Phinizy Swamp Nature Park
Teacher Field Trip Preparation Guide

Program: Butler Creek Blues

The following academic standards are covered on this field trip:
GPS6: CS1, CS2, CS3, CS4b, CS4c, CS5, E5h, E5i, E5j, M6M1, M6M2, M6P3a, M6P3b, M6P3c, M6P4
GPS7: CS1, CS2, CS3, CS4b, CS4c, CS5, CS7c, CS7d, L1b, L4c, L4d, M7P3a, M7P3b, M7P3c, M7P4c
GPS8: CS1, CS2, CS3, CS4b, CS4c, CS5, CS7c, CS7d, M8P4c
S.C. Science Standards: 6-1.1, 1.3, 1.5, 3.1, 3.2, 3.4; 7-1.1, 1.7, 4.3, 4.4, 4.5, 4.6; 8-1.6, 1.7, 2.1

Objective: To introduce students to the basics of stream ecology.

Vocabulary:

Acidic: Refers to a solution with a pH less than 7.
Adult: A sexually mature life stage of an animal.
Alkaline: Refers to a solution with a pH greater than 7; also known as basic.
Aquatic: Refers to plants or animals that live in water.
Basic: Refers to a solution with a pH greater than 7; also known as alkaline.
Biodiversity: A large variety of species living together in a habitat.
Blackwater: Refers to the dark orange, brownish, or tea-colored appearance of water in southeastern creeks in the Piedmont, Coastal Plain, and other low-lying areas. The coloration is caused by the presence of tannic acids.
Coastal Plain: A physiographic region characterized by flat, low-lying land and sandy soil. In Georgia and South Carolina, the Atlantic Coastal Plain lies east of the Piedmont and west of the Atlantic Ocean.
Complete Metamorphosis: A dramatic change in body form from young to adult that occurs in four steps: egg, larva, pupa, adult.
Dichotomous: Divided or separated into two parts or groups. A dichotomous key lets you make one of two choices in sequence to properly identify an animal or plant.
Dissolved Oxygen: Oxygen that is dissolved in water and available for aquatic plants and animals to breathe. Measured in parts per million.
Eutrophication: A condition characterized by excess nutrients in a waterbody, which can cause rapid growth of algae and other plants, leading to increased decomposition and resulting in very high levels of dissolved oxygen during the day and very low levels at night.
Exoskeleton: The hardened exterior covering of an insect.
Incomplete Metamorphosis: A dramatic change in body form from young to adult that occurs in only three steps: egg, nymph, adult.
Larva: An immature stage of an insect that undergoes complete metamorphosis.
Macroinvertebrate: An animal without a backbone that is large enough to be seen with the naked eye.
Nutrient: A substance that nourishes and promotes growth, such as nitrate or phosphate.
Neutral: Refers to a solution with a pH of 7; neither acidic nor basic.
Nymph: An immature stage of an insect that undergoes incomplete metamorphosis.

Piedmont: A physiographic region characterized by low, rolling hills and mostly clay soils. In Georgia and South Carolina, the Piedmont lies east of the Appalachian Mountains and west of the Atlantic Coastal Plain.
pH: A measure of the concentration of hydrogen (H^+) ions in a solution. The pH scale ranges from 0 to 14 where 7 is considered neutral. A pH describes the degree of acidity or alkalinity of a solution.
Pupa: A typically inactive, immature stage of an insect that undergoes complete metamorphosis. The pupa stage follows the larval stage and precedes the adult stage.
Sediment: Small particles of soil, clay, sand, or organic materials.
Tannic Acid: A weak acid that is formed when tannins (compounds present in plant materials, including leaves, cones, bark, and stems) leach out of plant materials and into water. Tannic acid gives water in some southeastern creeks and rivers a dark coloration, known as blackwater, and causes creek water to be naturally acidic.
Turbidity: The amount of suspended solids present in the water column. As the turbidity of water increases, water appears cloudier and less clear.
Velocity: A change in distance over a period of time; similar (but not equivalent) to speed. Velocity can be measured in units such as miles per hour or feet per second.
Watershed: The land area from which water, sediment, and dissolved materials drain to a common point along a stream, wetland, lake or river.
Whitewater: Refers to the clear, often foamy appearance of water in creeks and rivers in rocky, mountainous regions. The white, foamy appearance is caused by the mixing of atmospheric oxygen with water as it flows quickly over rocks in the stream.

