The Urban Naturalist Program

Fall 2013: 2nd Edition

An Interdisciplinary Educational Program Designed to Facilitate the Exploration of Nature in the Urban Environment
Developed for Greenville, South Carolina

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The Urban Naturalist Program

An Interdisciplinary, Place-based Approach to Exploring the Natural Environment in Urban and Developed Areas for Greenville, SC

There is often a tendency for people to think of nature as something that is separate from their everyday lives. Many times, nature is construed to be something off in the distance, or something that you must take a special trip to visit. In truth, nature is all around us. People are a part of the natural environment, and our environment is essential to healthy growth and survival. Clean water, clean air, healthy soil, and a wide variety of animals and plants (biodiversity) are as important to our health and well-being as shelter, good food, and transportation.

Though it is important to set aside protected areas for nature such as parks, national forests, and preserves, it is also essential to understand and appreciate the plants, animals, and ecosystems that are all around us and part of our everyday surroundings and to understand the pressures and threats that urban development may place on the natural environment. The Urban Naturalist Program was developed by the Livability Educator for the City of Greenville, SC as part of the Connections for Sustainability project. One of the goals of the Urban Naturalist Program is to introduce students to the idea that nature is present everywhere, even in the city, and that our daily activities bring us into contact with and affect the environment in many ways, and in turn, that our natural environment also affects us.

Acknowledgments

The development of the Urban Naturalist Program has involved collaboration from a number of individuals including City of Greenville Staff, Educators, Students, and many more. Thanks go out to all of the people who have helped to create, test, and edit the information and activities included in this program.

Specifically, I would like to thank Amanda LeBlanc, Librarian at A J Whittenberg Elementary School , who has been instrumental in the development and implementation of the program at A J Whittenberg, and the Connections Project staff team members Wayne Leftwich, and Christa Jordan. Without the hard work and dedication of these individuals, this program would not have been possible.

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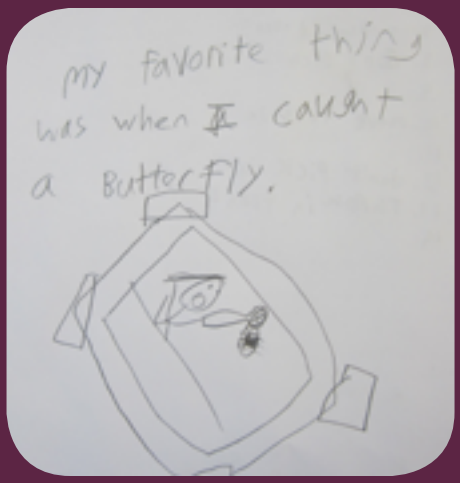
Introduction



About The Urban Naturalist Program

The Urban Naturalist Program has been developed through the Connections for Sustainability project by the Livability Educator for the City of Greenville, SC. The Urban Naturalist Program is part of the City of Greenville's "Curriculum for Sustainability" and can be used in conjunction with or separate from lesson plans from the curriculum for sustainability.

Program Objectives

- Introduce students to the concept that nature is an important part of the urban environment
- Develop an appreciation for the diversity of life present in the urban environment
- Foster a sense of responsibility for the environment
- Teach essential organizational and science skills through the creation of a field notebook
- Introduce students to a variety of nature identification tools
- Encourage teamwork, observation, and curiosity while forming a connection to the urban environment
- Emphasize safe and meaningful interaction with the natural world through field expeditions
- Fully integrate sustainability principles and conservation ethics into lessons in both the classroom and the field

How to use The Urban Naturalist Program

The Urban Naturalist Program was developed to be used in formal or informal educational programs as a classroom curriculum supplement, in after school programs, or as a part of a camp curriculum. Sections include classroom components, background information, and activities paired with field components and more. Extra supplemental materials, including powerpoint presentations, are available on the Connections website. Educators are welcome to use the program in part or in whole. It is strongly recommended that however you choose to use the program that you start with Chapter 1 and dedicate a class period to field safety and identifying dangerous plants and animals.

Photos page 4: Top: *A Jr. Urban Naturalist draws in his field notebook.* ***Middle:*** *An Urban Naturalist observes a grasshopper in a magnifying box.* ***Bottom:*** *Excerpt from a field notebook: "My favorite thing was when I caught a butterfly.*

Photos page 5: Top*: Urban Naturalist class at A J Whittenberg Elementary learns how to use their digital cameras before going out into the field.* ***Middle:*** *Urban Naturalists identify a tree near the Swamp Rabbit Trail in Greenville, SC.* ***Bottom****: An Urban Naturalist uses a field guide to identify a damselfly.*

It is also recommended that you study this teacher's guide thoroughly before beginning the Urban Naturalist Program. The guide provides copies of handouts that are available for use in the classroom as well as extra background information on each topic. The student handouts do include background information that is not covered in the background text, and vice versa. Activities and lesson suggestions for a variety of age groups and skill levels are also included. Many of the activities and collection and identification techniques can be used in multiple lessons. You may want to pick one technique (such as using a dichotomous key) and focus on that throughout a variety of topics, or you may choose to teach a different technique for each topic.

Depending on the amount of time that you have available, each portion of the program could be taught in a single lesson followed by time in the field for observation, collection, or identification. Or, each portion of the program could be stretched over the course of several days. Another option would be to teach the classroom components of each section first and then follow up with several field expeditions, allowing students to focus on observing a variety of plants and animals during the trips. Identification can take place in the field using field guides if available or can be done in the classroom following the field expedition. You may want to use each identification technique for different topics or a combination of the two where appropriate.

Ideally, classroom components will be paired with a field expedition geared towards observation and collection followed by extra time in the classroom for identification, work on the field notebook, and other follow-up activities (leaf pressing, observing collected specimens, uploading pictures, etc.). After all of the lessons have been completed, the class could include some general field expeditions that are guided by the interests of the students.

Though no student will become an expert in field identification, this program is designed to expose students to the impressive diversity of organisms and habitats in the upstate while introducing conservation and sustainability principles, developing a sense of place and responsibility related to the natural environment, and encouraging both curiosity and safety while exploring nature.

Top: Urban Naturalists use aerial nets to catch flying insects for observation

Bottom: Urban Naturalists learn how to press tree leaves in a simple plant press

Collection

As a part of the Urban Naturalist program, the collection of specimens for identification and study will be discussed and proper collection and preservation techniques can be briefly taught.

Why collection?

Scientists utilize a wide variety of data and data collection methods. Sometimes, this includes the collection of live organisms such as plants or animals. Scientists can learn a lot by collecting biological organisms; for example, the range and distribution of an animal or plant, and how that range or distribution changes over time. Collecting specimens of biological organisms is an important part of scientific study, and in order for the specimens to be useful for scientists, specific methods must be used in the collection, documentation, and preservation of the specimens. It is important for students to understand why and how to collect and preserve natural specimens. Capture of live animals (such as insects) must be done carefully so that students can observe the animal and then let it go unharmed.

For conservation purposes, encourage "collection" through digital photography if at all possible. Though photographs are not always enough for scientists, for this program, photography is a great alternative to live specimens. Photographs can be printed and added to the student's field notebook, or saved into a field notebook file in OneNote or another notebook program. Dead leaves, acorns, small rocks, cicada exoskeletons, and other natural artifacts may also make great additions to the students' nature collections and can be collected without harming or killing any organisms. Make sure that you are complying with state, federal, and local laws and regulations regarding collecting.

Rules for Collection

Never collect any part of a sensitive, threatened or endangered species without a permit. Not only is it bad for the environment, it is illegal to "take" ("harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect a listed species or attempt to engage in any such conduct") a listed species, and the penalties for harming endangered animals include up to $50,000 in fines and a year in jail. For per county lists of species of concern in South Carolina, check with the South Carolina Department of Natural Resources (SCDNR). The list for Greenville County is available at the following link: http://www.dnr.sc.gov/species/pdf/greenville.pdf

It is illegal to possess feathers of any migratory bird (this includes most of the native birds in South Carolina) as well as to disturb an active nest or eggs, or to raise a migratory bird in captivity without a permit. Though most people would see no harm in collecting a feather that they found on the ground, the Migratory Bird Treaty Act (16U.S.C. 703-712) makes it illegal to own most wild bird feathers. If you find a feather on one of your expeditions, explain to the students that it may be illegal to keep it, and take a picture for your field notebook. http://www.npwrc.usgs.gov/about/faqs/birds/feathers.htm

SCDNR also provides some fact sheets for species of concern in South Carolina. It is unlikely that you will come into contact with any endangered species while on a field trip, but it is possible. Thus, it is important that you are informed as to the habits and descriptions of endangered species so that you don't accidentally harm one of these organisms. http://www.dnr.sc.gov/cwcs/species.html

Materials

A major thematic concept found throughout the Urban Naturalist Program is sustainability. Developing appreciation for and a knowledge of our surroundings is just the beginning. We must also develop a sense of responsibility for our natural resources and understand how our actions affect the world around us. The Urban Naturalist Program provides students with a broad cross section of tools for inquiry so that they can become well informed stewards of their environment.

One of the goals of the Connections for Sustainability Project is to integrate livability and sustainability principles into educational programming. In order to keep this program as sustainable as possible, lists of free online guides and resources are provided when available to use for research and identification. The program and handouts are all available in pdf format, and handouts should be printed front and back if at all. If the technology is available, students can download pdf files and print them into OneNote or another notebook program, allowing them to make notes on their digital copies instead of printing hard copies. Craft activities that involve recycled and commonly available natural materials are included in the activities throughout the program.

Many of the materials needed for observation and sampling can be created from household items. For example, a pie tin purchased from a thrift store makes a great beginner's tool when panning for gemstones. Some specialized equipment is beneficial, but where possible, instructions are included for keeping costs low and reusing materials by making your own sampling equipment or substituting low cost, environmentally friendly alternatives.
This program should empower students to observe and identify nature themselves while instilling sustainability and conservation as core values. In order to do that, every effort has been made to make the Urban Naturalist Program accessible and inexpensive, and to include activity suggestions that actively address environmental concerns.

Suggested Materials List:

- Handouts: pdf files of handouts are provided
- Safety whistle
- Field notebooks: 3 ring binders – Think of the student's field notebook as a scrapbook. They will add handouts, pressed leaf or flower petal collections, photographs, and field notes. Encourage good data collection (especially date and place descriptions), but allow them to be creative with how they choose to display their data. The field notebook is something that they can keep, share with their parents or friends, and be proud of. Students will need their field notebook throughout the program.
- Clip boards – great for taking notes while in the field. Notes can be transcribed into the field notebook when in the classroom
- Pencils and pens
- Digital Camera – if available
- Compass
- Maps
- Dichotomous keys – leaf key, insect key, tree key, etc.
- Clippers or scissors
- Plant press (see section on collecting plants for how-to make a plant press)
- Field Guides (links to online resources are provided with lessons)
- Small shovel or spade

Urban Naturalists use many different tools to study the natural environment.

Digital cameras allow Urban Naturalists to record their findings without having to harm or kill biological organisms through collection

An Urban Naturalist draws pictures and records his observations in a field notebook

- Binoculars
- Hand lens
- Insect nets (how to make insect nets included with lessons)
- Containers for collecting viewing specimens (preferably an assortment of bags, envelopes, and plastic containers with lids (glass breaks!))

Additional Materials for Activities: Activities are supplemental and meant to be fun, educational extras that you may or may not have time for. Materials lists will be included with each activity as needed.

Integrating Sustainability

Developing environmental literacy and a culture of sustainability is essential to the continued healthy development of our society. Living sustainably means making certain that the needs of individuals in the present are met without compromising the ability of future generations to meet their own needs. Conservation, protection of natural resources and natural areas, reducing resource use, reusing and recycling are all a part of living sustainably.

Though sustainability principles can and should be taught in a classroom setting, the most important aspect of engaging students in thinking and acting sustainably is through action. This program is about connecting with the environment around us, and as such, sustainability principles should be fully integrated into every lesson and every field experience. The instructor can lead by example in a variety of ways including the following simple steps.

- Recycle and encourage students to recycle.
- Reuse materials as many times as possible.
- Discuss the ways that the built and natural environment connect and affect one another as well as the history of your area while in the field.
- Print front and back.
- Or, if the technology is available, go paperless and import pdfs into OneNote or another notebook program to create a digital field notebook
- Minimize the disturbance that you create while in the field. Treat animals and plants with care and respect and make every effort to return the environment to the way that you found it.
- Pick up trash. When you are in the field, carry a small litter bag and collect trash. Encourage the students to help. Young students can point out trash that you can pick up. Older students may want to start carrying their own litter bag (make sure you emphasize safety – students should not touch anything sharp. Gloves or a litter “grabber” are a good idea.).
- Discuss some reasons why litter is bad for the environment. This doesn’t have to be a classroom lesson, just mention how litter damages the environment as you pick it up.

    Will be washed into streams

    Animals may try to eat it and choke, be injured, be poisoned, tangled, or die

    Break down chemicals can be bad for soil and ground water

    Chemicals absorbed into the soil can be taken up by plants and passed along to herbivores and carnivores through the process of bioaccumulation

    Spreads or promotes diseases or attracts disease vectors (rats are attracted to trash, mosquitoes lay eggs in still water that collects in plastic, rubber tires, and other litter)

Chapter 1: Field Safety and Identifying Dangerous Plants and Animals

No matter how you choose to utilize the information provided in the Urban Naturalist Program, begin with a classroom component on safety. Fostering life long habits of safe and respectful behavior towards the natural environment is an important step in developing a healthy and sustainable society.

This information may be paired with an introduction to the Urban Naturalist Program, getting to know you exercises, and even a short excursion outside to practice observing nature safely.

Word Bank

Nature
Safety
Venomous
Toxic
Responsibility
Observation
Appropriate
Potential
Invasive
Threat
Defense
Respect
Disease Vector
Parasite
Emergency

FIELD SAFETY

Key Concepts and Skills

- There are many potentially dangerous plants and animals that people may interact with when studying nature
- The best way to stay safe when observing a dangerous plant or animal is to remain aware and calm and leave it alone
- Students will learn and practice some safe nature observation techniques
- Students will understand that safe behavior can drastically minimize their danger when interacting with the natural world
- Students will make a pledge to engage in safe and respectful behavior as an urban naturalist

Background Information

Animals and plants are an important part of our environment. When interacting with animals and plants, it is important that we respect and protect them, and follow guidelines for keeping ourselves safe as well as protecting the environment.

Personal Safety:
Much of this information is included in the field safety handouts that can be provided to the students.

> Wear sunscreen. Any extended trip outside can lead to sunburn, even in winter or on cloudy days. Require that students bring their own sunscreen or send a waiver home for parents to sign so that you can provide sunscreen for them.

Word banks will include possible vocabulary or research prompt terms related to each section. These terms are also covered in the glossary of the program but may or may not defined in the section text.

Field Safety Field Notebook Suggestions

Record responses to the safety obstacle course

Take photographs or draw pictures of any potentially harmful organisms that you find

Make up a short poem about a safety skill you have learned

Write a short paragraph about litter. What is litter? Why is litter a bad thing? What is the safe thing to do when you find litter during a field expedition?

Draw a picture of your buddy doing something safe.

Describe one law that you've learned about that applies to the field expeditions that Urban Naturalists take. Why is it important to obey that law?

Wear appropriate clothing. Appropriate clothing will vary depending on where you will be. A suggested minimum is closed toed tennis shoes, socks, and long pants when walking in the woods. Rubber boots if wading.

If going into the woods, marsh, wetlands, or other areas where you may find ticks and mosquitos, use bug repellent. Remind students that they should not put any body part with bug repellent on into water or touch amphibians.

Stay with a buddy and stay in sight of an adult. Either assign or have students chose a buddy prior to going out in the field. Make it very clear to them that they are responsible for each other's safety, and should never be out of ear shot and eye sight of each other (or an adult)

Wear your safety whistle at all times.

Know what poison ivy and poison oak look like, and stay away from these plants even if you don't think you are allergic. The second section in this chapter covers the characteristics of poison ivy and poison oak and includes handouts with photographs.

Handling and Collecting Specimens:

Make sure that the students understand that you expect them to utilize common sense as well as the urban naturalist rules for exploring nature. Exploring nature should be a lot of fun, but we still have to be careful to protect ourselves and the environment.

Simple but important points to cover include:

- Walk, don't run.
- When lifting rocks or logs to look underneath, use a tool to flip the log, and lift it away from your body. This way, if there are stinging insects or snakes underneath, they won't be able to bite you.
- NEVER stick your hand or foot in a hole or under a log or rock without looking. Many animals hide in holes and under logs.
- Be careful where you step. Nature isn't flat, and you need to watch for holes, roots, plants with thorns, and other obstacles that can trip or hurt you.

It is also important for students to know and understand proper collection techniques and the laws and regulations that govern the collection of biological specimens.

This is also a good time to discuss trespassing and the difference between private and public lands, as well as some of the laws that govern public spaces.

It is illegal to collect plants, animals, fossils, or other artifacts from many state parks, national forests, and preserves. In others, you must have a collection permit. Check into local laws before heading into the field. Most parks and other public areas have a website and someone on staff to help answer these questions.

Handling techniques

Most of the lessons in the Urban Naturalist Program involve observation of living organisms from a safe distance or utilize a digital camera in order to take pictures that can be placed in the field note book, but whether you are planning to collect animals or not, it is helpful to go over proper handling techniques ahead of time. Specific rules will vary depending on what you are studying, but some general rules include:

Don't touch amphibians (frogs and salamanders) if you have insect repellent on your skin. Amphibians absorb water through their skin and insect repellent can kill them.

Don't touch the wings of moths and butterflies. Moths and butterflies have tiny scales on their wings. Touching their wings can damage moths and butterflies so that they cannot fly.

Do not grab lizards or turtles by their tails. This can damage the spine and kill the animal. Lizards, salamanders, and skinks should be held gently in the hands. Turtles can be held by the back of the shell.

If you do catch animals or insects, it is best to keep them in a container for observation and make contact as little as possible.

Aquatic animals should be kept in a container with water from the same place that you found the animal. Adding water from another source may alter the environment enough to harm or even kill the animal.

If you turn a log or rock over to look underneath it, put it back the way you found it. If you found an animal underneath the log or rock, return it near where you found it. Don't place the animal under the log, but instead, place it on the ground near the log. Putting an animal underneath a log or rock could crush and kill it.

Take photographs of feathers, instead of collecting them

Aquatic animals should be kept in water from the place where they were found

Magnifying boxes are a great way to observe insects and other small organisms

Exploring Nature Safely

Animals and plants are an important part of our environment. When interacting with animals and plants, it is important that we respect and protect them, and follow guidelines for keeping ourselves safe as well as protecting the environment.

