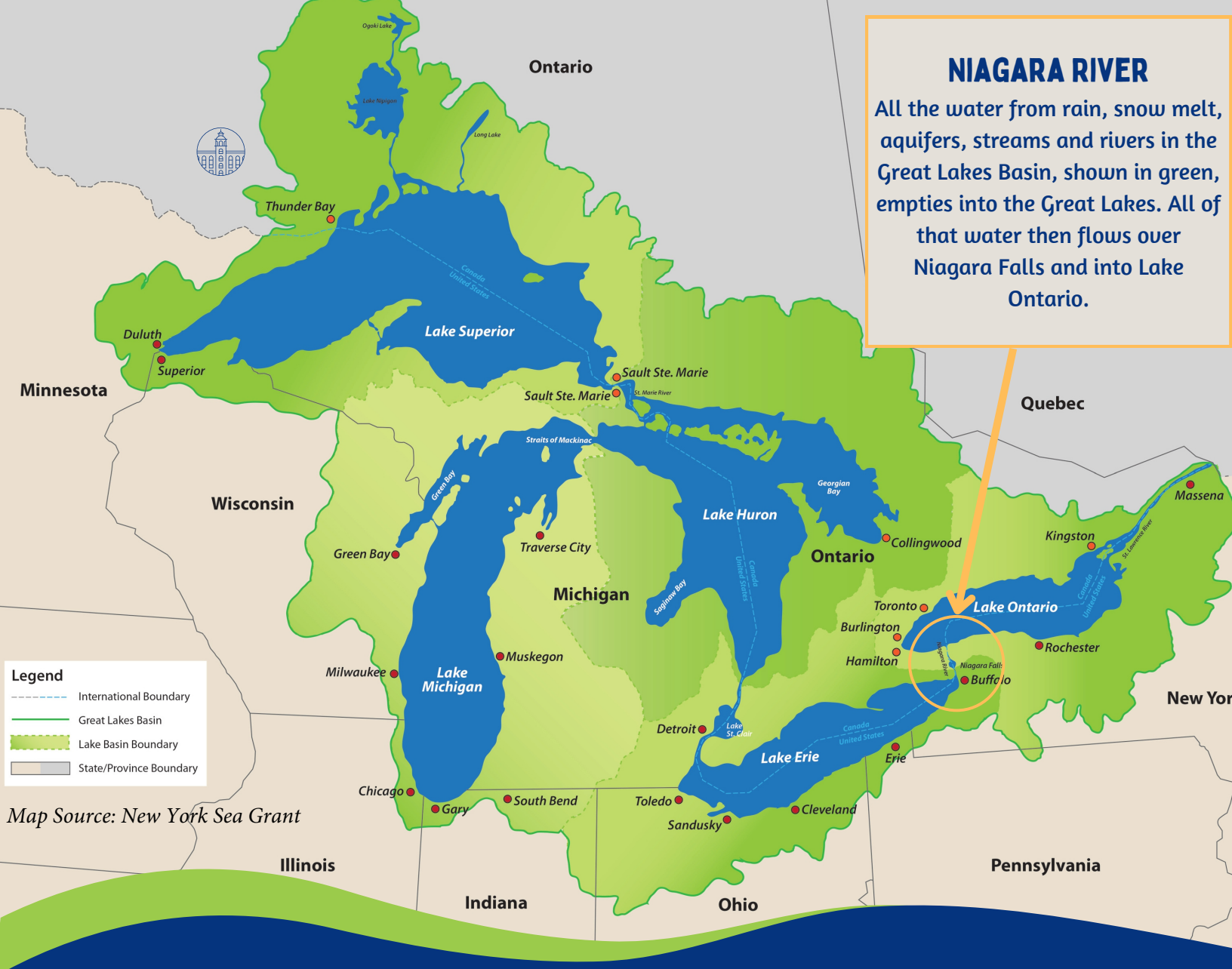
Youth Stewardship in the Niagara River Greenway

Middle and High School Lesson Series

Working together to protect and restore our environment!



Map Source: New York Sea Grant

NIAGARA RIVER

All the water from rain, snow melt, aquifers, streams and rivers in the Great Lakes Basin, shown in green, empties into the Great Lakes. All of that water then flows over Niagara Falls and into Lake Ontario.

WHY DOES THE NIAGARA RIVER MATTER TO YOU?

- The Great Lakes is the world's largest surface fresh water system, supplying over 30 million people in the US and Canada with drinking water
- The flow of Niagara Falls creates enough electricity to power 3.8 million homes
- Millions of tourists from all over the world visit Niagara Falls every year

Our mission is to engage the Buffalo / Niagara community in a greater awareness of the historical, cultural, economic and ecological significance of the Great Lakes and the Niagara River. We challenge our youth to discover the ancient stories of the Niagara River and gain a better understanding of why biodiversity is so important to the sustainability of the Niagara River.

Niagara River greenway

We support and rely on many important partners, like Buffalo Niagara Waterkeeper to help us conserve and maintain the health of the Niagara River.

www.niagararivergreenway.com

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The Building Stewardship and Strengthening Pride of the Greater Tonawanda Community Project was made possible with funding provided by the Office of the New York State Attorney General and the New York State Department of Environmental Conservation through the Tonawanda Community Environmental Benefits Program.

Letter to Educators

Dear Educators,

The Niagara River Watershed is home to one of the wonders of the world, where 3,000 tons of water rush over 180 feet of limestone, shale, and dolostone every second. People travel from across the world to see Niagara Falls, and to enjoy the other natural and cultural wonders that are unique to Western New York. The Niagara River Watershed is a part of the Great Lakes Basin, the source of 20% of the world's surface freshwater. Our watershed provides fresh drinking water, resilient ecosystems, and a place to connect with and enjoy the natural world. We are incredibly lucky to live near this resource and we have the responsibility to care for our water to ensure that it will continue to provide for and sustain future generations.

This lesson series is a part of a larger effort to build stewardship and strengthen pride in the Greater Tonawanda Community. Buffalo Niagara Waterkeeper and the Niagara River Greenway work together to provide teachers and students the knowledge, skills, and resources to tackle environmental problems in their communities and make meaningful change through the Youth Stewardship Program.

This lesson series introduces ways for students to engage in place-based learning by developing their understanding of their local environment. The activities here intend to provide opportunities for students to deepen their connection to the natural world and understand their place in it as a change maker. Students will engage in design thinking and apply that to real-world, local environmental problems that impact them and their community. The lesson series is organized into three sections – Watershed Basics, Issues and Solutions, and Stewardship. Educators can follow the lessons in order or pick and choose activities that fit their schedule. Educators are also invited to adapt the activities in this series to best fit the needs of their students. The activities can be scaled up or down, depending on student grade level and skill set. These lessons can be used as a part of small or large groups, remote or in-person, and in team approaches. Teachers can design grading rubrics based on each lessons learning objectives.

For thousands of years people have lived in Western New York and swam, drank, and fished from the water that flows through the creeks, streams, and rivers. Humans have not always done the best job in protecting and stewarding those waters. These lessons hope to inspire the next generation of environmental stewards and equip them with the knowledge and skills they need to make a real and lasting impact on the unique ecosystems and natural resources in the Niagara River Watershed.

This project would not be possible without the dedicated educators, staff, volunteers, and students that have contributed. Thank you!

Happy Teaching,

Buffalo Niagara Waterkeeper and Niagara River Greenway

Lesson Guide

Students can complete the activities as stand-alone lessons or as a series. Activities can be adapted to be completed in the classroom, as a homework assignment, with small or large groups, during field trips, or during after-school clubs. On the title page of each topic, you will find guiding questions that form the basis of the lessons within that topic.

Topic #1: Watershed Basics

Lesson 1: What is a Watershed?

Students will understand basic concepts related to watersheds, including topography, runoff, and pollution. Students will identify their watershed, the Niagara River Watershed, and their place within that space. In activity 1a, Watershed Lingo, students will read a passage and watch a video, then complete a student worksheet. In activity 1b, Create Your Own Watershed, students will design their own model of a watershed.

Lesson 2: Analyzing Water Quality Data

Students will explore the concept of water quality assessment and be able to identify and describe key parameters that can affect water quality, including pH, dissolved oxygen, conductivity, turbidity, and temperature. Students will review New York State water quality standards and describe what clues scientists look for when determining if a waterway is healthy or stressed. Students will then use existing water quality data from Buffalo Niagara Waterkeeper using the Water Reporter web widget, to identify potential areas for water quality improvement.

Lesson 3: Assessing Water Quality with Aquatic Macroinvertebrates

Students will assess water quality by discovering which aquatic macroinvertebrates live in a waterbody. This activity, best completed outdoors, introduces the concept of a bioindicator and includes resources for educators to organize a field trip to a waterbody for their students. Also included is an in-class extension activity that can be used as an alternative to a field trip experience or as a follow-up activity.

Topic #2: Watershed Issues and Solutions

Lesson 4: Environmental Justice in Your Environment

Students will explore environmental justice concerns within their environment and the United States at large. Students will read a critical thinking passage, watch a video, and answer discussion questions about environmental justice.

Lesson 5: Water Quality

Students will analyze two common water quality issues that impact waterways throughout the Niagara River Watershed. In activity 5a, students use a refractometer (salinity meter) to measure salt level in a sample of water, an indicator of road salt pollution. In activity 5b, students learn about wastewater, stormwater, and combined sewer overflows. Students will analyze and graph bacteria and weather data and reflect on potential infrastructure improvements to help improve water quality.

Lesson 6: Non-native Species

Students will explore the concepts of native, non-native, and invasive species, analyze the impact each can have on local ecosystems using examples, and evaluate methods for managing invasive species in an environment.

Lesson 7: Plastic Pollution Solutions

We all know litter is bad, but how much litter is in our environment? Where does it come from? This lesson allows students to collect, analyze, and interpret data on litter in the Niagara River Watershed, compare that data to a local cleanup, and explore litter data from around the world.

Lesson 8: Great Change in the Great Lakes

Students will define human-caused climate change as it relates to the carbon cycle and identify the different impacts we see here locally in Western New York and around the Great Lakes region. Students will work together to complete a series of activities.

Topic #3: Stewardship

Lesson 9: Conservation Biology

Students will explore the ways that habitat loss due to human development impacts the population of the endangered Karner Blue butterfly (*Lycaeides melissa*)**.** Students will practice critical thinking, scientific literacy, and scientific investigation skills to interpret and evaluate experimental results with graphing. Students will explore these concepts in the context of their local environment.

Lesson 10: Living Shorelines

Students will familiarize themselves with the concept of a Living Shoreline, as well as Buffalo Niagara Waterkeeper's work to create multiple Living Shorelines throughout Western New York. After reviewing key components of Living Shorelines, their benefits, and how they differ from degraded or 'non-living' shorelines, students will look at two completed Living Shoreline project highlights to observe their differences and successes. Afterwards, students will explore the benefits provided by shoreline plants with a hands-on activity that illustrates erosion in different ecosystem types.

Lesson 11: Designing a Stewardship Project

Students will design a stewardship project to address a local watershed issue! The activities will guide students through the project planning process, allowing them to assess areas where a stewardship project is needed, plan for their roles as the project team, and complete a grant application to get the resources that they will need to make their project come to life.

Topic #1: Watershed Basics

How does water move through our environment?

How can we determine if our water is clean and healthy?

What creatures live in our waterways? What do they tell us about the health of the water?

Headwaters of Upper Tonawanda Creek

Lesson 1 – What is a Watershed?

Activity for High School and Middle School Students

Description: Students will explore basic concepts related to watersheds, including topography, runoff, and pollution. Students will identify their watershed, the Niagara River Watershed, and their place within that space. In activity 1a, Watershed Lingo, students will read a passage and watch a video, then complete a student worksheet. In activity 1b, Create Your Own Watershed, students will design their own model of a watershed.

Teacher Information

- Background information about the Niagara River Watershed, its key features, and its impairments is available on the Buffalo Niagara Waterkeeper website: https://bnwaterkeeper.org/places/niagara-river/
- Background information about the Great Lakes Basin is available on the New York Sea Grant website: https://seagrant.sunysb.edu/articles/t/poster-the-great-lakes-basin-great-lakes-coastal-youth-education-news
- Comprehensive information about the Niagara River Watershed is available in the Niagara River Habitat Conservation Strategy: https://bnwaterkeeper.org/projects/habitat/habitat/habitatstrategy/

Learning Outcomes:

Students will be able to:

- Define the word watershed and describe where they live within the Niagara River watershed.
- Describe how topography and other factors impact the way water moves through a watershed.
- Explain key terms including tributaries, upstream, downstream, and groundwater.
- Design a model of a watershed.

New York State P-12 Science Learning Standards (MS and HS):

- MS-ESS2.C: The Roles of Water in Earth's Surface Processes
    - Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.
- HS-ESS2.C: The Roles of Water in Earth's Surface Processes
    - The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

Activity 1a: Watershed Lingo

Student Worksheet – Watershed Lingo

Name: _____ Date: _____

Directions: For this activity, you will read a paragraph and watch a video about the Niagara River Watershed. As you read, underline vocabulary words that you think are important for understanding what a watershed is and how it works. After reading and watching the video, answer the discussion questions and fill in the watershed diagram.

Materials Needed

- Writing utensil, highlighter
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit webpages

The Niagara River Watershed

Source: Buffalo Niagara Waterkeeper

When precipitation, like rain or snow, falls on land it can soak into the soil, evaporate into the atmosphere, be absorbed by plants, or run across the surface of the land and enter waterways. These waterways are part of a lager system - a watershed. The word watershed describes an area of land that drains water to a common area, like a lake, river, or ocean. Watersheds can be large or small and their shape is determined by the topography and geology of the land. Everyone lives in a **watershed**!

A watershed refers to the area of land where all of the water that is under it (e.g. **ground water** and aquifers) or on it (e.g. **surface water** like streams and rivers) flows into the same place. A watershed is like a funnel in that it collects all the water within an area (the wide part of the funnel) and moves it towards the same place (the narrow part of the funnel). Watersheds are not defined by political boundaries as they can cross city, state, and national boundaries. Watersheds are separated by topographically higher areas (highlands).

Watersheds come in many sizes from very small watersheds encompassing a few acres to very large watersheds that cover tens of thousands of square miles. Ultimately, the water gets to the ocean. In many areas, the term watershed is synonymous with the terms **drainage basin** and **catchment basin**.

Streams and lakes reflect the characteristics of the watersheds they drain. When investigating the water quality of a stream or lake it is important to consider the characteristics of the watershed it is within. A water sample taken from a river, for example, is a synthesis of everything that has happened to the water before it reaches the point where the measurement is taken. Characteristics of a watershed that should be considered include **topography**, vegetation, soils, and land use. It can be challenging for students to understand the water that flows past them at a single point along a stream or river is greatly impacted by the watershed upstream.

New York State is a Great Lakes State! This is a fact many forget, as New York also has a coastline along the Atlantic Ocean. We are so lucky to have so much freshwater on our doorstep here in Western New York. Water is life.

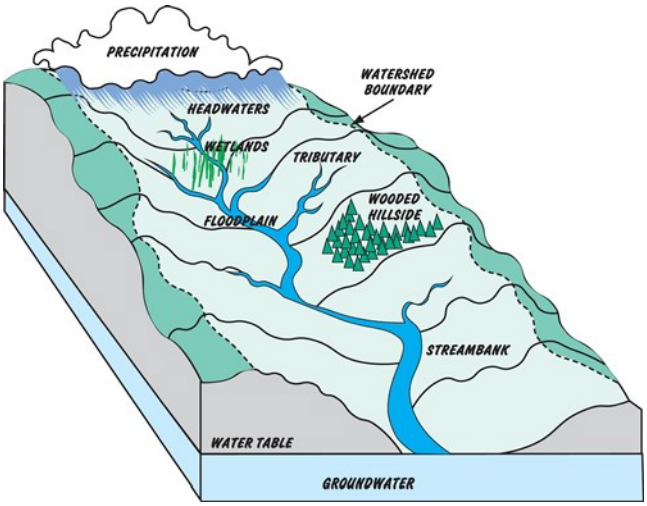
Even with this abundance of water, many communities have become disconnected from our water resources. This may stem from physical barriers, a lack of access or missed outdoor experiences in early childhood. Rekindling these connections to our waterways is folded into our mission, and a key component to our educational programming. So let's take a dive into a water concept that causes much bewilderment: the watershed.

Here are 4 questions that break down watershed knowledge!

Source: criticalzone.org

1. What's a watershed? A watershed is an area of land that drains into a river, lake or other bodies of water. Think of it as a bathtub. If water flows into the bathtub, it will travel towards the drain. If water escapes the bathtub, the water will flow elsewhere. The bathtub is your watershed, and the drain is a receiving waterway.

2. Why is it shaped that way? In reality, watersheds do not take the shape of a bathtub. The boundaries of a watershed are based on topographical features, like hills or the geology of the soil. These features control which way water will flow. In the Niagara River Watershed, the rolling hills of the Allegheny Plateau create the southern watershed border. The geography of the land changes as you travel toward the northern sections of the watershed. Here you will find flat low-lying areas. A prominent feature in the Niagara River Watershed is the Niagara Escapement. Learn more about this **geologic feature.**[1]



Areas of higher elevation will form the boundaries of a watershed.

3. Why should I care and learn about my local watershed? Water plays an essential role in our lives; it's connected to everything in our world. Water is used for drinking, cooking, agricultural irrigation, industrial processes, bathing, shipping, fishing, and aquaculture, plus our recreational enjoyment. It's essential to our lives, lifestyles and economy. In Western New York, the source of most residents' drinking water is the Great Lakes and the Niagara River. In rural areas, well water is also a source.

[1] https://www.niagarafallsinfo.com/niagara-falls-history/niagara-falls-geology/niagara-geological-areas/the-niagara-escarpment/

Understanding how various activities throughout the watershed impact water quality is so important to protecting our water resources. When it rains, or snows, water may be absorbed into the ground, or it will flow over the land's surface heading for a low point. In Western New York, most of this surface runoff flows into lakes and streams (and also storm drains, which in some circumstances overflow into our water bodies). This surface water runoff will carry sediment, nutrients and other contaminants with it. Many of our projects help to filter runoff before it gets to our creeks and rivers, including our cleanups, native plantings, and Living Shorelines.

4. What more do I need to know about the watershed? Here are a few other tidbits about the Niagara River Watershed.

- Located along the westernmost portion of New York State and encompasses lands that drain into the Niagara River, a channel that connects the Great Lakes of Erie and Ontario
- Part of the larger Great Lakes Drainage Basin
- Encompasses 903,305 acres of land, 71 municipalities, 3,193 miles of watercourses, and 52,979 acres of state and federally listed wetlands

Buffalo Niagara Waterkeeper works to protect and restore waterways throughout the watershed, including the lesser-known headwater region. Headwater streams are small tributaries (first-third order streams) in the upper reaches of a watershed. The protection and preservation of lands surrounding these streams are crucial for the protection of water quality in our bigger waterways, as well.

Map of the Niagara River Watershed showcasing headwater streams and undeveloped lands.

Video: After reading the paragraph, watch the video "Watershed 101" by Buffalo Niagara Waterkeeper on your smart device. The video provides basic information about what a watershed is, how our actions affect our watershed, and what we can do to protect the health of our watershed. There's also information about local entities that provide related assistance. (Approximately 20 minutes)

Link to video: https://www.youtube.com/watch?v=D9KunOJugeM

Discussion Questions:

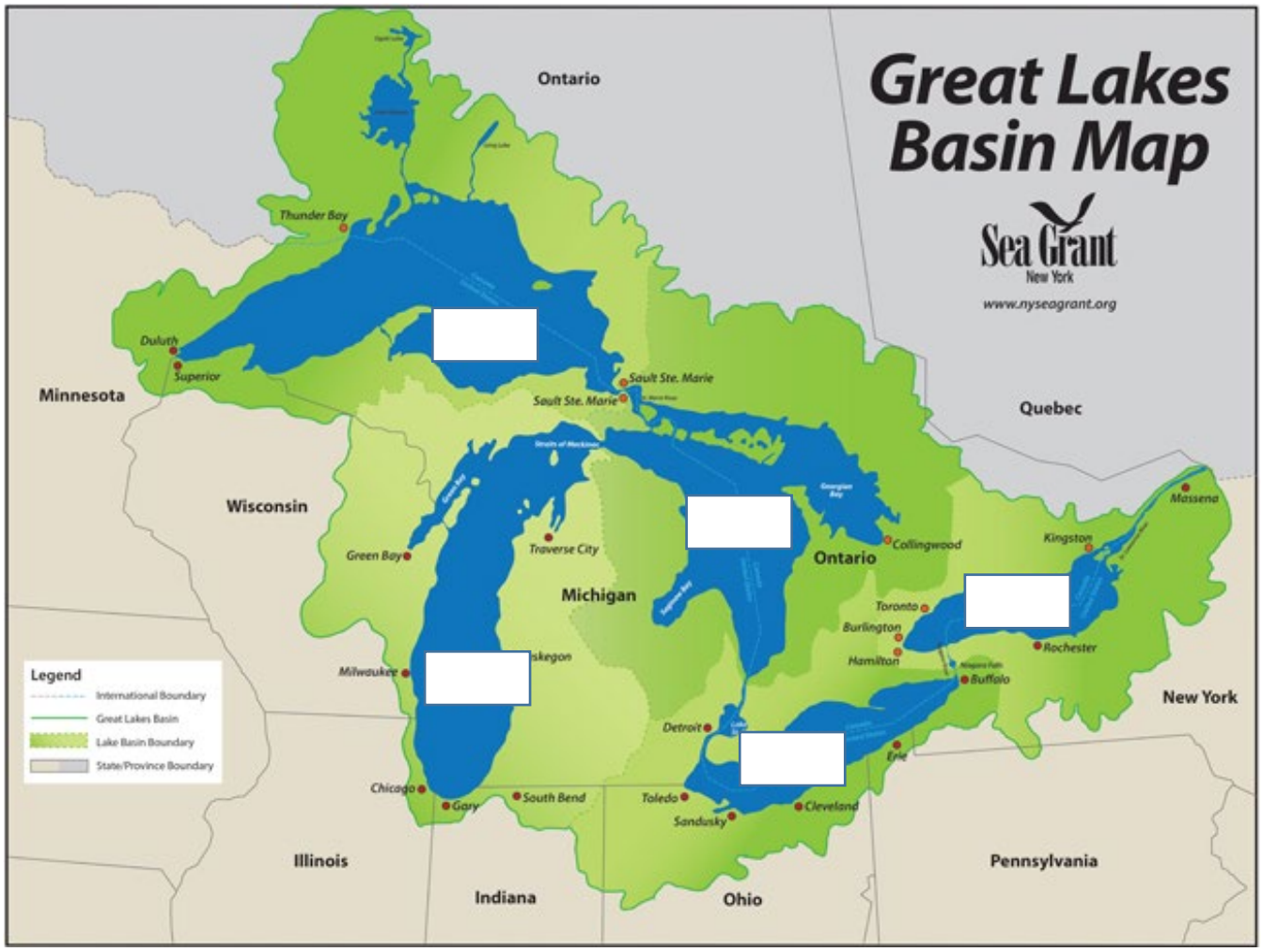
1. In your own words, define the word watershed.