Teacher Background Information:

Introduction

Clean water and healthy rivers and streams are vital to communities for several reasons:

- Everyone living or working in a community depends on the river for **drinking water**.
- Streams provide farmers with water for **irrigation**, which affects crops produced, which in turn affects the local economy.
- Businesses rely on rivers to provide water for **industrial processes**.
- People rely on the quality of their rivers and streams for **recreational activities**, such as fishing, swimming, and boating.
- Healthy streams are necessary to provide **habitat** for plants and animals.
- Clean water is vital to **biodiversity**, which promotes stable and sustainable wildlife populations.

To assess stream habitat and water quality, ecologists analyze a wide range of factors, including:

- Biological characteristics – the types and number of species living in or near the stream
- Chemical characteristics – temperature, pH, settleable solids (sediment), turbidity, dissolved oxygen concentration, and nutrient levels (nitrates, phosphates, and ammonia)
- Physical characteristics -- color, odor, velocity, volume of flow, appearance of bank, presence of woody debris and decomposing leaves in water, and stream shade cover

Typically, a stream ecologist would take data on as many of these features as often as he/she was able to establish a *baseline*, or what is normal for the stream. Major deviations from these baseline levels could indicate problems with stream health.

Aquatic Macroinvertebrates

Stream monitoring programs sample aquatic macroinvertebrates to assess habitat and water quality. An aquatic macroinvertebrate is an animal without a backbone that can be seen with the naked eye and lives primarily in the water. These organisms have special adaptations for obtaining oxygen from water, such as gills or special breathing tubes (such as in mosquito larvae or water scorpions). Some live in the water when they are young, then undergo metamorphosis and live in the air or on land as an adult, while others spend their entire lives in the water. Most aquatic macroinvertebrates belong to one of five categories:

- **Insects**, such as dragonfly nymphs, mayfly nymphs, midge larvae and mosquito larvae.
- **Arachnids**, such as aquatic mites.
- **Crustaceans**, such as crayfish, freshwater shrimp, scuds, and sowbugs.
- **Mollusks**, such as snails, clams, and mussels.
- **Worms**, such as leeches, planarians, and aquatic worms.

Biodiversity---a variety of species living in a habitat---indicates good stream health. A stream with many organisms of the same type is probably not as healthy as a stream with many different species. The biodiversity of macroinvertebrates present is used as an indicator of stream health because:

- Aquatic macroinvertebrates are relatively easy to sample and identify.
- They are present during all stream conditions.
- They are not very mobile and tend to remain within a small area of a stream for most of their lives. This makes aquatic macroinvertebrates good indicators of habitat and water quality on a local level.
- They are affected by the physical, chemical, and biological conditions of the stream. Some aquatic macroinvertebrates are more sensitive to changes in water quality parameters (e.g., DO, pH, turbidity, nutrient levels) than others. For example, stonefly nymphs are considered very sensitive, whereas midge larvae are considered pollution tolerant. This means that if DO in a stream drops below a certain level, stonefly nymphs are much more likely to die off than are midge larvae.

Complete and incomplete metamorphosis

All insects undergo a life cycle that is characterized by **metamorphosis**, a dramatic change in body structure that occurs as an insect grows from a juvenile into an adult. Typically, the aquatic insects used to assess stream habitat quality are the immature stages (nymphs and larvae) of flying insects. They often look completely different from the adults that they will become! There are two types of metamorphosis: complete and incomplete.

- **Complete metamorphosis** occurs in four steps: egg, larva, pupa, and adult. Examples of insects that undergo complete metamorphosis include butterflies, mosquitoes, black flies, and caddisflies.
- **Incomplete metamorphosis** occurs in only three steps: egg, nymph, and adult. Often several stages of nymph growth (called instars) must be completed before reaching the adult stage. It is also sometimes called gradual metamorphosis because nymphs gradually increase in size as they shed their exoskeleton between instars. Examples of insects that undergo incomplete metamorphosis include grasshoppers, dragonflies, damselflies, and mayflies.

- The juvenile stage of an insect that has complete metamorphosis is called a **larva** (plural: larvae), while those that have incomplete metamorphosis are called **nymphs**.