Personal Safety:

- Wear sunscreen. Any extended trip outside can lead to sunburn, even in winter.
- Wear appropriate clothing. Tennis shoes, socks, and long pants when walking in the woods. Rubber boots if wading.
- If going into the woods, marsh, wetlands, or other areas where you may find ticks and mosquitos, use bug repellent.
- Stay with a buddy and stay in sight of an adult. Wear your safety whistle at all times.
- Know what poison ivy and poison oak look like, and stay away from these plants even if you don't think you are allergic.

Handling and Collecting Specimens:

Be careful: exploring nature is a lot of fun, but we still have to be careful to protect ourselves and the environment.

- Walk, don't run.
- When lifting rocks or logs to look underneath, use a tool to flip the log, and lift it away from your body. This way, if there are stinging insects or snakes underneath, they won't be able to bite you.
- NEVER stick your hand or foot in a hole or under a log or rock without looking. Many animals hide in holes and under logs.
- Be careful where you step. Nature isn't flat, and you need to watch for holes, roots, plants with thorns, and other obstacles that can trip or hurt you.

Know and follow proper collection techniques

There are a lot of cool things to be found in nature. We will mostly observe animals and plants in the wild, but sometimes we may want to collect something. It is important to know how to collect a plant or animal without causing damage to the environment, the specimen, or ourselves.

We will learn a variety of collection techniques for plants and insects. Follow the instructions carefully, and when in doubt, ask an adult for help.

- Make sure that you are not killing something that is endangered or rare. A good rule for collecting plants is to look around. If you see more than 20 healthy plants, it is usually OK to collect one.

- Take pictures, and make sure to record where, when, and what the picture is in your field notebook.
- It is illegal to collect plants, animals, fossils, or other artifacts from many state parks, national forests, and preserves. In others, you must have a collection permit. Make sure that you know the rules and follow them.

Know and follow proper handling techniques

Most of the time, we won't be collecting animals, but we may want to hold them temporarily to photograph, identify, or share with the group. We need to be careful not to hurt the animal or it won't survive when we let it go.

- Don't touch amphibians (frogs and salamanders) if you have insect repellent on your skin. Amphibians absorb water through their skin and insect repellent can kill them.
- Don't touch the wings of moths and butterflies. Moths and butterflies have tiny scales on their wings. Touching their wings can damage moths and butterflies so that they cannot fly.
- Do not grab lizards or turtles by their tails. This can damage the spine and kill the animal. Lizards, salamanders, and skinks should be held gently in the hands. Turtles can be held by the back of the shell.
- If we catch animals or insects, it is best to keep them in a container for observation and make contact as little as possible.
- Aquatic animals (animals found in water) should be kept in a container with water from the same place that you found the animal.
- If you turn a log or rock over to look underneath it, put it back the way you found it. If you found an animal underneath the log or rock, return it near where you found it. Don't place the animal under the log, but instead, place it on the ground near the log. Putting an animal underneath a log or rock could crush and kill it.

Modeling safe behavior, like lifting rocks to open away from your body, helps students visualize the action

Urban Naturalists understand importance of safe behavior at all times

Field Safety Activities

Introduce the Urban Naturalist Program and the rules for safe conduct.

Ask students to write the following condensed rules on a sheet of paper and have them sign it as their pledge to follow these rules anytime that they are acting as Urban Naturalists.

(A space has been left at the bottom of the safety handout for this)

1) Stay with your buddy
2) Wear your whistle
3) Walk, don't run
4) Look before you touch
5) Be Careful

Model safe behaviors for the students and ***practice*** while in the classroom. Use a chair or stool to represent a log that they are crossing and a book to represent a rock or stick that they are turning over in order to look underneath.

Write an acrostic poem using one of these four words from the word bank as the subject: Respect, Appropriate, Responsibility, or Safety.

Ask students to share their poems and discuss how they think their subject word relates to nature exploration. The finished poems can be placed in the students' field notebooks.

Set up a safety obstacle course and have the students practice safe behaviors while interacting with the natural environment.

Set up numbered flags or other markers in a safe outside area. Each flag is a station where the students should make a decision about the correct way to react when faced with that situation during a nature exploration trip. Situation cards that you can place at each station are provided or make your own.

Allow the students to explore the course and write down or work in teams to photograph what they think they should do at each station. (Students should pretend that plastic animals are real)

If you know all of the places that you will be visiting during your class, you may want to set up stations that will correspond to the types of situations they may face such as how to respond when they are observing nature from a trail and a cyclist is coming.

Example of the set up for a safety obstacle course: in the school garden:

An urban naturalist photographs himself stepping safely over a rock

Print and copy the cards on the next four pages as part of a safety obstacle course, or make your own.

Flag	Item	Correct Response
1	Bone	Interesting item – safe to collect
2	Wildflower(more than 20)	There are more than 20 of these plants, so it is safe to collect one
3	Plastic Snake	Potentially dangerous: back away slowly and observe from a safe distance
4	Rock on a plastic Scorpion	Look around the rock; note that the scorpion is present. Potentially dangerous: leave it alone
5	Small log	Practice turning the log over; open away from the body
6	Plastic Grasshopper	Harmless animal: observe
7	Large log	Practice stepping onto the log, looking, and then steppin onto the ground on the other side of the log
8	Wildflower (only a few)	There are less than 20 of these plants in view, so it may be rare. Do not collect (except with a photograph)
9	Plastic Yellowjacket	Potentially dangerous: back away slowly
10	Pretty rock	Interesting item – safe to collect
11	Plastic Rat	Potentially dangerous: back away slowly and observe

There is a Vine Growing Here

1. Is it SAFE to touch the leaves of the vine in the picture?

2. You look around and don't see any other flowers that look like this....should you pick these flowers?

There's a Vine Growing Here

1. Is it safe to touch the vine in the picture?

2. Do you know what it is?

Check out this great rock!

1. You want to look under the rock and see what's there....how do you safely turn the rock over?

2. There's something there...where do you put the rock?

Check out this great rock!

1. You want to look under the rock and see what's there....how do you safely turn the rock over?

2. There's something there...is it safe to pick up?

You Found a Stick!

1. What should you do first?

2. How do you turn it over safely to look underneath?

Wow! You found something cool!

1. Is it safe to take a close up picture?

2. Should you collect it?

There's a Log in your path

1. How do you safely cross the log?

2. Don't forget to look around the log…is there anything cool there?

Uh oh! That doesn't belong here!

1. You found something that doesn't belong in nature.

2. Should you
   a. Pick it up and throw it away
   b. Pick it up and recycle it
   c. Leave it alone

Present the students with their safety whistle
Make this a big deal! If you are giving the students name badges to wear, present them with the whistle and badge at the same time.

Students will want to blow the whistle. Take a moment and let them (if appropriate), and then inform them that from here on out, the class will react to a blown whistle as if an emergency is happening.

Go over emergency procedure (when to blow the whistle and what others should do if they hear a whistle). Emergency procedures will vary according to where you are, how many adults are with your group, etc. Use your best judgment to develop emergency procedure. Keep it simple and make sure all students and adults know what the procedure is. Practice your emergency procedure so that everyone knows what they are supposed to do. The following is an example:

Establish a "Home Base" area at the beginning of each field expedition that is easy to find. One adult should always stay within sight of home base. Make sure the students know where home base is. Depending on the age of the students, you may also want to establish a perimeter that they should stay within and make sure that all students can be seen by an adult at all times.

When to blow the emergency whistle: if you or your partner is hurt, lost, or in any kind of danger.

What to do if you hear the emergency whistle. Similar to a fire drill at school: Stop what you are doing and calmly walk back to home base. One adult will be the "responder" and will immediately go towards the whistling team. One adult should stay at home base and account for the remaining students. If there are more adults, they should help with the emergency.

IDENTIFYING DANGEROUS PLANTS AND ANIMALS

Learning Objectives:

Students will

- become familiar with the characteristics of common plants and animals that can be dangerous to people
- practice safe nature observation and exploration habits including what to do if they encounter a dangerous plant or animal in the field
- understand that animals and plants which are potentially dangerous to humans are still an important part of many ecosystems

Background Information

Often, because something is dangerous to humans, that organism is hated and feared. It is important to remember that these plants and animals occupy important niches in their ecosystems and that their presence in our environment often provides people with a variety of benefits. Poison Ivy berries are an important food for a variety of wildlife, including Bobwhite Quail and White Tailed Deer, both of which are often eaten by humans. Spiders, wasps, and other predacious insects kill pest insects which can help prevent the spread of disease and reduce insect damage on crops. Just imagine how many more mosquitos and house flies would exist if it weren't for spiders and hunting wasps.

Dangerous plants and animals aren't just important parts of the food chain. Plants and animals are intricately connected within their environments in a variety of ways. For example, Poison Ivy roots help to stabilize soil and prevent erosion while the burrows and dens created by one species of animal may become homes for a variety of other species. Bees, wasps, beetles, flies, and other insects are all important pollinators and play an important role in plant reproduction, dispersal, and ensuring genetic diversity within plant populations. The removal of any plant or animal from an ecosystem can cause a variety of changes in the ecosystem, known as cascading ecosystem effects. So, it is important for students to understand that though these organisms can be dangerous to humans, they play vital roles in the natural environment.

Plants that are poisonous, such as Poison Ivy, often developed toxins in their leaves as a defense against herbivores and pathogens that could harm the plant. Venom in snakes and insects also evolved over a long period of time as a way to catch prey for food and a defensive mechanism. A Copperhead snake is not going to mistake a person for prey, since people are too large for them to eat, so the only reason that a copperhead would bite a person is in defense of its life. When discussing dangerous plants and animals, remind the students that any wild animal can be dangerous if frightened or sick and that all wild animals should be respected. Ask them to tell an adult if they see an animal that is acting strangely. For example, seeing a possum walking around as if disoriented during the day time suggests that the animal may have rabies or another disease since possums are normally nocturnal and shy.

Identifying Dangerous Plants and Animals Field Notebook Suggestions

Take photographs or draw pictures of any potentially harmful plants or animals that you find during observation time.

Research a potentially harmful plant or animal that is not on the student handout and report to the class.

Potentially harmful plants and animals are still very important to the natural environment. Have students research one of the animals or plants that you have found or discussed and give a short report to the class on it's importance and role in an ecosystem.

Define the word potential and discuss why that word is so important when thinking about potentially dangerous plants and animals.

Poison Ivy can look very different. Some plants are small, while others vine. Some leaves are dull, while others are shiny. So avoidance of any plant with "Leaves of 3" is an important safety precaution

The easiest way to stay safe and keep from being harmed by one of these organisms is to look carefully, have respect for nature, be able to identify things that could be dangerous, and to leave them alone.

The handout on Dangerous Plants and Animals provides students with information relating to plants and animals that they are most likely to come across when exploring nature in the urban environment in South Carolina's upstate region. The goal was provide an easy to understand handout for the students that makes them aware of dangerous plants and animals without scaring them. For these reasons, less common animals that you are unlikely to come into contact with, such as the Pygmy Rattlesnake, animals that are more common in the sand hills and coastal plain such as the Cottonmouth, and non-endemic species with spotty distributions such as the Brown Recluse Spider, have not been included in the student handout.

Plants:

The most common harmful plant that students will encounter in the upstate is Poison Ivy *(Toxicodendron radicans*). Poison Oak (*Toxicodendron pubescens*) is included in the names on the student handout because it shares general identification characteristics with Poison Ivy, but Poison Oak is not common in the upstate. Poison Ivy grows as a vine and a short herbaceous plant while poison oak grows only as a short herbaceous plant. Poison Oak is more common in dry soils and from the center of SC to the coast. Most of what we will see in the upstate is Poison Ivy.

Poison Ivy has many different growth habits. The plant can be a climbing vine, a trailing vine, or a short upright herbaceous plant. The leaves can be dark or light green, shiny or matte in color. The most reliable identification characteristic for Poison Ivy and Poison Oak are the leaves which are compound and have 3 leaflets.

"Leaves of Three, Leave it Be"

When going over the handout with the students, emphasize the importance of Poison Ivy as a winter food source for birds. Poison Ivy, like all of our native harmful plants and animals, is a natural and beneficial part of many upstate ecosystems.

Learning to identify Poison Ivy will help students practice the most important safe behavior that can be stressed throughout this section: avoidance. Even people who have touched Poison Ivy without harmful consequences in the past should avoid touching it. Based on the time of year, the life cycle of the plant, the chemical composition of the person's body, and many other factors, Poison Ivy susceptibility can change.

If students do come into contact with Poison Ivy, rinse the area with rubbing alcohol and wash it immediately using lots of soap and cold water.

Insects:

The most common dangerous animals that people interact with on a day to day basis in the urban environment are insects. Some insects, such as Assassin Bugs, bite. Other insects have poisonous body parts and can cause itching and burning if they are touched. Finally, some insects, including most members of the Order Hymenoptera (Bees, Wasps, and Ants), can sting.

Poison from insect stings can cause itching, irritation, burning, swelling, and in some cases Toxic Shock Syndrome (TSS). Make sure that you have signed health and allergy information sheets before taking students into the field so that you are aware of any known allergies, but also be aware that anyone can become allergic to insects. Practice emergency procedure, have a medical kit with you, and always have your cell phone with emergency numbers programmed in, just in case.

Animals create poison for two reasons; either as a defensive mechanism to protect themselves or as a way to capture prey for food. Poison is costly for the animal to make, in terms of energy. Most animals will avoid using poison on people because it is clear from our size that we aren't food, and using the poison will mean diverting energy away from other important survival needs, such as reproduction.

You will note a strong emphasis on "Leave it Alone" in the student handout. Make sure that the students notice. The best way to keep from being hurt by stinging insects is to leave them alone. If you do come into contact with one, stay calm and back away slowly. Often, flailing arms, running, and screaming may cause these animals to feel threatened and attack. No matter what you do, some students will be frightened of Bees and react this way: try to encourage being calm and lead by example any time that you encounter bees or wasps.

Of the insects covered in the student handout, Yellow Jackets and Fire Ants are the most aggressive. Yellow Jackets are social insects that usually nest in the ground. They are attracted to garbage and sugary foods and drinks, so keeping garbage cans closed and food or drink in closed containers will help reduce the risk of attracting yellow jackets. If disturbed, they release a chemical that will alert other Yellow Jackets to attack, so the best way to prevent stings is to watch carefully for Yellow Jackets and avoid getting close to nests.

Fire Ants are invasive species. They are indigenous to South America and are one of the more aggressive dangerous insects that you may come into contact with in the urban environment. They first latch onto the skin with their mandibles and then sting. Fire Ants live mainly in underground tunnels beneath mounds of dirt. The best way to avoid being stung by Fire Ants is to avoid disturbing the mounds.

More information on Fire Ants: http://uts.cc.utexas.edu/~gilbert/research/fireants/faqans.html

Spiders:

The two spiders with venom harmful to humans that can be found in South Carolina are the Black Widow Spider and the Brown Recluse.

South Carolina is out of the natural range of the Brown Recluse, but spider bites have been reported in the state, suggesting that though the spiders are very uncommon here, they can be found. Brown Recluses are very small spiders around 3/8 of an inch long, with 6 eyes, a solid colored abdomen, and uniformly light colored legs.

More detail for Brown Recluse Identification: http://spiders.ucr.edu/recluseid.html

Many organisms can be potentially harmful, so it's important for students to learn to observe carefully and treat everything in the natural world with respect

Copperhead Snakes are a good example of cryptic coloration. People often walk right by these snakes without ever seeing them.

Black Widow Spiders, on the other hand, are extremely common in the upstate. Black Widow Spiders are black with a distinctive red hourglass on the abdomen. The females are venomous. According to NC State University, Black Widow Spider venom is 15 times more toxic than the venom of a rattlesnake. Though only 5% of people bitten by a Black Widow die, if a child is bitten, you should seek immediate medical attention.

Students are most likely going to come across Black Widow Spiders while turning over rocks or logs. Black Widows like dark, hidden places. The best way to avoid being bitten by a Black Widow while exploring nature is to look carefully around the edges of logs or rocks, turn them over away from your body while grasping only the top, and to never put your hand somewhere you cannot see. Also, make sure that you carefully inspect equipment and shake out shoes, especially any that have been stored outdoors.

Snakes:

There are six species of venomous snakes native to South Carolina. Three of them, the Eastern Diamond Back Rattlesnake, Water Moccasin (aka Cottonmouth), and Coral Snake are located primarily in the midlands and coastal plain and are not located above the fall line. Three, the Timber Rattlesnake, Copperhead, and Pigmy Rattlesnake, are located in the upstate. Of these three, the Pigmy Rattlesnake is very uncommon, and though it is important to be aware of all of the venomous snakes in the area, has not been included in the student handout because it is highly unlikely that you will come across this snake in the urban environment.

A common rule of thumb to note is that most North American venomous snakes have a maximum strike distance of about 2/3 the length of their body. Timber rattlesnakes can grow up to 6 feet, while copperheads grow up to 3 ½ feet. These snakes can strike with little or no warning, but usually only strike in self-defense. Rattlesnakes do not have to rattle before they strike. The rattle is the snake's way of warning an intruder that they are getting too close, but there is no biological mechanism that prevents the snake from striking until they have rattled. Both copperheads and rattlesnakes are well camouflaged in leaf litter so it is very important to look carefully before you step or place your hand anywhere to avoid these and other snakes.

If you or one of your students is bitten by a venomous snake, remain as calm as possible, keep the affected limb lower than the heart, and seek immediate medical attention. Do not suck the venom out, do not cut the skin, do not apply ice, and do not apply a tourniquet.

Other Dangerous or Potentially Harmful Animals

Depending on the amount of time available for this course and the focus of your lessons, you may want to add the following organisms to your discussion of dangerous plants and animals:

Mosquitos

Ticks

Scorpions

Pygmy Rattlesnake

Brown Recluse Spider

Mosquitos and ticks are dangerous due to the diseases that they carry, and are considered disease vectors.

Additional References:

Clemson University information page: Black Widow and Brown Recluse Spiders http://www.clemson.edu/cafls/departments/esps/factsheets/medvet/poisonous_spiders_of_south_carolina_mv06.html

SC Department of Natural Resources (DNR) Fact Sheet for Venomous Snakes of South Carolina http://www.dnr.sc.gov/education/pdf/VenomousSnakesSC.pdf

Savannah River Ecology Laboratory: What to do in case of a venomous snake bite http://www.srel.edu/outreach/factsheet/snake-4.htm

The University of Georgia College of Agricultural and Environmental Sciences Natural History Series: Copperhead. http://www.caes.uga.edu/publications/pubDetail.cfm?pk_id=7152

USDA Forest Service: General Hiking and Trail Safety http://www.fs.fed.us/recreation/safety/safety.shtml

SCDNR video: South Carolina's venomous snakes. http://www.dnr.sc.gov/video/may06/mayvideo_snake.html

Urban Naturalists complete Safety Obstacle Courses by writing or taking pictures of the safe course of action for various pre flagged stations

IDENTIFICATION of Harmful plants and animals

It is important to be aware of animals and plants living in the same area that you do that could hurt you. Knowing what something looks like and how it behaves makes it easier for you to avoid being hurt and explore nature safely!

