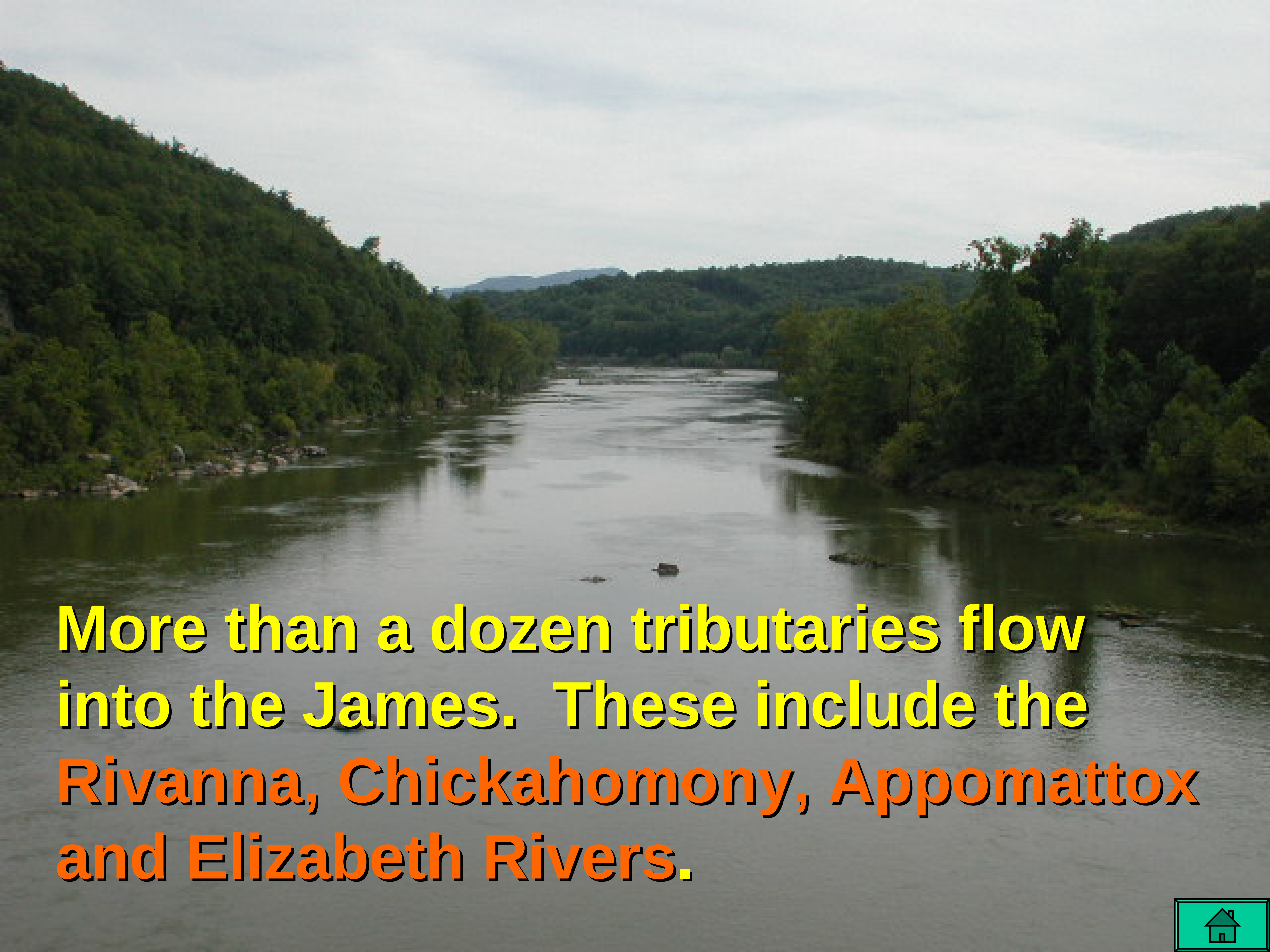
Watershed in Virginia

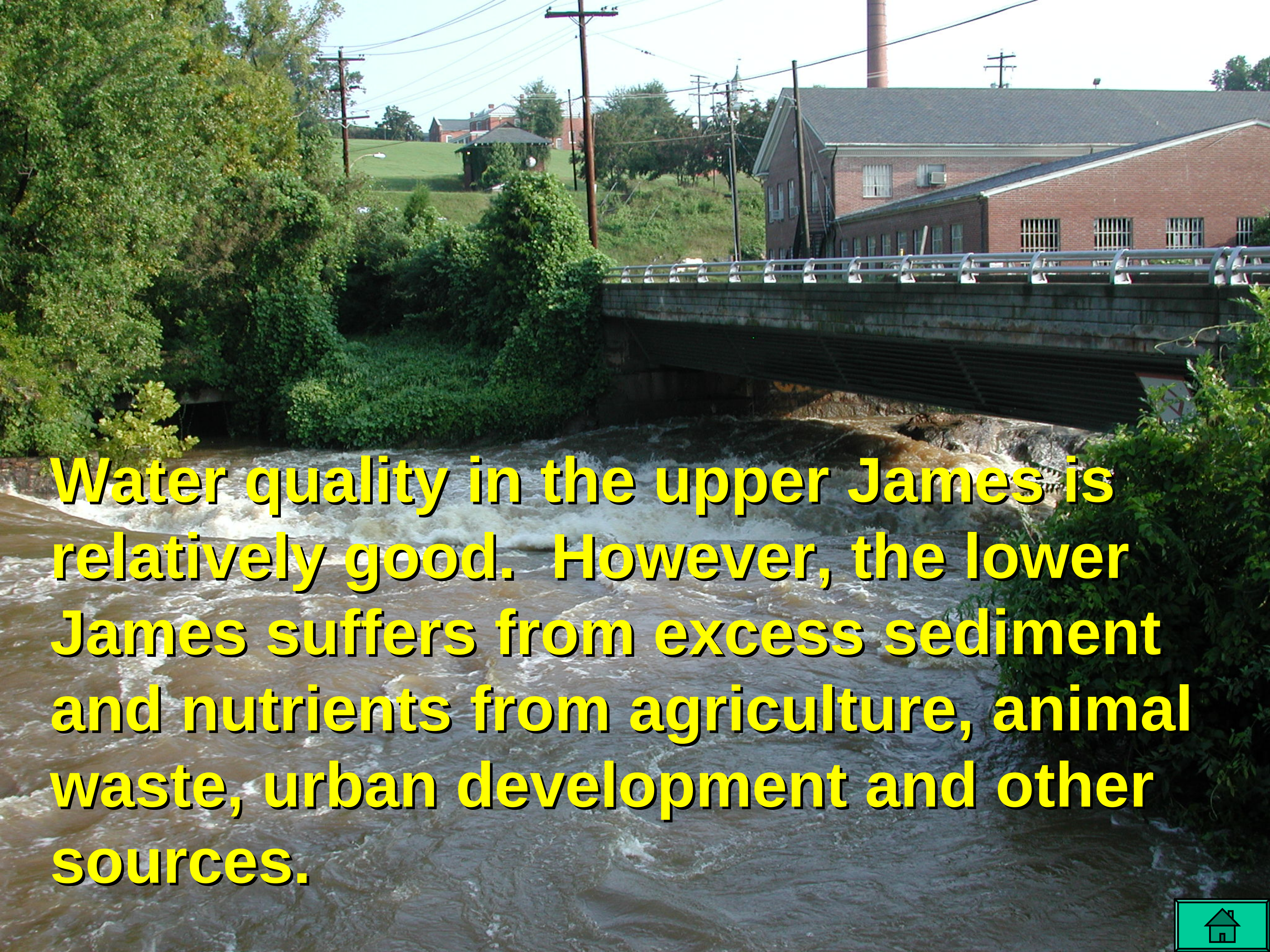


Native Americans called the river the Powhatan. English settlers renamed it after King James I. The **James River** is 340 miles long and drains almost one-fourth of the state.

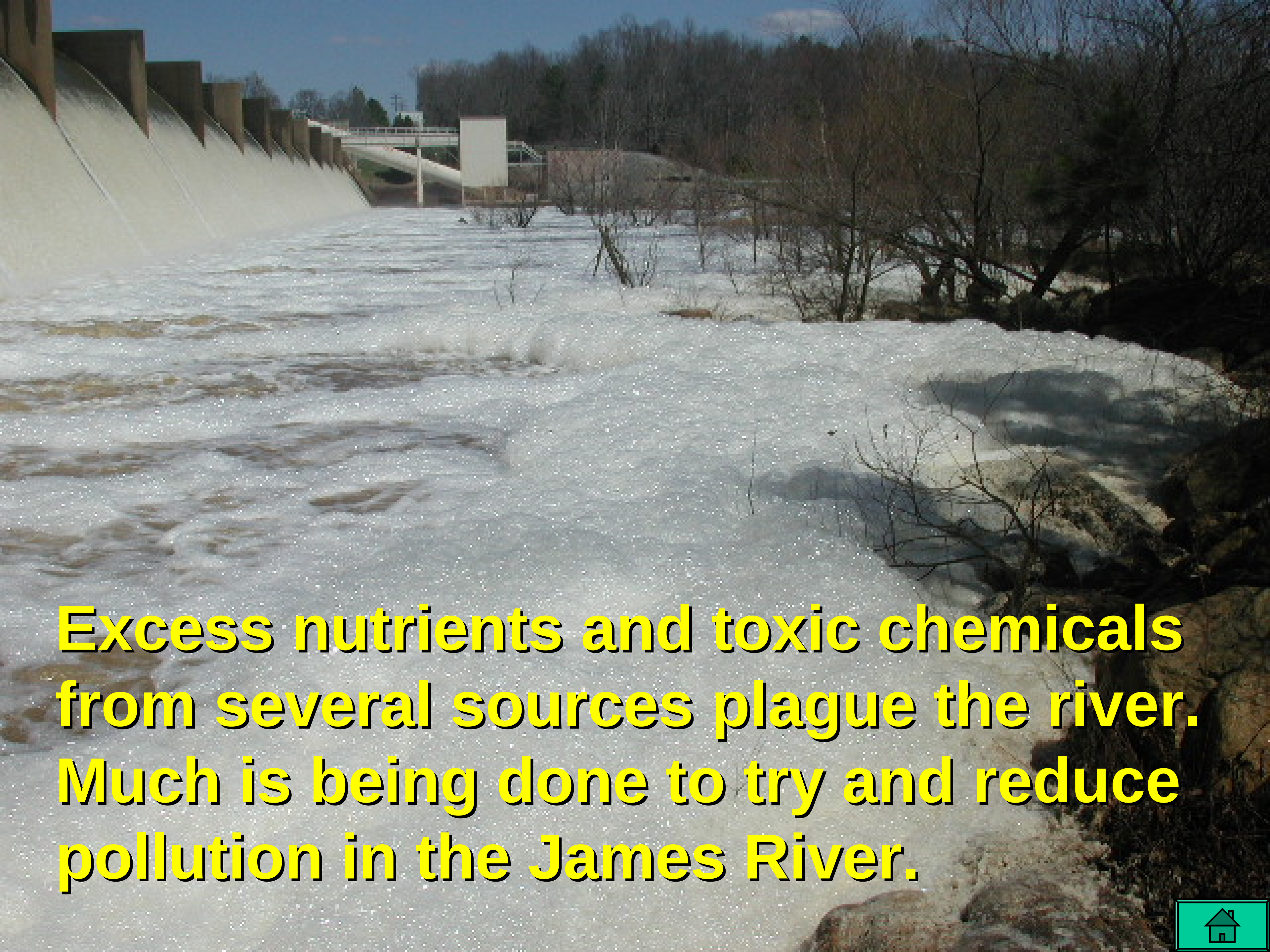

More than one-third of all Virginians lives in this watershed. The river is navigable to the fall line.

The James River has three ports: Hopewell, Richmond and, one of the nation’s busiest, Hampton Roads.

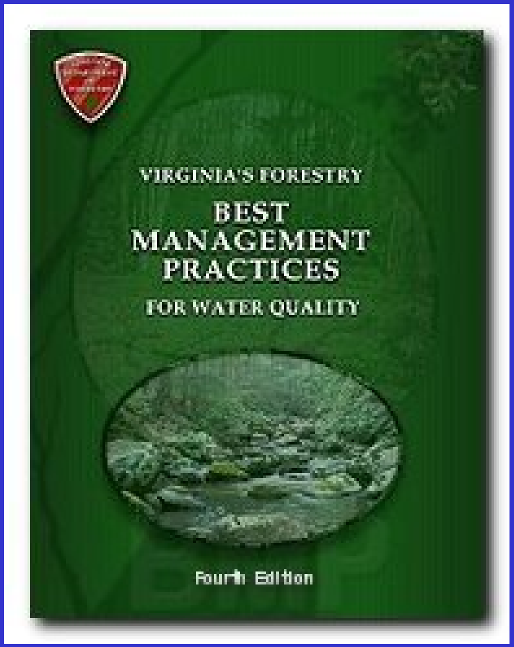

More than a dozen tributaries flow into the James. These include the Rivanna, Chickahomony, Appomattox and Elizabeth Rivers.



Water quality in the upper James is relatively good. However, the lower James suffers from excess sediment and nutrients from agriculture, animal waste, urban development and other sources.


Excess nutrients and toxic chemicals from several sources plague the river. Much is being done to try and reduce pollution in the James River.

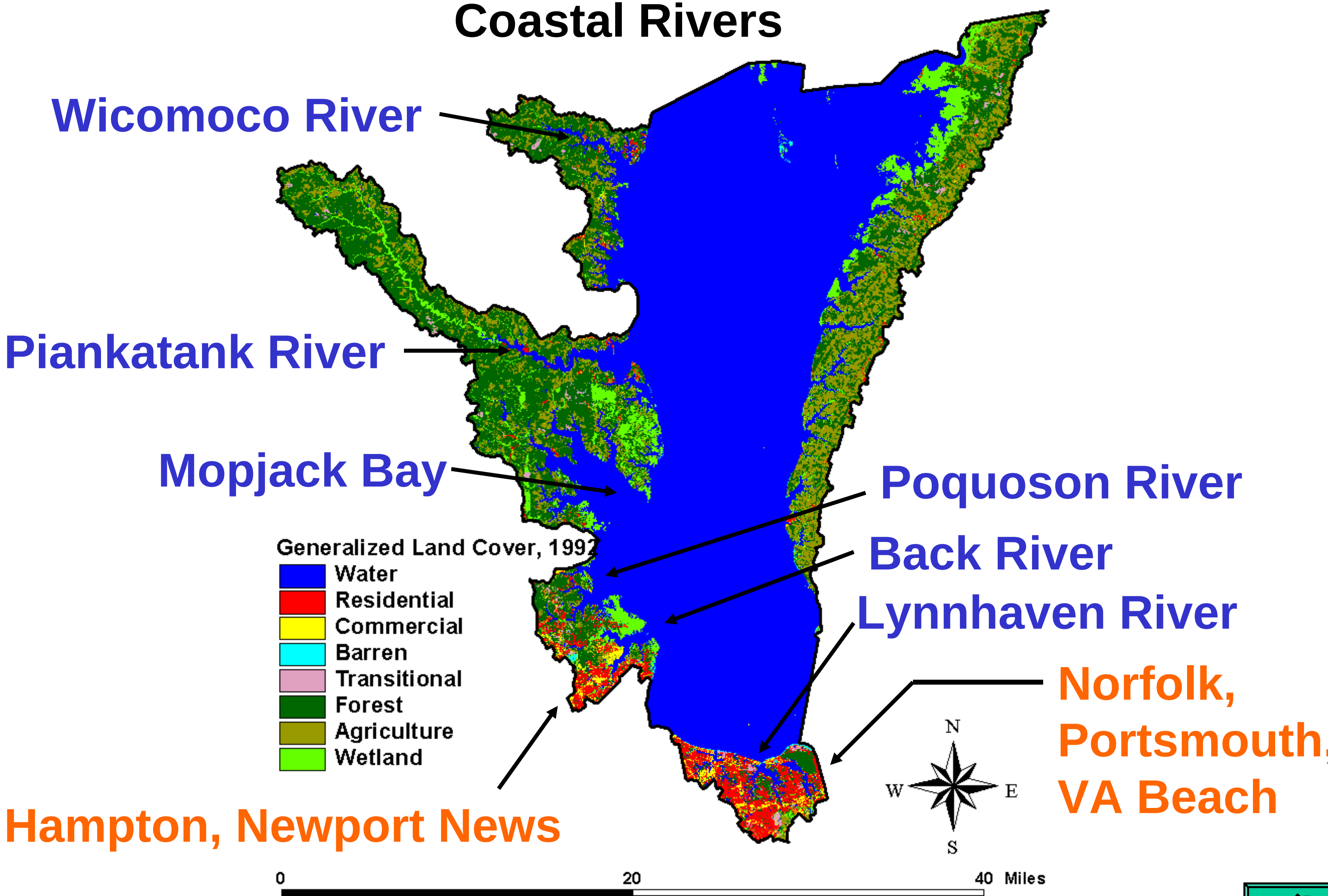
You can help by adopting effective Best Management Practices for your home, farm, school and community.

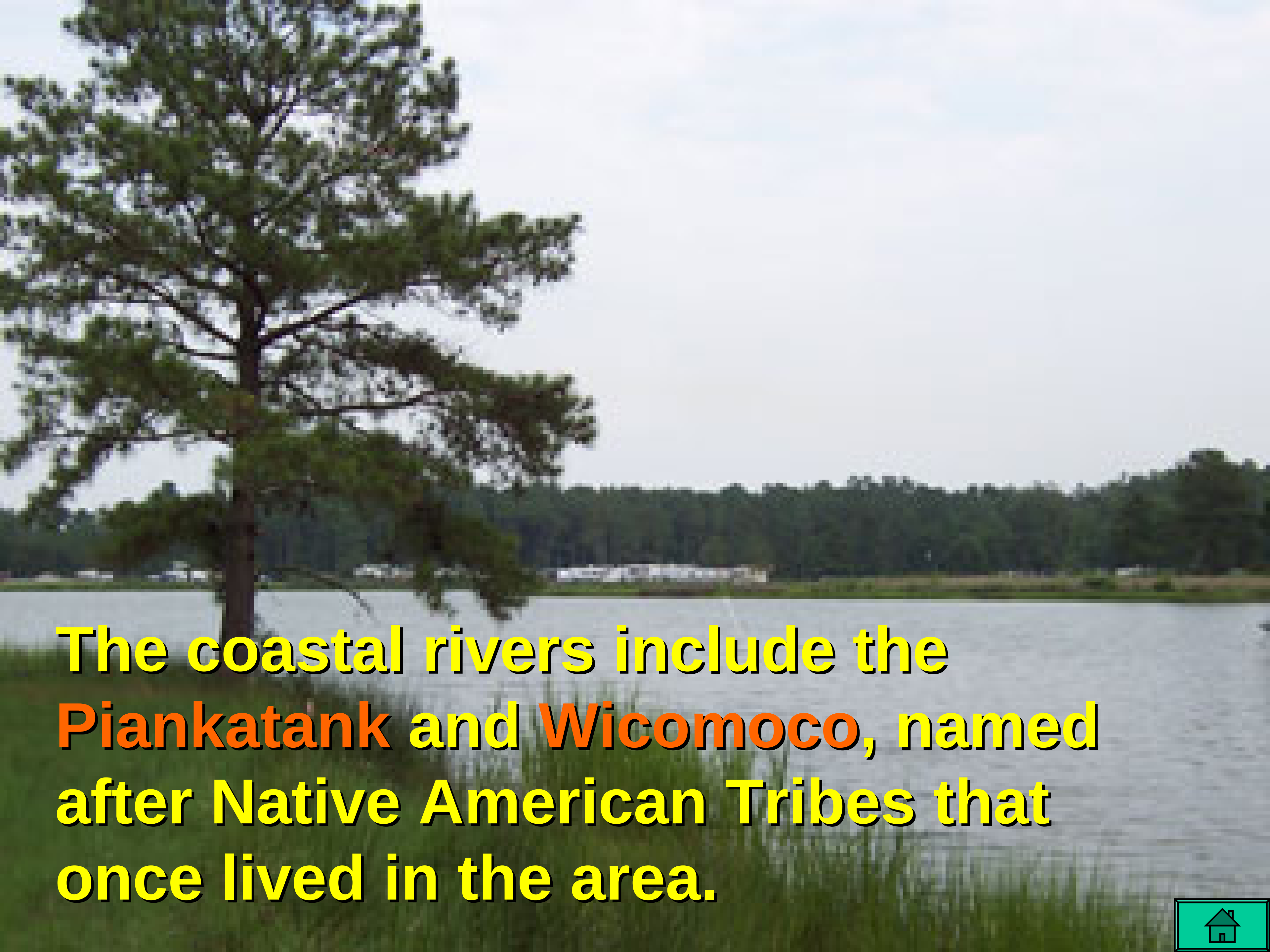


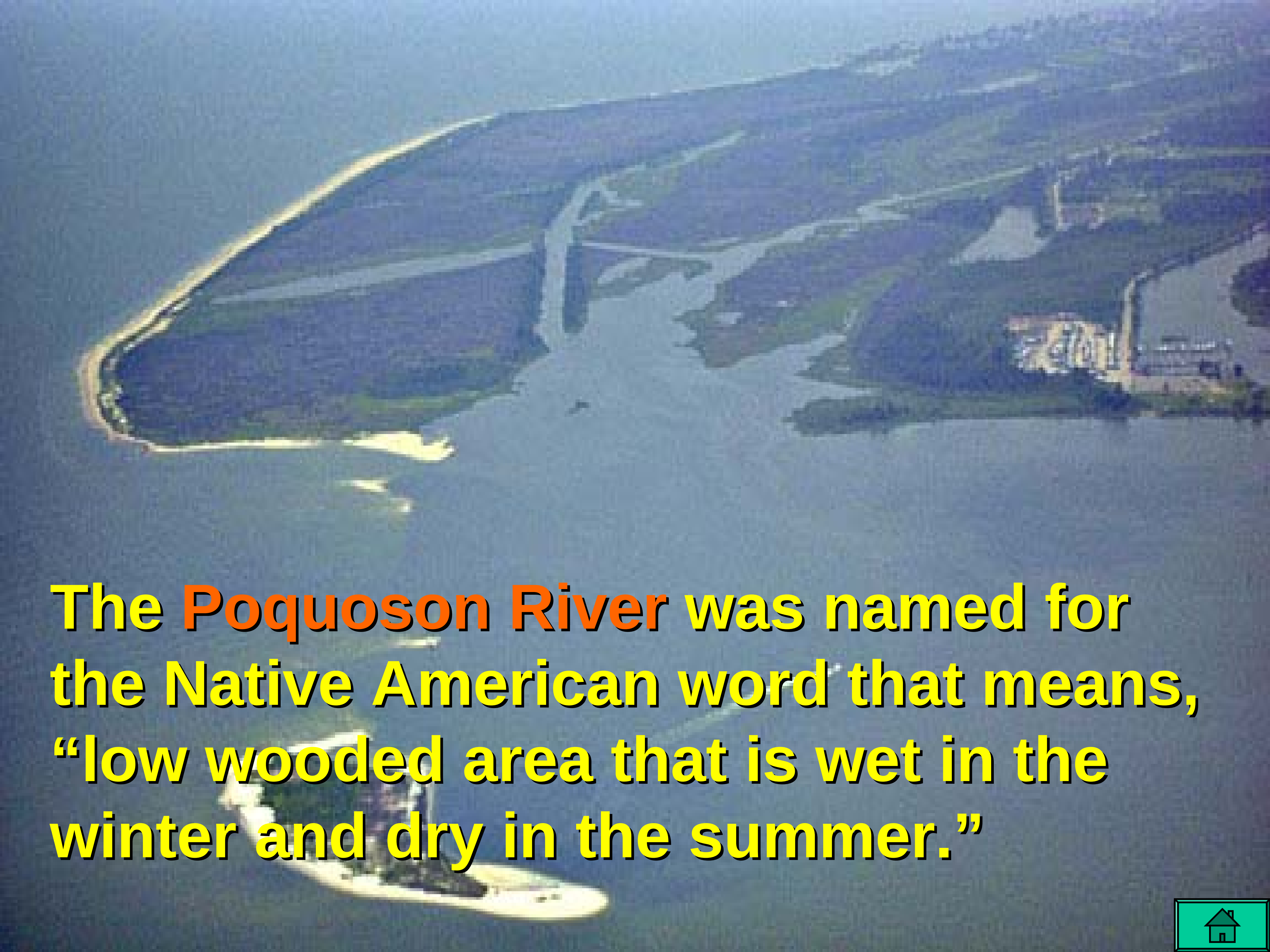
Give Water A Hand

Chesapeake Bay

Coastal Rivers



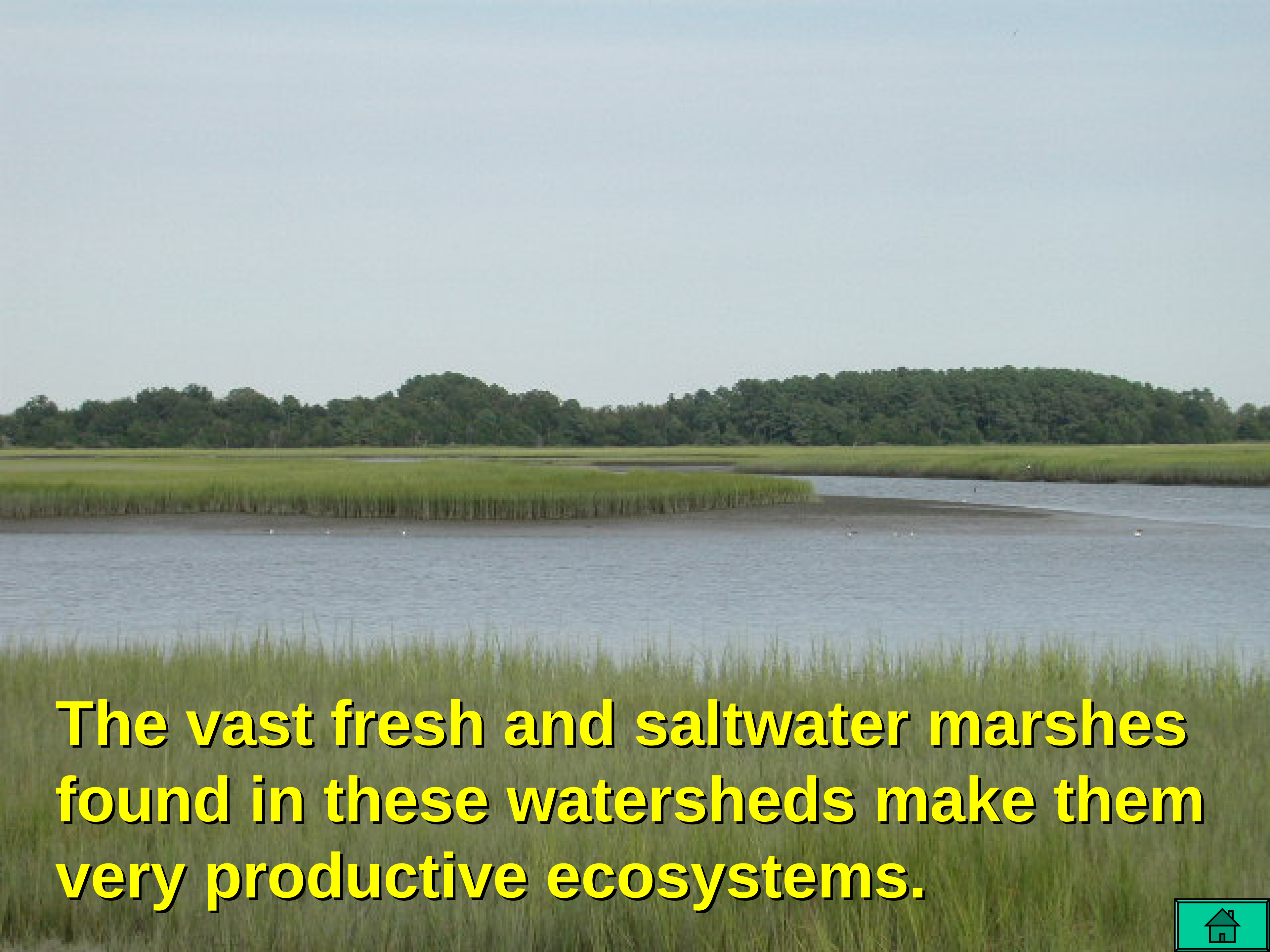

The coastal rivers include the Piankatank and Wicomoco, named after Native American Tribes that once lived in the area.



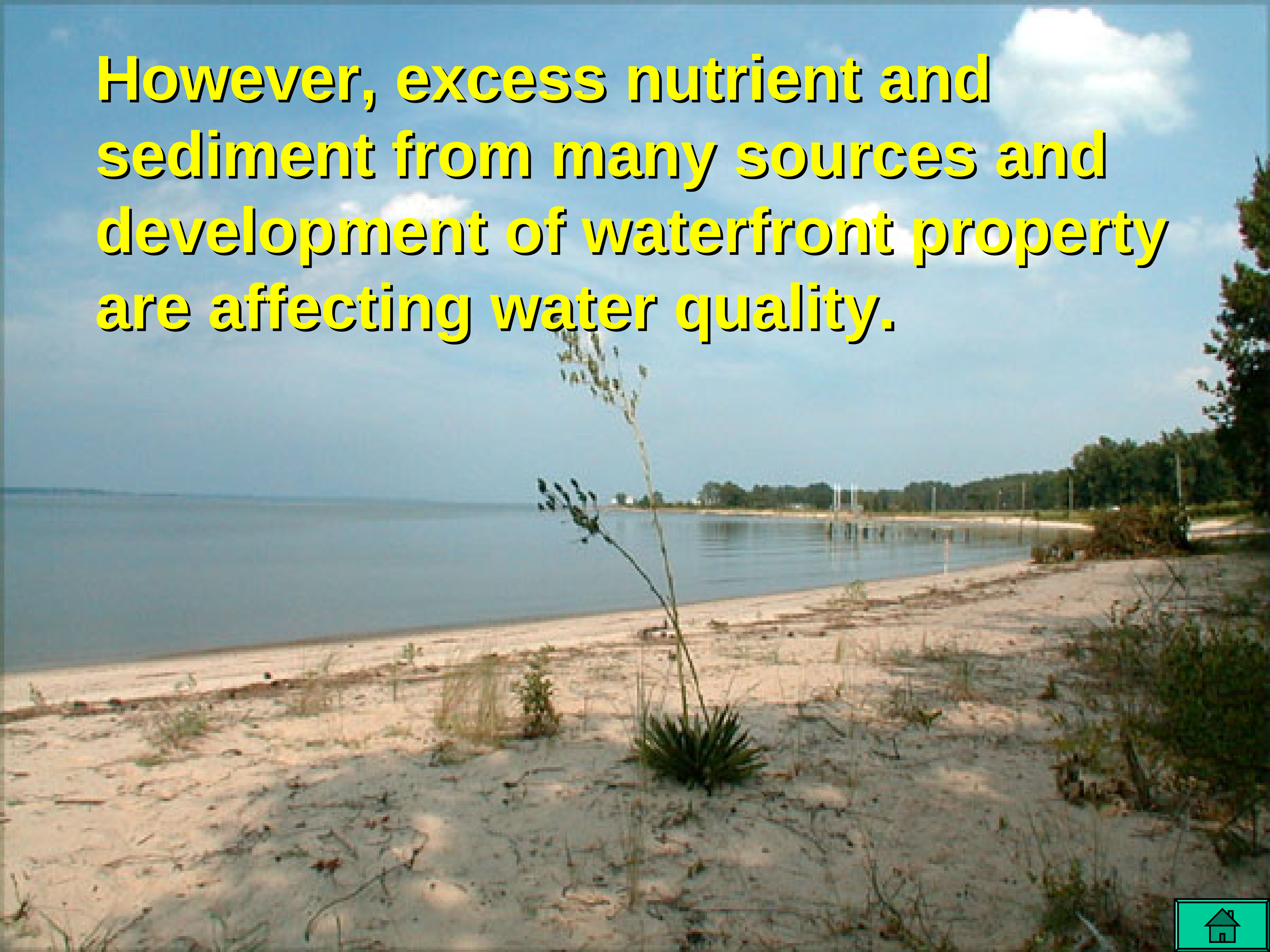
The Poquoson River was named for the Native American word that means, “low wooded area that is wet in the winter and dry in the summer.”

These watersheds, the **Lynnhaven River** and others support important industries. Commercial and sport fishing are big business.

In addition, vegetable, fruit and livestock farming, wood products and military bases are very important to the region's economy.


The vast fresh and saltwater marshes found in these watersheds make them very productive ecosystems.

However, excess nutrient and sediment from many sources and development of waterfront property are affecting water quality.



Communities are required to follow guidelines of the Chesapeake Preservation Act that will help control and reduce pollution.

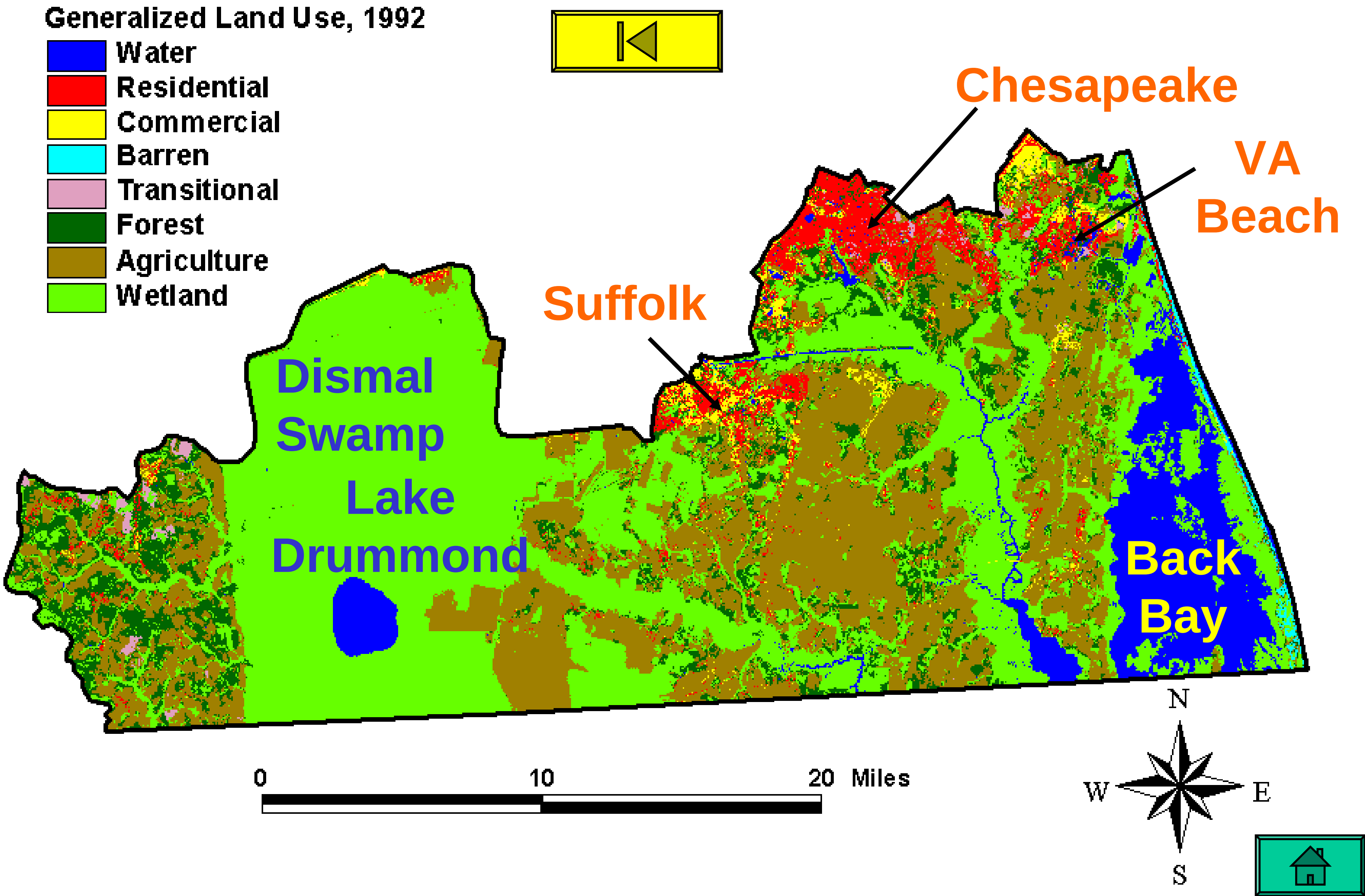
Department of Conservation and Recreation, Division of Chesapeake Bay Local Assistance

http://www.cblad.state.va.us/

Partnering with local government to protect the Chesapeake Bay and other state waters through sound land use management.

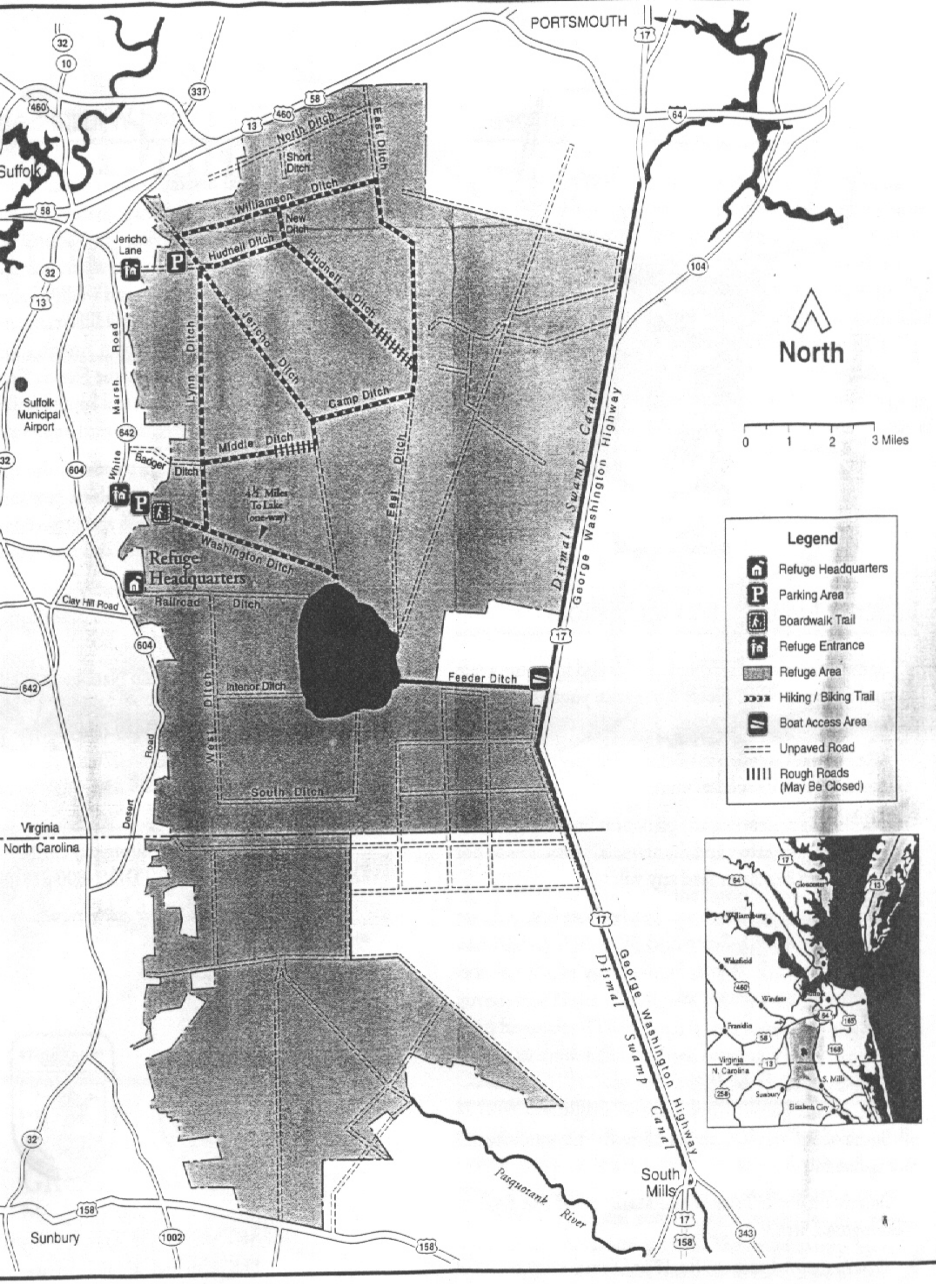
Albemarle Sound

Watershed in Virginia



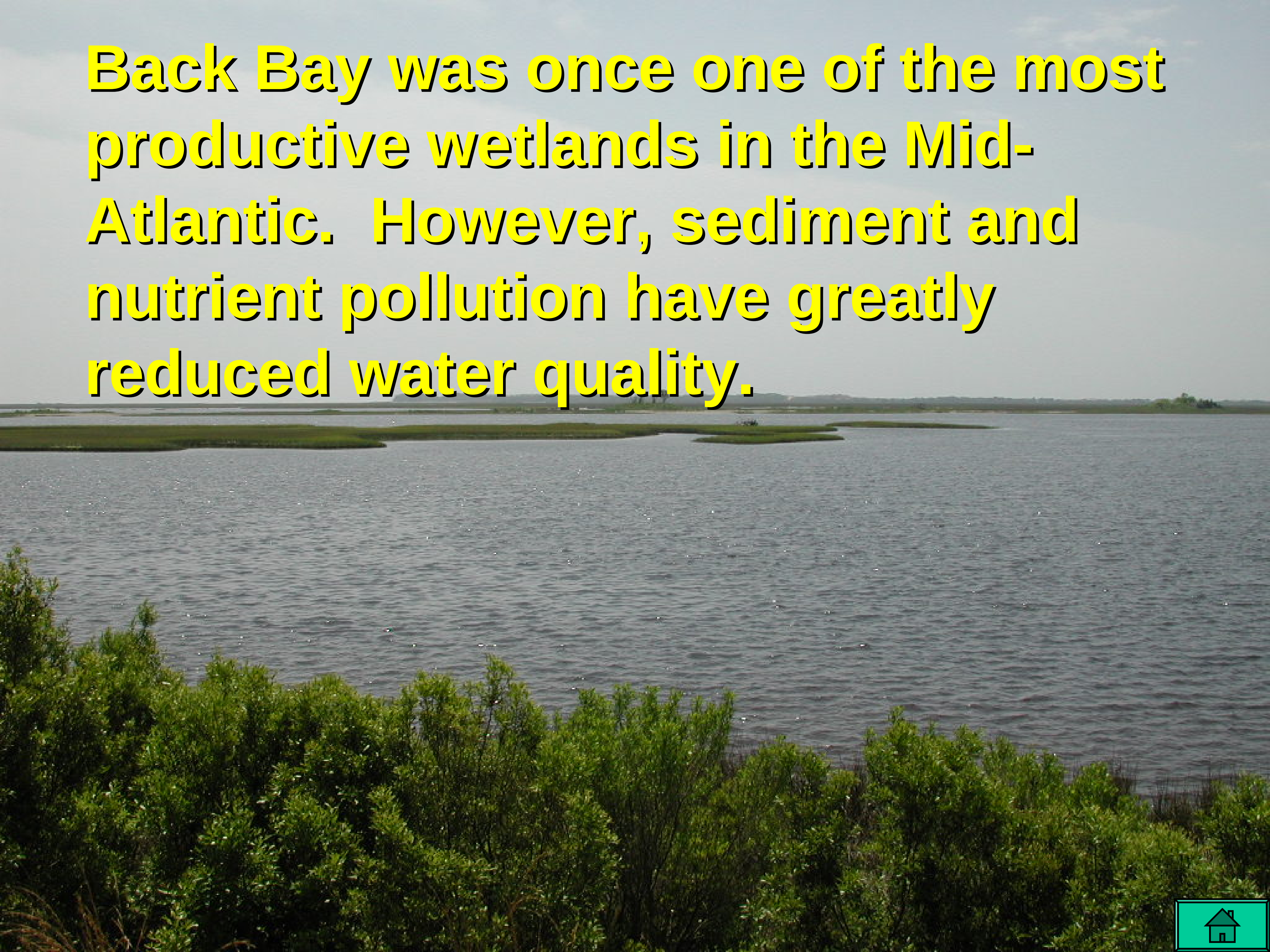
This watershed drains south into Back Bay and North Carolina coastal waters. The area is more than 45% wetland and 30% agriculture.

It is the home of the famous Dismal Swamp. Lake Drummond, in the Swamp's center, is one of Virginia's only two natural lakes.



Great Dismal Swamp
National Wildlife Refuge

George Washington surveyed the area for ditching in the mid-1700s. A major drainage ditch is named for him. Vast amounts of the original wetlands have been ditched and drained for farming.


Back Bay was once one of the most productive wetlands in the Mid-Atlantic. However, sediment and nutrient pollution have greatly reduced water quality.

Introduced plants, such as Eurasian Milfoil and *Phragmites*, have also affected fish and aquatic bird populations.

Tidal wetlands have long been protected. However, non-tidal wetlands were “legally” drained through a process called “Tulloch ditching.” It is illegal to drain and fill a wetland.

CBF Fact Sheet

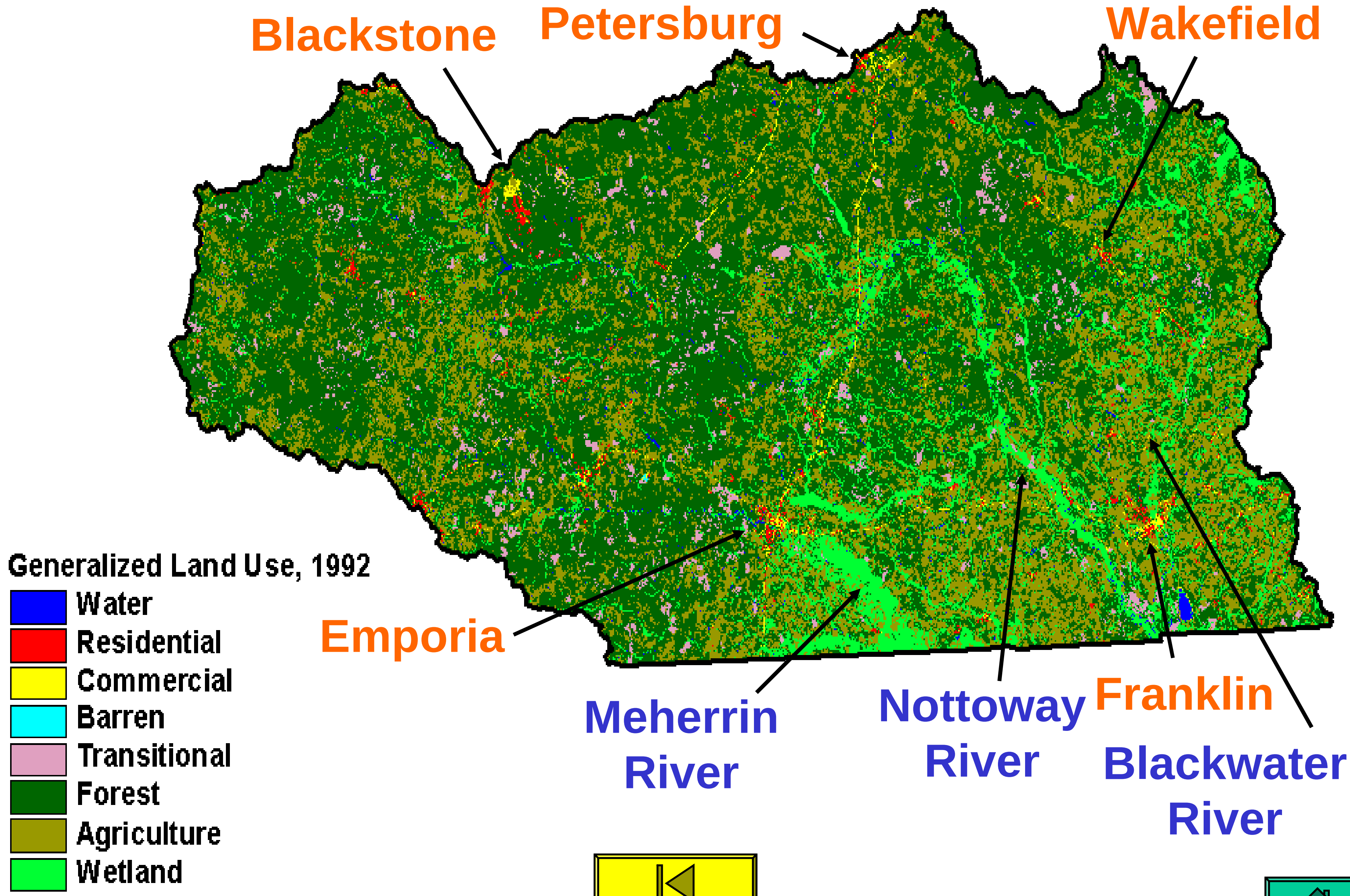
The "Tulloch" Loophole

WETLANDS DRAINING AND LOSSES IN VIRGINIA; THE "TULLOCH" LOOPHOLE AND MORE

Developers were allowed to ditch near a wetland area, allow it to drain and convert to non-wetland status. This loophole was closed with protective legislation in 2000.

Tulloch Drainage Ditch

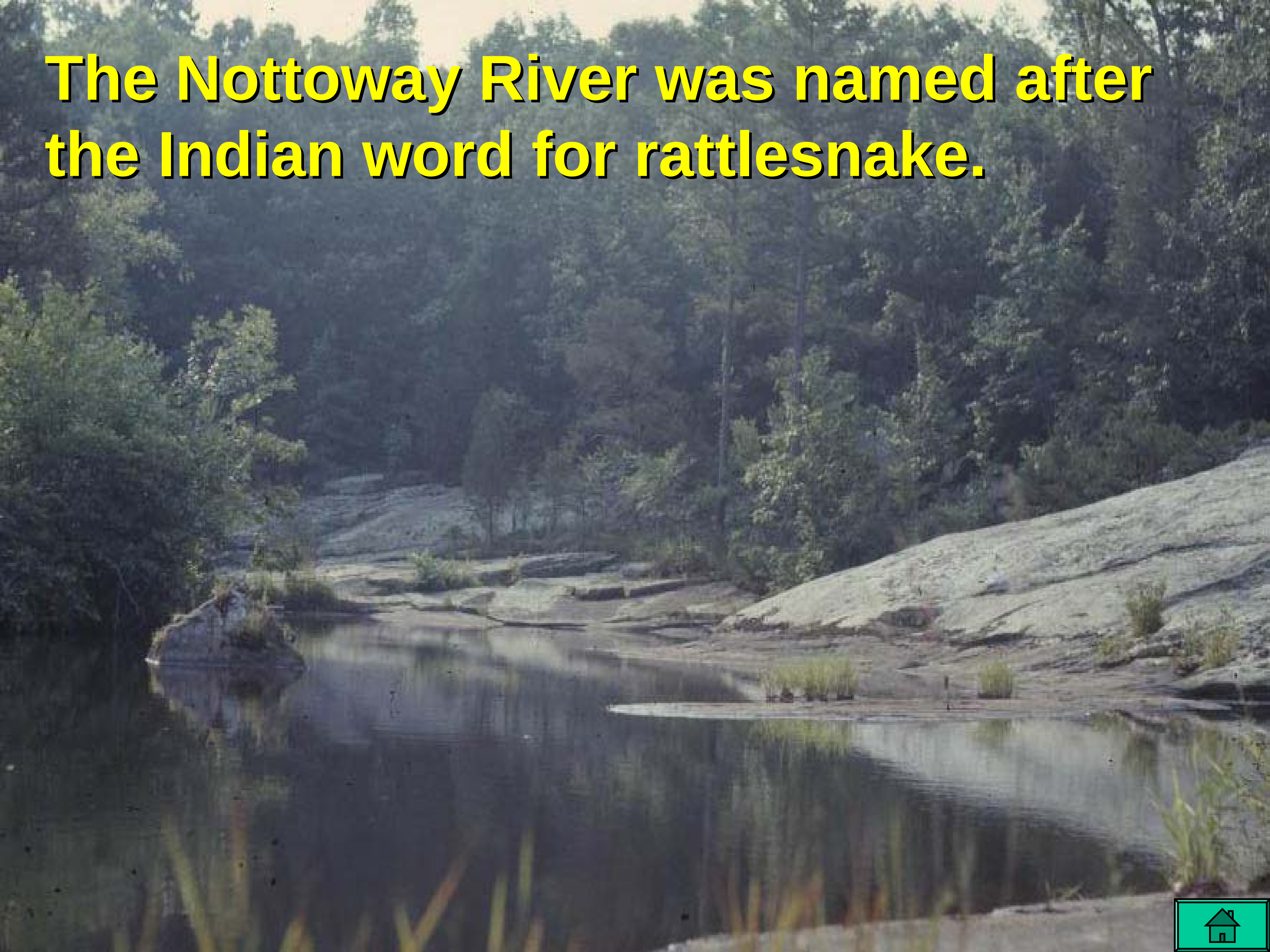
Chowan River Watershed in Virginia



Three Virginia rivers are part of this watershed: the Nottoway, Blackwater and Meherrin. All three join to form the Chowan River in North Carolina. The Chowan then flows south to Albemarle Sound.