   _____
   _____
   _____
   _____

2. What controls the way water flows in a watershed?

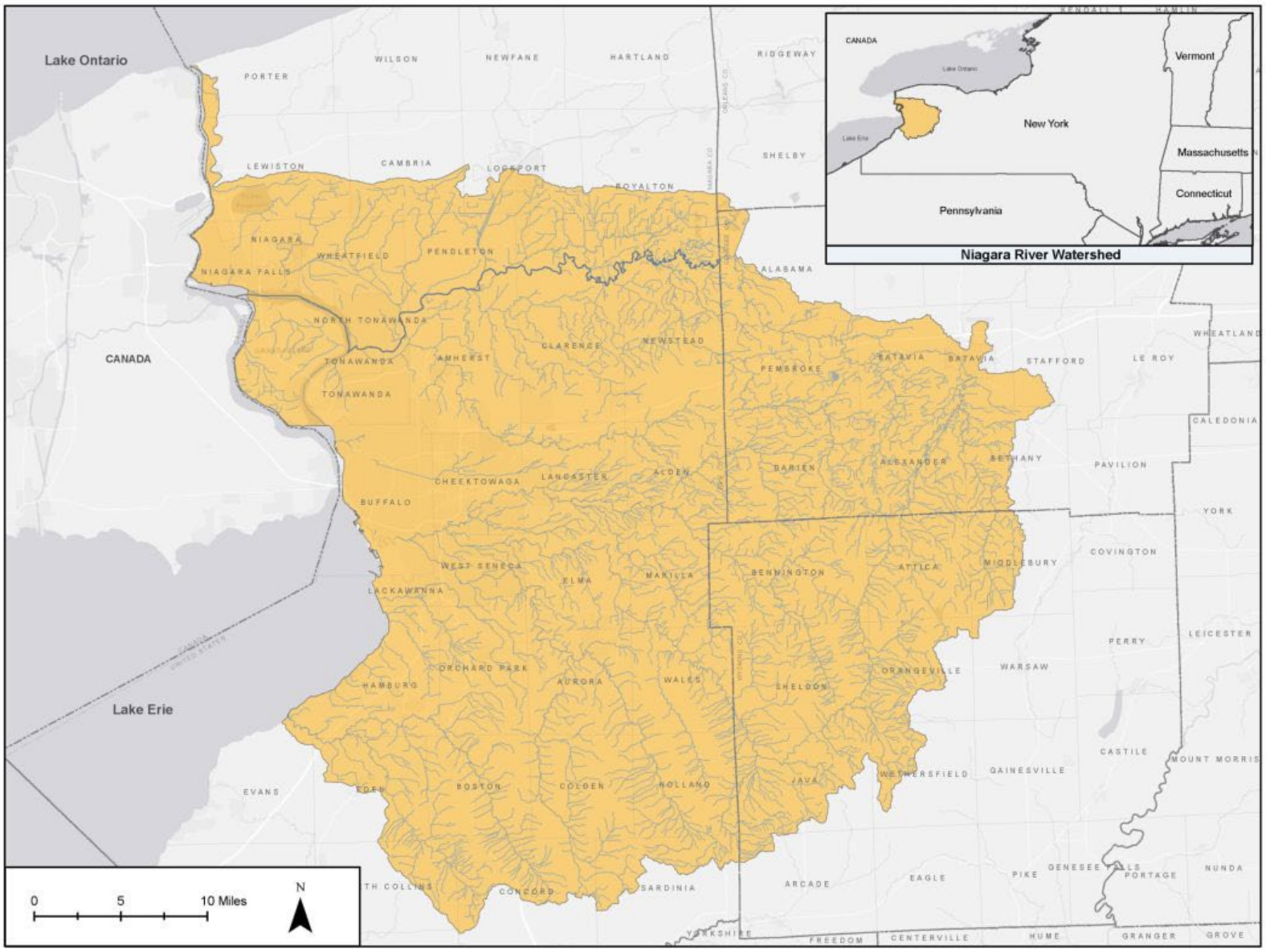
   _____
   _____
   _____
   _____

3. The map below shows the Great Lakes Basin, as well as US States and Canadian Provinces. The Great Lakes are the source of 20% of the world's available **freshwater**. Label the map with the names of the Lakes (Lake Superior, Lake Erie, Lake Ontario, Lake Michigan, Lake Huron).



Source: New York Sea Grant

4. The map below shows the Niagara River Watershed. Draw a star to show where you live. Circle where your school is.



Source: Buffalo Niagara Waterkeeper

5. Water is a powerful force! It can make changes to the landscape as it moves through the watershed. Explain how erosion and weathering can change a landscape.

_____
_____
_____
_____
_____
_____

6. Define pollution. Name one way that pollution can get into waterways like creeks, streams, or rivers.

_____
_____
_____
_____
_____

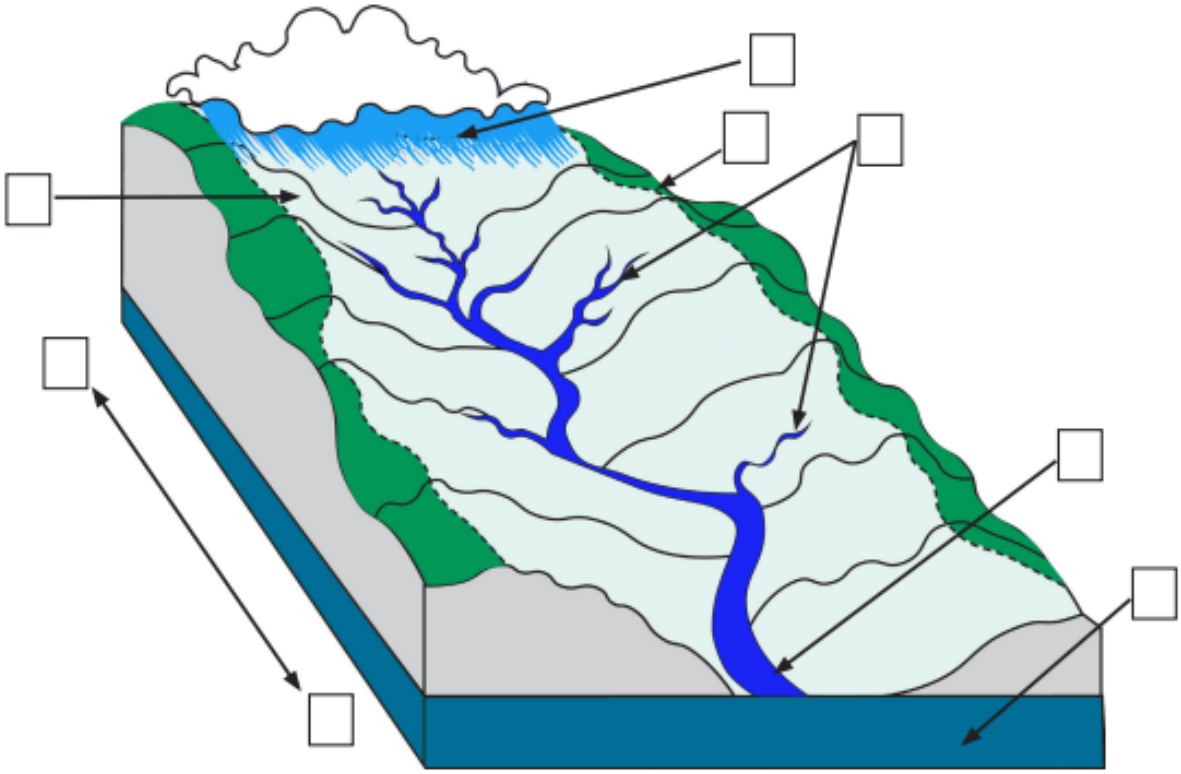
7. Have you noticed pollution in your community? If yes, please explain what you've noticed and how it might impact water quality.

_____
_____
_____
_____
_____
_____

8. Do you have any ideas as to the SOURCE of the pollution or where it came from?

_____
_____
_____
_____
_____
_____

9. Label the watershed diagram below and fill in the sentences.



Use the words in the box to complete the sentences. Mark the picture with the correct number.

tributaries	upstream	groundwater	precipitation	mouth	boundary	downstream	headwaters

1. Ridges and hills that separate two watersheds are called the watershed _____.
2. _____ are upstream areas where a river starts as a small stream.
3. A river or stream flows into a larger body of water at the _____.
4. The smaller streams or rivers that join larger steams or rivers are called _____.
5. A fish swimming opposite the direction of flowing water is swimming _____.
6. Rain, sleet, snow and hail are all types of _____.
7. _____ is the water that soaks into cracks and spaces and is stored beneath the earth's surface.
8. Water flowing _____ is flowing away from the river's source and toward the mouth.

BUFFALO NIAGARA WATERKEEPER www bnwaterkeeper.org

Activity 1b: Create a Watershed

Teacher Instructions

Students will design and create their own watershed model. Depending on the number of materials available, students can work independently or as a small group by following the activity steps below.

Materials Needed:

- Plastic or metal tray
- Crumbled newspaper, rocks, or pinecones
- Foil or white trash bags
- Sharpie markers
- Spray bottles of water
- Colored dye
- Small amount of dirt or sand
- Cotton balls or water dropper
- Map of the Niagara River Watershed

Activity Steps:

1. On the plastic or metal tray, arrange crumpled newspaper, rocks, or pinecones to represent the shape of a landscape.
    a. Explain the word **topography**. The items in the tray form the topography of a landscape, representing natural features like hills, valleys, and the connections between them.
2. Add the surface of the land to your model by placing foil or a plastic bag over the rocks, newspaper, or pinecones.
3. Draw the waterways on your model. Think about rain falling in your model watershed.
    a. Where would the rainwater go? Where would rivers and streams form?
    b. Would there be any waterfalls? Where will the water form lakes or ponds?
    c. Draw the locations where you think rivers and lakes would form with a permanent marker.
4. Draw the boundary of a watershed on your model:
    a. Using a different color of permanent marker, draw the boundary of the largest watershed in your model.
    b. Draw the boundary of a smaller watershed within the larger watershed. Mark a spot where you would like to live.
5. It's time for some rain! Use the spray bottle to 'rain' on the top of your highest 'mountain.' Continue raining until the water forms streams, rivers, and lakes.
6. How would pollution alter the water quality? Using a cotton ball soaked in red dye ‘pollute’ an area of your watershed.
    a. What areas are impacted by this source of pollution? How would wildlife be impacted?
7. Where will **erosion** happen? Sprinkle dirt or sand on your watershed model. Spray the bottle and see if the dirt or sand is washed away.
    a. Where does the dirt or sand go?
    b. How might we prevent the dirt or sand from being washed away?

Discussion Questions:

1. Where did the water accumulate?
2. How did the water flow over the surface of the land? Did you observe any patterns?
3. What direction did the water flow? What caused the water to flow that way?
4. How will humans affect the flow of water?
5. Using the map of the Niagara River Watershed, how could your model be changed to represent that watershed? What force created much of the topography in the Niagara River Watershed (hint – these giant ice sheets receded about 18,000 years ago).

Lesson 2 – Analyzing Water Quality Data

Lesson or Activity for High School and Middle School Students

Description: Students will explore the concept of water quality assessment and be able to identify and describe key parameters that can affect water quality, including pH, dissolved oxygen, conductivity, turbidity, and temperature. Students will review state water quality standards where applicable for each parameter and be able to differentiate between a healthy and an unhealthy waterway. Students will then use existing water quality data from Buffalo Niagara Waterkeeper using Water Reporter, to identify potential areas for water quality improvement.

Teacher Information

- Information about Buffalo Niagara Waterkeeper's water quality work, and Waterkeeper's annual Riverwatch Water Quality Report can be found here: https://bnwaterkeeper.org/riverwatch/
- Background information on Lake Erie and its role in the Great Lakes Basin can be found on the EPA's website: https://www.epa.gov/greatlakes/lake-erie
- Information about past and present water quality issues Lake Erie faces can be found on the Lake Erie Foundation's website: https://lakeeriefoundation.org/issues/lake-erie-water-quality/
- Information about the Niagara River and Buffalo River Area of Concerns can be found on the EPA's website:
    - https://www.epa.gov/great-lakes-aocs/buffalo-river-aoc
    - https://www.epa.gov/great-lakes-aocs/niagara-river-aoc
- General water quality data can be found on the USGS's website: https://www.usgs.gov/special-topics/water-science-school/science/water-quality-information-topic
- Data for the parameters we will explore in this lesson is also being collected by other organizations throughout the Lake Erie Basin, and can be found here: https://clevelandwateralliance.org/levsn

Materials Needed:

- Student worksheet
- Writing utensil, highlighter
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit webpages

Learning Outcomes:

Students will be able to:

- Define the concept of water quality, and identify/describe parameters that are measured to determine water quality
- List the parameters that Waterkeeper staff and volunteers measure on a regular basis
- Identify and describe past and present water quality issues, and how they affect the above parameters, that we face at a local (Buffalo and Niagara River) scale, and at a regional scale (Lake Erie and Great Lakes Basin)
- Familiarize themselves with state and regional standards for water quality
- Describe how different species of wildlife (specifically fish and insects) require different conditions in the water, and how certain species can serve as indicators for high water quality.
- List several of the threatened, endangered, and rare plant and animal species in New York State

New York State P-12 Science Learning Standards (MS)

- MS-ESS3-2: Human Impacts
    - Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
- MS-LS2-4: Matter and Energy in Organisms and Ecosystems
    - Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

New York State P-12 Science Learning Standards (HS)

- HS-LS2-7: Interdependent Relationships in Ecosystems
    - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-ESS2-5: Earth's Systems
    - Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes
- HS-ESS3-4: Human Sustainability
    - Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Student Instructions – Water Quality Assessment

Name: _____ Date: _____

Directions: For this activity, you will read about Buffalo Niagara Waterkeeper's water quality assessment work, and how we use certain measurements to determine the health of our local waterways. As you read, take notes on each parameter that is routinely measured, and how it impacts water quality. After you read the background information,you will compare water quality data collected by citizen science volunteers to New York State water quality standards. This can lead to a discussion about water quality conditions and waterway health. Afterwards, you will look at data for three waterways our Riverwatch volunteers monitor monthly, using data from the Water Reporter web widget on Buffalo Niagara Waterkeeper's website. Using this information, fill out a data sheet, and answer the questions about the water quality in that waterway, and discuss where water quality can be improved.

- Writing utensil, highlighter
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit Waterkeeper's website
- Data Sheets (provided)

Buffalo Niagara Waterkeeper Riverwatch Program

Source: Buffalo Niagara Waterkeeper

To inform decisions about future restoration projects, advocacy efforts, and outreach, Buffalo Niagara Waterkeeper assesses water quality of streams, creeks, rivers, and lakes throughout the Niagara River Watershed. Water quality can be thought of as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics (USGS). Buffalo Niagara Waterkeeper staff train concerned community members to gather important water quality data in the Niagara River Watershed. These volunteer citizen scientists conduct monitoring of waterways throughout the year while providing a network of "eyes on the water" to report pollution or improper land use on these waterways to staff at Waterkeeper. Volunteers may also become active agents for change in their communities, helping to educate and involve others in the effort to protect and improve our water resources. Through the Riverwatch program, Buffalo Niagara Waterkeeper seeks to:

- Provide surveillance monitoring to bolster regional baseline water quality data.
- Track the health of local waterways and determine if restoration efforts are having a positive effect on water quality.
- Monitor waterways to quickly respond to spills, discharges, and potential harmful algal blooms (HABs).

1. Waterway Conditions

Using testing equipment, our volunteers monitor the water quality of local waterways on a regular basis. Waterkeeper shares this data with the public, state agencies, and other organizations.

It is also important to be able to identify water quality issues without the use of this equipment. Below are some indicators of water quality issues you can observe with your difference senses like sight and smell. Please note that this list is just an overview and is intended for use as a general reference.

Pollution

1. Spills
2. Combined Sewer Overflows (CSOs) and Sanitary Sewer Overflows (SSOs)
3. Legal discharges
4. Stormwater runoff
5. Litter
6. Historic Contamination

Habitat

1. Land Use
2. Restoration

Public Access

1. Blocked or poorly maintained public access points
2. Dangerous conditions at public access points
3. Actual public uses of sites
4. Debris blocking boat access on waterways
5. Construction or maintenance of public access points in a way that damages wildlife habitat or water quality

Plastic Pollution (Nurdles) at Gratwick Park in Tonawanda, NY. (Credit: Buffalo Niagara Waterkeeper)

Combined Sewer Outfall Pipe (Credit: Buffalo News)

2. Parameters Waterkeeper Tests For

Although being able to make preliminary water quality assessments based on visual observations is important, it is valuable to also collect accurate and quality data. Waterkeeper uses water quality sensors to measure four parameters that can provide information about waterway conditions and quality. These parameters are Temperature, pH, Dissolved Oxygen (DO), Conductivity, Total Dissolved Solids (TDS), and Turbidity. Below are the definitions and importance of each of these parameters in assessing baseline water quality.

Temperature

The temperature of water governs what aquatic life will inhabit a waterway. Additionally, temperature controls the dissolved oxygen content of water (as the temperature of water increases, the

concentration of dissolved oxygen content decreases), and influences the rate of chemical and biological reactions. The water temperature can be impacted by sunlight duration and intensity, and discharges entering the waterbody.

pH

pH is a measurement of the potential activity of hydrogen ions (H+) in a sample. The pH reading of a water sample indicates its acidity on a scale from 0 to 14 with 7 being a neutral value. Solutions with a pH less than 7 are considered acidic and solutions above 7 are considered basic. The pH of water determines the solubility and biological availability of chemical constituents such as nutrients. The majority of aquatic animals prefer a range of 6.5 to 8. A pH outside this range stresses the systems of most organisms and can reduce reproduction, thereby reducing the diversity in the stream. Pollution sources can alter the waterway's pH.

Dissolved Oxygen (DO)

DO enters water from the atmosphere, from aeration as it tumbles over rocks and falls, and from photosynthesis. DO is essential for the survival of nearly all aquatic life and levels can decrease with the introduction of various pollutants including sewage discharges, stormwater runoff, and failing septic systems. Oxygen is essential for most living things. Certain macroinvertebrates, including most mayflies, caddisflies, and stoneflies, as well as certain fish, such as trout, require dissolved oxygen levels of at least 6 mg/L. The maximum amount of oxygen that can be dissolved in water is about 14 mg/L. The capacity of water to hold dissolved oxygen varies with water temperature. At every temperature, a water body has a maximum amount of dissolved oxygen (saturation). When a stream warms up, its ability to hold dissolved oxygen decreases. Other factors such as excess algae or suspended sediment can also lower DO levels.

Conductivity

Conductivity is a measure of water's capability to pass an electrical current and indicates the presence of inorganic dissolved solids such as salts, chlorite, nitrate, sulfate, and phosphate ions. Conductivity is affected by the geology of the area through which the water flows. Elevated levels may indicate the presence of sewage or stormwater discharges and runoff. Streams outside of the standard range may not support healthy fisheries and other aquatic life.

Total Dissolved Solids (TDS)

TDS is a measure of inorganic and organic substances dissolved in water which include salts and minerals. Salts from roadways may runoff into waterways resulting in an elevated TDS reading.

Turbidity

Turbidity is a measure of the clarity of a liquid. Suspended solids including soil particles, algae, plankton, and microbes impact turbidity. Erosion of sediment and stormwater runoff will increase the turbidity of waterways. High turbidity increases water temperatures, decreases DO, provides refuge for harmful microbes, and can clog the gills of fish and crustaceans. Turbidity is often related to nutrient enrichment of a river because nutrients such as phosphorus cling to suspended soil particles. Bacteria and toxic contaminants also cling to these particles, creating a more complex water quality problem.

3. Water Quality Standards

For most of the parameters listed above, there are standards or guidelines that indicate whether a given measurement is within an appropriate range or exceeds a potentially harmful threshold. Standards vary from state to state, but Waterkeeper uses local guidance to inform which standards are utilized for our results. Below are the standards for the parameters above, where applicable.

Parameter	Standard
Dissolved Oxygen	No less than 6.0 mg/L for Niagara River No less than 4.0 mg/L for all other streams
Conductivity[1]	Between 150 and 500 µS/cm
pH	Between 6.5 and 8.5
Turbidity	No more than 5.0 NTU

1 There is no standard set for conductivity by the NYSDEC or EPA. This range is a guideline for freshwater systems.

Parameter Standards for freshwater systems.

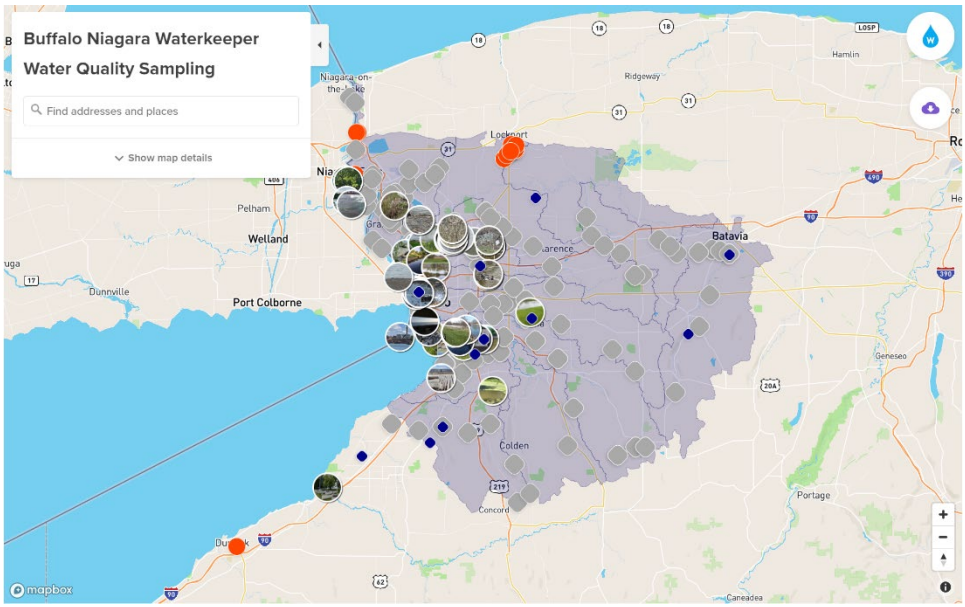
Activity: A Look at Waterkeeper Monitoring Sites

Waterkeeper's Riverwatch Program has been monitoring water quality throughout the Niagara River Watershed since 2011. Waterkeeper makes the data publicly accessible on our website using Water Reporter. Water Reporter is a social media tool that anyone can join to share data, observations, and questions about waterways and water bodies around the country (https://www.waterreporter.org/). Waterkeeper uses this service to engage volunteers, upload data, and create maps and graphs of our data over time. This data is available for private citizens, organizations, and local, state, and regional entities to use in their work, and for their decision making. The data collected through Waterkeeper's Riverwatch Program is uploaded on a monthly basis. The data can be viewed on the Waterkeeper website here: https://bnwaterkeeper.org/our-impact/water-quality/

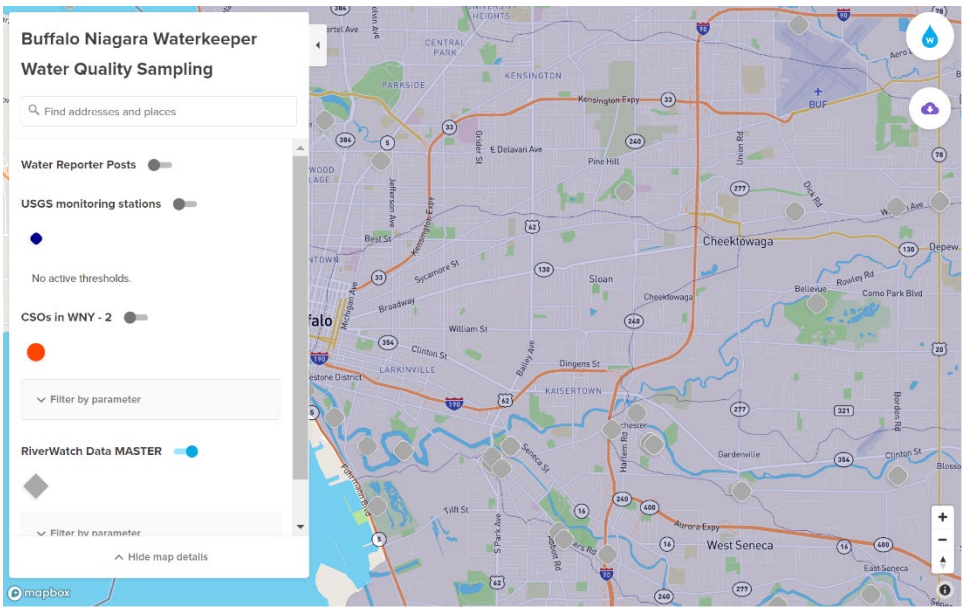
In this activity, you will analyze data collected by Waterkeeper volunteers at water quality monitoring sites around the Niagara River Watershed. You will pick one site along each of the following waterways to 'monitor': Buffalo River, Niagara River, and Cazenovia Creek. These waterways have been monitored by Waterkeeper for at least 3 years, which allows us to observe trends. At each of the sites you choose, you will record the data for each of the parameters (Temperature, pH, Dissolved Oxygen (mg/L), Conductivity, Total Dissolved Solids, and Turbidity) on a data sheet, using data from three separate years. After filling out the data sheet, answer the discussion questions below.