PLANTS:

Poison Ivy and *Poison Oak*

"LEAVES OF 3, LEAVE IT BE!"

- Poison Ivy and Poison Oak have 3 leaves.
- Leaves can be smooth, toothed, or lobed
- Sometimes, it is a short herbaceous plant growing on the ground.
- Sometimes, it is a vine growing up a tree.
- In spring and summer, poison ivy has green, sometimes shiny leaves. In fall, leaves range from yellow to red and even purple.
- Poison ivy vines can get thick and hairy.
- Poison ivy in the tree tops provides berries which are an important winter food source for birds.

What to do: When in doubt, don't touch it! If you do touch poison ivy, inform an adult immediately. Don't rub your skin or you will rub the oils from the ivy in. Rinse the area with rubbing alcohol if available and WASH the area immediately in cold water with soap.

INSECTS:

Most of the common stinging insects that we may encounter are in the order Hymenoptera and include Yellowjackets, Wasps, and Fire Ants. Though closely related, bees such as Honeybees and Bumblebees are less likely to sting people since they will lose their stinger and die after stinging.

If you encounter a honeybee or bumblebee, hold still. Once the bee realizes that you are not a flower, it will leave you alone. *Swatting at a bee will scare it and make it more likely to sting you.*

Yellowjackets

David Cappaert, Michigan State University, Bugwood.org

- Yellowjackets are small social wasps, which means that they live in a colony.
- Usually they build their nests in the ground
- Unlike bees, wasps can sting multiple times without losing their stinger. This is one adaptation that makes wasps more of a danger to humans than bees.
- Yellowjackets are attracted to garbage and sugar. Open soft drinks, juice, picnic food, and trash cans attract them.
- When threatened, they release a chemical into the air that alerts others to attack.

NEVER disturb a yellowjacket nest. If you see one, back away slowly and tell an adult where the nest is.

How to avoid yellowjackets:

- Keep food and drink in closed containers
- Be careful when turning over logs or digging in straw. Yellowjackets commonly nest in the ground, so if you see one going in and out of a hole, avoid that area.
- Stay calm. Swatting at a yellowjacket is likely to anger it. Calmly back away from the nest or wasp, and it will usually leave you alone.

Like many wasps and bees, yellowjackets are good to have around since they eat flies and caterpillars that feed on crop plants.

Solitary Wasps and Paper Wasps

Most solitary wasps are less aggressive than social wasps (yellowjackets and hornets), but will sting if disturbed. Wasps can sting multiple times.

The best way to avoid getting stung is to leave them alone. If you catch one in a collecting net, leave the net flipped over, lay it on the ground, and get an adult to help you release it safely.

Red Velvet Ant (Cow Killers)

Red Velvet Ants are not ants but wingless wasps.
Usually, these animals are not aggressive, but will sting if cornered. The sting of the Red Velvet Ant is extremely painful. DO NOT try to collect these animals. Observe from a distance, leave them alone, and they won't hurt you.

Jerry A. Payne, USDA Agricultural Research Service, Bugwood.org

Fire Ants

Pest and Diseases Image Library, Bugwood.org

Fire Ants are not native to the Southeast, but were introduced from South America in the early 1900s.

- Fire Ants build mounds which the colony nests in
- Fire Ants are very aggressive and will sting and bite repeatedly if their nest is disturbed
- Fire Ants tend to build nests in sunny areas.
- If you see a fire ant mound, tell an adult and avoid the mound

SPIDERS:

Black Widow Spider

Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

- Black bodied with a large rounded abdomen. Distinctive red "hourglass" on the abdomen
- Females build webs that are often near the ground, hidden in shady areas.
- The male is harmless. Females lay eggs in a round sack suspended in their web.
- The female tends to stay in the web, hanging upside down, protecting her young and catching prey.
- Black Widows are nocturnal and like to stay underneath things in the dark.

How to avoid black widow spiders:

- Use a stick or tongs to turn over logs and rocks.
- Look carefully before grabbing rocks, lumber, coiled water hoses, or other yard equipment that has been out. Be especially careful in out buildings and sheds.
- Shake out shoes, blankets and camping equipment, or anything else that has been stored outside for a long time before using it.

If you think you have been bitten, tell an adult immediately.

SNAKES

There are only 6 species of venomous snakes found in South Carolina, according to the South Carolina Department of Natural Resources, and only 3 occur in the upstate. The Copperhead is relatively common and can live in most habitats. The Timber Rattlesnake is less common but still occurs throughout a variety of habitats in the upstate. The Pygmy Rattlesnake is very rare. You are extremely unlikely to encounter one, though they are here.

Though most snakes that we encounter are not venomous, it is still important to know that even though they won't inject venom, they may still bite if frightened. Though nonvenomous snake bites aren't serious, they still hurt. Treat all snakes carefully and with respect. Most people that are bitten by snakes in the US are bitten while handling or trying to kill the snake. The best thing to do if you see a snake is to observe from a distance and leave it alone.

Copperhead Snake

Copperheads are the most common venomous snake in South Carolina.

- Young Copperheads have yellow tips on their tails.
- The coloring of Copperhead Snakes help them blend into leaf litter. (Like in the photograph of the Copperhead on the left)

Identification:

- Copperheads are light brown to tan in coloration with darker hourglass shaped patterns
- Triangular heads
- Slit pupils

Timber Rattlesnakes

J. D. Willson, UGA Savannah River Ecology Laboratory, srelherp.uga.edu

Identification:

- Light brown to black body with darker zigzag pattern
- Tail tends to be black with scaly “rattle” attached at the end
- Triangular head
- Slit pupils

Like it’s name suggests, the Timber Rattlesnake is often found in forested areas, brush piles, under logs, and sunning itself on rock outcrops. Like all rattlesnakes, it will often vibrate its tail to warn intruders to back away and leave it alone.

Identifying Dangerous Plants and Animals Activities:

Define "dangerous" as "perceived as harmful to people" and discuss the implications of this definition.

Some possible discussion prompts include:

- Is it fair to label an animal "dangerous" when it is only trying to protect itself or its young from a perceived threat?
- How can we prevent ourselves from being harmed by an animal?
- What ways that we have not discussed can we be harmed by animals or plants while exploring nature, and what is our responsibility?
- Is it OK to kill an animal or plant that we perceive as dangerous? Why or why not?

Go over the Dangerous Plants and Animals Handouts and take a practice nature walk to identify some of the organisms discussed.

Pair this lesson with "Field Safety" and put some of the organisms from this section into the ***Safety Obstacle Course.***

Have small groups or pairs of students ***act out possible scenarios*** where someone has come into contact with a potentially dangerous animal.

Ask one member of each group to play the animal. Have the other members of the class watch each scenario, ask questions, and debate how they might do things differently in the same situation.

Possible scenarios:
A student has been bitten by a black widow spider.
A student sees a venomous snake in the woods.
A student finds a wasp nest on the ground.
A student steps in a fire ant mound.
A yellow jacket wasp lands on a student's drink.
A student walks through a spider's web.
A student sees a raccoon during the day and acting strangely.

Chapter 2: Scientific Observation and Way Finding

Where is nature? If you are using the Urban Naturalist Program, then you probably live and work in an urban or suburban area and may be wondering where you will be taking the students to observe nature. Nature is all around us, even in an urban setting. It may take some creativity, but you can find nature almost anywhere! For planning purposes, familiarize yourself with the program and decide which sections and activities you are going to cover during your class. Once you know what you're looking for, it will be easier to decide where to go. Some ideas include:

Trails
Parks
Community Gardens
Back Yards
Stream or River Banks
Green Roofs
Bioswales
School Yards
Community Centers

Make sure you have permission from property owners before your expedition.

You may wish to use this chapter as a single lesson, combining a short lesson on scientific data collection, use and importance of the field notebook, and nature observation skills with a map reading lesson and a field trip, or keep these lessons separate.

Word Bank

Map
Data
Specimen
Sample
Topography
Orientation
Compass
Way finding
Direction
Compass Rose
Legend
Expedition
Navigation
Blaze
Scale

SCIENTIFIC OBSERVATION

Key Concepts and Skills:

- Good data collection is essential for scientists
- There are many different ways to collect data, and the most basic include careful observation using the five senses
- Students will receive and begin working with their own field notebook
- Students will practice observational techniques during a field expedition

Scientific Observation Field Notebook Suggestions

List some types of data that you might be able to take when observing a plant.

Practice making observations and fill out a page in the field notebook with a drawing of an organism and data that you have collected.

Write the difference between qualitative and quantitative data. http://web.cortland.edu/andersmd/stats/qual.html
List some data that would fall into each category.

Describe some reasons that a scientist might do the following
1) count the number of plants in an area
2) capture and weigh a bear
3) collect leaves from a tree

Background Information

Data collection is an essential part of science. Data collection methodology changes based on the field of study, and the data being collected changes based on the research questions and hypotheses being addressed. In order to assure accurate data collection, it is important to know what information that you need from the start. Urban Naturalists understand that data collection can tell us a lot about the natural world.

If you are planning on tying in a continuous research project or a citizen science project (a list of some citizen science projects is available in the activities section), this is a good time to discuss and plan data collection.
A short lesson on scientific data collection, use and importance of the field notebook, and nature observation skills could also be paired with a map reading lesson and in the field exploration.

The field notebook is an important part of any scientist's tools. When you are on a field expedition there are a lot of things to see and a lot going on. Taking notes helps students remember where they were and what they saw.

As naturalists:

Good field data makes it possible to go back and look at something again.

- For example, let's say the students find a bird's nest in a tree with eggs in it. They may want to go back in a week or two and see the baby birds, but you have to be able to find that particular tree.

Good field notes are essential for scientists to be able to monitor changes in the environment over time. Some things that field data is essential for determining include

- Finding where animals and plants live, and studying changes in population numbers, structure, or distribution over time
- Determining climate of a region, studying long term effects of natural disasters, anthropogenic disturbance, or other alterations in an ecosystem over time
- Management of endangered species, at risk ecosystems, and natural resources

The field notebook will act as a scrap book for the students to remember what they have learned. The more detailed their notes, the more they will be able to use them to continue their urban naturalist studies in the future.

There are a lot of fancy and expensive field notebooks available, including water proof ones that are only necessary for scientists doing field studies in the rain. For this program, the student's field notebook is more like a scrap book. Give the students suggestions on what to record, and provide some examples, but allow them to be creative. You may want to keep the field notebooks in the classroom and allow the students to take pages on clipboards into the field. Notes can then be transcribed or punched and added to the field notebook during classroom time.

Rainy days are perfect for working on the field notebooks. Provide old magazines and craft materials for the students to decorate the outside of their binder. Important data for the field notebook includes:

Date

Location

Category of organism observed (tree, insect, flower, lichen, etc.)

Drawing or picture

Other information: This will vary according to the organism. Examples:

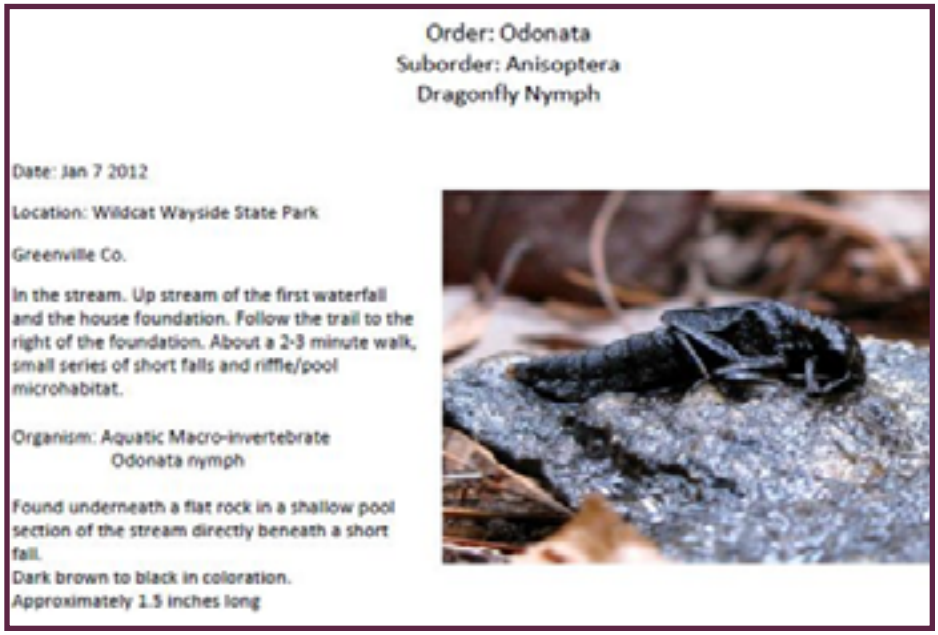
- size
- colors
- what the organism was doing
- sounds it made

Specimen or sample: sometimes students may collect items during their observations.

- If the sample is three-dimensional and not suited to being glued in the field notebook, have the student keep it in their collection box with a label to note which page in the field notebook corresponds with the specimen (examples: acorns, rocks)
- If the sample is two-dimensional (flower petals, leaves), help the student press it. Pressing botanical samples takes time. Completed pieces can then be glued into the field notebook at a later classroom time. Remember to label the paper that the specimen is pressed in with the student's name and an identifier to correspond with the entry in their field notebook.

Identification – though students will not be able to identify everything that they come across, try to encourage the students to identify the best they can.

A sample field notebook page:



Urban Naturalists take digital photos to go in their field notebooks

Excerpt from a field notebook: the safe thing to do when encountering a snake is to calmly and quietly back away

An Urban Naturalist records her observations in a field notebook

"Look with our eyes
Listen with our ears
Leave only footprints"

Scientific Observation

Scientists use a number of tools in order to collect data about the natural world. In order to be responsible naturalists, students should practice scientific observation techniques and be safe. Nature is all around us, we just have to stop and look. Various organisms and research questions require different types of data collection techniques, but in general, the following tips and tricks can be shared with the students to help them get the most out of their observation time.

Be still and listen carefully.

- What's that rustling in the grass? What is making that clicking sound? Lots of animals make noise. Mice, squirrels, lizards, and birds rustle through the leaves on the forest floor while others clamor through the trees looking for food. If you listen carefully, you may even hear a bark beetle digging through wood or a cricket rubbing its legs together. Often to see something cool, all you need to do is follow the noise.

Think small.

- Many animals are very small and easily missed.

Watch for movement

- Often, small animals have cryptic coloration to allow them to blend in with their environment and reduce the threat of predation. The easiest way to see those animals is to notice when they move.

Look everywhere, and look twice.

Check out anything different.

- A bump on a tree might be a bit of bark, but it could be a camouflaged insect, a fungus, some sort of cocoon, or any number of other things. Always look closer if you see something that looks different.

Turn things over.

- Insects and small animals love to hide. A great way to find some cool stuff is to turn over logs and rocks and check underneath. Just remind students to do so safely. Look first, and once you are sure that there is nothing dangerous visible, turn the far side of the log over so that it opens away from you. Check again for anything dangerous, and then explore the habitat underneath the log.
- Remember to replace logs and rocks the way that you found them. The bottom of a log or rock is a microhabitat with its own community of organisms.

Scientific Observation Activities:

Present students with their field notebooks. This lesson is a good time to introduce ongoing projects that involve data collection and scientific observation techniques or citizen science projects. Some suggestions for ongoing projects are:

Create a nature guide for your school yard/ neighborhood/etc.

Develop an Urban Naturalist Alphabet. Assign letters to each student. They are responsible for finding, identifying, and photographing a biological organism whose name (scientific or common is up to you) starts with their letter. Keep a special alphabet digital folder or scrap book for students to place their finds in. Each entry should include some of the data from the field notebook, such as where the organism was found, date, etc.

Digital nature rainbows: students should take pictures of organisms of various colors and arrange them in a rainbow or color progression as shown below.

Collect data for one of the citizen science programs listed, or create your own citizen science project.

Participate in a scavenger hunt: provide students with the Urban Naturalist Checklist of Cool Plants, Animals, and Natural Artifacts or make your own. Offer an incentive, like a special patch if they complete the checklist during the program

One option for the field notebook is to allow students to create their own. Ask students to decorate the cardboard with something they think of when they think of nature. Fill with recycled paper and bind

Urban Naturalists have many options for engaging in citizen science projects in the city.
Top: Looking for pollinators
Middle: An easily identifiable urban bird
Bottom: Inputting data

Citizen Science Options:

The National Science Foundation's ***Project BudBurst***: Students observe plants, record, and report their observations on the project website. Extras include teacher's guides, supplemental materials, data maps, and more.
http://www.budburst.org

Celebrate Urban Birds: Perfect for the Urban Naturalist. Students collect data for the Cornell Lab of Ornithology by watching and recording bird numbers and behavior for 15 minutes. Extra information and fun challenges are also available on the website.
http://celebrateurbanbirds.org/

Conservation Events Hosted by the Greenville Zoo, including Greenville's ***FrogWatch USA*** chapter:
https://www.greenvillezoo.com/conservation.aspx

The ***Great Backyard Bird Count***: Count birds for 15 minutes a day during a week in February and upload your results. Check out the kids page for extras your students may enjoy.
http://www.birdsource.org/gbbc/

Discover Life has an ongoing project called ***BeeHunt*** to find, document, and identify native pollinators.
http://www.discoverlife.org/bee/

The Great Sunflower Project: Another pollinator count. Students set up accounts and have four different options for collecting data. Extras include information, photographs, links, and data graphs that students can practice analyzing and interpreting.
http://www.greatsunflower.org

The Lost Lady Bug Project: Find and photograph ladybugs along with habitat data as part of an effort by scientists to track species of native ladybugs.
http://www.lostladybug.org/

Play an observation and data game.
Place a variety of safe household items in a bag or box. Discuss with the students what it means to make an observation and what types of observations they can make.

Ask students to close their eyes and pick an item out of the bag.
Prompts: Does it smell? Does it make a noise? Is heavy?

After making observations without opening their eyes, ask them to guess what item they are holding. Next, have them open their eyes and make more observations.

Allow each student to take a turn then discuss the types of observations that they made. Naturalists have to make observations about the things that they see in nature. Size, shape, color, texture, weight, sound, smell, and more help us to determine what an item is. Once we know what it is we can begin to ask other questions like "Why is it here?" "How did it get here?" "Is it healthy?" and more.

Take your observational skills outside and record observations in a field notebook.

This can be a guided or an open activity.