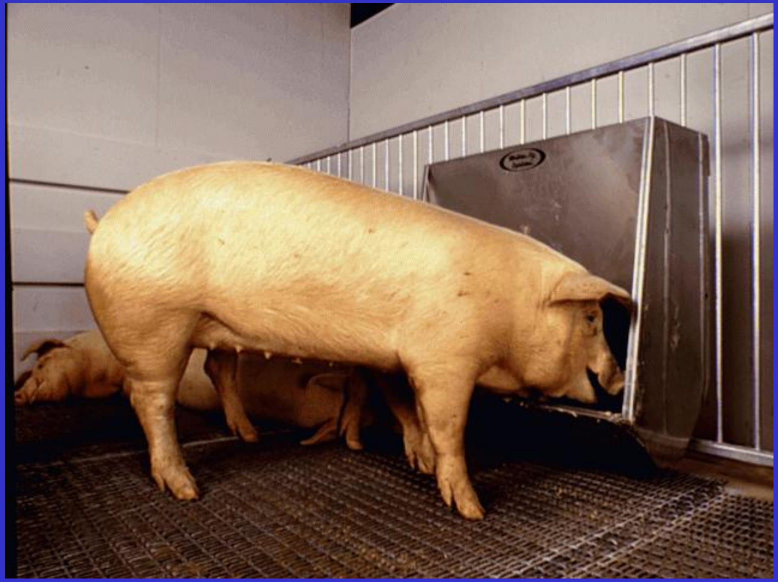
The Blackwater River got its name from its dark stained, acid waters.

The Nottoway River was named after the Indian word for rattlesnake.



The Meherrin was named for the Native American Tribe in North Carolina. It meanders back and forth across the Virginia/North Carolina border to join the Chowan.

Most of this watershed is forested. However, agricultural activity is the greatest source of water pollution. There is much pollution from swine and poultry farms.

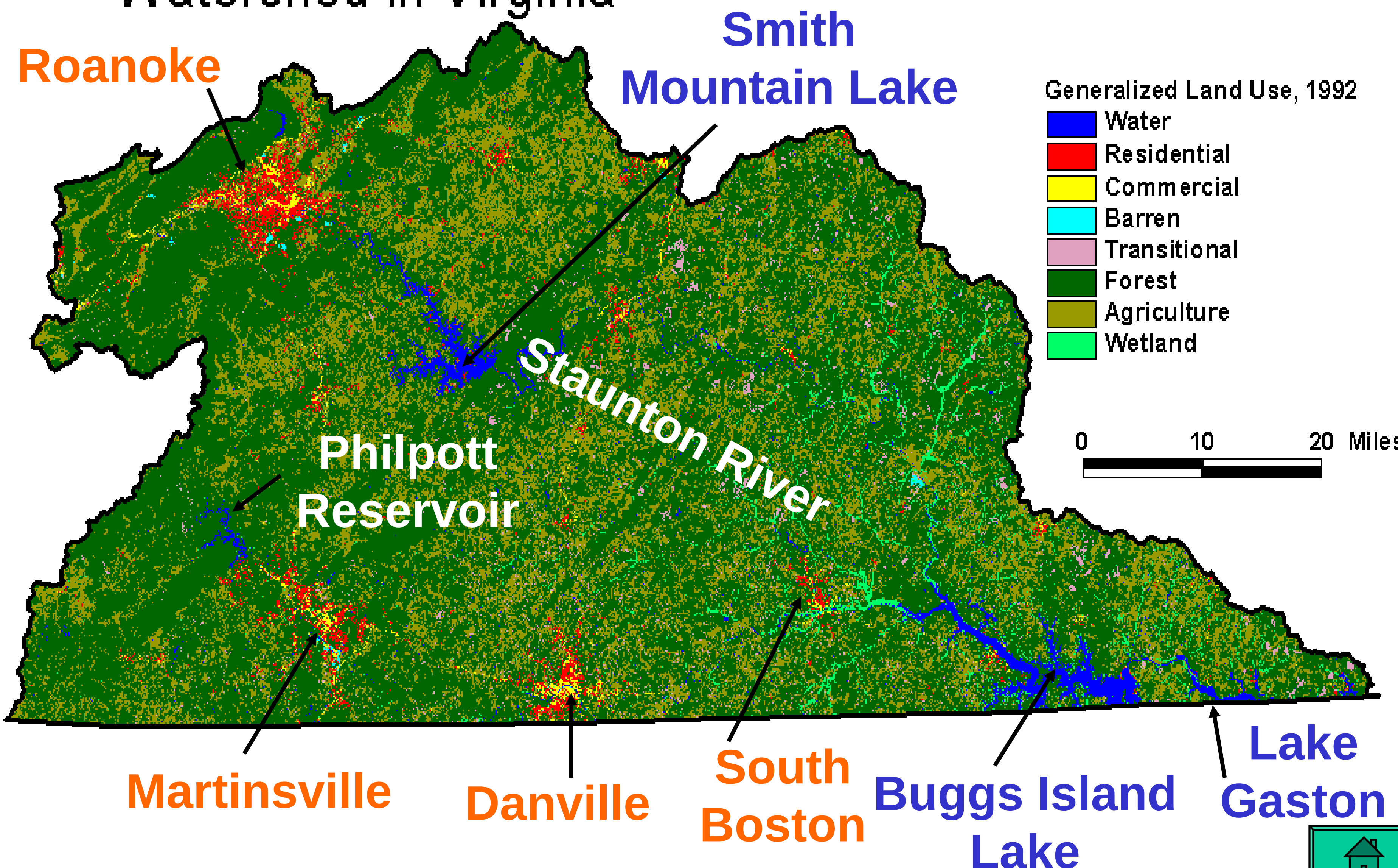


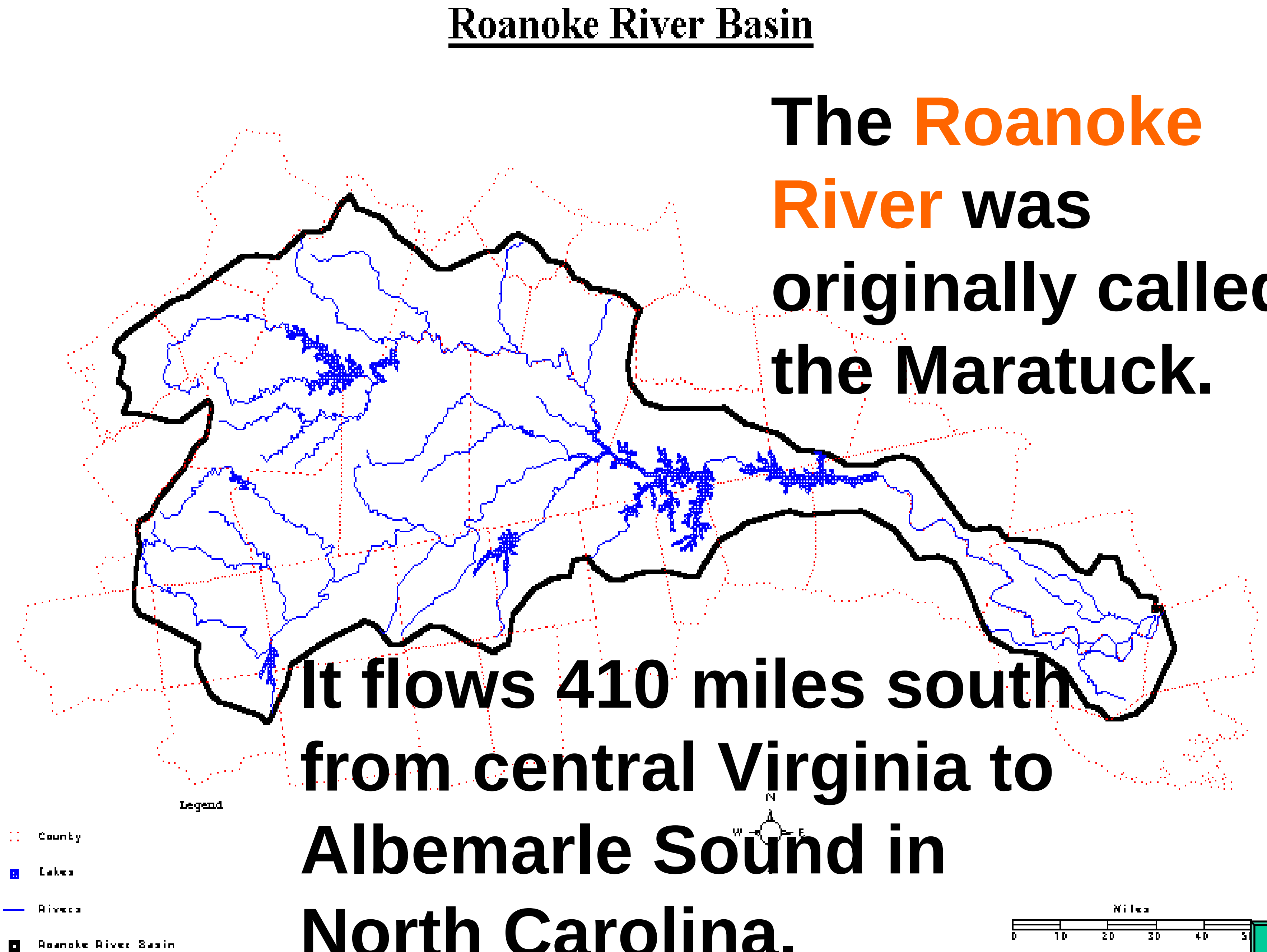
Large swine and poultry operations ae working to develop better ways of handling animal wastes. Producers, soil and water specialists and universities are working to address this problem.

Swine Manure Research

Roanoke River

Watershed in Virginia

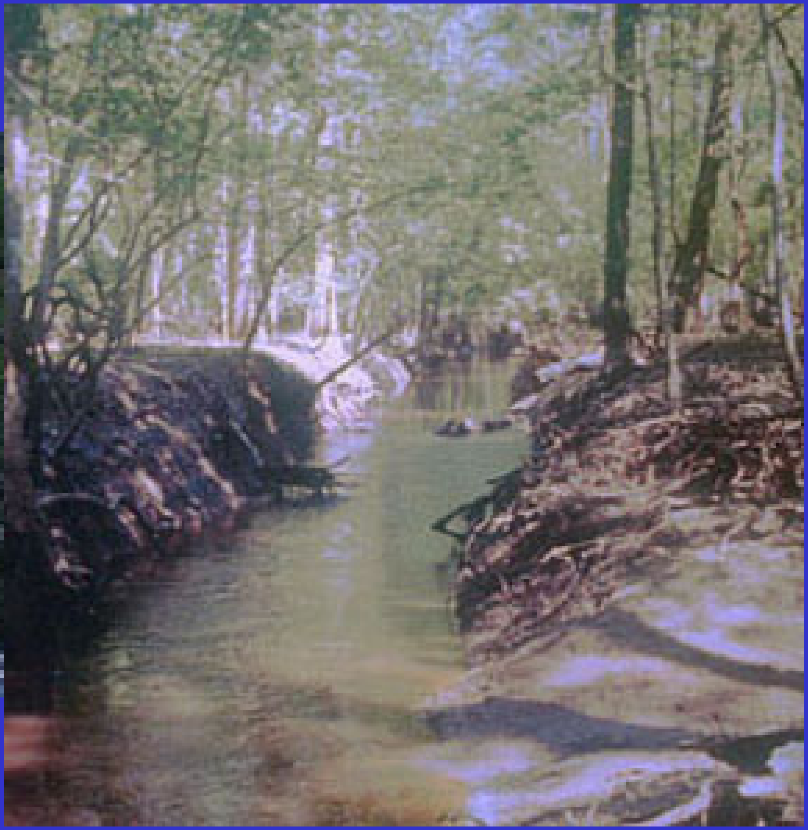




The **Roanoke River** was originally called the Maratuck.

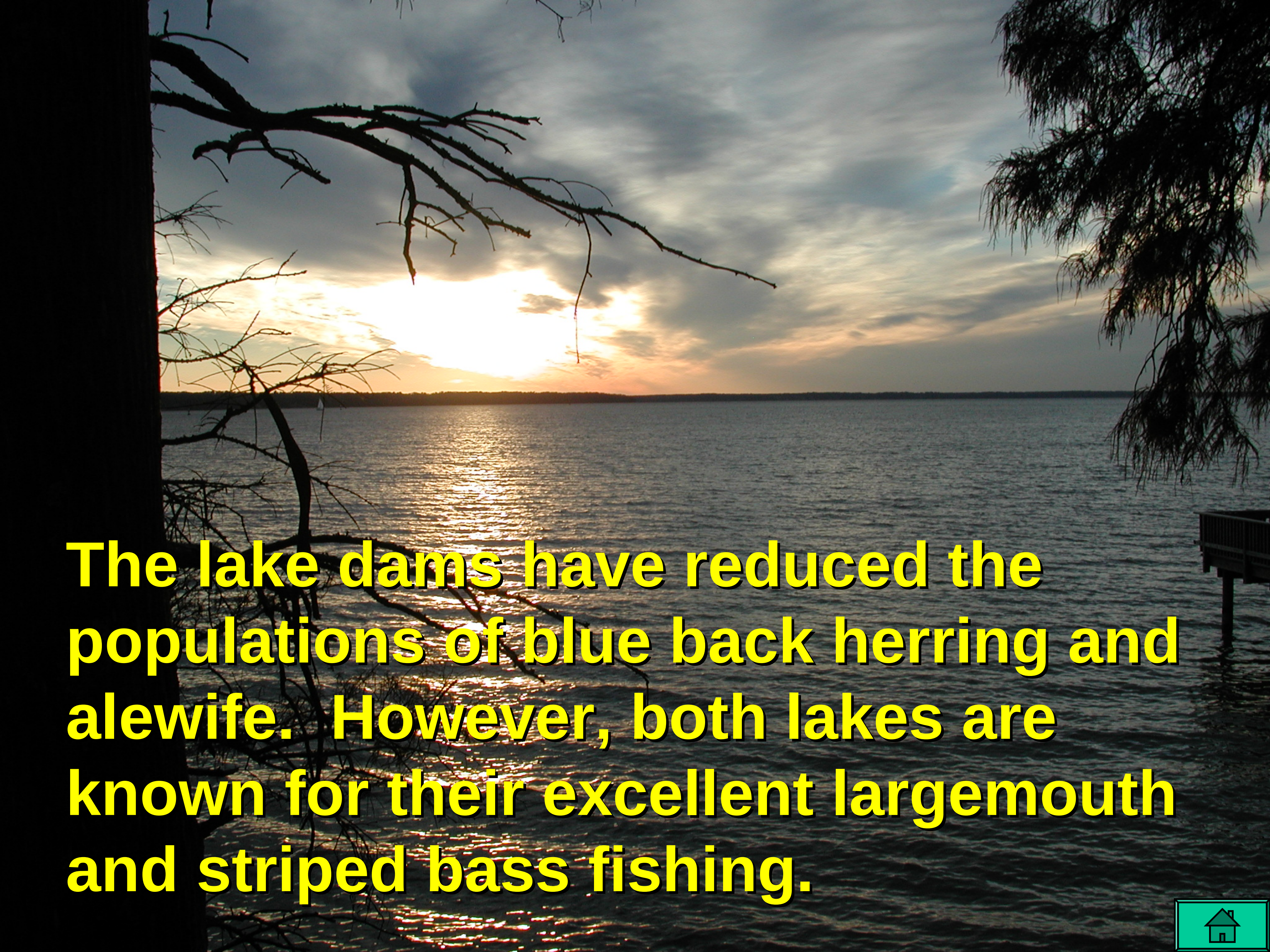
It flows 410 miles south from central Virginia to Albemarle Sound in North Carolina.

Nearly 360 miles of canals were built around its many rapids. However, most of the historic canals now lie underwater.



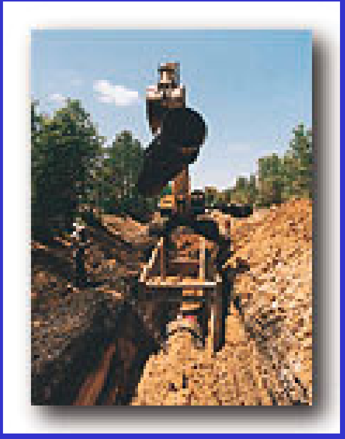

Two major lake systems were created for flood control, Smith Mountain and Buggs Island/Gaston.

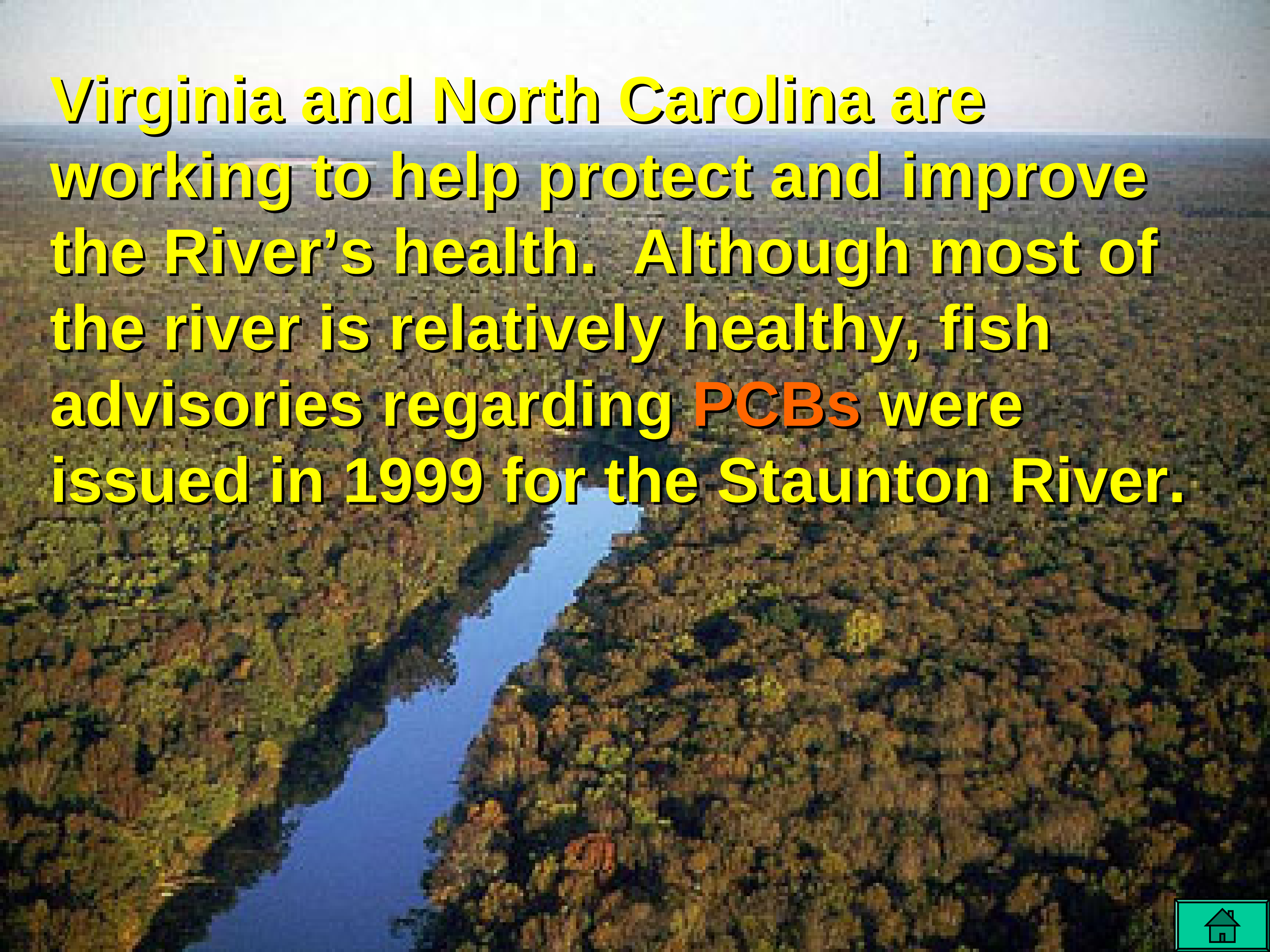
The Staunton River connecting the lakes was named for Henry Staunton, a Revolutionary War hero.



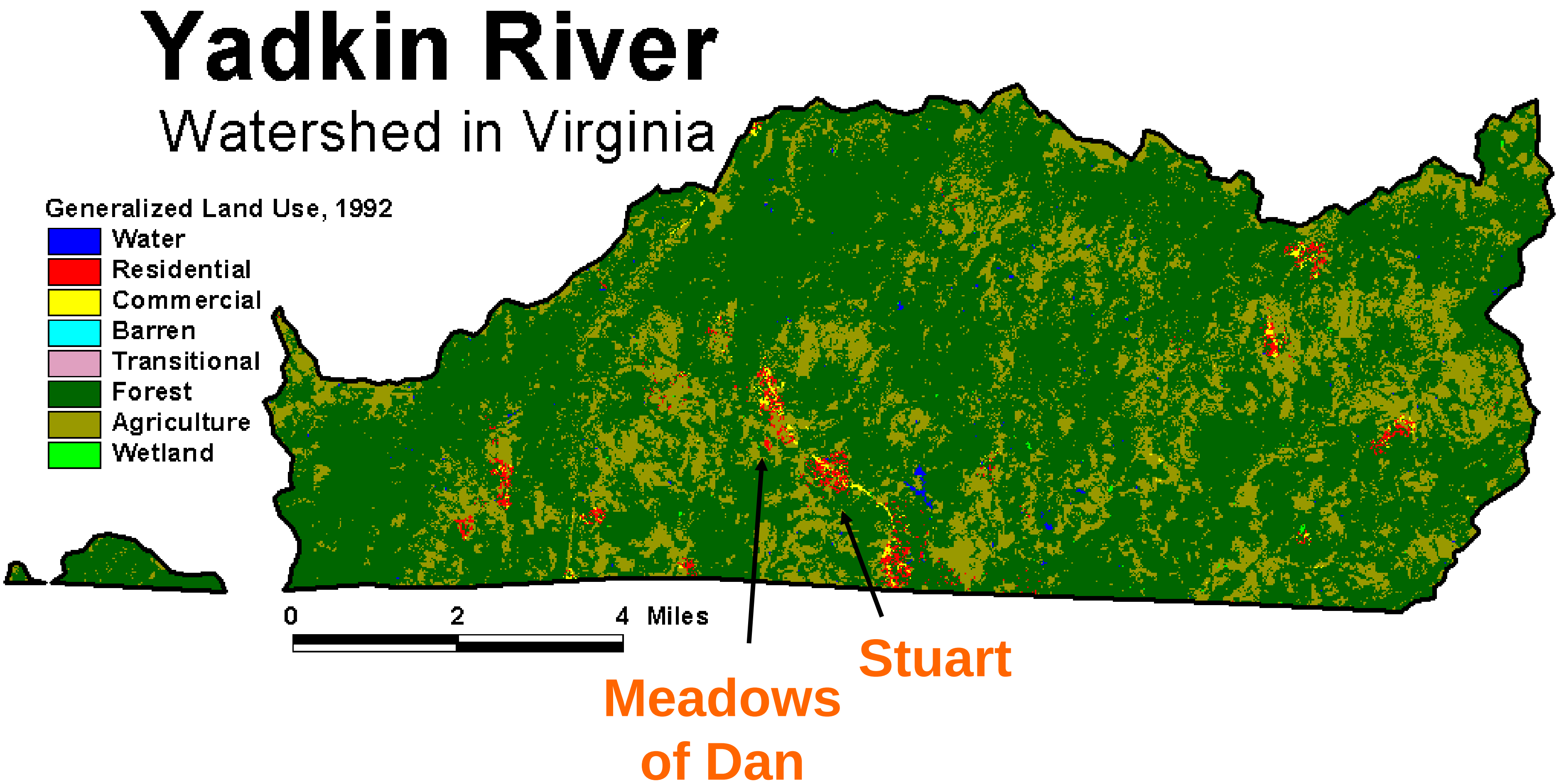
The lake dams have reduced the populations of blue back herring and alewife. However, both lakes are known for their excellent largemouth and striped bass fishing.

Gaston Lake also serves as a water source for Virginia Beach. A seventy-mile pipeline was constructed to carry water to the city.





Virginia and North Carolina are working to help protect and improve the River's health. Although most of the river is relatively healthy, fish advisories regarding PCBs were issued in 1999 for the Staunton River.


Yadkin River
Watershed in Virginia
Generalized Land Use, 1992
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland
0
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4 Miles
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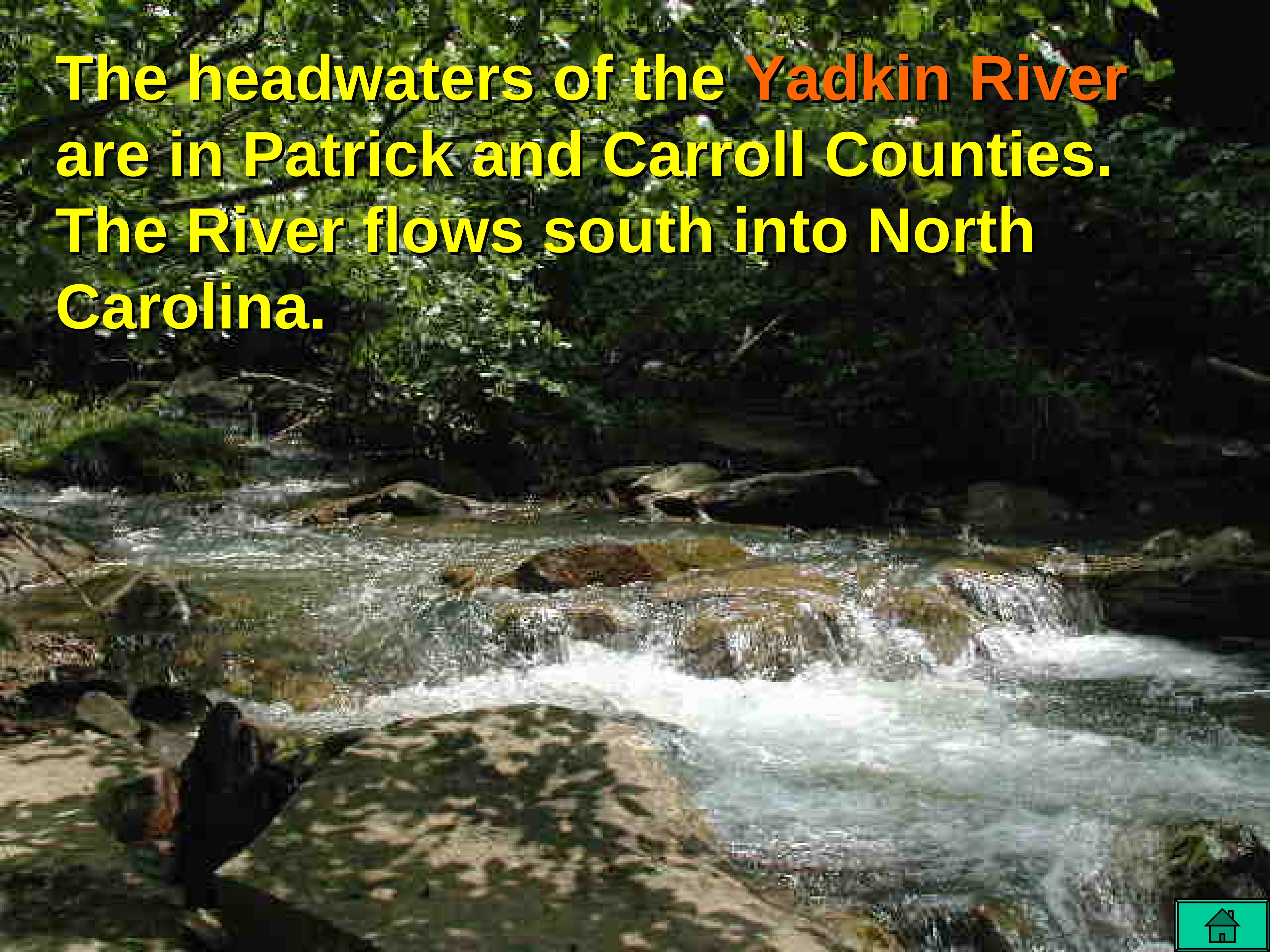
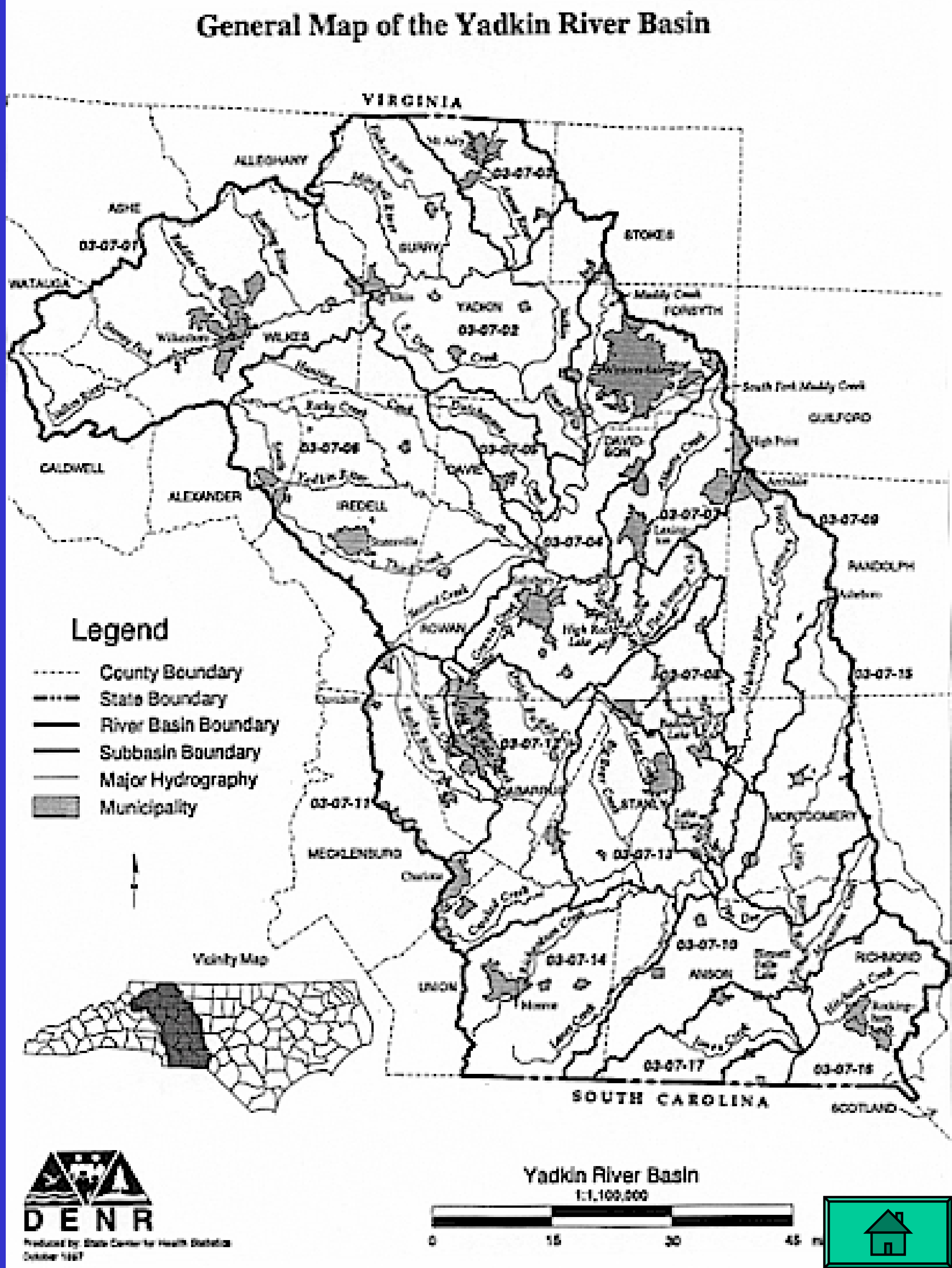
Meadows of Dan


The headwaters of the Yadkin River are in Patrick and Carroll Counties. The River flows south into North Carolina.

There it joins the Uwharrie River to form the Pee Dee River. The Pee Dee River flows through South Carolina to the Atlantic Ocean.



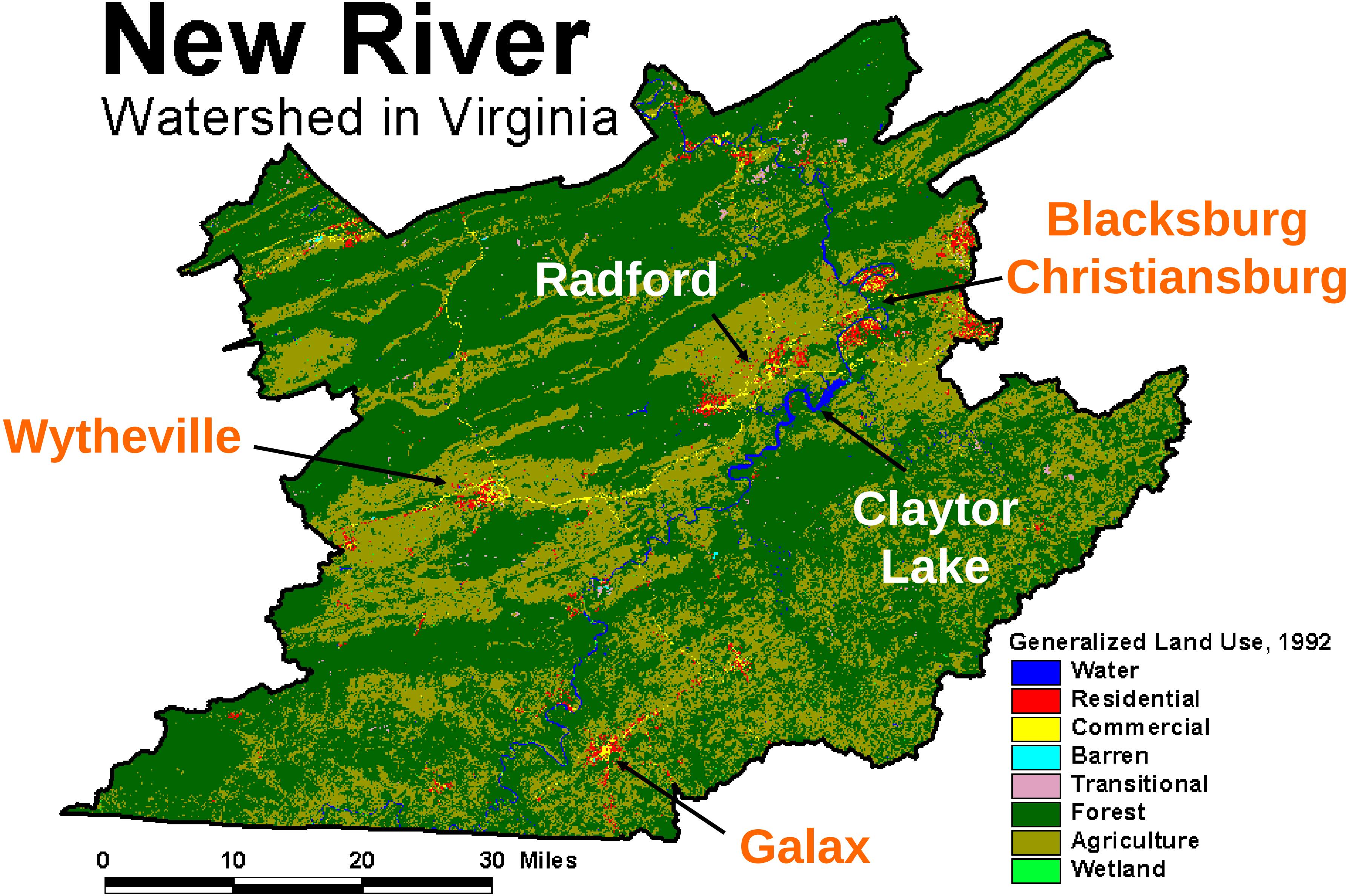
The North Carolina portion of the basin contains approximately 5,991 miles of freshwater streams and rivers. The Virginia section is nearly 80% forested and 20% agriculture.

Pee Dee River

Reservoir on the Pee Dee River

The W. Kerr Scott Dam located just over the border in North Carolina is 148 feet tall and 1,750 feet long. It creates a ten-mile reservoir.

New River
Watershed in Virginia

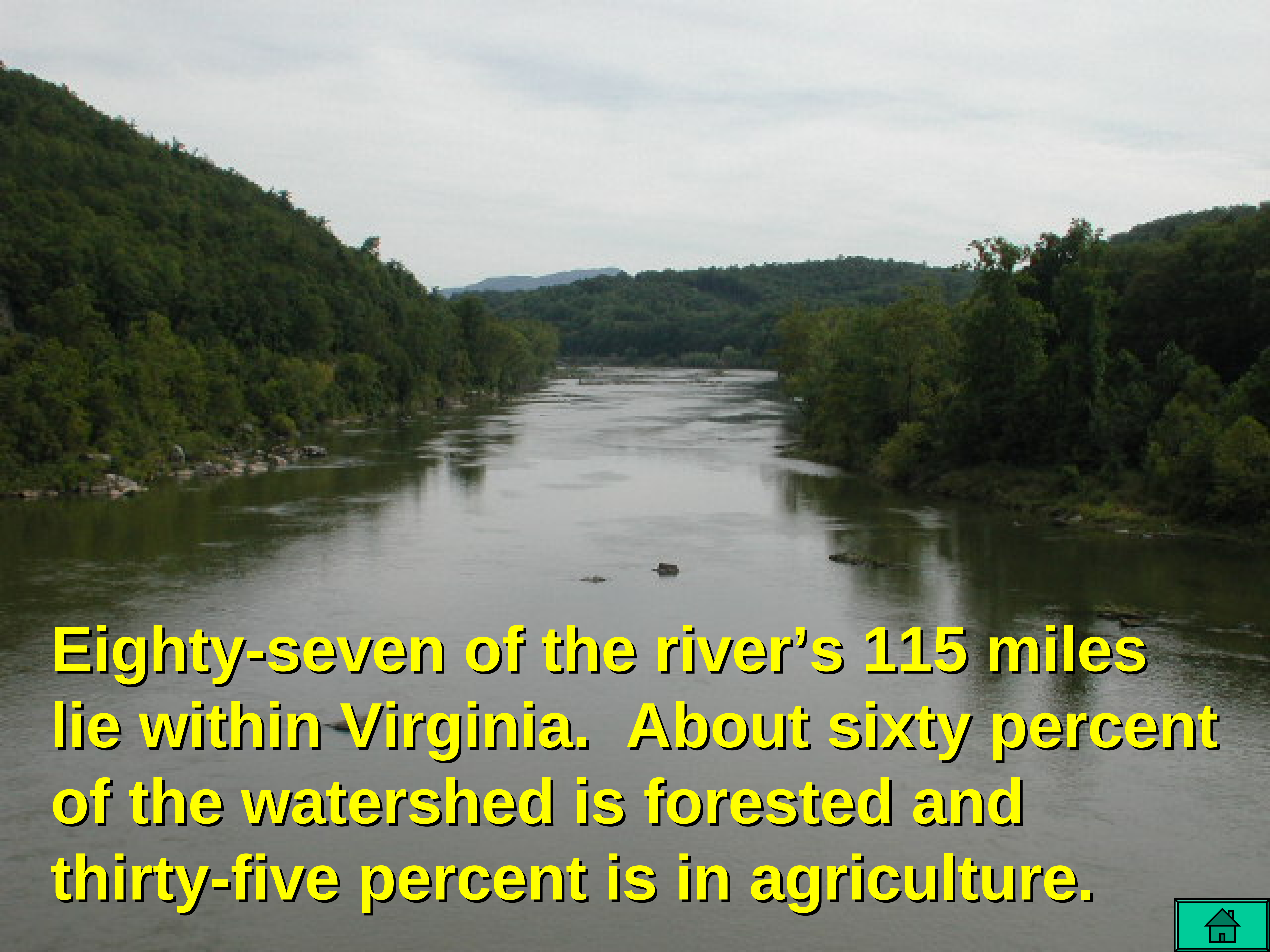


An American Heritage River, the New River begins in the Blue Ridge Mountains of North Carolina. It flows northward through Virginia and into West Virginia.

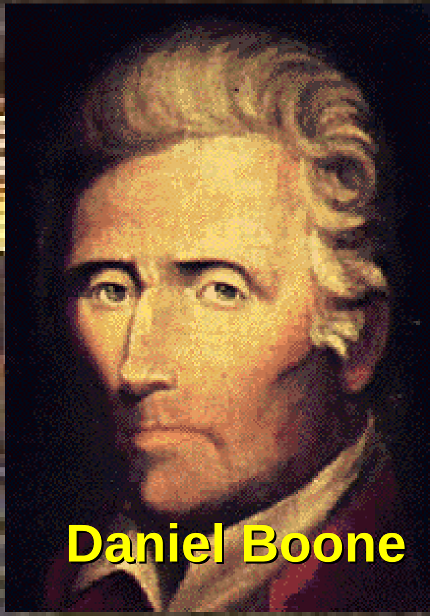
Base from U.S. Geological Survey digital data, 1:2,000,000, 1992 and National Park Service digital data, 1:24,000, 1996

There it joins the Gauley River to form the Kinawa. The waters then flow to the Ohio River and on to the Mississippi River.

New River Gorge

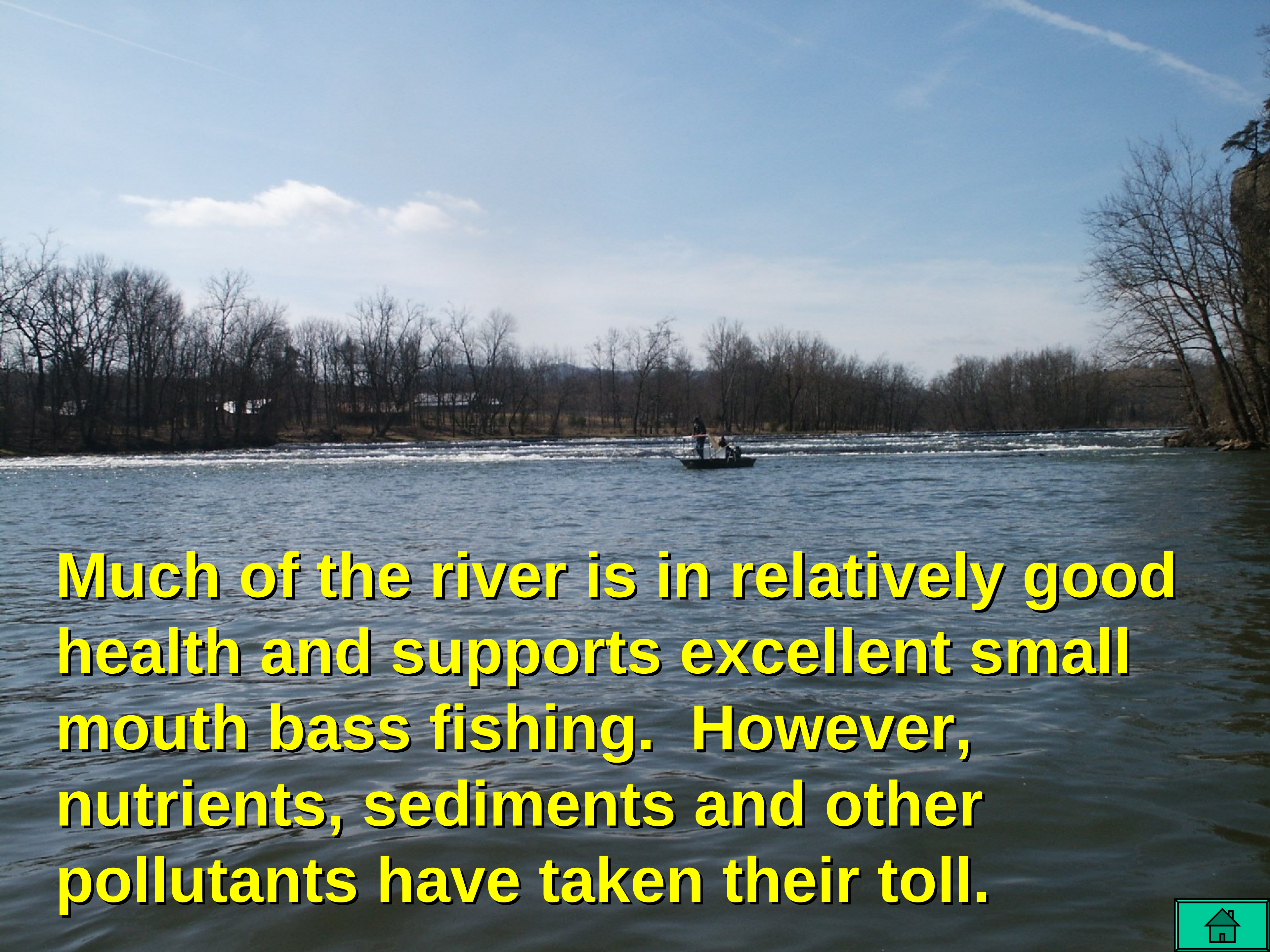

Eighty-seven of the river's 115 miles lie within Virginia. About sixty percent of the watershed is forested and thirty-five percent is in agriculture.

The New River Valley is rich in Pioneer, Revolutionary and Civil War History. Pioneers passed through the New River Valley on the Wilderness Road explored by Daniel Boone, now State Route 11.



Daniel Boone


Mountain Lake Resort
Today, the valley is known for its geology, natural beauty, rapids and music festivals. One of only two natural lakes, Mountain Lake, is located near Blacksburg.



Much of the river is in relatively good health and supports excellent small mouth bass fishing. However, nutrients, sediments and other pollutants have taken their toll.

Populations of native mussels and non-game fish species are rapidly declining. Many of these are listed as endangered or threatened.

This river system is easily polluted from surface runoff and groundwater contamination due to the large karst areas within the watershed.