Activity Steps:

1. Navigate to the Buffalo Niagara Waterkeeper Water Quality Testing web page using your computer or smart phone: https://bnwaterkeeper.org/our-impact/water-quality/
2. Scroll down to the 'Buffalo Niagara Waterkeeper Water Quality Data' map on the page

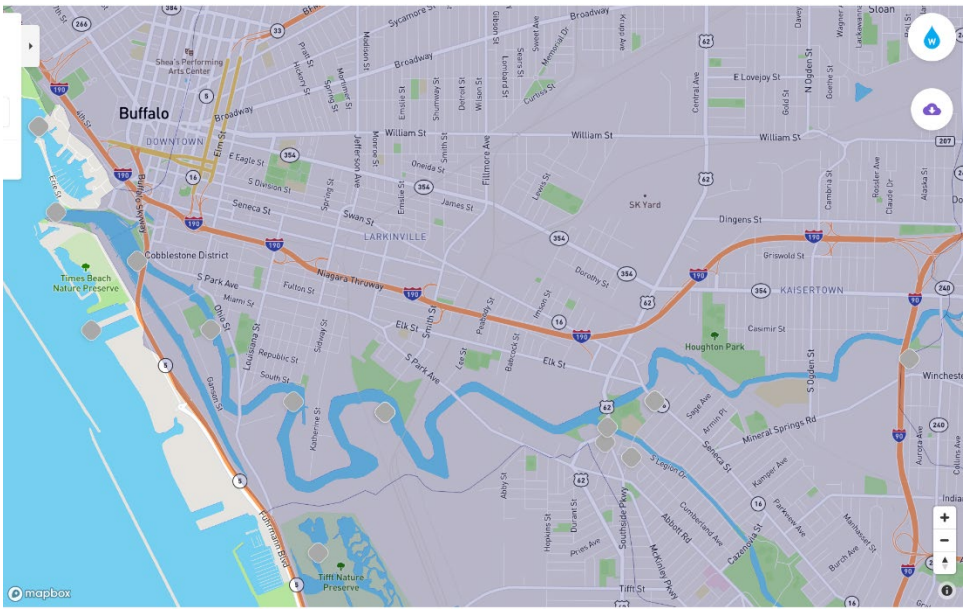


3. Using the drop-down menu, turn off data from 'Water Reporter Posts', 'USGS Monitoring Stations' and 'CSOs in WNY'. Leave on 'Riverwatch Data Master'

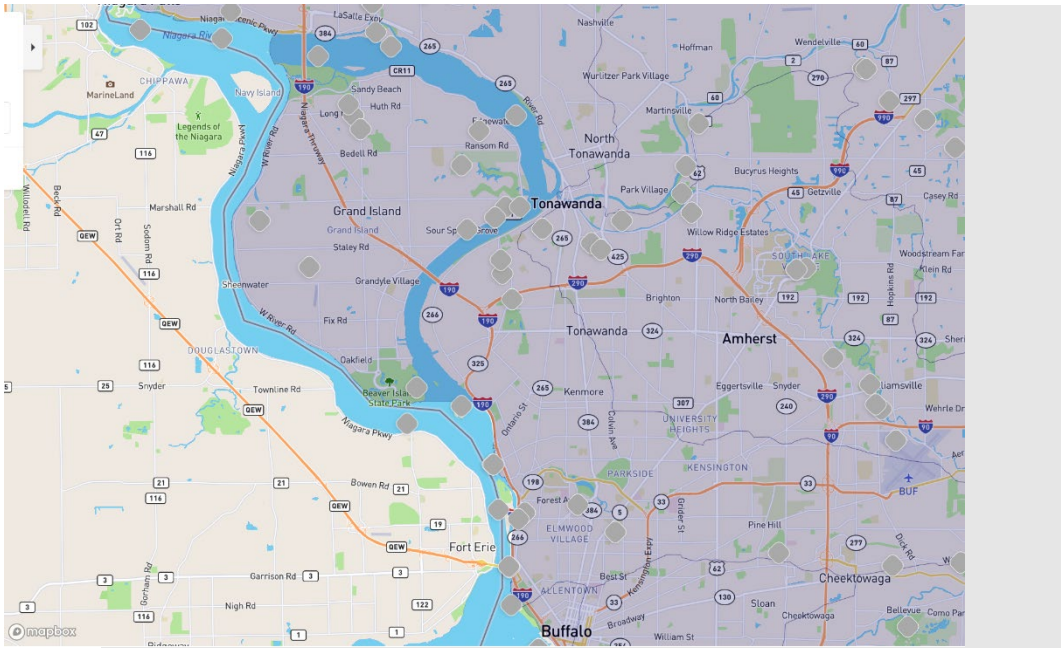


4. Explore the monitoring sites in grey around the Buffalo and Niagara Rivers, as well as Cazenovia Creek. The name of the sampling site will pop up when you click on a site.

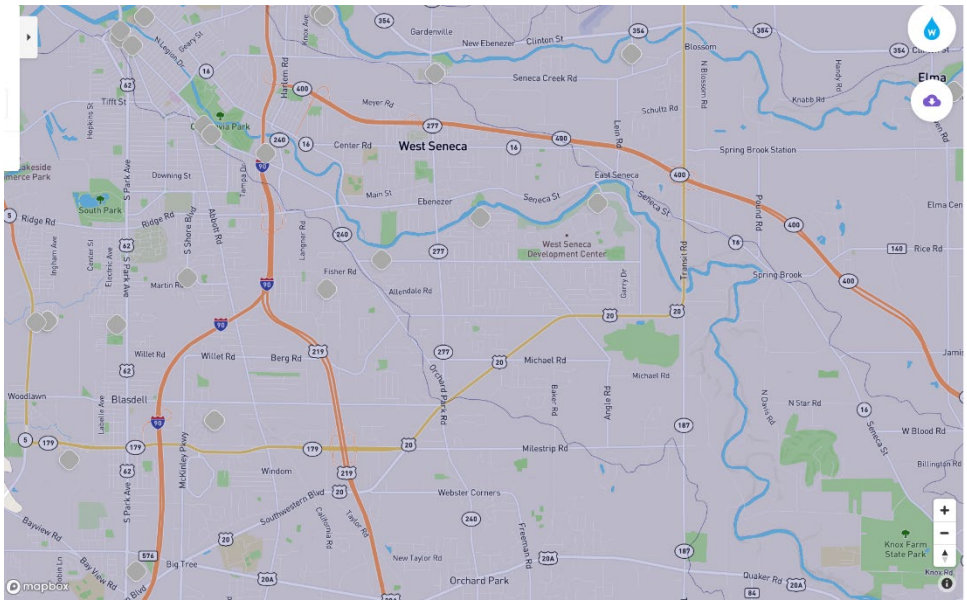
The river south of downtown Buffalo, which extends east is the Buffalo River



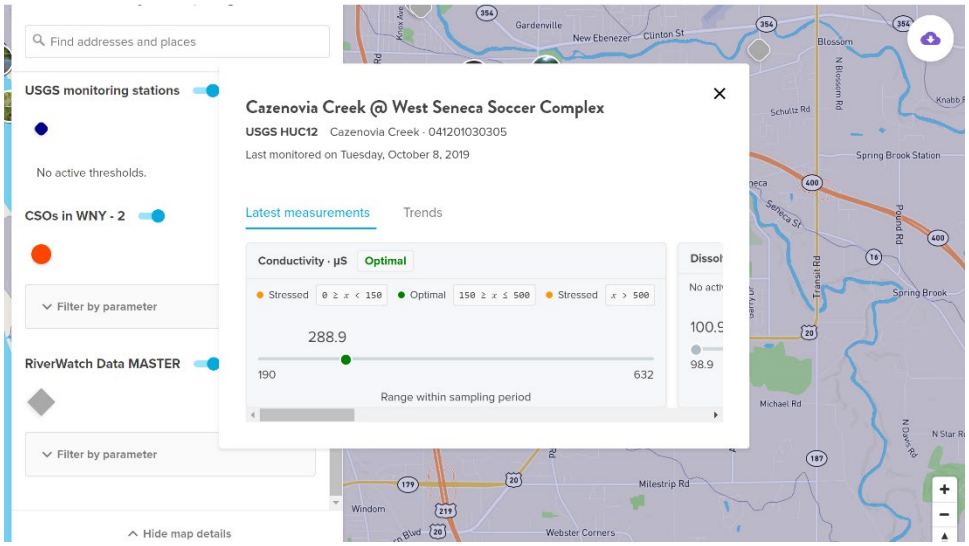
The river flowing north from Lake Erie, which flows on either side of Grand Island towards Niagara Falls, is the Niagara River



The creek that connects with the Buffalo River at the Bailey Peninsula is Cazenovia Creek

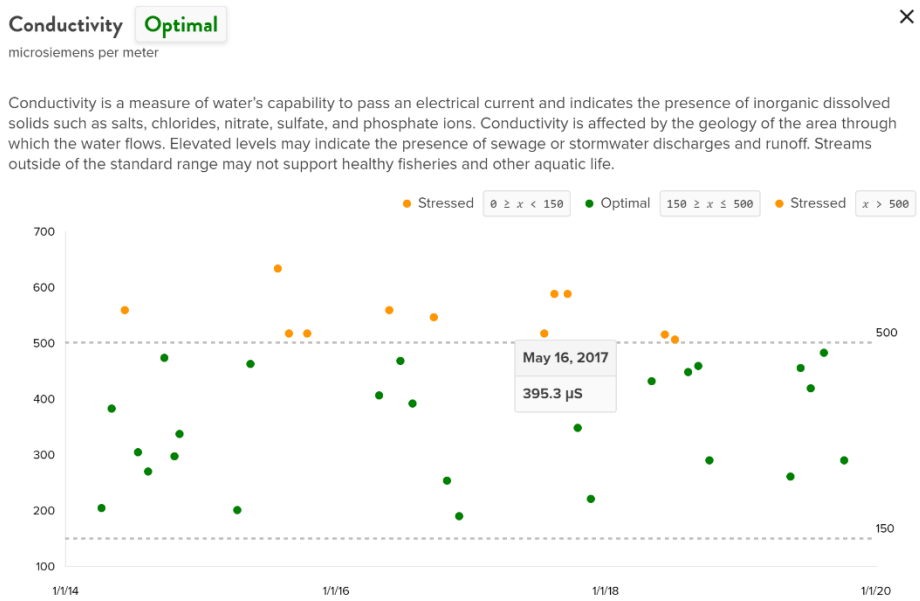


5. Click on the gray diamonds along each of the waterways – these indicate sites that Waterkeeper either has monitored or currently monitors
    a. The **bold text** at the top of the site data indicates the site name, and the smaller, non-bolded font below indicates what waterway this site is a part of. The site information also includes the date the waterway was sampled last.



6. Scroll through the data for the site, paying attention to whether the data for each parameter was in an appropriate range at the last sampling date.
7. Click on one of the parameters to view past data, and observe trends from past sampling dates/years

a. Dragging your mouse over one of the data points will reveal the date the measurement was taken



8. From each of the waterways above (Buffalo River, Niagara River, and Cazenovia Creek), select one site with at least three years of data, and record the data for all parameters measured on the data sheet below. You can select any date to represent the year. Make sure the sites you select are within the appropriate waterway!
9. After filling out the data sheet, answer the discussion questions below.

Student Name: _____ Date: _____

Water Quality Data Sheet

Buffalo River Site Name: _____

Parameter	Year 1:	Year 2:	Year 3:
Measurement Date			
Temperature (Celsius)			
pH units *DEC Standard range 6.5 -8.5*			
SpCond (Conductivity) (µS/cm)			
HDO (mg/L) *DEC Standard: no less than 4 mg/L* *Niagara River: no less than 6 mg/L*			
HDO (%)			
TDS (mg/L)			
Turbidity (NTU) *(DEC Standard: less than 5 NTU)*			

Niagara River Site Name: _____

Parameter	Year 1:	Year 2:	Year 3:
Measurement Date			
Temperature (Celsius)			
pH units *DEC Standard range 6.5 -8.5*			
SpCond (Conductivity) (µS/cm)			
HDO (mg/L) *DEC Standard: no less than 4 mg/L* *Niagara River: no less than 6 mg/L*			
HDO (%)			
TDS (mg/L)			
Turbidity (NTU) *(DEC Standard: less than 5 NTU)*			

Cazenovia Creek Site Name: _____

Parameter	Year 1:	Year 2:	Year 3:
Measurement Date			
Temperature (Celsius)			
pH units *DEC Standard range 6.5 -8.5*			
SpCond (Conductivity) (µS/cm)			
HDO (mg/L) *DEC Standard: no less than 4 mg/L* *Niagara River: no less than 6 mg/L*			
HDO (%)			
TDS (mg/L)			
Turbidity (NTU) *(DEC Standard: less than 5 NTU)*			

Discussion Questions:

1. How did each of your sites change from year to year? Which measurements increased? Which decreased?

   _____
   _____
   _____

2. Why do you think the measurements at each of the sites changed from year to year? If they didn't, why do you think they remained consistent?

   _____
   _____
   _____

3. What on-land activities could have impacted the water quality test results?

   _____
   _____
   _____

4. How can this data be used by local land-use planners, or policy makers (such elected officials, planning board members, or park managers)?

_____
_____
_____

5. Which waterway had the most consistent measurements outside of the standard ranges?

_____
_____
_____

6. If you were to design a restoration project at one of your sites, which site would you choose, and why? How would a restoration project impact the water quality at the site?

_____
_____
_____
_____

   a. Would you see the results of the project (improvement in water quality) right away, or would it take a while?

   _____
   _____
   _____

7. Why do you think Waterkeeper collects data from multiple sites along each of these waterways? How do we choose the sites to monitor?

_____
_____
_____
_____

Data from other sites throughout the Lake Erie Basin is being collected by other organizations outside of Buffalo Niagara Waterkeeper. Feel free to check the data out here:
https://clevelandwateralliance.org/levsn

Lesson 3 – Assessing Water Quality with Macroinvertebrates

Lesson or Activity for High School and Middle School Students

Description: Students will assess water quality by discovering which aquatic macroinvertebrates live in a waterbody. This activity, best completed outdoors, introduces the concept of a bioindicator and includes resources for educators to organize a field trip to a waterbody for their students. Also included is an in-class extension activity that can be used as an alternative to a field trip experience or as a follow-up activity.

This activity is adapted from the New York State Department of Environmental Conservation Water Assessments for Volunteer Evaluators (WAVE) protocol:
https://www.dec.ny.gov/docs/water_pdf/waveinstructions2021.pdf

Teacher Information

- NYS DEC WAVE video training series: https://youtube.com/playlist?list=PLnBbYubhbH1Xm88bAcosUMlHX58H4s6eK
- Stroud Center Aquatic Macroinvertebrate identification materials: https://stroudcenter.org/macros/key/

Materials Needed:

- Kick nets and/or dip nets
- Buckets
- Spoons
- Pipets
- Plastic petri dishes
- Macroinvertebrate data sheet
- Aquatic Macroinvertebrate field guide

Students use nets and buckets to collect aquatic macroinvertebrates at Cazenovia Creek

Learning Outcomes:

Students will be able to:

- Define the terms bioindicator and aquatic macroinvertebrate
- Name one species that is pollution tolerant
- Name one species that is pollution intolerant
- Make a hypothesis about the health of a waterway

New York State P-12 Science Learning Standards (HS)

- HS-LS2 Interdependent Relationships in Ecosystems
  - Use mathematical and/or computational representations to support explanations of biotic and abiotic factors that affect carrying capacity of ecosystems at different scales.
- HS-LS4 Natural Selection and Evolution
  - Construct an explanation based on evidence for how natural selection leads to adaptation of populations

Background and Activity Steps:

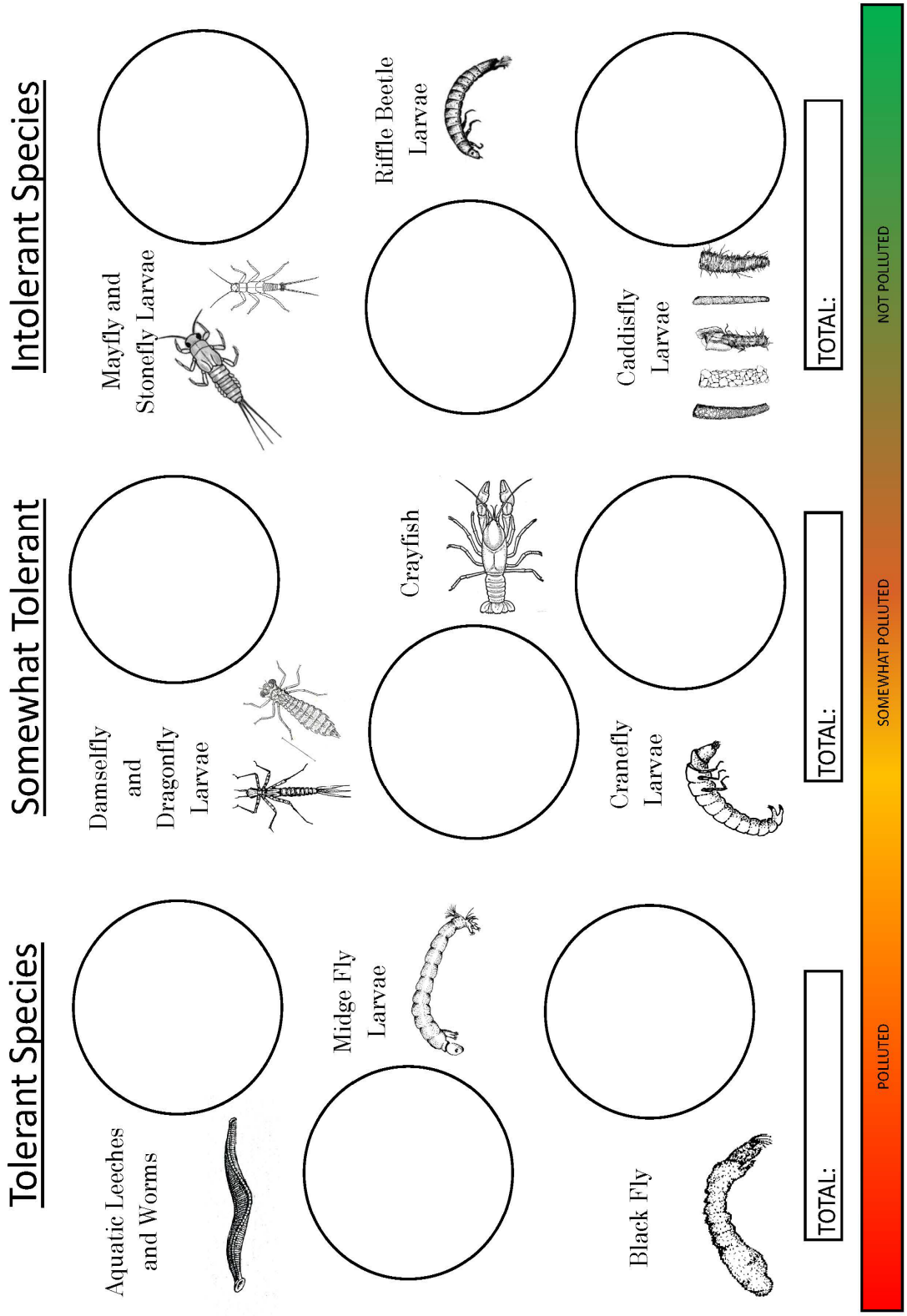
An **aquatic macroinvertebrate** is an insect without a backbone, that can be seen with your naked eye, and that lives some or all its life in aquatic environments like streams, creeks, and ponds. Macroinvertebrates like dragonflies, mayflies, and stoneflies spend the first stage of their life living in and around the sediment at the bottom of waterbodies. Later, they emerge from the water and undergo metamorphosis to become the flying adults that we most closely associate with those species. Immature stages of insects – nymphs, pupae, and larvae, are abundant in water and are an important part of the food web.

The insect orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies) are generally sensitive to pollution. Waterbodies with clean water are more likely to contain these macroinvertebrates. Other species of macroinvertebrates are not as sensitive to pollution and can be found in waterbodies even when they are polluted. When scientists find pollution sensitive insects in a water body, they can make conclusions about the quality of that water. Macroinvertebrates are **bioindicators** because their presence or absence in an ecosystem is used to analyze that ecosystems health.

1. Choose a field trip location / sample site. Be sure to consider safety and accessibility!
    a. Can students safely get to the water?
    b. Make sure to plan how you will manage the group when near the water.
2. Bring students and materials to site.
3. Explain sampling protocol to students
    a. One student will step into stream and place the mouth of the net so that it is facing the flow of the water. Another student will step into the stream, upstream from the net and disturb the stream bottom by kicking in the water.
4. The macroinvertebrates will be disturbed, and the flow of the water will bring them into the net.
5. Students can carefully pick up and rub stones directly in front of the net
6. Students can temporarily place insects in buckets filled with stream water, use pipets and petri dishes to carefully separate insects from one another.
    a. Using a field guide or other identification tools like a dichotomous key, guide students in noticing features about the insects. Compare them to one another.
7. Using the data sheet, determine and group the macroinvertebrates found.

Indoor Extension Activity: *If weather or other factors keep you indoors, this activity can be completed as a hypothetical trip to a local stream or creek. Explain the sampling protocol to students. This activity is also a chance for students to practice using keys and identifying aquatic macroinvertebrates in preparation for a field experience.*

1. Introduce key terms – aquatic macroinvertebrate, bioindicator, and pollution intolerant
2. Print photos of insects: https://stroudcenter.org/macros/gallery/
    a. Be sure to print photos without names of insects. Randomly group insect photos and present them to students as what was collected in a creek or stream.
    b. Have students work in small groups, using the dichotomous key and data sheet to identify and sort organisms as they would in the field. https://stroudcenter.org/macros/key/



Macroinvertebrate data sheet, insect drawings from the Stroud Water Resource Center

Topic #2: Issues and Solutions

What issues impact our waterways?

How can we work together to protect and restore our waterways and ecosystems?

View of the Niagara River at Beaver Island State Park

Plastic pollution along the shoreline at the Niagara River

Lesson 4 – Environmental Justice in Your Environment

Lesson for High School Students

Description: Students will explore environmental justice concerns within their environment and the United States at large. Students will read a critical thinking passage, watch a video, and answer discussion questions about environmental justice.

This activity is the first part of a separate, three-part series called "Environmental Justice in Your Environment". The full series combines critical thinking activities, outdoor activities, and virtual mapping activities using the United States Environmental Protection Agencies (USEPA) tool EJSCREEN. *https://bnwaterkeeper.org/wp-content/uploads/2021/02/Environmental-Justice-in-Your-Environment_Lesson-Series-2.pdf*

Teacher Information

Environmental justice focuses on the fair distribution of environmental benefits and burdens. An environmental justice issue or concern arises when the distribution of environmental benefits or burdens is unfair. **Environmental racism** is a term that describes actions or decisions that result in the disproportionate exposure of black, Indigenous, and people of color to environmental hazards. Environmental classism is a term that describes environmental justice issues that occur unfairly to poor and working-class people. Unfortunately, most environmental justice concerns are examples of environmental racism or **environmental classism**. Exploring **environmental justice issues** is the first step in responding to the unfair distribution environmental benefits or burdens in a community.

- United States Protection Agency Environmental Justice Information and mapping tool "EJSCREEN" : https://www.epa.gov/ejscreen
- Color of Pollution: Environmental Racism video by The Stream: https://youtu.be/nV4MCL-yBFM

Learning Outcomes

- Students will learn key terminology related to environmental justice
- Students will practice critical thinking, scientific literacy, and reading comprehension skills
- Students will make connections to their environment and environmental injustices in their community

New York State P-12 Science Learning Standards (HS):

- HS- ESS3 – Human Sustainability
- HS – ETS1 – Engineering Design
- HS – LS2 – Interdependent Relationships in Ecosystems

Materials Needed

- Student activity worksheets
- An electronic device (smart phone, tablet, and/or computer) with internet access

Student Worksheet - Introduction to Environmental Justice

Name _____ Date_____

Instructions: Gather the materials listed below and follow the instructions. Complete the worksheet by reading the passage, watching the video, and responding to the questions. Websites linked in the footnotes at the bottom of each page provide more information. If you are struggling to understand a concept or a question, click the link to read more about a topic. In this activity we will explore basic terminology that helps us think about what our environment is, how it benefits us, and how we impact it.

Materials Needed

- This student worksheet
- Writing utensil
- An electronic device (smart phone, tablet, and/or computer) with internet access to watch a video online

Read the passage below, **Introduction to Environmental Justice**

> Our ***environment*** encompasses where we live, work, play, and go to school, as well as the physical and natural world. When we talk about the environment we often focus only on the natural components- the land, air, water, and living things. These parts of the environment do provide us with many benefits. The land is space for animals to live, for humans to grow crops to eat, and for trees and forests. We depend on air to breathe. We need clean water to drink, fish, and for a place to swim.
>
> The other components of the environment are human, or human made. Just like the natural components, they provide us with many important benefits. A building is a safe place to live, work, or go to school. Roads help us get to where we need to go. Our educational system (the school you go to, sports you play, clubs you are a part of) provides us with functional space for learning and physical activities. The human components of the environment include families, individuals, and ***communities.***
>
> Figure 1 on the next page highlights the various components that make up an environment. Are there any components of your environment missing that you would add? Mark them on the diagram.