Top: An Urban Naturalist group sits together to write their observations in their field notebooks
Middle: A team of Jr. Urban Naturalists draw pictures in their notebooks
Bottom: Sometimes observations can surprise you. An Urban Naturalist finds a cool insect underneath the leaf she is observing

Urban Naturalist Checklist

of cool Plants, Animals, and Natural Artifacts

FOUND	NATURAL ARTIFACTS	LOCATION	DATE
	A Bird's Nest		
	Some Sort of Cocoon		
	Animal Tracks		
	A Spider Web		
	A Unique Rock		
	ANIMALS		
	Frog		
	Blue Jay		
	Millipede		
	Squirrel		
	Hawk		
	Carolina Wren		
	Cricket		
	Dragonfly		
	Skink		
	Beetle		
	PLANTS		
	A plant with berries		
	An aquatic plant		
	An evergreen tree		
	A plant with purple flowers		
	Moss		
	Lichen		
	Mushrooms		

The Field Notebook

A naturalist's field notebook is an important tool. Everything in nature is connected, and naturalists seek to find and understand these connections. The notebook allows a naturalist to take notes about what they observe when they are on a field expedition.

- Notes allow a naturalist to return to a particular location in order to find a plant or animal again.
- Notes help naturalists remember what they saw. When you are exploring nature, you will find a lot of different things and it can be difficult to remember all that you see. Notes, drawings, pictures, and other types of data will help you remember important or interesting things later.
- Notes and data in the field notebook allow naturalists to observe and identify ***patterns***. Patterns in nature happen for a reason, and the first step to understanding "WHY?" is to find the pattern.

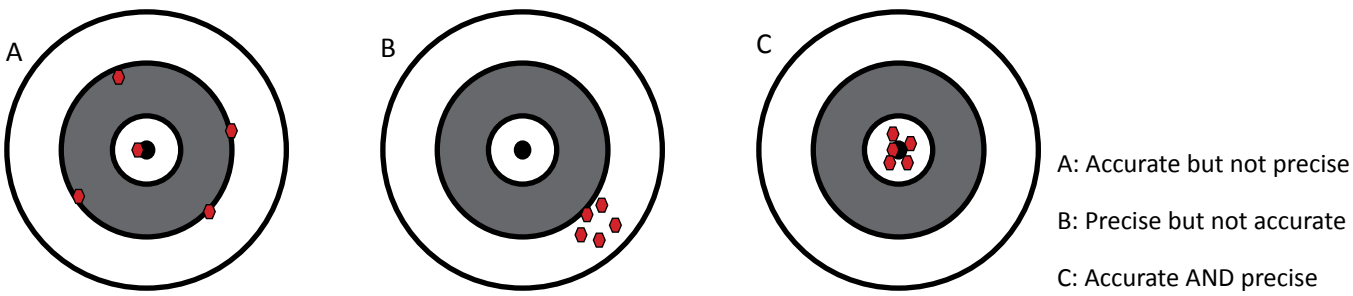
  For example, many species of birds migrate south for the winter. We know that this occurs every year and scientists have learned a lot about the migratory behaviors of birds by observing and studying this phenomenon. But, at some point, someone had to notice that there was a pattern to the birds' behavior; that every year, many birds began to fly in the same direction at about the same time.

Data for the field notebook

Your field notebook is YOUR work, and can include drawings, photographs, notes, pressed plant specimens, and more. When you are observing nature for fun or for personal study, it is up to you what data you feel is important, and how you will record that data.

When you are observing nature as a citizen scientist or a science student, you will need to record specific types of data. It is important to observe carefully and precisely follow any protocols that are specific to the science you are doing in order to generate good data.

Good data should be accurate and precise.
Accuracy = how close to the "true" or actual value
Precision = how close the data measurements are to one another



Data can be *Quantitative* or *Qualitative*

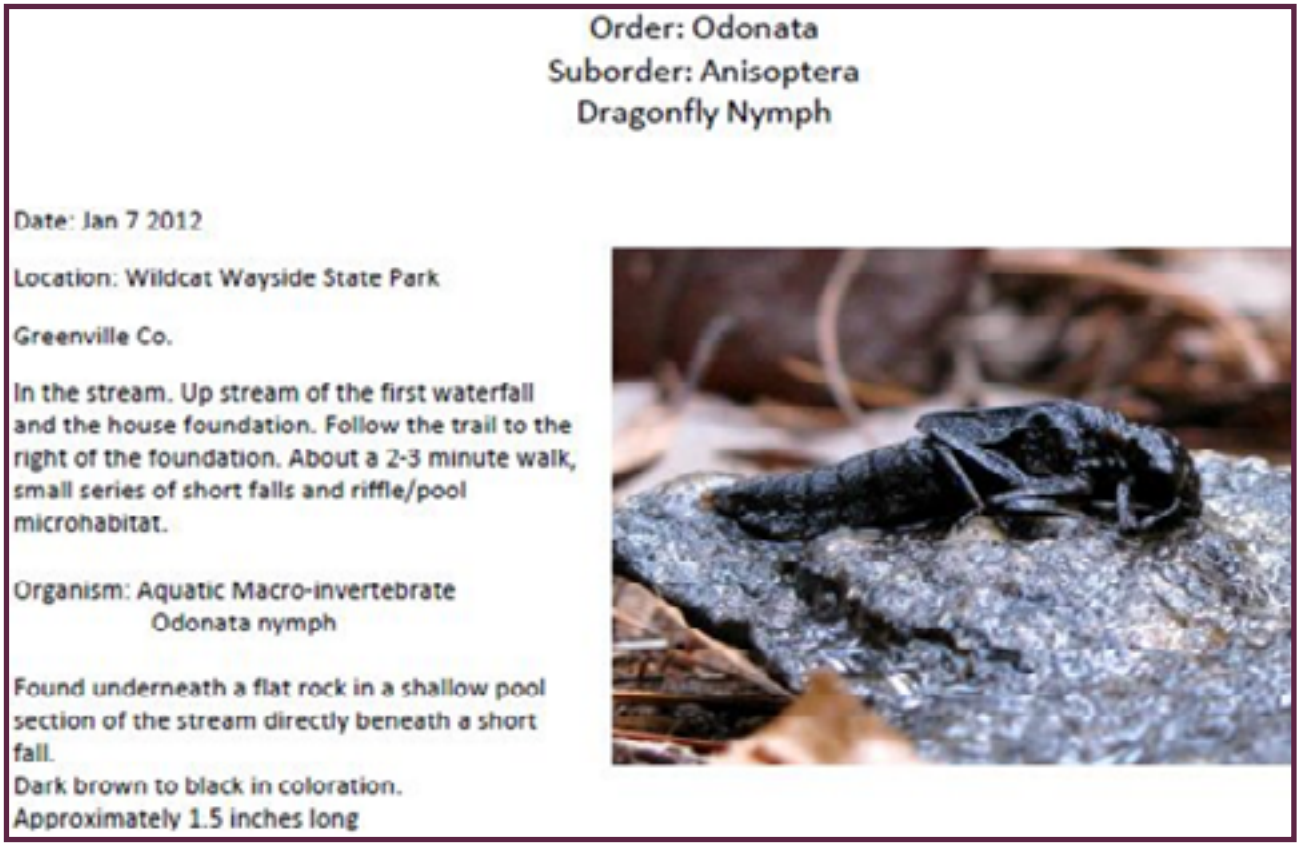
- Quantitative data is something that can be <u>counted</u> or measured and expressed as a number. It has a quantity.

  Examples include: the *number* of tree species in an area, *height* of a plant, *weight* of an animal, *how many* babies an animal has, the *length* of a leaf, *number* of petals on a flower, *diameter* of a tree, *velocity* of a stream, the *number of* wing beats per minute a flying bird makes, how *deep* a plant's root system goes, the *time* of day that something happens, etc.

- Qualitative data is all data that can not be represented by a number, but is descriptive. It is a quality.

  Examples include: the *color* of a flower, the *smell* of soil, the texture of a tree's bark, the *sound* a bird makes, the *shape* of a plant, an insect's *behavior*, the *pattern* of a spider's web, etc.

Sample Field Notebook Page



List 3 types of qualitative and 3 types of quantitative data that can be found in the sample field notebook page above.

MAPS

Key Concepts and Skills:

- Maps provide information about a place.
- There are many different types of maps, including resource maps, navigational maps, and topographical maps. Each type of map is used for a specific purpose.
- The parts of a map (title or description, legend or key, scale, and compass rose) help provide information that is needed to understand and use the map.
- A compass can be used to orient a map and/or a person in space. When in the field, a compass and a map is used to help a person find their way.

Background Information

Map reading is an important skill, not only for nature enthusiasts, but for everyone. Maps can be used as tools for encouraging reading, mathematics, and spatial skills as well as help develop a sense of place and direction.

Though many young people today may be more comfortable with a GPS, map reading is still an important tool.
What is a map?

A map is a tool that provides information about a place. There are many different types of maps, and we can use them for different things.

Data Maps

Data maps are often used by scientists, planners, resource managers, and many more to help understand a place. A data map may show the location of different natural resources, soil types, population density of an organism, locations of types of businesses, and much more. Geographical Information Systems (GIS) can combine a variety of data into one map allowing people to visualize and analyze data in a robust manner.

Some examples of data maps include:

- Natural resources
- Population data
- Weather or climate

Navigational maps

Navigational maps are tools that help people get from one place to another. Though navigational maps may include other map pieces, such as data or topography, their main purpose is to help people find a particular location.

Navigational maps are the most common map type that are *Not to Scale* and may often include only roads, trails, paths, or landmarks.

Maps Field Notebook Suggestions

Ask students to bring in a map of someplace that they have been and analyze it: does their map have all of the essential map parts? Is their map to scale? What kind of map is it?

The map reading hand outs and practice questions.

Create a map of an area. For older students, create a map to scale.

Practice using a compass and write out a set of directions to get from one spot to another.

Photographs of wayfinding signs or other signage.

Urban Naturalists learn to use a compass app and orient themselves to face North

Some examples of navigational maps include:

- Road maps
- Building maps
- Trail maps

Topographic maps

Topographic maps show the elevation of an area using lines. These maps are especially useful for navigation while hiking, for planning development, or any other time that it is important to know the elevation and slope of an area.

Boundaries

Boundary maps show the invisible lines between areas such as counties, states, countries, and continents.

Parts of a Map

Though not all maps include every part listed below, these pieces make a map much more useful.

Legend: All maps must have a key, called a legend, which explains what the symbols on the map mean. Often, different maps use the same symbols to represent different things. For example, a triangle on one map may be a mountain peak, and on another, it may be a building.

Compass Rose: All maps must have a compass rose, which defines the directionality of the map by pointing out which way on the map is North. Sometimes compass roses include the four cardinal directions and more, but North is all that is required, as the others can be determined using only North.

Scale: The scale of the map tells us how big the items on the map are in relation to real life. Not all maps are drawn to scale, and if they are not, it should say so somewhere on the map. It is very important to know whether or not a map is drawn to scale and what the scale is, or you won't know how far apart places depicted on the map actually are or how long it would take to get from one place to another.

Reading Maps

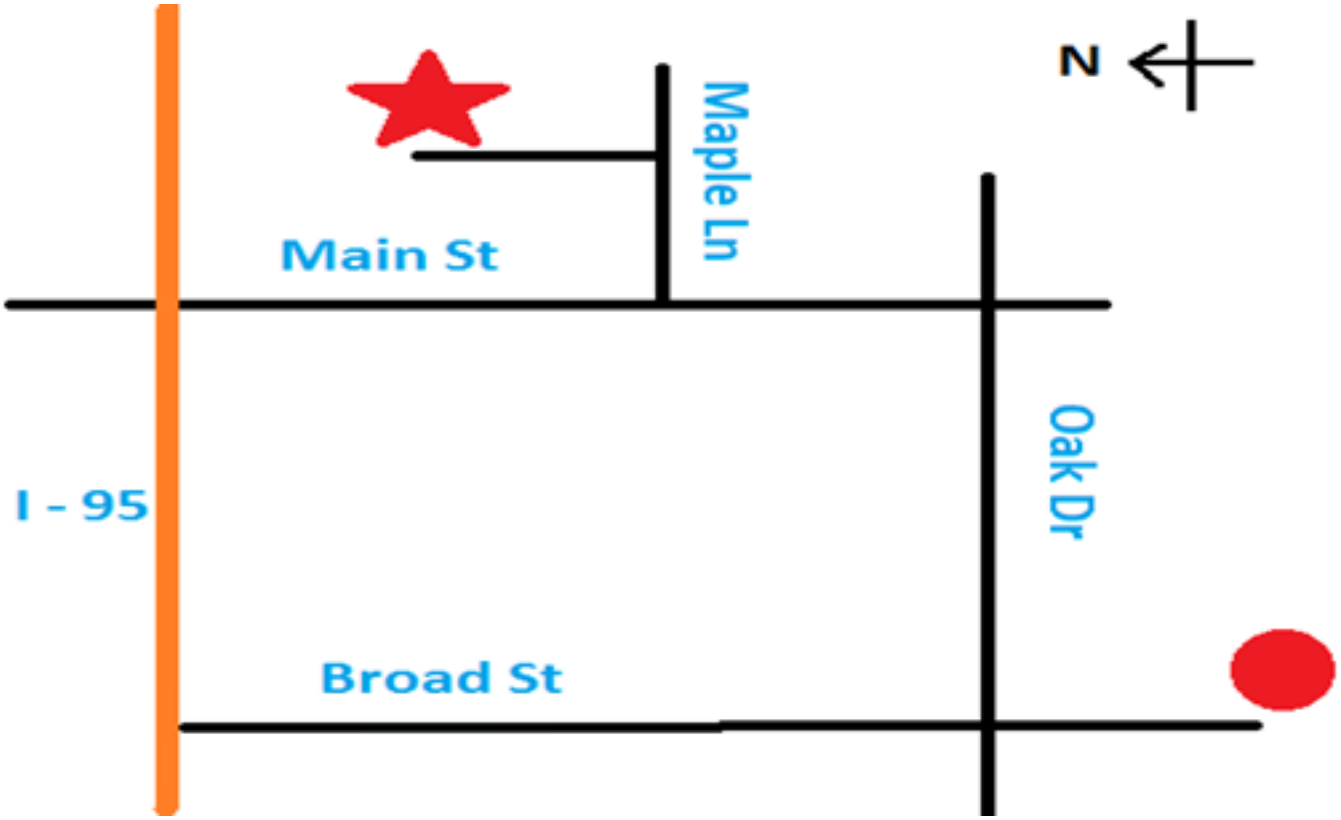
A map provides information about a place such as:

- How to get from one place to another (Navigational Maps)
- Location or boundaries (Political Maps)
- Elevation (Topographical Maps)
- Data about populations or resources (Resource Maps)

Parts of a Map

- Title or Description
- Legend or Key
  An explanation of what the symbols and colors on a map mean
- Scale
  What the distance on the map means in real life
- Compass Rose
  Provides direction so that you can orient yourself and the map to the real world

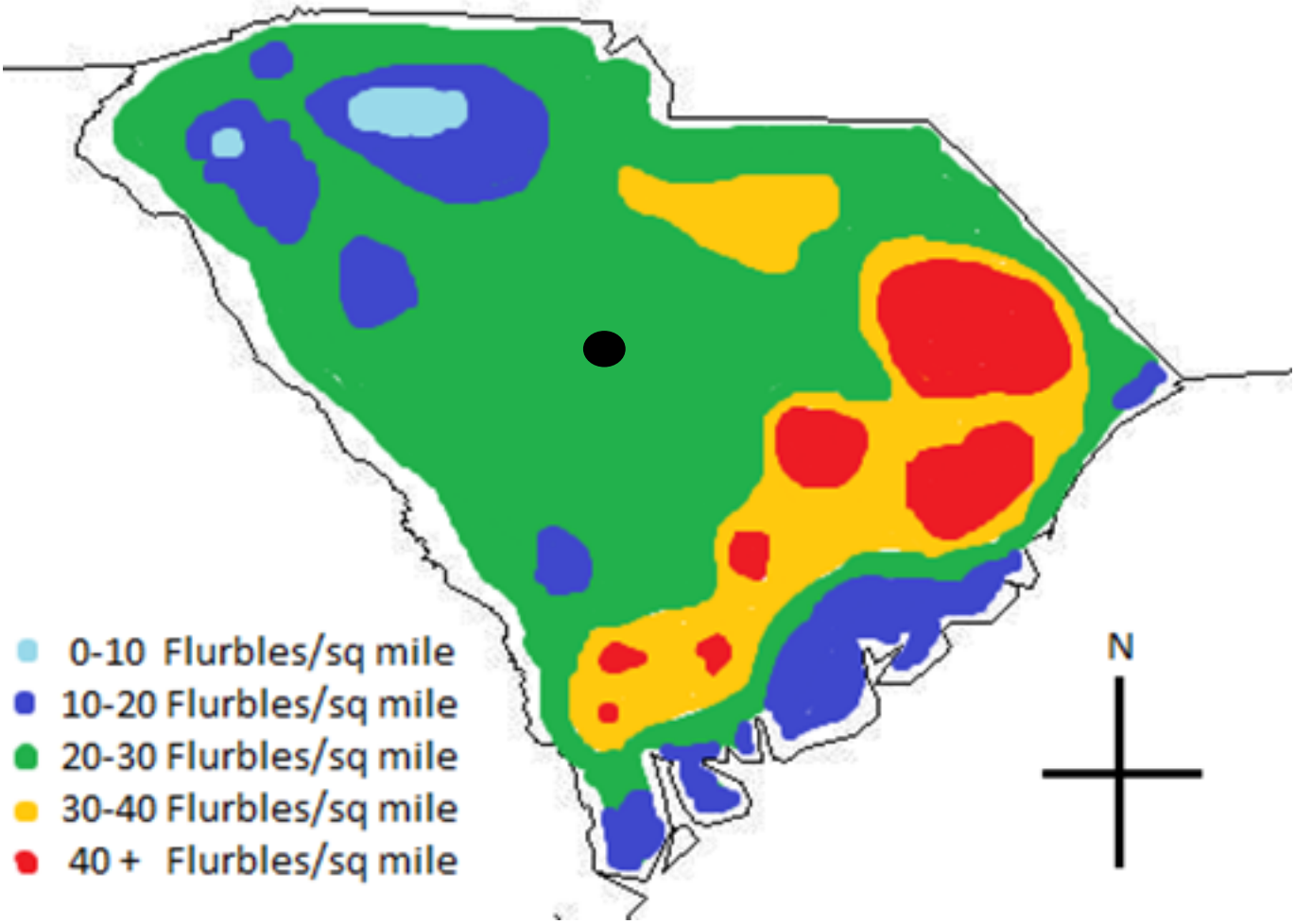
Navigational Map:



Map reading practice:

1) What direction would you have to drive to get from the red dot to the I-95?
2) Write instructions for driving from the red star to the red dot.
3) This map is “not to scale.” What does that mean?