Karst Spring

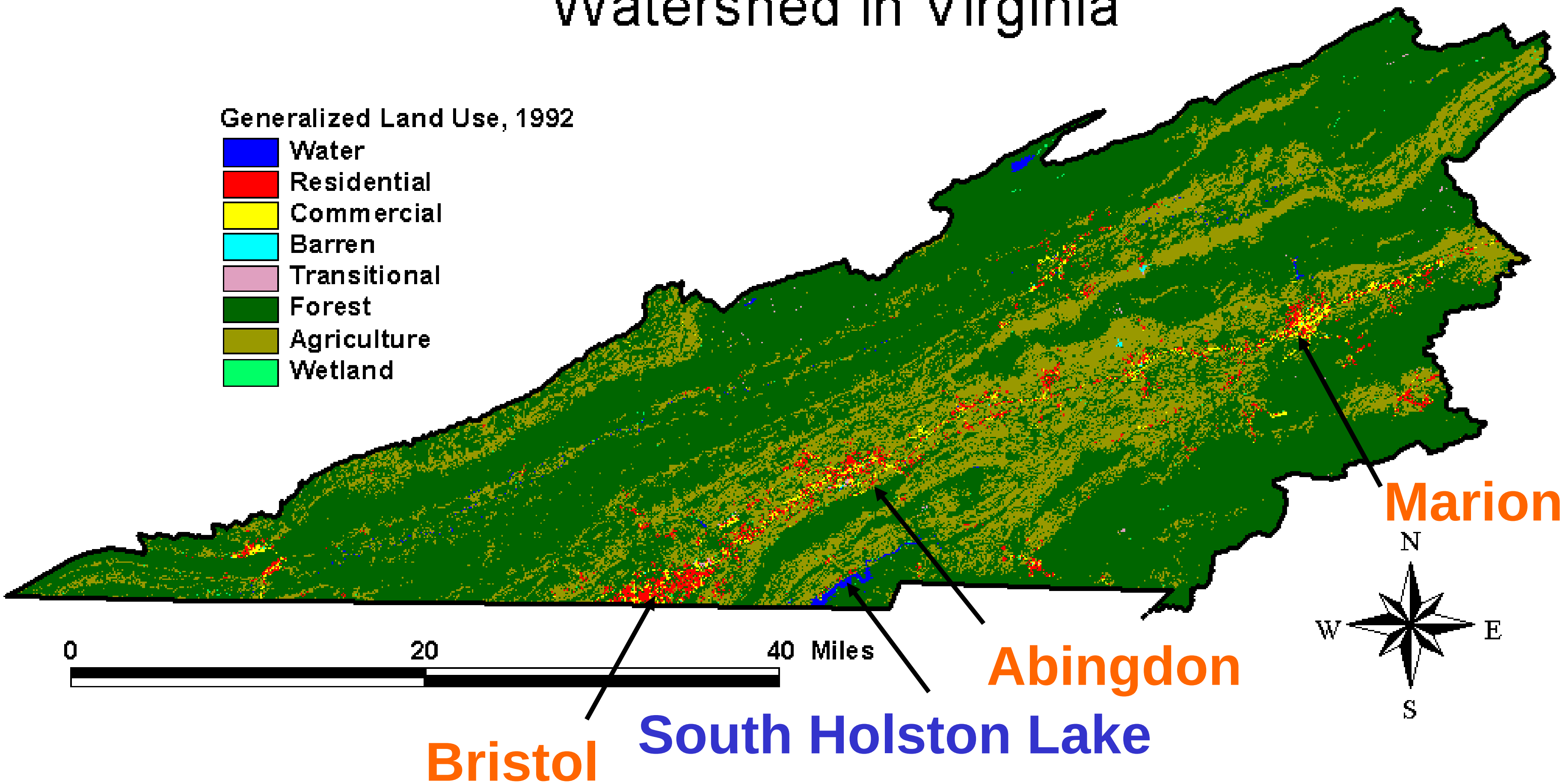
Sink Hole

Clinch/Powel Rivers

Big Sandy River

Holston River

Watershed in Virginia



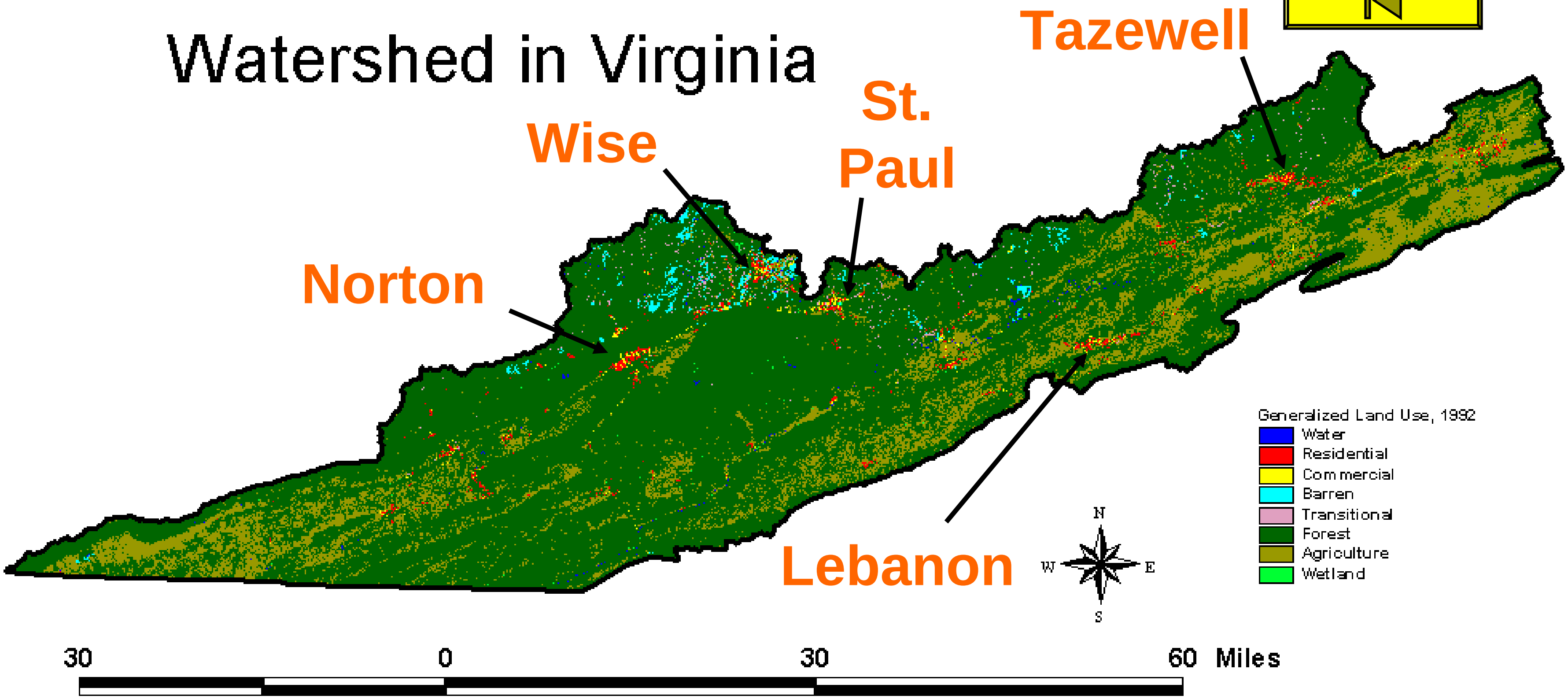
Description

Big Sandy River

Holston River

Clinch/Powell River

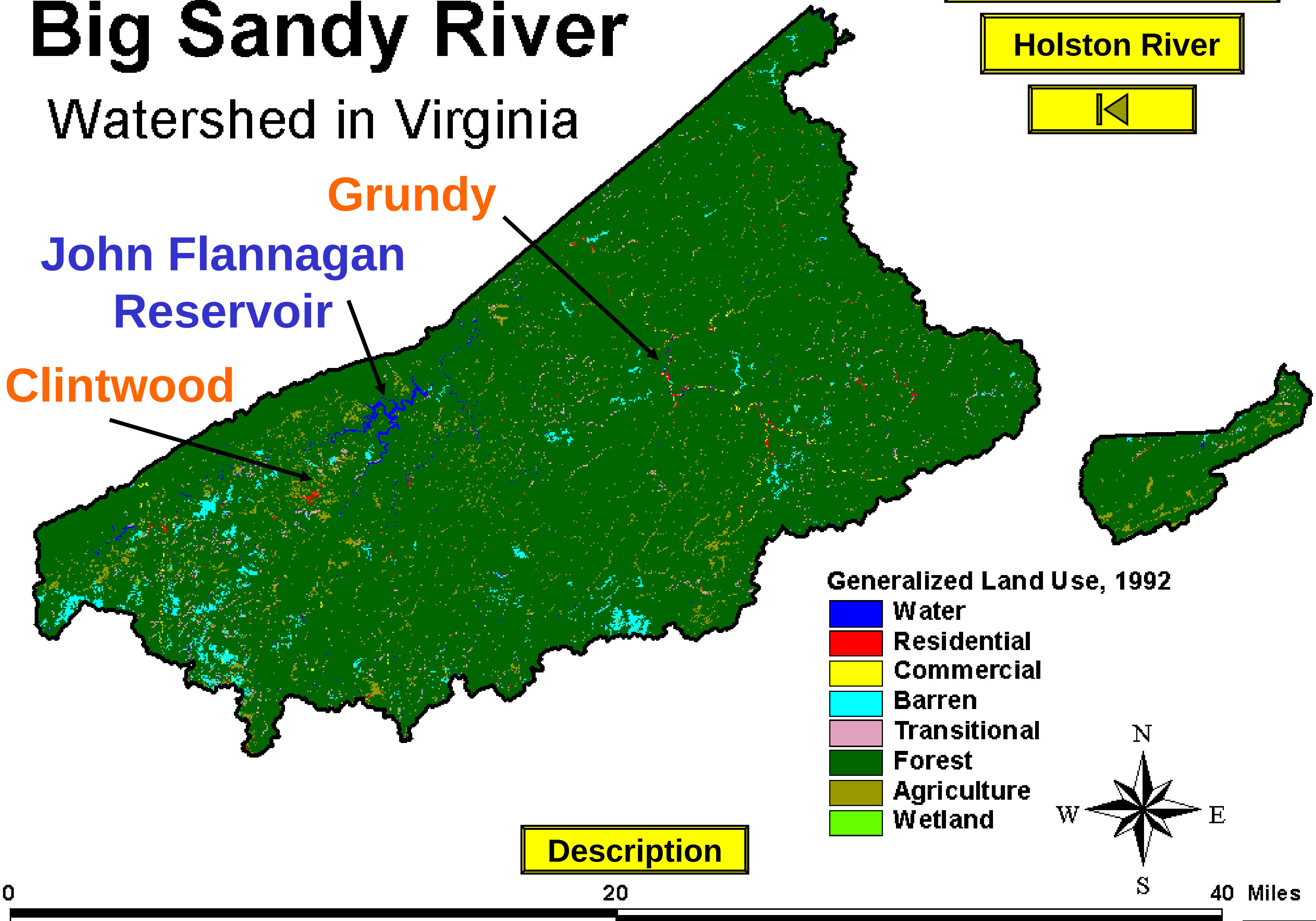
Watershed in Virginia



Description

Big Sandy River

Watershed in Virginia

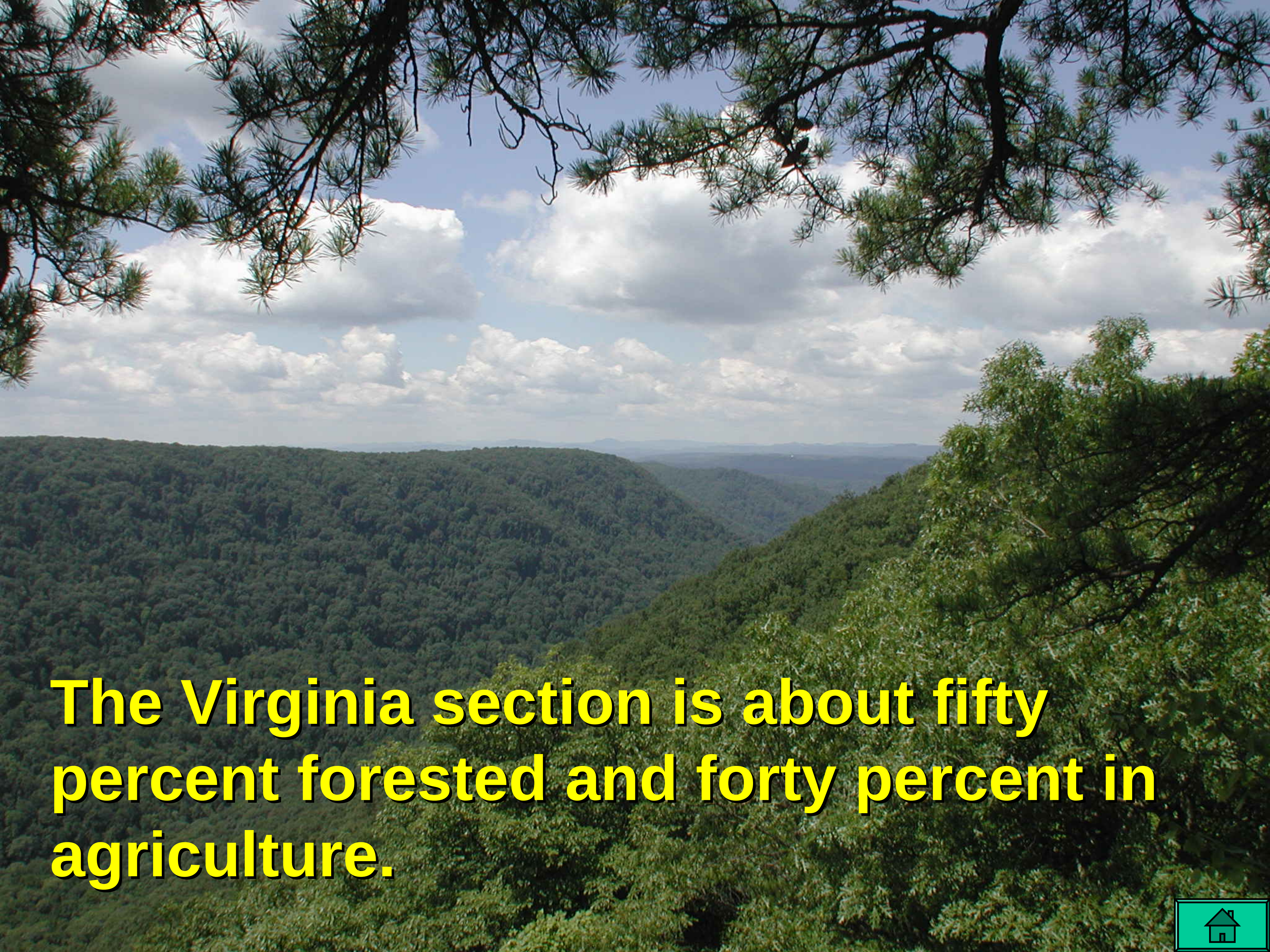


Clinch/Powel Rivers

Holston River

Description

The Clinch, Powell and Holston Rivers flow to the Tennessee River. The Tennessee then flows into the Ohio River, a major tributary of the Mississippi.


The Virginia section is about fifty percent forested and forty percent in agriculture.

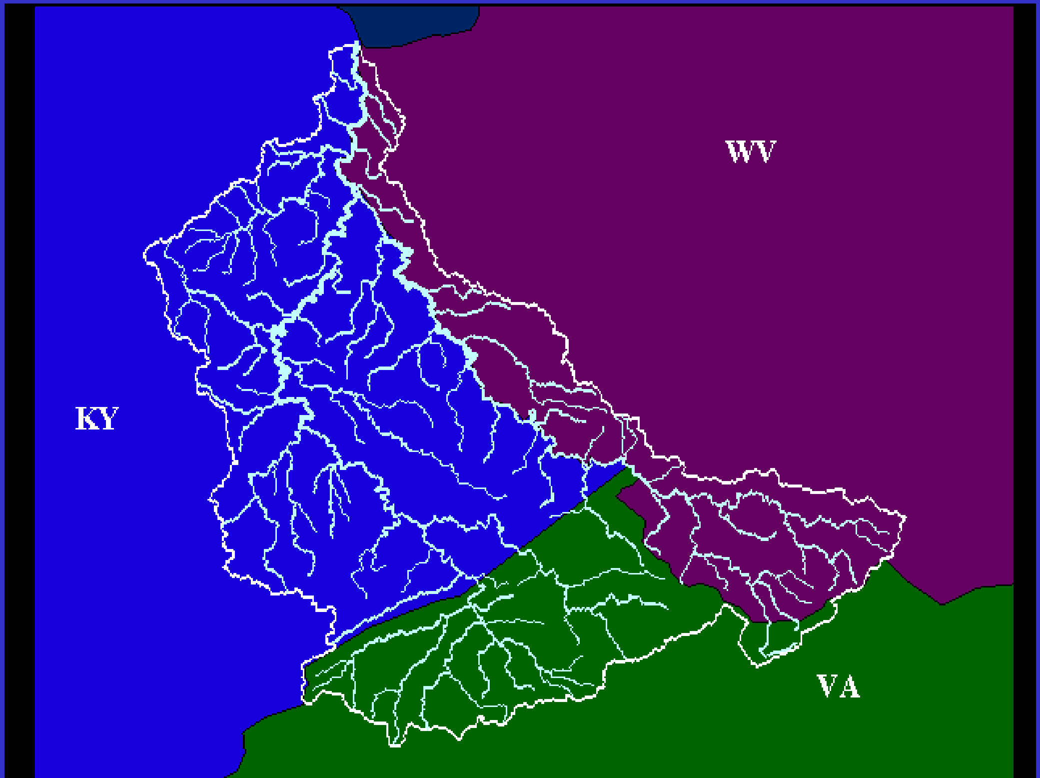
More than 300 rare, freshwater mussel species live in these watersheds. Nearly two-thirds of all the freshwater fish species in the eastern United States are found here.

Slender Chub

Yellowfin Madtom

Duskytail Darter

Russell/Levisa Forks and the Pound River are tributaries of the Big Sandy, which flows north to the Ohio River. This area is about ninety percent forested and five percent in agriculture.

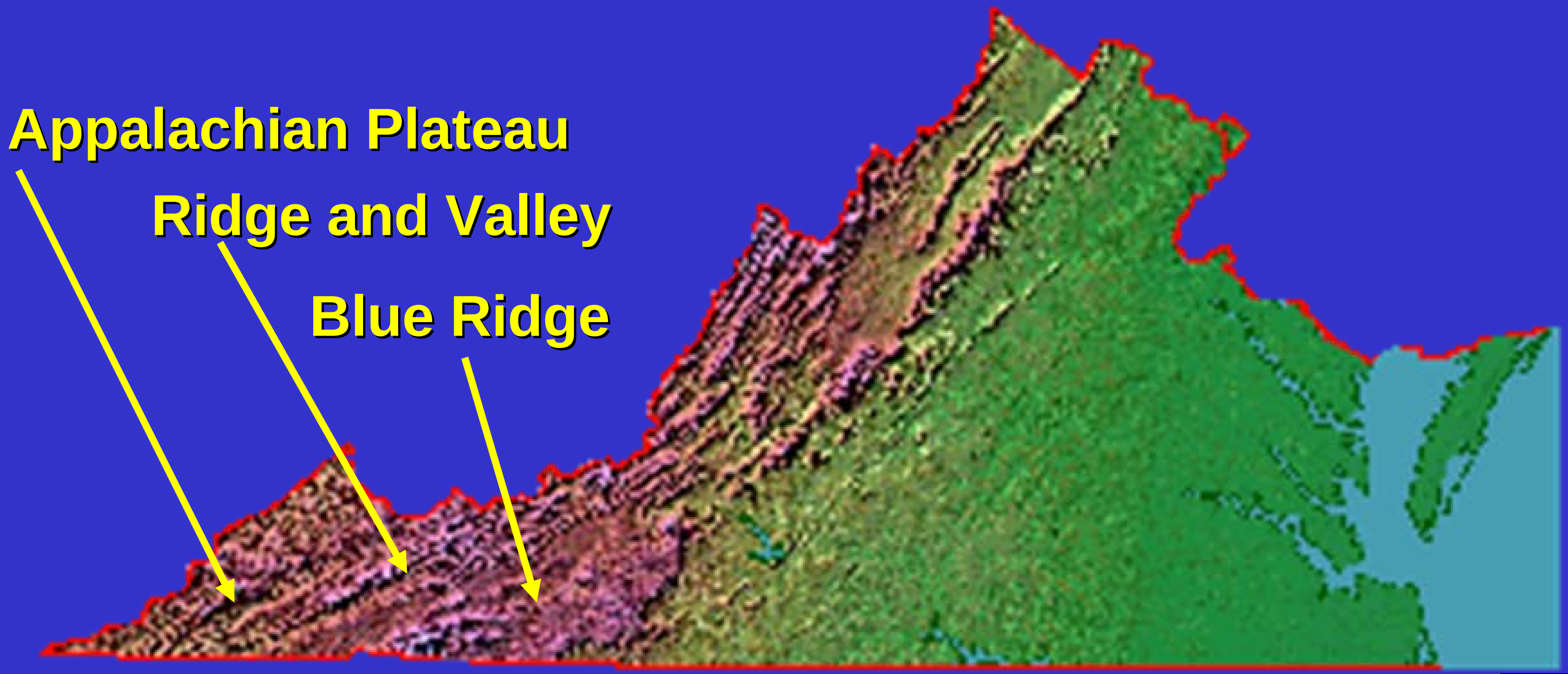


The Big Sandy drainage is prone to frequent flooding. Because of this, the town of Grundy in Buchanan County is being moved to higher ground.

Town of Grundy

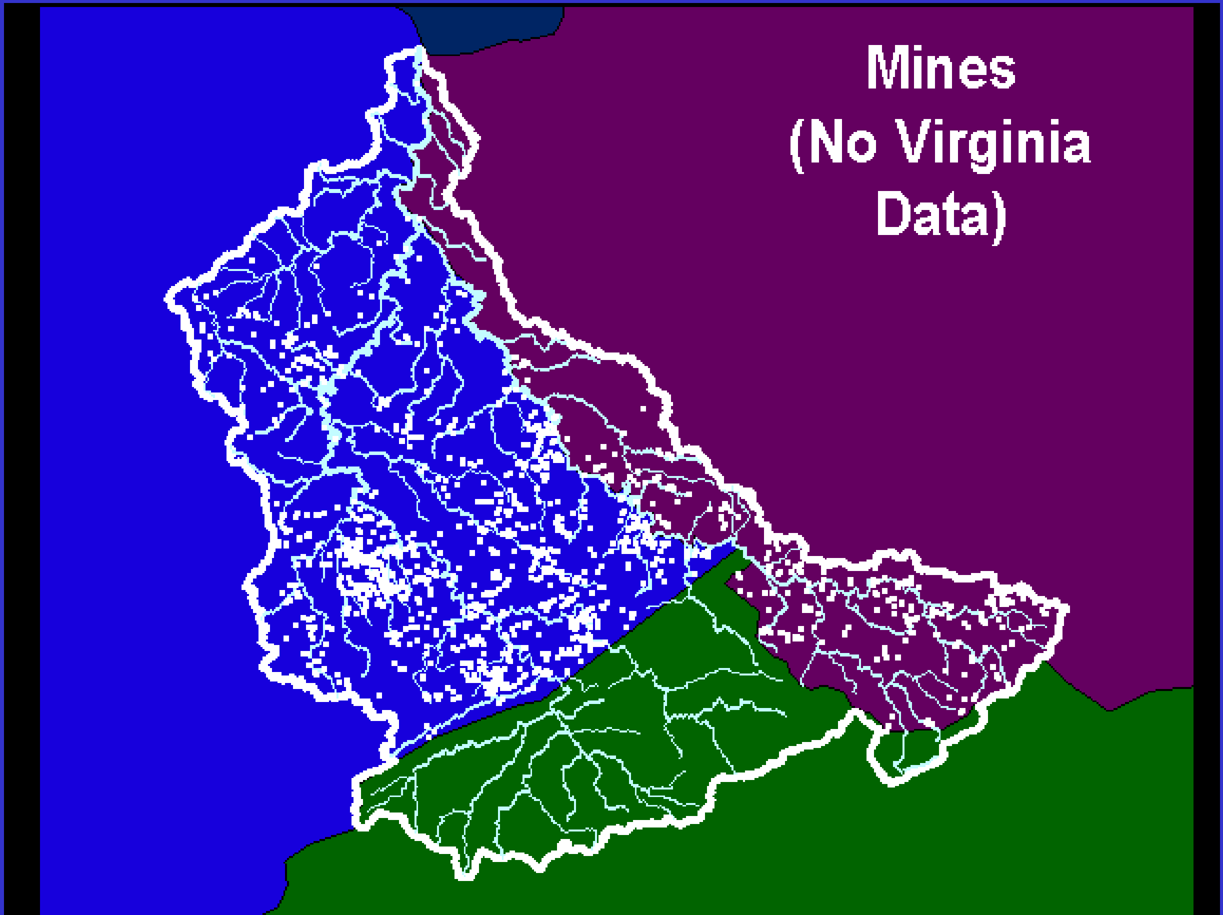
Flood Control Project

These rivers include three geologic provinces: Appalachian Plateau, Valley and Ridge, and the Blue Ridge.



Despite the picturesque scenery, these rivers suffer from excess sediment and nutrient loading. However, trout fishing is still an important recreation.

Coal and mineral mining activities have created serious acid and heavy metal pollution in some sections of the watershed.



The Powell River Project, the Saltville Superfund Program and other programs are helping to reduce these impacts.

What Do You Know About Water Quality?

This is an interactive game for grades six through twelve and adult that will challenge your knowledge of basic water quality. The games center around a number of water quality indicators including: dissolved oxygen, pH, hardness and others.

Skip Preparation

The 4-H adult publication,
Water Quality Indicators – an introduction to water quality indicators, what they mean and how they are measured,
is available on this disc. The links below provide additional information about water quality for adult leaders.

Valuable water quality Web sites are:

- **http://www.nal.usda.gov/wqic/**
- **http://www.epa.gov/water/**
- **http://water.usgs.gov/**
- **http://www.chesapeakebay.net/wquality.htm**

There are ten games. **Three Introductory Games** review general water quality terms and concepts used in the **five contest games**. There is a **Watershed Game** and a **Wild Card Game** that covers a variety of water quality topics.

Select new game

Types of	Things Goin' On	What It Is?	Measures	Not So Good
5	5	5	5	5
10	10	10	10	10
25	25	25	25	25
50	50	50	50	50
100	100	100	100	100

100

Lakes and streams that lack limestone in the soils may suffer from this type of pollution.

Play Preparation

Do you understand the basic water quality concepts? Explore the following questions to learn more.

What conditions may indicate poor water quality?

(murky water, stressed aquatic life, poor appearance, odor, foam, surface film, etc.)

What types of pollution affect water quality?

(sediment, nutrients, bacteria, toxins, sewage, fuels, heat, pesticides, etc.)

What are the sources of water pollution?

(erosion, industry, air pollution, wildlife, agriculture, storm water, groundwater, sewage treatment, transportation, etc.)

What are some of the indicators used to measure water quality?

(dissolved oxygen, pH, alkalinity, nitrate, phosphate, bacteria, toxic chemicals, temperature, etc.)

You need to understand the water quality indicators used in the games, such as: **dissolved oxygen, pH, and alkalinity.**

You can review the indicators at this link: Water Quality Indicators .

You can also use the links throughout this program to learn even more.

Find out the following information for each indicator.

What does the indicator mean?

In what units is the indicator usually measured?

Why is the indicator important?

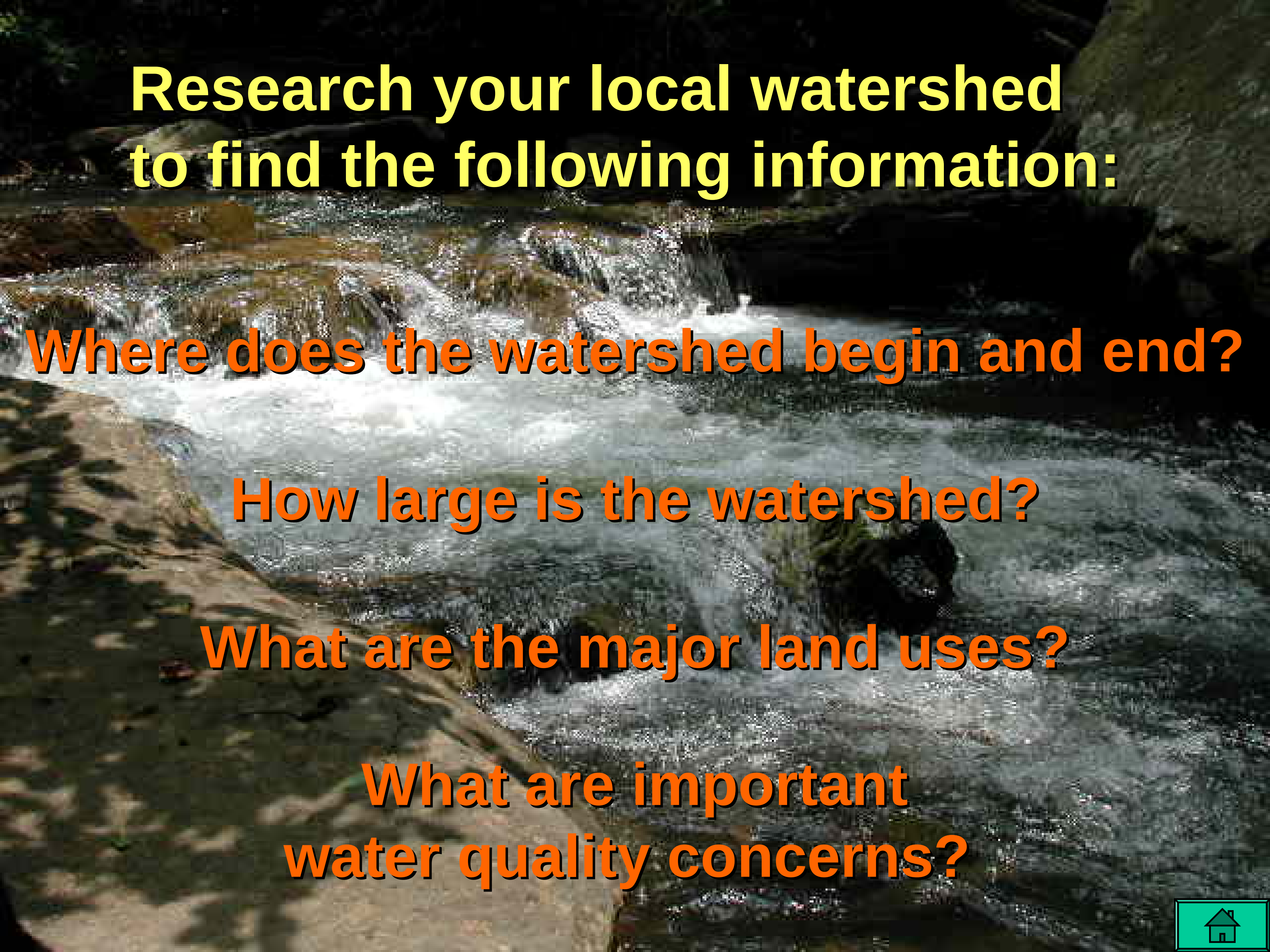
What are the results of a poor indicator reading, such as low pH?

The concepts of managing water quality and watersheds go hand-in-hand. You need to understand the watershed you live in. This will help you become a better steward for your local water resources.

Use the **Virginia's Watershed** section of this program and other resources to learn more about Virginia's watersheds.

Virginia's Watersheds

For more information about Virginia's watersheds, visit:
http://www.wm.edu/geology/virginia/rivers/rivers.html
and
http://www.cnr.vt.edu/PLT/watersheds.html.


Research your local watershed
to find the following information:
Where does the watershed begin and end?
How large is the watershed?
What are the major land uses?
What are important
water quality concerns?

After reviewing the water quality indicators, Virginia's watersheds and the game instructions, you are ready to find out:

What Do You Know About Water Quality?

Play Game

Game Instructions

• The object of the game is for players to win Pollution Credits (PCs). Pollution credits can be used to "clean up" their assigned watershed.

•The Introductory Games have a variety of answers that prepare students for the five water quality indicator games. Each water quality indicator game concentrates only on certain water quality indicators. These are listed on the title page for each game.

• The Watershed Game reviews facts about Virginia's watershed. These are presented in the Virginia's Watershed section of the program. The Wild Card Game has a variety of possible answers.

•A study list of suggested answers for students is provided with each game except where noted. Game answers are provided for the instructor. To print the study list or answer matrix, click on the respective link, select "End Show," and from the "File" menu, select "Print," and choose "current slide."

• The game format is a "jeopardy" style play. However, answers need not be stated as a question.

• Divide participants into teams of 2 – 4 players each. Number each team sequentially (1, 2, etc.). For small groups, the game can involve individual players.

• Give each team a noise maker (bell, shaker, etc.) to signal an answer. (optional)

• Start with teams 1 and 2. Select the appropriate game level. Advance to the category screen.

• Let team/player #1 select the first category and point value. Click on that section of the screen and a statement or question appears.

• After reading the statement/question, allow 5 - 10 seconds for one of the teams to answer. The first team/player to signal must be recognized before answering.

• After the correct answer is given, advance to the next slide which shows the correct answer and a brief discussion. From this screen, return to the category screen. If a team/player answers correctly, they earn the designated number of pollution credits (PCs). This team/player also selects the next category and point value.

• If a team/player answers incorrectly, the statement goes to the opposing team. Subtracting points for incorrect answers is at the discretion of the instructor. If neither team/player answers correctly, the question can be answered by the instructor or offered to any other team/player.

• Keep a running score of PCs each team/player earns. A score card and a blank answer page are available at the following links.

Score Card

Blank Answer Sheet

To print the score card and blank answer sheet, click on the links, select “End Show,” and from the “File” menu, select “Print,” and choose “current slide.”

• Teams/Players can clean up pollution in their watershed by using their Pollution Credits against the pollution types listed below. The more Pollution Credits they earn, the cleaner they can make their watershed.

Sediment – 50	Nitrate – 50	Bacteria – 50	Toxic Chemicals – 50
Pesticides – 40	Herbicides – 40	Acid Rain – 30	Heavy Metals – 30
Fossil Fuels – 30	Phosphate – 30	Heat – 20	Road Chemicals – 20
Trash – 10			

• Once play has started, select teams in any order that will allow everyone to participate.


Introductory Game 1
Introductory Game 2
Introductory Game 3
Turbidity, Temperature, Salinity, TSS, TDS, Bacteria, Toxics
Beginner
Advanced
Nitrate, Phosphate, Hardness, Alkalinity, pH, Dissolved Oxygen
Beginner
Advanced
Expert
Wild Card
Watersheds

Introductory Game 1

This game provides a basic introduction to common terms and concepts related to the water quality indicators presented in this program.

Study list of suggested answers

Play Game

ANSWERS

Study list of suggested answers for Introductory Level 1
(Some answers are used more than once.)

Acid	0 – 100 C°	Base
Dissolved Oxygen	Elements	Hard Water
Minerals	Neutral	Nutrients
Soft Water	Parts Per Million	pH
Pollution	Sediment	

Select new game

Types of	Things Goin' On	What It Is?	Measures	Not So Good
5	5	5	5	5
10	10	10	10	10
25	25	25	25	25
50	50	50	50	50
100	100	100	100	100

5

This is the opposite of an acid.

Base

Acids have a pH below seven and have free Hydrogen (H+) ions. Bases have a pH above seven and have free Hydroxyl (OH-) ions.

10

Calcium and magnesium are examples of these.

Elements

There are 109 naturally occurring elements. Many of these are also called minerals since they are commonly found in soil and rocks.

25

These include sediment, nutrients, pesticides, toxic substances, bacteria, heated water, petroleum, etc.

(Types of) Pollution

These types of pollution can be found in water, land and air.

50

Too much of this in the water keeps sunlight from reaching underwater plants.

Sediment

Excess sediment in the water blocks light and keeps underwater plants from getting enough light for photosynthesis.

100

Lakes and streams that lack limestone in the soils may suffer from this type of pollution.

Acid

Limestone neutralizes acids. If a lake or stream lacks limestone, the acid level can increase enough to harm aquatic organisms.

5

Fertilizer and animal manure contain these substances that are needed by plants.

Nutrients

Nutrients include nitrates, phosphates and other chemicals that plants use for growth.

10

Limestone contains compounds that neutralize this.

Acid

Limestone acts like an antacid. It neutralizes acids.

25

Water that flows over crystalline rocks (quartz, granite) will form (hard, soft) water.

Soft Water

Crystalline rocks do not dissolve easily in water. The water will have a low mineral concentration and be soft. Dissolved minerals add to the hardness of the water and change the water's chemistry.

50

Organisms that live on the bottom of lakes and rivers can be smothered by too much of this.

Sediment

Excess sediment settles to the bottom and smothers organisms that live there.

100

Many lakes, rivers and bays are suffering from too little of this in the water.

(Dissolved) Oxygen

Dissolved oxygen is measured in parts per million (ppm). Most organisms need at least 5 – 6 ppm. Water at the bottom of many bodies of water have less than 5 ppm dissolved oxygen.

5

Nitrate and phosphate are important for plant growth. These types of chemicals are called ______________.

Nutrients

Plants need a variety of nutrients to grow properly.

10

Water that has a lot of minerals is often called this.

Hard Water

Water high in minerals is called hard water. Water low in minerals is called soft water.

25

Oxygen that is dissolved in water is called this.

Dissolved Oxygen

This term is also abbreviated as DO.

50

The abbreviation ppm means this.

Parts Per Million

This term is used to describe the concentration of a substance in one million parts of water.

100

If a liquid has a pH below seven, it is this.

Acidic (an acid)

pH ranges from 0 – 14. Seven is neutral. Below seven is acid. Above seven is basic. The farther from seven, the stronger the acid or base.

5

Cool, clean water holds more of this than warm, polluted water.

(Dissolved) Oxygen

Warm water holds less oxygen than cold water. Oxygen molecules are forced out by high energy water molecules. Polluted water holds less oxygen than clean water. Oxygen molecules are displaced by dissolved or suspended particles.

10

The strength of acids and bases is measured by this.

pH

pH is the measure of the concentration of hydrogen ions (positively charged H atoms). The more hydrogen ions in solution, the stronger the acid. Fewer hydrogen ions indicate a stronger base.

25

The freezing and boiling temperatures of water in degrees Celsius.

0° and 100° Celsius (°C)

Water freezes at 0° C and boils at 100° C.

50

A pH of seven means the water is this.

Neutral

A pH of seven means there are equal amounts of hydrogen (H+) and hydroxyl (OH-) ions in solution.

100

A change in the Hydrogen ion concentration (H^+) causes this water quality measure to change.

pH

The concentration of Hydrogen ions (H+) determines the pH. Most organisms live within a narrow range of pH, 5.5 – 9.5. If the pH gets too far above or below this, or if it changes rapidly, most organisms can not survive.

5

Anything that reduces the quality of the environment is called this.

Pollution

There are many types of pollution. Even substances that are beneficial can become a form of pollution under certain situations.

10

Muddy water carries a lot of this.

Sediment

Eroded soil particles are carried by flowing water. Heavier particles settle out first as the water slows. Very small particles may remain suspended in the water for a long time.

25

Acid rain and certain types of chemical pollution can affect this water quality measure.

pH

Acids in rain water and certain types of chemical pollution can affect the pH of a body of water.

50

Algae will bloom (grow rapidly) when there is too much of this in the water.

NUTRIENTS

Algal blooms usually occur when there is excess nutrient in the water. The algal population increases rapidly. This can cause a decrease in dissolved oxygen as the algae die and decay. Some algae can also produce toxins.

100

Too much algae means too much decay which means less of this.

(Dissolved) Oxygen

Bacteria decay organic matter and consume oxygen. Even though an algal bloom produces more algae that produce more oxygen, as the algae die and decay, much of the oxygen is used by bacteria.

Introductory Game 2

This game provides an introduction to common terms and concepts related to water quality indicators presented in this program.

Study list of suggested answers

Play Game

ANSWERS

Study list of suggested answers for Introductory Level 2

Acids/Bases	**Ammonia**	**Anaerobic**
BOD/COD	**Buffers**	**Conductivity**
Dissolved Oxygen	**Erosion**	**Eutrophication**
Fecal Coliform Bacteria		**Hardness**
Impaired Water	**Inorganic**	**Nitrogen Cycle**
Non-Point Source	**Nutrients**	**Organic**
Parts Per Million	**Photosynthesis**	**Point Source**
Respiration	**Salinity**	**Temperature**
TDS/TSS	**Toxic**	

Select new game

Types of	Things Goin' On	What It Is?	Measures	Not So Good
5	5	5	5	5
10	10	10	10	10
25	25	25	25	25
50	50	50	50	50
100	100	100	100	100

5

Water pollution that flows through pipes or has a directed flow.

Point Source Pollution

Pollution that flows thought pipes such as treated sewage or factory wastes and stored wastes at combined animal feed lots is called point source pollution. It is easier to control and treat pollution at a point source than a non-point source.

10

Water pollution that comes from a wide area and is not controlled by pipes or other means.

Non-Point Source Pollution

Water pollution that comes from surface runoff, air pollution, groundwater or other non-controlled sources is called non-point source pollution. It is much more difficult to control and treat than point-source pollution.

25

A term that refers to poisonous substances such as pesticides, petroleum products and heavy metals.

Toxic

The term toxic refers to any substance that causes harm to living organisms. Even normally non-toxic substances can become toxic at very high levels or under certain conditions. Toxicity can be acute (quick acting) or chronic (slow acting).

50

A term that refers to carbon-based substances produced by living organisms.

Organic

Organic compounds are usually associated with complex life processes in living organisms. They can also include the thousands of man-made (synthetic) carbon compounds created for industry and agriculture.

100

A term describing elements, minerals and compounds associated with non-living substances.

Inorganic

Elements and compounds that are not carbon-based are called inorganic. However, elements can exist in both organic and inorganic forms. For example, phosphorous can exist in an inorganic compound such as sodium phosphate or an organic compound such as adenosine triphosphate (ATP), the energy molecule.

5

The process that wears away soil by the action of wind, water and ice.

Erosion

Soil erosion is a major source of water pollution. It adds sediment to the water and any chemicals carried by the soil.

10

The process by which green plants use sunlight, water, minerals and carbon dioxide to make food and give off oxygen.

Photosynthesis

Photosynthesis is the energy transforming process that allows life to exist. The energy in sunlight is converted to chemical energy and passed on to all organisms by food webs.

25

The process by which organisms consume organic matter to get energy and give off carbon dioxide.

Respiration

The term respiration is often used in place of the term breathing. Breathing is the physical process of forcing air in and out of the lungs. Respiration is the chemical process of converting food to energy.

50

Abbreviations for the terms: Biological Oxygen Demand and Chemical Oxygen Demand.

BOD (biological oxygen demand)
COD (chemical oxygen demand)

Biological demand usually refers to the difference between the amount of oxygen produced and the amount consumed. Certain chemicals react with oxygen and make it unavailable to living organisms. This is chemical oxygen demand.

100

The process by which nitrogen is converted to its various forms.

Nitrogen Cycle

The Nitrogen Cycle involves different types of bacteria that change nitrogen to its various forms. Ammonia from decaying organic matter is converted to nitrite then nitrate. Plants use nitrate for cell growth. Animals eat the plants and use the nitrogen to form proteins. Certain types of bacteria can use nitrogen gas to make nitrate and others can convert nitrate to nitrogen gas.

5

Salts and other compounds that help keep the pH stable are called this.

Buffers

Buffers are compounds that keep the pH stable. Acid buffers remove excess acid (H^+) while alkaline buffers remove excess base (OH^-). Sodium bicarbonate (baking soda) is a common acid buffer.

10

Most decaying organic matter that contains proteins breaks down to this nitrogen-based compound.

Ammonia

Muscle and other types of tissue are composed of proteins. Proteins are nitrogen-based compounds. Decay breaks protein down into its basic building blocks including ammonia, carbon dioxide, water and other substances.

25

The expression for the amount of a substance dissolved in one million units of water.

Parts Per Million

One gram of calcium dissolved in one million liters of water produces a liquid concentration of 1 part per million (ppm) calcium. Milligrams per liter also represents parts per million.

50

The abbreviations for the terms:

Total Dissolved Solids and Total Suspended Solids.

TDS

Total Dissolved Solids refers to all compounds and elements dissolved in water. They cannot be filtered out. It is related to Hardness, Salinity and Conductivity.

TSS

Total Suspended Solids refers to all particles suspended in the water column. They can be filtered out. It is related to Turbidity.

100

The measure of water’s ability to conduct electricity.

Conductivity

Pure water is not a good conductor of electricity. Dissolved substances that form charged particles, such as salt, increase the conductivity - the greater the concentration, the greater the conductivity. For example, saltwater has a greater conductivity than freshwater.

5

The measure of the heat energy of matter.

Temperature

Temperature is measured in degrees Fahrenheit (F) or Celsius (C) (also called Centigrade). The freezing point of water is 32°F or 0°C and the boiling point is 212 °F or 100 °C.

10

The measure of the mineral content of water, primarily calcium and magnesium.

Hardness

Calcium and magnesium are the most abundant minerals found in freshwater. Their concentrations are used to determine Hardness. Total Hardness is the combined concentrations of both minerals. Water with high concentrations is called "hard" water and with low concentrations is called "soft" water.

25

Hydrogen ions (H^+) and hydroxyl ions (OH^-) help identify these two types of compounds.

Acids and Bases

Acids are characterized by hydrogen (H^+) ions and bases by hydroxyl (OH^-) ions. Hydrochloric acid (HCl) forms hydrogen ions and chlorine ions in water. Sodium hydroxide ($NaOH$) forms sodium ions and hydroxyl ions in water.

50

Nitrate, phosphate and potassium are examples of what plants need for growth.

Nutrients

Plants need nutrients for growth the same as we do. The primary nutrients for plants are nitrogen, phosphorus and potassium: nitrogen for leaves and stems, phosphorus for roots and potassium for reproduction.

100

The measure of the salt content of seawater.

Salinity

Salinity is measured in parts per thousand. Ocean water has about 35 parts per thousand sodium chloride salt. In addition, only seven salts make up about 99% of the mineral content of seawater.

5

Refers to free oxygen that is found in water.

Dissolved Oxygen

Oxygen is necessary to support aquatic life. The small amount of oxygen that dissolves in water (only a few parts per million) is enough to support the vast numbers of organisms that live in water.

10

Refers to waters that do not meet standards for their designated use (fishing, swimming, etc.).

Impaired Waters

The Federal Government has set water quality standards for the different types of water use. These standards identify pollution, dissolved oxygen, pH and other water quality measures for each use. Nearly 40% of our waters nationwide do not meet designated standards.

25

The aging process in waterways involving excess nutrients and sediment.

Eutrophication

Excess nutrients cause excess algae to grow which die and decay. As they decay, bacteria consume oxygen. More oxygen is consumed by the bacteria than is produced by the algae. The result is low dissolved oxygen. Excess sediment smothers bottom organisms and blocks sunlight entering the water. These processes result in an environment that can support little life.

50

Biological activity that occurs without oxygen.

Anaerobic

Some bacteria can use certain compounds in the absence of dissolved oxygen to get the energy they need. As a result, they produce substances such as hydrogen sulfide (smells like rotten eggs) and methane (an explosive gas).

100

Bacteria associated with human and warm-blooded animal waste.

Fecal Coliform Bacteria

Coliform bacteria are widespread and found in most surface waters. Small amounts are expected. However, the presence of large numbers of coliform bacteria may indicate the potential for waterborne illness. Fecal coliform bacteria are found in human and warm-blooded animal waste. Many types of bacteria, viruses and parasites accompany human and animal waste.

Introductory Game 3

This game provides a basic introduction to common terms and concepts related to water quality indicators presented in this program.

Study list of suggested answers

Play Game

ANSWERS

Study list of suggested answers for Introductory Level 3
(Some answers are used more than once.)

Ammonia	Bacteria	Brackish
Groundwater	Clay	Turbidity
Dissolved Oxygen	(Fecal) Coliform Bacteria	
Heavy Metals	Herbicides	Hydrometer
Liter	Nutrients	Parts Per Thousand
Pesticides	Saltwater	Secchi Disk
Sediment	Sodium Chloride	Total Dissolved
Solids	Total Suspended Solids	
Toxic Substances	Chemicals	

Select new game

Chemical Names	What it is?	Measures of:	What's in Water?	Solutions
5	5	5	5	5
10	10	10	10	10
25	25	25	25	25
50	50	50	50	50
100	100	100	100	100

5

Chemicals used to control animal and plant pests are called this.

Pesticides

There are several ways pesticides kill the target animal or plant. Some interrupt vital body functions by affecting enzymes or the nervous system. Some cause tissue to break down affecting different systems. Some pesticides kill the organism upon contact while others must be absorbed into the organism's body in order to take effect.

10

Chemicals used to control plant pests and weeds.

Herbicides

Plant pests compete with lawn grasses, crop and nursery plants for water and nutrients. Herbicides are used to control plant pests by interrupting certain chemical processes in the plants. Herbicides should always be used according to instructions and only when there are no other methods that can control the pests.

25

Muscle tissue in animals is composed of proteins. After animals die, this tissue breaks down to produce this compound.

Ammonia

Animal muscle is composed mostly of protein. When the animal dies, the protein breaks down to form ammonia. Animal waste also contains proteins and ammonia. Bacteria then convert the ammonia to nitrite then nitrate. Plants use the nitrate for growth. This is part of the nitrogen cycle.

50

Mercury, lead and chromium are examples of these.

Heavy Metals

Heavy metals occur naturally. However, industrial and chemical activity has greatly increased their presence in the environment. Many are passed along in food chains, the larger predators getting higher doses than smaller prey organisms.

100

A major concern with water quality is the long-term exposure to low levels of these.

Toxic Substances

There are many types of toxic substances. Many are carefully regulated, especially when it comes to drinking water. In addition, there are allowable limits of contamination of water in the environment. In spite of these limits, water pollution is a concern. Over a lifetime, individuals can be exposed to many different contaminants but at very low levels. Scientists do not fully understand how this affects the human body.

5

Septic systems are used to treat household sewage waste. Failing systems can be a direct pollution source for

______________.

Groundwater

Septic systems use a digestion box that allows bacteria to decompose organic waste. The liquid waste is distributed to a drain field and slowly moves down into the groundwater. Failing systems can release bacteria and household chemicals into groundwater. Even properly working systems add nitrate to groundwater.

10

Because the particles are very small, this soil type does not readily settle out of water.

Clay

Clay particles are so small that it would take more than 1000 of them to equal the size of a small grain of sand. Since they are so small, they can stay suspended in water for a long time. In fact, the movement of the water molecules in non-flowing water can keep clay particles from settling out.

25

The nitrogen cycle involves these types of organisms in changing nitrogen into its different forms.

Bacteria

Different types of bacteria cause the decay of organic matter (proteins) and produce ammonia. Other types of bacteria change ammonia to nitrite, then nitrate. Plants use nitrate for growth, creating proteins and other substances that are consumed and used by animals. Certain types of plants, such as clover and alfalfa, have bacteria in their roots that turn nitrogen gas into nitrate. In addition, certain bacteria can change nitrate to nitrogen gas. This entire process is called the nitrogen cycle.

50

About 40% of Virginians depend on well water for their water supply. What is the one test that is required before a well is approved for household use?

Coliform Bacteria

Although there are many factors that can affect water quality, most county and city health departments only require a test for total and fecal coliform bacteria. If the well does not pass, the water cannot be used for human consumption. In most cases, an occupancy permit for the property will not be issued.

100

The three most wide-spread types of pollution.

Nutrients, Sediment, Bacteria

Surface runoff carries a great deal of pollutants including fertilizer, sediments, animal waste, and just about anything that lies on the land. Although toxic chemicals are part of this, these three pollutants are the most widespread.

5

Most of the salt in the sea is composed of this compound.

Sodium chloride

The salt in seawater is 86% sodium chloride, known as table salt. There are six other salts that make up 13% of the substances dissolved in seawater. The remaining 1% contains nearly every other element found on earth. There are also many types of organic compounds and many types of human-made substances.

10

This is an indicator of water clarity.

Turbidity

Suspended sediments and dissolved substances in water can affect how much light can pass through the water. If the water is holding a significant amount of suspended and dissolved material, it will become murky or cloudy. This material absorbs or reflects light, preventing it from passing through the water. Turbidity is the measure of the "murkiness" of the water.

25

Sediment suspended in water can be filtered and weighed to measure the total amount of these.

Total Suspended Solids

A measured amount of water (1 liter) is filtered. The material trapped in a filter is dried and weighed in milligrams. This gives the amount of suspended sediment (solids) in milligrams per liter of water. High levels of suspended sediments affect water temperature, dissolved oxygen levels, plant growth and other factors.

50

This is an instrument used to measure turbidity.

Secchi Disk

The secchi disk is a weighted plastic plate about 8 inches in diameter. It is lowered into the water on a marked cord until it is no longer visible. It is slowly raised until it just becomes visible. The depth of the secchi is recorded, indicating the clarity of the water. Secchi readings can vary from a few inches in very turbid water to hundreds of feet in clear ocean water.

100

This is an instrument used to measure water density or specific gravity.

Hydrometer

A hydrometer is a floating tube or dial that measures the Specific Gravity (density) of a liquid. Pure water has a specific gravity of one. Solutions with a specific gravity greater than one are denser than pure water. Ocean water has a specific gravity of about 1.022 and is denser than pure water.

5

Trout generally do not survive in water warmer than 65ºF because it does not supply enough of this.

Dissolved Oxygen

Cold water holds more dissolved oxygen than warm water. The reason is the water molecules are less active when cool. Warm water molecules are more active and drive the oxygen molecules out of solution.

10

Sediment and suspended solids can add these types of pollutants to water.

Nutrients, Chemicals, Bacteria

Many types of chemicals attach to soil particles. These chemicals include toxic wastes, fertilizer, pesticides, petroleum products and many others. When soil is washed (eroded) into waterways, it carries these chemicals with it. In addition, bacteria in the soil and in animal wastes enters the water.

25

Groundwater in shallow coastal wells is often affected by this.

Saltwater

As freshwater is pumped from shallow coastal wells, salty groundwater from the ocean will seep in to take its place. The result is called salt intrusion. Many coastal well owners have to chemically remove the salt from their well water before using it.

50

Excess nutrients cause algae to grow in excess (bloom). As the algae die and decay, this water quality indicator is reduced.

Dissolved Oxygen

Algae need a certain amount of nutrient. However, when there is too much nutrient, the algae grow in excess (bloom). As algae die and decay, bacterial populations also increase. This causes the dissolved oxygen level to decrease because the bacteria consume more oxygen than the algae can produce.

100

These bacteria can indicate human sewage or animal waste pollution.

Fecal Coliform Bacteria

Coliform bacteria are found everywhere and most are harmless. However, too many coliform bacteria can indicate polluted water. In addition, certain types of coliform bacteria, called fecal coliforms, are found in the intestines of humans and animals. Their presence in water indicates sewage or animal waste pollution that can cause serious illness in humans.

5

One thousand milliliters equals one of these.

Liter

The liter is a common liquid measure and is a little more than one quart. Metric measures are easy to use in determining concentrations because they are in multiples of 10. Look at the label of most liquid products and you will see the volume expressed in pints/quarts/gallons and in milliliter/liters. Most liquid products are now sold by the liter.

10 PC

Water that is partially salt and fresh is called this.

Brackish

Brackish water (a mix of salt and fresh water) has less than 20 parts per thousand salinity. Ocean water has a salinity of around 35 parts per thousand (35 grams of salt per 1000 milliliters of water).

25 PC

Salinity is measured in these units.

Parts Per Thousand

One thousand milliliters of seawater (one liter) contain about 35 grams of salt. This is expressed as 35 parts per thousand (ppt) salinity.

50 PC

Total dissolved and suspended solids determine how much light penetrates the water. The indicator of water clarity is called…

Turbidity

Particles suspended in water absorb light and prevent it from passing through the water. The more suspended material in the water, the greater is the turbidity. Certain substances dissolved in water also absorb light and increase turbidity.

100 PC

A conductivity reading can also be used to determine this water quality indicator.

Total Dissolved Solids

Pure water does not conduct electricity very well. However, as solids are dissolved in water, the conductivity increases. This increase is directly related to the amount of dissolved solids. In general, the amount of total dissolved solids (TDS) in parts per million equals one-half the conductivity reading.

Beginner

The following questions are related to these water quality indicators:

Temperature	Total Dissolved Solids	
Salinity	Total Suspended Solids	
Turbidity	Disease	Toxics

Study list of suggested answers

Play Game

ANSWERS

Study list of suggested answers for Beginner Level (Some answers are used more than once.)

Air	Antifreeze	Clay
Coliform Bacteria	Density	Dissolved Oxygen
Erosion	Human/animal Waste	Mercury
Parts Per Thousand	Sand	Salinity
Silt	Sodium Chloride	Temperature
Turbidity	Total Dissolved Solids	
Total Suspended Solids		

Select new game

Hot or Cold	One Lump or Two?	With a Grain of Salt	Can't See The Bottom	I Don't Feel So Good
5	5	5	5	5
10	10	10	10	10
25	25	25	25	25
50	50	50	50	50
100	100	100	100	100

5

Thermometers that have this element are not safe to use.

Mercury

Mercury is a highly toxic (poisonous) substance. A broken thermometer can expose a person to this toxic material or it can find its way into the environment.

10

The amount of soluble substance that water can dissolve is greatly affected by this.

Temperature

Warm water more readily dissolves substances than cold water. Warm-water molecules have more energy than molecules of cold water.

25

Coldwater fish species may have this type of chemical in their blood to protect them from freezing water.

Antifreeze

Fish that live in very cold climates often have “antifreeze” in their blood. These are special molecules that prevent their blood from freezing when the water temperature drops below the freezing point. This occurs in polar ocean regions.

50

The most accurate type of thermometer is the ___________ thermometer.

Digital Thermometer

Digital thermometers are accurate to hundredths of a degree and more. They are quick and safe to use.

100

This water quality indicator affects the dissolved oxygen level in water and metabolic rate of aquatic organisms.

Temperature

Warm water holds less dissolved oxygen than cooler water. In general, an organism in warm water will have a higher metabolic rate than in cooler water. However, some organisms are adapted to cool environments (trout) while others require warmer water (tropical fish).

5

The abbreviation TSS stands for…..

Total Suspended Solids

Erosion adds soil to water. These soil particles are called sediment. As long as the water is flowing, sediment will remain suspended in the water column. As the water slows down, heavier particles settle out first. Smaller particles settle out as the water flow slows even more.

10

The abbreviation TDS stands for .....

Total Dissolved Solids

Many substances dissolve in water. The most common substances include salt, calcium and magnesium compounds, carbonates and many others. Water hardness is a measure of these dissolved substances. In general, the harder the water, the more dissolved solids it contains.

25

Which of these particles would settle out of water first?

A. Silt B. Sand C. Clay

B. Sand

Sand particles are heavier than silt or clay particles and would be the first to settle out of water as sediment.

50

Fast moving river water carrying a lot of sediment will cause this to increase along a river bank.

Erosion

The heavy sediment load of the water actually causes more sediment to be picked up by the water. The suspended particles act like mini-hammers, knocking shore-line sediment loose so it can be washed away. Erosion rates increase with increasing sediment load.

100

High TSS and TDS usually result in lower:

A. Dissolved oxygen

B. Temperature

C. Water hardness

Dissolved Oxygen

The dissolved and suspended sediment displaces the oxygen. It increases the dissolved solids in the water (hardness) and allows the water to absorb more heat energy, thereby increasing the temperature.