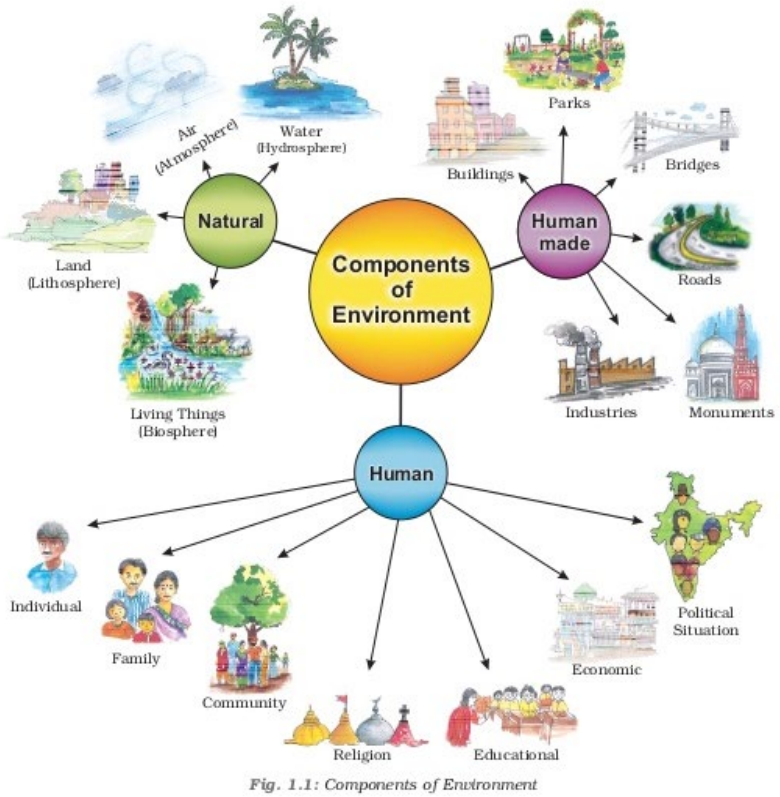


Figure 1: *Components of an Environment [2] This figure shows the natural, human-made, and human parts of the environment.*

Environments can be healthy, unhealthy, or somewhere in between. A ***healthy environment*** supports healthy communities of people, plants, and animals. An ***unhealthy environment*** can cause health problems in people and does not support healthy ***ecosystems*** or biodiversity. An ***ecosystem*** is the biological community of interacting organisms and their physical environment. A human ***community*** is a lot like an ecosystem because it is made up of people interacting with each other and the natural and human-made components of their physical environment.

Humans create ***pollution*** that spreads throughout the environment. Industries produce chemicals and toxins like PCBs, mirex, dioxin, pesticides, heavy metals, and plastic that pollute waterways and harm the fish that live in our streams, rivers, and lakes.[3] Landfills or hazardous waste sites can put chemicals into the soil, air, or water. Power plants put chemicals like mercury into the air. [4]

[2] From Human-Environment Interaction to Environmental Informatics (III): the Social-Ecological Systems dynamics in Knowledge-based Society, Coman, Mirela and Cioruța, Bogdan

[3] New York State publication – Health Advice on Eating Sportfish provides information on the types of pollution that impacts fish and people who eat fish https://www.health.ny.gov/publications/2800.pdf

[4] US EPAs webpage about pollution in the air and power plants https://www.epa.gov/mats/cleaner-power-plants

Pollution in the water, soil, or air causes human health problems such as cancer, asthma, and a wide-array of other devastating health issues.[5] In the United States, people of color and people in low income communities are ***disproportionately*** impacted by this pollution.[6] To disproportionately impact means that one group is impacted at a rate that is higher than that of another group when the size of the two groups is the same.

People of color and people in low-income communities are more likely to live near polluting facilities like industries, hazardous waste sites, and landfills, and therefore more likely to live in an area with poor air and water quality. These communities of people are disproportionately at risk of certain health problems because their homes are closest to the most polluted places. Specifically, in New York State, people of color suffer disproportionately from numerous health problems compared to other racial and ethnic groups.[7]

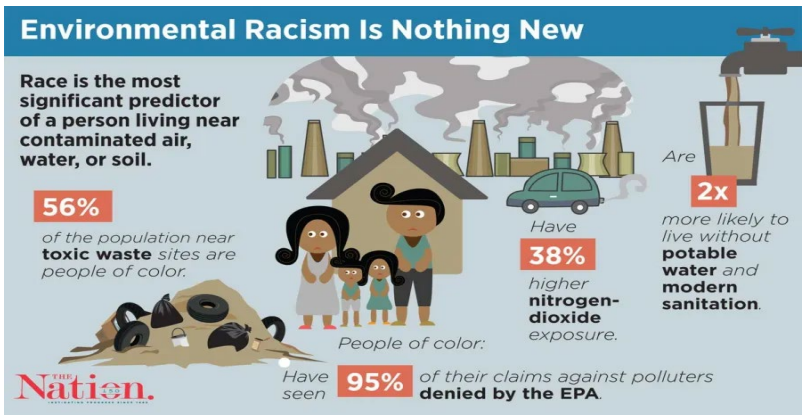


Figure 2: *The diagram above shows that race is the most significant predictor of a person living near contaminated air, water, or soil. Class or income is the second most significant predictor. These groups of people experience health disparities due to their higher likelihood of exposure to environmental risks like pollution.* [8]

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[5] USEPA EnviroAtlas Tool webpage explores the public health connections to environment and ecosystem services https://enviroatlas.epa.gov/enviroatlas/Tools/EcoHealth_RelationshipBrowser/index.html

[6] Environmental Justice Atlas webpage provides information on environmental justice concerns in the United States and around the world https://ejatlas.org/

[7] New York State Health Equity Report from April 2019 https://health.ny.gov/community/minority/docs/health_equity_report_2019.pdf

[8] "Race Best Predicts Whether You Live Near Pollution" by Bryce Covert https://www.thenation.com/article/archive/race-best-predicts-whether-you-live-near-pollution/

While an unhealthy environment can lead to human health issues, a healthy environment can improve human health in a community. Forests and other green spaces reduce concentrations of pollutants in the air, such as carbon monoxide, sulfur dioxide, nitrogen dioxide, and ozone. Public parks, trails, and waterways provide a space for people to exercise, which improves health. People of color and low communities have less access to green spaces, public parks, and trails and are less likely to have access to their benefits.

Environmental justice focuses on the fair distribution of environmental benefits and burdens. An ***environmental justice issue or concern*** arises when the distribution of environmental benefits or burdens is unfair.

Environmental justice means that everyone should have fair treatment regardless of race, color, national origin, or income, when it comes to environmental policies and regulations. Exploring environmental justice issues is the first step in responding to the unfair distribution environmental benefits or burdens in a community. The goal of environmental justice is to have a society where everyone has the same degree of protection from environmental and health hazards, and equal access to the decision-making process to have a healthy environment in which to live, learn, and work.

Please respond to the following questions

1. In your own words, using context clues from the passage above, please define the vocabulary terms:

   Environment:

   _____
   _____
   _____

   Community:

   _____
   _____
   _____

   Pollution:

   _____
   _____
   _____

   Disproportionate:

   _____
   _____
   _____

Environmental Justice:

_____
_____
_____

2. Look back at **Figure 1***: Components of an Environment*. What components would you add and why? If you do not have any to add then describe which component of your environment that you use the most.

_____
_____
_____
_____

Please watch this video called "Environmental Injustice Explained" (https://www.youtube.com/watch?v=dREtXUij6_c) [9] and answer the questions below:

2. What community do you live in? _____

3. Do you believe your environment and your community is healthy? Please explain why or why not.

_____
_____
_____
_____
_____

4. Have you ever visited an environment or community that you thought was healthy? Where was that environment? What led you to believe that it was healthy?

_____
_____
_____
_____
_____

[9] "Environmental Justice Explained" video produced by Grist https://www.youtube.com/watch?v=dREtXUij6_c

Description: Students will analyze two common water quality issues that impact waterways throughout the Niagara River Watershed. In activity 5a, students use a refractometer (salinity meter) to measure salt level in a sample of water, an indicator of road salt pollution. In activity 5b, students learn about wastewater, stormwater, and combined sewer overflows. Students will analyze and graph bacteria and weather date and reflect on potential infrastructure improvements to help improve water quality.

Teacher Information

Learning Outcomes:
Students will be able to:

- Define runoff and explain how it impacts local waterways and wildlife
- Analyze water quality samples for salinity using a refractometer
- List best management practices for deicing roads and alternatives for road salt
- Explain where their water goes when they flush, how it is treated, and how it enters back into the watershed
- Graph and analyze bacteria and weather data
- Design solutions to sewage pollution issues

New York State P-12 Science Learning Standards (HS):

HS. ESS2: Earth's Systems

- Students will be able to analyze and graph local water quality and weather data and construct an argument based on evidence that Earth's systems, specifically the water cycle, are impacted by human-designed sewer systems and climate change.
- Students will be able to make an evidence-based forecast of the impacts of climate change on their local communities and Earth's systems.

HS-ESS3: Human Sustainability

- Students will be able to construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- Students will be able to evaluate a solution (green/living infrastructure)- to the issue of combined sewer overflows to mitigate the human impacts to Earth's natural systems.

HS-ETS1: Engineering Design

- Students will be able to develop a solution to a complex real-world problem in their local community – combined sewer overflows– through designing green infrastructure solutions to be used at their home or school.

Activity 5a - Road Salt

The goal of this activity is for the audience to understand that road salt and other items on roadways have the potential to **runoff** into local waterways. When **pollutants** like road salt enter a waterbody, they impact water quality and can harm local wildlife.

Materials

- Portable Refractometer
- Pipettes
- Kim wipes
- Various water samples with varying level of salt content
- Watershed Model (if desired)
- Salt shaker

Vocabulary: watershed, groundwater, impervious surface, pollution, runoff, salinity, brine, infiltration, refractometer, chloride

Facts:

- Water than cannot soak into the ground is called **runoff**. If a **pollutant** is on the ground, especially on an **impervious surface** like a roadway, it can be carried along with the runoff directly into a waterbody. Runoff can be a serious source of water **pollution**.

- Western New York and the Great Lakes region receive high amounts of snowfall. These areas use road salt to help melt the snow and ice. The most commonly used de-icing chemical is **sodium chloride (NaCl)** also known more commonly as **road salt.** Road salt is used to reduce the adherence of snow and ice to the pavement, preventing the formation of hard pack.

- Salt lowers the freezing point of water, but loses its effectiveness below 15-20°F.Salt crystals pull water molecules out of the ice on the ground. This forms a brine. This brine accelerates melting.

- Road salt enters our water supplies through **runoff** into surface waters and i**nfiltration** into groundwater.

- In Erie County, 50 cities, towns and villages pool together to get their road salt. A ton of road salt cost $56 in 2018, increasing from years past. ○ According to Erie County Department of Public Works, the price in road salt contributed to a $400,000 budget hit to the county.

- **Chloride** concentrations are increasing at a rate that threatens the availability of fresh water in the northeastern United States. Increases in roadways and deicer use can impact salinity and chloride content in fresh waters, resulting in degradation of habitat for aquatic organisms, and impacting large supplies of drinking water for humans throughout the region. Road salt is currently not regulated as a primary contaminant to fresh waters of the United States.

- **Salinity** is the saltiness or dissolved inorganic salt content of a body of water. ○ Seawater has a chloride ion concentration of about 19,400 mg/L (a salinity of 35.0 ppt or 35%)

- Brackish water in tidal estuaries may have chloride levels between 500 and 5,000 mg/L (salinity of 1 to 10 ppt).

- Freshwater streams and lakes have chloride levels that can range from 1 to 250 mg/L (salinity of 0.001 to 0.5 ppt or less than 0.05%).

Activity:

- Use a plastic pipette to collect water from one of the provided sample jars.
- Open the cover plate on the refractometer and place 2-3 drops on the prism surface (blue)
- Close the cover plate and ensure the water has spread out over the surface of the prism
- Wait for a few moments, then look into the eyepiece. Works best in a bright area.
- Read for Salinity. Compare to other water samples.

Note, water quality can also be tested specifically for Chloride to indicate presence of Road Salt Runoff. You can use a salinity meter for educational purposes as the test can be replicated over and over again at a low cost.

Discussion Questions

1. After a snowstorm, describe what the roads are like near your home or school.

2. How can we test to see if road salt applied to streets is in the waterway?
    a. Test water supplies before and after road salting

3. How does road salt get into the waterway?
    a. Road salt dissolves into melt water and can runoff into a waterway
    b. Road salt can dissolve into water and move through the soil into groundwater

4. How would you expect stream water in an area with a lot of roads to compare to stream water in an area with a forest without many roads?
    a. More salt will be used in areas with more roadways.

5. Is salt a normal part of a forest or freshwater ecosystem? How will Salt impact these ecosystems?
    a. No, organisms in these environments are not adapted to excess salt

6. Do alternatives to Road Salt exist?
    a. Sand, Sugar beet juice, various salty brines

7. Best Management Practices exist to help municipalities use the correct amount of road salt to keep drivers safe, but also protect waterways and wildlife. Ask your local government official to learn more.

Activity 5b – Sewage and You

Sewage and You: Data Analysis, Graphing, and Interpretation

Overview: What happens when you flush the toilet or when water runs down the sink drain? Does this wastewater impact our local waterways? This lesson allows students to learn the basics about sewer systems and how water quality can be impacted through data analysis.

Materials:

- Photos of combined sewage system and separate sewage system
- Photos of green/living infrastructure
- Video: https://vimeo.com/238134756

Discussion Topics:

Start by reviewing the water cycle – be sure to include the concept of runoff! Ask students what happens when water soaks into lawns or gardens. Ask students what happens when water lands on roadways or parking lots.

Watch this video with students to enforce terms like permeable/pervious and impermeable/impervious and to introduce the concept of sewer systems: https://vimeo.com/238134756

Discuss the differences between combined sewer systems and separate sewer systems. What system is in your local community? Where is the wastewater treatment facility located? Ensure students understand what causes CSOs and how they impact water quality of streams and rivers. Discuss potential solutions to combat CSOs.

Explain the activity to the students. They will graph 2 sets of data: Bacteria data collected by Buffalo Niagara Waterkeeper and weather data collected at regional weather stations. Using these graphs students will answer several questions to ensure their understanding of CSOs.

Sewage and You: Data Analysis, Graphing, and Interpretation

STUDENT GUIDE

Objectives:

- Analyze and graph bacteria and weather data.
- Interpret the data to understand the impact of Combined Sewer Overflows (CSOs) on local water quality.
- Reflect on potential infrastructure improvements and consider applications for specific locations.

Materials:

- Pencil
- Graph paper (provided)

Background:

According to the USEPA, the average American family uses more than 300 gallons of water per day at home. Much of this water ends up going down the drain (down the toilet, down the sink drain, etc) and becomes **wastewate**r. This wastewater can contain many pollutants that can negatively impact the environment and human health.

Sewer systems are a network of pipes and pumps that collect wastewater from homes, businesses, and industries. Before sewer systems, wastewater was often discharged untreated into waterways resulting in many health and environmental issues including water-borne diseases. Today, sewer systems bring wastewater to wastewater treatment plants. These plants take the wastewater through many complex processes to remove large debris and fecal waste and smaller pollutants before discharging the cleaned **effluent** into a waterway.

In older cities, including Buffalo and Niagara Falls, the sewer systems were designed to collect and transport both the waste from homes and business as well as **stormwater**. These types of sewer systems are known as **combined sewer systems**. During wet weather events, like a heavy rainfall, a lot of stormwater enters the sewer system and can be too much water for the sewer system to handle. These wet weather events trigger **combined sewer overflow** (CSO) events. By design, combined sewer systems have overflows or outfall pipes. This is an opening into a local river or stream that allows waste to overflow and exit the sewer system. This design prevents waste from backing up into basements. However, these overflow events bring untreated wastewater into waterways. This increases the number of harmful bacteria in the water, often making it unsafe to swim or engage in other water recreation. In areas where there is a lot of **impermeable** surfaces, the likelihood of a CSO increases as excess stormwater enters the system from parking lots and roadways.

There are several ways to address CSO's.

- **Storage Tanks:** Underground storage tanks that capture and store excess combined sewer flow. During dry weather periods these retention basins can be pumped out and the sewer flow can be directed to the wastewater treatment plant.

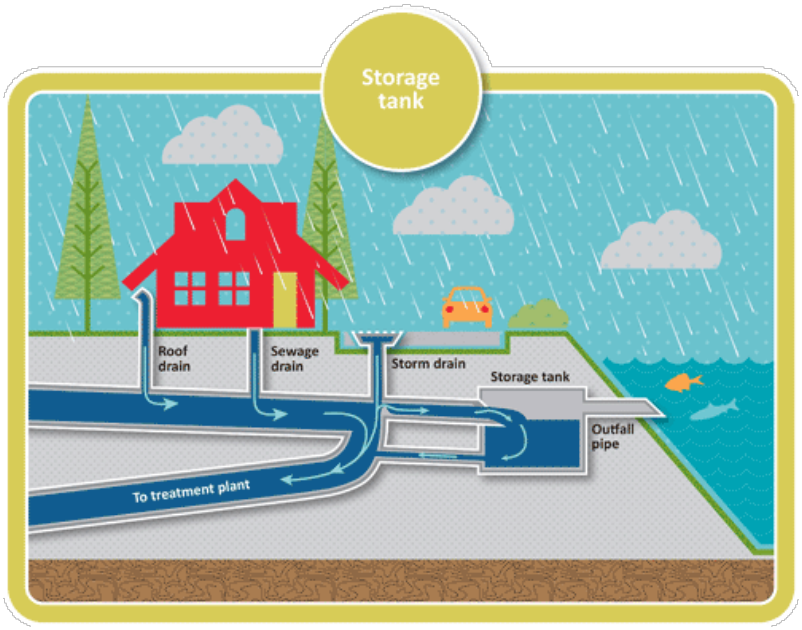


Image: www.kingcounty.gov/

*The following are **Green/Living Infrastructure** examples which uses vegetation, soils, and other elements to manage water in a way that mimics the natural water cycle. These examples keep stormwater from entering the sewer system, helping to prevent CSOs.*

- **Bioswales:** Bioswales or vegetation swales (sometimes called rain gardens) are channels or depressions in the earth that are designed to capture, and filter stormwater. These are typically vegetated to assist with water absorption. There is often a pipe allows for excess stormwater not absorbed through the system to exit, cleaner than when it entered the bioswale.

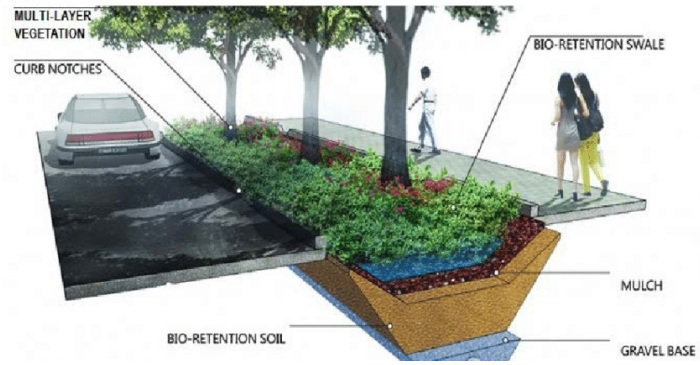


Image: www.researchgate.net/

- **Pervious Pavement:** pervious or permeable pavement can be used on streets, sidewalks, or parking lots. The porous design allows rainwater to soak into the earth and not runoff into a storm drain.

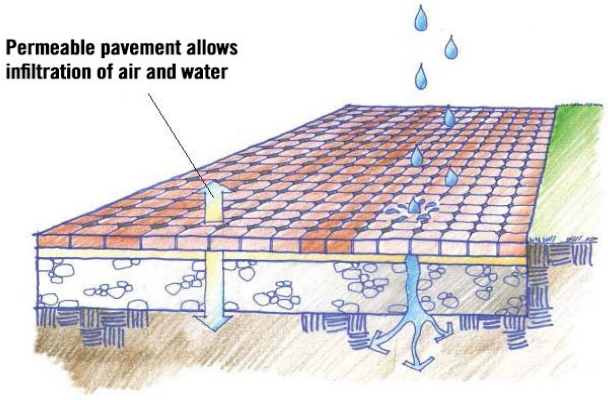


Image: www.cityofdubuque.org

- **Green Roofs:** Green roofs encompass plants, layers of soil and other materials installed on top of a building. There is an important membrane and drainage layers to protect the building. Green roofs absorb rainfall and help improve air quality.

Green Roof Detail:

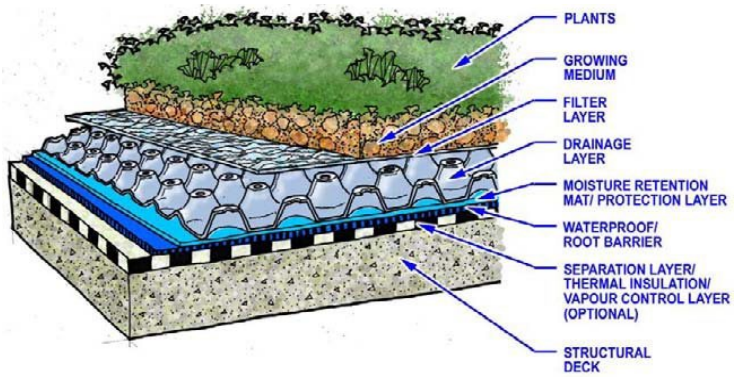
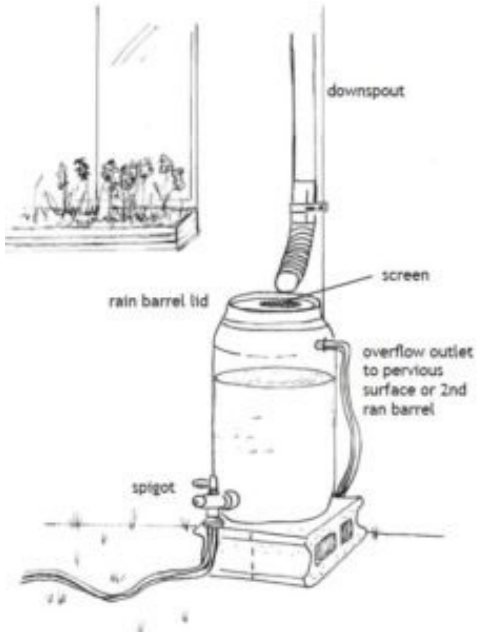


Image: www.researchgate.net/

- **Rain Barrels:** Rain barrels are containers that collect and store rainwater for future uses (like watering a garden) while decreasing the amount of stormwater runoff that leaves your property. A rain barrel is placed under the downspout to channel rainwater into the barrel for later use.



A different type of sewer system is a **separate sewer system**. In this system water from homes, businesses, and industries are collected separately from stormwater. Sanitary sewer systems can also experience overflows when sewer pipes get clogged, pumping stations break down, if a sewer line is broken, of because of illegal tie=ins of home downspouts and sump pumps to the sanitary sewer. These overflows may occur at manholes on the street, pipes leaking underground, or at home (sewage backup). Sanitary sewer overflows can also result in water quality issues.

If you live in a rural community your home may have a septic tank to collect wastewater. Regular maintenance is required to prevent system failures, which can negatively impact groundwater.

When untreated sewage flows into waterways during overflow events, bacteria, chemicals, and other pollutants enter the waterway.

Bacteria are single-celled organisms that occur in a variety of forms and have a wide range of properties. Some cause disease while others decompose decaying organic material and serve as food for other organisms in the food chain.

Pathogenic (disease-causing) bacteria, viruses, and protozoans are often found in fecal waste. These pathogens can cause a variety of illnesses and diseases when ingested during recreational contact or consumed in contaminated water and shellfish. Fecal waste from humans or other warm-blooded animals may enter a waterbody from various sources including:

- faulty wastewater treatment plants
- livestock, wildlife, or pets
- malfunctioning septic systems
- untreated sewage discharge
- stormwater runoff
- boat waste.

The presence of indicator species suggests the presence of fecal waste that may include pathogenic microorganisms that pose a health risk. In addition to possible health risks associated with elevated levels of fecal material, it can also cause cloudy water, nutrient enrichment, unpleasant odors, and an increased oxygen demand.

Escherichia coli (*E. coli*) is a species within the fecal coliform group that is specifically associated with the fecal waste of warm-blooded animals. Buffalo Niagara Waterkeeper collects water samples at various sites throughout the Niagara River Watershed and tests the water for *E. coli.* Results of the water tests are presented as # of colony forming units per 100mL of water. The higher the # of colony forming units, or CFUs, the more *E. coli* in the water. When *E. coli* levels are elevated water recreation is not safe. The Environmental Protection Agency (EPA) has a Beach Action Value of 235 CFUs/100mL of water that can be used by states to make beach notification decisions (like closures).