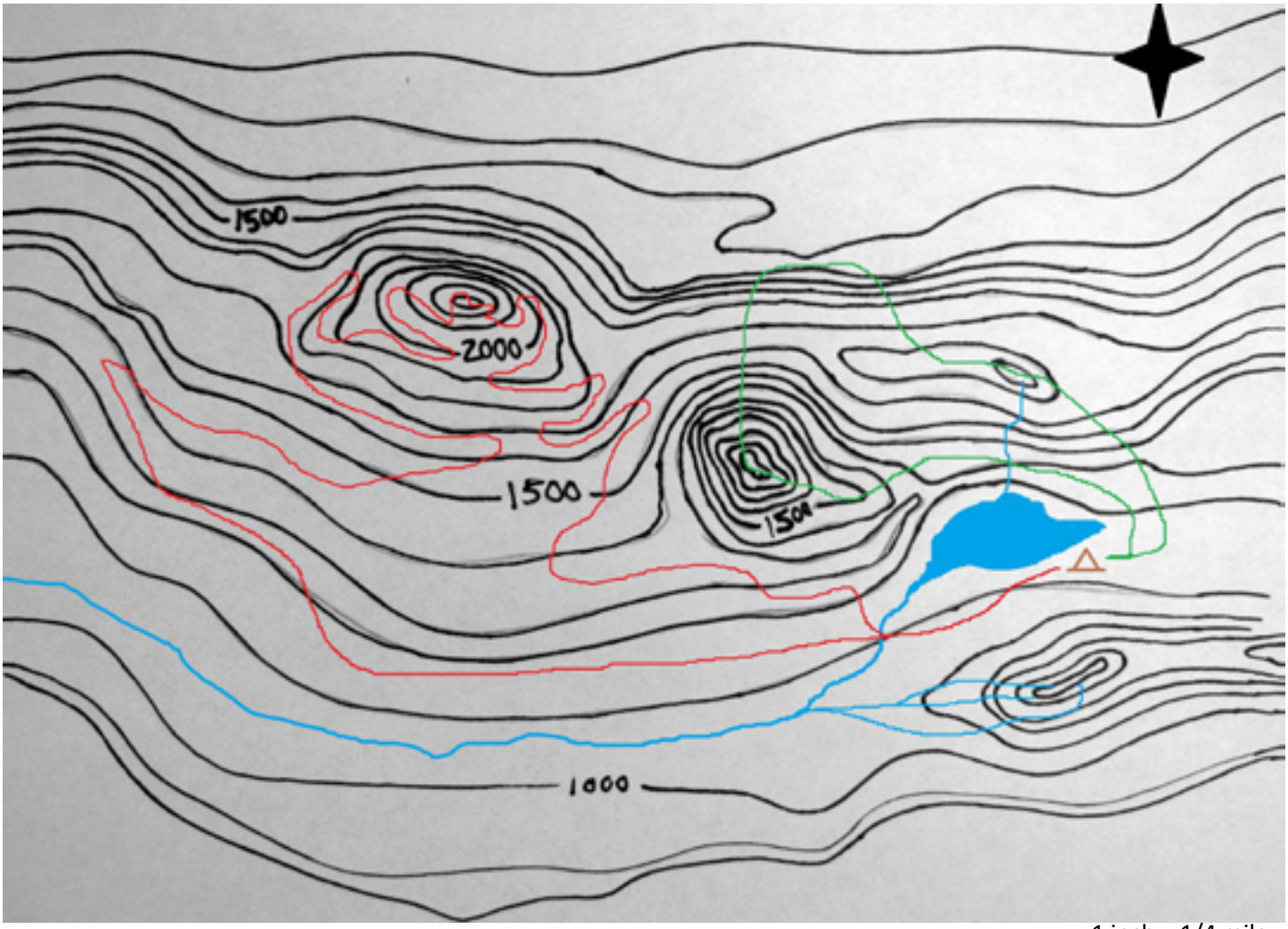
Resource Map: Flurble Populations in South Carolina



1) If you wanted to hunt Flurbles, what part of the state would you want to go to?
2) What is the most common population density of Flurbles in South Carolina?
3) If you were allergic to Flurbles, what direction from Columbia (black dot) would you want to live?

Which of the three maps provided would you be most likely to use if you were hiking?

Topographic Map



1 inch = 1/4 mile

1) Which of the two hiking trails (red or green) is steeper?
2) What direction is the river flowing?
3) What elevation is the lake?
4) Each line represents how much of a change in elevation?
5) Draw an arrow to the highest point on the map.
6) Approximately how long is the green trail?

Using a compass:
*Set the compass on a flat surface***.**
First, turn the compass until you have found North.
Next, orient your map so that the compass rose on the map is lined up with North on your compass.
Now you should be able to tell what direction you need to travel.

Maps Activities:

Go over the background information, presentation, and handout on maps.

Utilize the sample maps provided on the handout or maps brought in from home and find parts of each map.

Additional sample questions for discussion if using the navigational map on the handout:

1) Why do you think that the road labeled I-95 is a different color than the rest of the roads?
2) Do we know what the red star and red circle represent?
3) Why do you think there is no scale on this map?
4) Using a compass, orient this map in the classroom. Pretend you are standing on the red star and point out which direction you would have to walk to get to Broad St; I-95; Oak Dr.

Additional sample questions for discussion if using the resource map on the handout:

Flurbles are an imaginary creature, but resource maps like this can be used to denote population demographics for animals, plants, and people as well as to indicate other data such as the amount of average rainfall an area receives, soil type, and many other things.

Ask the students to spend some time studying the Flurble population map then make up a scenario that explains the distribution. (Create a hypothesis) Then ask them what they would have to do, or what data they would have to gather to determine whether or not their hypothesis is correct.

Pre-make a map of the outdoor study area and have the students ***use the map*** to find specific items. Provide them with a set of questions that they have to answer about the points on the map.

Have the students ***create a simple map*** of the classroom or of an outdoor study area. Provide the students with paper, measuring tape, and crayons, colored pencils, etc. and allow them to create their own maps.

If you have the time, you can have the students create "treasure" maps. Ask them to explore the area, find something that they think is interesting, and then draw a map of the area, marking the spot of their "treasure" with an X. Then have each student trade maps with a partner and see if they can find each other's treasure.

Demonstrate and then have the students ***practice using a compass.***

Ask them to determine what direction they would need to travel in order to reach items at different places in the room.

Divide students into pairs. Using a compass, each member should ***write directions*** to a place or item of their choice in the room, such as:

Start at the red carpet square
Go North 4 steps
Next go West 8 until you reach the table
Etc.

Once they have finished their directions, they should trade with their partner, and try to find the item or place using their partner's directions.

For more map information and ideas: http://www.brainpopjr.com/socialstudies/geography/readingmaps/grownups.weml

Compass Practice

How to Use a Compass:

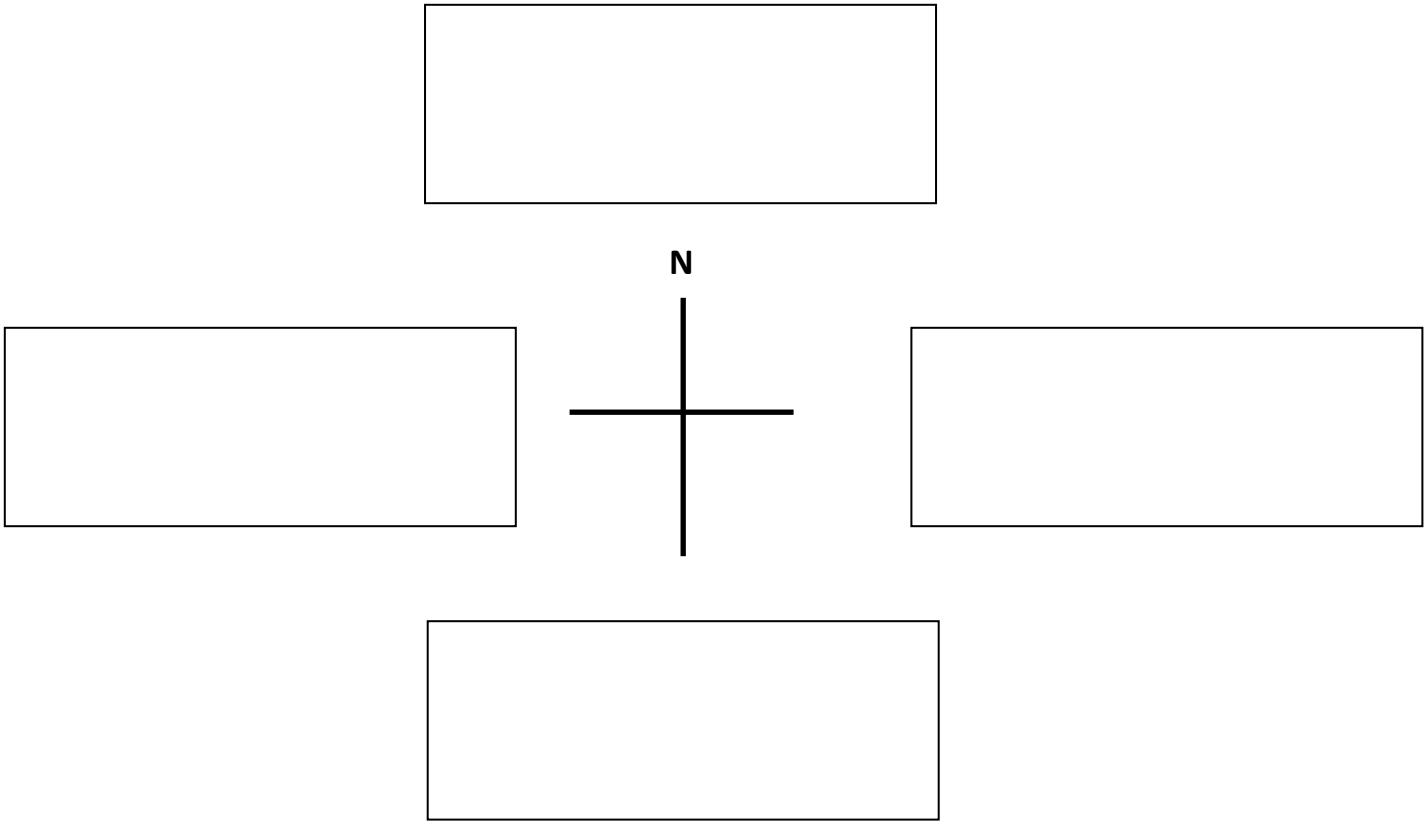
*Set the compass on a flat surface***.**
First, turn the compass until you have found North.
Next, turn your body and your map so that the compass rose on the map is lined up with North on your compass.
Now you should be able to tell what direction you need to travel.

1) Use a compass to find North. Go to another place in the room and use the compass again to find North. Are you facing the same direction?

2) Use your compass to find North. Walk 10 paces to the WEST.

3) Turn and face South East.

4) Use a compass to orient yourself to face North. Label the cardinal directions on the compass rose below and write an item in each box that you see when you face that direction.



Chapter 3: Plants

Plants are biological organisms that have cell walls. Most plants are autotrophic, meaning that they create their own food, primarily through the process of photosynthesis by using the energy from sunlight to convert Carbon Dioxide and water into sugar.

Plants are one of the easiest organisms to find and study in an urban environment, mainly because they are sessile, putting down roots in one place and remaining there until they die or are moved by another organism.

Word Bank

Growth Habit
Herbaceous
Plant
Moss
Fern
Algae
Shrub
Autotrophic
Monocot
Dicot
Photosynthesis
Producer
Vascular Plant
Dichotomous Key
Adventitious Roots
Conifer
Deciduous
Gymnosperm
Angiosperm
Seed
Cone
Carbon Sink
Xylem
Phloem
Roots
Bark
Branches
Trunk
Crown
Canopy
Botany
Stomata
Fruit

PLANT GROWTH HABIT

Key Concepts and Skills:

- Plants are autotrophic multicellular organisms. Most plants create their own food through the process of photosynthesis.
- Plants can be classified in many ways including by growth habit, or the way that the form of the plant looks.
- Students will learn some of the most common plant growth habits found in the urban environment and South Carolina.
- Students will identify plants during a field expedition by growth habit.
- Students will learn to use a plant press for specimen collection and preservation.

Background Information

There are many different ways to classify plants. The growth forms of plants that can be commonly distinguished and recognized are called growth habits. A growth habit is not a biological classification in the same way that Order, Family, or Species is. Rather, completely unrelated plants may share similar growth habits due to the need to survive in similar environments or circumstances. Think of a growth habit as an easily recognizable set of external traits that different plants may share, or to simplify, a similar looking group of plants.

Growth habits are a good place to begin exploration of plants, as classification based on growth habit is relatively easy for young students to grasp yet can easily be expanded into a study of the characteristics of plants that would be appropriate for older students and even adults. Some of the categories we will use are biological classifications, like moss, while others are not.

Plant Growth Habits Field Notebook Suggestions

Draw pictures or take photographs of plants displaying various common growth habits.

List the characteristics of one of the growth habits that you have learned about.

Describe a plant that you have found. Use qualitative and quantitative data.

Draw and label the parts of a plant that you are observing.

Choose two plants that exhibit the same growth habit but are different species. Compare and contrast the two plants.

Choose two plants that exhibit different growth habits. Compare and contrast the two plants.

Much like a habit that a person may have, such as brushing their teeth after every meal or tapping their fingers when they are nervous, a plant's growth habit can vary based on external factors such as weather and water availability. A shrub on a windy hill side with very little water will look different from the same species of shrub on the banks of a river in a well-protected forest.

The following list of plant growth habits is a good starting point to begin exploration, but should not be considered a complete list.

Common Growth Habits:

Moss

Mosses are non-vascular plants. They don't produce seeds, but rather reproduce through spores. Mosses require water for reproduction and grow in groups, forming clumps or carpets of moss made up on many tiny individual plants. Mosses can't grow tall, due to the lack of a vascular system, and are generally found in damp and shady areas.

Ferns

Ferns are vascular plants, containing tubes called xylem and phloem that transport water from the roots to the leaves and sugar water from the leaves to the rest of the plant. Like mosses, ferns do not have seeds, but reproduce by spores. Fern leaves start as fiddle heads and unfurl as they grow. Most ferns have multiple small leaflets growing opposite on a single stem.

More information about the growth and reproduction of ferns: http://faculty.fmcc.suny.edu/mcdarby/animals&plantsbook/Plants/03-Ferns.htm

Grasses

Grasses are simple flowering plants. They are monocots with long, thin, blade-like leaves and hollow rounded stems. Most grasses have very small flowers and reproduce using the wind as a vector and as a method of seed dispersal.

Vines

Vines are flowering plants that have thin woody stems. Sometimes these plants will sprout extra sets of roots, called adventitious roots from the stem that allow the vines to attach to other surfaces and climb. Though some vines are parasitic and absorb nutrients from a host plant, most only utilize another plant, like a tree or shrub, for support in order to get their leaves closer to light. In general, vines can be divided into two sub categories of growth habit:

- Trailing vines grow across the ground.
- Climbing vines climb other structures. In the wild, vining plants mostly climb trees, but in the urban environment, climbing vines may be found utilizing buildings, fences, lamp posts, and other man-made structures for support.

Herbaceous plants

Herbaceous plants are small flowering plants.

*Herbaceous plants can be divided into many different subcategories such as succulents, perennials, and annuals.

Shrubs

Shrubs are flowering plants that have multiple woody stems.

Trees

Trees are generally tall vascular plants with a single woody stem. They can be divided into two subcategories

- Conifers (Gymnosperms) which do not produce flowers, but instead reproduce through wind driven pollination. Most conifers have needle or scale like leaves and are green year round (evergreen).
- Hardwoods (Angiosperms), flowering trees, which do produce flowers and generally utilize animals as pollination vectors. Most hardwoods have broad leaves and are deciduous, losing their leaves in winter.

Collecting and Preserving Botanical Specimens:
Students may wish to collect leaves, flowers, fruit, or twigs from trees for their field notebooks. In order for a botanical specimen to be useful to scientists, it must contain the elements listed below. You may or may not wish to include this as part of your lesson.

A scientific botanical specimen must include the following:

- A reproductive part (either a flower or a fruit)
- As many parts of the plant as possible (for herbaceous plants, this is often the whole plant: including the roots)
- A label with good field data that includes

  Date

  Name of collector

  Location (GPS if available)

  Habitat information and associated species

  Description of the plant

  Specimen number

Botanical specimens are collected in the field and carefully arranged between sheets of newspaper and pressed. Once the specimen is dry, it can be glued onto a piece of acid free herbarium quality paper (or in the students' case, the field notebook).

Ferns and mosses are some of the more primitive types of plants that reproduce with spores instead of seeds

Make sure that plants are arranged neatly before they go into the press. Dried specimens are delicate and cannot be rearranged

How to build a plant press:

For a simple plant press, you need two pieces of plywood that are approximately the same size, sheets of cardboard, newspaper, and old boy scout style belts (or rope)

*an even better press can be made with lattice or strips of wood in a checkerboard pattern: the holes allow for more airflow.

Layer the press like a sandwich: Plywood on the bottom, followed by cardboard, then newspaper, then a sheet of newspaper ***labeled*** with a plant neatly arranged in it (remind students that once the plant dries, you will not be able to change its shape), followed by a few more sheets of newspaper, another piece of cardboard…and so on. Finish with the other piece of plywood and bind tightly with the belts or rope.

The press must be kept in a warm, dry environment. Unless you have access to a botanical drying oven, DO NOT put the plants in an oven.

After 2-3 weeks, your specimens should be dry.

Tips for students collecting botanical specimens:

Make sure you are collecting what you think you are collecting. This may seem easy, but often trees and shrubs may have vines growing up them, or two plants may be growing close together. Make sure you are collecting leaves, flowers, fruits, or twigs from the plant you want to identify.

Carefully arrange flowers and leaves before pressing them. Once your plant is dry, you will not be able to move it without breaking it. (Try to arrange at least one flower so that you can see inside it when possible. The reproductive parts of the plant are often essential in correct species identification)

If collecting a twig off of a living tree, place a little anti-bacterial ointment on the cut tip (the same kind you put on your own minor scrapes and cuts). This will protect the tree from infection while it heals the cut.

Do not take multiple specimens off of the same tree or shrub.

If you are collecting small herbaceous plants (flowers), follow the rule of 20. If you can see 20 plants, it is probably OK to collect one.

Leaves, flowers, and fruit that have already fallen off of a tree make great specimens, though if they are too dry, they may not press well. Encourage collection of botanical materials that do not require taking live specimens when possible.

Photographs of the whole plant can be a great addition to your field notebook alongside a pressed specimen.

If you are using a large plant press, you may want to keep it in the classroom and have students collect and store plant specimens in folded newspaper inside file folders while in the field. OR have each student create their own simple press using cardboard, the same sandwich idea of newspaper, and place the mini-presses in between heavy books.