5

This term refers to the salt content of seawater.

Salinity

The salt content of seawater is referred to as salinity. The primary salt is sodium chloride. There are seven salts that make up 99% of the "salt" in seawater. The remaining one percent is composed of many other elements and compounds.

10

Salinity is measured in parts per ___________.

Parts Per Thousand

There are 1000 milliliters in a liter of water. Ocean water has about 35 grams of salt per liter. This is expressed as 35 parts per thousand salinity.

25

Saltwater is (denser, less dense) than freshwater.

Denser

The density of water is affected by its temperature and amount of dissolved solids it contains. Since saltwater contains much dissolved solids, it is about 1.022 times denser than freshwater.

50

Most of the salt in seawater is composed of this compound.

Sodium chloride

(table salt)

About 86% of the “salt” in seawater is composed of this compound. Six other salts make up 13% of the “salt.” The remaining one percent is composed of just about every element found on earth.

100

The density of water is affected by:

A. Temperature

B. Salinity

C. Temperature and salinity.

C. Temperature and salinity

The colder and saltier the water, the denser it is.

5

This indicator is a measure of water clarity.

Turbidity

Turbid water contains a large amount of suspended and/or dissolved solids. In addition, excess algae and bacteria can also increase turbidity.

10

A secchi disk is used to measure this water quality indicator.

Turbidity

The secchi disk is a round, weighted plastic plate about 8 inches in diameter. It is lowered into the water on a marked cord until it is no longer visible. It is slowly raised until it just becomes visible. The depth of the secchi is recorded, indicating the clarity of the water.

25

This type of soil particle can remain suspended in water, keeping the water turbid.

Clay

Clay particles are so small that the actual movement of water molecules can keep them in suspension.

50

Because of high turbidity, much of the submerged vegetation in the Chesapeake Bay has died out due to lack of this.

(Sun)Light

High turbidity prevents sunlight from penetrating water. As a result, plants cannot get the light needed for photosynthesis.

100

Murky (highly turbid) water has at least 150 ppt suspended sediment per liter. How many grams of sediment is this?

150 grams

(about 5 ounces)

There are 1000 milliliters per liter. Therefore, 150 ppt (parts per thousand) equals 150 grams in 1000 milliliters.

5

Coliform bacteria are found

A. Only in soil.

B. Only in water.

C. In both soil and water.

C. In both soil and water

There are several types of coliform bacteria and they are found everywhere. High populations can indicate the potential for disease-causing organisms.

10

The presence of fecal coliform bacteria indicates this type of contamination.

Human and/or animal waste

All warm-blooded animals and humans have fecal coliforms in their intestines. Presence of these organisms in water indicates human or animal waste pollution.

25

There are many types of fecal coliform bacteria that can cause illness in humans.
(True/False)

False

One type of fecal coliform bacteria (*E. coli* 0157:H7) causes illness in humans. It results in "travelers diarrhea," better known as Montezuma's Revenge. The illness can be severe and should be promptly treated.

50

About 25% of the pollutants that enter water come from this non-point source.

Air

Air pollution has become a critical source of water pollution. Air pollutants come down to the earth's surface with rain and snow. These pollutants find their way into the soil, surface water and eventually groundwater.

100

How many synthetic chemicals are in use today?

A. 10,000

B. 50,000

C. 85,000

C. 85,000

Nearly 85,000 synthetic chemicals are in commercial use today. Many now known to cause cancer and/or damage to the brain, nervous, endocrine and reproductive systems.

http://www.nrdc.org/health/effects/default.asp

Advanced

The following questions are related to these water quality indicators:

Temperature	**Total Dissolved Solids**	
Salinity	**Total Suspended Solids**	
Turbidity	**Disease**	**Toxics**

Study list of suggested answers

Play Game

ANSWERS

Study list of suggested answers and related terms for Advanced Level

Alkalinity	**Anopheles Mosquito**	**Atrazine**
$C = 5/9(F - 32^{o})$	**Celsius**	**Cholera**
Conductivity	**Enterococcus**	**$F = 9/5C + 32^{o}$**
Fahrenheit	**Fecal Coliform**	**Giardia**
Hardness	**Hepatitis A**	**Hydrometer**
Legionnaire's	**Malaria**	**pH**
Refractometer	**Salinity**	**Salmonella**
Secchi Disk	**Sediment**	**Temperature**
Thermocline	**Tidal (Salt) Wedge**	**TDS**
TSS	**Turnover**	**Typhoid**

Select new game

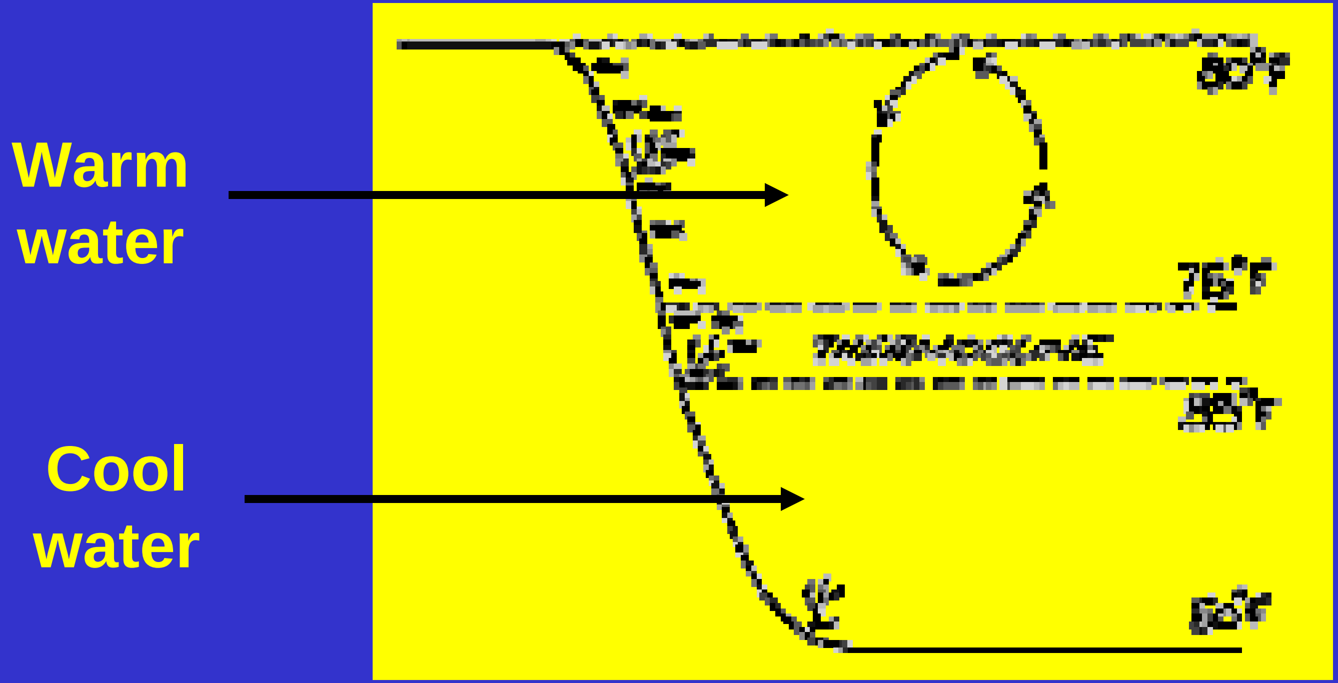
Hot or Cold	One Lump or Two?	With a Grain of Salt	Can’t See The Bottom	I Don’t Feel So Good
5	5	5	5	5
10	10	10	10	10
25	25	25	25	25
50	50	50	50	50
100	100	100	100	100

5

Freshwater lakes and ponds will form layers of water separated by differences in this indicator.

Temperature

During the summer, a warm-water layer that is several feet thick forms on the surface of ponds and lakes. A cool-water layer forms below this.

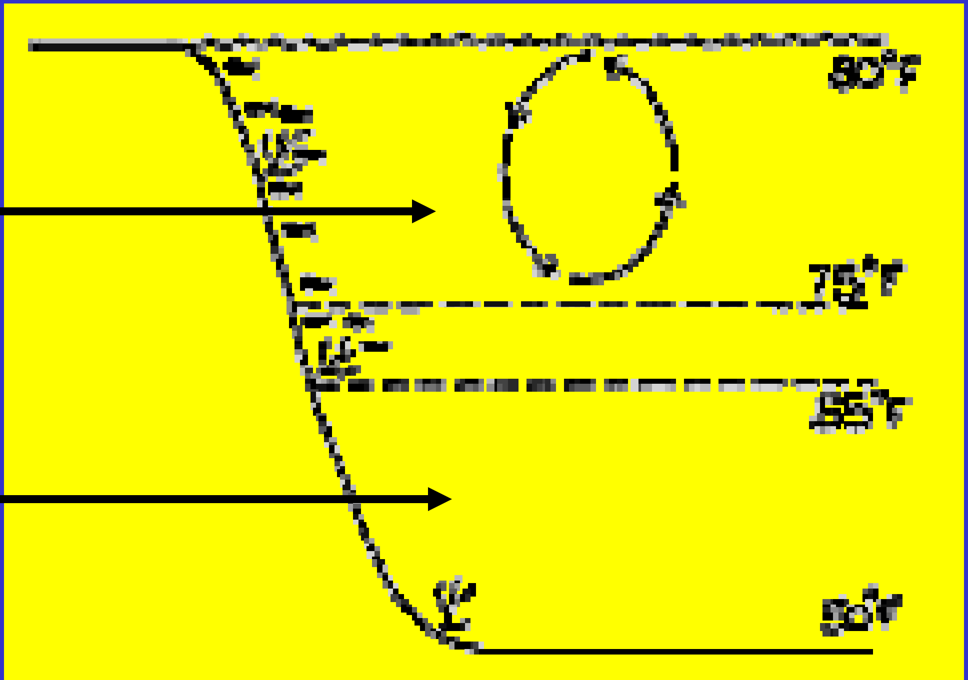


Turnover Cycle

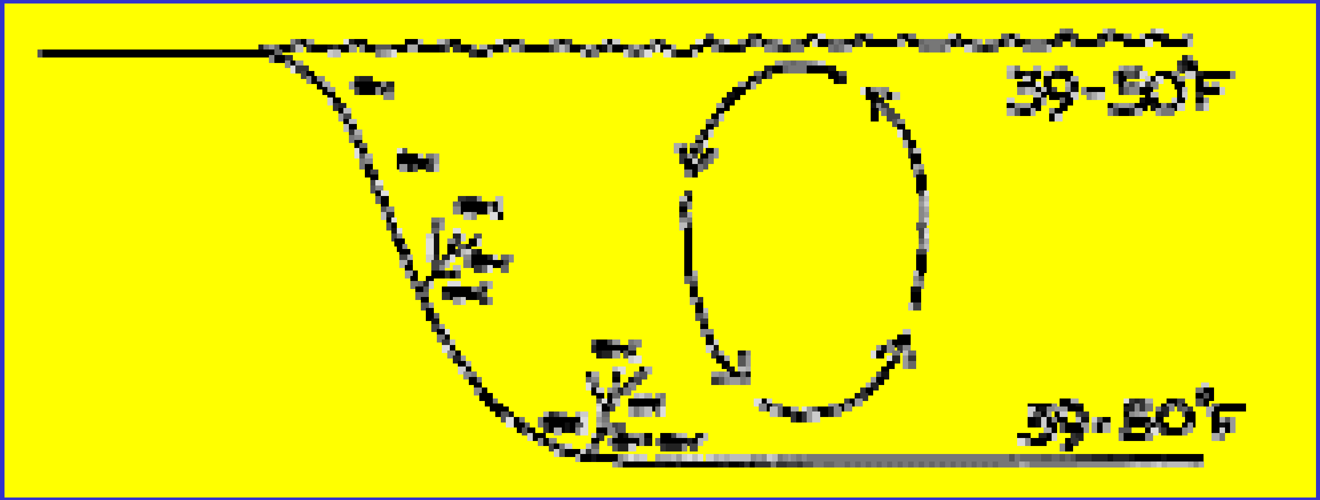
Anyone who has ever swum in a lake or pond has certainly felt the two layers. The boundary between the two is called the <u>thermocline</u>.

Warm water

Cool water

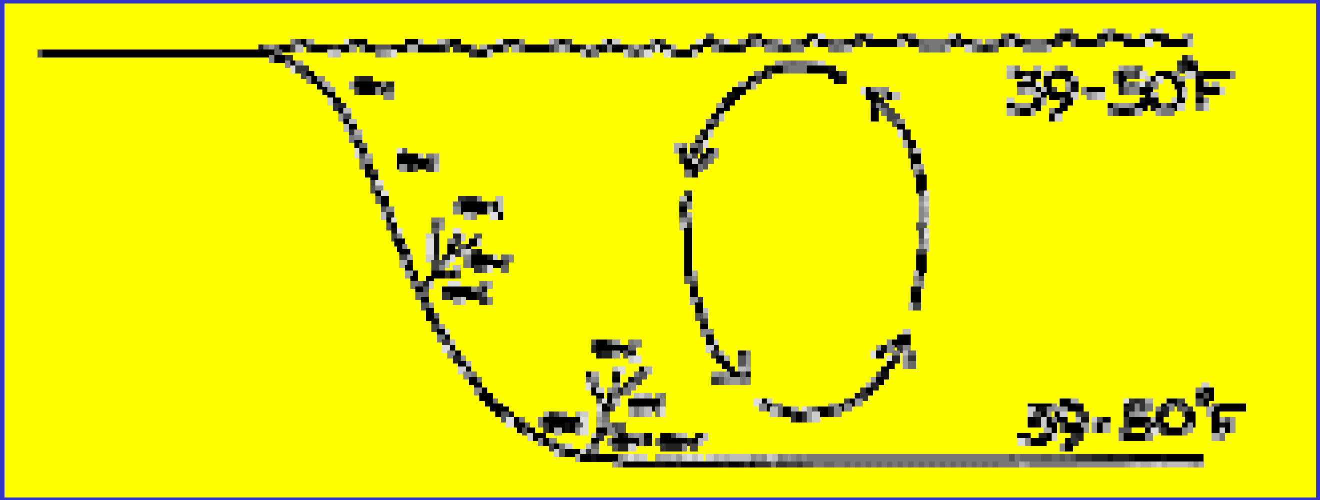


As the warm surface water cools in the fall, it sinks and displaces the water below, causing the water to circulate. This process is called turnover.



During a cold winter, ice forms on the surface and water at 39° F (4 ° C) is on the bottom. Water is densest at 39º F.

During spring, the ice melts and water begins to circulate (turnover) until warmer weather allows the warm/cool layers to form again.



Return to Topics

10 PC

Water is densest at 39° F (4° C). Where would water at that temperature be located during winter in a deep pond?

On the Bottom

During a cold winter, ice forms on the surface of a lake or pond because it is less dense than liquid water. Water at 39° F (4 ° C) is on the bottom because water is densest at this temperature.

25 PC

Polar seawater can be below 32° F and still not freeze. This is because it has a high __________.

Salinity

The salt in seawater decreases the freezing temperature.

50 PC

To convert Celsius to Fahrenheit degrees:

$F = 9/5 \; C + 32$

If C = 0º, then F = ??

$F = 32°$

$F = (9/5 \times 0°) + 32° = 32°$

This is the formula for converting degrees Celsius to degrees Fahrenheit.

100 PC

To convert Fahrenheit to Celsius degrees:

$C = 5/9 (F - 32)$

If F = 212°, then C = ??

C = 100°

$C = 5/9(212^{o} – 32^{o}) =$

$5/9 \times (180^{o}) =$

100^{o}

This is the formula for converting degrees Fahrenheit to degrees Celsius

5 PC

Which factor determines how much sediment water can carry?

A. The rate of water flow.

B. The size/weight of the particles.

C. The structure of the river bed.

D. A and B

E. B and C

F. All of these

F. All of these

Fast-flowing water can move more sediment than slower water. The heavier the particles, the more energy is required to move them. The structure of the stream or river bed can allow the water to slow down or speed up, affecting the water's ability to move sediment.

10 PC

Salinity, hardness and alkalinity all contribute to this water quality indicator.

Total Dissolved Solids

Salinity, hardness and alkalinity are all the result of certain types of substances dissolved in water. Water with a high level of TDS will have high levels of one or more of these indicators.

25 PC

A liter of water is filtered. The filtered material is dried and weighed. This gives the amount of ________________________________.

Total Suspended Solids

Special filtering equipment is used to collect the sediment suspended in the water. Once dried, it is weighed and the result is expressed as milligram per liter (parts per million) for less turbid water or grams per liter (parts per thousand) for more turbid water.

50 PC

A liter of water is filtered. The filtered water is then evaporated and the remaining material left is dried and weighed. This gives the amount of ______________________________.

Total Dissolved Solids

Special filtering equipment is used to remove sediment suspended in the water. The filtered water is then evaporated in a pre-weighed container. After the water has completely evaporated, the container is reweighed to determine the amount of dissolved material remaining.

100 PC

High conductivity also indicates a high level of

______________________________.

Total Dissolved Solids

Many of the substances dissolved in water will conduct electricity. Therefore, water with a high TDS usually has a high conductivity.

5 PC

A salinity of 35 ppt means there is 35 grams of salt for every _________ of seawater.

Liter

Thirty-five grams in 1,000 milliliters of water represents 35 parts per thousand (ppt).

10 PC

Refractometers, hydrometers and conductivity meters can all be used to measure

______________________.

Salinity

A refractometer uses the light to measure salinity. Light bends (refracts) when it enters water. The saltier the water, the greater the refraction.

A <u>hydrometer</u> measures the specific gravity (density) of a liquid compared to pure water.

A <u>conductivity meter</u> measures the amount of current that can pass through a liquid. The saltier the water, the greater the conductivity.

25

Cold seawater is denser than:

A. Cold freshwater
B. Warm seawater
C. Cold freshwater
D. All of these
E. None of these.

D. All of these

The colder and saltier the water, the denser it is.

50 PC

The salinity of the ice in an ocean iceberg is:

A. 35 ppt

B. > 35 ppt

C. Near 0 ppt

C. Near 0 ppt

As ocean water freezes, almost all of the salt comes out of the water. The ice in an iceberg has almost no salt in it. In addition, most icebergs originate from glaciers which are created from snow in polar regions.

100 PC

At a coastal river's mouth, saltwater can move upriver along the bottom during high tide. This is called a ____________ ____________.

Tidal (Salt) Wedge

An incoming tide will contain saltwater that flows into the river along the bottom. Called a salt wedge, the effect of the tidal surge can often be felt upriver for many miles.

5 PC

Which one of these indicators most severely affects benthic (bottom) organisms?

A. Hardness
B. TDS
C. TSS

TSS
(Total Suspended Sediments)

Suspended sediments eventually settle out of the water and can smother benthic organisms.

10

High sediment loads in water can also indicate high levels of:

A. **Bacteria.**

B. **Nutrients.**

C. **Chemicals.**

D. **All of these.**

D. All of these

Sediment can include anything that is contained in the soil. Animal waste, yard and farm chemicals, industrial waste and petroleum products are just a few of the types of pollutants that accompany suspended sediments.

25

High TSS usually results in higher:

A. Dissolved oxygen.

B. Temperature.

C. Water Clarity.

B. Temperature

Particles suspended in water will absorb solar energy and increase water temperature. In clear water, much of the solar energy passes through the water.

50 PC

A secchi reading of 18 inches indicates:

A. Low turbidity.

B. High TSS/TDS.

C. Low TDS.

B. High TSS/TDS

The secchi disk measures how far light can penetrate into the water. A reading of 18 inches indicates that high total suspended and/or dissolved solids are blocking light penetration.

100 PC

Which one of these indicators is <u>not</u> usually associated with TSS?

A. Temperature
B. pH
C. Bacteria

B. pH

pH is affected by dissolved solids, not suspended solids. High suspended solids can increase bacterial levels and water temperature.

5

Enterococcus bacteria are commonly found in swimming water where people have become ill. What does their presence indicate?

Fecal contamination

Enterococcus bacteria are related to fecal contamination. They are more often associated with illnesses resulting from contaminated swimming water than fecal coliforms and can survive in saltwater.

10 PC

Which of these illnesses is/are <u>not</u> water-related?

A. Typhoid B. Giardia

C. Cholera D. Hepatitis- A

F. Legionnaire's disease

E. Salmonella F. None

F. None

All of these illnesses are water-related. Typhoid, Cholera, Salmonella and Legionnaire’s disease are caused by bacteria. Giardia is a protozoan parasite and Hepatitis A is a viral disease.

25 PC

This water-related, non-bacterial disease kills more than one million people each year.

Malaria

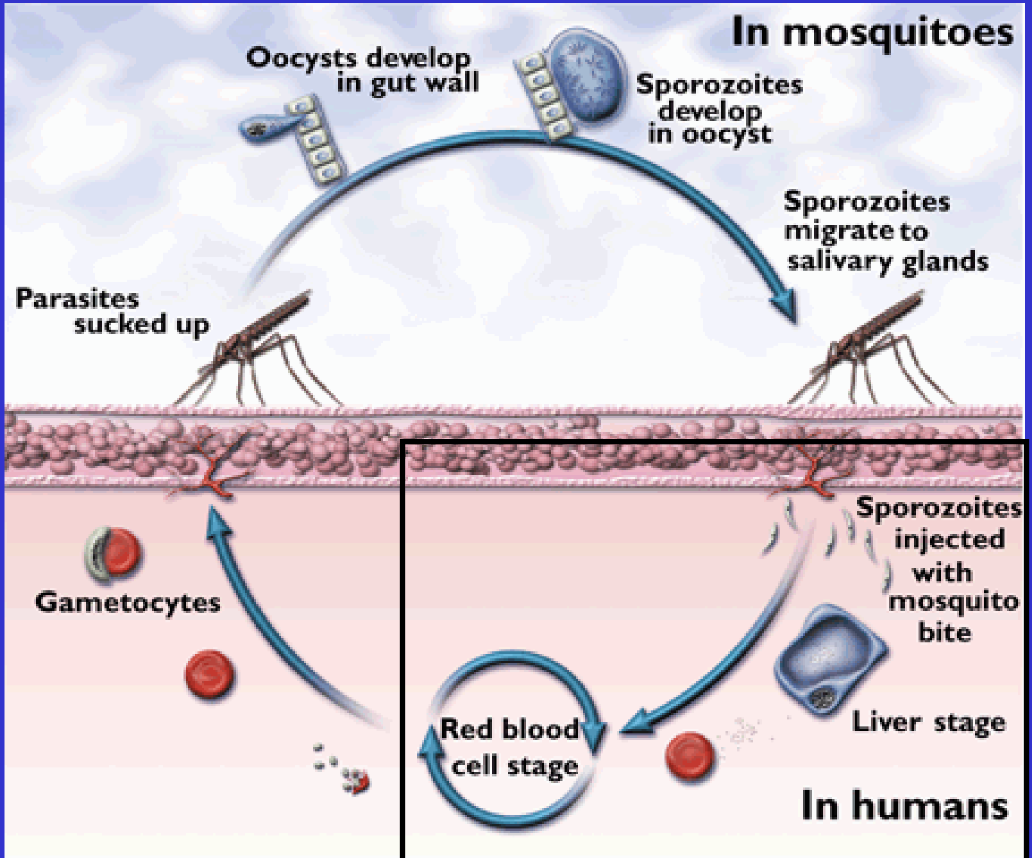
Malaria parasites are spread by infecting two types of hosts: humans and female *Anopheles* mosquitoes. The parasites go through two life cycles, one in humans and one in mosquitoes. The mosquito transmits the disease from human to human.

Malaria Life Cycle

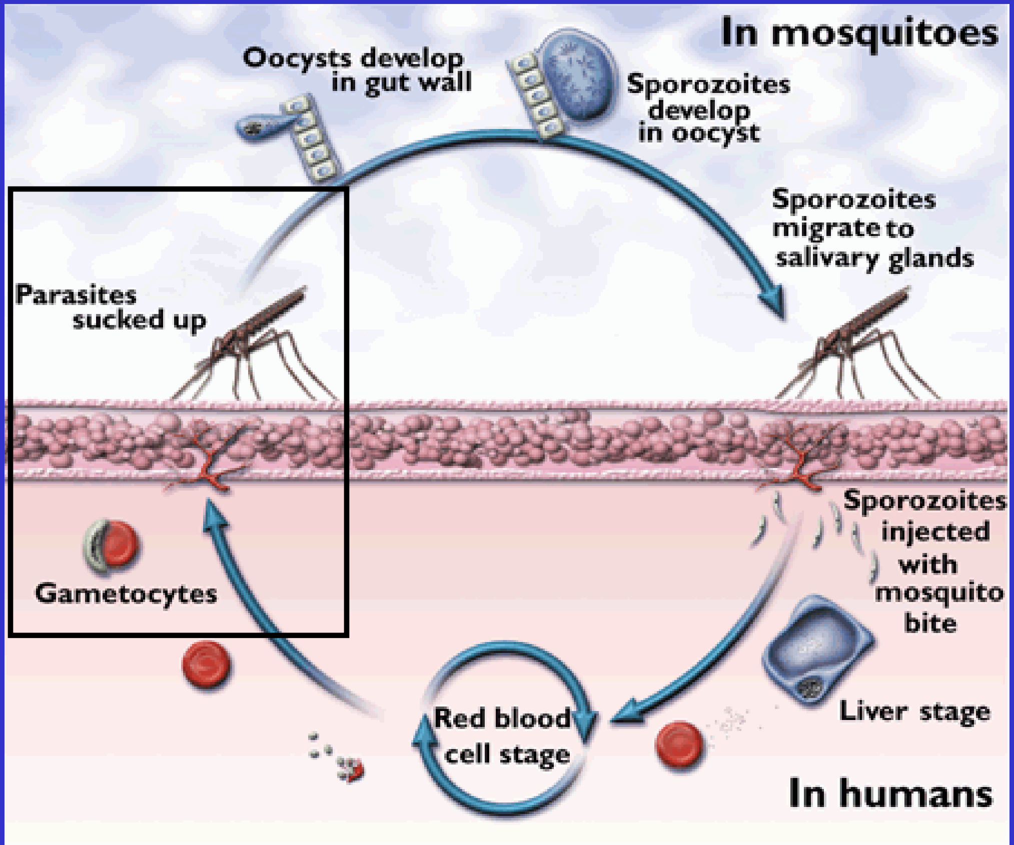
Malaria

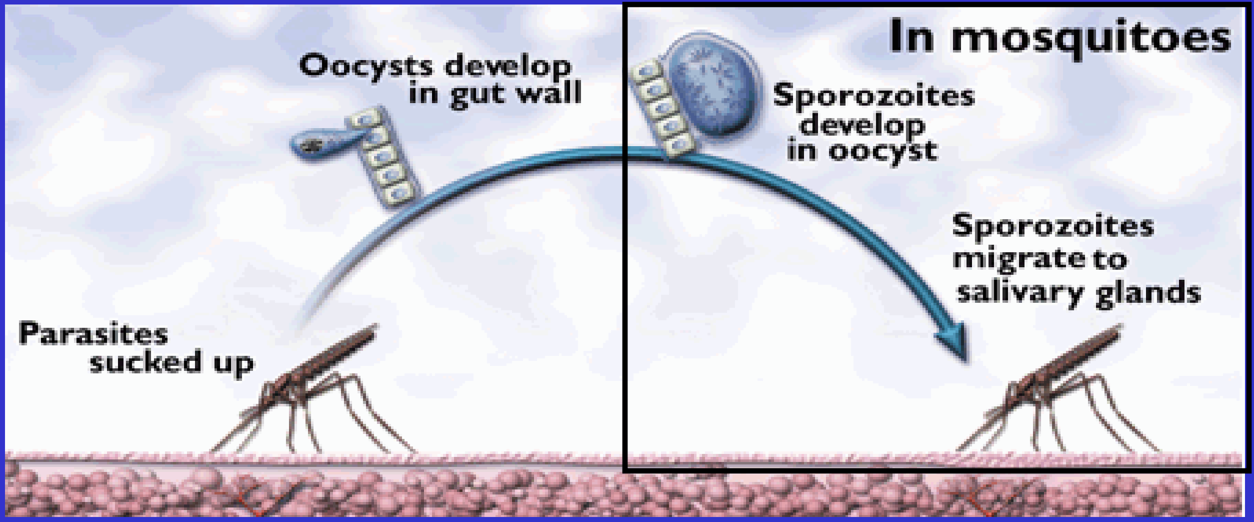
In nature, malaria parasites are spread by infecting two types of hosts: humans and female *Anopheles* mosquitoes. In humans, the parasites grow and multiply first in the liver cells and then in red blood cells.

Successive broods of parasites grow inside the red cells and destroy them, releasing daughter parasites (merozoites) that continue the cycle by invading other red cells.



When certain forms of the parasites (gametocytes) are picked up by a female *Anopheles* mosquito during a blood meal, they start a different cycle of growth in the mosquito.

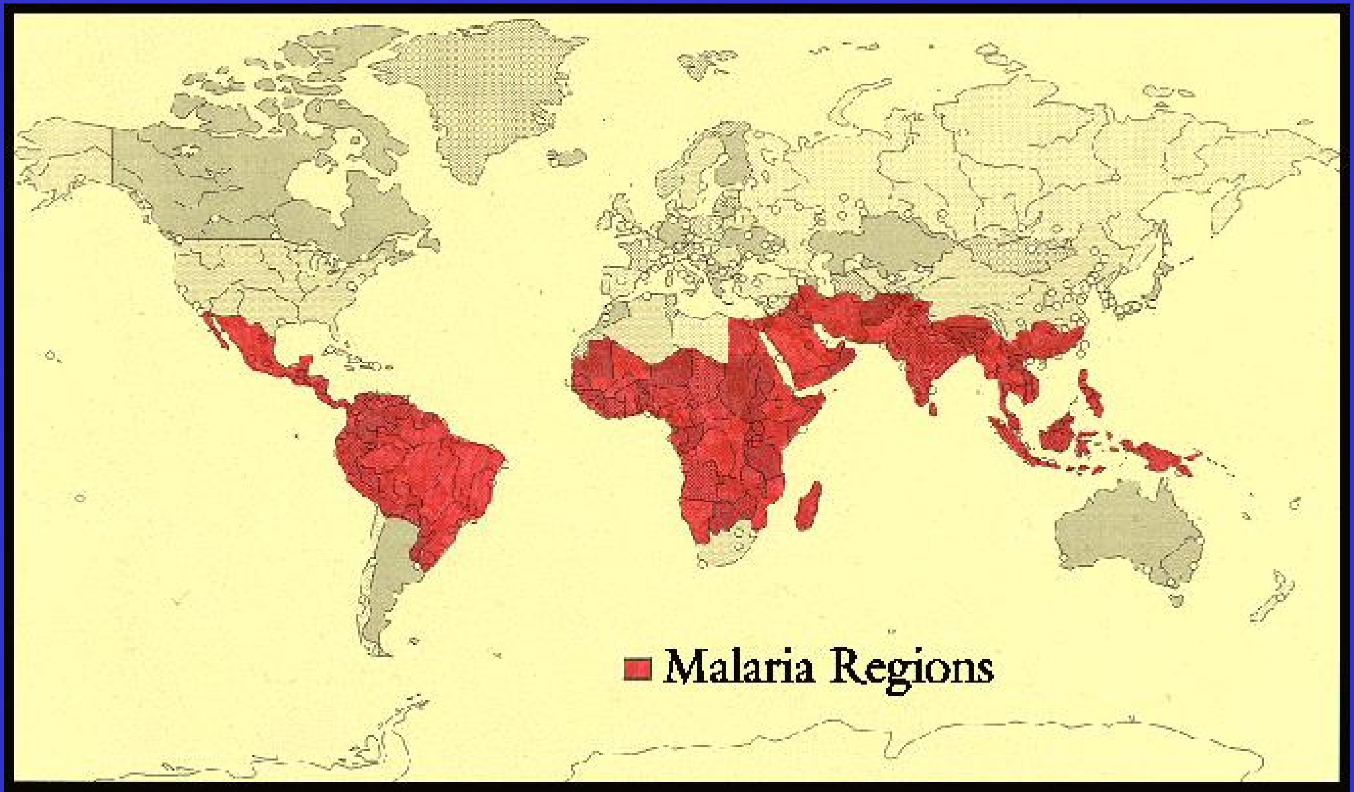




In 10-18 days, the parasites (sporozoites) are found in the mosquito's salivary glands. When the *Anopheles* mosquito takes a blood meal on another human, the sporozoites are injected with the mosquito's saliva and start another human infection.

Thus the mosquito carries the disease from one human to another. The mosquito host does not suffer from the presence of the parasites.

http://www.cdc.gov/malaria/biology/index.htm



Return to Topics

50 PC

A beach front community with septic systems is being pressured to hook up to sewers (at a cost of $5,000 per household), because a study found about 80 human fecal coliforms per 100 ml of water.

Do you agree or disagree? Why?

Disagree

The allowable level of fecal coliforms in swimming water is 200 cells per 100 milliliters of water. In addition, the bacteria could have come from some source other than the septic systems (i.e., wildlife, surface runoff, baby diapers, etc.). The 80 cells per 100 milliliters equals about one teaspoon of "poop" in 30,000 gallons of water.

http://oasisdesign.net/water/quality/coliform.htm#nooneunderstands

100

These are some of the trade names for a commonly used herbicide that is being closely studied for its effects on wildlife and humans.

Aatrex	Actinite PK	Akticon	Argezin
Atazinax	Atranex	Atrataf	Atred
Candex	Cekuzina-T	Chromozin	Crisatrina
Cyazin	Fenamin	Fenatrol	Gesaprim
Griffex	Hungazin	Inakor	Pitezin
Primatol	Radazin	Strazine	Vectal
Weedex A	Wonuk	Zeapos	Zeazine

Atrazine

The EPA states that more than 70 million pounds of this herbicide are applied to croplands each year. Research indicates that the chemical causes sexual abnormalities in frogs and increased risk of prostate cancer in humans. The European Union will ban the chemical this year but the United States still continues to use it.

http://www.nrdc.org/health/pesticides/natrazine.asp

Beginner

Use only these six terms to answer the following questions. Each term is used more than once.

Dissolved Oxygen **pH** **Alkalinity**

Phosphate **Hardness** **Nitrate.**

Play Game

ANSWERS

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

This indicator is measured in values of zero to 14.

pH

The numbers 0 – 14 are derived from the actual concentration of hydrogen ions, which is expressed as a negative log ($10°$ to 10^{-14}).

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

Most organisms suffocate at very low levels of this indicator.

Dissolved Oxygen

Most aquatic organisms require at least 4 – 5 parts per million dissolved oxygen or they will suffocate due to the lack of oxygen.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

As temperature increases, this decreases.

Dissolved Oxygen

The warmer the water, the less dissolved oxygen it can hold due to the increase in molecular activity.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

Sink stains and poor soap lather indicate an excess of this.

Hardness

The excess mineral in hard water stains sinks and toilets and interferes with the sudsing action of soaps.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

It is important for root growth of plants.

Phosphate

Phosphate is the primary nutrient for root growth. It is derived mostly from soil minerals and is important in enzyme production, cell structure and energy transfer.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5 PC

Some plants can get this nutrient using special bacteria.

Nitrate

Nitrogen-fixing bacteria, found in the roots of plants such as clover, alfalfa and peanuts, are able to convert nitrogen, that the plant absorbs from the air, to nitrate.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

It attaches to soil particles and moves with the sediment.

Phosphate

Phosphate is not very water soluble. It attaches to soil particles where plant roots can extract it from the soil with the aid of bacteria.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

It is the primary nutrient for plant growth.

Nitrate

Nitrogen is an important component of proteins and exists in several forms. Plants need nitrogen for stem, leaf and seed growth.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

It more readily diffuses out of water than into water.

Dissolved Oxygen

Oxygen does not readily dissolve in water. Increased temperature, dissolved substances and suspended matter reduce the amount of oxygen water can hold.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

Acid streams and lakes often lack this.

Alkalinity

Alkalinity refers to the water's ability to neutralize acids. If a lake or stream is acidic, it usually lacks the complex salts needed to neutralize acids.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

Excess amounts often come from sewage and air pollution.

Nitrate

Secondary sewage treatment removes toxic substances and bacteria but does not remove nutrients such as nitrogen. Air pollution from automobiles and factories also contains nitrogen compounds that are picked up by rainfall.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

Deep lake and river bottoms often have low levels of this indicator.

Dissolved Oxygen

Dissolved oxygen is consumed by bacterial decay at the bottom of lakes and rivers. Poor circulation between surface and bottom water also limits the addition of oxygen to bottom water.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

Large amounts are often trapped in the sediments that build up behind dams.

Phosphates

Phosphate has low solubility. It attaches to soil particles that settle out of the water (sediment). These sediments build up behind dams and slowly fill in the lake or reservoir.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

Excess amounts can cause water to taste bad.

Hardness

Hardness is measured in parts per million (ppm). Soft water has a hardness of less than 75 ppm. Extremely hard water, above 350 ppm, can have a noticeable taste and may not be safe to drink.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

Nitrogen and sulfur compounds can cause rain to have low levels of this indicator.

pH

Nitrogen and sulfur compounds can react with rainwater to produce nitrogen and sulfur acids. These create acid rain which has a low pH.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

It means Power of the Hydrogen.

pH

pH is an abbreviation for Power of the Hydrogen. pH is the measure of hydrogen ion concentration.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

It is the measure of the amount of calcium and magnesium in water.

Hardness

Total hardness is the measure of both minerals. Calcium hardness can be measured separately. Magnesium hardness is the difference of the two measures.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

It is a measure of the water's ability to neutralize (buffer) acids.

Alkalinity

Alkalinity is the measure of the carbonate and bicarbonate concentration. These salts can neutralize acids. Common antacids used for indigestion also contain carbonate and bicarbonate salts.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

This is the water soluble nutrient.

Nitrate

Nitrogen is very soluble in water in its different forms. This makes it highly mobile in the environment.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

It is increased by photosynthesis, water movement and diffusion.

Dissolved Oxygen

Aquatic plants release oxygen into water through photosynthesis. Water movement allows more water to come in contact with the air so more oxygen can diffuse into it.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

A reading of 4 or less parts per million in freshwater is bad.

Dissolved Oxygen

Most aquatic organisms require a minimum of 4 – 5 parts per million dissolved oxygen. Many coldwater species such as trout require even more.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

Most organisms live within a range of 5 – 9 of this indicator.

pH

Most organisms cannot tolerate a pH below 5 or above 10. There are some exceptions but these organisms are very hardy.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

The more that is available in the water, the higher the pH.

Alkalinity

If the alkalinity is sufficient, it will neutralize acids and increase the pH. Alkalinity is derived from limestone rock and other carbonate (marine) sediments.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

Drinking water should have less than 10 parts per million of this.

Nitrate

A nitrate level of 10 ppm or higher in drinking water can be harmful to human health, especially for young children.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

Less than one part per million can cause excess algal growth.

Phosphate

Phosphate, even at low levels, can readily increase algal growth.

Advanced

Use only these six terms to answer the following questions. Each term is used more than once.

Dissolved Oxygen	pH	Alkalinity
Phosphate	Hardness	Nitrate

Play Game

ANSWERS

Select new game

More or Less	Gettin' Around	Danger! Danger!	What it is?	How Much?
5	5	5	5	5
10	10	10	10	10
25	25	25	25	25
50	50	50	50	50
100	100	100	100	100

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

High sediment loads, bacterial and chemical action can reduce this indicator.

Dissolved Oxygen

High sediment loads displace dissolved oxygen. Bacteria consume oxygen during aerobic decay. Certain chemicals can also react with oxygen and make it unavailable to aquatic organisms.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

Carbon dioxide added to water decreases this indicator.

pH

Carbon dioxide reacts with water to produce carbonic acid. It is a weak acid so it does not cause a large decrease in pH.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

Often the limiting factor for plant growth in freshwater systems.

Phosphate

Phosphate is not as available as nitrogen in most freshwater systems because it is usually bound to the sediments. As phosphate is used, it is slowly replenished.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

Acidic water usually has 40 ppm or less of this indicator.

Alkalinity

Alkalinity, or carbonate hardness, is measured in parts per million (ppm). Low levels of carbonate are not sufficient to neutralize large amounts of acids.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

An important compound in biological energy transfer.

Phosphate

Phosphate is a key element in the energy transfer mechanism in photosynthesis. Solar energy captured by chlorophyll is transferred between different phosphate compounds.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

Daily cycles are driven by the availability of carbon dioxide.

pH

During the day, plants remove carbon dioxide (CO_2) from the water for photosynthesis. This causes the pH to slowly increase. During the night, plants release CO_2 through respiration. This causes the pH to decrease as carbonic acid is formed.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

Mostly a bi-product of ocean plankton, corals and shellfish.

Alkalinity

Ocean water contains an abundance of calcium. The addition of carbon dioxide (CO_2) creates calcium carbonate ($CaCO_3$) and calcium bicarbonate ($CaHCO_3$). These compounds provide the material for shell and bone growth in marine organisms. This material then becomes part of the marine sediment layers (limestone, marl, etc.) as organisms die.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

The terms hypoxic and anoxic refer to this indicator.

Dissolved Oxygen

The term hypoxic indicates low dissolved oxygen, more than 0 but less than 4ppm. The term anoxic indicates the absence of dissolved oxygen.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

Involves Nitrosomonas and Nitrobactere bacteria in the formation process.

Nitrate

Nitrosomonas bacteria convert ammonia to nitrite while Nitrobactere convert nitrite to nitrate, both in the presence of oxygen.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

The absence of oxygen increases its solubility in water.

Phosphate

Low oxygen levels usually result in lower pH which increases phosphate solubility. In addition, certain bacteria may use phosphate compounds as an energy source, releasing phosphorus into the water.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

Banned from detergents as a point-source pollution control.

Phosphate

Phosphates were banned from detergents in the early 1980s in an effort to reduce nutrient pollution from point sources of water pollution (i.e., sewage plants).

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

Nearly half of the Chesapeake Bay's main channel has low levels of this indicator.

Dissolved Oxygen

Excess organic matter and sediment settle to the bottom. Bacterial decay consumes the oxygen in these deeper waters. In addition, the lack of surface to bottom circulation due to temperature and/or salinity differences prevents the replenishment of oxygen.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

Excess levels can result in household plumbing and water use problems.

Hardness

Excessively hard water can create stains in sinks and bathtubs, cause mineral scale to form in pipes, make water unpleasant tasting and reduce soap and detergent action.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

These two indicators change little over time and are derived mostly from soil minerals.

Alkalinity and Hardness

Both of these indicators are fairly stable and do not readily change. Both originate from surrounding soils and sediment. Excessive erosion may temporarily increase these indicators. Evaporation can increase them in closed bodies of water.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

Its absence results in the production of hydrogen sulfide, methane and other gases due to anaerobic decomposition.

Dissolved Oxygen

Aerobic bacteria require oxygen to metabolize organic matter, producing carbon dioxide and water. If oxygen is absent or at very low levels (< 2 ppm), anaerobic bacteria use oxygen-bearing compounds as their oxygen source and release methane, hydrogen sulfide and other gases.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

Expressed as a negative log.

pH

pH is a measure of the hydrogen ion concentration. In pure water, there are equal amounts of Hydrogen (H+) and Hydroxyl (OH-) ions at a concentration of 1 X 10^{-7} moles per liter each. The negative log of 1 X 10^{-7} is 7. The pH range of 0 – 14 is the negative log expression of the H+ concentration.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

A good indicator of the amount of total dissolved solids.

Hardness

Total dissolved solids refers to all of the compounds and elements dissolved in the water. Since hardness is a measure of the two major elements found in water, total dissolved solids usually reflects the hardness of the water.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

Usually associated with calcium hardness.

Alkalinity

Alkalinity is usually associated with calcium carbonate and/or bicarbonate. Therefore, carbonate hardness (alkalinity) usually approximates the calcium hardness.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50 PC

Usually exists as a calcium, iron or aluminum salt.

Phosphate

Phosphorus rarely exists in its free form. If it is not tied up with organic matter (from living organisms), it usually exists as a salt.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

Exists in organic, inorganic and particulate forms.

Phosphate

Phosphate exists as dissolved organic or inorganic compounds or part of decaying, organic material called detritus. It is also found in the cells of living organisms.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

A small but rapid change in this indicator stresses most aquatic organisms.

pH

Since pH is expressed as a log, a small change in the measurement indicates a large change in the actual hydrogen ion concentration. A pH of 4 is ten times more acidic than a pH of 5.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

Ranges from zero to several hundred parts per million carbonate.

Alkalinity

The amount of carbonate is determined by the type of rocks and soils. Granite and quartz-based sediments produce low carbonate hardness while limestone sediments produce high carbonate hardness.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

Air pollution accounts for nearly 25% of this pollutant.

Nitrate

Nitrogen compounds are common byproducts of auto exhaust and factory/sewage plant emissions. These gases are absorbed by moisture in the atmosphere and fall with the rain and snow.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

One reason for the diversity and abundance of freshwater mussels in Virginia's western watersheds.

Hardness or Alkalinity

The high carbonate and calcium hardness of these mountain streams and rivers provides the material for freshwater mussels to build their shells.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

For this indicator, a reading of five is ten times greater than a reading of six.

pH

pH is a logarithmic scale: 10●❼ = .01, 10●❽=.001, etc. Therefore, each pH value is ten times greater or less than the previous value.

Expert

Use only these six terms to answer the following questions. Each term is used more than once.

Dissolved Oxygen	pH	Alkalinity
Hardness	Nitrate	Phosphate.

Play Game

ANSWERS

Select new game

More or Less	Gettin' Around	Danger! Danger!	What it is?	How Much?
5	5	5	5	5
10	10	10	10	10
25	25	25	25	25
50	50	50	50	50
100	100	100	100	100

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

The amount available to living organisms can be reduced by biological and chemical demands.

Dissolved Oxygen

Bacterial decay and cell respiration create a Biological Oxygen Demand (BOD). Chemicals that react with oxygen in the water create a Chemical Oxygen Demand (COD). Both processes reduce the amount of dissolved oxygen available to aquatic organisms.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

A reading of 75 parts per million or less indicates the “soft” condition of this.

Hardness

Total hardness is measured in parts per million calcium and magnesium. The terms “soft” and “hard” are used to describe relatively low or high concentrations of these minerals. Soft water has a hardness of 75 ppm or less (drinking water standards).

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

Decreases with increasing temperature and total suspended or dissolved solids.

Dissolved Oxygen

Increasing temperature increases molecular activity which tends to drive oxygen molecules out of solution. Increased suspended and dissolved material displace oxygen molecules in solution.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

Often the limiting factor for plant growth in marine or estuarine systems.

Nitrate

In many estuarine systems, nitrate is the limiting growth factor because of its rapid uptake by marine plants and algae. As the supply of nitrate is used, it is slowly replenished by bacterial action. Phosphorus is abundant in its various forms.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

Only a trace amount is usually found in the (fresh) water column.

Phosphate

Phosphate is not readily soluble in water and is usually bound to sediment. It is quickly used by plants. In normal conditions, this keeps the water concentration minimal. If excess phosphate becomes available, algal growth can be rapid.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

Mining for this mineral has created serious fluoride pollution problems.

Phosphate

Phosphate ore usually contains high levels of fluoride. The fluoride, once emitted as a gas, created serious air pollution problems. It is now captured and sold as “fluoride acid” for fluoridating drinking water. The fluoride is still finding its way into the environment through waste water discharge.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

The most challenging nutrient pollution to control.

Nitrate

Nitrate is highly water soluble in all of its forms and is readily transported throughout the environment. It is a major pollution concern in both point and non-point sources of water pollution.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

Associated with the carbon dioxide, carbonate, bicarbonate buffer system.

Alkalinity

Carbon dioxide reacts with water to form carbonic acid. This in turn forms carbonate and bicarbonate radicals. There is a constant "war" between acid-forming and acid-removing compounds in the environment. This is called the carbonate buffer system.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

Excess levels of this nutrient can interfere with hemoglobin’s ability to carry oxygen.

Nitrate

High levels of nitrate in animal food or in drinking water can cause an excess of nitrite in the gut. The nitrite enters the blood and combines with hemoglobin, interfering with its ability to carry oxygen. The organism may suffocate if the nitrite level does not decrease.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

Reduced to the free, gaseous form by facultative anaerobic bacteria in low oxygen environments.

Nitrate

At low oxygen levels, facultative anaerobic bacteria use nitrate as an oxygen source. They release nitrogen as a gas. This process is call denitofication.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

As little as two parts per million can cause algal blooms.

Nitrate

Nitrate is readily assimilated by aquatic plants. As levels increase above a few parts per million, plant growth increases rapidly. Excess levels of nitrate can result in algae blooms.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

Limestone is added to streams to increase pH and artificially restore this indicator.

Alkalinity

Lime is a source of calcium carbonate. It is the primary pH buffer in aquatic systems. Acidified streams can be artificially but temporarily buffered by adding large amounts of limestone to their sources.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

Many coastal areas have groundwater with elevated levels of this indicator.

Hardness

In many coastal areas, groundwater withdrawal has resulted in saltwater intrusion into the aquifer. The groundwater will have an elevated hardness and often objectionable taste.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

Acid rain can deplete this parameter in low carbonate soils.

Alkalinity

The carbonate buffer in the soil will neutralize acid rain. Over time, soils with low carbonate will lose their buffering capacity as the carbonate is used up.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

A human health issue in drinking water at 10 parts per million or more.

Nitrate

Nitrate affects humans in much the same way it affects livestock. In the nitrite form, it combines with hemoglobin and interferes with the blood's ability to carry oxygen. This is especially serious for small children and results in a syndrome called "Blue Baby."

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

Most aquatic organisms require a minimum of 4 - 6 parts per million of this indicator.

Dissolved Oxygen

Most warm-water organisms require at least 4 ppm DO while many cold-water organisms require 6 ppm DO or more. Sensitive indicator species, such as trout, stoneflies and mayflies require higher DO levels than more tolerant species.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

The numerical expression based on the dissociation constant of water.

pH

Pure water has equal amounts of hydrogen (H+) and hydroxyl (OH-) ions. The concentration is determined by the dissociation constant of 1 X 10^{-7} moles per liter. Therefore neutral water has a pH of 7.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

The atmospheric form is "fixed" by plants such as clover and alfalfa.

Nitrate

Plants such as alfalfa, clover and peanuts contain bacteria in their root systems that are able to take free nitrogen gas and convert it to nitrate. This is then used for plant growth. These bacteria are called nitrogen fixing bacteria.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

Usually a mirror of alkalinity.

Hardness

Hardness is a measure of calcium and magnesium. The calcium is usually generated by calcium carbonate which also generates the carbonate/bicarbonate hardness known as alkalinity.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

This indicator is one of the forms that also includes free, hydrogenated, oxidized and organic molecules.

Nitrate (Nitrogen)

Nitrogen also exists as a free gas (N_2), ammonia (NH_3^- or NH_4), Nitrite ($NO_2^=$) and as part of complex organic molecules.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

5

Supersaturated levels found at dam outfalls can cause hyperextension of the swim bladder of young fish.

Dissolved Oxygen

Fish regulate their buoyancy by adjusting the amount of oxygen gas in their swim bladder. Water at dam outfalls may be supersaturated with DO. The excess gas may "force" its way into the swim bladder causing a fatal hyperextension of the bladder.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

10

Usually found at low levels in areas with crystalline rock formations (granite).

Hardness, Alkalinity, or pH

Crystalline rocks are typically quartz, granite, feldspar and contain non-soluble minerals. These do not add hardness or alkalinity-generating minerals to the water. As a result, the pH can be also low.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

25

Can become mobile in areas where the soils have become supersaturated with this indicator.

Phosphate

Phosphate normally binds to soil particles. However, the soil can hold only so much phosphate. In areas where there is an excess of phosphate (i.e., mining operations, animal feed lots), the “unattached” phosphate will be picked up by surface runoff.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

50

Excess nutrient and sediment loading are the primary causes for the general decrease of this indicator.

Dissolved Oxygen

Nutrient enrichment generates excess algal growth. The algae die and decay and resulting bacterial growth consumes large amounts of oxygen. The algae also consume oxygen at night and on cloudy days. Excess sediment displaces dissolved oxygen from the water column.

Dissolved Oxygen, pH, Alkalinity, Hardness, Nitrate, Phosphate

100

Low calcium hardness may or may not justify low levels of this indicator.

Alkalinity

Generally calcium carbonate (limestone) is the source of calcium and carbonate hardness. However, other minerals such as potassium or sodium carbonate also generate carbonate hardness. This results in calcium hardness but the carbonate hardness (alkalinity) will be higher.

WILD CARD

These questions will have a variety of answers.

Study list of suggested answers

Play Game

ANSWERS

Study list of suggested answers for Wildcard Contest
(Not all answers are used.)