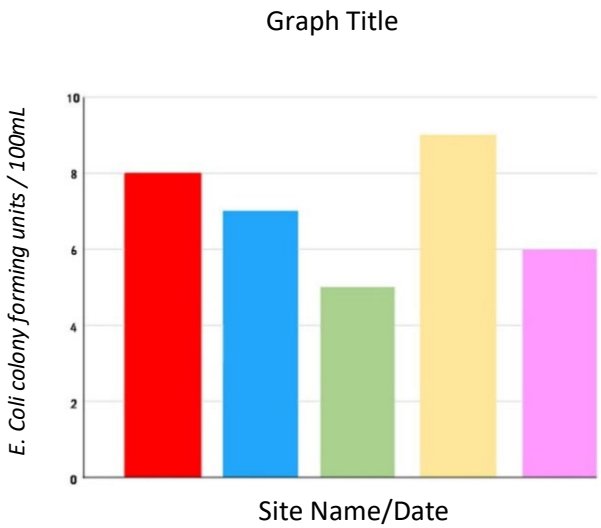
Before moving onto the activity, please watch these videos:

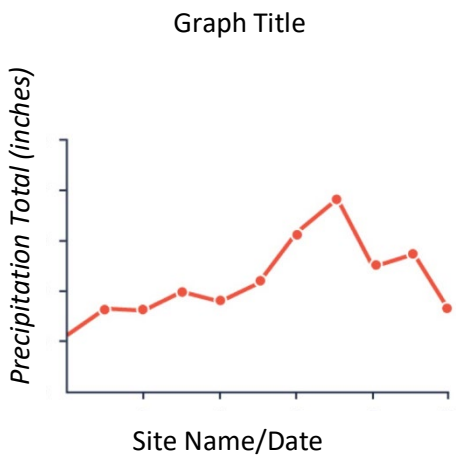
- https://vimeo.com/238134756
- https://www.youtube.com/watch?v=U6pR7wNFSe4&feature=youtu.be

Activity:

Using the following 2 data sets (Bacteria and Weather) create a graph of each, separately, on the graphing paper provided. Create a bar graph for the bacteria data and a line graph for the weather data. Be sure to label the x and y axis and create a descriptive title for each graph.

Example graphs:





Bacteria Data:

DATE	SITE	Coordinates	*E. coli* colony forming units /100mL
5/18/2020	Cazenovia Creek at Southside Parkway	42.859502, -78.822733	2900
6/9/2020	Cazenovia Creek at Southside Parkway	42.859502, -78.822733	200
6/9/2020	Hyde Park Lake	43.099997, -79.023319	200
7/17/2020	Hyde Park Lake	43.099997, -79.023319	600
9/21/2020	Buffalo River at Riverworks	42.869795, -78.871293	0
9/30/2020	Buffalo River at Riverworks	42.869795, -78.871293	2900

Weather Data:

Source: Weather Underground https://www.wunderground.com/

Date	Weather Station Location	Precipitation Total (inches)
5/18/2020	Buffalo, NY	0.56
5/18/2020	Niagara Falls, NY	0.39
6/9/2020	Buffalo, NY	0.00
6/9/2020	Niagara Falls, NY	0.00
7/17/2020	Buffalo, NY	0.89
7/17/2020	Niagara Falls, NY	0.42
9/21/2020	Buffalo, NY	0.00
9/21/2020	Niagara Falls, NY	0.00
9/30/2020	Buffalo, NY	0.80
9/30/2020	Niagara Falls, NY	0.32

Questions:

Answer the following questions based on the bacteria data, weather data, and the two graphs you created.

1) Did precipitation values impact the level of *E. coli* in the waterway? Explain how or how not.

_____

_____

_____

_____

_____

2) What do you believe to be the source(s) of the *E. coli* at these locations? Do you believe the sources are the same at each site or different? Why?

_____

_____

_____

_____

_____

3) What type of Sewer System is in your community? (combined or separate) Where is the Wastewater Treatment Plant Located? Review this list for some assistance. Look for a facility located in your town or nearby. Use the name of the facility as a clue! If you get stuck, use the internet to search for more information about your local treatment facility. https://bit.ly/3cS2SvW

_____

_____

4) In a combined sewer system what is 'combined'?

_____

_____

5) Are you aware of any locations that experience Combined Sewer Overflows? What evidence do you have to support your answer?

_____

_____

_____

6) How does the type of land surface impact a combined sewer system? Compare highly developed land and a forest. Utilize this website to help support your answer: https://runoff.modelmywatershed.org/

_____

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7) Do certain types of surfaces increase the chances of CSOs? If so, which ones and why?

_____

_____

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_____

8) If you could choose one type of green/living infrastructure to incorporate at your home or school, which would it be and why?

_____

_____

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_____

9) What would be the most effective way to make green/living infrastructure mandatory in cities?

_____

_____

_____

_____

10) Scientists predict that climate change will cause an increase in severe weather events like hurricanes, increased precipitation in the Northern United States, and increased flooding. As the world's climate continues to change, what will be the impact on combined sewer overflows?

_____

_____

_____

_____

11) The locations where Combined Sewer Overflows may take place are mapped and can be viewed here: https://maps.waterreporter.org/5c91b0349a8af8ba/ Do you notice any patterns or similarities in their distribution? Do you think that there are some communities that are more likely to be exposed to polluted waterways than others?

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Lesson 6 – Non-native Species

Lesson for High School Students

Description: Students will learn the difference between a native and a non-native species, and the impacts they have on an ecosystem. Students will also be introduced to native and non-native species of plants found around Western New York and explore food web interactions for other local species through the Web of Life Activity.

This activity is adapted from Buffalo Niagara Waterkeeper's Young Environmental Leaders (YELP) Program Curriculum

Teacher Information

- A digital copy of Buffalo Niagara Waterkeeper's Native Plant Guide can be received by signing up for our email list: https://bnwaterkeeper.org/nativeplantguide/
- Profiles of local invasive species can be found on Western New York PRISM's website: https://www.wnyprism.org/invasive_species/
- Fact sheets for both native and non-native species of plants can be found on the USDA's Natural Resource Conservation Service website:
    - https://plants.usda.gov/home/factSheetPlantGuideSearchResults?resultId=6bd00dd9-d348-4d31-a5dd-617458ae77b7
    - https://plants.usda.gov/home/noxiousInvasiveSearch
- Basic watershed information and healthy watershed indicators can be found on the EPA's website: https://www.epa.gov/hwp/basic-information-and-answers-frequent-questions
- An alternative version of the Web of Life Activity can be found on the EPA's website: https://www.epa.gov/sites/default/files/documents/weboflifeactivity.pdf

Materials Needed:

- Printed plant species fact sheets (if students will not be using their phones)
- Writing utensil
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit webpages
- For Web of Life Activity:
    - Index cards (One for each student)
    - Marker or pen
    - Ball of twine or string

Learning Outcomes:

Students will be able to:

- Describe the difference between a native and non-native species
- List several of the native and non-native species of plants found in New York State
- Identify the effects both native and non-native species have on their environments
- Describe food web interactions for local species

New York State P-12 Science Learning Standards (HS)

- HS-LS2 Interdependent Relationships in Ecosystems

Activity 6a: Native and Non-Native Plants of New York

Student Worksheet – Native and Non-Native Plants of New York

Name: _____ Date: _____

Directions: For this activity, you will look at information on several native and non-native species of plants in New York. As you read, underline vocabulary words descriptions, and other information you think might be important for understanding the ecological impacts these species have on their environment. After reading the fact sheets, answer the discussion questions.

Materials Needed

- Writing utensil, highlighter
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit webpages

Native and Non-Native Plants of New York

Source: Buffalo Niagara Waterkeeper

To understand the value of maintaining a healthy ecosystem, we need to understand what impacts the health of an ecosystem. The presence of native species of plants along a shoreline, in a park, and throughout our watershed is important to keeping ecological connections intact, but what exactly is a 'native species'? According to the National Parks Service, 'native species are natural to the area in which they are found and are specially adapted to that particular ecosystem.' In other words, native species come from the area in which they are found!

Native species of plants provide multiple benefits to their environments, including shelter, food, erosion control, and many others. However, the introduction of non-native and invasive species of plants to an area can disrupt ecological relationships and push out native species. So, what is a non-native species, and is it the same as an invasive species? As you might guess, a non-native species is an organism that was introduced to an area outside of its' native range, either intentionally or unintentionally. While they may not be specifically adapted to the environment they are introduced to, they are hardy enough to survive in a new area. When these non-native species start to push out native species of plants, fail to provide ecological benefits, and cause harm to the ecosystem they were introduced to, they are considered 'invasive'. Often, invasive species grow faster and more densely than native species and can outcompete native species that exist there. When other organisms depend on the native species that are being pushed out, their health is impacted as well.

1. Plant Species Native to New York State

Visit the USDA 'Fact Sheet' and 'Plant Guide' pages for the three following species of plants, all of which are native to New York State. As you read, highlight or take note of important information, including its uses in the environment, the relationships it has to other organisms, and the conditions to which it is adapted. Afterwards, answer the following questions for each of the species. Feel free to use additional resources you may find online to help you answer the questions.

- Tree - Red Maple (*Acer rubrum*):
  - Fact Sheet
  - Plant Guide
- Shrub – Eastern Redbud (*Cercis canadensis*):
  - Fact Sheet
  - Plant Guide
- Grass – Big bluestem (*Andropogon gerardii*):
  - Fact Sheet
  - Plant Guide

Discussion Questions (answer for each of the species above):

1. Give a brief description of the plant: What are the leaves like? How large does it get? Is it a woody or herbaceous plant?
2. What is the native range of this plant?
3. How does this plant spread seed? Is it pollinated by any birds or insects?
4. When does this species reproduce?
5. What ecosystems is this plant adapted to? Can it tolerate a range of conditions?
6. Is this species the target of any native herbivores? Nonnative herbivores?
7. What relationships to other species (including humans) does this species have?
8. Is this species commonly planted in other areas (i.e., gardens, greenhouses, farms)?
9. Is this species susceptible to any diseases?
10. Is this species considered endangered, threatened, or neither?
11. Does this species require any specific conditions for its seeds to germinate?

2. Plant Species That Are Not Native to New York State

Visit the USDA and Western New York PRISM invasive species pages for the three following species of plants, all of which are non-native to New York State. As you read, highlight or take note of important information, including its uses in the environment, the relationships it has to other organisms, and the conditions to which it is adapted. Afterwards, answer the following questions for each of the species. Feel free to use additional resources you may find online to help you answer the questions.

- Tree – Norway Maple (*Acer platanoides*):
  - USDA Profile
  - Western New York PRISM Profile
- Shrub – Japanese Barberry (*Berberis thunbergii*):
  - USDA Profile
  - Western New York PRISM Profile
- Grass – Chines silvergrass (*Miscanthus sinensis andersson*):
  - USDA Profile
  - Western New York PRISM Profile

Discussion Questions (answer for each of the species above):

1. Give a brief description of this plant: How does it grow? What does it look like?
2. What is the native range of this plant?
3. What conditions is the plant adapted?
4. How, and if applicable, why was this plant introduced to New York?
5. Where else is the non-native species present?
6. How does this species spread?
7. Are there any laws in place preventing the sale of this species?
8. What other plant species might this plant compete with?
9. Does this species grow fast or slowly?
10. What potentially harmful ecological effects does this plant have on the areas in which it is introduced?
11. How is this species managed/controlled? Have control efforts been successful?
12. Is this species a high priority for control in New York?

Activity 6b: Web of Life

Student Worksheet – Web of Life

Name: _____ Date: _____

Directions: For this activity, you will explore and discuss interactions between living and non-living components of an ecosystem. Your class will work together to determine how organisms are connected to their environment and each other, and how their presence or absence affects the health of the ecosystems in which they live. As you complete the activity, consider how these interactions might change if the species were placed in different environments, or if an invasive species were to be introduced.

Materials Needed

- Index cards (At least one for each student)
- Marker or pen
- Ball of twine or string

Web of Life Activity

Source: Adapted from the Environmental Protection Agency and Project Learning Tree

All ecosystems are composed of living and non-living components. These components make up a complex web of interactions, including sources of food and shelter, and the living components depend on each other and the environment to survive. The presence or absence of even one of these components can drastically affect the ecosystem and destabilize it. A food chain is a simplified way of showing energy relationships between plants and animals in an ecosystem. For example, a food chain of sun, plant seed, mouse, owl shows that a plant seed that grows from the sun's energy is eaten by a mouse, which in turn is eaten by an owl. However, it is rare for an animal to eat only one type of food. A food web represents the interaction of many food chains in an ecosystem. Before beginning this activity, think about what the food web of various ecosystems might look like. What does the food web of your backyard look like? What about the nearest forest? Or Lake Erie? Food webs can be drawn out at both small and large scales, each containing complex sets of interactions.

Directions:

1. Label a set of index cards with various organisms and non-living components of an ecosystem. Try to make them relevant to New York State, and make sure there are at least enough for each student to have one card. Below are some examples
    a. Sun
    b. Water (rain, lake, pond, river, etc.)
    c. Boulder
    d. Leaf litter
    e. Bumblebee
    f. Earthworm
    g. Robin
    h. Sugar Maple
    i. Big bluestem (see previous activity)

2. Punch holes in the index cards and use some twine to make necklaces for each of the students. Pass one out to each person.
3. Stand in a circle with your class. Think about which card represents the resource that all life needs to grow. Hand the end of the ball of twine to the student with the card that all life needs to survive. This student should hold onto the end of the twine.
4. The student at the beginning of the web now throws the ball of twine to another student with a card that interacts in some way to the starting card. The student who catches the ball should describe how their card is connected to the person who threw it to them. If they get stuck, the class can help determine the relationship.
5. The student who caught the ball of twine should then throw it to someone else in the circle. Repeat the previous step until all the students have a piece of the twine, and the web of life is complete.
6. The student with the original end of the string should now gently begin tugging. If someone feels a tug, they should tug their end in response. Eventually, everyone in the circle should feel a tug on their piece of twine. Notice how all components of the ecosystem are connected!
7. At this time, an environmental stressor can be introduced. It can be human made (like an oil spill), or natural (like a hurricane or severe storm).
8. Talk as a class about how the stressor impacts the entire ecosystem, and how the web would be impacted if this stressor removed one of the components of the web.
9. Have one or more students drop out of the circle and examine how the web changes.
10. Repeat this activity with students playing different roles, both living and non-living. Explore their relationships to multiple other components.
11. Consider the following questions once the activity is complete:
    a. What happens when an element of the food web is removed?
    b. What happens when an element of the food web is added? What if that element is an invasive species?
    c. Are changes to the ecosystem more dramatic when the system was composed of many parts, or when it had fewer parts?
    d. Are certain roles more important than others in the web? Are there replacements for certain components?
    e. In general, is the ecosystem more stable when it is complex and diverse, or when it is simple?
    f. What other stressors exist in our environment? Are they becoming more common?
    g. What might the future of this web look like? What do other webs of life look like?

Description: We all know litter is bad, but how much litter is in our environment? Where does it come from? This lesson allows students to collect, analyze, and interpret data on litter in the Niagara River Watershed and compare that data to a local cleanup and explore litter data from around the world.

This lesson is adapted from the "Litter in the Tennessee" by the Cumberland River Compact.

Teacher Information

Materials Needed:

- A piece of litter or photo of litter
- Video: https://www.youtube.com/watch?v=lrRsQi9jQ38
- **TIDES** Global Litter Database: https://www.coastalcleanupdata.org/

Background information:

The definition of a *watershed* is an area of land where all streams, rivers, and stormwater drain into the same waterbody. This means that all the trash found on land, on roads or in parking lots can eventually make its way to our waterways when it rains. Litter flows from small streams and eventually flows into major waterways like Lake Erie or the Niagara River, which is a drinking source for millions of people – including Western New York! Individuals taking action to collect litter in different spaces can help protect our local waterways and collecting data on that litter collected increases your impact!

In this activity, students explore litter pollution through data graphing, analysis, and interpretation. Students collect their own litter, record the data and compare their data to previously collected data from a large cleanup event. For extra points, students can upload their data to the Ocean Conservancy's largest litter database in the world, TIDES (*Trash Information and Data for Education and Solutions*), which helps to support data driven solutions to prevent litter pollution.

Students will submit a graph and narrative interpretation of the data to assess their understanding.

Discussion Topics:

Show the students a piece of litter you found or the photo of litter. Ask them what words come to mind when they see it. Tell students you are not sure where this litter came from, but you found it near a local stream or river. Have students brainstorm ideas about how that piece of litter got there. All of the ideas brainstormed should be connected to humans. Additional question: Have students seen this type of litter anywhere else? Why would it be important to collect information on the types of litter we find?

Watch the video. This will help students understand how litter gets in our waterways through storm drains.

Explain the activity to the students. They will collect their own data through a cleanup and also compare their data to cleanup data from a Buffalo Niagara Waterkeeper cleanup event.

Learning Outcomes:

Students will be able to:

- Collect data on the litter they pick up during a cleanup here locally
- Analyze that data by graphing their findings and entering that information into the largest litter database in the world, TIDES (*Trash Information and Data for Education and Solutions*)
- Interpret data they collect by comparing it to a larger local cleanup, as well as compare it to other datasets from around the world in TIDES.

New York State P-12 Science Learning Standards (HS)

- MS-ESS3-3 – Earth and Human Activity - Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- HS-ESS3-4 - Earth and Human Activity - Evaluate or refine a technological solution that reduces impacts of human activities on natural systems

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Plastic Pollution Solutions: Data Collection, Analysis, and Interpretation

STUDENT GUIDE

Objectives:

- Collect data on litter in your community through a **Solo Sweep**
- Analyze and graph litter data
- Interpret your data to understand how litter may impact water in the Niagara River Watershed
- Compare your data to cleanup data from a Buffalo Niagara Waterkeeper cleanup event and enter the data into the largest litter database in the world TIDES (*Trash Information and Data for Education and Solutions*)

Materials:

- Pencil
- Data collection paper
- Graph paper
- Gloves (for litter cleanup)
- Trash bag (for litter cleanup)

Background:

We have all seen litter or trash on the ground. Think of places where you often see litter. Litter can have negative impacts on the environment. During rain events, litter can also wash from the land into waterways directly, or through storm drains.

You can make a difference by cleaning up litter in your neighborhood, around your school, or other places you recreate. In these activities you will participate in a litter cleanup, collect data on the types of litter you find, and share the results using a graph. You will also compare your data to data from a Buffalo Niagara Waterkeeper cleanup event and have the opportunity to share your results on the Ocean Conservancy's global litter database, TIDES, (*Trash Information and Data for Education and Solutions*). After you analyze the data, you will create an interpretation, or explanation, of how the litter ended up on the group and what impact would it have had if it entered a local waterway.

Safety Note Always wear gloves when picking up litter. Do not enter busy roadways to pick up litter. Stay on public property and do not work alone. Use caution when picking up sharp objects like glass. To safely remove glass, pick it up using tongs and place it in an empty container, such as a coffee tin. When it is full, place the entire container in the trash bag.

Before moving on to the lesson activity, please watch this video:
https://www.youtube.com/watch?v=lrRsQi9jQ38

Activity: Litter Pickup/Solo Sweep

1. Review Safety Guidance: https://bnwaterkeeper.org/wp-content/uploads/2020/04/Cleanup-Safety-Infographic.png

2. Complete a litter pickup around your home, school or a public space in your local community. Spend at least 20 minutes picking up litter and complete the Data Sheet on the following page. (*20 points)*.

3. Graph your results on the graph paper provided. Create a bar graph with how many items you found. (*10 points)* Litter type and number of items should be used on the x and y axis. Which one goes where? Be sure to label your axes! (*2 points*)

4. Create an account on the Ocean Conservancy's largest litter database in the world, TIDES, (*Trash Information and Data for Education and Solutions*). Click on "Enter Data," in the top right-hand corner which will bring you to the world map. In the search bar, enter the street or location name where you completed the litter pick up. Click on the exact location on the map and a red pin will appear. Next click the blue button underneath the app that says "Enter Data." Then enter number of each item you found into the database and click "Submit and Finish" once you added all of your data! (5 *bonus points*)

Litter Collection Data Sheet:

Count how many of each item you find to make a graph.

_____Plastic Bag

_____Drink Can

_____Plastic Bottle

_____Glass Bottle

_____Snack Wrapper

_____Plastic Fork, Knife, or Spoon

_____Fast Food Wrapper or Bag

_____Cigarette Butt or Cigar Plastic Tip

_____Plastic Straw

_____Styrofoam Piece

_____Small Plastic Piece

If you find something not listed above, create your own category below.

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What was the strangest item you found? _____

What area did you clean up? _____

Were you surprised by what you found? Why or why not?

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1. Write a paragraph explaining what you found. Include how you think the litter ended up where it did. Include your thoughts on how the litter would impact on a local waterway if it made it that far. Refer to your data and observations for this explanation. (*10 points)*

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2. Look at data collected from a Buffalo Niagara Waterkeeper Cleanup event here: https://bit.ly/2UEgzEB Graph this data in the same way you graphed your own cleanup data on the following page. Compare to your cleanup data. What is similar? What is different? How many people do you think participated in this cleanup event? What does the data tell you about the site of the cleanup event and how could it be helpful to have this data? (*10 points*)

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Read the following excerpt from a Greenpeace Article
(https://www.greenpeace.org/international/story/21792/plastic-waste-environmental-justice/)

Corporations Profit from Plastics

Corporations like Nestlé (world's largest food & beverage company) and Unilever (British multinational consumer goods company) profit wildly from single-use plastic packaging, while peddling the myth of recycling as a solution. But anyone who has thought seriously about the issue can see that recycling could never handle the amount of plastic surrounding our everyday life.

Also, don't forget that plastic is itself created from fossil fuels and lobbied for by the fossil fuel industry, while they desperately try to maintain the single-use plastic status quo instead of tackling the problem at source. Only by stopping the production of single-use plastics can this crisis be addressed. But these companies try to keep you in the dark by claiming recycling can solve the plastic pollution crisis to ensure their profit at the expense of people right now, today.

Answer the following questions:

Who will ultimate pay for the damaging effects of plastic production? Do your parents and school pay for the cost of hauling their trash to the dump? Who do you think pays to maintain the dump in perpetuity? (*10 points*)

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Description: We know the oceans are rising, weather patterns are changing, and temperatures are increasing in response to global climate change, but where do we see the impacts here locally? In this lesson, students will define the difference between weather and climate, and learn about how climate change is impacting the Great Lakes region and here locally in Western New York.

Teacher Information

Background Information:

Climate change is driven by the burning of fossil fuels, development of land, energy production, and other human activities that increase the amount of carbon and other greenhouse gases into the atmosphere. Although global changes can be slow and hard for any one person to identify, scientists all over the world are studying a variety of factors that can identify patterns and predict how climate change will impact the planet in the future. The scale and scope of climate change is complex and intersects with many other societal issues around the globe. It is so important to learn how to define climate change, how it connects to the carbon cycle, and understand how it impacts where you live.

Discussion Topics:

Weather vs. Climate

"It's cold today, so the planet must not be warming", is a sentiment made by individuals that don't have a solid understanding of the difference between the two terms weather and climate. Ask the class to brainstorm any words or phrases that relate to the weather on sticky notes. Have them put all their sticky notes on the board and then as a class, categorize them as relating to weather or climate. Discuss the difference between the two and ask them to define each word.

1) **Weather**: The conditions of the atmosphere **over a short period of time**, at a **particular time and place** in terms of temperature, atmospheric pressure, wind, and moisture at a particular time and place.
2) **Climate**: A description of the **long-term pattern** of weather in a particular area. (Average weather conditions, identifiable patterns, occur over a long period of time)

The Carbon Cycle

Although the climate is always changing, it is currently changing faster than it ever has in human history. These rapid changes are causing catastrophic problems around the globe. The Earth's climate is regulated by complex interactions. The carbon cycle identifies how carbon impacts the climate as it moves through the four primary spheres of the planet: biosphere, atmosphere, hydrosphere, and lithosphere. The amount of carbon on earth has not changed since it was created and can be found in both living organisms, as well as in the atmosphere, rocks, and water. The carbon cycle influences many critical life processes such as photosynthesis and respiration, contributes to fossil fuel formation, and

impacts the earth's climate. How carbon moves through the cycle has significantly changed and understanding that change is fundamental for understanding the cause of the increasing global temperature.

1) **Carbon Cycle** - Cycle by which carbon is exchanged between the lithosphere, hydrosphere, biosphere, and the atmosphere.
    a. **Short term** – This includes photosynthesis, respiration, and predator-prey transfer of carbon. On land, photosynthesis allows carbon to flow from the atmosphere to plants and in water, the plants take carbon dioxide out dissolved in the water (Carbon dioxide constantly moves between water and the atmosphere via diffusion). Respiration and decomposition both allow carbon to flow back into the atmosphere.
    b. **Long term** – Lithospheric processes, like weathering and erosion of carbon-containing rocks, the accumulation of carbon-rich plant and animal material in sediments (**fossil fuels**).
2) **Greenhouse Gas** – Gas that absorbs heat and keeps the planet warm (water vapor, carbon dioxide, methane, nitrous oxide, and ozone). Carbon dioxide (CO2) is the primary greenhouse gas emitted due to human activities.
3) **Fossil Fuels** – Fuels that are burned for energy which are composed of decaying plants and animals (carbon and hydrogen) that have been extracted from the earth's crust. Examples include coal, oil, and natural gas.