Plant presses are great for drying botanical specimens for gluing into the field notebook, using in collages, or other “flat” crafts. For a 3-D effect for use in dry arrangements, hang flowers upside down in a dark, dry space (closets work well) for two to three weeks. For this method, you can use a coat hanger and tie the stems of the flowers to it with twine. Make sure that the flowers are spaced out and not touching one another.

Plant Growth Habit Check List

Find and photograph or draw the following:

- Moss
- Fern
- Trailing Vine
- Climbing Vine
- Conifer Tree
- Shrub
- Herbaceous Plant
- Hardwood Tree
- Grass
- A plant with a flower

Plant Growth Habit Scavenger Hunt

Find and photograph or draw the following:

- A plant that reproduces through spores
- An herbaceous plant with seeds
- The leaf from a hardwood tree
- A vine
- Fruits or flowers on a tree
- A fiddlehead
- A cone
- A plant with a hollow stem
- A non vascular plant
- A woody plant with multiple trunks
- Flowers from an herbaceous plant
- Adventitious roots
- A leaf that isn't green

Plant Growth Habit Activities

Plants are an important part of our daily lives. People eat plants, wear clothes made from plants, live in buildings built from plant parts, and decorate our homes and cities with plants. Throughout our daily lives, we come into contact with plants.

Ask the students to ***create a list*** of things that they see in the classroom or use on a daily basis that come from plants. Have each student ***research*** one of the items they listed to determine what plant it comes from, what habitat the plant grows in naturally and what the plant's growth habit is.

Finding Plants in the Urban Environment

Plants are all around us. Some have been planted for a specific purpose, such a providing shade, stabilizing river banks, providing fruit, or for aesthetics. Others have grown naturally.

Take the students on an urban nature walk to try and identify as many different plant growth habits as they can find. Provide each group with a plant growth habit checklist to use in a digital scavenger hunt, or ask them to draw quick sketches of the plants that they find in their field notebook along with the location of the plant, whether they think the plant has been purposely planted or grown naturally, the plant's growth habit, and any other important identifying information.

Top: Jr. Urban Naturalists learn how to spot the difference between a tree and a shrub
Middle: An Urban Naturalist class observes a vine
Bottom: Trees, vines, and shrubs alongside the swamp rabbit trail

Identifying Trees Field Notebook Suggestions

Take photographs or draw pictures of trees found on a nature walk.

Research a common tree species in your area. Include the tree's habitat, characteristics, and use to people.

Make a list of all of the things that people get from trees.

Leaf rubbings and identification.

Pressed leaves, seeds, flowers, or fruit from trees that you have identified.

Describe a tree that you see in detail. Include quantitative and qualitative data that you have collected about the tree.

Choose leaves from 5 different trees. Describe them in detail, including color, shape, texture, and margin.

IDENTIFYING TREES

Key Concepts and Skills:

- Trees are vascular plants that have a single woody trunk.
- There are two main categories of trees: conifers and deciduous
- A tree has 3 main components: the roots, the trunk, and the crown: *leaves and branches*
- Tree leaves perform photosynthesis, while the roots absorb water and nutrients, anchor the tree in the soil, and store energy
- A dichotomous key is a tool used for identification that utilizes paired questions that lead to a final answer.
- Students will learn to recognize some common characteristics of tree leaves and use these characteristics along with a dichotomous key to identify trees to species.

Background Information

A tree is a vascular plant with three main components: a single woody trunk, roots, and a crown made up of the leaves and branches. The single woody trunk is what differentiates trees from shrubs.

The trunk of a tree is what differentiates it from other types of plants. The trunk is made up of layers of tissue that contribute to the tree's growth, support the tree, move water and nutrients through the tree, and provide protection and defense.

The outer layer of a tree's trunk is the bark.

- The outside layer of the bark is made up of dead cells and is believed to serve a mostly protective function.
- The inner layer of the bark is alive, and is a part of the vascular system of a tree, called phloem. The phloem transports sugars (food) throughout the plant.
- Bark is a complex structure, and in addition to the phloem, the living tissue can contribute to the tree's health in a variety of ways, including the creation of chemicals to deter herbivores, water retention and insulation, and more.
- For more information on bark: http://www.botgard.ucla.edu/html/botanytextbooks/generalbotany/barkfeatures/index.html

The way that the trunk grows and operates allows trees to live much longer than other types of plants. As some vascular cells grow old and die, new cells are created. This process forms the rings that can be seen inside of the tree.

All trees have roots which play three major functions: support, water and nutrient absorption, and energy storage.

Tree roots act as an anchor, holding the upper portion of the tree in the soil. Most tree roots grow out, rather than down, forming a strong base which will keep the tree from falling over.

**In addition to holding the tree in place, roots also anchor soil. In the section on urban trees, the importance of roots in soil stabilization is discussed.*

Tree roots absorb water and nutrients from the ground. Water is transported through the xylem, dead cells surrounded by living cells, which act as a pipeline, from the roots to the leaves.

Tree roots also store energy and other materials. These energy reserves can be utilized by the tree in winter, in times of environmental stress, and by some species, to resprout if the tree is damaged or cut down.

All trees have a crown, made up of branches and leaves.

The branches continue the support, defense, transport, and storage functions of the trunk while providing a much larger surface area for leaves to grow, allowing the tree to absorb more sunlight than it would be able to without branches.

The tips of the branches is where the apical meristem, the area of the tree tissue responsible for increasing growth in height, is located.

Leaves absorb sunlight and create food for the tree during the process of photosynthesis.

During photosynthesis, Carbon Dioxide and Water are combined in the presence of sunlight to create Sugar with Oxygen as a by-product. Due to this process, trees act as a sink of Carbon Dioxide, a major greenhouse gas.

Leaves are green due to the presence of chlorophyll, the material in the chloroplasts that absorbs red and blue sunlight and reflects green light.

For more detailed information on photosynthesis: http://biology.clc.uc.edu/courses/bio104/photosyn.htm

There are two main categories of trees: Angiosperms (deciduous trees) and Gymnosperms (conifers)

Angiosperms

Trees that are angiosperms have flowers and fruit.

Angiosperms have more complex tissue makeup in the trunks and branches than gymnosperms.

Most angiosperm trees have broad, flattened leaves. This characteristic earned them the common name *broad leaf*.

Most angiosperms lose their leaves in winter, earning them the name *deciduous*. Notable exceptions include the American Holly and Rhododendrons.

Gymnosperms

Trees that are gymnosperms do not create flowers or fruit, but instead create male and female cones. The male cones contain pollen and the female cones contain the ovule. Once the ovule is fertilized by pollen, it becomes a seed.

Top: Water Oak leaves
Middle: Maple fruit
Bottom: Red Bud flowers

Distinguishing characteristics of trees may include bark color or texture, leaf scars on twigs, leaf arrangement and shape, and more

The presence of cones instead of flowers and fruit is why most gymnosperms are also called *conifers*.

Gymnosperms are mainly wind pollinated.

Most gymnosperms have needle or scale like leaves. A notable exception is the ginkgo.

Most gymnosperms retain their leaves in winter, earning them the nickname *evergreens*. A notable exception is the Bald Cypress

Trees are an important part of the urban environment, providing a variety of benefits to people and the plants and animals that live there. A complete lesson on the benefits of trees is available in the Green Space chapter of the Community Quest Program.

Generally, trees benefit the urban environment in the following ways:

Air Quality

Trees take in Carbon Dioxide, the major greenhouse gas emitted due to human activities, combine it with water to make food, and release Oxygen. They also absorb other airborne pollutants and collect small particles on their leaves, helping to improve urban air quality.

Water Quality

Tree roots help stabilize the soil, preventing erosion. During and following rain storms, trees, especially trees planted alongside streams and rivers, absorb pollutants and reduce storm water runoff which helps protect water quality.

Shade

Trees lower surface and air temperatures, helping to reduce the urban heat island effect and keep us cooler. In addition, shade can save us money. Trees help reduce energy costs of cooling buildings during summer and the USDA center for Urban Forest Research found that streets in the shade needed less maintenance over time and that shade reduced repaving costs by 58% over a 30 year period.

Habitats for animals

Urban trees provide refuges and habitats for beneficial insects, birds, lizards, and other animals, creating vital linkages to natural areas.

Social benefits

A variety of social benefits are associated with trees from reduced crime to improved mental health. Multiple studies have linked trees to improved quality of life and increased economic benefits to business owners and communities.

Why learn to identify trees:
Trees are one of the most easily distinguishable types of plants, and many can be identified utilizing only the characteristics of their leaves, making them an easy start for learning to use a dichotomous key and for introduction into studying plants.

Trees are extremely beneficial to the urban environment. A greater familiarity with the trees in a location and their benefit will help students develop a more advanced sense of place and of environmental stewardship.

Trees have variable growth requirements. Some trees grow very well in wetland areas while others will die if their root systems are flooded for any length of time. Identifying tree species is a first step in understanding the way that plant communities are structured and change based on environmental conditions. Identification is also essential to know prior planting a tree in order to make sure that the tree will grow and function as desired.

Tree Terminology:
In order to identify trees, it is essential to understand certain botanical terms. The most useful and common have been included on the tree identification student handouts.
A more complete list is available at www.botany.com/index.16.htm.

Extra Tree Keys:
Clemson University Online Leaf Key
http://www.clemson.edu/extfor/publications/bul117/leaf_key.htm

Booklet: *Familiar Trees of South Carolina.*
Produced by Clemson University, contains line drawings and some general information about common tree species in South Carolina. Also has a dichotomous key and line drawings explaining terminology towards the end of the booklet. Great starting point for simple identification trip and any tree related research projects
http://library.rawlingsforestry.com/clemson/familiar_trees/bul117.pdf

Booklet: *Common Forest Trees of North Carolina.*
Many of the trees of North Carolina are present in the South Carolina upstate, and though this is not a key, this book contains helpful line drawings and information about many SC trees. In addition, this book contains very clear and easy to understand line drawings of leaf, bud, and fruit shapes.
http://library.rawlingsforestry.com/ncdfr/common_forest_trees/common_forest_trees_of_nc.pdf

Identifying Trees

- *Make sure you have a tree.* Trees are usually medium to large sized plants that are woody and have a single stem (the Trunk) from which branches grow. Smaller woody plants and medium sized woody plants with multiple stems are usually considered shrubs, not trees.

- Identify the parts of the tree.
  In order to determine what kind of tree you have, you must first make some observations about the tree.
    - Size – how tall and how big around is the tree? (estimate)
    - Shape – is the tree larger at the bottom than the top? Are the bottom branches close to the ground or higher up?
    - Leaf shape and arrangement
    - Bark (color, texture)
    - Fruit or Flower

- Record your observations
    - Take a picture of the tree along with a close-up of a branch with leaves, and fruit if you can. OR Draw a picture of the tree and a twig with leaves
    - Collect a leaf for your field notebook
    - Make sure you write down WHERE and WHEN you saw the tree.

- Use a dichotomous key to identify the tree

Using a dichotomous key.

What is a dichotomous key:
A dichotomous key is a tool used to identify something by asking questions. Each question leads you to a new question until you find the correct answer. Using a dichotomous key is kind of like the game 20 questions. Each question that we ask helps us narrow down the list of possible answers until we find the right one.

How to use a dichotomous key:
Answer the first question. For trees, the first question is usually "Is the tree coniferous or deciduous?" Use your field notebook, pictures, or leaves to answer this question.

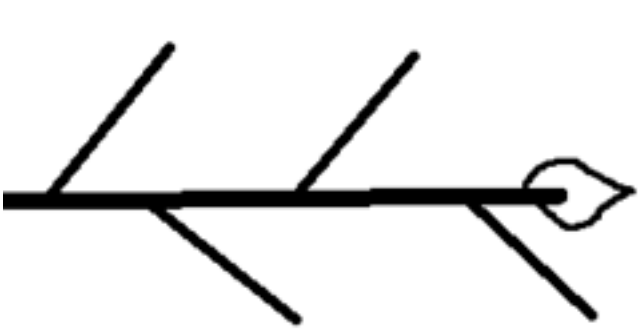
The answer will lead you to a new question. Continue using your photographs, drawings, or specimens to help you answer the questions until you have identified your tree.

Vocabulary for using a tree key

Coniferous (Evergreen) – trees that have needle or scale-like leaves, produce cones, and keep their leaves year round

Deciduous (Hardwood) – trees that shed their leaves in fall and winter

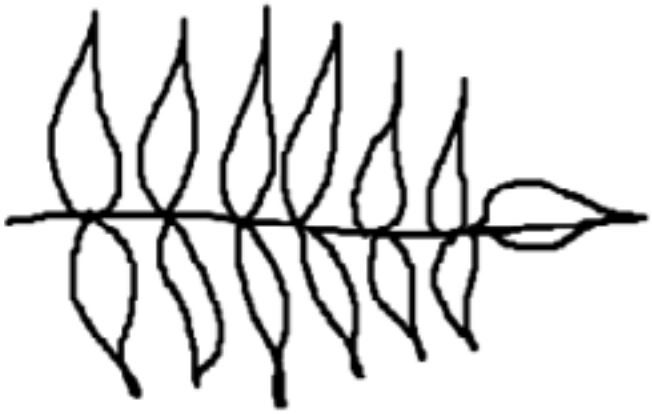
Alternate – a leaf or twig where two leaves or twigs grow in a zigzag pattern from different places on either side of a branch.



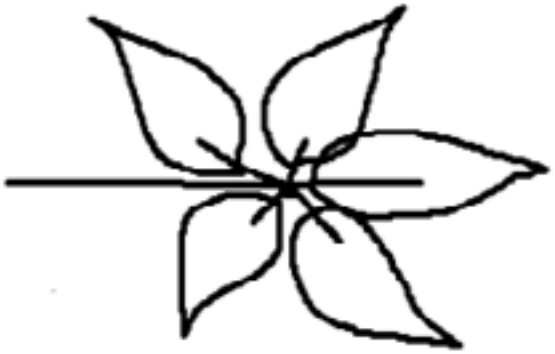
Opposite – a leaf or a twig where two leaves or twigs grow from the same place on opposite sides of the main branch.

Simple Leaf – a single leaf coming from a leaf stem. The leaf stem becomes the midrib of the leaf.

Compound Leaf – multiple leaves (called leaflets) originate from a single leaf stem.



Pinnate Compound Leaf



Palmate Compound Leaf

Pinnate – "Feather" like. Pinnate refers to the shape of a leaf along the leaf vein or the arrangement of leaflets around a stem.

Palmate– radiating outward from a single point, like the fingers on your hand. Palmate refers to the shape of a leaf along the leaf vein or the arrangement of leaflets around a stem.

Leaf Shape:
Lobed – refers to a leaf with multiple deeply rounded edges.

Toothed – refers to a leaf edge that is not smooth, but has small pointy "teeth"

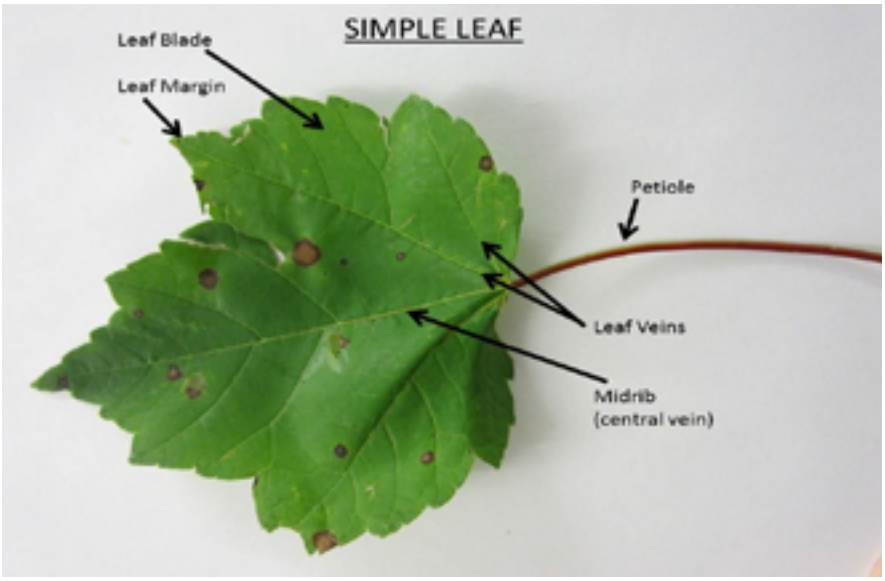
Smooth – refers to the leaf edge being smooth, without teeth

*a leaf can be lobed and toothed (below) or lobed and smooth

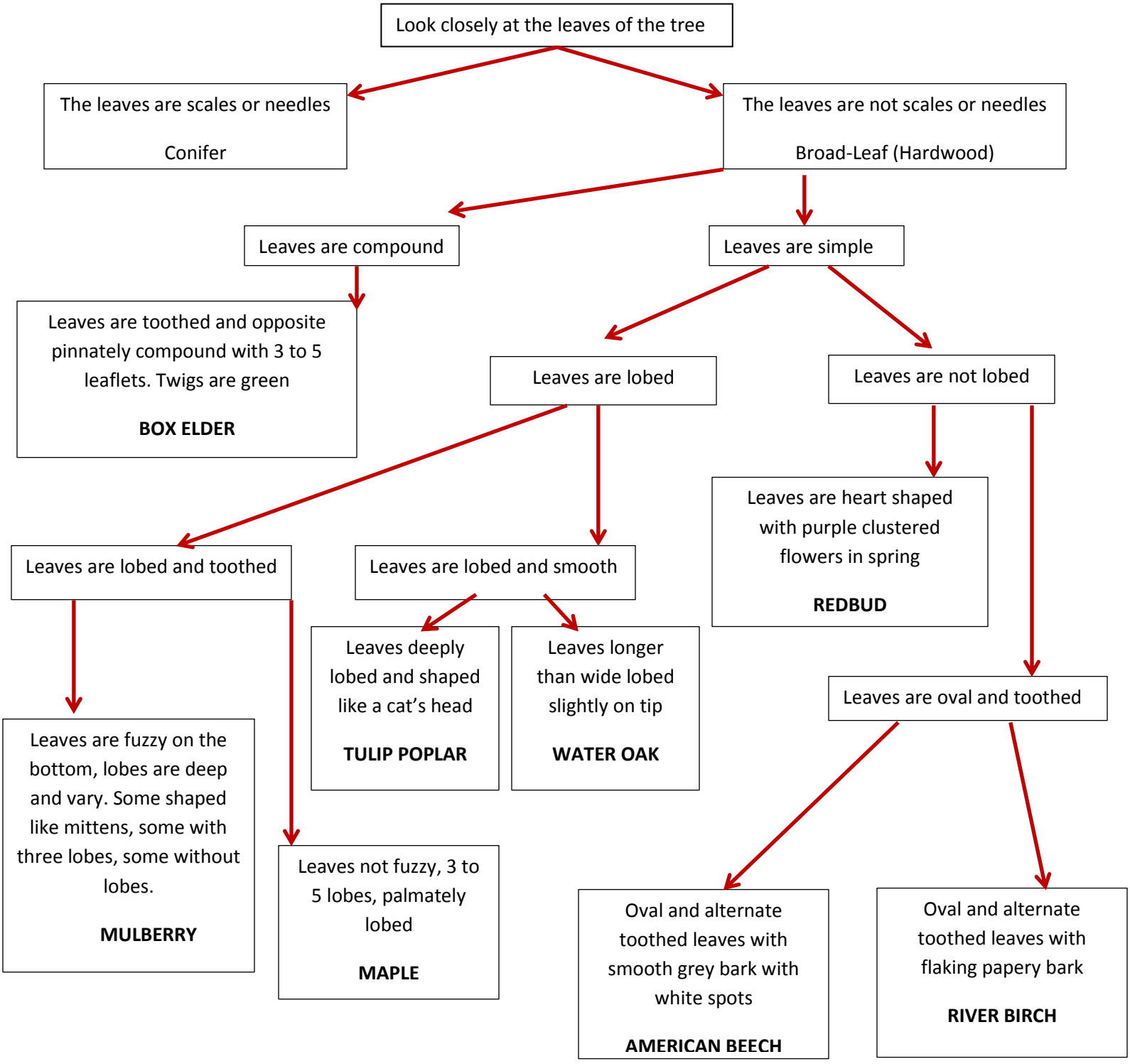
Leaf Margin - outer edge of the leaf

Leaf Blade - flat surface of the leaf

Petiole - stem of the leaf



Swamp Rabbit Tree Key



Swamp Rabbit Tree Identification

American Beech
(*Fagus grandifolia)*

Simple, alternate, toothed oval leaves and smooth grey bark with white spots. Buds are long and pointed. Dead brown leaves remain on tree in winter