AQUIFER	BACTERIA	CATTAIL
COPPER	DETRITUS	DIOXIN
EURASIAN MILFOIL	FECAL COLIFORMS	HYPOXIC
IRON	MANGANESE	MERCURY
MTBE	NITRITE	PERCHLORATE
pH	PFIESTERIA	PHRAGMITES
POINT SOURCE	PCB	PURPLE LOOSTRIFE
SALTWATER	SALVINIA	SILICA
STORM WATER	SULFUR	TMDL
TRIHALOMETHANES	MEGALOPS	ZEBRA MUSSEL

COMBINED ANIMAL FEEDLOTS

Select new game

More or Less	Gettin' Around	Danger! Danger!	What it is?	How Much?
5	5	5	5	5
10	10	10	10	10
25	25	25	25	25
50	50	50	50	50
100	100	100	100	100

5

This term refers to dissolved oxygen levels greater than zero but less than four.

Hypoxic

The prefix “hypo” means low. Therefore, hypoxic means low oxygen.

10

Excess levels or rapid changes in this indicator can affect the electrolyte balance in aquatic organisms.

pH

When there is a rapid pH shift or the pH becomes extreme, the electrolyte balance in aquatic organisms can be upset, causing stress or even death.

25

Nearly all chlorinated drinking water that contains natural organics can be contaminated with these cancer-causing compounds.

TRIHALOMETHANES

THMs form when chlorine reacts with humic (decayed plant) substances or Fulvic acids. The result is a group of chlorinated or brominated compounds. Toxicity is low but pregnant women are at highest risk. Acceptable levels are set at <100 ppb for total THMs. For more information, go to:. http://www.southerndatastream.com/thm/index.htm#organic

50

The number of toxic substances identified in the Chesapeake Bay is:

A. 100 B. 250

C. 800 D. >1000

D. > 1000

Toxic contamination in the Chesapeake Bay is not as severe as in other water bodies, such as the Great Lakes. However, there are more than 85,000 synthetic chemicals in use today. Less than 2% have been tested for toxicity. The long-term exposure to low-level concentrations of a mix of chemicals is a concern for all.

100

This material is a source of particulate, organic phosphate in freshwater/marine systems.

Detritus

Detritus is composed of decaying particles of organic matter, plant and animal. It contains a large amount of organic phosphate. Detritus feeds the bacteria that start the complex food webs in many marine and freshwater ecosystems.

5

An orange/brown flocculent in shallow, still water indicates the presence of this element.

Iron

Iron-oxidizing bacteria use iron mineral in the soil as an energy source in the presence of oxygen. They produce iron oxide which we call rust.

10

This yellow element can give well water an objectionable taste and odor.

Sulfur

In low-oxygen aquifers and surface waters, certain bacteria use sulfur as an energy source and create hydrogen sulfide. This smells like rotten eggs at low levels and gives the water an objectionable taste. It is a dangerous gas at levels above 300 ppm and can quickly kill a person exposed to it.

25

Acidic well water can result in bluish-green sink stains, indicating the presence of this element.

Copper

Acidic water reacts with copper metal to create a copper oxide. This creates blue-green stains in sinks and tubs. The presence of these stains indicates that the water is “eating away” at the plumbing. Eventually the pipes will need replacing. In addition, residents should flush their water pipes for a few minutes before consuming any water.

50

This disinfectant has replaced chlorine for most municipal water suppliers.

Chloramine

Chlorine disinfectant produces trihalomethanes in drinking water that contains certain dissolved organic compounds. To reduce this risk, a chlorine-nitrogen molecule called chloramine is used. It is not as effective as chlorine but very toxic to aquatic life.

100

This is a common contaminant of wells in coastal areas.

SALTWATER

As groundwater is withdrawn in coastal areas, saltwater can intrude into the aquifer if the rate of withdrawal is greater than the rate of groundwater recharge. Many private wells must use filtration systems to remove the excess hardness and salt. Even then, the water may have a bad taste.

5

A serious groundwater contaminant in California and other states originating from gasoline spills and storage tank leakage.

MTBE

(Methyl tertiary butyl ether)

MTBE is a gasoline additive used to increase performance. It has contaminated groundwater from spillage or leakage involving underground storage tanks. The EPA recommends a health safety warning at levels of 20 – 40 ppb.

10

This contaminant has resulted in fish advisories for the Shenandoah, Potomac and Staunton Rivers.

PCB

Polychlorinated biphenyls are a group of 209 synthetic compounds once used heavily in paper and electrical insulation production. PCBs are still contaminating waterways from groundwater, obsolete landfills and industrial sites. PCBs can cause a wide variety of immune, hormone and growth-related illnesses.

25

Worldwide ocean levels of this contaminant are increasing as much as three percent annually.

Mercury

Mercury pollution comes from a wide variety of sources including coal-burning energy plants, industrial wastes, crop fumigation, and mining. The heavy metal is concentrated in the higher trophic levels of food webs and in humans. Pelagic ocean species, including swordfish, tuna and whales, are showing elevated levels of mercury in their blood and tissues. Mercury poisoning causes kidney and neurological dysfunction.

50

A live colony of this invasive mollusk was found in a Prince William quarry. It is now established in the upper Susquehanna River.

Zebra Mussel

The Zebra Mussel is a native of Europe. It was introduced into the Great Lakes by ship ballast and has caused many problems due to its prolific reproduction potential. A colony discovered in Prince William County was thought to have been introduced by divers wanting to clear up the water in a favorite diving quarry.

More about Invasive Species

100

A tall, highly invasive, emergent aquatic plant that is taking over many coastal marshes and moving inland.

More about Invasive Species

Phragmites

(common reed)

There are two forms of this plant: a native, non-invasive species and the highly invasive Asian species. It readily establishes itself in any disturbed wetland site. Dense stands of Asian Phragmites displace native wetland plants and provide little food or structural habitat for wildlife.

5

A phytoplankton parasite that has caused much concern in North Carolina, Virginia and Maryland.

Pfiesteria

The Pfiesteria “hysteria” that occurred during the late 1990s has since died down. There was much debate about the organism. Current research indicates that another organism (*Karlodinium*) can cause fish kills by producing neurotoxins. Pfiesteria then feeds on the dieing fish.

10

A highly invasive flower that turns marshes to a sea of purple.

Purple Loosestrife

This is a highly invasive and tenacious plant that can take over freshwater marshes. It quickly spreads due to its tremendous seed production.

More about Invasive Species

25

An invasive, submerged aquatic plant that has choked out much of the native vegetation in Back Bay and other areas.

Eurasian Milfoil

This highly invasive aquatic plant is now found in more than 40 states. A single plant can produce thousands of plants in a year through seeds and fragmentation. It spreads rapidly and out competes most other submerged plants.

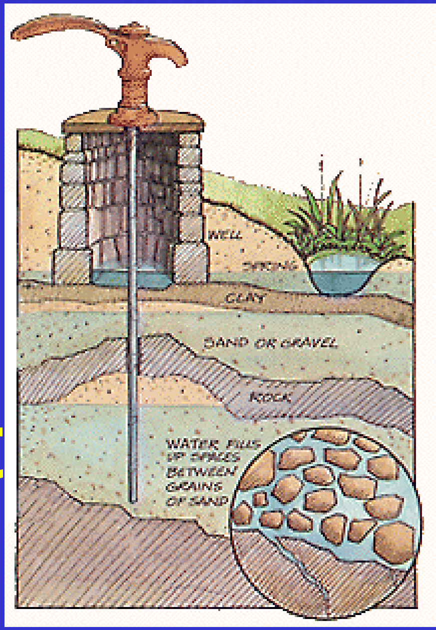
More about Invasive Species

50

An area of underground sediment or rock that holds a significant amount of water.

Aquifer

Aquifers can range from a few feet to thousands of feet deep. The amount of fresh groundwater is about 30 times greater than all surface waters combined. Aquifers are a primary water source for about 40% of Virginians. Discharge rates are rapidly exceeding recharge rates.



100

An element that is important to the structure of diatoms, desmids and sponges.

Silica

The mineral is used by certain types of algae (desmids, diatoms) in the construction of their shells. Sponges have spicules made of silica throughout their tissues for support. In addition, silica is the predominant mineral in quartz-based sand and gravel and is extensively used in the manufacture of glass.

5

A high school student in West Virginia researched and discovered a variety of these types of medicinal chemicals in the Ohio River.

Antibiotics

"Ashley Mulroy took water samples from a variety of locations on the Ohio River near her home. With no trouble at all, she found drugs like Penicillin, Tetracycline and Vancomycin in the river water. Her research eventually led to her winning the prestigious Stockholm Junior Water Prize."

http://www.purewatergazette.net/antibiotics.htm

10

A black flocculent or glass-like oily sheen found in shallow, still water is an indicator of this element.

Manganese

Manganese-oxidizing bacteria produce manganese oxide that is black/brown in color. It is insoluble and settles out in still water. It can stain sinks and clog pipes where well water is high in manganese. Another form produces a glass-like oily sheen on the water's surface.

25

Combined animal feedlot operations (CAFOs) are now regulated as this type of pollution source.

Point Source

Large animal feed lots produce large amounts of animal waste. Due to the confines of the animals and the ability to direct movement of the waste, these areas are considered to be point sources of water pollution.

50

This term is used to describe efforts to regulate and monitor nutrient and sediment loading in tributaries.

Total Maximum Daily Load

This term refers to the total amount of pollutants that a water body can receive and still meet water quality standards for its designated use (swimming, fishing, drinking, etc.).

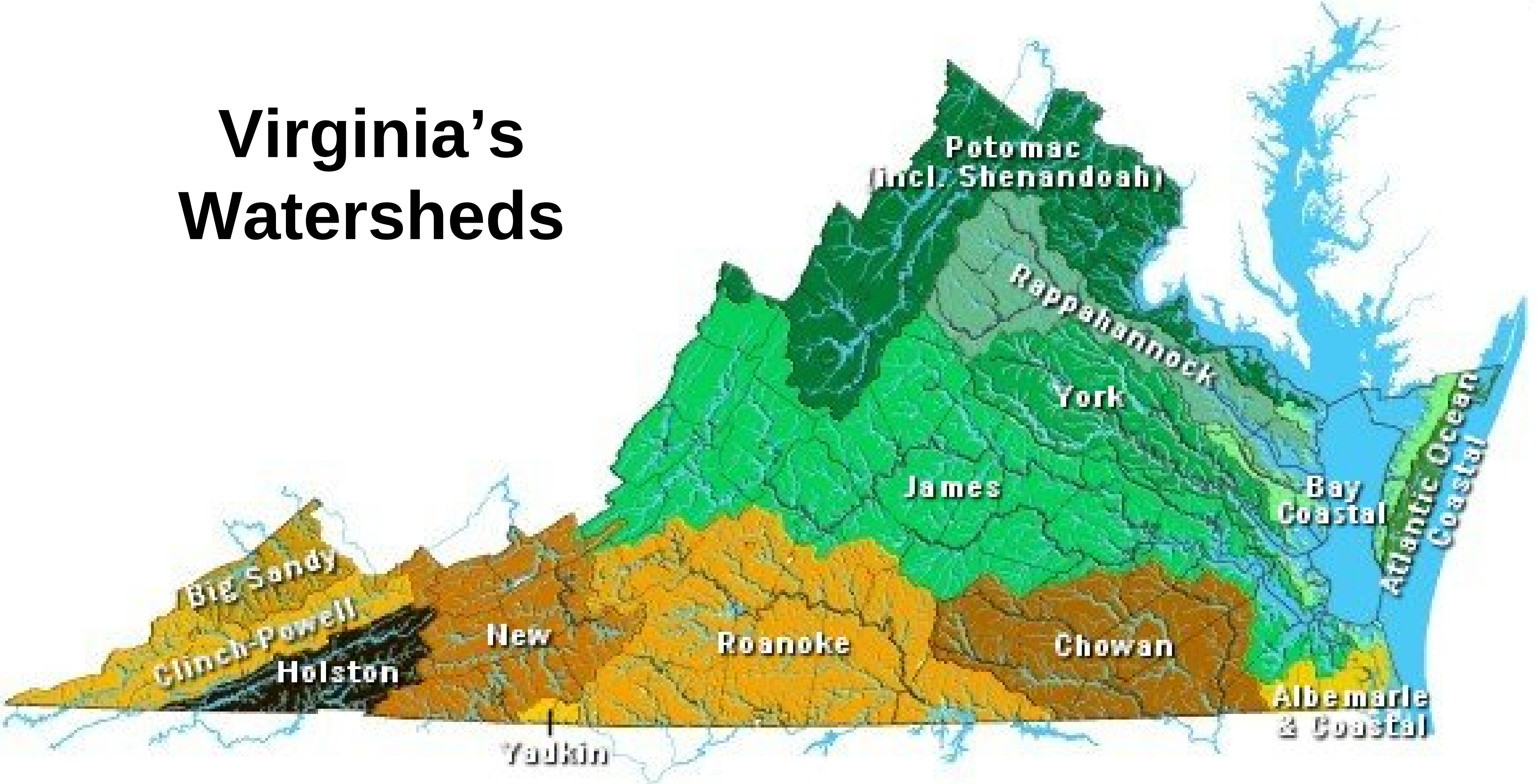
100

The most difficult non-point source of water contamination to control in urban and suburban areas.

Storm Water

Storm water refers to the surface runoff from storm events that often flood city streets and overwhelm municipal sewage treatment plants. Not only is the volume difficult to control, but the level of pollutants carried by the storm water is significant.

Virginia's Watersheds



Review the *Virginia's Watersheds* Section.

Play Game

ANSWERS

Select new game

Name That River	Tributaries	People	Items of Interest	Problems
5	5	5	5	5
10	10	10	10	10
25	25	25	25	25
50	50	50	50	50
100	100	100	100	100

5

The name means
“Daughter of the Stars.”


Shenandoah River

10

The name means “People of the Alternating Stream.”

Rappahannock River

25

The Piankatank, Wicomico and Poquoson are examples of these.


Coastal Rivers

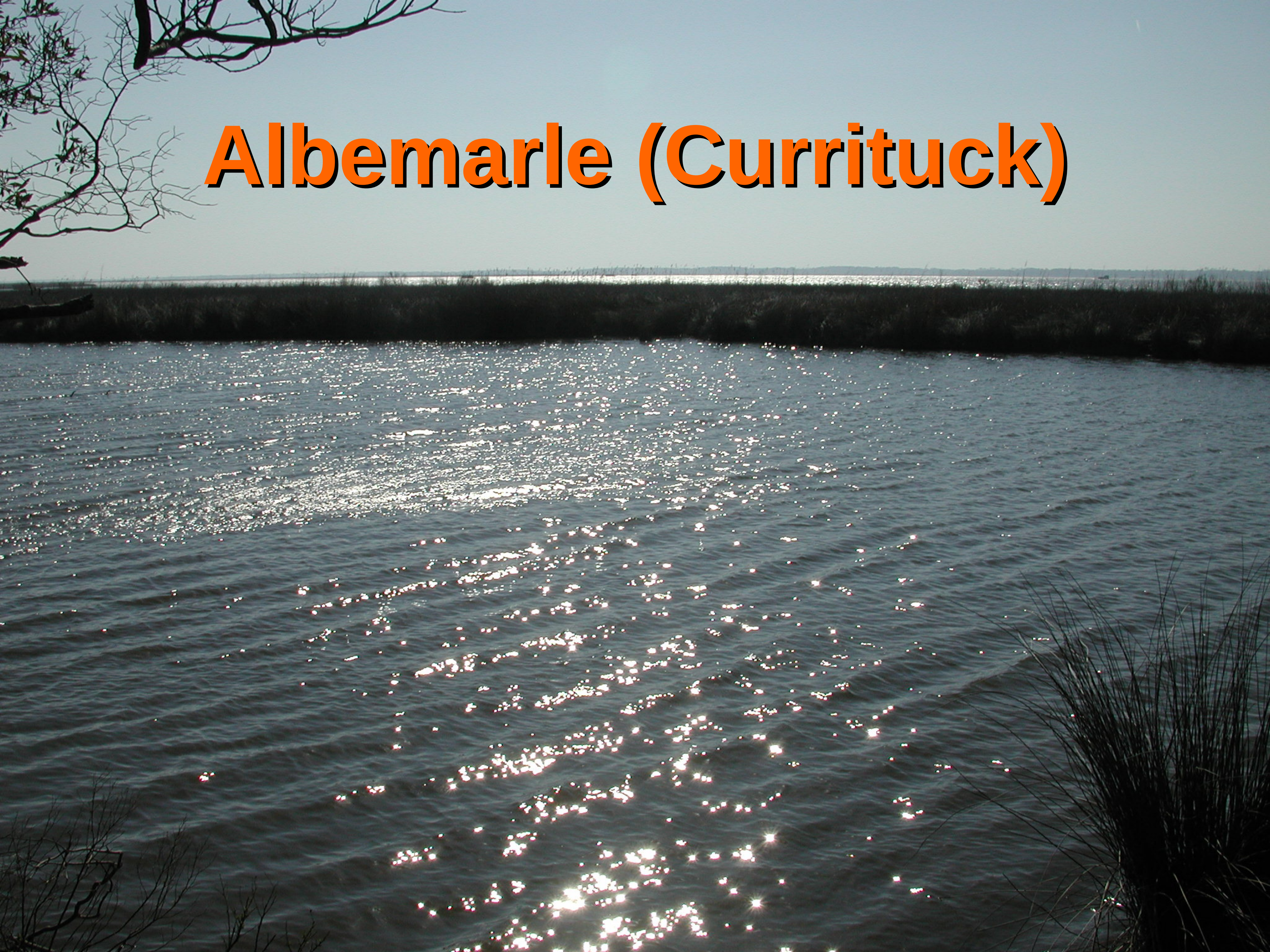
50

This river has Virginia's three busiest ports: Hopewell, Richmond and Hampton Roads.

James River

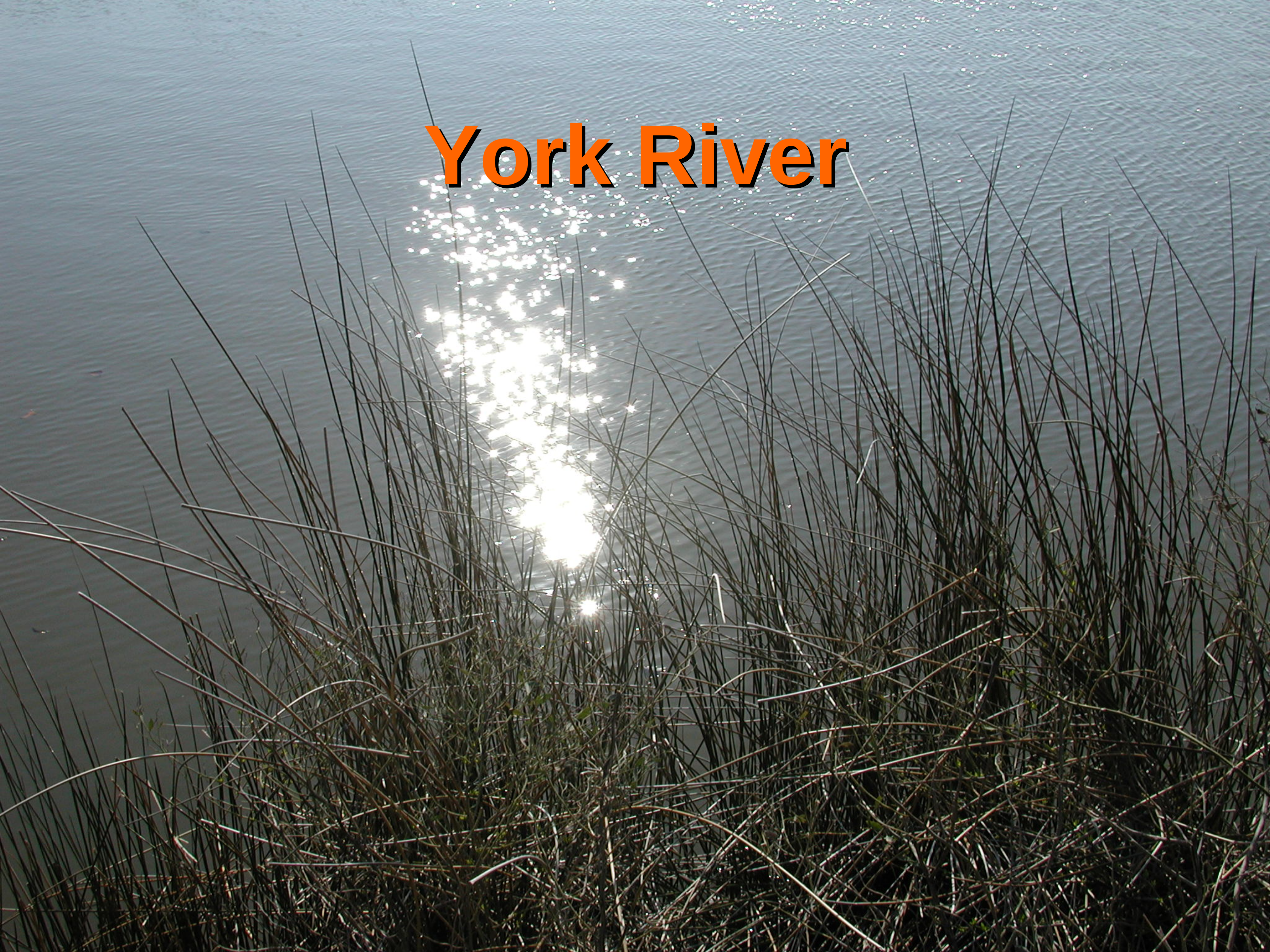
100

This watershed includes Back Bay, Dismal Swamp, Lake Drummond and flows to North Carolina.


Albemarle (Currituck)

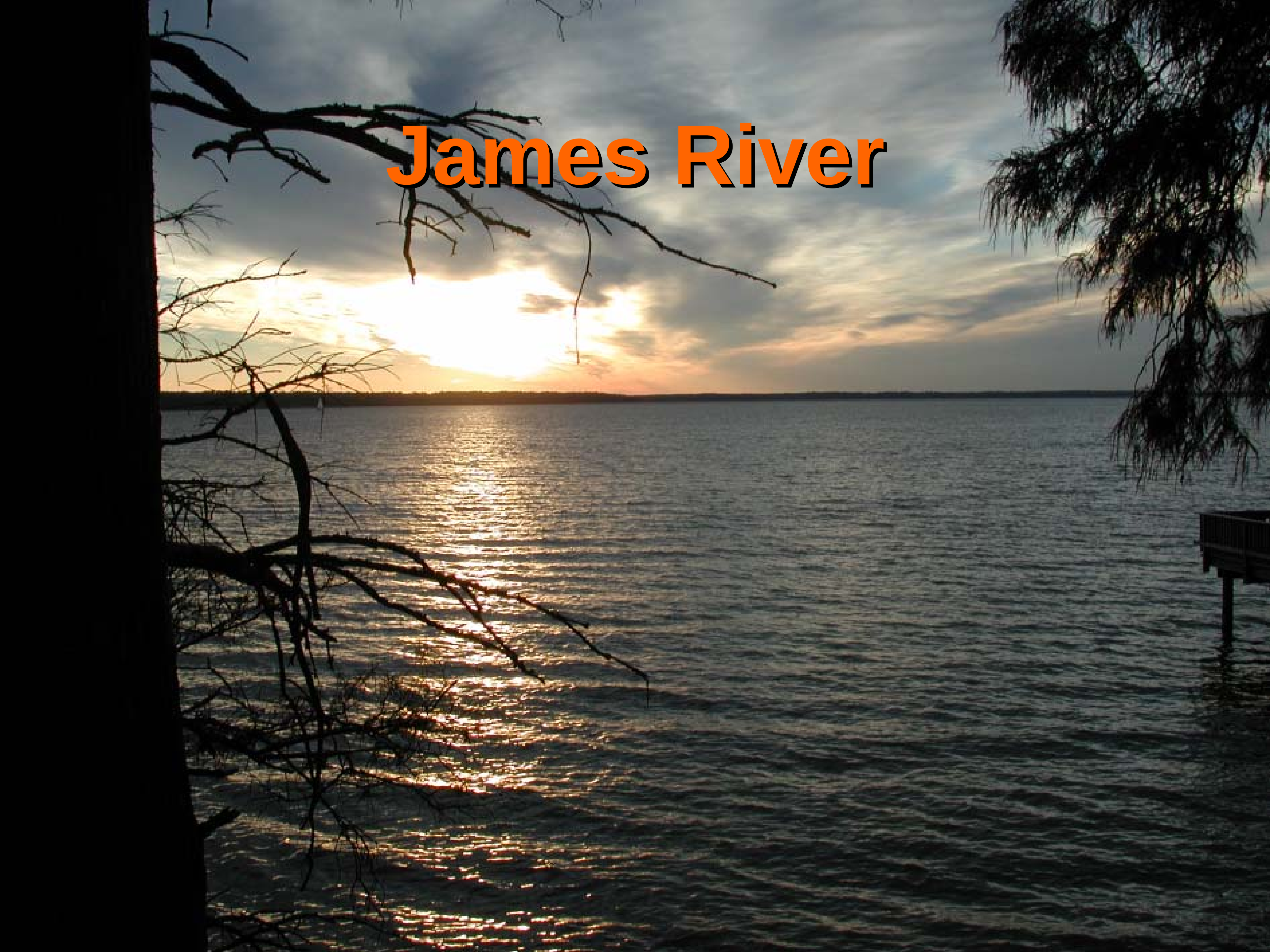
5

Its tributaries include the Mattaponi and Pamunkey Rivers.


York River

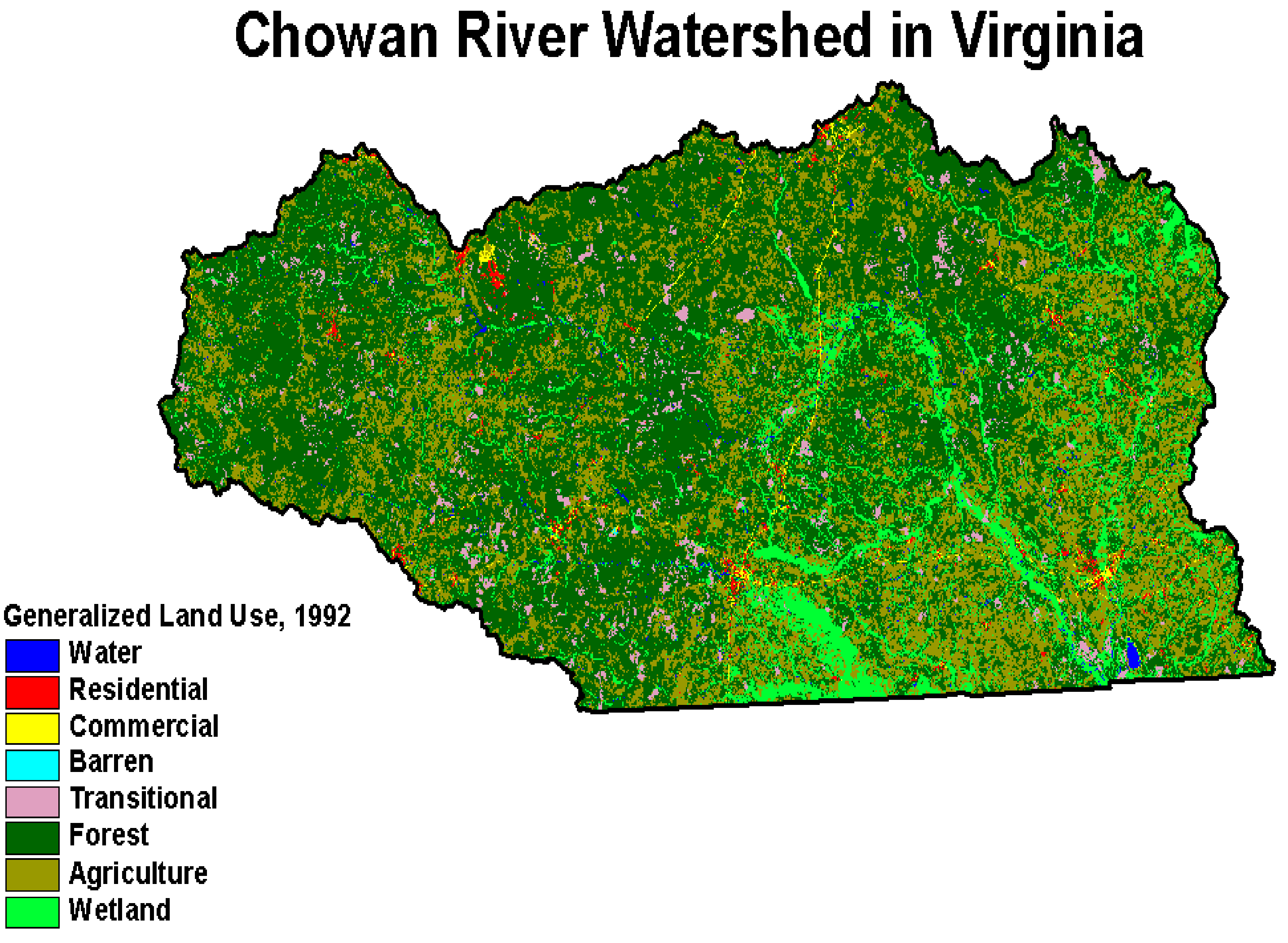
10

Its tributaries include the Appomattox, Chickahominy and Elizabeth Rivers.


James River

25

The Nottoway, Meherrin and Blackwater Rivers are Virginia tributaries of this watershed.


Chowan River Watershed in Virginia
Generalized Land Use, 1992
Water
Residential
Commercial
Barren
Transitional
Forest
Agriculture
Wetland

50

One of Virginia’s western rivers that flows into the Tennessee and Mississippi Rivers.

Clinch, Powell or Holston River

100

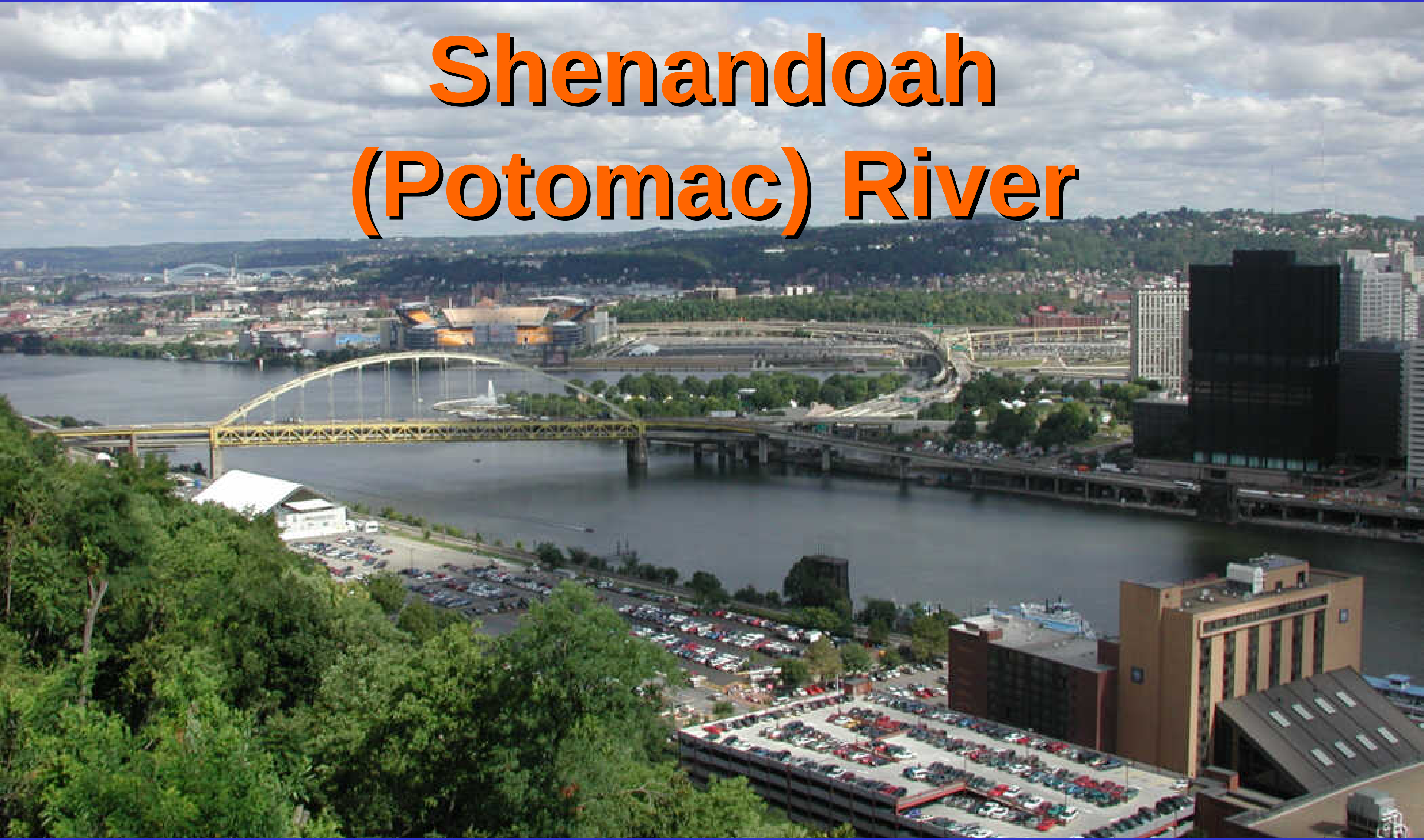
Forms the headwaters for the Pee Dee River in South Carolina.


Yadkin River

5

Home of Virginia’s most densely populated counties: Arlington and Fairfax.

Shenandoah (Potomac) River

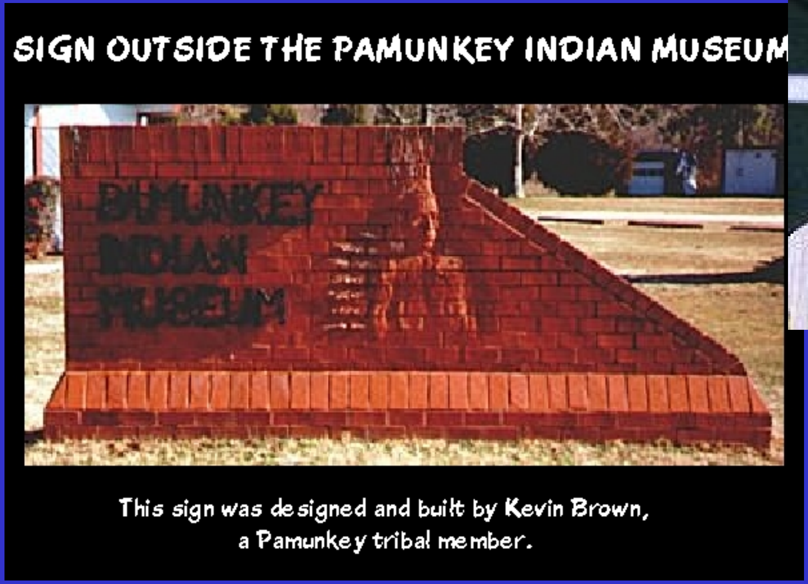


10

Well known for the presence of two Native American Tribes in its watershed: the Pamunkey and Mattaponi.

York River

Chief William P. Miles, Pamunkey Tribal Government

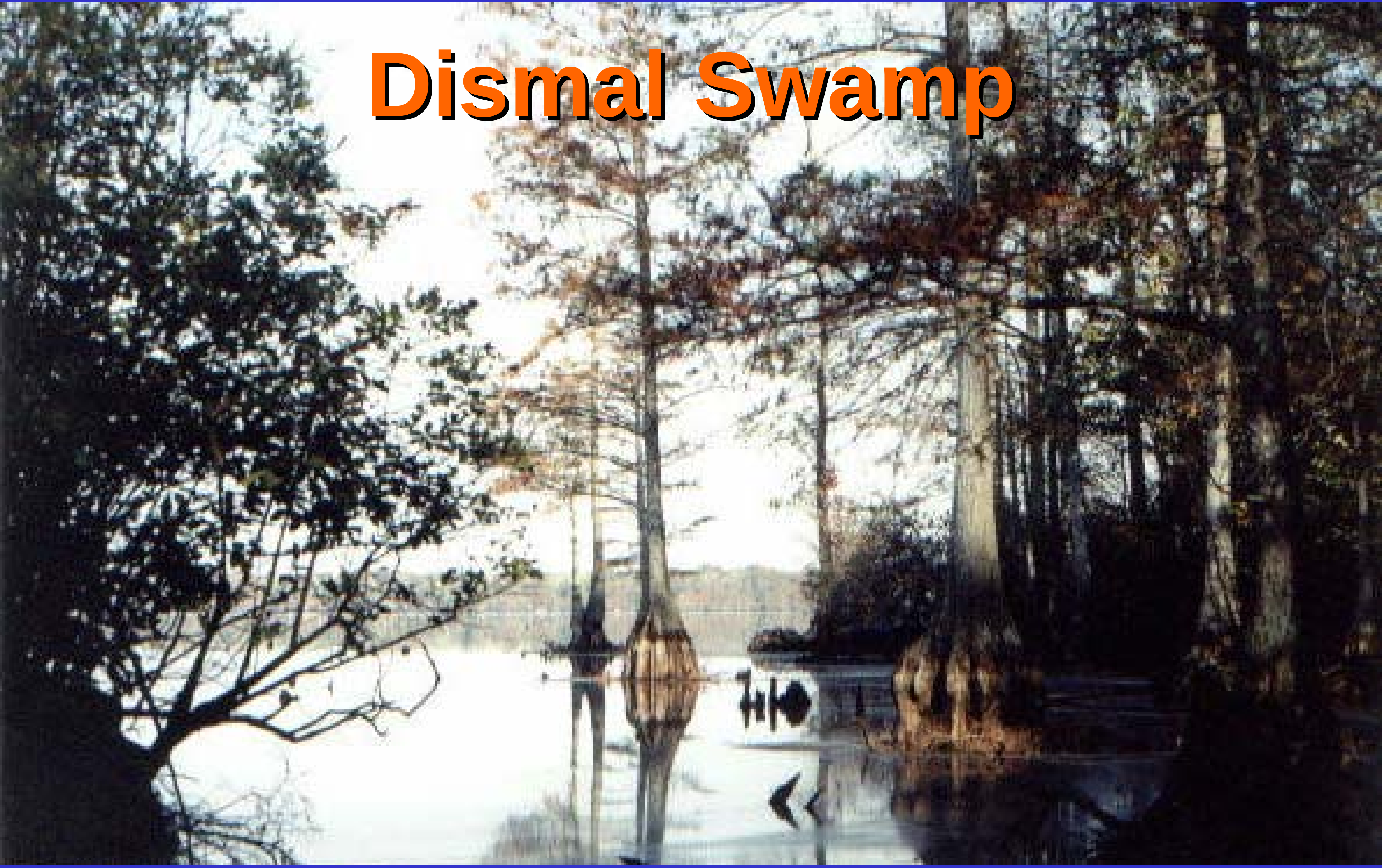


Chief Webster "Little Eagle" Custalow, Mattaponi Tribal Government

Mattaponi Shad Hatchery

25

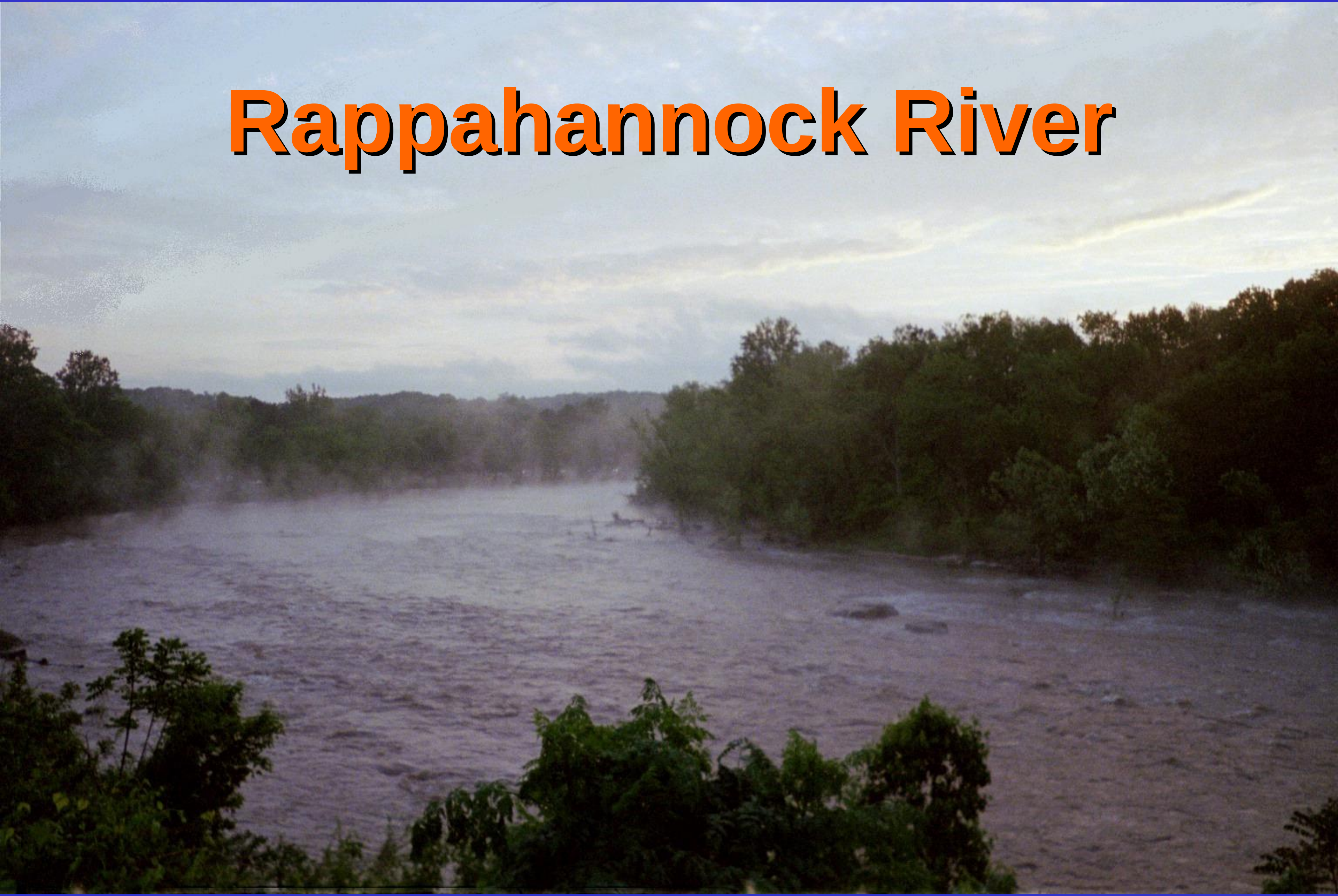
George Washington helped survey and ditch this national wildlife refuge wetland.


Dismal Swamp

50

Home of the Rapidan River and threatened by population growth coming from Northern Virginia.

Rappahannock River



100

Geologists love the Karst and kayakers love the rapids.

New River

5

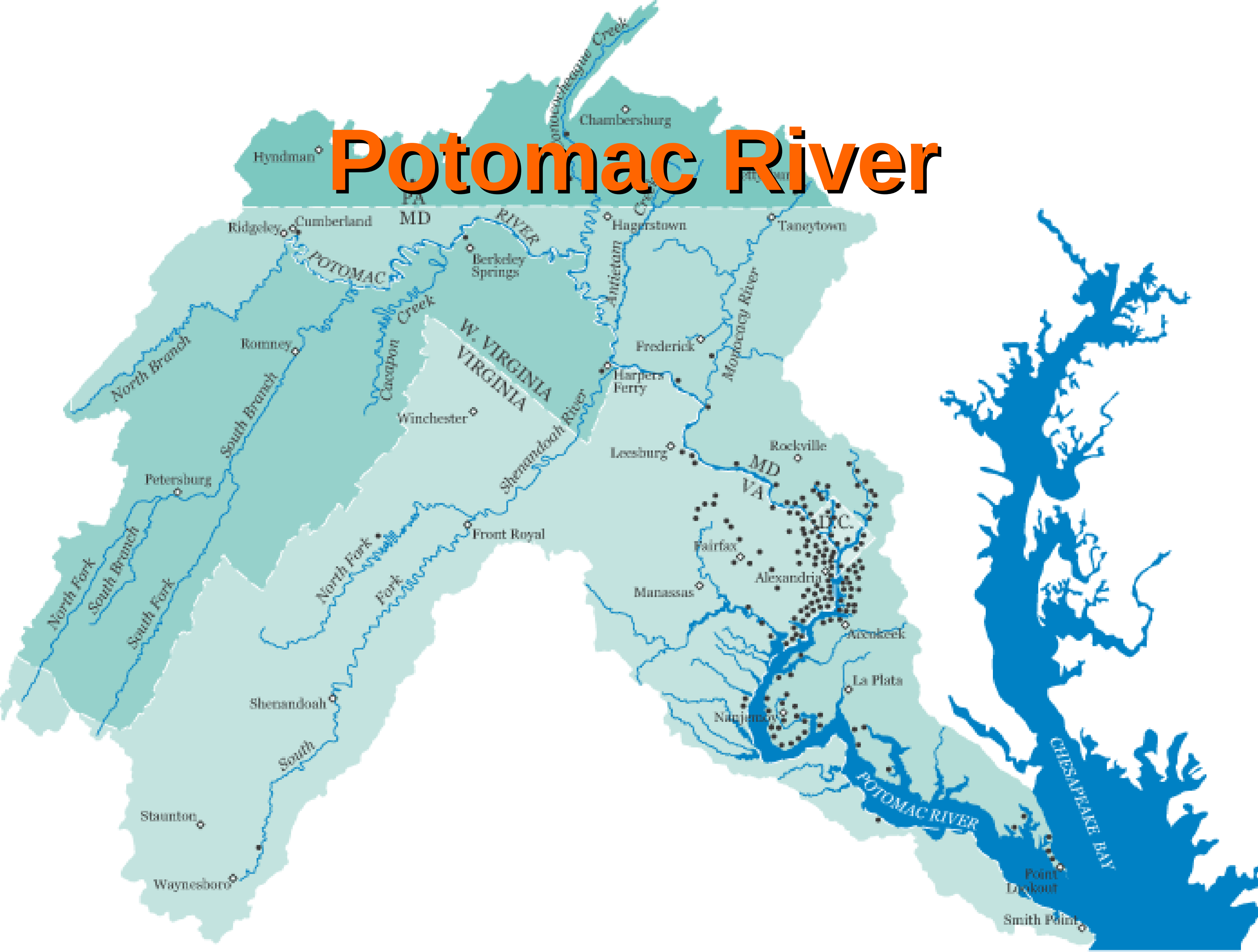
Known for its “Great Falls.”

Potomac River

10

Belongs to Maryland but thirty percent of Virginians live within its watershed.

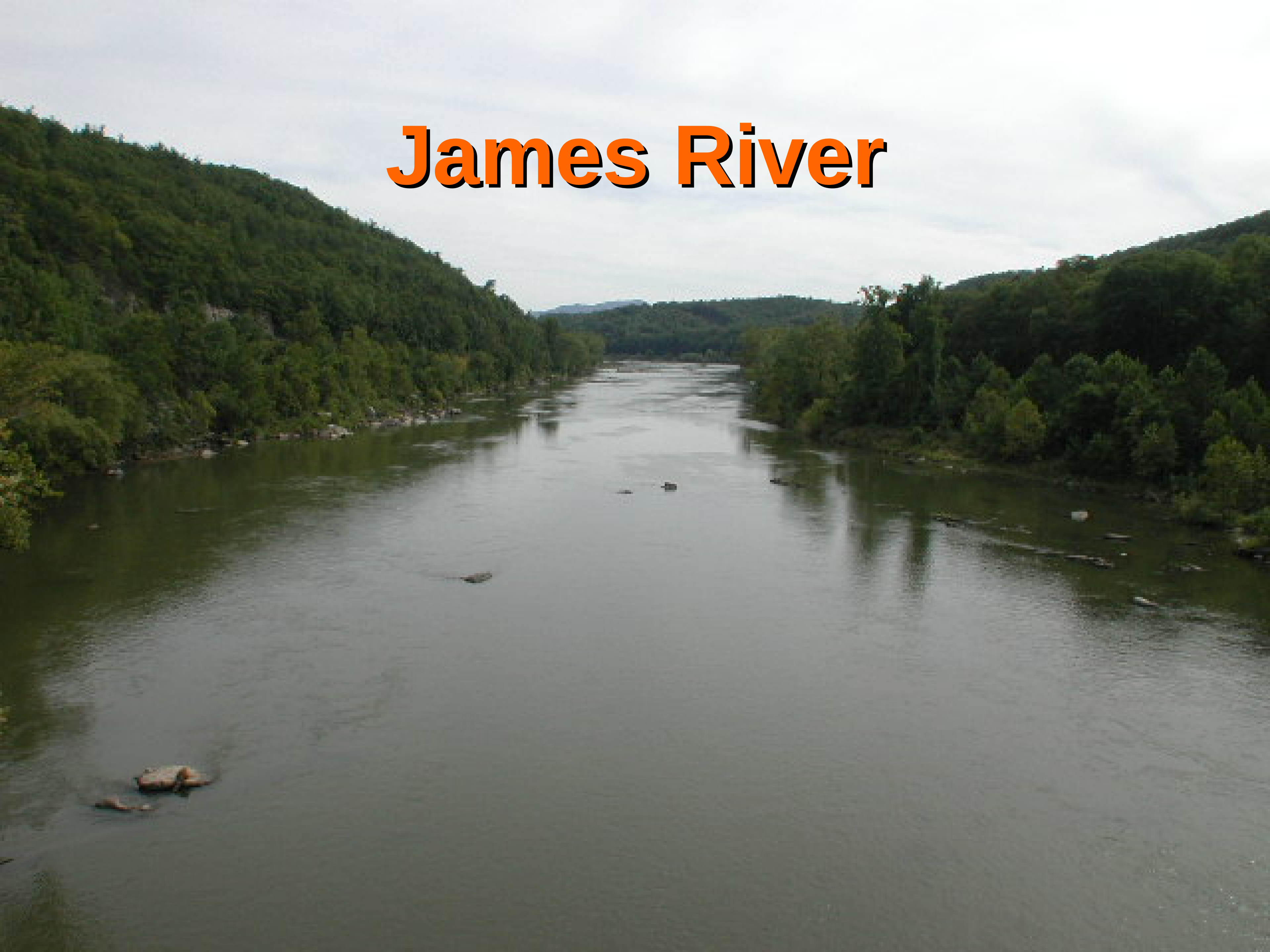
Potomac River



25

This watershed drains nearly one-forth of Virginia.

James River



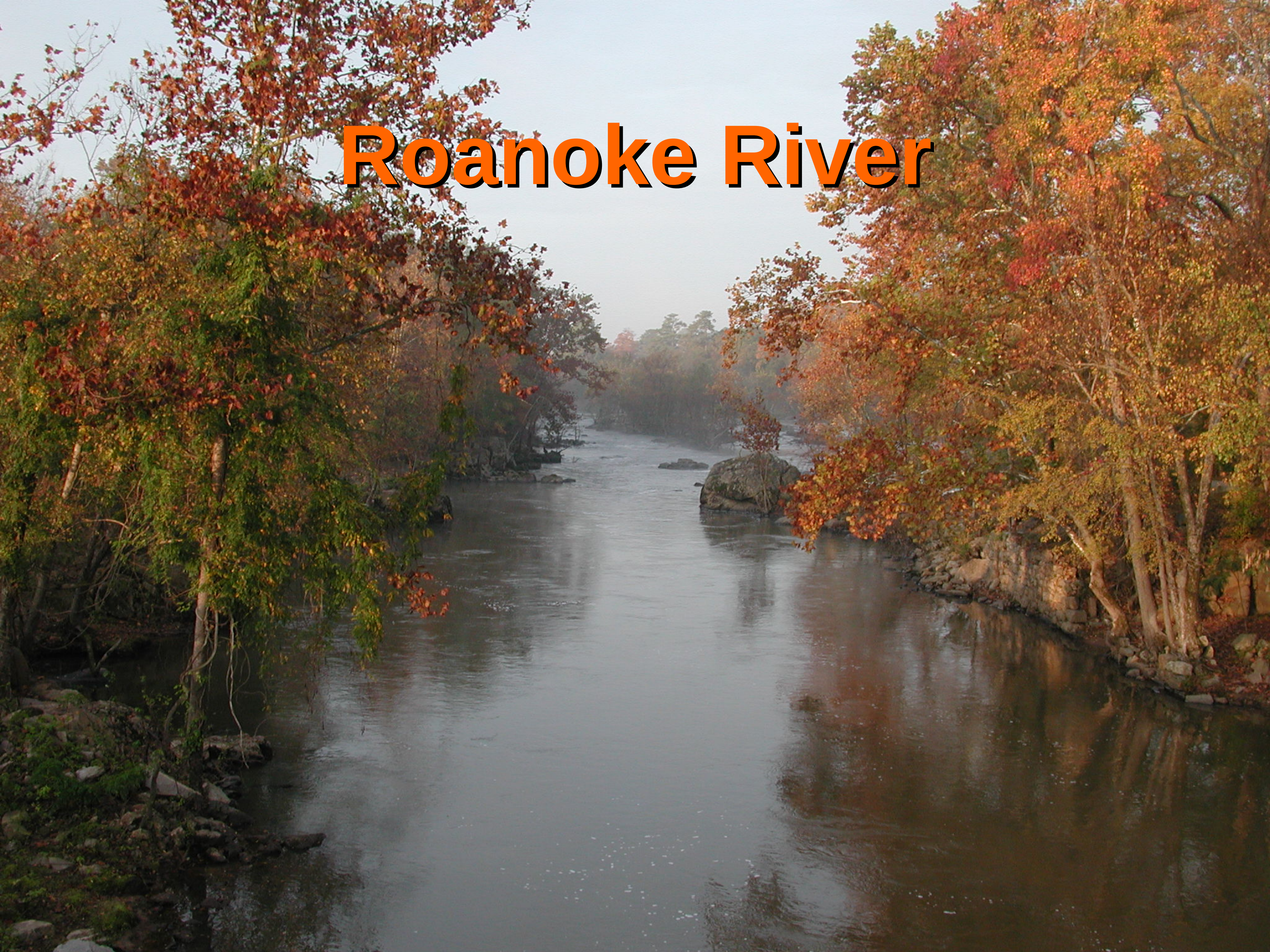
50

The cities of Petersburg, Richmond and Fredericksburg are located along this geologic feature.