<u>Materials Needed:</u>

- Pencil or pen, markers
- Printed Carbon Cycle Role Play activity cards and ping pong or other light object to represent carbon

<u>Learning Outcomes:</u>

Students will be able to:

- Differentiate weather from climate
- Understand the carbon cycle
- Understand the evidence of climate change
- Visualize climate changes in the Buffalo Niagara and Great Lakes region

<u>New York State P-12 Science Learning Standards (HS)</u>

- MS-LS2-B: Cycle of Matter and Energy Transfer in Ecosystems Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

- HS-ESS2-D: Weather and Climate
  Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

- HS- 5-ESS2-A: Earth Materials and Systems
  Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes.

- HS- 5-LS2-B: Cycles of Matter and Energy Transfer in Ecosystems Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.

Activity 8a: Carbon Cycle Role Play

In this activity, students will act out the carbon cycle to explore where carbon moves, and how that unequal movement can throw off the balance of this cycle and cause damaging impacts. Explain to your students that the carbon is a common element on earth and ask them to list things in their daily life that contain carbon. Carbon does not stay in any one thing forever and moves from one thing to another through the carbon cycle. Parts of the carbon cycle happen very quickly, like when plants take in carbon dioxide from the atmosphere for photosynthesis. However, other parts of the carbon cycle happen very slowly.

Print the images on the pages below this activity to represent 7 of the planet's carbon reservoirs.

1. Carbon is one of the building blocks of the planet. The element is found in the earth's crust, inside the oceans, in the atmosphere, and inside all living things. Carbon does not stay in the same state. It moves through cycle flowing from one reservoir to another.

2. Show the class an image of the carbon cycle and discuss the different parts
    a. Carbon Reservoirs: Places where carbon is stored
    b. Carbon Flow: The movement of carbon between reservoirs, constantly on the move through the atmosphere, land, and water (ocean and freshwater)
    c. Carbon Cycles - Short-term and long-term cycles

3. Divide the class into 7 groups of carbon reservoirs. Hand each reservoir a card and have them review how carbon flows from their reservoir to others. Give each reservoir 4 ping-pong balls that will represent carbon atoms.
    a. Explain that they can give their carbon to only one other group, or if they have plenty, they can give the carbon to more than one group.
    b. Explain that carbon exists in all these things at the same time and only a portion of the carbon in each thing moves. Therefore, when each group moves their carbon, they can't give away all their carbon: **they must keep at least one carbon atom.**
    c. As they move their carbon, they must say their script lines to explain the carbon movement that they have chosen (see Role Play Summary Table)

4. One at a time, ask each group to give their carbon to another group (or groups).

5. Run the role-play several times, telling students to make different choices about carbon movement each time. Students can run through the role play by looking at one carbon atom to explore a particular pathway, or have the carbon be moving through the groups all at once to display the natural chaos in the movement of carbon.

Human Impacts

1. After a couple rounds ask the students if anything is missing from the cycle. Explain that they just replicated the carbon cycle that existed **<u>before</u>** humans began impacting the cycle.

2. Have the students guess how they think humans will impact the carbon cycles. Have them guess what movement corresponds to the following human activities:
    a. **Humans extract and burn fossil fuels for energy.**
        - Carbon moves from the sediments and rocks where fossil fuels are buried into the atmosphere
    b. **Humans cut and burn trees to use land for buildings, housing, farming, or ranching.**
        - Carbon moves from the land plants into the atmosphere

3. Explain that humans have not created more carbon on earth, but that we move carbon from one place to another more quickly than would naturally happen and that this has consequences for the climate of the planet.
    c. Some examples:
        i. Burning fossil fuels takes carbon from sediments and rocks where fossil fuels are buried and puts it into the atmosphere because when fossil fuels are burned, they release carbon-containing gases.
        ii. Cutting and burning trees takes carbon from the land plants and puts it into the atmosphere because when trees are burned, the carbon that was stored in their structures is released as carbon-containing gases.

4. Ask students if they can think of other human activities that might affect the carbon cycle.

5. Now enact the activity with humans as a part of the carbon cycle

6. Discuss how it changed. Humans do not add any carbon to the earth but alter how and the rate at which it flows from one reservoir to another.

7 Carbon Reservoirs – Images to print below (p.74 - 77)

Source: California Academy of Sciences

Carbon Reservoir – Waterbody (ocean or freshwater)

Lake Erie: One of the 5 Great Lakes that absorbs carbon from the atmosphere.

Carbon Reservoir – Filter Feeder (Marine or freshwater)

Native Mussel (Threehorn wartyback): Native freshwater mussels are the "livers of our rivers" and filter the water column for microscopic organisms

Carbon Reservoir – Aquatic Plant

Eel Grass: An important aquatic species of vegetation that provides habitat and resources to wildlife

Carbon Reservoir – Land Plant

Tulip Tree: This native tree has beautiful flowers in the spring and works to remove carbon for our atmosphere all summer long

Carbon Reservoir – Rocks and Sediment

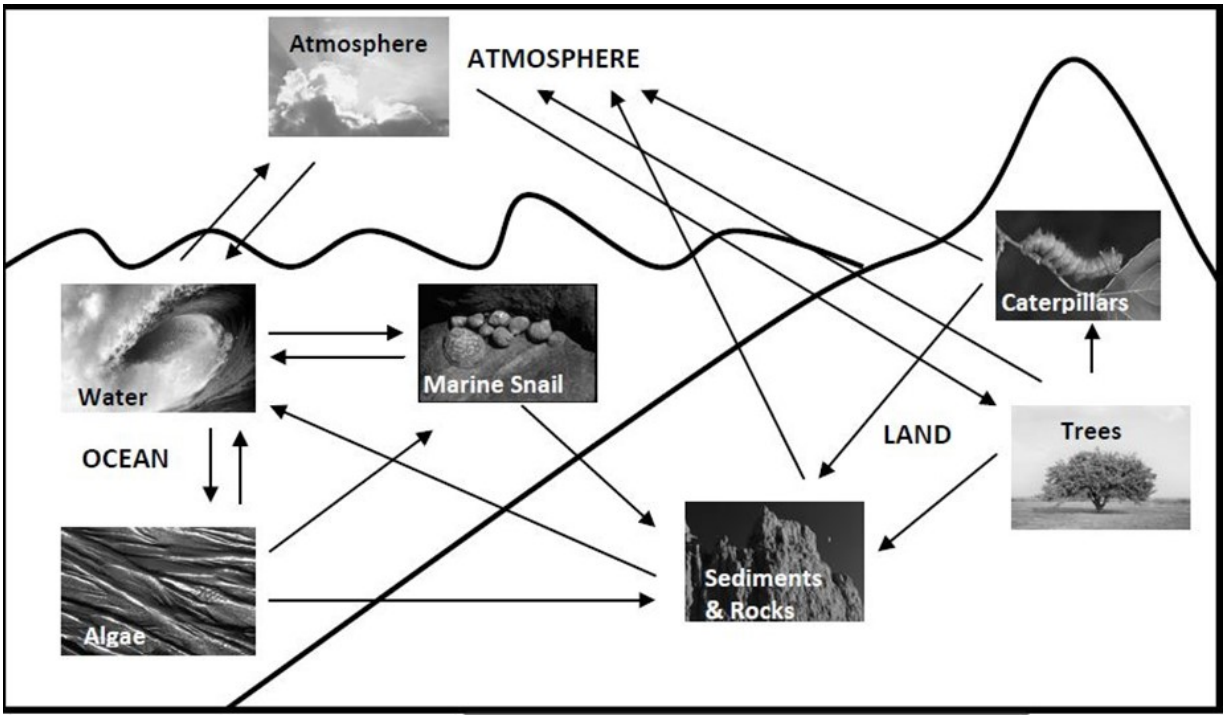
Lockport Dolomite: The geological rock formation that made Niagara Falls possible

Carbon Reservoir – Atmosphere

Carbon Reservoir – Land animals

Monarch Caterpillar: This native species of butterfly lay eggs on milkweed plants, which are toxic to other animals and protects them from predators throughout their life cycle.

Carbon Cycle Diagram



Role-Play Summary Table

NAME of GROUP	Options for CARBON FLOWS	Explanation for each CARBON FLOW	SCRIPT LINES
Atmosphere	1. water 2. trees	1. Carbon dioxide from the atmosphere diffuses and dissolves into water. 2. Carbon dioxide is taken up by land plants to perform photosynthesis.	1. I am giving carbon dioxide gas to water. It will dissolve in water. 2. I am giving carbon dioxide gas to trees to use for photosynthesis.
Water	1. algae 2. marine snails 3. atmosphere	1. Aquatic plants use carbon dioxide from the water to perform photosynthesis. 2. Some marine organisms take carbon from the water to build their skeletons and shells. 3. Carbon dioxide can diffuse back into the atmosphere.	1. I am giving dissolved carbon dioxide to algae for photosynthesis. 2. I am giving carbon to marine snails to help build their shells. 3. I am taking dissolved carbon dioxide and putting it back in the atmosphere as carbon dioxide gas.
Algae (Aquatic Plants)	1. water 2. sediments and rocks 3.marine snails	1. Cellular respiration and decomposition put carbon back into the water. 2. Carbon from dead plants can be incorporated into sediments. 3. Animals consume aquatic plants and use it as energy or store it in tissues.	1. I am giving carbon to water when I die and decompose and when I perform respiration. 2. I am giving carbon to sediments and rocks because after I die, some of the carbon in my structures is laid down in sediments, which can turn to rock. 3. I am giving carbon to marine snails because they use their mouths to scrape me off the rocks and eat me.
Marine Snails (Aquatic Animals)	1. water 2. sediments and rocks	1. Respiration and decomposition put carbon back into the water. 2. Carbon from dead animals can be incorporated into sediments on the ocean floor and can eventually	1. I am giving carbon to water when I perform respiration and when I die and decompose. 2. I am giving carbon to sediments and rocks because when I die my hard, carbon-containing shell sinks to the ocean floor and becomes

NAME of GROUP	Options for CARBON FLOWS	Explanation for each CARBON FLOW	SCRIPT LINES
		become sedimentary and metamorphic rocks.	part of the sediment, which can then become rock.
Sediments and Rocks	1. water 2. volcano to atmosphere	1. Weathering and erosion of rocks deposits carbon in rivers and oceans. 2. Volcanic eruptions spew carbon-containing gases into the atmosphere.	1. I am giving carbon to water because when I am weathered and eroded, my carbon flows into water. 2. I am giving carbon to the atmosphere in a quick fury because volcanoes erupt and put carbon from rocks back into the atmosphere.
Trees (Land Plants)	1. atmosphere 2. sediments and rocks 3. caterpillars	1. Cellular respiration and decomposition put carbon back into the atmosphere. 2. Carbon from dead trees can be buried and incorporated into sediments. 3. Plants are consumed by animals that use carbon for energy or store it in tissue.	1. I am giving carbon to the atmosphere when I perform respiration and when I die and decompose. 2. I am giving carbon to sediments and rocks because when I die, I can be buried in sediments and slowly become part of the rocks. 3. I am giving carbon to caterpillars because you have eaten me and will use my carbon for energy or to make your body's structures.
Caterpillars (Land Animals)	1. atmosphere 2. sediments and rocks	1. Respiration and the decomposition of dead animals put carbon back into the atmosphere. 2. Carbon from dead animals can be buried and incorporated into sediments.	1. I am giving carbon to the atmosphere because when I breathe I release carbon dioxide to the atmosphere. 2. I am giving carbon to sediments and rocks because when I die I can be buried and some of the carbon in my body can become part of sediments.

Activity 8b: Global Climate Change, Local Consequences

Background:

Climate change is a global problem with local consequences. Depending on your geographic location, those consequences can look very different from one shoreline to another. In the United States, areas in the Southwest are experiencing increased drought from recurring heat waves and warming, while cities on the East Coast are seeing increased precipitation, more intense storms, and a rising sea level.

The Buffalo-Niagara Region is part of the larger Great Lakes ecosystem, and we face our own set of unique challenges due to climate change. The temperature in Western New York is increasing at a rate of 0.4°F per decade which causes Lake Erie to warm, reducing the amount of lake ice cover over winter and leading to earlier ice-out dates. *What impacts do you think a lack of ice and freezing has on the Great Lakes and surrounding ecosystems?*

More intense rainfall events and severe thunderstorms are predicted to continue to rise, which results in more severe and frequent flooding, and increased amounts of pollutants into the water in the form of runoff. *What impacts do you think increased precipitation and severe thunderstorms have on water quality and humans?*

In our region, increased temperatures throughout the year means some people may use their air conditioning more frequently, while other people may be faced with dangerous heat conditions if they do not have home cooling systems. This is just one example of how people with lower incomes who may not have the additional resources to heat or cool their homes, are disproportionately impacted by climate change. *What are some other examples of how low-income communities can experience disproportionate impacts of climate change in our region and around the world? (Examples include higher rates of asthma and other harmful health conditions, less resources to relocate after an environmental disaster, less access to affordable sustainable energy options)*

The purpose of the activity below is to predict what impacts a changing climate will have on the Great Lakes and the Buffalo Niagara Region. As we continue to adapt to climate change and aim to reduce the amount of carbon emissions we are putting into the atmosphere, it is important to be aware of how an increasing global temperature is affecting other aspects of life. How we grow food, manage our drinking water, develop our communities, and interact with our environment is changing. Can you picture how your life might change?

<u>Visualizing Changes in the Great Lakes Activity</u>

(This activity is from the Ohio Sea Grant Great Lakes Climate Change Curriculum)

1) Set up the “Impact” and “More/Less” cards up in the front of the room.

2) Students will come up to the board and pick a card that will have a scientific or social impact of climate change.

3) They will have to decide if climate change will cause more or less of that impact to be witnessed in the region. Using a “more” or “less” card they will attach their impact to the web already started on the board. Help guide their thinking, but ultimately there is no right and wrong answer.

4) Encourage students to build off impacts already placed on the board.

Topic #3: Stewardship

How does protecting and restoring habitat protect endangered or threatened species?

What makes a shoreline living?

How can we work together to design a stewardship project?

Students plant a native tree at Ellicott Creek Park

Lesson 9 – Conservation Biology

Lesson or Activity for High School Students

Description: Students will explore the ways that habitat loss due to human development impacts the population of the endangered Karner Blue butterfly (*Lycaeides melissa*)**.** Students will practice critical thinking, scientific literacy, and scientific investigation skills to interpret and evaluate experimental results with graphing. Students will explore these concepts in the context of their local environment.

This activity is adapted from the Conservation Biology lab in "Laboratory Biology" by Daniel W. Benjamin and Gilbert D. Starks, Central Michigan University.

Materials Needed:

- Student worksheet
- Writing utensil, highlighter
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit webpages

Learning Outcomes:

Students will be able to:

- List several of the threatened, endangered, and rare plant and animal species in New York State
- Predict the effects of a change in one or more components in a biological system based on data
- Demonstrate through simulation, the consequences of habitat loss on an animal population over time and use that data to evaluate a hypothesis
- Review and apply several terms used to describe the biology of a population
- Construct a graph and interpret population trends over several generations
- Appreciate that the Great Lakes support a broad diversity of life and ecosystems.

New York State P-12 Science Learning Standards (HS)

- HS-LS2 Interdependent Relationships in Ecosystems
- HS-ESS3 Human Sustainability

AP Biology Curriculum

- Unit 4 – Cell Communication and Cell Cycle (4.5 Feedback Mechanisms)
- Unit 8 – Ecology (8.3 Population Ecology, 8.6 Biodiversity, 8.7 Disruptions to Ecosystems)

Conservation Biology

Student Worksheet – Conservation Biology

Name _____ Date_____

Instructions: Gather the materials listed below and follow the instructions. Complete this lesson by reading the introductory passage, watching the video, and responding to all questions. Websites linked in the footnotes at the bottom of each page provide more information. If you are struggling to understand a concept or a question, click the link to read more about a topic. In this activity we will explore the ways that habitat loss due to human development impacts the population of the endangered Karner Blue butterfly (*Lycaeides melissa*)**.**

Materials Needed

- Writing utensil, highlighter
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit webpages

Part A: Introduction to Conservation Biology: *Read the passage below. Highlight any terms you think are important. Summarize the paragraph in three sentences or less.*

Investigation of the Impact of Habitat Destruction on the Endangered Species, the Karner Blue Butterfly (*Lycaeides melissa)* in New York State

Biodiversity (biological diversity) is a collective term used to describe the astounding variety of life on Earth. Biodiversity can be defined as the number of different species of plants, animals, and other living things found in an area. It is also a measure of variation at all levels - from genes within a species to ecosystems and plant and animal communities. The field of ***conservation biology*** combines the areas of ecology, geography, genetics, economics, and many other disciplines to work at conserving this biodiversity. The interactions between different plant, animal, and microbial species form the basis of what is known as the ***biosphere***. The removal of just one of these species can cause a chain reaction which effects all levels of the ***food web*** within an ***ecosystem***. Biodiversity is integral to ecosystem health and stability because the more biodiversity present in a system, the more likely that system is to maintain its health in the face of disruption.

When humans destroy or degrade the quality of a ***habitat***, the effect that it has on the species that inhabit that area can be devastating. The counties that make up the Niagara River Watershed (including Erie, Niagara, Genesee, Wyoming, Cattaraugus, and Chautauqua County) added 14,727 acres of urbanized areas between 2000 and 2010, while at the same time losing 37,450 people.[10] When an area that was once natural becomes urbanized due to human development it inevitably loses habitat value and biodiversity.

[10] Niagara River Watershed Management Plan, Buffalo Niagara Waterkeeper website https://bnwaterkeeper.org/projects/healthyniagara/

The world is facing an interconnected crisis of rapid biodiversity loss and climate change.[11] The impacts of these issues are being felt right here in the Great Lakes Basin and Western New York. In New York State alone, there are over 90 species of threatened or endangered animals and hundreds of species of rare or vulnerable plants. Why does this matter? Douglas Tallamy, ecologist, and author of "Bringing Nature Home" put it best when he said:

> *"Biodiversity losses are a clear sign that our own life-support systems are failing. The ecosystems that support us – that determine the carrying capacity of the earth and our local spaces – are run by biodiversity. It is biodiversity that generates oxygen and cleans water, creates topsoil out of rock, buffers extreme weather events like droughts and floods, pollinates our crops, and recycles the mountains of garbage we create every day. And now, with human-induced climate change threatening the planet, it is biodiversity that, if given half a chance, will suck that carbon out of the air and sequester it in living plants.*
>
> *Humans cannot live as if they are the only species on this planet. Why? Because it is other species that create the ecosystem services that are so essential to us. Every time we force a species to extinction, we are encouraging our own demise. Despite the disdain with which we have treated it in the past, biodiversity is not optional."* [12]

An n ***ecosystem*** is the biological community of interacting organisms and their physical environment. An ***ecosystem service*** is the variety of benefits that a healthy, functioning ecosystem provides to humans.

In this activity we will use a simulation to demonstrate the impact of habitat degradation on the population of one endangered species in New York State, the Karner Blue butterfly (*Lycaeides melissa)*. We will experimentally manipulate environmental variables associated with the ***life cycle*** of this species. You will graph population trends over time and make some predictions concerning the health of the butterfly population.

The New York State Department of Environmental Conservation (NYSDEC) describes the Karner Blue butterfly as an insect that, like all butterflies, has four stages in its life cycle - the egg, the larva (caterpillar), the pupa (chrysalis), and the adult (butterfly). There are two generations per year. The first-generation adults appear in late May to mid-June. Females lay eggs on the underside of a leaf or stem of the food plant, Blue Lupine (*Lupinus perrennis*). Forty to fifty percent of the eggs survive to the adult stage. The resulting second brood adults, emerging in mid-July to early August, lay their eggs singly in dried lupine seed pods or near the ground on the stems. Eggs of the second brood overwinter, to hatch the next May. Karner Blue butterfly adults are nectar-feeders, aiding in the pollination of a variety of wildflowers. The larvae, however, are highly specialized, feeding exclusively on the wild Blue Lupine leaves. Without blue lupine, the Karner Blue butterfly would not survive.

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[11] National Geographic article "Global Biodiversity is in Crisis"
https://blog.nationalgeographic.org/2019/09/23/global-biodiversity-is-in-crisis-but-there-is-hope-for-recovery/
[12] American Forests article "A Call For Backyard Biodiversity" by Douglas Tallamy
https://www.americanforests.org/magazine/article/backyard-biodiversity/

Figure 1: *Karner Blue butterfly and its larval food plant, Blue Lupine*

The Karner Blue butterfly is experiencing a population decline primarily due to human activities such as agriculture, urbanization and fire suppression. The sandy habitat essential to the Blue Lupine, and therefore the Karner Blue, occurs mostly along river valleys and outwash plains. Because of the location and topography of such areas, they have been heavily favored as settlement sites. Extinctions of entire populations of the Karner Blue have occurred around large urban centers such as Chicago and New York City. Other populations, such as those in the Albany Pine Bush, have been reduced both by habitat destruction from urbanization and by loss of lupine through natural succession resulting from fire suppression. [13]

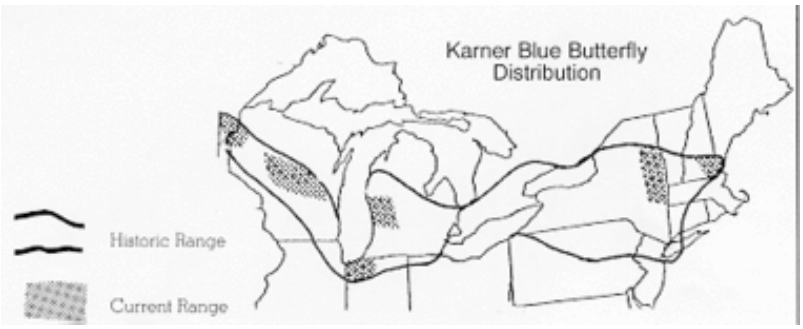

Figure 2: *Karner Blue butterfly distribution in the Great Lakes region* [14]

1. What specific plant does the Karner Blue butterfly require? _____

2. In what type of habitat is this plant found? _____

3. Hypothesize three possible reasons that the Karner Blue butterfly is at risk of extinction:
   a. _____
   b. _____
   c. _____

[13] The Karner Blue butterfly and Blue Lupine photographs are from the New York State Department of Environmental Conservation and the United States Fish and Wildlife Service website, respectively.
[14] The information in the passage above and the map are from the New York State Department of Environmental Conservation Karner Blue Butterfly Fact Sheet

Watch "Feedback loops: How nature gets its rhythms", narrated by Anje-Margriet Neutel on the Ted-ed YouTube channel (https://www.youtube.com/watch?v=inVZoI1AkC8).[15]

4. Define positive feedback. Give an ecological example.

   _____
   _____
   _____

5. Define negative feedback. Give an ecological example.

   _____
   _____
   _____

6. ***Environmental justice issues*** occur when communities of Black, Indigenous and People of Color as well as poor and working-class communities are ***disproportionately*** harmed by environmental burdens like pollution. Explain how the disruption of ecological feedback loops, and ecosystem services, could also present an ***environmental burden*** that negatively impacts those communities.

   Hint: Consider the ecosystem services a healthy, functioning wetland ecosystem provides to a community in the Niagara River Watershed [16]

   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

[15] "Feedback loops: How nature gets its rhythms", narrated by Anje-Margriet Neutel on the Ted-ed YouTube channel https://www.youtube.com/watch?v=inVZoI1AkC8

[16] Fact sheet from the United States Environmental Protection Agency (USEPA) on the Function and Values of Wetlands https://nepis.epa.gov/Exe/ZyPDF.cgi/200053Q1.PDF?Dockey=200053Q1.PDF

<u>Part B: Ideal Population Growth (Exponential Growth)</u> *This portion of the experiment will represent the ideal growth of a population in a habitat without any human disturbance.*

1. For this experiment, assume that you have an equal number of males and female Karner Blue butterflies in all of the populations. Begin with an initial population size of 12 individuals. Therefore, you have 6 breeding pairs of butterflies.
2. Using the random number generation wheel https://pickerwheel.com/tools/random-number-generator/ set the maximum number to 36 and spin the wheel one time for each breeding pair. This spin represents the reproductive success for the pair of butterflies. The numbers in the left-hand column of your data chart will correspond to each of the pairs. With each spin, record the number in the column marked *number spun* on the data sheet below.
3. **If you spin an even number**, this means that the patch of land that your butterfly pair landed in is of poor quality; therefore, they only have the potential to produce 2 offspring. Record this number (2) in the column marked *offspring* in your data sheet below.
4. **If you spin an odd number**, this means that the patch of land that your butterfly pair landed in is of good quality; therefore, they will produce 3 offspring. Record this number (3) in the column marked *offspring* in your data sheet below.
5. **If you spin 0**, this means no reproduction due to predation.
6. Continue this process for each of the 6 breeding pairs in generation # 1.
7. When you are finished with this generation, sum the numbers in the *offspring* column. This is the number of individuals that will be reproductive in generation # 2. **Use this number to determine how many pairs reproduce in the next generation.**
8. Follow this protocol for each of the next four generations. Continue as you just did for each of these new generations.