Box Elder
(*Acer negundo*)

Pinnately compound leaves with 3 to 5 coarsely toothed leaflets. Twigs are green

Maple
(*Acer rubrum, Acer saccharinum*)

Simple, opposite leaves. Palmately lobed with three to five lobes

Swamp Rabbit Tree Identification

Redbud
(*Cercis canadensis)*

Simple, smooth, alternate heart shaped leaves.
Lavender flowers in clusters in spring

Mulberry
(*Morus rubra, Morus alba*)

Simple, alternate leaves. Leaves very variable: 3 deep lobes, mitten shaped, unlobed. Toothed margin. (Rubra leaves fuzzy underneath)

River Birch
(*Betula nigra*)

Simple, alternate, diamond to oval shaped toothed leaves.
Papery, peeling bark

Swamp Rabbit Tree Identification

Tulip Poplar
(*Liriodendron tulipifera)*

Leaves are alternate, simple, palmately lobed with a "cat's head" shape. Flowers are tulip like.

Water Oak
(*Quercus nigra*)

Simple, spatula shaped leaves that are wider at the tip than the base. Slightly lobed, smooth and alternate. Bark is smooth when young and gets scaly as the tree ages.

Tree Identification Activities

Go over the tree identification traits, using a dichotomous key, and leaf key vocabulary with students in class then ***practice using the key to identify trees*** through a nature walk.

Sample simple dichotomous leaf keys that were developed along with lesson plans for the Urban Naturalist Program are available in the appendices. You are welcome to use these keys for your class, or you may want to make your own.

To create a dichotomous key and pictorial tree guide:

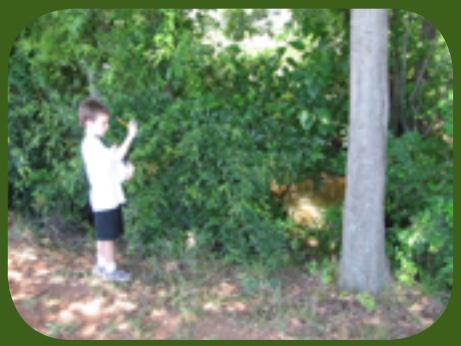
- Identify the trees that you are going to study. Depending on the age range of your students, you may want to make sure that the trees you choose have leaves that can be easily reached. Often one of the hardest parts of tree identification is trying to identify a tree with leaves and branches so far away that they are hard to see.
- Take photographs of the whole tree, and close ups of any distinguishing features (leaves, bark, twigs, buds, fruit, flower, etc.)
- Write a list of the trees you have chosen. Include short descriptions in your list.
- Organize the list:

Start by separating your trees into the broadest two categories (conifer and broad-leafed).

Next, separate the trees into the second broadest categories (for broad-leafed trees, this is usually opposite vs. alternate leaf arrangement).

Continue organizing the trees until you have all of them in pairs, then draw out your key.
If you have access to the internet, you may want to use the Clemson University leaf key online:
http://www.clemson.edu/extfor/publications/bul117/leaf_key.htm

Go over the parts of a tree and their functions and the two major types of tree. Take a field expedition to find and identify the parts of a tree and the two major types of tree.



Urban Naturalists use dichotomous keys and the tree characteristics that they have learned to identify trees

The American Beech tree has very smooth bark, and many people carve their names in it. Point out to the students that damaging the bark on a tree can reduce its ability to transport water, introduce pathogens through open wounds, and otherwise harm or even kill the tree

Do evergreen trees lose their leaves?

YES

No leaf lasts forever. Trees are constantly losing and replacing their leaves. The difference between evergreen and deciduous trees is that deciduous trees lose all of their leaves at one time.

Set up a ***field identification quiz*** as a fun way to assess the students' progress.

Choose a few trees that are relatively easy to identify and in the key. Clearly mark each one with marking tape or flags and a number, and provide the students with a simple map to the marked trees. Have the students identify each tree using their field guides and dichotomous key.

Have students ***research the differences*** between angiosperms and gymnosperms.
Introduce the terms Hardwood, Deciduous, Broad Leaf, Conifer, and Softwood. Ask each group to choose one of these five terms and decide whether it refers to angiosperms and gymnosperms.

Then ask them to decide if these terms are truly representative of the group as a whole. (Are all angiosperms deciduous? Are all broad leaf trees angiosperms? etc.)

Take your students outside to a spot with pre-marked trees. Have the students work in pairs. One student in each pair should be blindfolded. The other student will lead the blindfolded student to a tree. (have them gently spin the blindfolded student a few times before and after finding the tree to confuse their sense of direction)

The blindfolded student should spend some time touching the tree. Once returned to the center spot, the student may remove their blindfold and should guess which tree was "their" tree.

Have the pairs switch and repeat the exercise.

This activity works the best in an area with a variety of tree species and ages.

*Make sure that there are no poison ivy vines on the trees that you have marked
Discuss: Were students able to pick their tree? What about their tree made it possible for them to identify it? What kind of data is this?

Chapter 4: Fungi

Many people think that mushrooms are a type of plant, but mushrooms are actually members of the kingdom Fungi. Unlike plants, mushrooms cannot produce their own food, but like plants, they are important parts of most ecosystems.

Word Bank

Fungi
Mushroom
Mycelium
Heterotrophic
Mycorrhizae
Decomposer
Lichen
Symbiosis
Mutualism
Parasitic
Pathogen
Hyphae
Spore
Nutrient Cycling
Germinate
Kingdom

INTRODUCTION TO FUNGI

Key Concepts and Skills:

- Fungi are multicellular, heterotrophic organisms that can be found in almost every environment on Earth.
- Mushrooms are the reproductive structure of certain types of fungi.
- Fungi perform a variety of important functions in nature including decomposition, nutrient cycling, and mycorrhizal associations with the roots of many plant species.
- Students will find and observe different types of fungus.
- Students will take spore prints of mushrooms.

Background Information

Mushrooms, along with yeasts, molds, smuts, and more, are members of the Fungi Kingdom. These are biological organisms that are multicellular and heterotrophic, meaning that they cannot make their own food, like plants do, but instead use enzymes to break down and absorb nutrients from external sources.

Fungi are made up of multicellular filaments called hyphae. The body of the fungus is called the mycelium, and is made up of many hyphae. The mycelium is the living body of the fungus. For many mushrooms, the mycelium is underground or inside of a decaying log or animal body, and rarely seen. Or, when it is seen, it is rarely recognized as a fungus. The mycelium may look like a whitish web. The part that we think of as the mushroom is the reproductive structure of the fungus, called the fruiting body, temporarily produced by the fungus in order to release spores.

Introduction to Fungi Field Notebook Suggestions

Take photographs or draw pictures of mushrooms.

Spore prints

Fungi are used by people in many ways: bread, fermented drinks, medicines, food, and more. Research one of these uses and make an infographic about the important fungi.

Describe a lichen.

Find a fungus and a plant that are growing in the same area. Describe each using qualitative and quantitative data. Then, compare and contrast the plant and the fungus.

Research one of the words in the word bank and write the definition.

Fungi perform a variety of important functions in nature:

Many fungi are decomposers. These can be found on logs, dead animals, in leaf litter, etc. Decomposers break down organic matter and aid in nutrient cycling.

Many fungi form mycorrhizal associations with plant roots. This is an example of a mutualistic symbiotic relationship where both organisms benefit. Plants provide the fungi with food in the form of sugars from photosynthesis while the fungi provide the plants with nutrients from the soil. Mycorrhizae can be found around the base of plants.

Lichens are a specialized form of symbiotic relationship, a fungal-algal symbiosis. In this instance, the fungus provides a structure for the algae to live in, and the algae provide sugars created through photosynthesis for the fungus. Neither fungus nor algae can survive without the partner, but the mutualistic relationship allows both to survive in very inhospitable environments such as very cold places, dry places, and even bare rock.

Fungi are important food items for many organisms, including people. Mushrooms, bread, and beer all come from fungi. Fungi have provided people with a variety of medicines, including penicillin, and are also important pathogens affecting plants, animals, and people; including ringworm, athletes foot, dutch elm disease, powdery mildew, and many more.

Fungi identification to species is very complicated and beyond the scope of this program, but observing mushrooms and taking spore prints are easy and fun ways to get started exploring the world of fungi.

Tips for finding fungi:

The easiest part of a fungus to find and observe is the fruiting body, also known as a mushroom.

Mushrooms are created by the fungus in order to produce spores, which are similar to plant seeds in that they can create a new mycelium if they land in a place where the correct food for the fungus is available.

Fungi need certain environmental conditions in order to create mushrooms. Though the conditions required vary depending on species, in general, mushrooms are most common when it is warm and humid or moist. A good time to find mushrooms in the upstate is Spring, Summer, and Fall following a rain storm.

Many mushrooms are small, so carefully. Decaying logs, leaf litter, the base of trees and shrubs are all great places to search for mushrooms.

Spore prints

Spores are very small, and impossible to see with the naked eye, but a single mushroom creates many spores, making it possible to create a spore print. When gathered in mass, it is possible to tell the color of the mushroom's spores.

Making a spore print:

Print the spore print field notebook page following the student handout on mushrooms. Students should fill out the data in the field prior to collecting a mushroom to print.

Carefully collect the entire mushroom. Use a small spoon or knife to dislodge the mushroom at the base and try to disturb the surrounding soil or leaf litter as little as possible.

To take the spore print, remove the stem from the mushroom and carefully place the cap on the center of the black and white rectangle on the spore print page. Cover the mushroom with a bowl to prevent air flow from interfering with the print, and leave the mushroom for at least 24 hours.

When you remove the bowl, the spore print will be visible on one or both sides of the rectangle.

> The purpose of the black and white rectangle is to be able to see a spore print no matter what color it is. If the spores are light colored, they will show up on the black side and if they are dark they will show up on the white side. If you don't want to print the field page, you can use white note cards or glass which can then be placed over a black or white background. You can even make your own spore print page with half black construction paper and half white card stock.

Once the spore print has been made, use clear spray to fix the spores in place and create a keepsake for the students' field notebooks.

Remember that many wild mushrooms are toxic, and that some of our native mushrooms are deadly if ingested. Make sure that students wash their hands very well after any field experience, and **NEVER** eat any mushroom that has not been properly identified by an ***expert.***

More information on making a spore print:
http://namyco.org/education/spore_prints.html

Mushrooms can be found in any terrestrial ecosystem. Look for them on or near plants, in leaf litter, at the bases of trees, and on decaying logs

Mushrooms

A mushroom is the fruiting body of a fungus.

The living part of the fungus, the part of the fungus that is actively growing and digesting food, is made up of very small filamentous (thread like) structures called ***hyphae*** that live in the ground or inside of decaying organic matter such as logs and leaf litter. Together, the group of hyphae that make up a single fungus is called the ***mycelium.*** When environmental conditions are right, the mycelium will produce one or more mushrooms.

The mushrooms create very small spores. The spores are carried by wind or water to a new place where they will germinate and become a new hypha. If the spore landed in a place where a food source is available for the fungus, then the new hyphae will continue to grow and become a new mycelium.

Fungi are highly variable in structure, form, and needs for survival. Some species of fungus are very specific and will only colonize a certain type of food while others are more general and will colonize many different types of food.

We will be looking for fungi that create mushrooms. These can be divided into three main categories:

Saprophytic fungi: A saprophyte is an organism that feeds on dead organic matter. Saprophytic fungi are important decomposers and can be found on logs, in leaf matter, and even on animal dung.

Mycorrhizal fungi: These fungi form a relationship with the roots of plants. The mycelium allows the plant to absorb nutrients from the soil and the plant provides food in the form of carbon for the fungus. Some mushrooms formed by mycorrhizal fungi can be found near the base of plants. (Remember that tree roots may cover a very large area)

Parasitic fungi: These fungi colonize other living organisms including plants, animals, and other fungi, and feed off of them. Many plant and animal diseases are caused by parasitic fungi. The easiest mushrooms to find from parasitic fungi are mushrooms growing on living plants.

Collecting mushrooms:
Mushrooms are the fruiting body of the fungus, so as long as the fungus is not a rare, threatened, or endangered species, it is OK to collect them for identification or to make a spore print. Use a small spoon to carefully cut around the stem of the mushroom and lift the whole thing. Try to disturb the area around the mushroom as little as possible and only take one mushroom from an area.

Caution: ***Some mushrooms contain toxins that can cause serious illness and even death***. Mushrooms in an urban environment that aren't naturally toxic, can act as sponges absorbing pollutants from the air and soil. **Never** eat a mushroom that hasn't been properly identified by an expert, and never eat a mushroom found in the city.

Name: Date:

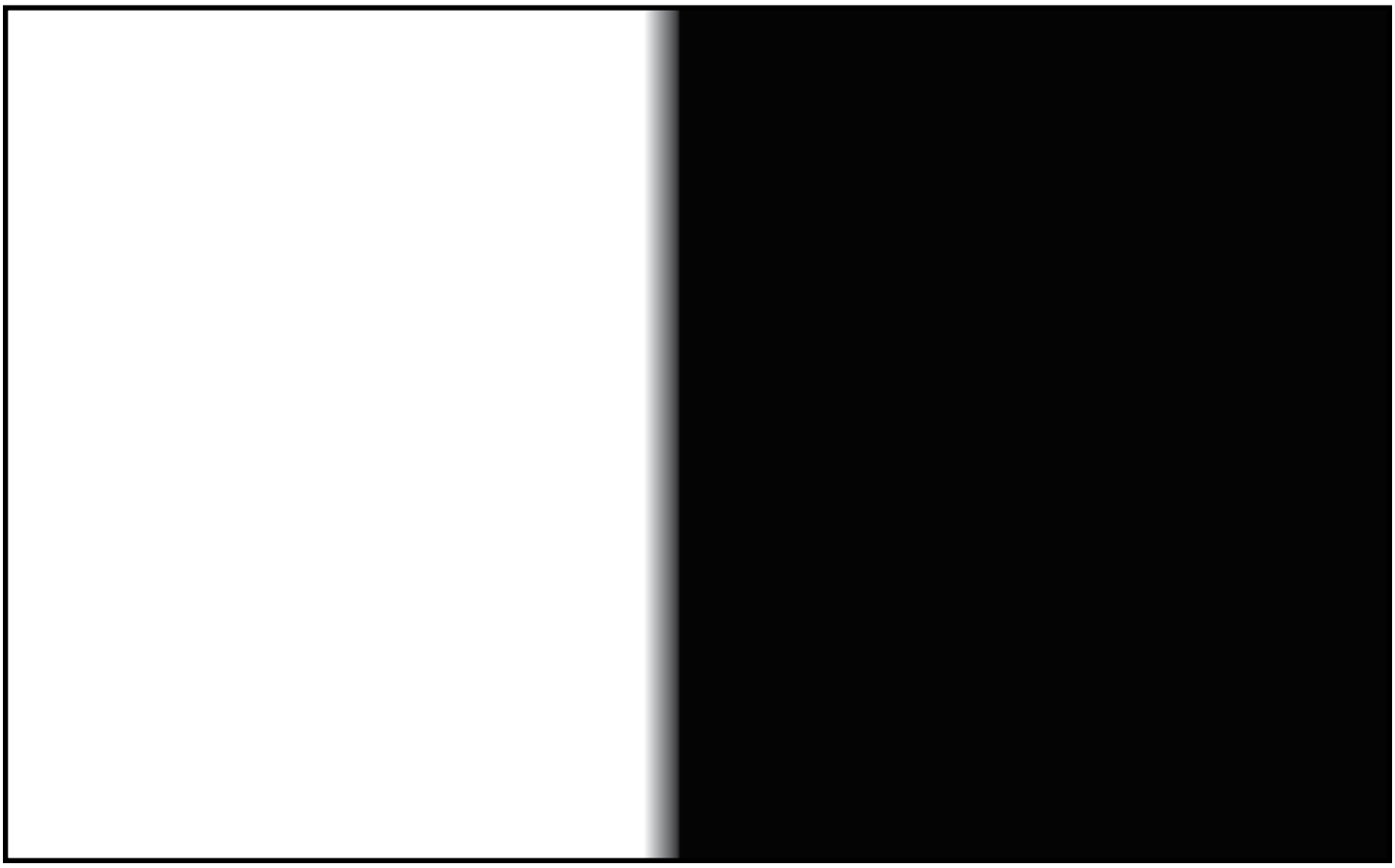
Location of mushroom:

Mushroom habitat:

Other identifying features:

Photograph or drawing of the mushroom

Spore print:



Fungi Activities:

Go on a field expedition to ***find and collect mushrooms for observation*** and to make a spore print. Only collect what you need for the spore print, and have students photograph or draw other mushrooms that they find for their field notebooks.

Bring in some mushrooms from the grocery store (button, or portabello works well) and allow students to ***study and draw the mushrooms*** in the classroom. Go over the parts of the mushroom, the cap, stem, and gills that can be seen on the button and portabello mushrooms. Then, ask students to look for these parts on mushrooms that they find in the field and note similarities and differences.