Aquatic macroinvertebrate habitats
Aquatic macroinvertebrates are a food source for many larger aquatic animals, such as fish, frogs, birds, snakes, and other invertebrates. They don't live as free-floating organisms in the water column, but rather are attached to objects to avoid detection by predators or being washed away in the stream channel. These include:

- **Vegetative margins**, which refers to plants located along the edges of stream channels.
- **Woody debris**, including logs, sticks, and roots and trunks of trees standing in water.
- **Substrate**, which can be rocks, gravel, sand, silt, or clay composing the streambed.
- **Riffles**, which are shallow areas of whitewater streams with fast-moving current flowing over rocks.
- **Leaf packs**, which includes decomposing vegetation (such as leaves and twigs) that is submerged in the water.

Dissolved oxygen (DO)
Dissolved oxygen is oxygen that is dissolved in water. It does not include the oxygen contained in the water molecule (H_2O), since this oxygen cannot be used by organisms for respiration. It also does not include visible bubbles in water. The oxygen that sustains aquatic life is the small amount of molecular oxygen (O_2) directly dissolved in the water and is the single most important chemical variable that affects aquatic life. Dissolved oxygen is measured in parts per million (abbreviated ppm). One ppm is equal to one milligram of O_2 dissolved in one liter of water. Clean, room temperature water holds about 8 ppm DO. DO levels of 5-6 ppm are usually required for growth and activity. DO levels below 3 ppm are stressful to most aquatic life, and streams with DO levels below 1-2 ppm will not support fish populations.

Factors affecting DO in water

- **Diffusion**: Most DO enters water by diffusion from the air at the water's surface. When water is stirred or splashed, such as running over rocks or down a waterfall, a greater amount of its surface area makes contact with the air, adding oxygen to the water. Fast-moving mountain streams (i.e., whitewater creeks) tend to contain the high DO concentrations.
- **Plants**: Plants and algae also add oxygen to water as they perform photosynthesis (consuming CO_2 and emitting O_2) in the presence of sunlight, but they also use oxygen for respiration at night. Some aquatic plants produce so much oxygen that the water surrounding the plant becomes supersaturated and literally squeezes the oxygen into visible gas bubbles coming from their underwater leaves. At night, when plants and algae stop photosynthesizing and begin respiring (consuming O_2 and emitting CO_2), DO levels drop. An algal bloom (a rapid increase in algae in a waterbody) can deplete all of the DO in a pond, lake, or slow-moving stream during nightly respiration, often causing a massive die-off of fish and other aquatic animals.
- **Temperature**: Cold water holds more DO than warm water. In the summer when lakes and ponds heat up, fish kills are more likely because DO levels drop. Since cold water is denser than warm water, fish that require high oxygen levels are often found at greater depths of lakes where the water is colder. Temperature also affects microbial respiration and decomposition rates. As temperature increases, decomposition rates speed up.

- **Organic materials**: Organic materials are decomposed by bacteria and fungi, which utilize oxygen for respiration. The higher the organic load, the greater the number of microorganisms needed to decompose the material and the more oxygen consumed. Natural sources of organic materials include animal wastes and decaying plants and animals, while man-made sources include domestic sewage, grass clippings, pet and livestock waste, fertilizers, wastewater effluent, and discharge from paper mills and food-processing plants.

Biochemical oxygen demand (BOD)

Biochemical Oxygen Demand (BOD) is a measure of the demand for oxygen in the water. BOD is a combined measurement of oxygen used:

- By microorganisms in decomposition (respiration)
- By the use of oxygen for chemical reactions such as oxidation of sulfides, iron, and ammonia
- For respiration of aquatic life including plants and animals

pH

Water molecules (H_2O) spontaneously break into hydrogen (H^+) and hydroxyl (OH^-) ions; pH represents the concentration of hydrogen ions in an aqueous (water-based) solution, which is a measure of its acidity or alkalinity. The pH scale ranges from 0 to 14. If the H^+ ion concentration is greater than the OH^- ion concentration, the solution is **acidic** and the pH is less than 7. When the reverse situation exists, the solution is **basic** or **alkaline** and the pH is greater than 7. A solution with a pH of 7 has an equal balance of H^+ and OH^- ions and is **neutral**. The pH scale is logarithmic, meaning that a solution with a pH of 3 is 10 times more acidic than a solution of pH 4, 100 times more acidic than a solution of pH 5, and 1,000 more acidic than a solution of pH 6.

pH is an important factor of water quality for several reasons:

- Most organisms have a relatively narrow range of pH in which they are able to live and thrive. When pH is outside that range, the organism can die. A pH range of 6.4 - 8.2 is optimal for most aquatic organisms.
- Many nutrients present in soil (such as phosphates and nitrates), are negatively-charged. Positively-charged H^+ ions in acidic water can interact with these nutrients and cause them to leach out of the soil and into groundwater.
- pH can be affected by photosynthetic rate. Carbon dioxide (CO_2) released from plants during respiration interacts with water molecules to form a weak acid. During the day, aquatic plants use CO_2 for photosynthesis. Under eutrophic conditions, plants can remove more CO_2 than is being produced through respiration, causing the pH to increase during the day and decrease at night when photosynthesis stops.