Generation # 1			Generation # 2			Generation # 3			Generation # 4			Generation # 5		
Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring
1			1			1			1			1		
2			2			2			2			2		
3			3			3			3			3		
4			4			4			4			4		
5			5			5			5			5		
6			6			6			6			6		
			7			7			7			7		
			8			8			8			8		
			9			9			9			9		
			10			10			10			10		
			11			11			11			11		
			12			12			12			12		
			13			13			13			13		
			14			14			14			14		
			15			15			15			15		
			16			16			16			16		
			17			17			17			17		
			18			18			18			18		
			19			19			19			19		
			20			20			20			20		
			21			21			21			21		
			22			22			22			22		
			23			23			23			23		
			24			24			24			24		
			25			25			25			25		

Total # of Butterfly Offspring: Generation #1: Generation #2: Generation #3: Generation #4: Generation #5:

9. Graph the data! Plot the data that you just recorded on the graph on the last page of this lesson packet.

10. If the ideal growth (exponential growth) of this population continues and the habitat for the Karner Blue butterfly remains undisturbed, what is your hypothesis for further growth of the population? Will it continue to increase, decrease, or stay the same? Explain.

    _____
    _____
    _____
    _____

11. What factors do you think might influence the growth of a population? List at least three factors and describe what their influence would be on the growth of a population.

    a. _____
    _____
    _____

    b. _____
    _____
    _____

    c. _____
    _____
    _____

12. The next portion of our experiment will include the destruction of 25% of the Karner Blue butterfly habitat. Will the population continue its exponential growth after that? Explain why or why not.

    _____
    _____
    _____
    _____

Part C: Habitat Destruction *While population growth could continue indefinitely without decline, habitat changes can drastically alter this picture. This portion of the experiment will look at the result of habitat destruction, a 25% reduction, on the size of our breeding population.*

1. Select 9 squares to represent the areas will houses will be built in this ecosystem. Place an X across those squares.

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36

2. Transfer the number of pairs from the fifth generation onto the new data sheet below.
3. Repeat the procedure of the experiment in Part B for five generations.
   a. This time, if you spin one of the numbers selected for housing development, record an offspring number of 0 for that pair.
   b. If the number is something other than one selected for housing development, follow the procedures as described in Part B (odd numbers represent 3 offspring, even number represent 2 offspring)

Generation # 6			Generation # 7			Generation # 8			Generation # 9			Generation # 10		
Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring
1			1			1			1			1		
2			2			2			2			2		
3			3			3			3			3		
4			4			4			4			4		
5			5			5			5			5		
6			6			6			6			6		
7			7			7			7			7		
8			8			8			8			8		
9			9			9			9			9		
10			10			10			10			10		
11			11			11			11			11		
12			12			12			12			12		
13			13			13			13			13		
14			14			14			14			14		
15			15			15			15			15		
16			16			16			16			16		
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21			21			21			21			21		
22			22			22			22			22		
23			23			23			23			23		
24			24			24			24			24		
25			25			25			25			25		

Total # of Butterfly Offspring: Generation #6: _____ Generation #7: _____ Generation #8: _____ Generation #9: _____ Generation #10: _____

4. Graph the data! Plot the data that you just recorded in your data sheet on the graph on the last page of this lesson packet.

5. How did the population respond to the removal of 25% of its habitat?

_____
_____
_____

6. Is this what you hypothesized? Explain why or why not.

_____
_____
_____

7. What trends have you observed in the population over time?

_____
_____
_____
_____

Part D: Will increased habitat loss lead to population problems? *This portion of the experiment will simulate an additional 25% destruction of the existing habitat. We will examine the impact this additional change will have on the size of our butterfly population.*

1. Mark the same 9 squares as you did in Part C. Select 9 additional squares to remove as a result of housing development. Remember, if a breeding pair of butterflies selects any of the now 18 squares selected, they will be reproductively unsuccessful and will not produce any offspring.

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36

2. Remember to start this part of the experiment with the number of offspring left at the end of the tenth generation from Part C.
3. In this part of the experiment, continue as you did for parts B and C expect that id a butterfly lands on one of the additional squares, the pair will produce 0 offspring. Continue for at least 5 more generations.

Generation # 11			Generation # 12			Generation # 13			Generation # 14			Generation # 15		
Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring
1			1			1			1			1		
2			2			2			2			2		
3			3			3			3			3		
4			4			4			4			4		
5			5			5			5			5		
6			6			6			6			6		
7			7			7			7			7		
8			8			8			8			8		
9			9			9			9			9		
10			10			10			10			10		
11			11			11			11			11		
12			12			12			12			12		
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21			21			21			21			21		
22			22			22			22			22		
23			23			23			23			23		
24			24			24			24			24		
25			25			25			25			25		

Total # of Butterfly Offspring: Generation #11: Generation #12: Generation #13: Generation #14: Generation #15:

4. Graph the data! Plot the data that you just recorded in your data sheet on the graph on the last page of this lesson packet.

5. After what you have just seen with this simulation, does it surprise you to learn that climate change, along with habitat destruction and degradation, is the number one threat to biodiversity throughout the world? [17]

Circle YES or NO

6. Have you noticed increasing or decreasing biodiversity (the number of different species of plants, animals, and other living things) in your community? If you can, give an example of a specific plant or animal whose population you have noticed changing.

_____
_____
_____
_____
_____
_____

7. Do you think the changes in the population of that plant or animal will impact other species? The ecosystem as a whole? Explain. [18]

_____
_____
_____
_____
_____
_____
_____
_____

[17] "Climate Change Is Becoming a Top Threat to Biodiversity" by Chelsea Harvey, Scientific American https://www.scientificamerican.com/article/climate-change-is-becoming-a-top-threat-to-biodiversity/

[18] Check out this list of endangered species in New York State https://www.newyorkupstate.com/outdoors/2017/10/endangered_threatened_species_new_york_state_animals.html

Part E: Applying the concepts to the Niagara River Watershed

The Great Lakes support a broad diversity of life.[19] The Niagara River corridor is recognized as a RAMSAR Wetland of International Importance because its unique coastal fish and wildlife habitat supports numerous rare and threatened ecological communities and is an incredibly important overwintering site for waterbirds. [20]

The map below was created using the New York State Department of Environmental Conservation Natural Resource Mapper tool. The pink color represents significant natural communities, such as the Calcareous talus slope woodland community located along the Niagara Gorge.[21] The orange color represents rare plants or animals, such as the threatened fish species that lives in the Niagara River called the Lake Sturgeon.[22]

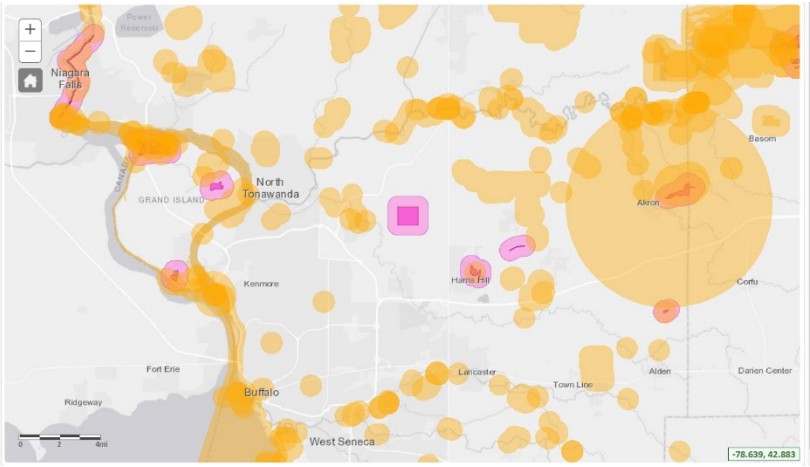


Figure 3: *Significant Natural Communities and Rare Plants or Animals in Western New York* [23]

1. Do you live in Western New York? If you can, mark your home on the map above.

2. Do you live near a significant natural community and/or rare plants or animals (within the colored boundaries)?

   Circle YES or NO

3. Did you know that Western New York was home to so many significant natural communities?

   Circle YES or NO

---

[19] Center for Great Lakes Literacy https://www.cgll.org/for-educators/great-lakes-literacy-principles/principle-5/
[20] Ramsar Convention on Wetlands of International Importance webpage for the Niagara River Corridor site https://rsis.ramsar.org/ris/2402
[21] New York Natural Heritage Program guide to Calcareous Talus Slope Woodland community https://guides.nynhp.org/calcareous-talus-slope-woodland/.
[22] New York State Department of Conservation Lake Sturgeon webpage https://www.dec.ny.gov/animals/26035.html
[23] New York State Department of Conservation Environmental Resource Mapper https://gisservices.dec.ny.gov/gis/erm/

4. Read and respond to the prompt below.

   In this hypothetical scenario, there is an area of land proposed for development near the Niagara River. A company is planning to build its storage facilities on forested and wetland ecosystems. Building these facilities would require thousands of trees to be cut down, miles of road to be built, and the area near the river that had resisted development for many years would dramatically change. Take into consideration the fact that the forest, wetland, and the river provide valuable habitat for fish and wildlife.

   Specifically, this habitat is home to threatened, endangered, or rare species like the Bald Eagle (*Haliaeetus leucocephalus*), Sky Blue Aster (*Symphyotrichum oolentangiense*), and the Red-headed Woodpecker (*Melanerpes erythrocephalus*). Write a letter to the local planning board, which is an elected or appointed group that makes decisions about the growth and development in a community or municipality, as a concerned community member. Could this development co-exist with the environmental concerns?

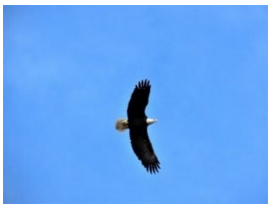
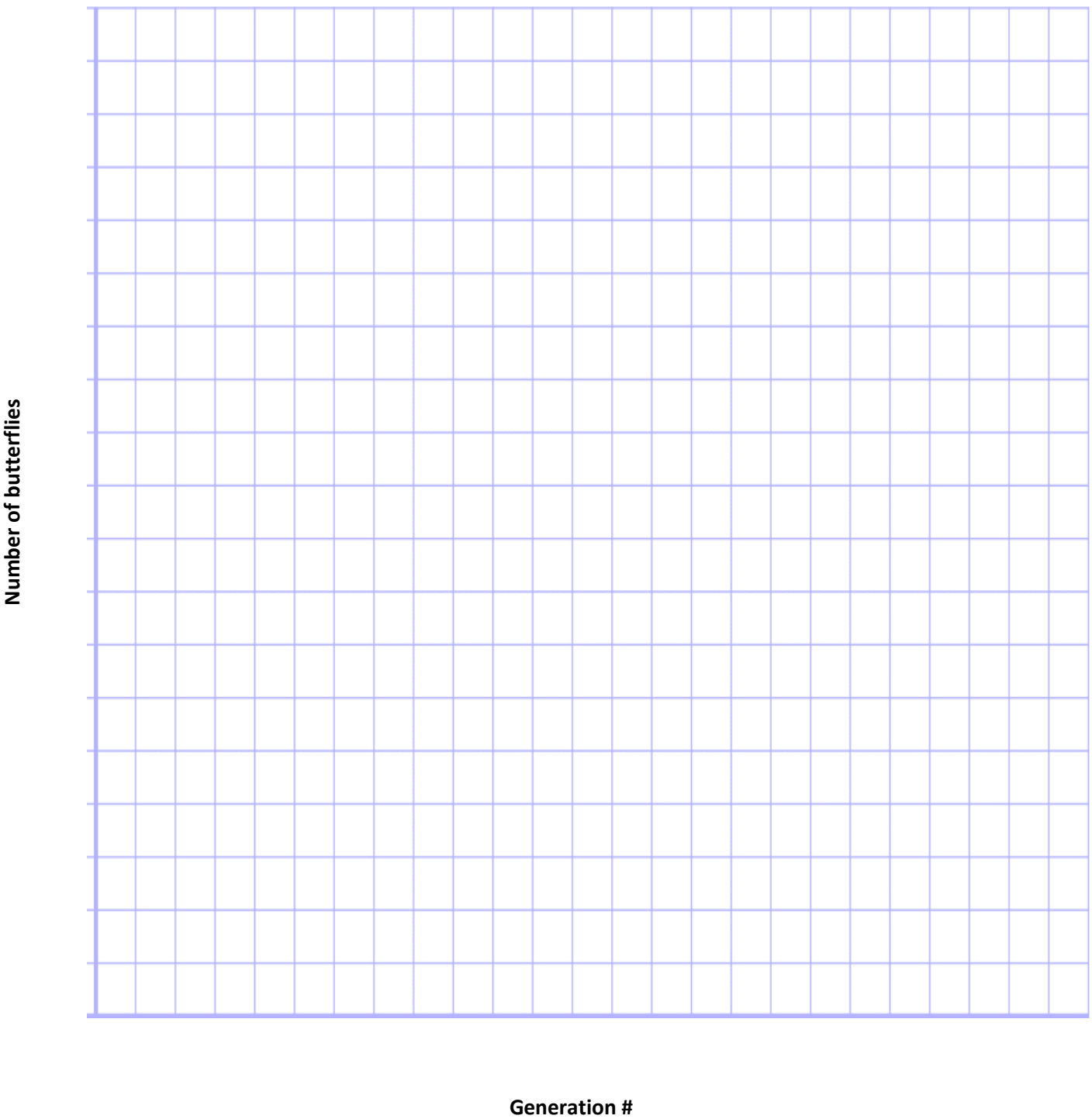


Figure 4: *Bald Eagle, Sky Blue Aster (Kimberly J. Smith)[24], and Red-headed Woodpecker*

[24] New York State Natural Heritage Guide Sky Blue Aster https://guides.nynhp.org/sky-blue-aster/

Graph – *Impact of Habitat Destruction on Karner Blue butterfly population*



Lesson 10 – Living Shorelines

Lesson for High School and Middle School Students

Description: Students will familiarize themselves with the concept of a Living Shoreline, as well as Buffalo Niagara Waterkeeper's work to create multiple Living Shorelines throughout Western New York. After reviewing key components of Living Shorelines, their benefits, and how they differ from degraded or 'non-living' shorelines, students will look at two completed Living Shoreline project highlights to observe their differences and successes. Afterwards, students will explore the benefits provided by shoreline plants with a hands-on activity that illustrates erosion in different ecosystem types.

Teacher Information

- An overview of Buffalo Niagara Waterkeeper's Living Shoreline Initiative can be found here: https://bnwaterkeeper.org/projects/livingshorelines/
- Information about the Living Shoreline project at Hyde Park in Niagara Falls can be found here: https://bnwaterkeeper.org/projects/livingshorelines/hyde-park/
- A guide for stewardship of waterfront properties can be found here: https://bnwaterkeeper.org/wp-content/uploads/2016/02/PDF-Version-for-Website.pdf
- Information on invasive species can be found here: https://bnwaterkeeper.org/wp-content/uploads/2018/09/Final-Invasive-Species-Booklet_website_small.pdf
- Information on Waterkeeper's Native Plant Guide can be found here: https://bnwaterkeeper.org/projects/nativeplantguide/
- A video about shoreline habitat and restoration can be found here: https://www.youtube.com/watch?v=G0NTYQSOJ0A&ab_channel=BuffaloNiagaraWaterkeeper
- The lesson on which the following lesson is based can be found here: https://drive.google.com/file/d/15YX9DmTvJLBYzBhKh_1RFAzjgJkRWv0H/view

Materials Needed:

- Student worksheet
- Writing utensil, highlighter
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit webpages
- 3 large plastic water jugs
- Potting soil
- Grass
- 3 plastic water bottles
- Yarn
- Scissors

Learning Outcomes:

Students will be able to:

- Define what a Living Shoreline is, and how it differs from a 'non-living' shoreline
- Explain 3 key features and 3 ecological benefits provided by living shorelines
- Identify Living Shoreline project sites around Western New York, and locate sites that might benefit from the creation of a Living Shoreline

New York State P-12 Science Learning Standards (HS)

- HS-LS2 Interdependent Relationships in Ecosystems
- HS-ESS3 Human Sustainability

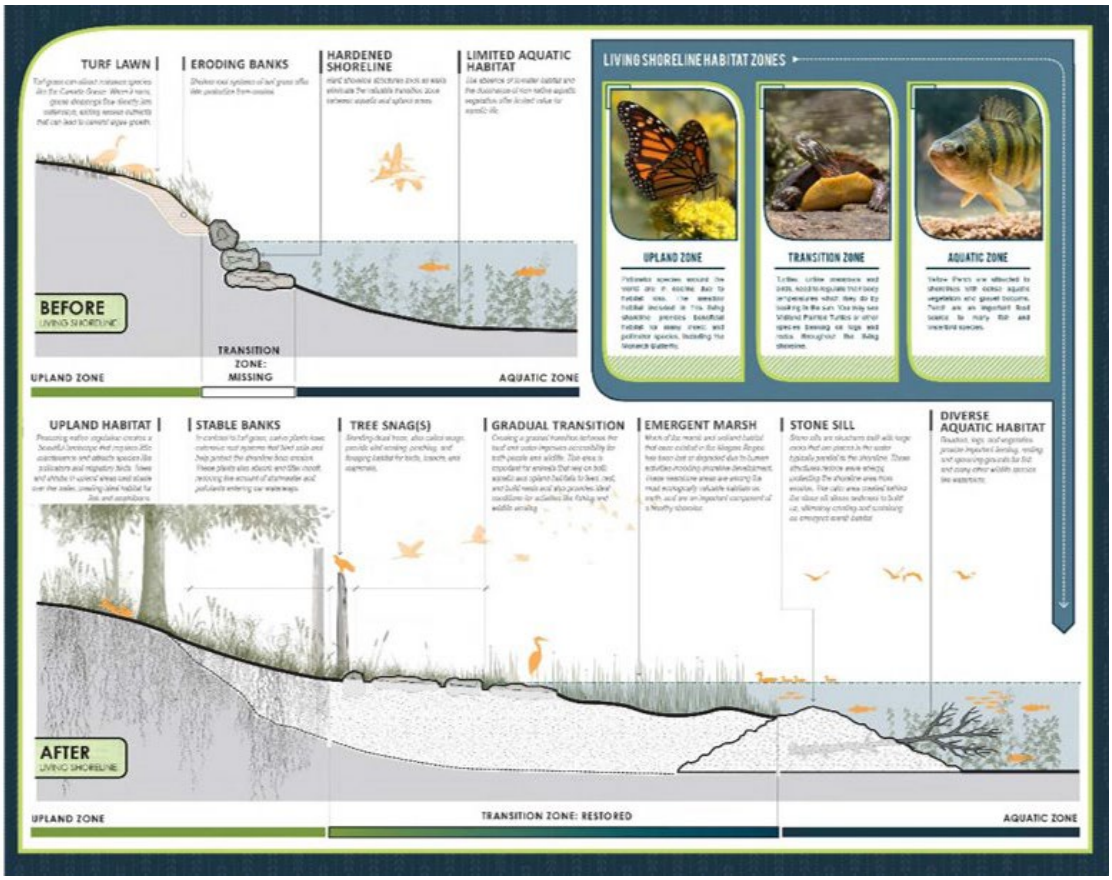
Buffalo Niagara Waterkeeper Living Shoreline Initiative

Directions: Read the passage below. Then, follow the activity instructions to create an erosion model.

A gradual transition between habitats is a defining feature of living shorelines. Each habitat, when connected with the others and the waterway, provides ecosystem services that benefit wildlife and water quality. **Living Shorelines** are a combination of different natural ecosystems such as meadows, woodlands, wetlands, and aquatic habitats which create a seamless transition from land to water. These incredibly productive and sustainable shoreline landscapes provide a wide range of benefits including improvements to: runoff filtration, habitat diversity, the visual character of the shoreline, flood mitigation, and erosion resistance along the edge. A living shoreline is like a "ribbon of life." It is estimated that 90% of all lake and river life is born, raised and fed along the shorelines of water systems. Since 2017, Waterkeeper has created multiple Living Shoreline sites throughout the Niagara River Watershed, a few of which will be highlighted in this lesson.

1. Living Shoreline Components

Living Shorelines are made up of many components, including different types of natural ecosystems and habitat areas, all of which are important in providing ecosystem benefits and improving water quality. Below are the key components of a Living Shoreline.



Meadows

Meadows, and the edge of woodlands contain grasses and shrubs that act as coarse filters that strain stormwater runoff, removing sediments and contaminants as water drains downhill towards the waterbody. Deep root zones add stability to the shoreline and soak up excessive nutrients carried in stormwater runoff before it enters a waterbody.

Woodlands

Woodlands contain large trees such as cottonwoods and willows that have deeper root systems compared to the shallow, spreading roots of upland tree species. These deep roots hold soil together, improving shoreline resistance to erosion. The large canopies of these trees provide habitat for birds and the shade they cast onto the water is idea for fish and amphibians which eat mosquito larva.

Figure. Examples of native grass root structures (Credit: Marcus Rosten)

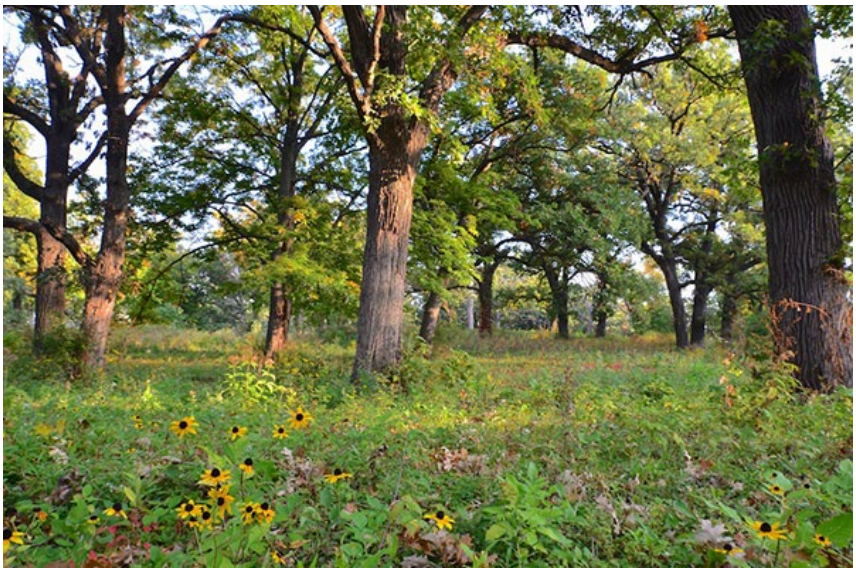


Figure. Example of a woodland, with evenly spaced trees. (Credit: Good Oak Ecological Services)

Wetlands

Wetland ecologies absorb flood waters and regulate stream function, further improving shoreline stability. Aquatic vegetation grows here which provides food for fish, and the fallen woody debris that collects along the edge offers juvenile fish protection from predators and dissipates wave energy, protecting the fragile ecosystems located closer to shore. Learn more about wetlands from Waterkeeper here:
https://www.youtube.com/watch?v=T3p9cAbxs_I&t=572s&ab_channel=BuffaloNiagaraWaterkeeper

Figure. Example of a wetland

Completed Living Shoreline

When these components come together, they provide a diverse array of ecosystem services that both humans and wildlife can enjoy. Life thrives where the "**green meets the blue**." Wildlife depends upon areas of gradual transition from shoreline to water. It is extremely important to protect the shorelines of the streams, creeks and rivers in the Niagara River Watershed. Below is a diagram of an ideal Living Shoreline!

2. <u>Components of a Non-Living Shoreline</u>

It's easy to understand the preference of natural, healthy ecosystems compared to unhealthy ones, but what does an unhealthy, or non-living shoreline look like? Below are some conditions of a non-living shoreline that contribute to unhealthy ecosystems.

Hardened or Eroded Banks

When the soil directly next to the shoreline isn't supported by native plants, and is improperly cared for, significant erosion can occur. Sometimes, shorelines are intentionally 'hardened' off with concrete and rocks in an effort to prevent erosion, but this can result in the opposite of the intended effect. Overall, these conditions can lead to loss of habitat space, and excess runoff from potentially harmful chemicals, bacteria, and excess nutrients.

Figure. Example of an eroded shoreline

Figure. Example of a hardened shoreline

Non-Native Plant Landscapes

Incorporation of non-native plants in landscape management is a common practice everywhere from lawns to shorelines. While not always harmful, these plants often don't establish as well as species that are adapted to the conditions of our local environments, and can further the process of erosion. Incorporating native plants into shoreline management can stabilize the soil, preventing erosion and runoff.