Fall Line

100

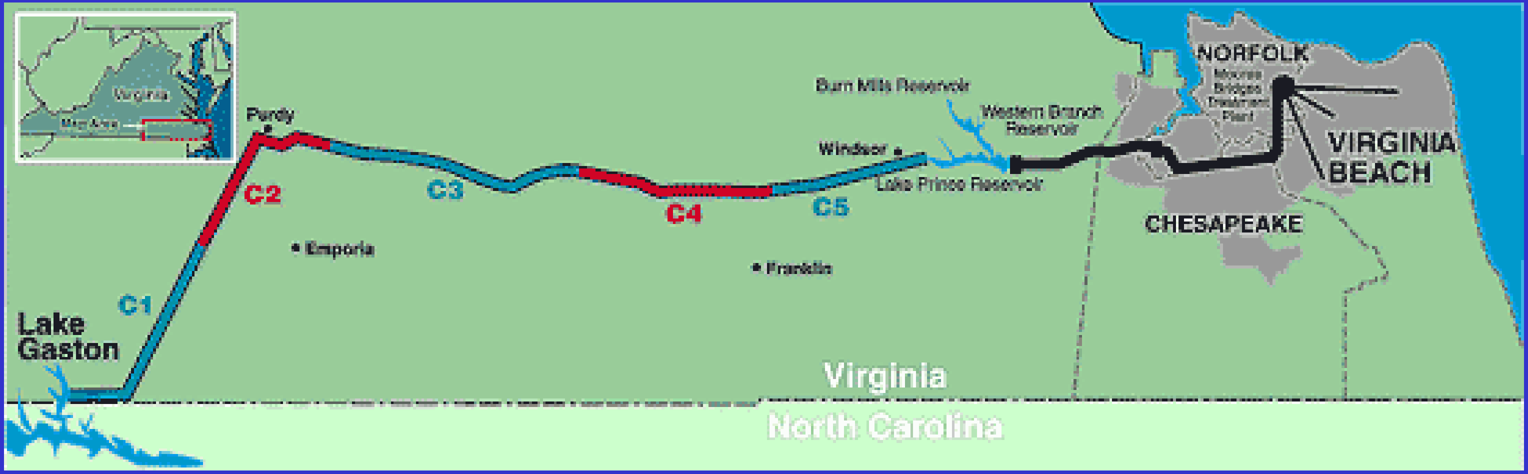
This watershed includes Smith Mountain and Gaston/Buggs Island Reservoirs.


Roanoke River

5

The public water source for Virginia Beach, located nearly 70 miles away.

Lake Gaston

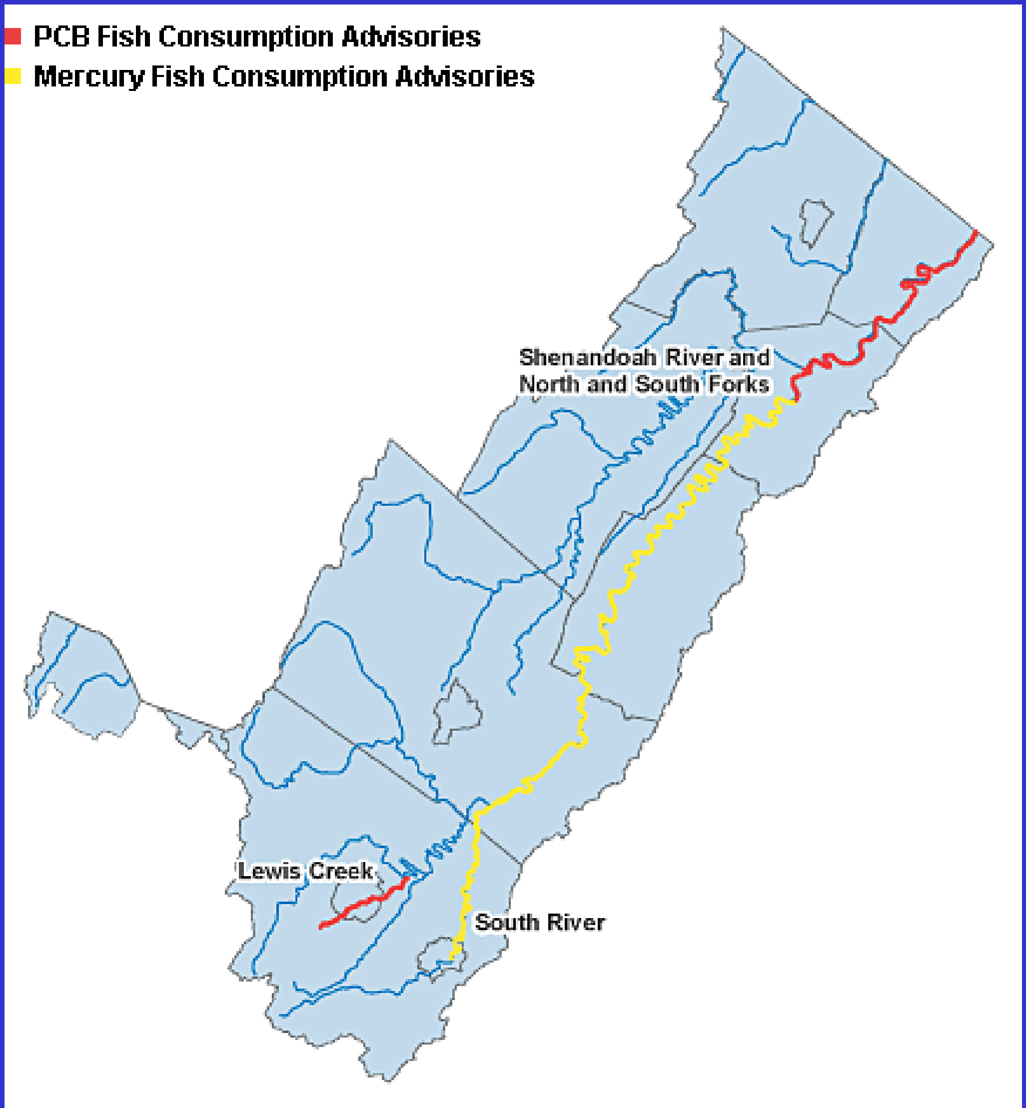


Virginia
Map Area
Purdy
C1
C2
C3
C4
C5
Lake Gaston
Emporia
Franklin
Burn Mills Reservoir
Western Branch Reservoir
Windsor
Lake Prince Reservoir
NORFOLK
VIRGINIA BEACH
CHESAPEAKE
Virginia
North Carolina

10

The location of the former Avtex and Dupont factories that caused PCB and mercury pollution.

Shenandoah River



25

This town in Southwest Virginia is being moved due to frequent flooding in the Big Sandy drainage.

Grundy

Town of Grundy

Flood Control Project

50

For years, the “Tulloch Ditching” rule allowed developers to drain these protected habitats.

(Non-tidal) Wetlands

100

Large swine and poultry operations are major pollution sources for this southeastern watershed.

Chowan

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Special thanks is extended to the following individuals for editorial and technical comment:
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Manufacturing – http://web.center.edu/enviro/photolib.htm (slide #5)
Virginia Beach monitoring - http://www.vdh.virginia.gov/whc/external_whc/BeachMonitoring.asp (slide #20)
Limestone - http://csmres.jmu.edu/geollab/Fichter/SedRx/Rocks/micrite1.html (slide #28)
Powell River Spring - http://www.dcr.virginia.gov/dnh/karsthome1.htm (slide #29)
Chesapeake Bay oxygen - http://www.chesapeakebay.net/lowdo2003.htm (slide #36)
Water hardness map - http://www.water-research.net/hardness.htm (slide #38)
Nitrogen cycle - http://epa.gov/maia/html (slide #40, 42-45)
Fertilizer graphic - http://www.agr.state.nc.us/cyber/kidswrld/plant/label.htm (slide #41)
Bay Journal - http://www.bayjournal.com/ (slide #46)
Fish bowl cartoon - http://www.claybennett.com/archives.html (slide #49)
pH scale- http://library.thinkquest.org/3659/acidbase/ph.html (slide #56)
Phosphate mine - http://nc-es.fws.gov/ecotox/envrest.html (slide #57)
Algae bloom - http://www.sfwmd.gov/org/wrp/wrp_okee/2_wrp_okee_inlake/ab/index.htm#photos (slide #58)
Saltwater intrusion - http://users.coastal.ufl.edu/~jnking/SGD/index.htm (slide #60)
Secchi disk - http://www.ecy.wa.gov/programs/wq/plants/management/joysmanual/secchi.html (slide #70)
Virginia's Watersheds - http://www.cnr.vt.edu/PLT/watersheds.html. (slides # slides 71 - 88, 97, 105, 114, 122, 130, 138, 145, 153, 167 – 169, 679)
Potomac River Rapids - http://www.lug.udel.edu/~acaro/pics/Album2004/08August/20040813-15_Camping/20040815_River/index.html (slide #89)
C&O Canal - http://richreader.com/cando/id28.htm (slide #90)
Potomac River sunset - http://www.chesapeakekayakco.com/potomacjourney/HPIM1201.html (slide #91)
Shenandoah River - http://www.dcr.state.va.us/parks/pictures/andyfoto.htm (slide # 92)
Avtex Fibers demolition,flyash, recovery - http://www.avtexfibers.com/ (slide #94)
Dupont law suit - http://www.greendel.org (slide #95) (Article has lapsed)
Shenandoah River Advisories - http://www.vdh.virginia.gov/HHControl/ShenandoahRiver.asp (slide #96, 724)
Rappahannock River Falls – http://www.riverfriends.org/ (slides # 98 – 102)
Oysters - http://www3.csc.noaa.gov/scoysters/html/bio.htm (slide #103)
Charles I - http://www.utexas.edu/courses/moorecomedy/congreve.htm (slide #106)
Victory at Yorktown - http://www.archives.gov/education/lessons/revolution-images/ (slide #107)
Mattaponi River - http://images.amrivers.org/objects/view.acs?object_id=2352 (slide #108)
Pamunkey Chief - http://www.baylink.org/pamunkey/ (slide #109, 704)
Pamunkey Museum - http://home.earthlink.net/~pamunkey/ (slide #109, 704)
Shad Hatchery - http://www.baylink.org/Mattaponi/shad.html (slide #109, 704)
Chief Little Eagle - http://www.baylink.org/Mattaponi/ (slide #109, 704)
York River basin - http://www.dcr.state.va.us/grassroots/archive/index0204.htm (slide #111)
Taskinaskis creek - http://www.dcr.virginia.gov/parks/pictures/yorkfoto.htm (slide #113)
Hampton Roads - http://en.wikipedia.org/wiki/Image:Norfolk_Ship_Yard.jpg (slide #117, 126)
Give Water a Hand - http://www.uwex.edu/erc/gwah/ (slide #121)
Forestry BMPs - http://www.dof.virginia.gov/wq/index-bmp-guide.shtml (slide #121)
Factory Point - http://www.windvisions.com/factorypoint.html (slide #124)
Crab boat - http://www.photolib.noaa.gov/fish/fish0571.htm (slide #125)
Chesapeake Bay Local Assistance Division - http://www.cblad.state.va.us/ (slide #129)
Dismal Swamp map - http://www.waterlandfarm.com/Dismal_Swamp.htm (slide #133)
CBF Fact sheet - http://www.cbf.org/site/PageServer?pagename=resources_facts_tulloch_1 (slides #136, 137)
Chowan River map - http://149.168.72.84/ee/ecoadr/ChowanRiverBasin.htm (slide #139, 696)
Swine research - www.nsric.ars.usda.gov (slide #144)
Roanoke river map - http://www.ncwater.org/Data_and_Modeling/Roanoke_River_Basin_Operations_Model/ (slide #146)
Cat Rock Sluice - http://www.oldhalifax.com/county/CatRockSluice.htm, Andrew Bohanon (slide #149)

Gaston pipeline – http://www.acipco.com/pipeprogress/ (slide #151)
Yadkin River map - http://h2o.enr.state.nc.us/basinwide/images/yadkin.jpg (slide #155)
Peedee River and reservoir - http://www.centralparknc.org/regionshistory.htm (slide #156)
Kerr Dam - http://www.saw.usace.army.mil/jhkerr/index.htm (slide #157)
New River map - www.nps.gov/ neri/library.htm (slide #159)
Wilderness Road - http://www.dcr.state.va.us/parks/pictures/wildfoto.htm (slide #162)
Daniel Boone - http://library.thinkquest.org/4034/daniel_boone.html (slide #162)
Mountain Lake resort - http://www.mtnlakehotel.com/ (slide #163)
Yellofin Madtom - http://www.conservationfisheries.org/Species%20Accounts%20Archive/noturus_flavipinnis.htm (slide #172)
Slender Chub - http://www.cnr.vt.edu/efish/families/slenderchub.html (slide #172)
Duskytail darter - http://www.tva.gov/environment/land/dusky.html (slide #172)
Big Sandy maps - http://kywater.org/bsr/maps/index.htm (slide #173, 177)
Grundy flood control - http://www.grundyvirginia.com/flood.htm (slide #174, 726)
Trout fishing - http://www.usda.gov/oc/photo/94cs3005.htm (slide #176)
Powell River Project - http://www.cses.vt.edu/PRP/Ed_Center/PRP_Education_Programs.html (slide #178)
Secchi disk - http://www.chesapeakebay.net/images/wqc_secchi.gif (slide # 330)
Combined sewer - http://permanent.access.gpo.gov/waterusgsgov/water.usgs.gov/pubs/circ/circ1205/major_findings.htm (slide #397)
Lake turnover - http://www.conservation.state.mo.us/fish/ponds/laketurn/ (slide #410 - 414)
Malaria life cycle - http://www.traveldoctor.co.uk/malaria.htm (slide #462 - 464)
Malaria map - http://www.icp.ucl.ac.be/~opperd/parasites/images/malaria_map.jpg (slide #465)
Aquifer - http://octopus.gma.org/katahdin/aquifer.html (slide #666)
Shenandoah River - http://www.fosr.org/images/ex11.gif (slide #682)
James River Port - http://www.nps.gov/phso/nhlphoto/WinnersVPacific.htm and http://www.accessnoaa.noaa.gov/feb1202/ (slide #688)
Holston River - http://www.biol.vt.edu/faculty/cherry/Envirotoxlab/webimages/bigspring.jpg (slide #698)
Arlington - http://www.geology.pitt.edu/GeoSites/Arlington%20photo%203.jpg (slide #702)
Rappahannock River - http://www.rappriverbasin.org/Pics/rrriver4%20-%20fixed.JPG (slide #708)
Great Falls - http://pubs.usgs.gov/circ/2004/1264/ (slide #712)
Potomac River map - http://www.fergusonfoundation.org/04cleanup2.gif (slide #714)
Gaston pipeline - http://www.pipesite.com/gastonmap.gif (slide #722)
Phosphate Cycle - http://www.elmhurst.edu/~chm/vchembook/308phosphorus.html (slide #825 - 827, 829)
Sea lamprey - http://soma.npa.uiuc.edu/courses/physl490b/models/lamprey_swimming/lamprey_swim.html (slide #832)
Asian clam - http://www.jaxshells.org/ascl.htm (slide #832)
Silver carp - http://www.invadingspecies.com/Invaders.cfm?A=Page&PID=20 (slide #832)
Mute swan population - http://www.dnr.state.md.us/wildlife/muteswans.html (slide #849)
Nutria - http://www.invasivespeciesinfo.gov/profiles/nutria.shtml (slide #852)
Zebra mussel - http://www.fort.usgs.gov/resources/spotlight/EcoForecasting/default.asp (slie #856)
- http://www2.nature.nps.gov/YearinReview/yir2000/pages/04_resource_risks/04_08_sidebar_inverts.html (slide #858)
Zebra mussel map - http://www.unl.edu/nac/conservation/atlas/Map_Html/Ecosystem_Health/National/Current_zm_map/Current_zm_map.htm (slide #857)
Northern snakehead - http://cars.er.usgs.gov/pics/snakehead/snakehead.html (slide #860)
Blue catfish - http://www.dgif.virginia.gov/fishing/shad/images/blue_catfish_large.jpg (slide #862)
Flathead catfish - http://www.dgif.virginia.gov/fishing/shad/images/flathead_catfish_large.jpg (slide #863)
Rapa Welk - http://thechesapeakebay.com/veined_rapa.shtml (slide #864)
Asian longhorn beetle damage - http://www.umassgreeninfo.org/fact_sheets/wood_attackers/asian_longhorned_beetle.html (slide #866)
Gypsy moth larva - http://www.fs.fed.us/ne/morgantown/4557/gmoth/ (slide #867)
Adult/eggs - http://www.na.fs.fed.us/spfo/pubs/fidls/gypsymoth/gypsy.htm (slide #867)
Gypsy moth distribution - http://www.fs.fed.us/ne/morgantown/4557/gmoth/spread/ (slide #868)
Gypsy moth in VA - http://www.gypsymoth.ento.vt.edu/vagm/GM_in_VA.html (slide #869)
Adelgid distribution - http://www.njarboristsisa.com/alerts_hwa.php (slide #872)
Wetland Nutria damage - http://www.nutria.com/site5.php (slide #853)
Water Quality Monitor - http://www.tcwrc.org/councils/nestucca/wqmonvol.jpg, and http://clark.wsu.edu/volunteer/ws/images/WQmonitoring.jpg (slide #879)

Irrigation - http://www.geography.learnontheinternet.co.uk/images/agri/irigation.jpg (slide #881)
Mining - http://www.dlr.enr.state.nc.us/images/Mining-Site.jpg (slide #881)
Point Source - http://www1.sac.ac.uk/info/images/Outlook2002/Waste-water.jpg (slide #882)
Nonpoint Source - http://www.water.ky.gov/NR/rdonlyres/2FD32A29-D931-487C-8BAE-7E1CD45D6691/0/Cows_in_Stream.jpg (slide #882)
Rain garden - http://www.dof.virginia.gov/rfb/images/rain-garden-001.jpg (slide #883)
Mulching - http://www.ars.usda.gov/is/AR/archive/sep98/mulch.jpg (slide #883)
Backyard habitat - http://impact.ifas.ufl.edu/TV/grimesyard.jpeg (slide #883)
Plant riparian buffer - http://www.rce.rutgers.edu/njriparianforestbuffers/images/MTHOLLYTWO3.jpg (slide #883)
Plant a tree - http://www.nycgovparks.org/sub_newsroom/biennial_report/biennial_02_03/images/biennial2002-2003_1x7x1.jpg (slide #884)
Children's garden - http://www.metrokc.gov/dchs/csd/wsu-ce/Gardening/Graphics/KidGardenSgn.jpg (slide #890)
Garden chemicals - http://www.atsdr.cdc.gov/HAC/PHA/vlstripping/vls_p1.html and http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/TTAR-62Q5Y2?open (slide #891)
Collecting hazardous wastes - http://www.earthscan.co.uk/news/images/hazardous_waste_01_275.jpg (slide #892)
Landfill - http://www.nowaste.act.gov.au/styles/muggalanelandfillimage.JPG (slide #899)
U.S. Fish and Wildlife Service - http://images.fws.gov/ (slides #18, 31, 147)
Chesapeake Bay Program - http://www.chesapeakebay.net (slide #36, 878)
U.S. Geological Survey - http://water.usgs.gov (slide #8)
- http://ga.water.usgs.gov (slide #6)
- http://va.water.usgs.gov (slides #166, 684)
Invasive Species - http://www.invasive.org/eastern/ - (Slides #135, 658, 662, 664, 832, 855, 864, 865, 870, 871, 873, 874)
Wikipedia - http://en.wikipedia.org/wiki/Main_Page (slides #10, 13, 106, 115, 117, 126, 115, 839, 840, 841, 843, 845, 847, 848, 851)
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***18U.S.C.707**

Score Card

Teams or Players

1	2	3	4	5	6	7	8	9	10

<u>Points required to clean up different types of pollution.</u>

Sediment – 50
Pesticides – 40
Fossil Fuels – 30
Trash – 10

Nitrate – 50
Herbicides – 40
Phosphate – 30

Bacteria – 50
Acid Rain – 30
Heat – 20

Toxic Chemicals – 50
Heavy Metals – 30
Road Chemicals – 20

ANSWER SHEET

Write in the topics across the top line.

5 PC					
10 PC					
25 PC					
50 PC					
100 PC					

Answers to Introductory Level 1

	TYPES OF	THINGS GOIN' ON	WHAT IT IS?	MEASURES	NOT SO GOOD
5 PC	Base	Nutrients	Nutrients	Dissolved Oxygen	Pollution
10 PC	Elements	Acid	Hard Water	pH	Sediment
25 PC	Pollution	Soft Water	Dissolved Oxygen	0º - 100º Celsius	pH
50 PC	Sediment	Sediment	Parts Per Million	Neutral	Nutrients
100 PC	Acid	Dissolved Oxygen	Acid	pH	Dissolved Oxygen

Answers to Introductory Level 2

	TYPES OF	THINGS GOIN' ON	WHAT IT IS?	MEASURES	NOT SO GOOD
5 PC	Point Source Pollution	Erosion	Buffers	Temperature	Dissolved Oxygen
10 PC	Non-Point Source Pollution	Photo-synthesis	Ammonia	Hardness	Impaired Waters
25 PC	Toxic	Respiration	Parts Per Million	Acids and Bases	Eutro-phication
50 PC	Organic	BOD COD	TDS TSS	Nutrients	Anaerobic
100 PC	Inorganic	Nitrogen Cycle	**Conductivity**	Salinity	Coliform Bacteria

Answers to Introductory Level 3

	CHEMICAL NAMES	WHAT IT IS	MEASURES OF	WHAT'S IN WATER	SOLUTIONS
5 PC	Pesticides	Ammonia	Sodium Chloride	Dissolved Oxygen	Liter
10 PC	Herbicides	Clay	Turbidity	Nutrients, Chemicals, Bacteria	Brackish
25 PC	Ground water	Bacteria	Total Suspended Solids	Saltwater	Parts Per Thousand
50 PC	Heavy Metals	Coliform Bacteria	Secchi Disk	Dissolved Oxygen	Turbidity
100 PC	**Toxic Substances**	Nutrients, Sediment, Bacteria	Hydrometer	Fecal Coliform Bacteria	Total Dissolved Solids

Beginner Level (Turbidity, Temperature, etc.)

	HOT OR COLD	ONE LUMP OR TWO	WITH A GRAIN OF SALT	CAN'T SEE THE BOTTOM	I DON'T FEEL SO GOOD
5 PC	Mercury	Total Suspended Solids	Salinity	Turbidity	Both Soil and Water
10 PC	Temperature	Total Dissolved Solids	Parts Per Thousand	Turbidity	Human and Animal Waste
25 PC	Antifreeze	Sand	Denser	Clay	False
50 PC	**Digital Thermometer**	Erosion	Sodium Chloride	Sunlight	Air
100 PC	Temperature	Dissolved Oxygen	Temperature and Salinity	150 grams	85,000

Advanced Level (Turbidity, Temperature, etc.)

	HOT or COLD	ONE LUMP or TWO	WITH A GRAIN OF SALT	CAN'T SEE THE BOTTOM	I DON'T FEEL SO GOOD
5 PC	Temperature	F. All of these	Liter	TSS	**Fecal Contamin-ation**
10 PC	On The Bottom	Total Dissolved Solids	Salinity	All of These	None
25 PC	Salinity	Total Suspended Solids	All of these	Temperature	Malaria
50 PC	F = 32°	Total Dissolved Solids	Near 0 ppt	High TSS	Disagree
100 PC	C = 100°	Total Dissolved Solids	Tidal (Salt) Wedge	pH	Atrazine

Beginner Level (Nitrate, Phosphate, etc.)

	MORE OR LESS	GETTIN' AROUND	DANGER! DANGER!	WHAT IT IS?	HOW MUCH
5 PC	pH	Nitrate	Nitrate	pH	Dissolved Oxygen
10 PC	Dissolved Oxygen	Phosphate	Dissolved Oxygen	Hardness	pH
25 PC	Dissolved Oxygen	Nitrate	Phosphate	Alkalinity	Alkalinity
50 PC	Hardness	Dissolved Oxygen	Hardness	Nitrate	Nitrate
100 PC	Phosphate	Alkalinity	pH	Dissolved Oxygen	Phosphate

Advanced Level (Nitrate, Phosphate, etc.)

	MORE OR LESS	GETTIN' AROUND	DANGER! DANGER!	WHAT IT IS?	HOW MUCH
5 PC	Dissolved Oxygen	pH	Phosphate	pH	pH
10 PC	pH	Alkalinity	Dissolved Oxygen	Hardness	Alkalinity
25 PC	Phosphate	Dissolved Oxygen	Hardness	Alkalinity	Nitrate
50 PC	Alkalinity	Nitrate	Alkalinity & Hardness	Phosphate	Hardness or Alkalinity
100 PC	Phosphate	Phosphate	Dissolved Oxygen	Phosphate	pH

Expert Level (Nitrate, Phosphate, etc.)

	MORE OR LESS	GETTIN' AROUND	DANGER! DANGER!	WHAT IT IS?	HOW MUCH
5 PC	Dissolved Oxygen	Phosphate	Nitrate	Dissolved Oxygen	Dissolved Oxygen
10 PC	Hardness	Nitrate	Alkalinity	pH	Hardness or Alkalinity
25 PC	Dissolved Oxygen	Alkalinity	Hardness	Nitrate	Phosphate
50 PC	Nitrate	Nitrate	Alkalinity	Hardness	Dissolved Oxygen
100 PC	Phosphate	Nitrate	Nitrate	Nitrate	Alkalinity

Answers to Wild Card Level

	MORE OR LESS	GETTIN' AROUND	DANGER! DANGER!	WHAT IT IS?	HOW MUCH
5 PC	Hypoxic or Hypoxia	Iron	**MTBE Methyl tertiary butyl ether**	Pfiesteria	Antibiotics
10 PC	PH	Sulfur	**PCB Polychlorin-ated biphenol**	Purple Loosestrife	**Manganese**
25 PC	Trihalo-methanes	Copper	Mercury	Eurasian Milfoil	Point Source
50 PC	> 1000	Chloramine	Zebra Mussel	Aquifer	Total Maximum Daily Load
100 PC	Detritus	Salt or Saltwater	Phragmites	Silica	Storm Water

Answers to Virginia's Watersheds

	Name That River	Tributaries	People	Items of Intertest	Problems
5 PC	**Shenandoah River**	York River	**Shenandoah River**	Potomac River	Lake Gaston
10 PC	Rappa-hannock River	James River	**York River**	Potomac River	**Shenandoah River**
25 PC	Coastal Rivers	Chowan	Dismal Swamp	James River	Grundy
50 PC	James River	Clinch, Powell, or Holston River	Rappa-hannock River	Fall Line	(Non-tidal) Wetlands
100 PC	Albemarle (Currituck)	Yadkin River	New River	Roanoke River	Chowan

Glossary

A glossary is provided as a reference for students. This can be viewed on screen or printed and distributed as a study guide for the games. Puzzles are also provided to assist with the vocabulary.

Glossary

Word Search

Printable Glossary

Crossword Puzzle

Glossary

Acids – Compounds that release free hydrogen ions (H+).

Alkalinity – A measure of the carbonate/bicarbonate concentration in water (acid buffering capacity).

Ammonia – A compound composed of nitrogen and hydrogen, produced by organic decay.

Anoxic – Indicates the absence of oxygen.

Aquifer – An underground sediment or rock layer that holds a significant amount of water.

Base – Compound that reacts with acids to form a salt and releases free hydroxyl (OH-) ions in solution.

Best Management Practice – Methods used to reduce different types of pollution (contour plowing, filter strips, etc.).

Biological Oxygen Demand – The measure of the dissolved oxygen consumed by microscopic organisms.

Chemical Oxygen Demand – The measure of the dissolved oxygen consumed by chemical reactions.

Chesapeake Preservation Act - 1988 legislation requiring communities to implement land use and water quality protection measures that will help to preserve the environmental quality of the Chesapeake Bay.

Conductivity – A measure of water's ability to conduct electricity.

Detritus – Sediment composed of decaying fragments of organic matter.

Dissolved Oxygen – Free oxygen that is dissolved in water.

Erosion – The movement of soil by wind, water or ice.

Eutrophication - The addition of excess nutrients and sediment that reduces the oxygen-carrying capacity of water.

Fall Line - The area where the crystalline rocks of the Piedmont end and the sedimentary rocks of the Coastal Plain begin. Rivers have non-navigable waterfalls and rapids at this boundary.

Fecal Coliform Bacteria – Bacterial indicators of human and mammalian waste contamination.

Hardness – A measure of the mineral (calcium/magnesium) content of water.

Hypoxic – Indication of a low dissolved oxygen level (0 > ppm < 5).

Impaired Water – A waterway that is too polluted to meet its designated use.

Inorganic – Refers to non-carbon based compounds.

Karst - Geologic formations of limestone bedrock including caves and sinkholes.

Mercury - A toxic, heavy metal that can have serious neurological and developmental effects.

Nitrate – A nutrient compound important in plant growth.

Nitrite – A toxic form of nitrogen derived from ammonia.

Non-point Source Pollution – Pollution that originates over a wide area.

Organic – Refers to carbon-based compounds.

PCB – (Polychlorinated biphenyl) A toxic group of compounds known to cause cancer and affect fetal development.

pH – The measure of the hydrogen ion (H+) concentration.

pH Buffer – Compounds that help keep the pH level constant.

Phosphate – A nutrient compound important in plant growth and energy transfer.

Photosynthesis – The process by which green plants use carbon dioxide and water in the presence of sunlight to produce food and oxygen.

Point Source Pollution – Pollution that originates from a specific or controlled site.

Respiration – The process by which organisms use oxygen to metabolize food and give off carbon dioxide.

Salinity – A measure of the salt content of seawater.

Storm Water – Urban/suburban runoff that originates during rainstorms.

Temperature – The measure of thermal energy.

Total Dissolved Solids – A measure of the amount of substances dissolved in water.

Total Maximum Daily Load (TMDL) – The greatest amount of pollution a waterway can receive and retain its designated-use status.

Total Suspended Solids – A measure of the amount of matter suspended in water.

Toxic – Poisonous, harmful.

Tulloch Ditching – A construction method used by developers to drain non-tidal wetlands.

Turbidity – A measure of the cloudiness or murkiness of water.

END

Acids – Compounds that release free hydrogen ions (H^+).

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Turbidity – A measure of the cloudiness or murkiness of water.

Search Word Puzzle

Advanced Search

D	P	H	O	S	P	H	A	T	E	T	H	N	O
I	H	S	E	R	H	H	L	G	E	Y	Y	A	M
S	O	E	E	O	R	A	K	R	P	O	A	E	T
S	T	E	M	P	E	R	A	T	U	R	E	Y	I
O	O	R	I	T	I	D	L	E	T	G	H	C	N
L	S	S	A	L	I	N	I	T	Y	A	T	S	I
V	Y	I	B	A	S	E	N	B	T	N	A	O	E
E	N	I	A	R	A	S	I	A	H	I	R	S	A
D	T	I	E	G	P	S	T	C	D	C	R	L	O
O	H	A	E	E	E	N	Y	T	I	T	I	N	O
X	E	S	S	R	S	A	L	E	T	B	N	E	T
Y	S	P	H	H	N	I	T	R	A	T	E	T	Y
G	I	N	O	R	G	A	N	I	C	I	A	A	T
E	S	A	M	M	O	N	I	A	I	A	I	I	G
N	R	A	A	V	R	T	N	O	D	R	O	I	A

ACID
ALKALINITY
AMMONIA
BACTERIA
BASE
DISSOLVED OXYGEN
HARDNESS
INORGANIC
NITRATE
ORGANIC
PH
PHOSPHATE
PHOTOSYNTHESIS
SALINITY
TEMPERATURE

Advanced Search Word Puzzle

A	M	M	O	N	I	A	P	H	O	S	P	H	A	T	E
N	H	U	E	I	P	N	O	R	O	P	H	I	P	O	B
T	E	M	P	E	R	A	T	U	R	E	O	P	O	X	A
M	S	N	S	U	I	D	E	T	R	I	T	U	S	I	S
D	A	R	O	T	P	O	I	N	T	S	O	U	R	C	E
L	L	E	O	R	H	A	R	D	N	E	S	S	N	O	B
D	I	S	S	O	L	V	E	D	O	X	Y	G	E	N	A
O	N	P	H	P	A	T	S	S	R	P	N	B	O	D	C
I	I	I	A	H	L	E	T	S	G	A	T	H	R	U	T
N	T	R	N	I	K	R	O	P	A	T	H	Y	A	C	E
O	Y	A	O	C	A	O	R	R	N	O	E	P	Q	T	R
R	F	T	X	A	L	S	M	D	I	U	S	O	U	I	I
G	E	I	I	T	I	I	W	T	C	T	I	X	I	V	A
A	C	O	C	I	N	O	A	D	T	T	S	I	F	I	C
N	O	N	P	O	I	N	T	S	O	U	R	C	E	T	I
I	D	I	X	N	T	O	E	B	U	F	F	E	R	Y	D
C	U	H	R	B	Y	I	R	N	I	T	R	A	T	E	R

AMMONIA
BACTERIA
BUFFER
DETRITUS
EUTROPHICATION
INORGANIC
ORGANIC
PHOTOSYNTHESIS
SALINITY
TEMPERATURE
TSS

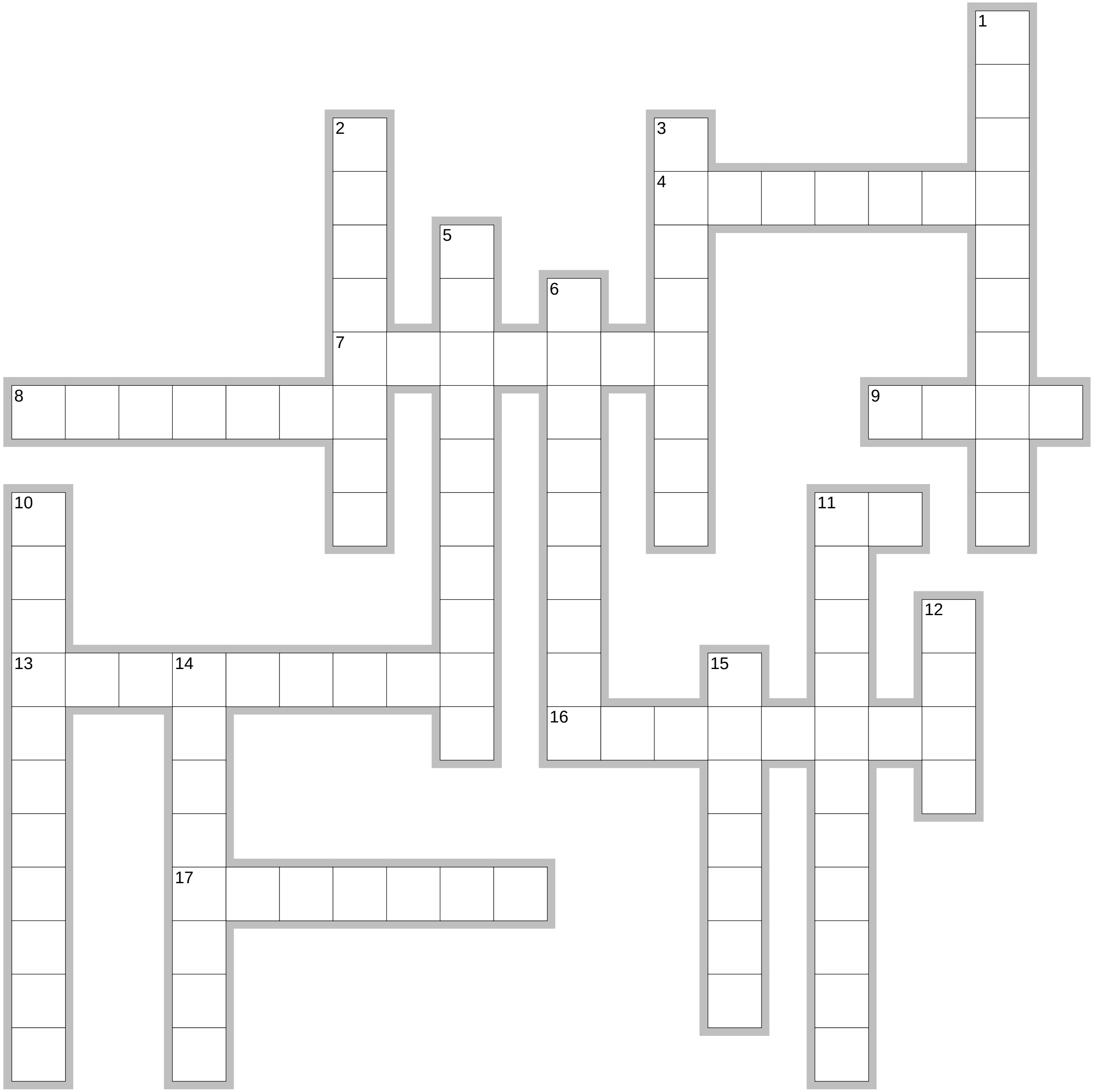
ALKALINITY
AQUIFER
BOD
CONDUCTIVITY
EROSION
HYPOXIC
NONPOINT SOURCE
PHOSPHATE
RESPIRATION
TDS
TOXIC

ACID
ANOXIC
BASE
COD
DISSOLVED OXYGEN
HARDNESS
NITRATE
PH
POINT SOURCE
STORMWATER
TMDL

Crossword Puzzle #2

Crossword Puzzle #1

Answers



ACROSS

4. Product of protein decay

7. Soil on the move

8. Groundwater layer

9. PH less than 7

11. Power of the Hydrogen

13. Important in root growth

16. Particles of organic matter

17. Primary plant nutrient

DOWN

1. Buffers pH

2. What coliform is

3. Measures calcium and magnesium

5. Urban runoff

6. What oxygen is in water

10. Measured in ºF and ºC

11. Pollution from a pipe

12. PH greater than 7

14. Saltwater measure

15. From living matter

Crossword Puzzle #1 - Answers

ACROSS

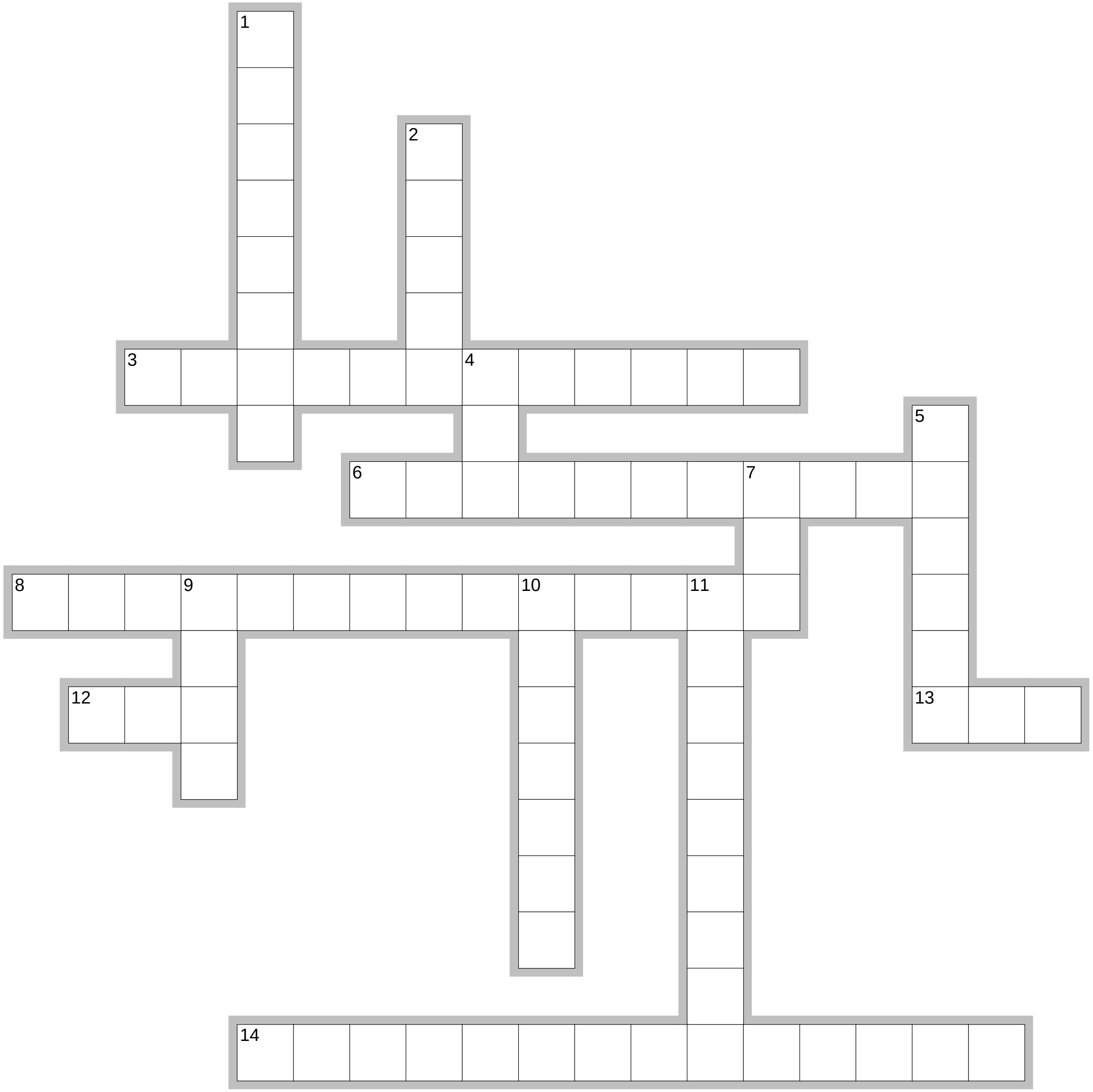
4.	Product of protein decay	AMMONIA
7.	Soil on the move	EROSION
8.	Groundwater layer	AQUIFER
9.	PH less than 7	ACID
11.	Power of the Hydrogen	pH
13.	Important in root growth	PHOSPHATE
16.	Particles of organic matter	DETRITUS
17.	Primary plant nutrient	NITRATE

DOWN

1.	Buffers pH	ALKALINITY
2.	What coliform is	BACTERIA
3.	Measures calcium and magnesium	HARDNESS
5.	Urban runoff	STORMWATER
6.	What oxygen is in water	DISSOLVED
10.	Measured in ºF and ºC	TEMPERATURE
11.	Pollution from a pipe	POINTSOURCE
12.	PH greater than 7	BASE
14.	Saltwater measure	SALINITY
15.	From living matter	ORGANIC

Crossword Puzzle #2

Answers



ACROSS

3. **Electrical current in water**

6. **Food + oxygen = energy + CO2 + water**

8. **Sunlight + water + CO2 = food + oxygen**

12. **Biological oxygen demand**

13. **Chemical oxygen demand**

14. **Aquatic aging process**

DOWN

1. **A broad pollution source**

2. **Poisonous**

4. **Total dissolved solids**

5. **Without oxygen**

7. **Total suspended solids**

9. **Total maximum daily load**

10. **Low oxygen**

11. **Not living**

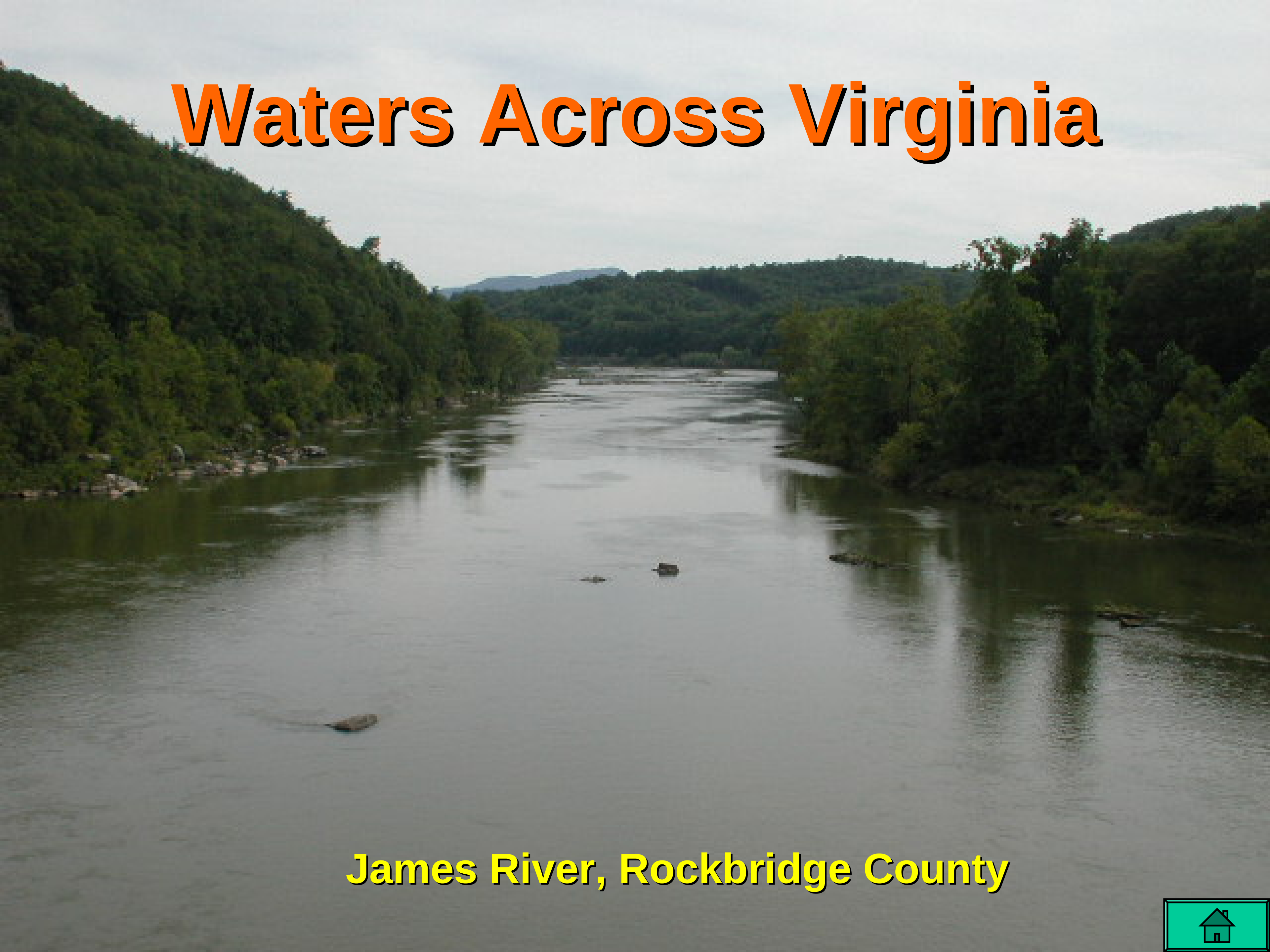
Crossword Puzzle #2 - Answers

ACROSS

3.	Electrical current in water	CONDUCTIVITY
6.	Food + oxygen = energy + CO2 + water	RESPIRATION
8.	Sunlight + water + CO2 = food + oxygen	PHOTOSYNTHESIS
12.	Biological oxygen demand	BOD
13.	Chemical oxygen demand	COD
14.	Aquatic aging process	EUTROPHICATION

DOWN

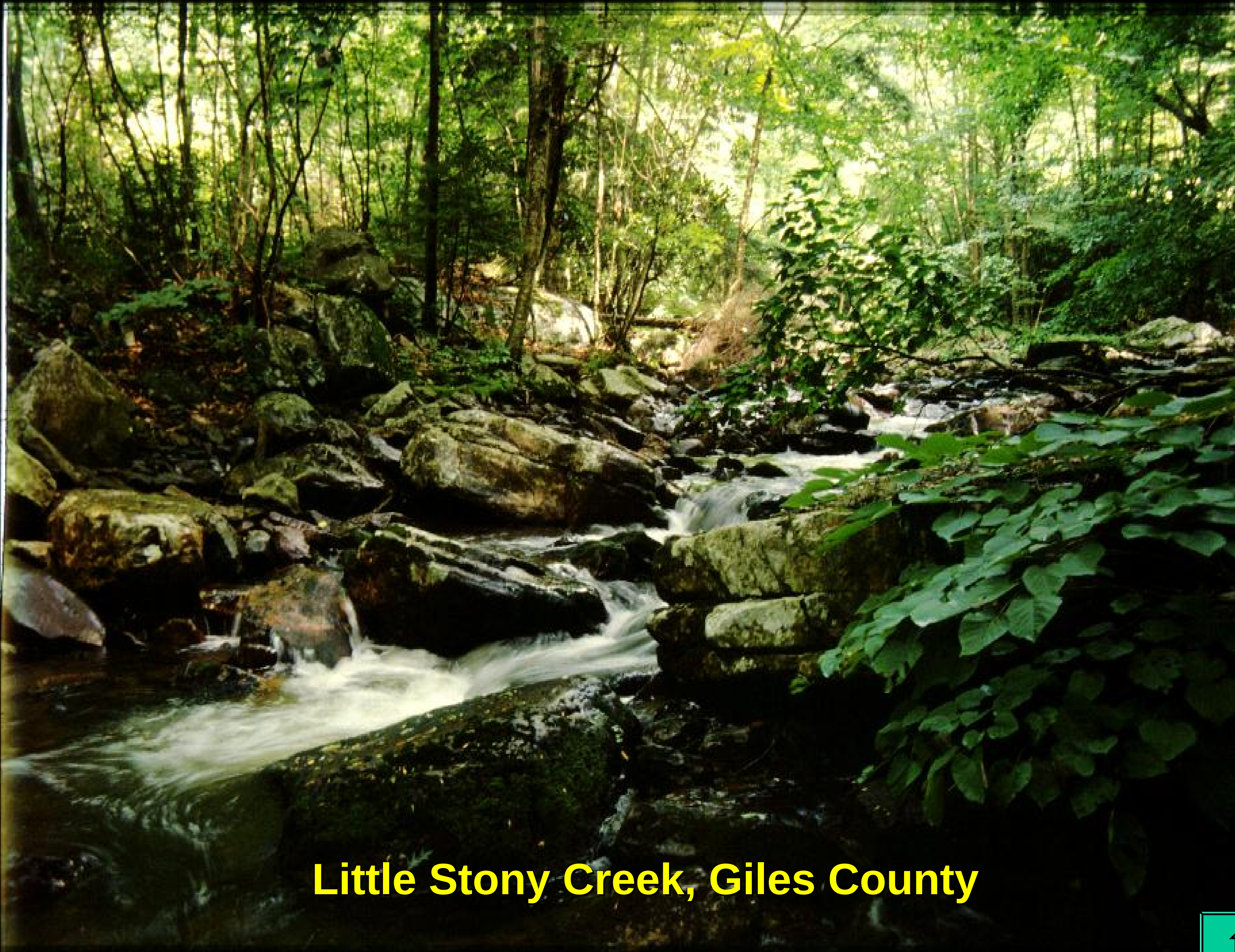
1.	A broad pollution source	NONPOINT
2.	Poisonous	TOXIC
4.	Total dissolved solids	TDS
5.	Without oxygen	ANOXIC
7.	Total suspended solids	TSS
9.	Total maximum daily load	TMDL
10.	Low oxygen	HYPOXIC