Turbidity

Turbidity refers to the clouded, murky appearance of water containing suspended solids (sediment). An excessive amount of sediment is actually a form of pollution that results from erosion along a stream or surface runoff from the watershed. Turbidity can negatively impact stream habitat in several ways, including:

- In slow-moving water, sediment settles on the bottom, often smothering habitat for fish and other aquatic life.

- High turbidity can block sunlight to aquatic plants and clog the gills of fish and macroinvertebrates.
- Turbid water absorbs more heat from the sun, decreasing the amount of dissolved oxygen in the water.

Nutrients

Nutrients such as nitrogen and phosphorus are added to lakes and streams primarily by decomposition of organic material (mostly plants), discharge from wastewater treatment plants, and surface runoff from farms and lawns. Animal waste and chemical fertilizers are the main sources of added nutrients in streams. It is important to monitor levels of nutrients in streams because:

- High levels of nutrients stimulate algae and plant growth at a faster than normal rate. This growth rate can lead to **eutrophication**, which can cause large daily fluctuations in dissolved oxygen and pH, creating an inhospitable environment for most aquatic organisms.
- A sudden increase in nutrient levels from one monitoring event to the next can indicate a sewage spill, a leaking septic system, an influx of surface runoff from a rain event, or other discharge to the steam.
- The EPA and the Georgia Environmental Protection Division has set standards for nutrient levels in our waterways in accordance with the Clean Water Act.

Physical stream characteristics

A variety of physical stream characteristics are used to determine the quality of stream habitat, including color, odor, velocity, volume of flow, appearance of bank, presence of woody debris and decomposing leaves in water, and stream shade cover.

Velocity refers to the speed of water as it moves downstream. Different streams will have different velocities as a result of many factors, including rainfall, snow melt, and topography, as well as human activities such as dams, channelization, and replacing vegetation with paved surfaces that increase runoff. Some streams are naturally fast-flowing, while others are very slow-flowing. When a typically slow-flowing stream has a sudden increase in velocity (due to heavy rains or a large discharge), plants, animals, and sediments can be washed away, damaging the stream habitat. A fast-moving stream has organisms in it that depend on high levels of dissolved oxygen. A slow-down in these systems (caused by dam construction, large water withdrawals for agriculture, or drought) can decrease oxygen concentrations and threaten aquatic organisms.

Volume of Flow is measured as an additional way to assess how much water is flowing through a creek ecosystem. It is calculated by multiplying velocity, creek width, and creek depth. (volume of stream flow = velocity x width x depth)

Color: Most southeastern streams can be categorized as either **blackwater** or **whitewater** creeks. This is often determined by the topography of the watershed. Whitewater creeks are located in the mountains and Piedmont, while blackwater creeks are on the Coastal Plain and other low-lying areas. Many larger streams and rivers flow through more than one type of topography and contain both whitewater and blackwater reaches. The dark color of blackwater creeks is caused by **tannic acid** in the water, a product of plant decomposition. The presence of this weak acid causes blackwater creeks to be slightly acidic. A blue-green tint in water often indicates elevated levels of cyanobacteria (formerly known as blue-green algae).

Woody debris and leaf packs provide habitat for aquatic macroinvertebrates. The absence of this material from the stream can limit the biodiversity and abundance of macroinvertebrates, as well as the organisms that feed on them.

Stream shade cover protects the stream from the intense, direct heat of the sun, specifically during the summer. Without shade over the stream, water temperatures can increase substantially, which decreases the capacity of the water to hold dissolved oxygen.

Vegetation on banks minimizes erosion by providing structure and stability. Without plant roots to hold soil in place, it can be easily washed into the stream during rain. Heavy rain events can cause bare stream banks to erode and collapse, increasing turbidity and damaging aquatic habitat.