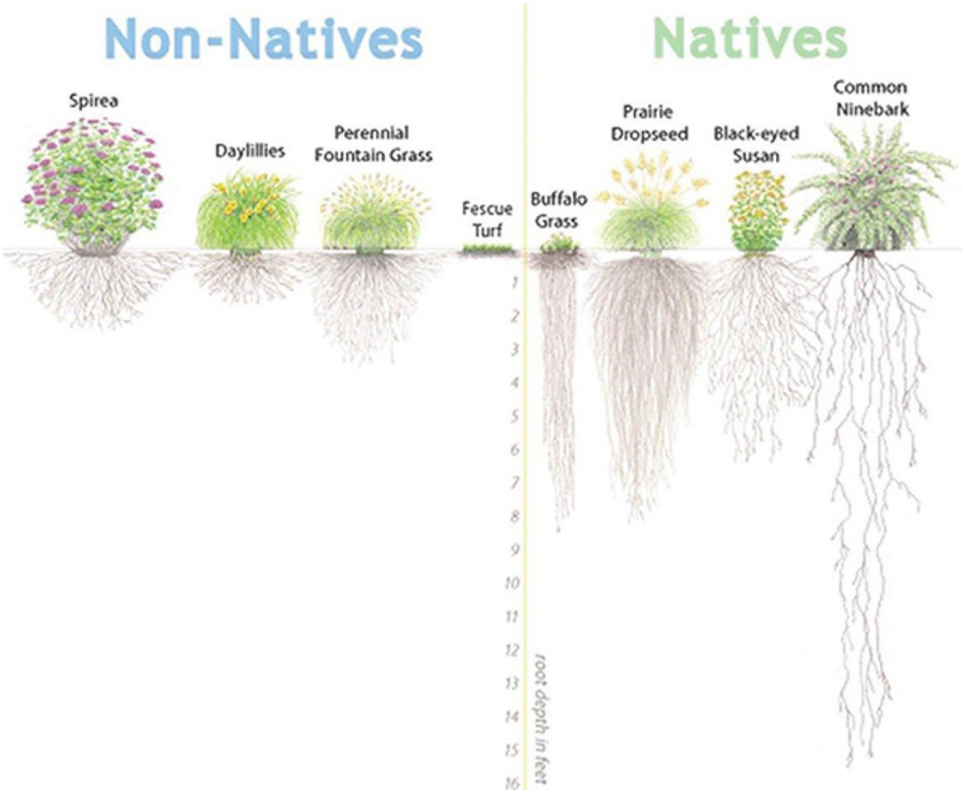


Figure. Non-native plant root depth compared to native plant root depth.

3. Project Highlights

Waterkeeper staff select sites based on existing shoreline conditions, public accessibility, and funding requirements. From site selection, through design and construction, the creation of a living shoreline can take years! Below are two project highlights from Living Shorelines that have been completed and are still being stewarded by Waterkeeper staff and volunteers!

Ellicott Creek Park

Ellicott Creek Park is a forested floodplain that historically helped to absorb floodwater from Ellicott Creek and Tonawanda Creek. These fertile floodplain areas were later cleared for agriculture and the development of transportation routes. By the 1950's, residential development projects began to appear. Ellicott Creek Park was replanted with many fast-growing tree species such as Silver Maple and Willow to create a quick canopy. Unfortunately, fast-growing species are also often shorter-lived, and many are already dying out. Additional damage from the Emerald Ash Borer and Dutch Elm Disease are threatening nearly 75% of tree stock in Ellicott Creek Park. Because of this site's history, ecological importance, and current problems, it was an ideal place for a living shoreline! Designing a living

shoreline can be a complicated process, landscape architects from Buffalo Niagara Waterkeeper worked to determine which habitat features would work best. Topography, hydrology, flood patterns, and soil type data was collected to develop field analysis maps and identify ideal planting sites, and Waterkeeper has offset the loss of absorption capacity resulting from age-out of tree stock planted in the 1940's by planting new trees to reduce stormwater inputs, soil erosion, and sediment/nutrient loading to Ellicott Creek and Tonawanda Creek. Since 2018, over 1,000 plants have been introduced throughout the park, with many right along the shoreline. These include native species of trees, shrubs, grasses, and flowering plants. In addition, in-water habitat was created using downed trees, which provide shade for fish species, and perches for birds.

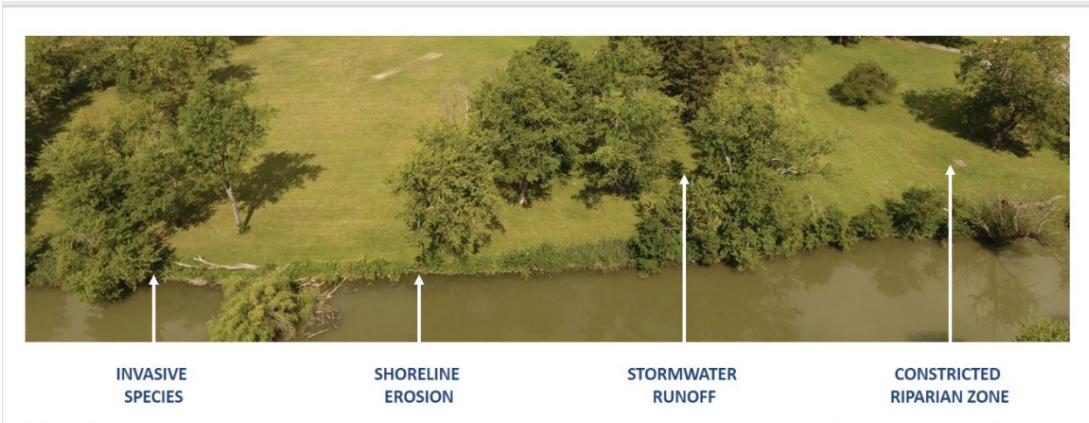


Figure. Site conditions before construction, illustrating deteriorated ecosystem conditions.

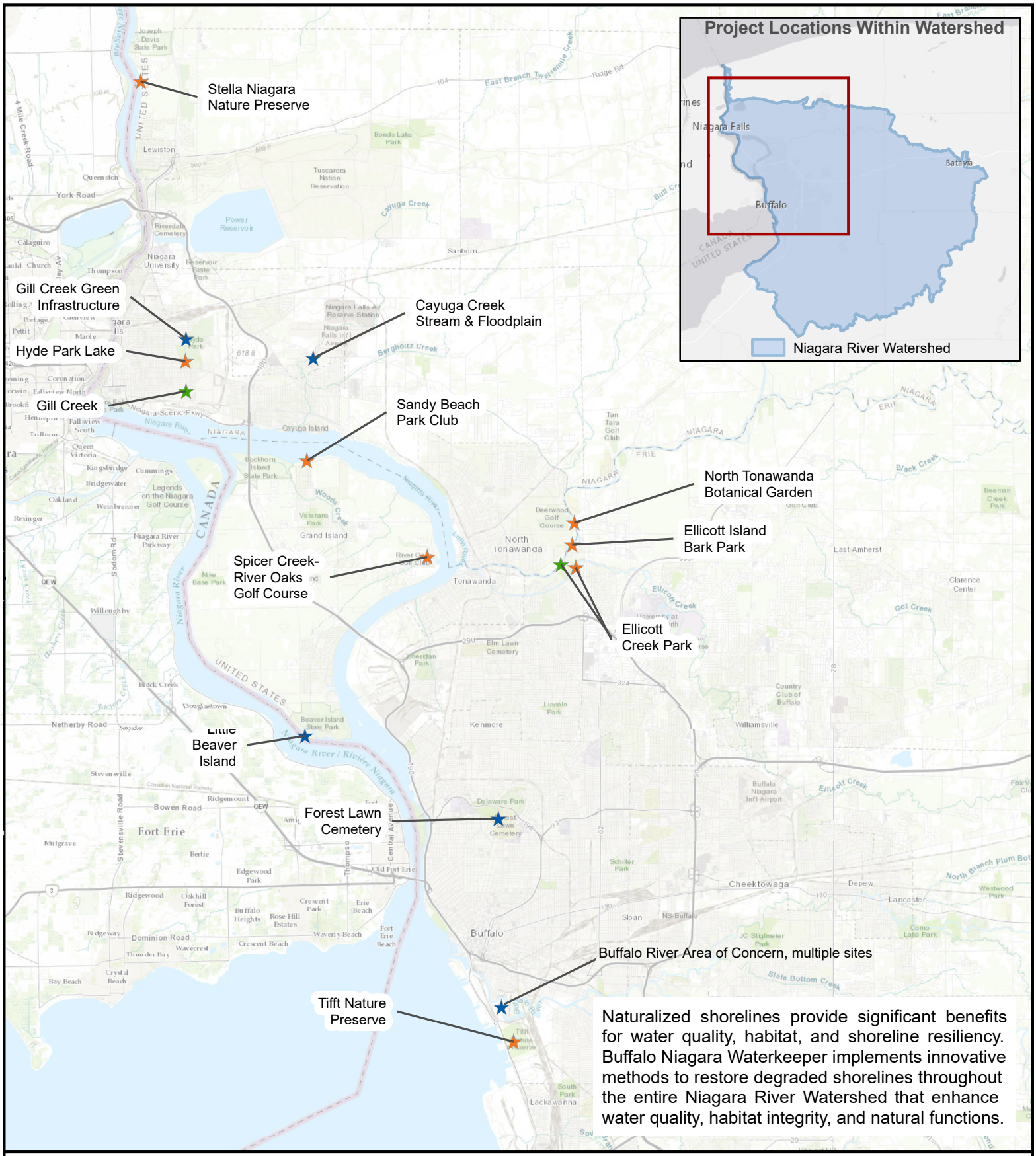
Figure. Existing site conditions post-construction, including improved habitat space for wildlife.

Hyde Park

Buffalo Niagara Waterkeeper recently implemented a Living Shoreline project located in Hyde Park in the City of Niagara Falls. Hyde Park is a large municipal park with Hyde Park Lake and Gill Creek as its central features. The Living Shoreline project begins to address the ongoing bank erosion that can be seen along much of Hyde Park Lake. The project restored habitat along the shoreline and will continue to help address the lake's poor water quality and algae blooms which has been a concern in recent years. The Living Shoreline project improves approximately 600 feet of shoreline along the southeast portion of Hyde Park Lake, adjacent to the former rose garden. Living Shoreline improvements include:

- New grading to create a gentle slope along the shoreline, improving connectivity between the land and water.
- Creation of diverse habitat types including cattail marsh, woodland glade, meadow, and aquatic.
- Plantings of over 1,300 native plants along the shoreline and in the water to protect the shoreline from erosion, improve water quality by absorbing pollutants and adding oxygen to the water, and providing important habitat for a variety of species.
- Creation of habitat complexity in the water and along nearshore areas to reduce erosive forces from reaching the shore, and to provide critical resting, spawning, feeding, and nursery habitat for fish, and perching areas for birds. This was achieved through strategic placement of boulders, plants, and woody material.

Hyde Park shoreline pre-construction on the left and post-construction on the right.



BUFFALO NIAGARA WATERKEEPER RESTORATION PROJECTS

BNW Project Types

- ★ Waterway Revitalization
- ★ Reforestation
- ★ Living Shoreline

N

0 0.5 1 2 3 4
Miles

Notes: Buffalo Niagara Waterkeeper Summer 2022

BUFFALO NIAGARA WATERKEEPER®

4. <u>Activity – Erosion Model</u>

This activity is adapted from: https://www.soils4teachers.org/home

This experiment is meant as a hands-on exploration of how plants keep our soil intact and help to purify water! The experiment can be carried out over several lessons, or a single lesson. If possible, visit a local waterway or living shoreline habitat restoration project with your students. This experiment shows the importance of plants as a part of our shoreline habitats. Water running into a waterbody that passes through soil with vegetation will be clearer and cleaner. Plants help to stabilize shorelines, prevent erosion and sedimentation, and keep water clean.

Materials Needed

- 3 large plastic water jugs
- Potting soil
- Grass or seeds
- 3 plastic water bottles
- Yarn
- Scissors
- Dried leaves/detritus from outside

Directions

1. Collect three large plastic water jugs. Have students carefully cut the top portion of each jug, leaving a large open space.

2. In the first water jug, plant seeds, or take plant already established plants.

3. In the second water jug, place dried leaves and other "detritus" collected from outside.

4. In the third and final water jug, place only soil.

5. Carefully remove the bottom half of each of the three plastic water bottles. Using hole puncher or scissors, attach yarn the sides and hang from the larger water jugs. Ensure that the cap of each plastic water bottle is tightly closed.

6. Add an ample amount of water to each large water jug, containing the plants, dried leaves, and soil. The water should slowly percolate through and collect in the plastic water bottles.

7. Make observations as a group about the differences between each jug.

8. The roots of plants hold soil in place. When water runs through the jug with plants it comes out clearer than the jug with leaves and the jug with only soil.

Figure. Possible set-up model for activity.
(Credit: Geography Pods Soil Degradation: https://www.geographypods.com/soil--change-4hrs.html)

Discussion Questions

1. Why are Living Shorelines important?
2. How can native plants prevent water pollution?
3. Why is aquatic habitat important?
4. What are some key differences between a Living Shoreline and a 'non-living' shoreline?
5. Where else can Living Shorelines be found? (Hint: check Waterkeeper's website!)
6. How are the components of a Living Shoreline connected?
7. What are three ecosystem benefits provided by a Living Shoreline?
8. How do humans benefit from Living Shorelines?
9. What areas around Western New York could benefit from the creation of a Living Shoreline?
10. How could we measure the success of a Living Shoreline project?

Lesson 11 – Designing a Stewardship Project

Lesson for High School and Middle School Students

Description: Students can work together to design a project that will make a real impact in their environment! Now that we've learned about the issues facing our Niagara River Watershed – we can take action.

This activity is adapted from the Strengths and Concerns and the Cause-and-Effect Tree Activities, Earth Force 2020

Teacher Information

- Earth Force designs tools that educators and students can use to plan and implement environmental action projects: https://earthforce.org/
- Make Waves 4 Change: Develop Your Action Plan to Change the World: https://drinklocaldrinktap.org/wavemaker/book/
- Examples of other stewardship and restoration Projects in the Niagara River Greenway are described on the Niagara River Greenway website: https://www.niagararivergreenway.com/

Materials Needed:

- Writing utensil, highlighter
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit webpages
- Sticky notes or dot stickers

Learning Outcomes:

Students will be able to:

- Design a stewardship project that will address an environmental issue in their community
- Assess a natural area for native plant gardens

New York State P-12 Science Learning Standards (HS)

- HS-LS2 Interdependent Relationships in Ecosystems
    - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-ESS3 Human Sustainability

Part A: Mapping Environmental Issues

Guide the students through the activity using the steps below.

1. The first step in designing a stewardship project is to get a better understanding of the problem you would like to address. Ask your students to brainstorm environmental concerns that impact them, their school, or community. It can be any environmental concern – big or small!
    a. If you've completed previous lessons in this series, this is a great time to call back to Topic #2 – Issues and Solutions. Examples of environmental concerns include environmental justice issues, water pollution with contaminants like sewage or road salt, invasive species, plastic pollution, and climate change.
    b. Use the EPAs environmental justice mapping tool to explore environmental issues locally: www.Ejscreen.epa.gov/mapper/

2. Our community is not without its strengths! Now that you've thought about environmental concerns, make a list of the positive aspects of your community. This can be environmental assets like important habitat or species, as well as people-power or other assets in the community.

3. After brainstorming, have the students work individually or in small groups to design a cause-and-effect tree around one of the environmental concerns.
    a. If working in a group, introduce the concept of democratic decision making with dot voting to choose which issue to explore.
    b. Each student gets two votes – can use sticky notes or dot stickers. Write all the choices on the board or on a piece of paper to pass around and have each student vote by placing their dots next to the issue they'd like to focus on. They can use both their votes on the same issue or split their vote. Re-vote if needed to choose 1 issue.

4. Complete Root Cause Analysis by designing a cause-and-effect tree. Have students draw a tree – with a brown circle in the center representing the trunk, several green circles at the top representing leaves, and several brown circles at the bottom representing roots. Write the chosen concern in the center of the tree in the brown circle.

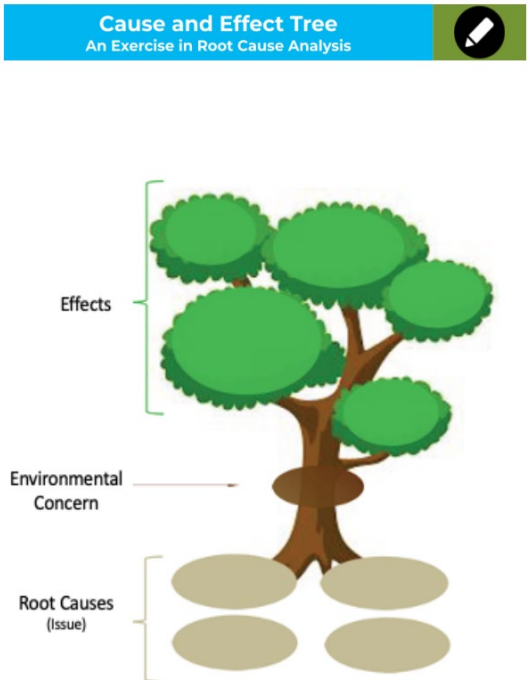
5. Prompt students to think about what effects this concern can have on their community and write down their thoughts in the branches and leaves in the tree.
    a. Who is most affected by this concern?
    b. Are different groups of people affected by this concern differently?
    c. How could this affect our lives?
    d. Environmental impacts – wildlife, water quality, habitat
    e. Impacts on our built environment – buildings and infrastructure

6. Shift focus to think about the systemic root causes of your concern. Why is this happening in the first place? Have students brainstorm their thoughts in the circles near the roots of the tree.
    a. The class may find that the concerns they identified are already root causes, which is great! Or they may have originally identified effects of a deeper root cause. Come together and talk about the root causes (real community issues) of the concerns that they identified.

b. Come back and build the tree together. Take a picture!
c. Mention that although the Issue might seem local – we are connected to the Great Lakes! Just like our strengths, issues span the Great Lakes Basin.

7. Now What?
    a. Working on an effect of a root cause is not usually a good project strategy to move forward on. Root causes are the best issues to tackle because changing them have high impact and create sustainable change in your community.

Example – Contaminated drinking water



Credit: Earth Force 2020

Issue: Water Pollution
Effect: People are getting sick because their drinking water is polluted
Cause 1: Companies put their waste into the water and waste like single-use plastic accidentally enters the water
Cause 2: Runoff containing non-point source pollution like oil from cars or fertilizers and pesticides from yards enters the Niagara River
Root Cause 1: It is the cheapest and easiest option to dump waste into local waterways, and there are little consequences to doing so
Root Cause 2: The Niagara River and its tributaries have had their shorelines hardened and they no longer filter or mitigate runoff and non-point source pollution like a living shoreline would

The example above shows two potential root causes to the issue of water pollution in the Niagara River. Students can take action to address either root cause! To address cause #1 students can use civic action to research and advocate for smart policies locally, state-wide, and federally that minimize the amount of pollution companies are allowed to produce or put into the water. Students could also act by organizing a litter cleanup, recording what they find, and sharing this information with decision makers! Root cause #2 can be addressed through designing and implementing a shoreline project, rain garden, or pollinator garden. Students could also join forces with a local park or volunteer group.

Keep the ultimate goal of **student action** in mind when facilitating this discussion. Guide the students to focus on a root cause that they will be able to take timely action on. If a root cause is big, or does not align with your stewardship project goals, timeline, or budget restraints, work with students to ground their ideas and discussion.

Extension Activity - Power Mapping

If time allows, have students complete a **Power Map**. Who are people in power, who decides on this stuff? Make a map with each person (or group of people) who has power to make decisions, draw lines to connect them to each other.

- Home (parents, elders)
- School (teacher, principal, administration, board)
- Neighborhood/City (block clubs, police, mayor)
- Municipality (county executives, planning board, dept. of public works, city clerk)
- State (mayor, state police/sheriff, attorney general)
- Country (president, senate)

Part B: Assessing a potential stewardship project location

1. Take your students for a walk at your project site – whether this is a local park, shoreline, or your schoolyard.
2. When at the site, take time to notice **features** of the site. What components are present? Ask students to make observations and write them down.
    a. Look for both natural and manmade features –plants or natural areas and habitats, trees, wildlife, as well as park features and necessities like trash cans or recycling cans. If there is a shoreline, pay special attention to the habitat there and make sure to understand which waterway it is and where it flows.
    b. Utilize resources like maps and field guides to identify features that you find as accurately as possible.
    c. If possible, invite an expert to join your tour at the project site. Consider inviting a decision maker your students identified during the power mapping exercise – this could be your school principle or administrator, a park manager, or an ecologist or naturalist from an organization like the Niagara River Greenway or Buffalo Niagara Waterkeeper.
3. After identifying features at the site, focus on the issue your students choose to address during Part A of this lesson. Where are there opportunities for a project at this site?
    a. Which features could help address the issue? Are there any features that could be important but are missing?
    b. Utilize good facilitation practices and make sure everyone has a chance to voice their opinion and listens to others
4. Now you need to decide on a **clear goal** to address the issue and a **strategy** to get there.
5. When you return from your site visit, utilize the Earth Force Resources on this page to write and fine tune an action plan with your students: https://earthforceresources.org/act-planning-and-taking-action/
    a. If you are applying for funding for your project – this is a good time to introduce the grant application.
    b. Have students review the project proposal instructions. What questions will they need to answer when applying for the grant? Can they answer those questions now? Can they start a budget estimate? Create a draft application to write down ideas.

Part C: Project Planning

1. Everyone has different strengths – when we come together to solve an issue that can be very powerful! As a project team, you need to decide which part of the project each person (or persons) is responsible for.
    a. Large groups can divide work up by creating committees. For example, a project team that would like to build a community garden could have a Plant Committee who is responsible for choosing which plants to purchase and where to buy them, a Marketing Committee who is responsible for sharing about the project and gaining support from the community, and an Implementation Committee who is responsible for planning a day for the team to work together to plant the garden.
2. Make sure everyone has a clear goal! Consider creating **SMART goals** for each Committee or person. Make sure to explain **deadlines** or other restrictions like budget amount.
    a. A SMART goal is specific, measurable, attainable, relevant, and time-based
        i. For example – the Plant Committee will develop a list of 10 native plants to put in the community garden and write a paragraph for each describing how much each plant costs at the nursery, its wildlife benefits, and how to plant them by November 1st
3. All of your SMART goals together make a **workplan**. A workplan is a list of tasks that need to be done to complete a project. Often workplans have a **workflow** – some tasks must happen before others can happen. For example, the implementation committee can't work in the garden until the Plant Committee has chosen and purchased plants.
    a. If there is time, work with students to create a workplan or task list. This could be presented as a calendar with deadlines or a list of SMART goals.
    b. Make a plan for project committees to team members to share updates on their work with the whole group.
4. Who can you call in to help you?
    a. Don't forget that your students are not alone! Make sure to ask others at school, at home, or in the community for help when needed.
    b. Research will most likely be a necessary first step! Assign students to look up best practices to achieve their goal, talk with experts, and share what they've learned.
5. Budget
    a. Consider the budget as your students work on their project. It may be necessary to remind students of the budget. Have the group think creatively and think about cost-saving!
    b. If you are applying for funding for your project, assign students to complete the project proposal.

Students in Buffalo Niagara Waterkeepers Young Environmental Leaders Program brainstorm together (left) and complete a stewardship project (right)

Resources for pollinator gardens, rain gardens, and other green infrastructure projects

- Native Plant Guide: https://bnwaterkeeper.org/nativeplantguide/
- Tree Planting Guide: https://bnwaterkeeper.org/wp-content/uploads/2020/07/Planting-Field-Guide_Container_WEB-1.pdf
- Green Infrastructure Solutions: https://bnwaterkeeper.org/wp-content/uploads/2011/04/BSAReport_Final_REV_4.11.11_LR_11.pdf
- Designing Waterfront Properties Guide: https://bnwaterkeeper.org/wp-content/uploads/2016/02/PDF-Version-for-Website.pdf
- Rain Barrel Information: https://bnwaterkeeper.org/rainbarrels/
- National Wildlife Federation Habitat Resources: https://www.nwf.org/Garden-for-Wildlife/About/Resources

  Extension Activity – Choosing Plants for a Garden:
  Why should you choose to plant native species over exotic species? Use the Native Plant Guide to answer this question and design a garden for your yard, schoolyard, or local park. List 5 native species, why you chose them, if you think they will survive at the project location, and what wildlife will be attracted to the garden location. Lastly, is there any way you could design your project to reduce stormwater runoff? https://bnwaterkeeper.org/nativeplantguide/

Resources for invasive species management projects

- Western New York Partnership for Regional Invasive Species Management: https://www.wnyprism.org/
- Invasive Species Plant Guide: https://bnwaterkeeper.org/wp-content/uploads/2018/09/Final-Invasive-Species-Booklet_website-9.21_small.pdf

Resources for plastic pollution solution projects

- Guide for organizing a safe litter cleanup: https://bnwaterkeeper.org/solo-sweep/
- Plastic Pollution Prevention: https://bnwaterkeeper.org/pollution-prevention/

Buffalo Seminary Students cleanup along the Buffalo River