Waters Across Virginia
James River, Rockbridge County


Hungry Mother Lake, Smyth County

Hungry Mother Lake, Smyth County

Little Wilson Creek, Grayson County



Little Stony Creek, Giles County


Little Stony Creek, Giles County


Cascades, Giles County

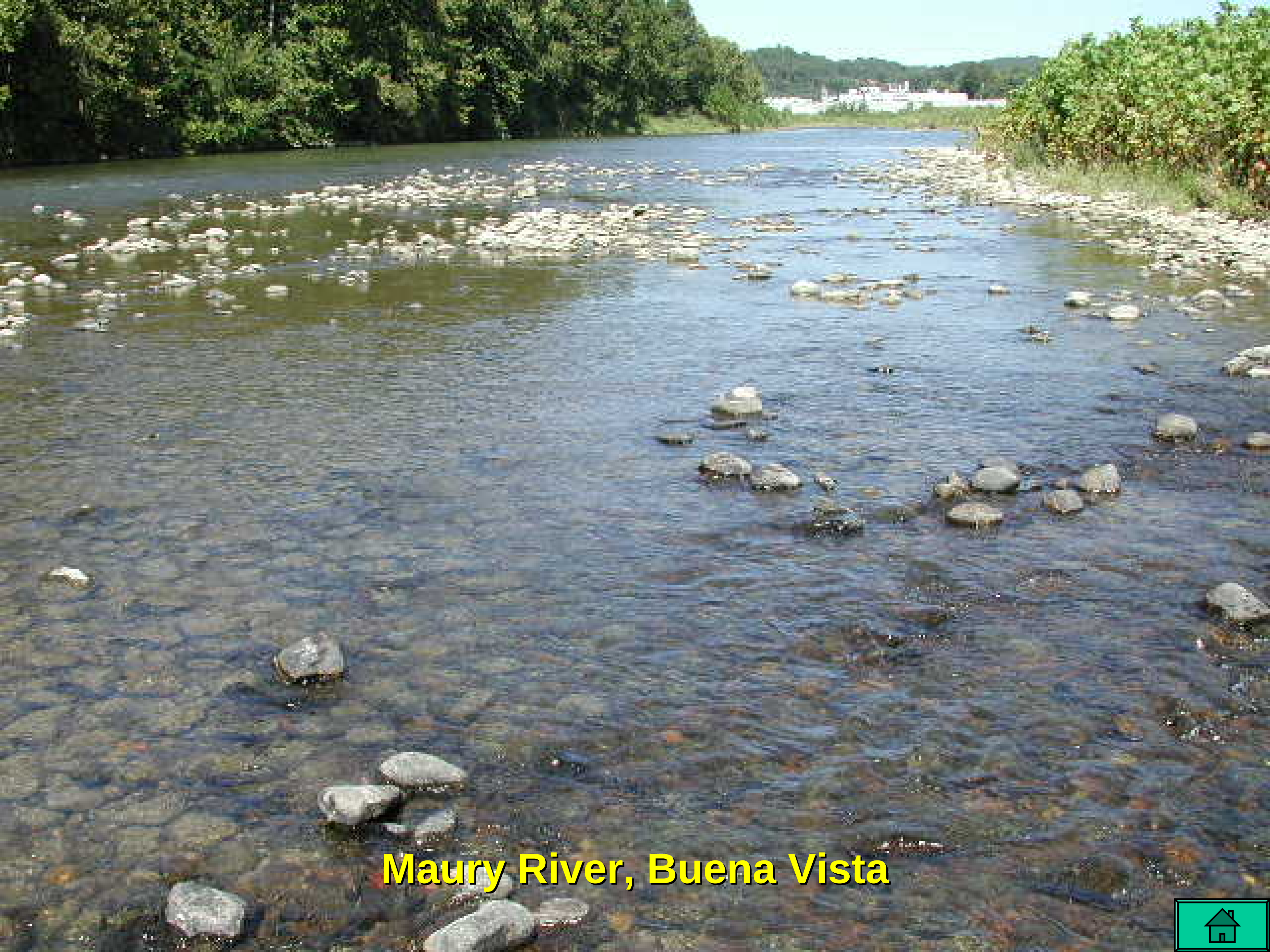
Shamokin Spring, Nelson County


Shamokin Falls, Nelson County

Giles County, frozen cascade

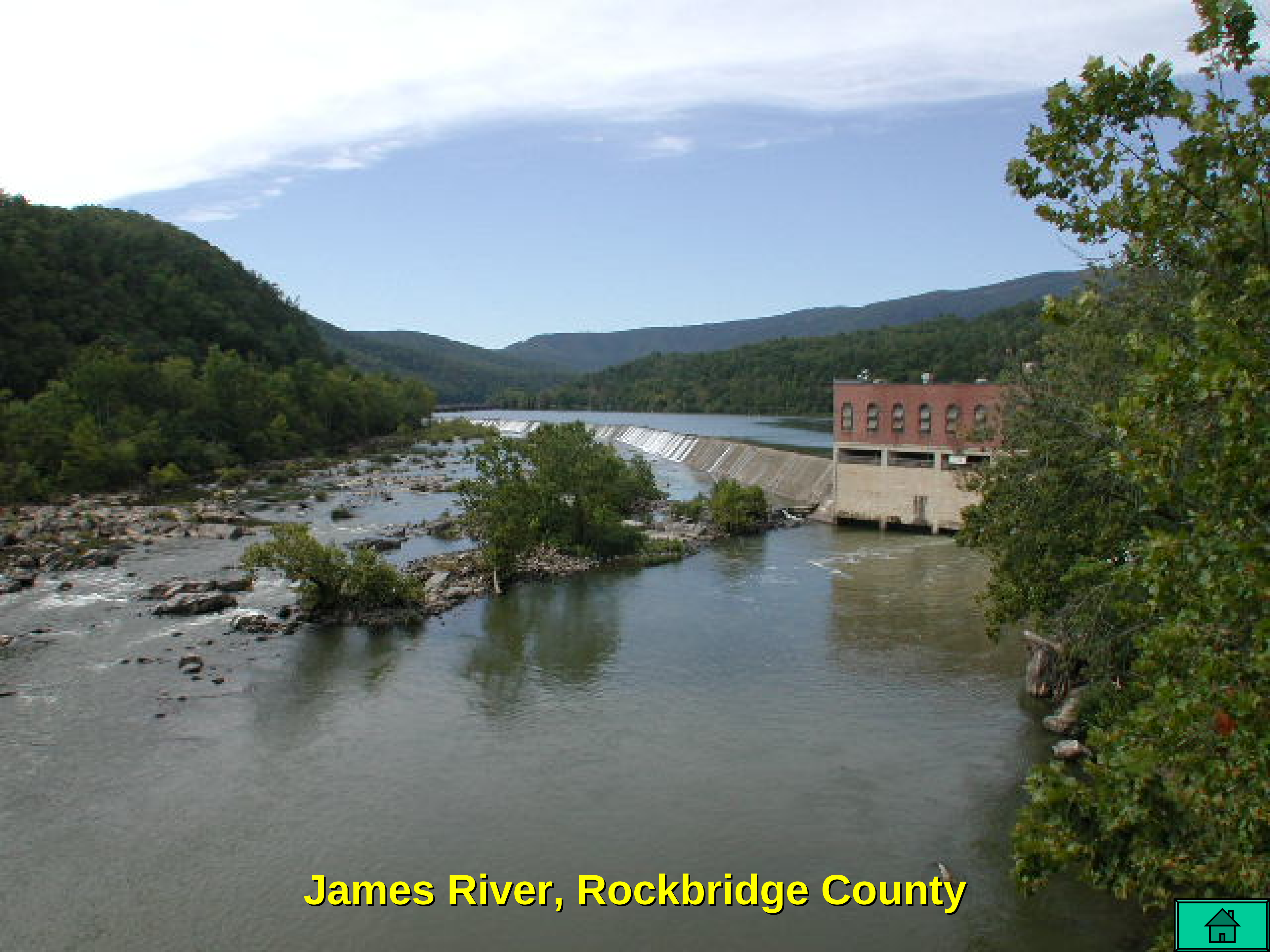

Crabtree Falls tributary, Nelson County

Front Royal, beaver dam



Maury River, Buena Vista


Augusta County, freshwater marsh



James River, Rockbridge County

Rivanna River tributary, Charlottesville


Holiday Lake, Appomattox County


Holiday Lake, Appomattox County

Holiday Lake backwater, Appomattox County


Appomattox County, vernal pool

Staunton River State Park, Halifax County

Little Nottoway River, Nottoway County

Nottoway County, beaver pond


Deep Creek, Nottoway County


Beaver Lake, Chesterfield County

Brisefield Dam, Lake Chesdin, Chesterfield County

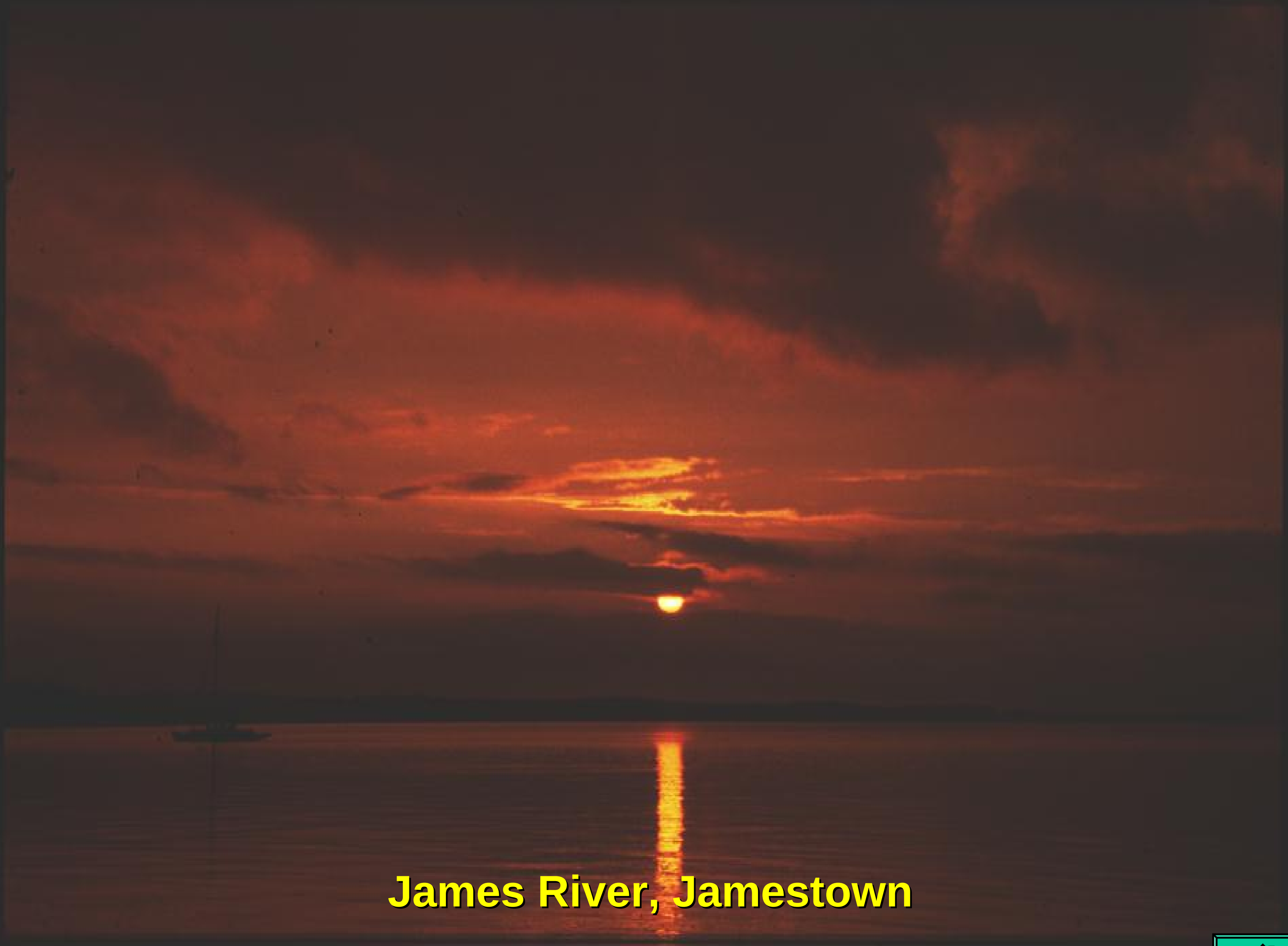

Appomattox River, Petersburg


Appomattox River, Petersburg


Appomattox River, Petersburg


Ragsdale Lake, Dinwiddie County


James River, Jamestown


James River, Jamestown


Nottoway Falls, Sussex County


Airfield Lake, Sussex County


Airfield Lake, Sussex County

Southampton County, swamp

Spartina marsh, Accomac County

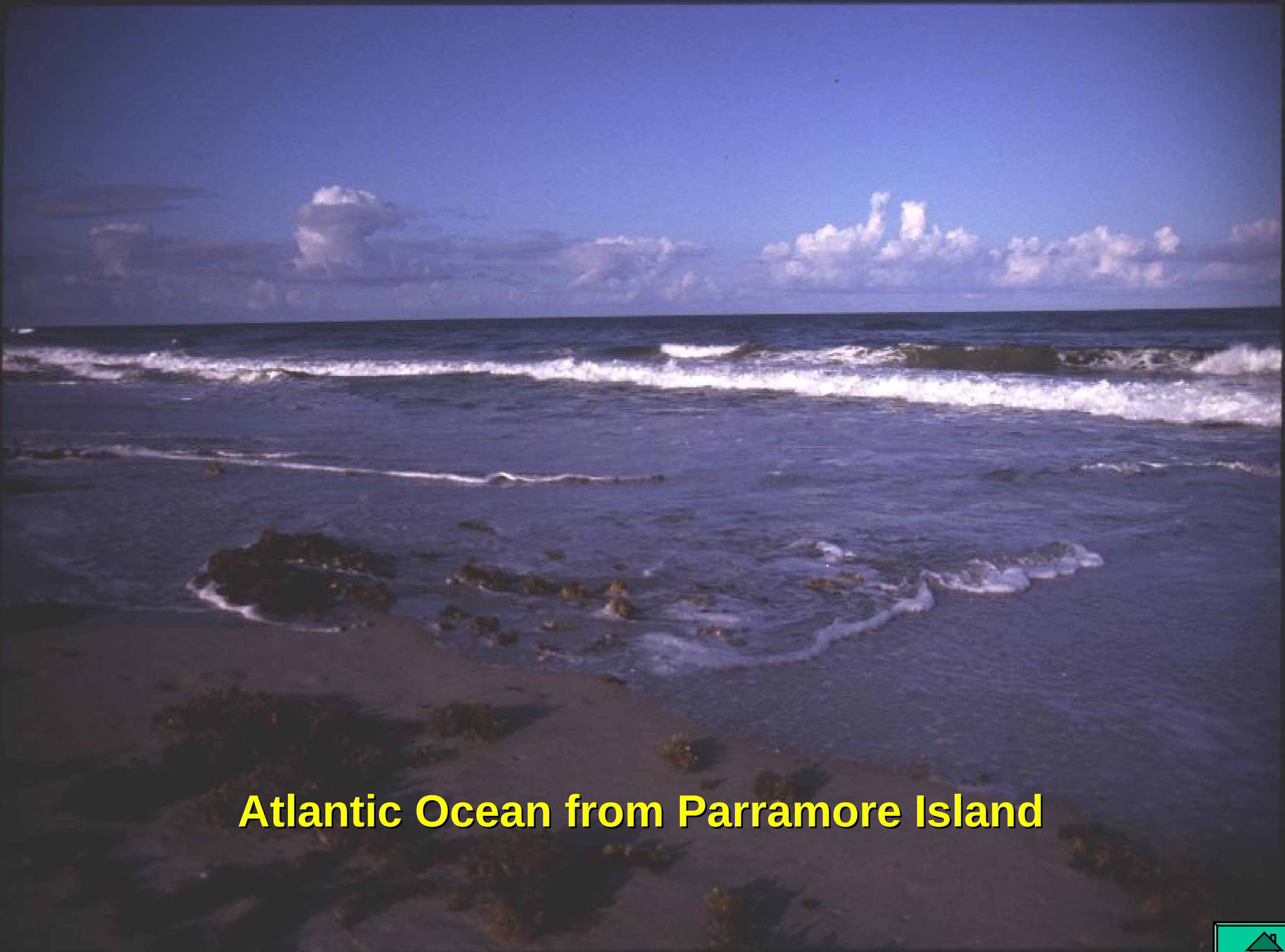

Eastern Shore National Wildlife Refuge, Northampton County


Assateague Wildlife Refuge, winter marsh


Back Bay, Virginia Beach


Little Island Beach, Sandbridge


Chesapeake Bay Bridge from Fisherman's Island


Atlantic Ocean from Parramore Island

Allowable Levels of Common Contaminants in Drinking Water

For more information about these and other water contaminants, go to:
http://www.epa.gov/safewater/mcl.html#mcls

Contaminant	MRDLG[1] (mg/L)[2]	MRDL[1] (mg/L)[2]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Chloramines (as Cl_2)	4	4	Eye/nose irritation; stomach discomfort, anemia	Water additive used to control microbes
Chlorine (as Cl_2)	4	4	Eye/nose irritation; stomach discomfort	Water additive used to control microbes

Contaminant	MCLG (mg/L)	MCL (mg/L)	Potential Health Effects	Sources of Contamination
Arsenic	0	0.010 as of 01/23/06	Skin damage or problems with circulatory systems, and increased risk of getting cancer	Erosion, runoff from orchards, runoff from glass & electronics production wastes
Asbestos (fiber >10 micrometers)	7 million fibers per liter	7 MFL	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits
Cadmium	0.005	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; waste batteries and paints
Chromium (total)	0.1	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects	Sources of Contamination
Copper	1.3	TT Action Level=1.3	Short-term exposure: Gastrointestinal distress Long-term exposure: Liver or kidney damage People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits
Fluoride	4.0	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects	Sources of Contamination
Lead	zero	TT Action Level=0.015	Infants/children: Delays in physical or mental development; slight deficits in attention span and learning abilities Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Mercury (inorganic)	0.002	0.002	Kidney damage	Erosion, runoff discharge from refineries and factories
Nitrate (measured as Nitrogen) Nitrite	10 1	10 1	Infants below the age of six months could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects	Sources of Contamination
Atrazine	0.003	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops
Carbofuran	0.04	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa
2,4-D	0.07	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops
1,2-Dibromo-3-chloropropane (DBCP)	zero	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, orchards

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects	Sources of Contamination
Dioxin (2,3,7,8-TCDD)	zero	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories
Diquat	0.02	0.02	Cataracts	Runoff from herbicide use
Endothall	0.1	0.1	Stomach and intestinal problems	Runoff from herbicide use
Glyphosate	0.7	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use
Heptachlor	zero	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects	Sources of Contamination
Lindane	0.0002	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, gardens
Methoxychlor	0.04	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock
Oxamyl (Vydate)	0.2	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes
Polychlorinated biphenyls (PCBs)	zero	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; risk of cancer	Runoff from landfills; discharge of waste chemicals

Contaminant	MCLG[1] (mg/L)[2]	MCL or TT[1] (mg/L)[2]	Potential Health Effects	Sources of Contamination
Simazine	0.004	0.004	Problems with blood	Herbicide runoff
Toxaphene	zero	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle
Vinyl chloride	zero	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories

Notes[1] (Definitions)

Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water.

Maximum Contaminant Level Goal (MCLG) - The level of a contaminant in drinking water below which there is no known or expected risk to health.

Maximum Residual Disinfectant Level (MRDL) - The highest level of a disinfectant allowed in drinking water.

Maximum Residual Disinfectant Level Goal (MRDLG) - The level of a drinking water disinfectant below which there is no known or expected risk to health.

Treatment Technique - A required process intended to reduce the level of a contaminant in drinking water.

[2] Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million.

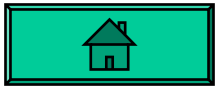
Program Guide

This program is divided into the following sections:

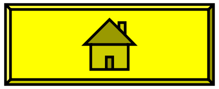
- **Introduction:** An overview of why water quality is important and the different sources and types of water pollution.
- **Glossary:** On-screen and printable list of terms and definitions. Search word and cross word puzzles are also provided.
- **Water Quality Indicators:** An overview of important water quality indicators, what they mean and how they are measured.
- **Virginia's Watersheds** – A description of Virginia's watersheds including water quality issues.
- **Topic Information:** Additional information about processes and topics presented in the program.
- **Watershed Tour:** A virtual tour across Virginia's watersheds.
- **Personal Action:** Suggestions for home, school and community-based actions to improve water quality.
- **Play Preparation:** Familiarize students with water quality indicators and Virginia's watersheds.
- **Game Instructions:** How to play the "Jeopardy" style games.
- **Play Game:** Navigation page for the ten interactive games.
- **Credits:** List of reviewers and information/graphic sources.

These sections are listed on the main **Navigation Slide**. This serves as the **Home Page** for the program. Click on any link on the home page and you will automatically move to the respective section. A click of the mouse will advance you to each page within a section. Many pages will show text and pictures automatically and sequentially. A click of the mouse will speed their appearance.

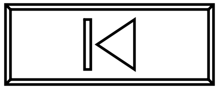
The following **Action Buttons** are used throughout the program:



Home Page (green) – Returns you to the main navigation slide.



Home Page (yellow) – Returns you to the respective game board.



Returns you to the title slide of a respective section. The appearance of this button indicates that you are viewing the last slide within that section.

Text	Advances you to a special information section. These are distributed throughout the program or can be selected from the link on the main navigation slide.
◁	Returns you to the previous slide.
▷	Advances you to the next slide.

Be sure to click directly on the action button and that the cursor has changed to a “hand.” In most cases, the action button is embedded in the slide and you will automatically be directed to the correct slide. The program may also be navigated using the slide sorter view or the function button located at the bottom left of any page. Use the function button and click on “previous” to correct inadvertent advances.

WEB Links

Links to the World Wide Web are embedded throughout the program. To access these links, be sure your computer is Web accessible. The links provide additional information, educational activities and instructional resources concerning topics presented in the program.

Using the Program

Explore each section individually and familiarize yourself with the navigation tools prior to using the program with students. The program is designed for students in grades 6 through twelve and adults. Students can progress through the different levels of the program at their own pace. Even middle school students can explore the higher-level games as they build their water quality knowledge base. However, higher-grade students often do not have a good understanding of water quality processes and issues. It may be beneficial to review the introductory sections with them as well.

The program is correlated to the **Virginia Science Standards of Learning**. Click on this link to view the correlations.

Standards of Learning

If students are unfamiliar with basic water quality terms and processes, do the following:

- Review the **Glossary** and use the **Word Puzzles** to help students become familiar with definitions. These can be printed and distributed to students.

• Review the **Introduction** section with students so that they understand the sources and types of water pollution.

• Review the **Water Quality Indicators** and **Virginia Watersheds** sections with students. There are **Puzzle Games** provided with the water quality indicators to assist in instruction.

• The **Topic Information** section will introduce students to additional topics presented in the program. Encourage discussion as these sections are studied.

• Always begin with the **Introductory** and **Beginner Games** for students unfamiliar with water quality topics. The contents of the games are developed sequentially. These are especially recommended for students in grades 6 – 8.

The games are provided with a study list of **Suggested Answers**. This can be printed and distributed to students prior to game play. An **Answer Sheet** is also provided for the instructor to assist in game presentation. The **Watershed Game** relies on students' knowledge of Virginia river systems. It is suggested that students review the **Virginia's Watersheds** section before attempting this game. The **Wild Card Game** covers a variety of topics from antibiotics to Zebra Mussel.

To increase student attention and comprehension during the introductory sections, use the following strategies:

• Let students take turns advancing through the program slides and call on students at random to read the slides. The person who is called on can read or "pass it on" to another student who must read.

• Ask students to share information or a story related to the slides being viewed. In addition, ask students to write down terms presented on the slides that they are unfamiliar with to build a vocabulary list to share with the class.

• Ask students to create questions from the information viewed in the slides. These can be collected and later used for review.

• Playing a particular game two or more times will increase student learning; especially if games are a "friendly" competition between teams of students. Hand out copies of the blank answer sheet (found in the game instructions) to students and play a bingo-style game as students try to answer questions correctly.

This program was developed in an effort to help youth and adults understand the importance of good water quality and why individuals must be good stewards for this resource. Water quality is vitally important to everyone's welfare. Working together, we all can make a difference in protecting and conserving our water resources.

If you have a question or suggestion, please contact the author: Barry Fox, Box 9081, Virginia State University, Petersburg, VA 23806 (804-524-5848) (bfox@vsu.edu).

Topic Information

Invasive Species

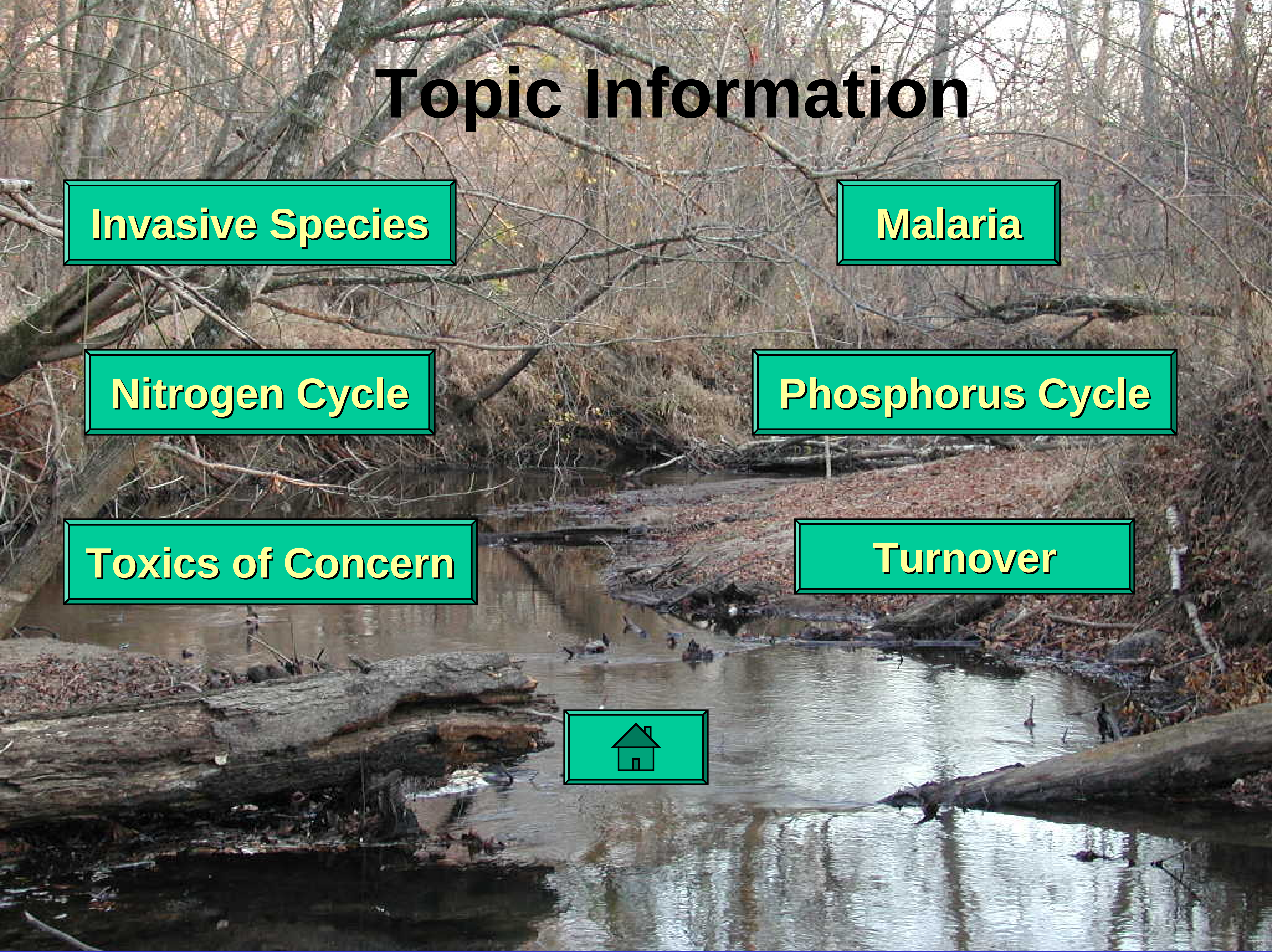
Malaria

Nitrogen Cycle

Phosphorus Cycle

Toxics of Concern

Turnover

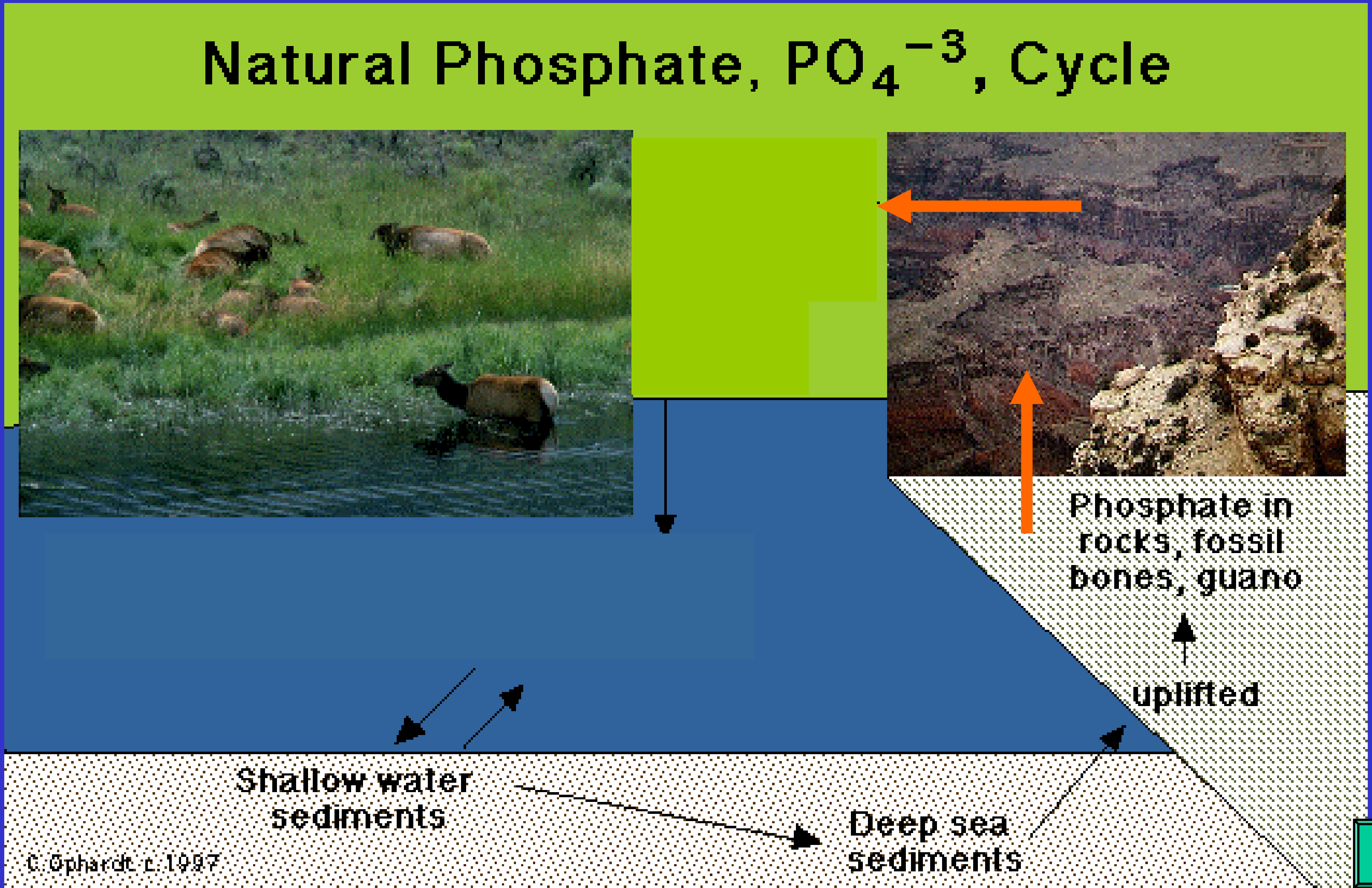


Phosphorus Cycle

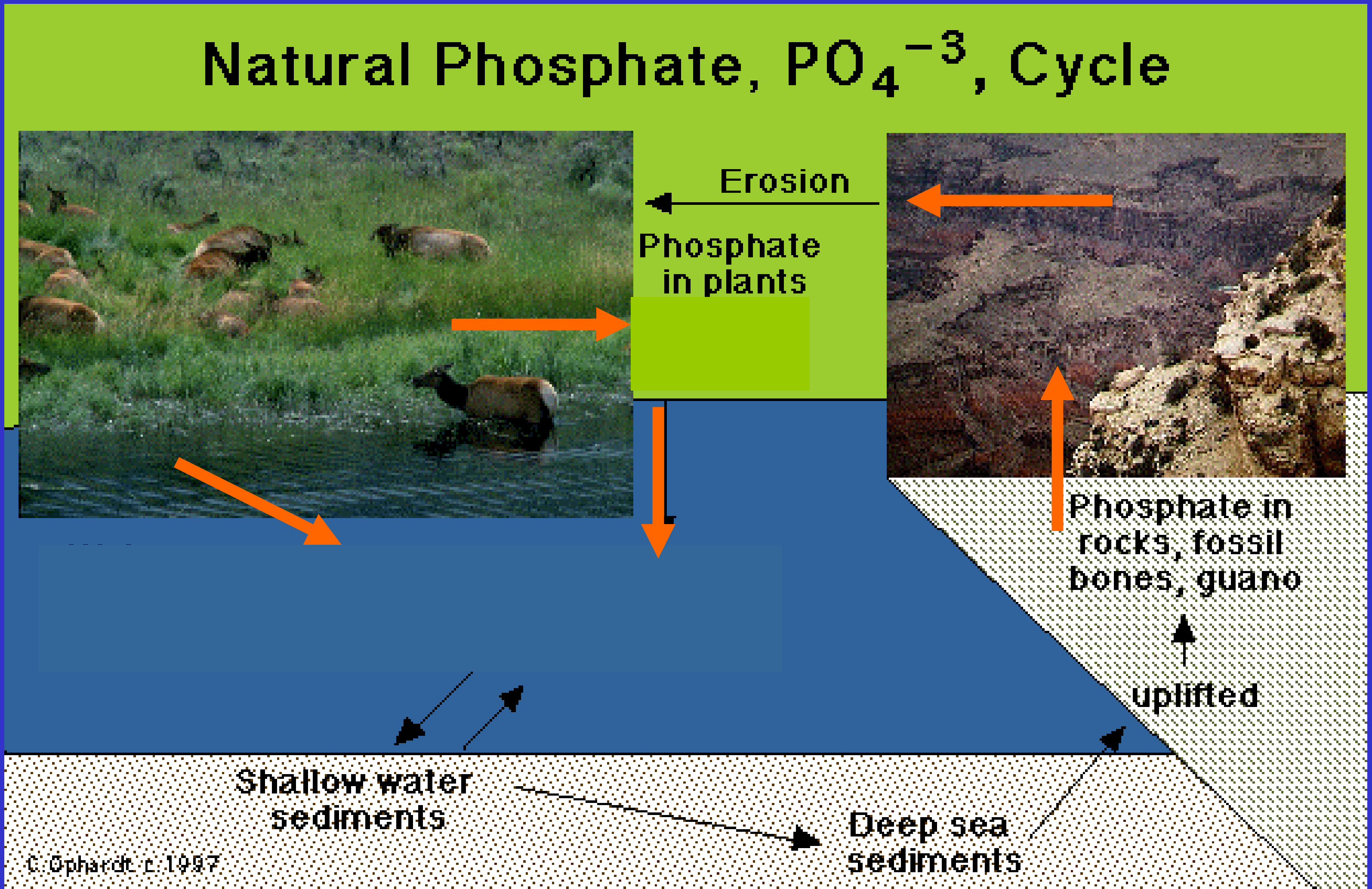
Phosphorus exists in several forms:
• Dissolved Inorganic Phosphorus (DIP),
• Dissolved Organic Phosphorus (DOP), •
• Particulate Organic Phosphorus (POP).
It is constantly changing form due to physical and biological cycles.

DIP is found in soil nutrients, DOP is found in living organisms and water, and POP is found in detritus (decaying plant and animal matter).

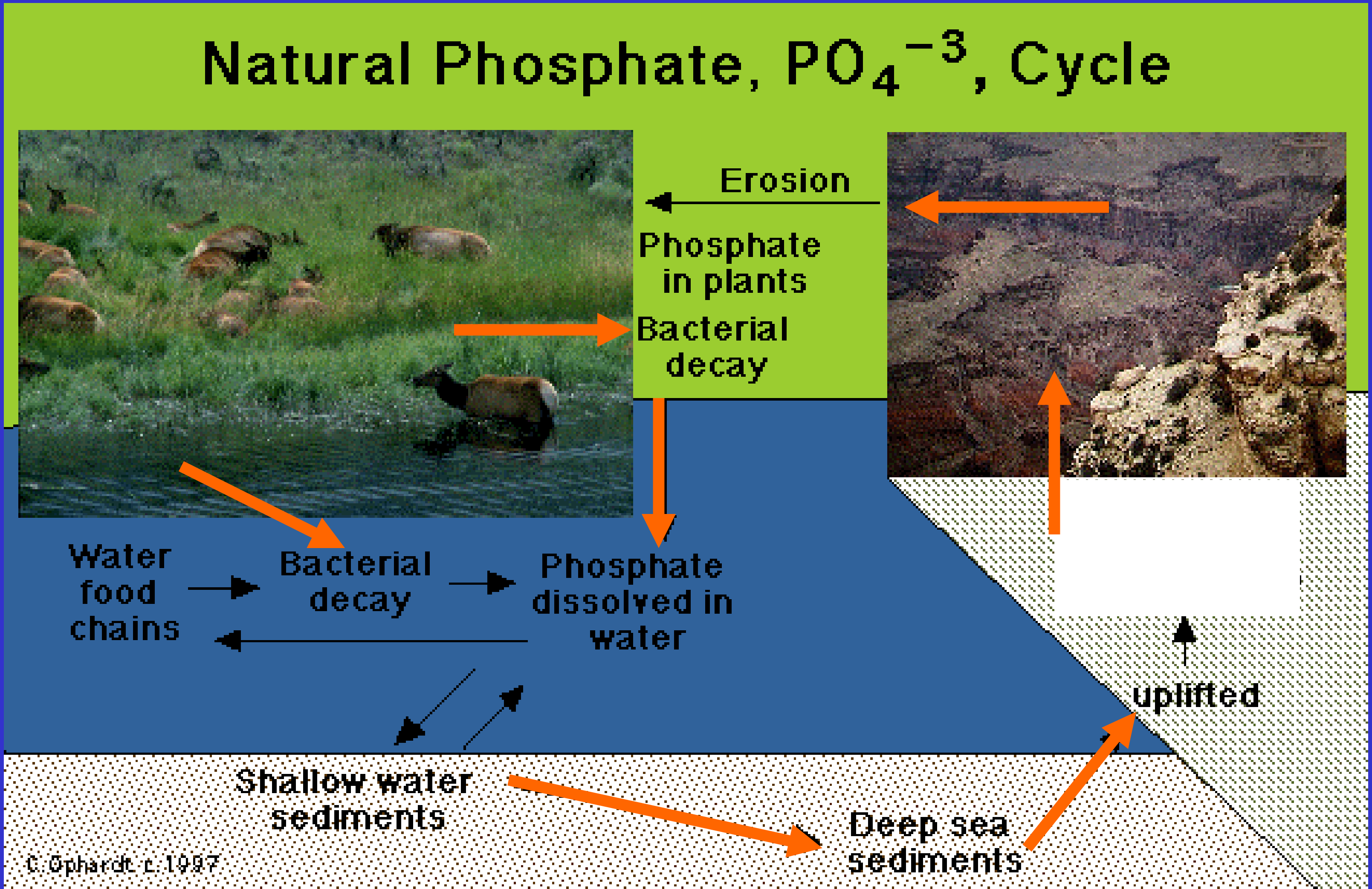
Phosphorus is released by erosion where it becomes available for plants on land and in water.



Plants and animals use the phosphate for growth and energy. When they die and decay, they release organic phosphorus.



The phosphorus settles to the bottom of lakes and oceans to become part of the rock and mineral cycle.



Phosphorus Facts

Phosphorus is an important part of DNA, RNA and the energy molecule ATP.

Plants grow poorly with too little phosphorus. Too much phosphorus results in algal blooms.

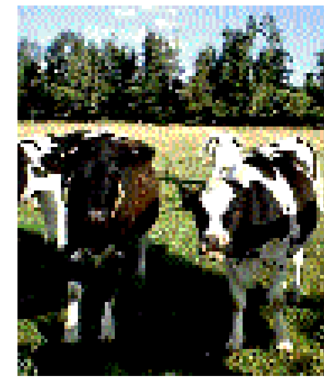
Much of the earth's phosphorus is locked deep in the ocean floor.

Excess phosphorus from fertilizer, sewage and livestock threatens water quality.

Human Influences on Phosphate Cycle

Mining Phosphate Rock

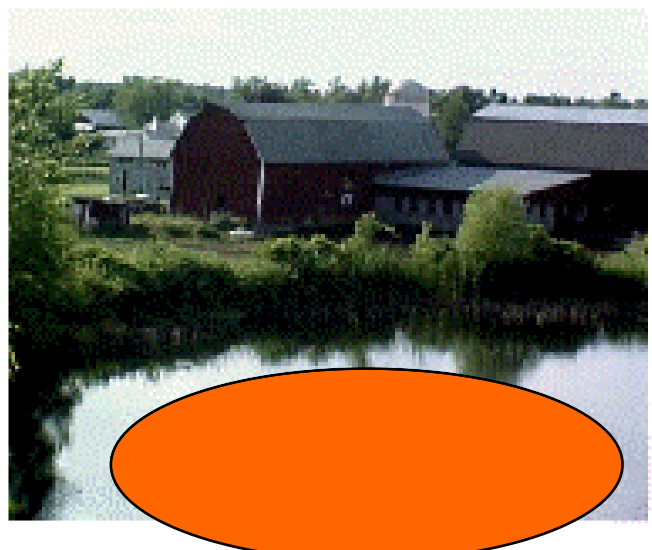
Phosphates in fertilizers



Animal Wastes

Run off and erosion

Phosphates in municipal sewage



Return to Topics

C. Ophardt c.1997

Virginia Tech Invent the Future | Virginia Cooperative Extension — A partnership of Virginia Tech and Virginia State University — www.ext.vt.edu | VIRGINIA STATE UNIVERSITY

Virginia's Most Unwanted

Invasive and Nuisance Wildlife Species

Barry Fox
Extension Specialist
4-H Marine/Aquatic Education

Issued in furtherance of Cooperative Extension work, Virginia Polytechnic Institute and State University, Virginia State University, and the U.S. Department of Agriculture cooperating. Mark McCann, Director, Virginia Cooperative Extension, Virginia Tech, Blacksburg; Alma Hobbs, Administrator, 1890 Extension Program, Virginia State, Petersburg.

What is an invasive species?

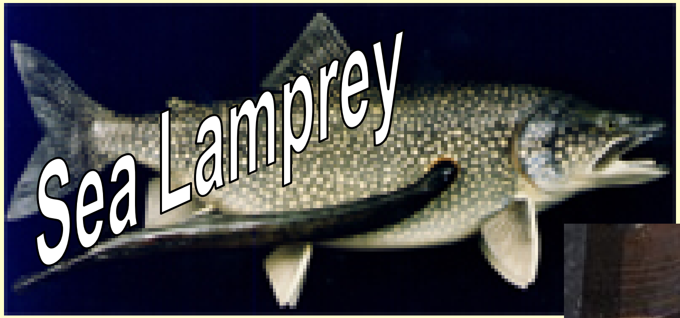
An invasive species is defined as a species that is:

1) non-native (or alien) to an ecosystem and

2) whose introduction causes economic or environmental harm or harm to human health.

Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions.

Thousands of "exotic" species have been introduced into the United States either accidentally or purposefully. Most have quietly blended into our ecosystems with little ill effect. However, some introductions have had catastrophic results.



What makes a species "invasive?"

- Lack of population controls (predators, herbivores, diseases, parasites, etc.)
- Has high reproductive or growth rate.
- Out competes other species for resources.
- Adaptable to a wide range of conditions.
- Takes advantage of disturbed habitats or open niches.

Where do invasive species come from?

- Native species expand their range due to human activity. (Common Grackle, Blue Catfish)

- Native species change behaviors due to human intervention. (resident Canada Geese)

- Foreign (exotic) species are purposefully introduced. (Kudzu, Starling, Nutria, Tree of Heaven, Autumn Olive, Mute Swan)

- Foreign (exotic) species are accidentally introduced. (Zebra Mussel, Asian Clam, Sea Lamprey, Asian Longhorn Beetle, Fire Ants)

- Foreign species escape captivity. (Tilapia, Feral Hogs, South American Killer Bees)

How are invasive species transported?

- **Ship ballast** accounts for hundreds of introduced species of invertebrates, bacteria, algae, aquatic plants and even fish.
- **Exotic pet and horticulture trade** accounts for many animal and plant introductions.
- **Hitchhikers** on/in plants, soils, wood products and other natural materials.
- **Black market** and related activities account for many introductions.
- **Weather systems** can transport aerial-born invasives.

What is the impact of invasive species?

- Alter ecosystems, particularly food webs.
- Displace native species.
- Reduce biological diversity.
- Cost billions of dollars in lost revenue annually.
- Create the need for expensive response and control programs.
- Increase threat to native “endangered” species.
- Introduce plant, wildlife and/or human diseases.
- Threaten agricultural crops and livestock.

How can invasive species be controlled?

- Use of pesticides or herbicides. (Gypsy moth, Kudzu)

- Introduction of biological controls. (Bacteria, virus, parasitic insects, herbivorous insects, etc.)

- Physical removal.

- Changes to habitat structure and/or resources.

- Interrupt reproductive cycles. (Pheromones, sterility)

- Removal of host or commensal species.

How can we cope with invasive species?

- Prevention of Additional Introductions
- Early Detection and Rapid Response
- Control/Management of Established Species
- Restoration/Recovery of Natural Ecosystems

This is a long-term process. It is probably not feasible to completely remove established populations of most invasive species. The best we can hope for is manageable control of the populations to reduce their impact on natural ecosystems and agricultural resources.

Nuisance Wildlife

Under the Code of Virginia [4 VAC 15-20-160], ten species are defined as nuisance species. These include:

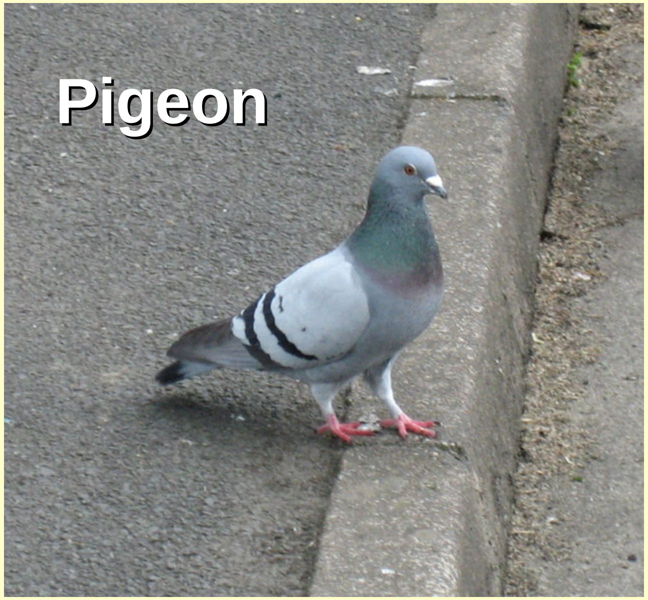

Black Rat


Coyote


Feral Hog


Groundhog


Nutria


Pigeon


Starling


House Sparrow

These species can be killed at anytime and in any manner that is legal under state and local laws. It is NOT legal to live-trap wildlife and move it to another location.

These are the only species this applies to and a permit or hunting license is required to use lethal methods on other wildlife that become a nuisance. Specific regulations can be obtained from the Virginia Department of Game and Inland Fisheries (DGIF).

Virginia Department of Game and Inland Fisheries

Canada Geese

(***Branta Canadensis***)

Canada Geese are regulated by the U.S. Fish and Wildlife Service under the guidelines set forth by the Migratory Bird Treaty Act of 1918. It is unlawful to kill, sell, hunt, disturb nests and eggs, or purchase and possess migratory birds unless permitted by the Secretary of the Interior.

An effort to establish resident populations to increase declining migratory stocks began in the 1930s. The result has been a drastic increase in resident populations in the past 25 years.

The U.S. Fish and Wildlife Service estimates the current national resident goose population at 5 million. At an average annual growth rate of 10%, within three years 1.5 million new geese will be added to the current population.

Goose Life Facts

- Life Span of up to 24 years.
- Average nest size: 3 to 6 eggs, up to 12.
- An adult goose eats up to 4 lbs of grass daily.
- An adult goose drops 2 lbs of fecal matter daily.
- Fecal matter carries diseases and bacteria.
- Population increases 10 to 17% annually.

Control Methods

- **Altering habitat**
- **Fencing**
- **Use of frightening and harassing techniques***
- **Live-trapping and removal***
- **Population reduction through lethal control methods***

***Require state and federal permits**

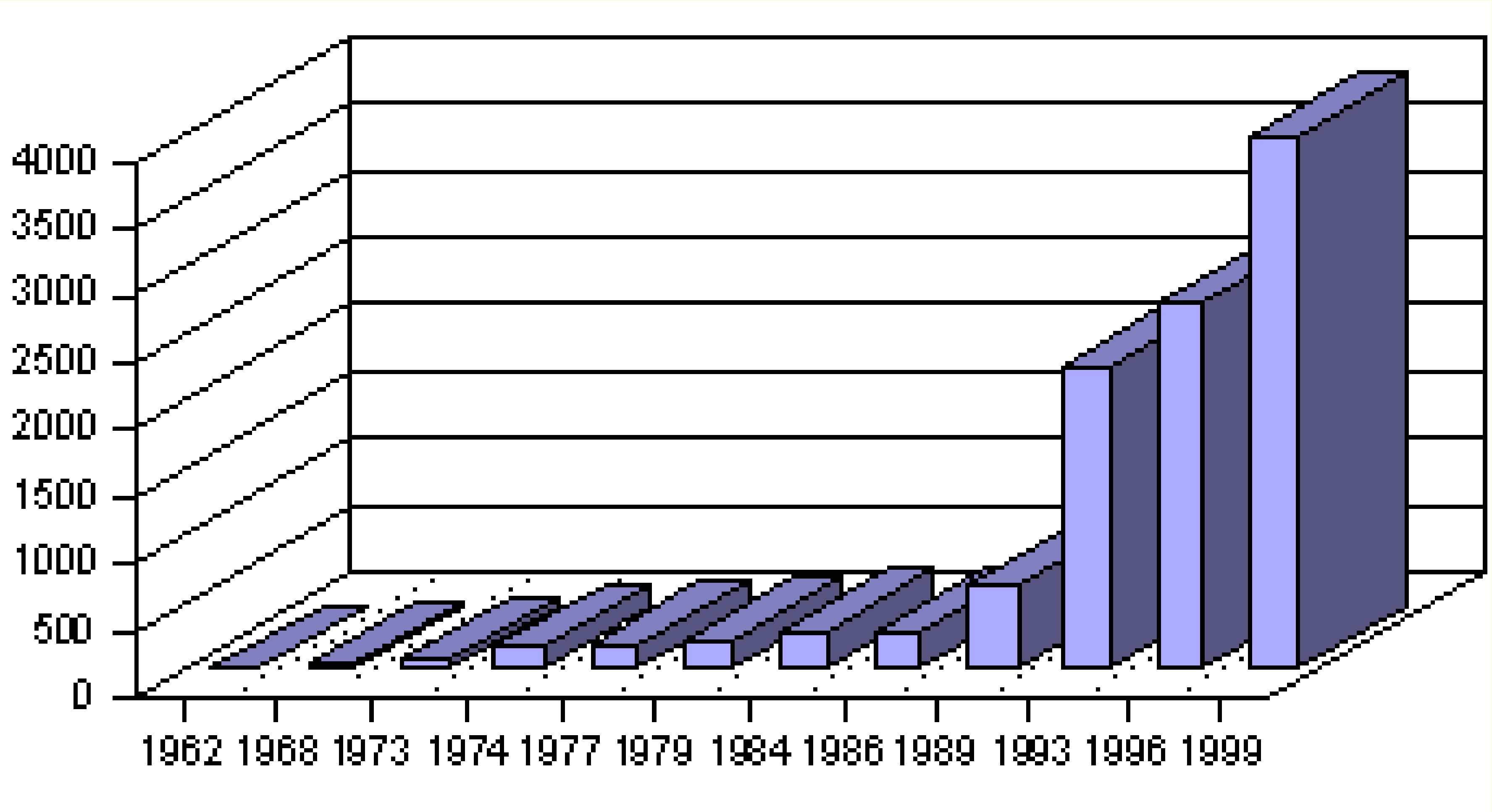
However, there are a number of animal-rights groups who are against controlling resident goose population.

Mute Swan

(*Cygnus olor*)

Description:

- **Large (60-inch wing span), white waterfowl**
- **Orange bill with black base**
- **Holds neck in an "S" shape when relaxed**
- **This is a highly aggressive species that readily displaces native waterfowl.**



Mute Swan Population Increase in Maryland

Mute swans do not fall under federal migratory waterfowl regulations. Control methods require a state DGIF permit.

Similar Species

Non-invasive

Snow Goose – much smaller, reddish bill, black wing-tips

Tundra swan – smaller with distinct black bill

NUTRIA, COYPU

(*Myocastor coypus*)

The Nutria was introduced into North America in the late 1890s for the fur trade. When the fur market did not materialize, captive animals were released and rapidly invaded Louisiana and Texas marshes.

Description: The nutria is a large aquatic mammal reaching two feet in length and 20 pounds in weight. It is light to dark brown in color with a long, round tail.

Similar Species

- **Muskrat** – smaller, dark brown, vertically flattened tail
- **Beaver** – much larger with broad flat tail

Today the animal is found in 40 states. It was introduced into the Chesapeake Bay region in the 1940s.

Impacts

- Destruction of wetlands through burrowing and feeding activities
- Reduction of wetland plant species
- Reduction of native muskrat habitat

Blackwater National Wildlife Refuge

Aerial photographs of nutria damage to wetlands.

1939

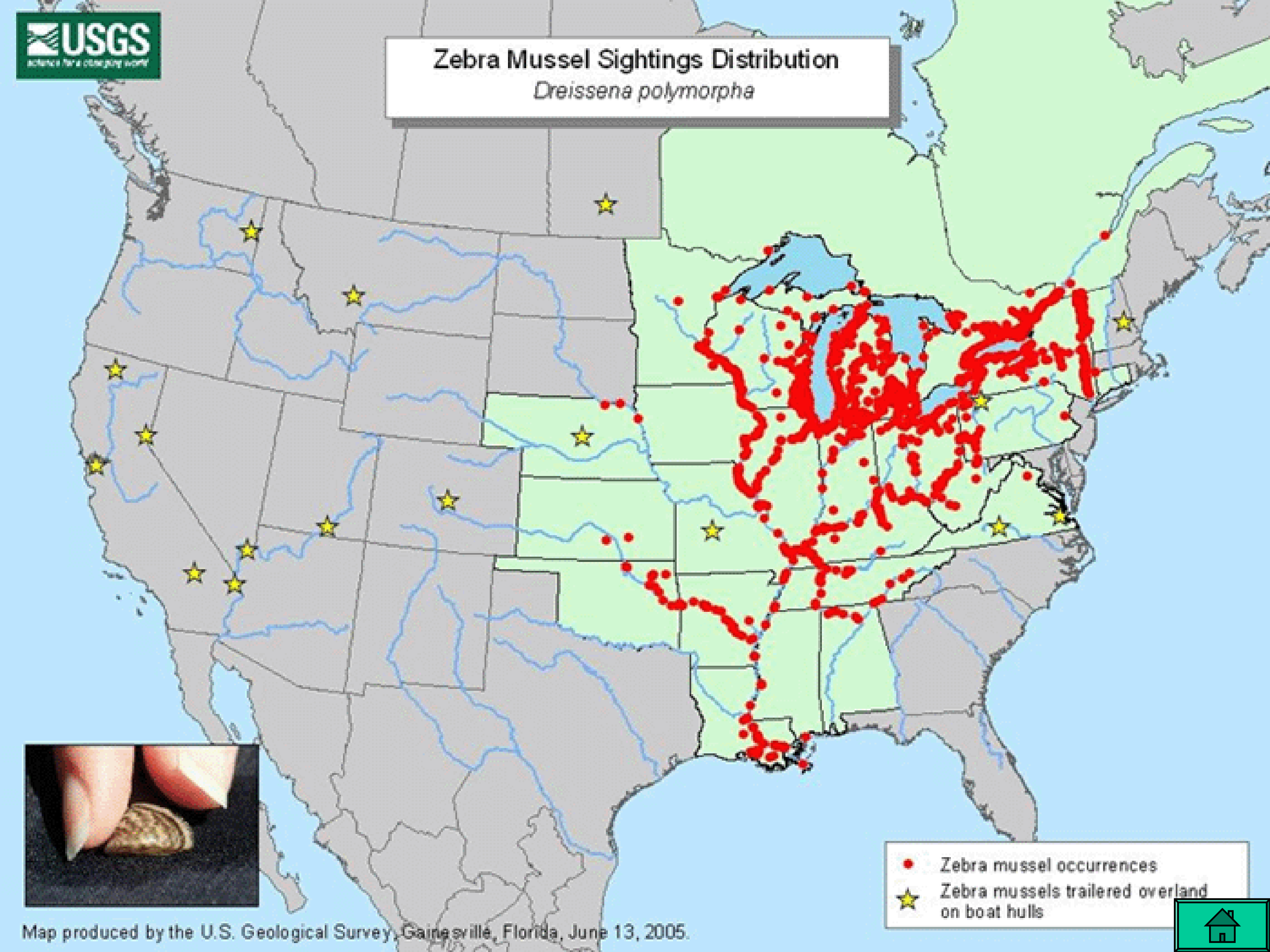
1989

Zebra Mussel

(Dreissena polymorpha)

- **Freshwater bivalve**
- **Alternating light and dark bands**
- **Average shell length 1.5 cm (up to 6 cm)**
- **Attaches to hard substrates**
- **Mature females can produce one million eggs per year**

- **Origin – Caspian Sea**
- **Spread throughout Europe during the 1800s**
- **Transported by ship ballast**
- **Currently distributed throughout the Great Lakes and Mississippi Drainage in 21 states**
- **Currently invading the upper Susquehanna leading into the Chesapeake Bay**


USGS
science for a changing world
Zebra Mussel Sightings Distribution
Dreissena polymorpha
Zebra mussel occurrences
Zebra mussels trailered overland on boat hulls
Map produced by the U.S. Geological Survey, Gainesville, Florida, June 13, 2005.

Impacts:

• Filter feeding activity reduces available food resources for native wildlife

• Increases water clarity encouraging plant and algae growth

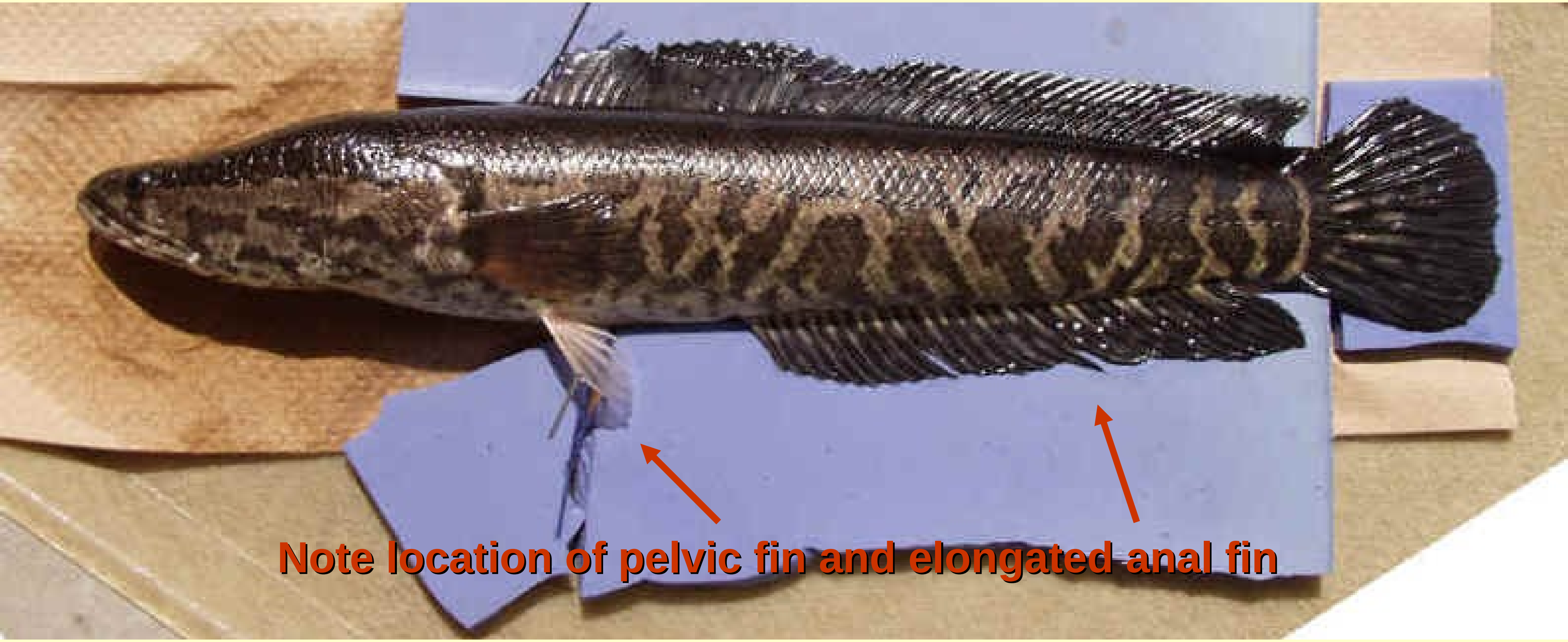
• Competes with native organisms

- Fouls beaches with shells and decaying organisms
- Fouls boats
- Clogs water and sewer pipes
- Costly removal and control

Any sightings of Zebra Mussel should be reported to the Virginia DGIF.

Northern Snakehead

(Channa argus)

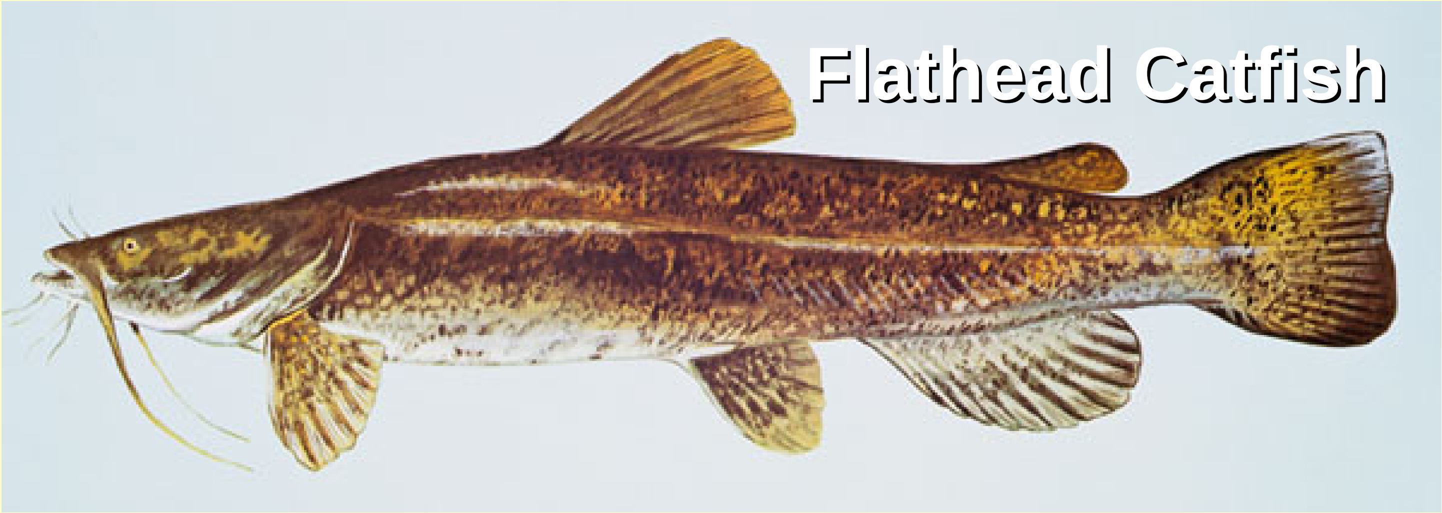


This voracious fish grows to 30 inches and can survive in stagnant ponds and swamps. It was first reported in Maryland in 2002. Breeding populations are established in the Potomac River.

The Snakehead looks similar to our native Bowfin. Note the difference in fin structure and location. Both have formidable teeth and jaws. Be careful when handling either. Report any Snakehead catches to the VA DGIF.

Fish you should love to learn to hate.

This fish has been stocked in the Rappahannock and James and other waters. It can reach 100 pounds and five feet in length. It is severely impacting native fish populations. Live fish should not be relocated.



This fish has been stocked in the James, Roanoke and New Rivers and other waters. It reaches more than 50 pounds and can have a detrimental effect on native fish populations. Live fish should not be relocated.

Be on the lookout for:

Rapa Welk

This is a large marine mollusk that threatens native shellfish. Report sightings to the Virginia Institute of Marine Science.

Round Goby

This is a large freshwater goby established in the Great Lakes. It feeds on fish eggs. Report sightings to the VA DGIF.

Asian Longhorn Beetle

In the northeast, the beetle has been attacking maple (*Acer*) species, including Norway, red, sugar, silver, boxelder and sycamore maple. Horsechestnut, elms, poplars, willows and fruit trees have also been heavily attacked.

Male

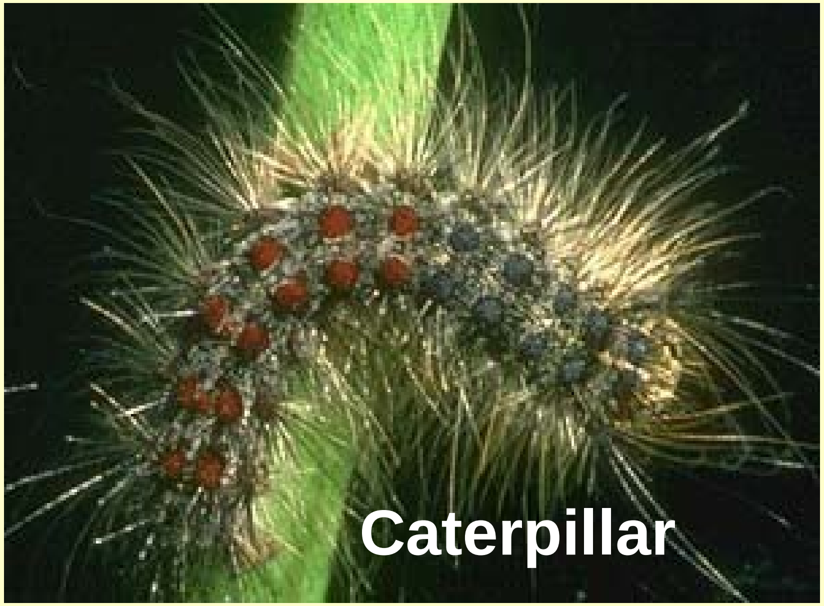
Female

The insect probably arrived in pallets made overseas. It is important to limit its spread because it may become a significant tree pest here. The only control currently available is cutting infected trees plus those in a buffer area.

Sawdust from beetles leaving an infected tree.

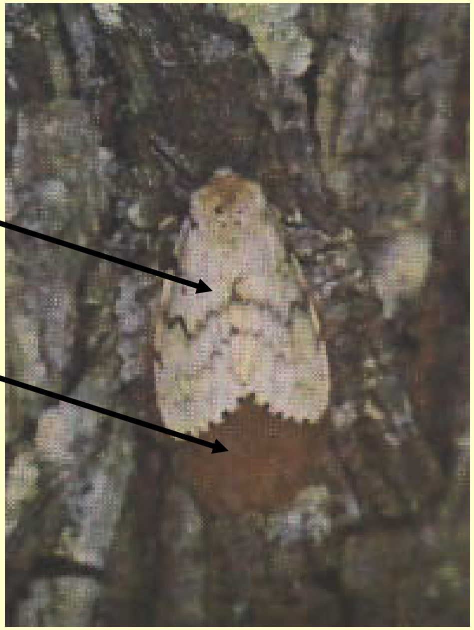
Gypsy Moth

This insect was introduced in New Jersey in the late 1880s from imported trees. It prefers oaks and aspens but will feed on most other plant species. Outbreaks are cyclic and often extend its range.

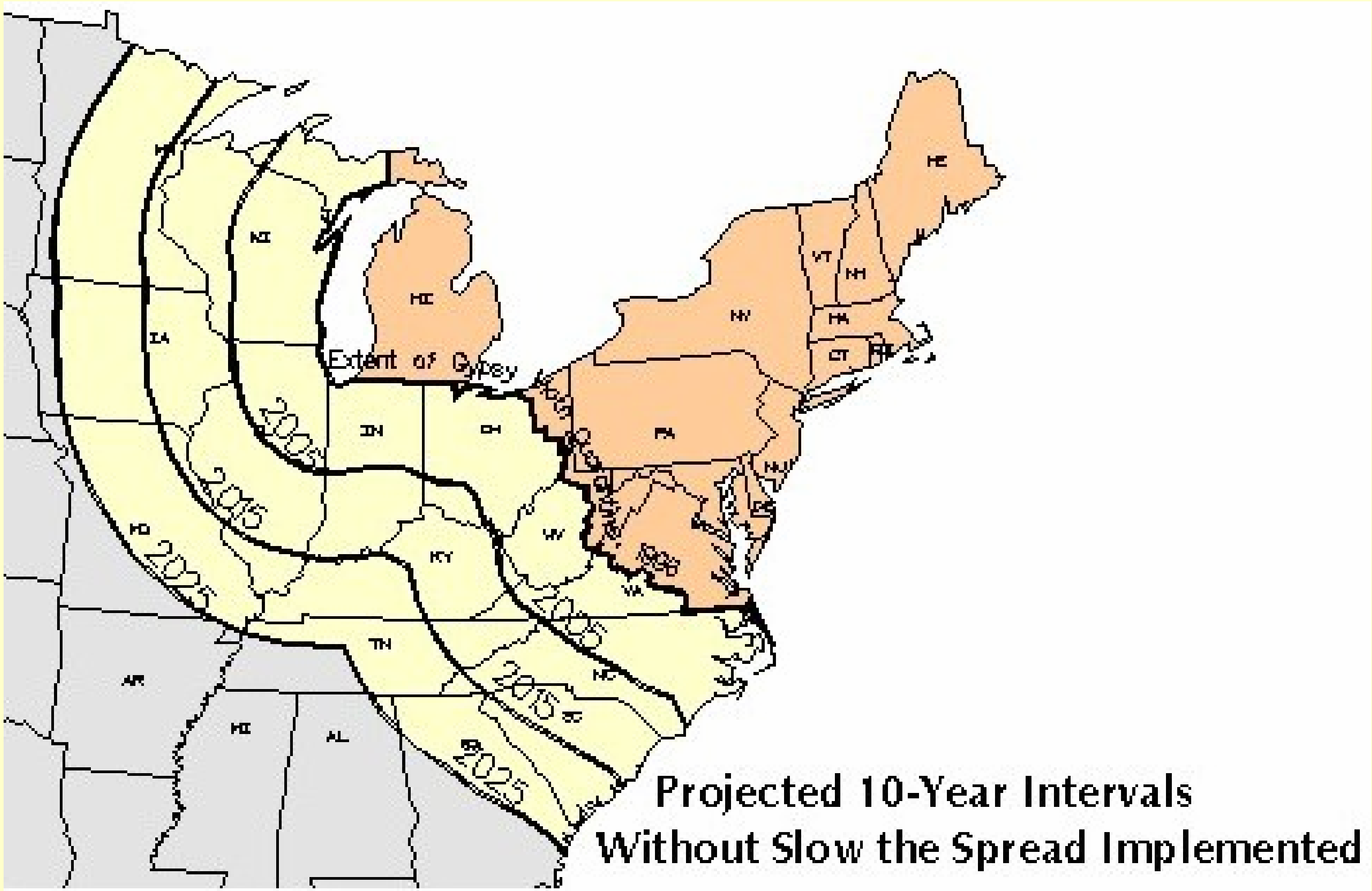


Adult

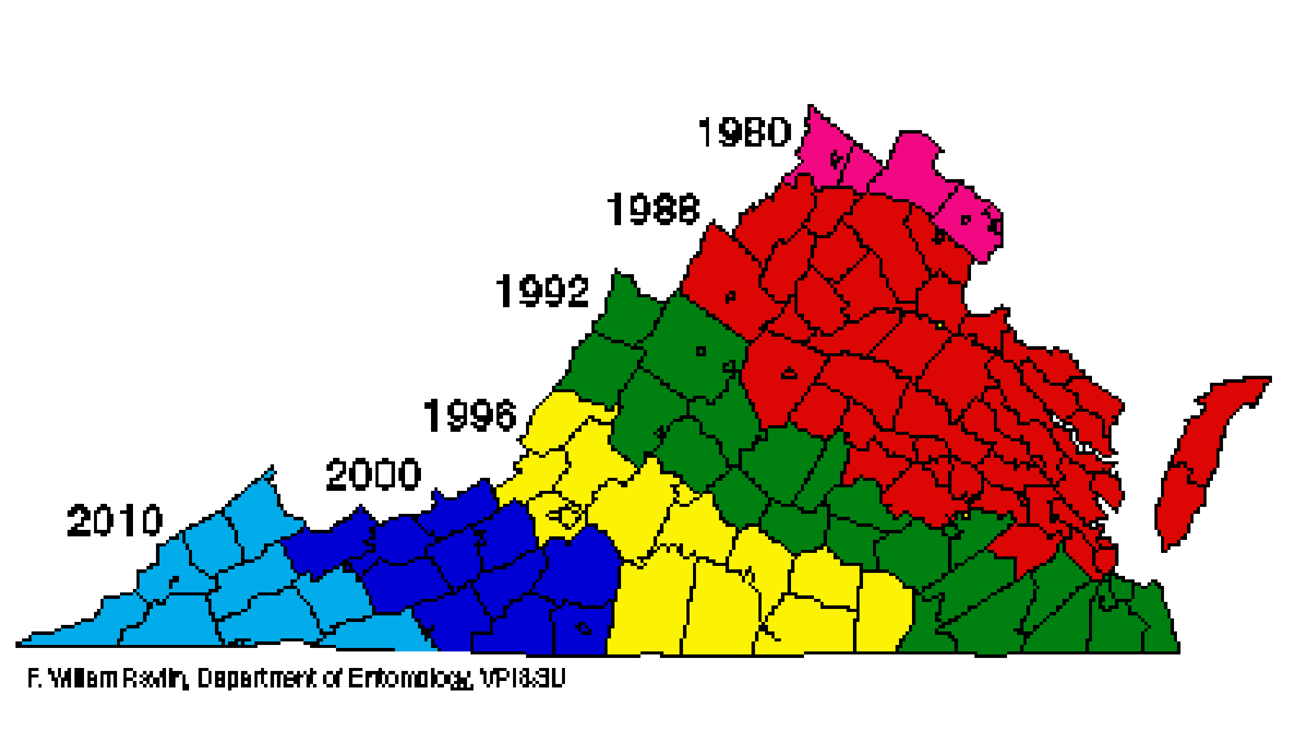
Egg Mass



Distribution of this pest is expanding. Current controls include pesticide spraying, use of *Bacillus thuringiensis* bacteria, pheromone traps, sterile insect releases and host removal.



Gypsy moth defoliation in the United States approaches two million acres each year. In Virginia, defoliation began in 1984 with 374 acres. In 1992, almost 800,000 acres were defoliated and over a million acres during a single growing season in 2000. By 2010, virtually every county in Virginia will experience some level of gypsy moth impact.

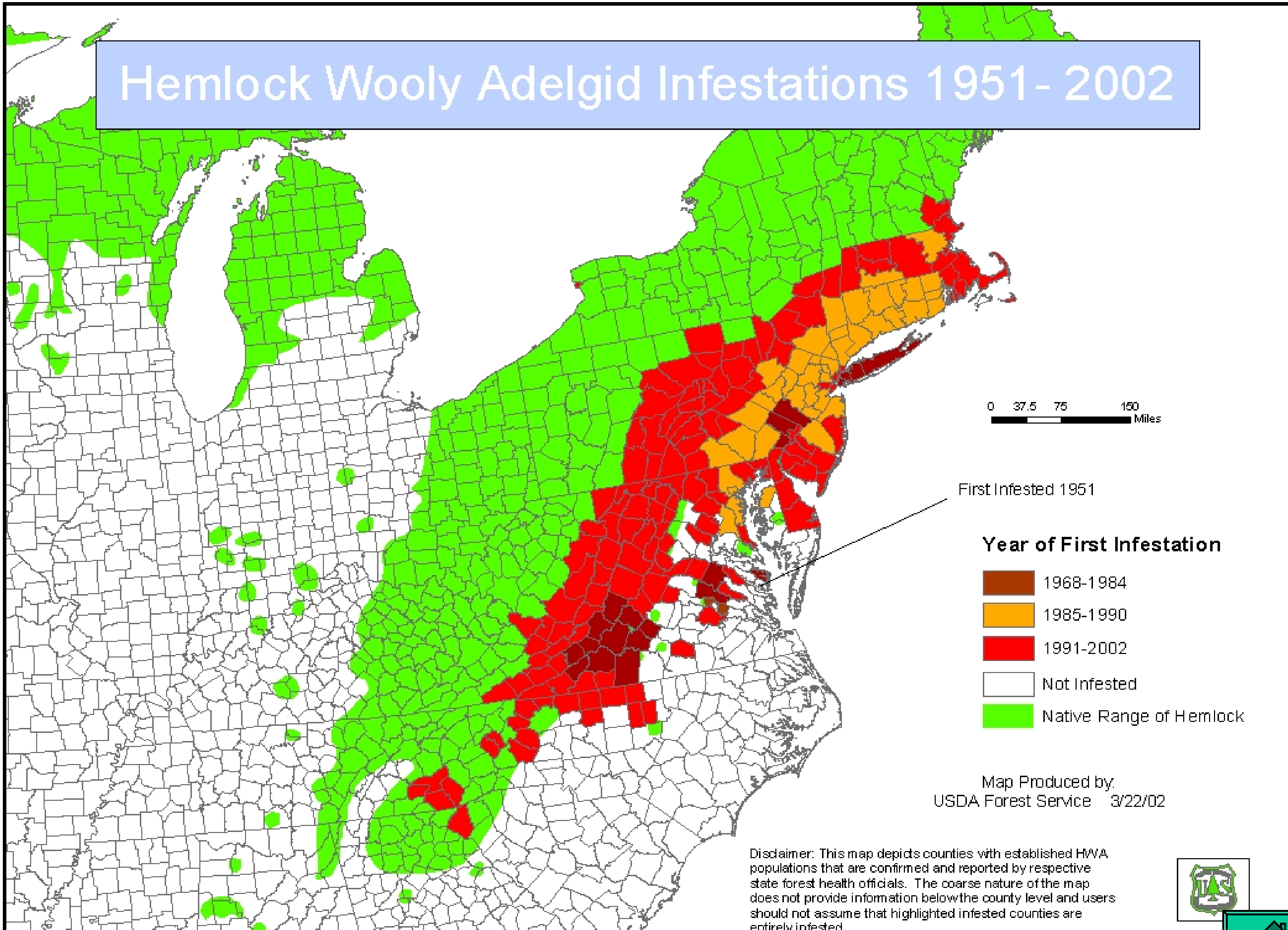


Wooly Adelgid

The hemlock woolly adelgid, *Adelges tsugae*, has been in the United States since 1924. This Asian introduction is a serious pest of eastern hemlock and Carolina hemlock. It is present from the Smoky Mountains, north to the mid-Hudson River Valley and southern New England.

White cottony sacs of the base of the needles are good evidence of a hemlock woolly adelgid infestation. These sacs resemble the tips of cotton swabs. They are present throughout the year, but are most prominent in early spring.

There is no effective control available. Biological and chemical controls are being tested.


Hemlock Wooly Adelgid Infestations 1951- 2002
0 37.5 75 150 Miles
First Infested 1951
Year of First Infestation
1968-1984
1985-1990
1991-2002
Not Infested
Native Range of Hemlock
Map Produced by:
USDA Forest Service 3/22/02
Disclaimer: This map depicts counties with established HWA populations that are confirmed and reported by respective state forest health officials. The coarse nature of the map does not provide information below the county level and users should not assume that highlighted infested counties are entirely infested.

Conclusion

Invasive species are a global problem. The rapid increase in world trade and transportation makes it much easier for species to be translocated. Once a species finds itself in a habitat where it lacks competition or other population controls, it then has the potential to become invasive.

What can you do?

- Stay current on invasive species issues in your community.
- Be observant and report any sightings.
- Use effective, legal controls where possible.
- Use native plants when landscaping.
- Work to improve native wildlife habitat.
- Educate others about invasive species.

WEB Resources - Invasive Species

Invasive Species in the Chesapeake Bay Watershed

Gypsy Moth in Virginia

Invasive Species

Federal Government Invasive Species Web Site

National Biological Information Interface on Invasive Species

Union of Concerned Scientists

100 “worst” invasive species

Return to Topics

Return to Game

Personal Action

Asian oyster backers seek first test in open waters

Rain Forest Damage Much Worse Than Thought

European Union Must Do More To Fight Climate Change

Shenandoah River fish kills have attention, need action

Invasive Plant and Animal Species Threaten to Crowd Out State's Native Life Forms

All this bad news about the environment makes it difficult to think that each of us can make a difference. But we CAN!

If each person does their part in protecting and conserving natural resources, it would add up to a lot.

Students Create Wetland Habitat On School Grounds

More Retailers Building Environmentally Friendly Stores

Scientists Draft Blueprint To Protect World Oceans

Virginia Healthy Rivers Coalition seeks $2.3 billion

Teacher's Yard Doubles As Habitat Oasis

Wal-Mart Launches Environmental Drive To Cut Energy Use, Waste

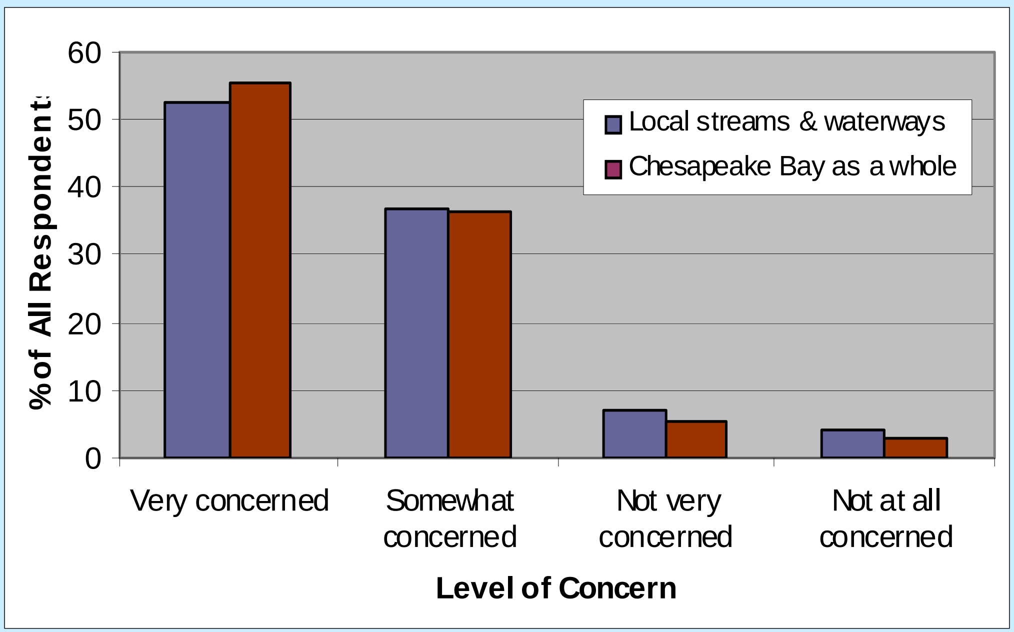
Push Begins For Cleaner Waters

Most people are concerned about the environment and want to do things to protect our natural resources.

Perceptions of Bay Watershed Residents

Water Quality

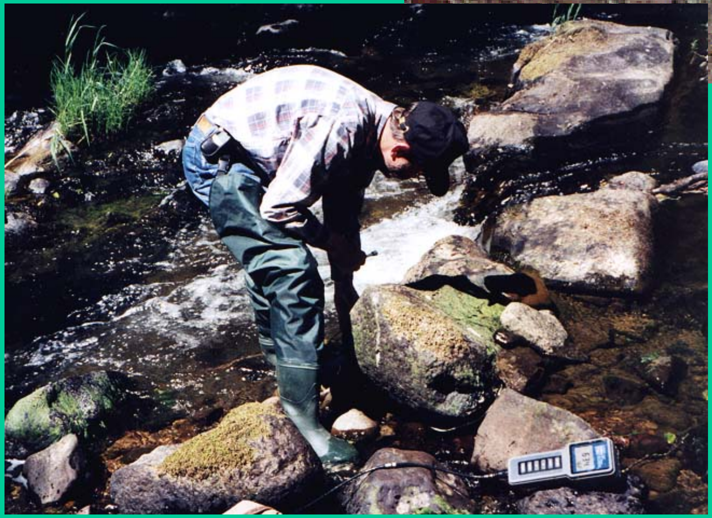
? How concerned are you with the quality of local streams and waterways? Chesapeake Bay as a whole?



Source: "A Survey of Knowledge, Attitudes and Behaviors Towards Chesapeake Bay Watershed Water Quality Issues." Chesapeake Bay Program, 2002.

This presentation will help you learn about actions that “make a difference.”

There are many community groups that are already working to improve and protect the environment.



There are many sources of information and assistance that can help you select, plan and conduct an environmental improvement project.

Give Water A Hand

COMMUNITY
SCHOOL
FARM
HOME

Welcome to the
Water Conservation Coalition

No project is too small if it helps you do your part. So let's get started.

Do you know what threatens the waterways in your community?

Is it point source pollution?

Is it non-point source pollution?

What can you do to help protect and conserve water resources? **Plenty!**

The projects shown below are rewarding and will help the environment.

You can:

Build a rain garden

Plant a tree.

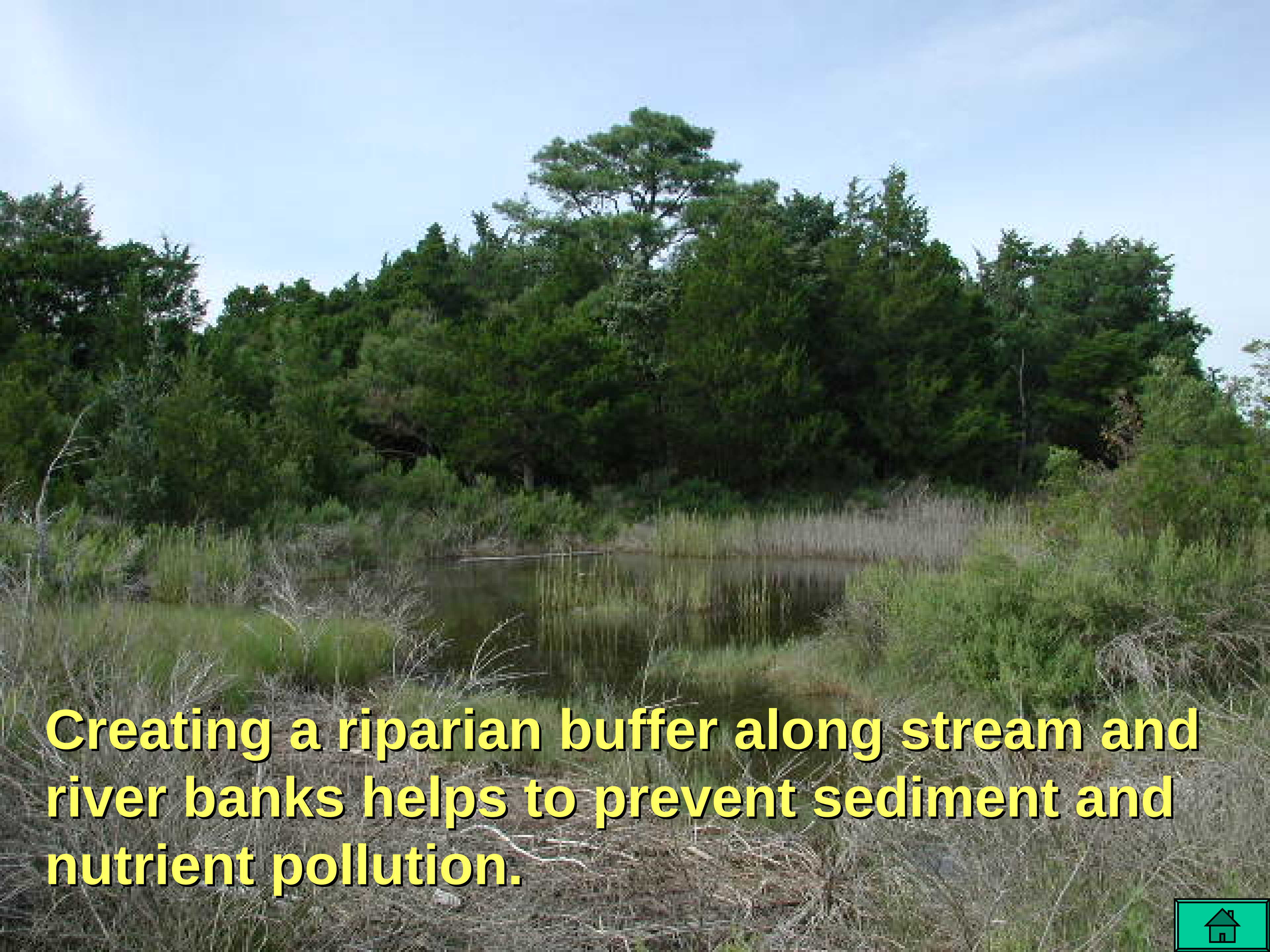
Build a wildlife habitat.

Plant Trees

Prevent pollution from entering waterways by planting trees, especially along streams and shorelines.

Why plant trees? Trees:

- **Reduce erosion.**
- **Provide wildlife habitat, shade and keep waterways cooler.**
- **Trap carbon dioxide.**

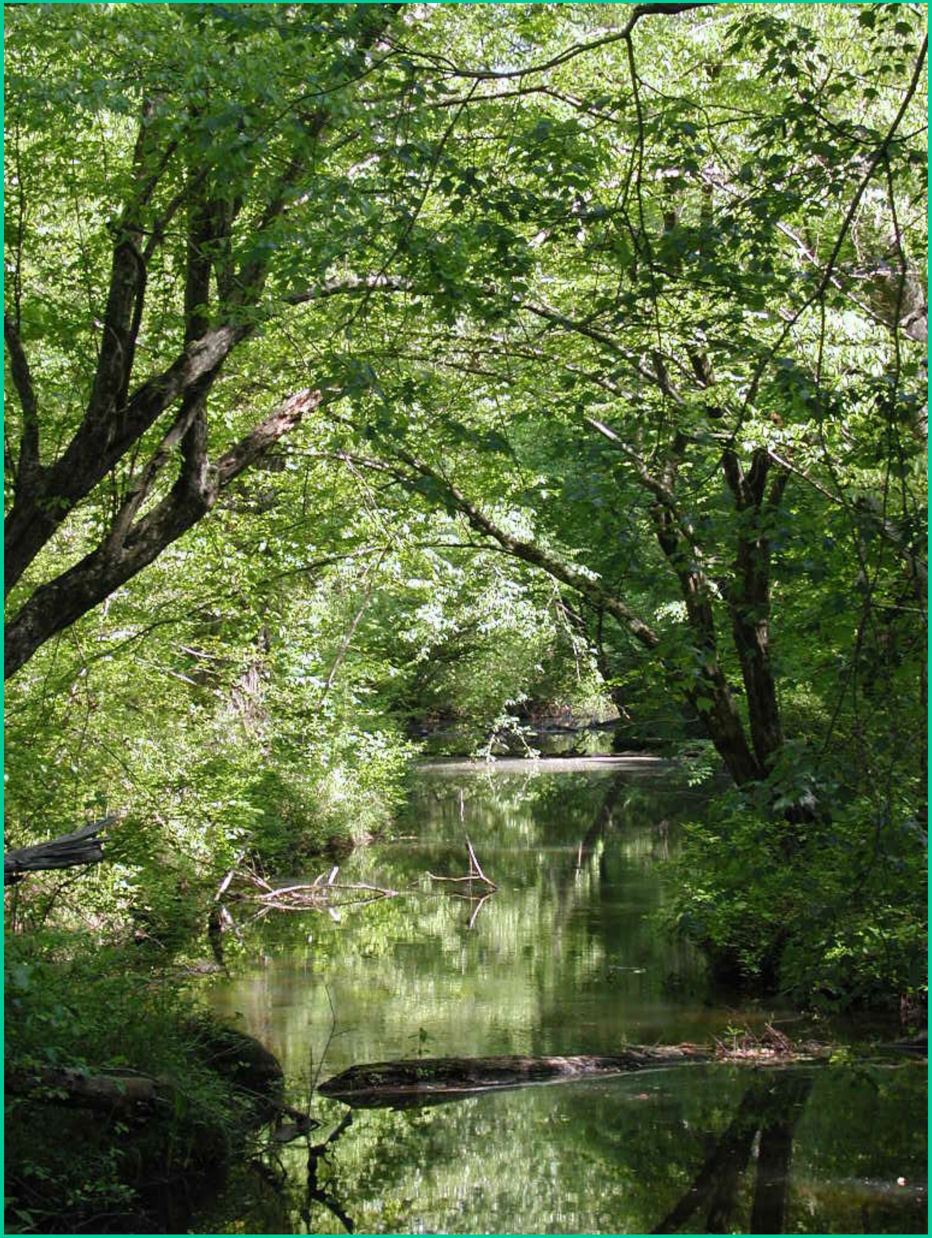

Creating a riparian buffer along stream and river banks helps to prevent sediment and nutrient pollution.

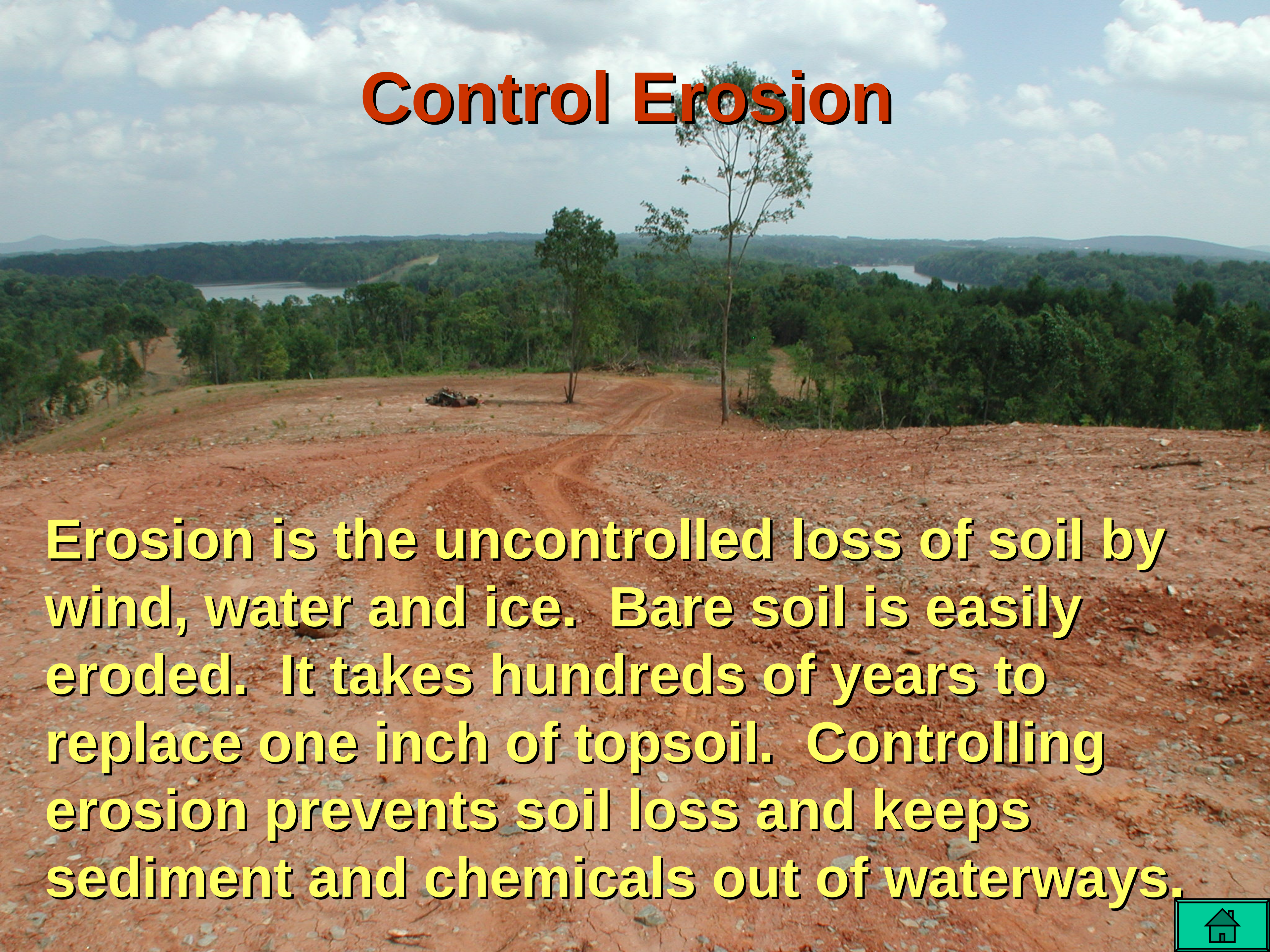
For more information about trees, go to:

Virtual Forest

Tree Identification

Tree Planting Guide




Control Erosion
Erosion is the uncontrolled loss of soil by wind, water and ice. Bare soil is easily eroded. It takes hundreds of years to replace one inch of topsoil. Controlling erosion prevents soil loss and keeps sediment and chemicals out of waterways.

To control erosion:

Plant shrubs and trees to protect soil.

Plant grass. Cover soil with straw until grass is established

Mulch bare soil areas.

Construct water diversion structures to slow or redirect flowing water.

Plant native vegetation that requires less water and chemicals.

Learn about selecting native plants.

Virginia Native Plants

Limit Fertilizer Use

Learn about good gardening and lawn care practices.

Learn more about soil nutrients.

Use Chemicals Properly and Safely

Learn about yard and garden chemical safety.

THE WRONG WAY

THE RIGHT WAY

Dispose of Hazardous Wastes Properly

Take them to a collection site.

Recycle or use up chemicals.

Learn more about handling, storing and recycling household hazardous wastes

Conserve Electricity and Fossil Fuels

Conserving energy and fuel helps protect water quality. Less pollution is generated and less resources are consumed. It also saves money and reduces our need for foreign oil.

Twenty ways to conserve energy around your home.

Play the energy-hog game.

Prevent Pollution By Reducing, Reusing and Recycling

Virginia is the second largest importer of trash in the nation. More than 15 private, regional landfills require at least 2000 tons each day to provide income from tipping fees. Do your part to reduce the amount of trash we generate.

Home and Farm Environmental Survey

Go to this site to learn how to survey your farm and home for environmental hazards and pollution sources.

Farm*A*Syst Home*A*Syst

Farm*A*Syst

http://www.uwex.edu/farmasyst

If you are interested in farm environmental management, click here.

Home*A*Syst

http://www.uwex.edu/homeasyst

If you are interested in environmental and health issues in and around the home, click here.

Farm*A*Syst/Home*A*Syst
303 Hiram Smith Hall
1545 Observatory Drive
Madison, WI 53706-1289
608-262-0024

farmasys@uwex.edu
homeasyst@uwex.edu
Web Coordinator

To Learn more about protecting and conserving water resources, go to:

Give Water A Hand Action Guide **- Learn how to identify and correct water pollution sources around your home, school and community.**

Story of Drinking Water **- Learn about the characteristics of water and how it is managed as a valuable resource.**

Mr. Leaky Game **- Visit Mr. Leaky's house and discover how to conserve water and protect this valuable resource.**

H2O University **- Discover fun science, history and geography facts about water.**

100 Ways to Save Water - Discover many quick and easy ways you, your neighbors and friends can help conserve water in your community.

National Geographic - Play games, learn about habitats and what you can do to protect our natural resources.

Planet PA

Discover exciting things about the environment and what you can do to help protect our planet.

Join a local “Friends of the River” group. Get involved in community action. The following are links to some of Virginia’s river organizations:

Alliance for the Chesapeake Bay

Chesapeake Bay Foundation

Virginia Save Our Streams

Clean Virginia Waterways

James River Association

The Friends of:

The Shenandoah River

The Rappahannock River

The New River

The North Fork of the Shenandoah River

Get involved with community groups and watershed organizations to help protect our water resources.

WATERSHED WATCH

We're all in it together!

Correlation to the Virginia Standards of Learning (January 2003 version)

6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems.
a) The health of ecosystems and the abiotic factors of a watershed;
b) The location and structure of Virginia's regional watershed systems;
c) Divides, tributaries, river systems, and river and stream processes;
d) Wetlands;
e) Estuaries;
f) Major conservation, health, and safety issues associated with watersheds; and
g) Water monitoring and analysis using field equipment including hand-held technology.

6.9 The student will investigate and understand public policy decisions relating to the environment.
a) Management of renewable resources (water, air, soil, plant life, animal life);
b) Management of nonrenewable resources (coal, oil, natural gas, nuclear power, mineral resources);
c) The mitigation of land-use and environmental hazards through preventive measures; and
d) Cost/benefit tradeoffs in conservation policies.

LS.6 The student will investigate and understand the basic physical and chemical processes of photosynthesis and its importance to plant and animal life.
a) Energy transfer between sunlight and chlorophyll;
b) Transformation of water and carbon dioxide into sugar and oxygen; and
c) Photosynthesis as the foundation of virtually all food webs.

LS.7 The student will investigate/understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment.
a) The carbon, water, and nitrogen cycles;
b) Interactions resulting in a flow of energy and matter throughout the system;
c) Complex relationships within terrestrial, freshwater, and marine ecosystems; and
d) Energy flow in food webs and energy pyramids.

LS.11 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time (daily, seasonal, and long term).
c) Eutrophication, climate changes, and catastrophic disturbances.

LS.12 The student will investigate and understand the relationships between ecosystem dynamics and human activity.
d) Population disturbances and factors that threaten or enhance species survival; and
e) Environmental issues (water supply, air quality, energy production, and waste management).

ES.7 The student will investigate and understand the differences between renewable and nonrenewable resources.
c) Resources found in Virginia;
d) Making informed judgments related to resource use and its effects on Earth systems; and
e) Environmental costs and benefits.

ES.9 The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans.
b) Development of karst topography;
d) Identification of other sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle;
e) Dependence on freshwater resources and the effects of human usage on water quality; and
f) Identification of the major watershed systems in Virginia including the Chesapeake Bay and its tributaries.

BIO.3 The student will investigate and understand the chemical and biochemical principles essential for life.
a) Water chemistry and its impact on life processes;
b) The structure and function of macromolecules; and
d) The capture, storage, transformation, and flow of energy through the processes of photosynthesis and respiration.

CH.4 The student will investigate and understand that quantities in a chemical reaction are based on molar relationships.
e) Solution concentrations;
f) Chemical equilibrium; and
g) Acid/base theory: strong electrolytes, weak electrolytes, and non-electrolytes; dissociation and ionization; pH and pOH.

Puzzle Games
Water Quality Indicators

(pH, Hardness, Alkalinity, Dissolved Oxygen, Nitrogen, Phosphate)

- Copy a puzzle on card stock or glue paper to a heavier stock.
- Cut along the solid lines.
- Mix the pieces.
- Challenge students to reform the puzzle while learning about the indicator.

Ranges from

0 – 14

Power of the

Hydrogen

7 is

Neutral

<7 = Acid

pH

>7 = Base

Connected to

the CO_2 Cycle

A Negative

Log

A Small

Change

Affects Organisms

Measure of

Ca and Mg

Causes

Sink Stains

High in

Limestone Country

0 - 75 ppm

Soft Water

HARDNESS

>75 ppm

Hard Water

Affects How

Soaps Work

Can Clog

Water Pipes

Often Equals

Alkalinity

Neutralizes Acids

Creates the Buffer System

Carbonates & Bicarbonates

Often Equals Hardness

ALKALINITY

>75 ppm is Good

Acts Like a Rolaid

Low in Acidic Water

The Source is Limestone

Ranges From

0 - 15 ppm

Involves

Photosynthesis &

Diffusion

< 5ppm

Is Not

Good

Reduced by

Excess

Nutrients

DISSOLVED OXYGEN

Reduced

By High

Temperature

Coldwater Animals

Require More

Biological and

Chemical

Demands

Reduced by

Sediment

Water Soluble Nutrient

< 2 ppm is Good

Primary Plant Nutrient

NITROGEN

Product of Ammonia

Important in Proteins

80% of the Atmosphere

Clover Fixes It

High in many Fertilizers

Not Water Soluble

Adheres to Soil

Important in Energy Transfer

<0.5 ppm is Good

PHOSPHATE

Important in Root Growth

Detergent Ban Reduced Pollution

Chickens & Pigs Produce A Lot

Mining Releases Fluoride