*ask students to observe natural mushrooms carefully, without destroying them when possible.

Read and discuss the "Fungal Pathogens: Chestnut Blight" page.

Fungal Pathogens: Chestnut Blight
By Emily Hays

“Chestnuts roasting on an open fire, Jack Frost nipping at your nose…” are words to a popular Christmas-time jingle played on the radio every December. However, have you ever paused to consider that you don’t typically see or have “chestnuts roasting on an open fire” and why? Formerly one of the tallest trees in eastern hardwood forests, the American chestnut was infected and the population was decimated by a fungal pathogen known as chestnut blight in the early 1900s.

Believed to have originated in Japan, the chestnut blight spread rapidly throughout the American Eastern forests. The fungus, originating in New York, swiftly spread up to Maine and down to Georgia, infecting nine million acres of land and about three billion trees.

Chestnut blight attacks the bark, releasing oxalic acid that kills tree tissue. This causes cankers to form on the trees, inhibiting a tree’s ability to carry water and nutrients from the roots to its branches. The fungus spreads via many vectors, including insects, rain, wind, birds, and other animals. Once inside the tree, it multiplies rapidly. Chestnut blight does not kill trees, but infects them badly enough so that they are very susceptible to other diseases and inhibits their growth. In this way, the fungus virtually eliminated a quarter of the standing timber in Eastern United States forests.

The destruction of the American chestnut tree population redefined eastern hardwood forests, as its unanticipated removal impacted wildlife, the natural environment, and people. Wildlife populations were impacted because many species, including black bears, turkey, deer, and other animals, ate the chestnut fruits. The species composition of many forests changed completely. The disappearance of these trees is also believed to have contributed to an increase in mountain soil erosion. Additionally, chestnut trees grow straight and branch-free for about fifty feet, providing excellent wood for lumber. People depended on American chestnut trees for lumber and income. The chestnut tree was a crux in rural economies throughout the east and its disappearance altered eastern hardwood forests as other tree species became dominant and people were left without jobs.

There currently is no cure for chestnut blight. The fungus is still widespread and continues to infect American chestnut trees. Today, American chestnuts typically exist as an understory resprouts that reach only about 10-12 feet in height. Researchers are trying to find a solution to save the American chestnut by breeding it with Asian chestnuts, which are resistant to the blight in order to create a tree that will have the blight resistance of the Asian chestnut and the fruit and growth characteristics of the American chestnut. Whether or not scientists succeed, the chestnut blight has forever altered the ecology of American forests.

Chapter 5: Insects

Of all of the known animals on Earth, Insects make up 73%. That's 1,000,000 species of insects compared to only 5,490 mammals, and there are a lot more insects out there that we haven't identified yet

Due to their ubiquitous nature and the fact that they are highly variable and relatively easy and safe to catch, the section about insects is one of the most extensive in the Urban Naturalist Program and could span several classes and field expeditions. A list of the insect orders that you are most likely to come into contact with and an insect identification checklist is included in the student handouts for use in identifying insects to order.

If you have limited class time, you may want to move these lessons and activities earlier in the series or skip some of the background information. You can teach proper insect collection techniques in the field such as the use of sweep nets, beating pans, and pitfall traps. A detailed explanation of these techniques is included in the background information provided. Students can collect, observe, and release, or keep some specimens in clear containers for observation and identification in the classroom. If a limited amount of time is available, pair a short field expedition to collect and observe insects with a discussion of insect features and importance, and skip the identification.

It is beneficial to have hand lenses, magnifying glasses, or magnification boxes to use for observation and identification of insects.

Word Bank

Insect
Arthropod
Order
Antenna
Halteres
Elytra
Aspirator
Terrestrial
Metamorphosis
Exoskeleton
Molt
Larva
Nymph
Pupa
Migrate
Dormancy
Pest
Beneficial Insect
Natural Enemy
Predator
Pollinator
Parasitoid

INTRODUCTION TO INSECTS

Key Concepts and Skills:

- Insects are the most numerous animals on Earth and can be found in almost every terrestrial and aquatic habitat other than the Ocean.
- Many insects go through complete or incomplete metamorphosis, so the larval or nymph forms often look very different from the adult forms and may live in different habitats.
- Insects are classified into groups based on their similarities in the same way that animals are. The broadest categories of insects are the insect orders.
- Students will learn to use a simple dichotomous key to insect orders to identify adult insects to order using common names.

Introduction to Insects Field Notebook Suggestions

Insects are everywhere. Have students list 10 places where they have seen insects.

Identify and then compare and contrast insects from 2 different Orders. How are they similar? How are they different?

Pretend that you are talking to someone who has never seen an insect before. Describe a beetle.

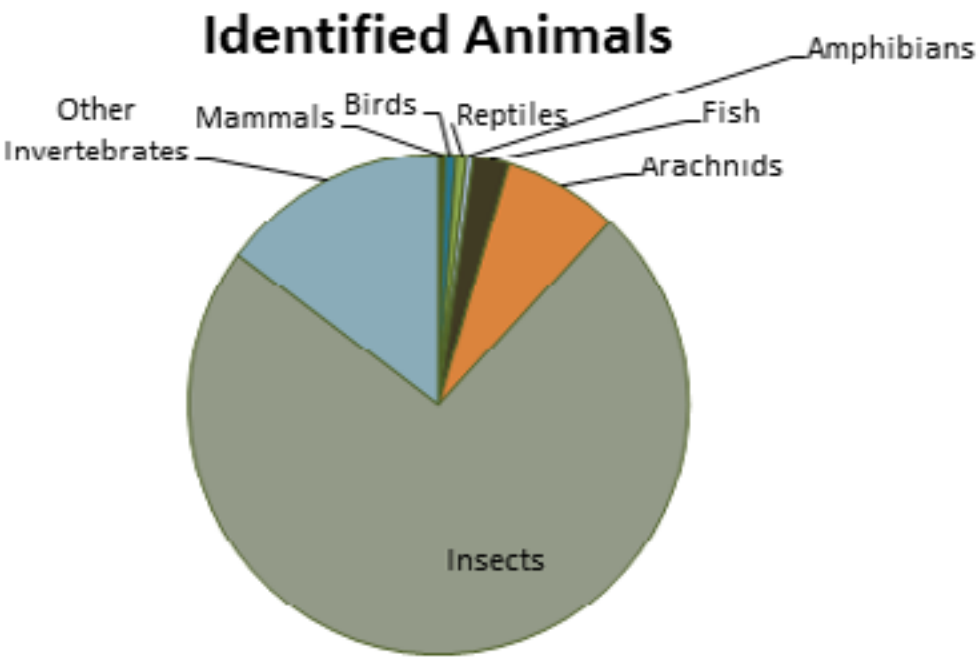
Draw a picture of an insect that you discovered on an Urban Naturalist expedition.

Describe a habitat where you were surprised to find an insect during an Urban Naturalist expedition.

Pretend you are a butterfly. Write a paragraph about your day living in an urban environment.

Background Information

Of all of the known animals on Earth, Insects make up 73%. That's 1,000,000 species of insects compared to only 5,490 species of mammals.



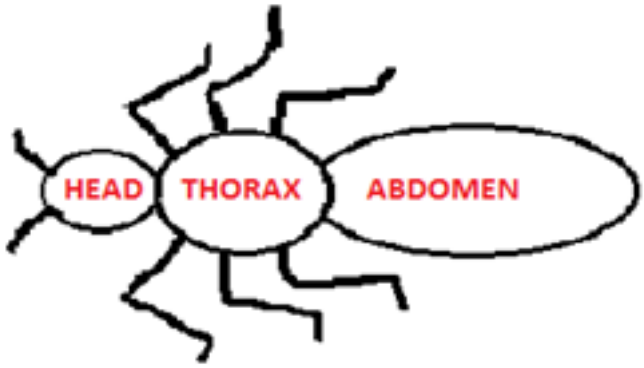
It is very common for students identifying insects for the first time to want to know "which one?" Most insects are very difficult to identify to species, and very few (mostly the unique, beautiful, and the economically important) have common names. Remind students of how many insects there are in the world when they want to know what species an insect is, and explain that Order or Family identification may be the best that you can do.

Since there are so many insects sharing our planet, obviously, they are doing something right. Though there are lots of different kinds of insects, they all share some characteristics:

All insects share 3 traits:

- Insect comes from the Latin word for "segmented." Insects have bodies that are segmented into 3 main parts, a head, thorax, and abdomen.
- Adult insects have 6 segmented legs (3 pairs).
- All insects have a hardened outer layer called an exoskeleton. The presence of an exoskeleton is one of the reasons that insects are mostly very small compared with other animals.

Insects are highly variable in body shape, size, and modifications, but the general body plan of 3 segments and 3 pairs of segmented legs is important because this is one of the major differences between insects and other arthropods like spiders, crabs, millipedes, and centipedes.



Other common traits

- Many insects have large multi-faceted eyes.
- Many insects have antenna as sensory organs.
- Some insects have wings, while others do not.
- Insects with wings may have one pair of wings, or two pairs of wings.
- Sometimes when insects have only one pair of wings, the second pair has been modified. On Flies, the second pair of wings have been modified into knob like structures called halteres which aid in flight.
- Sometimes when insects have two pairs of wings, the front pair has been modified to become a protective covering. Some are hardened shells, called elytra, such as those found on beetles. Other front wings are modified to be leathery, such as the wings of grasshoppers and leaf footed bugs.
- Insects do not breathe through their mouths but through small holes in their exoskeletons on the abdomen and thorax called spiracles.

Insects come in a variety of shapes and sizes and live in almost every habitat on Earth. Often the two go together. Insects have adapted both physically (shape, size, color, wings, etc.) and behaviorally to live in a variety of habitats and make use of a wide variety of food types.

Most insects go through some form of metamorphosis. This allows different life stages to survive in different habitats and specialize in various functions. In addition to other changes, because the exoskeleton is hard and cannot grow, the insect has to molt, or shed its exoskeleton during metamorphosis.

Some insects go through complete metamorphosis, where the insect looks completely different in the juvenile and adult forms. These insects typically follow a life cycle from egg to larvae to pupa to adult.

- An example of an insect that undergoes complete metamorphosis is a Butterfly, Beetle, or Wasp.

Insects found in the school garden during Urban Naturalist Class at A J Whittenberg

Examples as to why it is important to make sure the insect is an adult when trying to use a key for identification.
Above: Dragonfly nymph and adult
Below: Cranefly larva and adult

Some insects go through incomplete metamorphosis, where the juvenile insect looks similar to the adult insect but lives in an environment completely different than the environment the adult lives in.

- An example of an insect that undergoes incomplete metamorphosis is a Dragonfly. Juvenile dragonflies live in water.

Other insects go through gradual metamorphosis. When an insect goes through gradual metamorphosis, the juvenile and adult insects look almost identical, but the juveniles change in size, body proportion, and often grow wings as they progress from juvenile to adult.

- An example of an insect that goes through gradual metamorphosis is a Grasshopper or Praying Mantis.

Insect Classification System:
We have identified and classified (named) around 1 million insect species, and scientists believe that there are a lot more insects that have not been identified yet. Their ability to specialize as well as their small size make it likely that millions of insect species are still waiting to be found and classified. Scientists are constantly learning new things about insects.

For our purposes, we will learn to identify insects to Order. An order is the broadest grouping of different types of insects. There are 31 Orders of Insects, but we will just learn the 15 that we are most likely to come into contact with.

Younger students will definitely use common names for identifying insects. This break down of common insect orders paired with their common names is provided for the instructor's benefit as well as for use with older students.

Order	**Common Name**
Ephemeroptera	Mayflies
Odonata	Dragonflies and Damselflies
Orthoptera	Grasshoppers and crickets
Phasmatodea	Leaf and Stick Insects
Plecoptera	Stoneflies
Isoptera	Termites
Mantodea	Mantids
Blattodea	Cockroaches
Hemiptera	Bugs, Leafhoppers, Cicadas, Scales, Aphids
Coleoptera	Beetles
Neuroptera	Lacewings and Antlions
Hymenoptera	Bees, Wasps, and Ants
Tricoptera	Caddisflies
Lepidoptera	Butterflies and Moths
Diptera	Flies

Identifying Insects:
A simple dichotomous key is provided to help your students identify insects to Order. The key will help identify the 10 of the orders of insects in the table above by their ADULT form.

Other more detailed keys are available online, but for beginning exploration, finding and identifying insects from 15 Orders is a good start.

Once you have insects to identify, students should observe the insects and try and answer the following questions in order to figure out which Order the insect belongs to:

How many legs does it have?

- If the answer is 6, then you have an Insect.
- If the answer is 8, you have an Arachnid (spiders and scorpions).
- If the answer is more than 8, you probably have a Millipede or Centipede.

Does it have wings? If the answer is YES, try to see if you can count how many wings (hint, the answer will be 0, 2, or 4).

What is the shape and texture of the wings?

- Are the front and back pairs of wings the same in shape and texture, or are they different? (Look carefully – Beetles have two pairs of wings, but the front pair is a hardened shell that works as a protective covering for the back pair of wings)

Does the insect have antennae? What are the antennae shaped like?

Look at the shape of the insect's body.

- How long is the abdomen in relation to the head?
- Is the abdomen wider than the head?
- Does the insect have a "waist" between the abdomen and thorax?
- Are there any hairs or odd looking pieces at the tip of the abdomen?
- Are any of the legs different looking, and if so, describe them?

An identification check list has been provided to help students mark off characteristics of insects for identification. They will not always be able to answer all of these questions, but the more that can be answered the easier it will be to identify the insect.

Cool Links:
Discovery Channel's List of 10 most important insects
http://curiosity.discovery.com/topic/importance-of-biodiversity/10-most-important-insects1.htm

Smithsonian article on how many insects there are.
http://www.si.edu/Encyclopedia_SI/nmnh/buginfo/bugnos.htm

Website with a variety of short educational videos and quizzes for kids about insects
http://www.neok12.com/Insects.htm

Urban Naturalists work with different types of keys to try and identify insects.

Top: Urban Naturalists practice using sweep nets and aerial nets to catch insects
Middle: An Urban Naturalist observes insects that have been removed from a sweep net
Bottom: An Urban Naturalist uses a bowl and a piece of cardboard to capture insects in grassy areas

Capturing Insects for Observation or Collection
There are a variety of methods and materials used for capturing insects. If you are trying to catch a specific type of insect, it helps to know a little bit about that insect's behavior in order to know how and where to catch one. For example, you cannot catch a butterfly by turning over a log, but that may be a great place to find beetles or termites.

Tips:

Insects are always around, but many are definitely more active during the warmer months. For the best collecting, aim for spring and summer.

If you are trying to collect a specific type of insect, do a little bit of background research to determine what time of day is best and where to look: some insects are nocturnal while some are more active in the middle of the day.

Look for edges and hedges: edge habitats are generally more diverse (water's edge, forest edges), and hedges and tree lines provide safe habitats for insects. Insects will be more diverse in areas that contain more diverse plant species and land features.

Common tools for collecting insects:

Nets: All insect nets are basically a wire frame, cloth net bag, and a handle. Instructions on how to create your own insect nets is available in the activities section.

Aerial nets: Aerial nets are made for catching insects in flight. They are light weight, and usually transparent. The fabric of aerial nets is specifically made to not damage delicate species like butterflies. Aerial nets are most useful to catch specific individual insects that you already know are there.

Sweep nets: Sweep nets are medium weight to heavy weight nets made for use in brush or grass. The heavier material is harder to damage than the aerial nets. Sweep nets are often used by scientists across transects or for a set amount of time to get samples of insect populations in an area without knowing what is there.

Aquatic Nets: Aquatic nets are made for catching insects in the water. Most often, they are a mix of weights, with mesh at the end, allowing water to pass through.

How to use insect nets:
Make sure that students are using the correct net.

Aerial nets are used for collecting insects while flying, such as butterflies and dragonflies. Aerial nets are generally very light weight and delicate and can rip easily if snagged on vegetation. If you have access to an aerial net, you may want to limit its use to adult helpers and older students.

Using an aerial net:

Quickly sweep the net through the air, ending with the bag end of the net flipped over the opening so that the insects are caught in the net and cannot escape.

Approach insects from behind with the net if at all possible

Dragonflies are difficult to catch. Dragonflies are adept fliers with surprising maneuverability and speed. Do not get frustrated if it takes you awhile to catch one.

Check to see if you caught your insect (make sure there are not any wasps or bees in the net before sticking your hand in there). Depending on what you plan to do with the insect, either transfer it to a container for observation or a kill jar for collection.

Handling butterflies and moths (most often collected with aerial nets): while in the net, grasp the body of the insect underneath the wings and apply gentle pressure to the thorax. This will temporarily immobilize the insect and allow you to remove it from the net without damage. Butterflies and moths are very fragile. DO NOT touch the top side of the wings. If releasing the insect, allow students to look while you hold it, and then release it onto a nearby flower or off of the tip of your finger.

Sweep nets are more appropriate for young collectors, as they are more durable and are meant to be used by sweeping them rapidly through vegetation (preferably herbaceous vegetation without thorns: though less delicate than aerial nets, sweep nets can still tear).

Sweep nets can be used to collect a specific insect by sneaking up behind it and sweeping in a downward angle. Once the insect is in the net, flip the end of the net over the hoop to trap the insect.

To randomly catch insects that you may or may not see: Quickly sweep the net back and forth across vegetation such as high grass, twisting at the end of each pass so that the open end of the net crosses the plants. After 6 – 10 passes, flip the end of the net over and check to see what you have caught.

Removing insects from the net:

Place the net flat on the ground with the opening facing downward.

After making sure that no bees or wasps are in your net, lift the closed end upward, leaving the opening flat on the ground. Most insects will crawl or fly upward, allowing you to see what you have and lift the open end of the net without releasing all of the insects.

Take a collecting container and place it over the insect, slide the container and insect towards the open end of the net and quickly slip the lid onto the container. This takes practice.

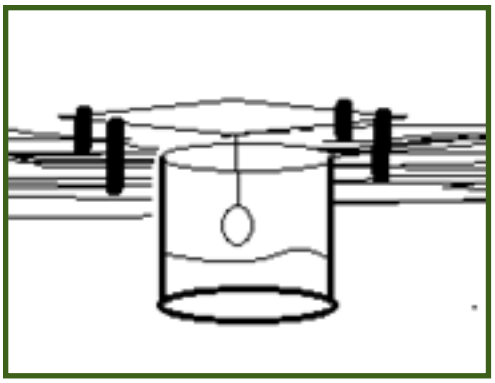
If you have an aspirator, use it to collect small insects.

Finally, bring a white hand towel or piece of cloth or paper with you, dump the net onto the white cloth or paper and observe the insects you caught before they fly away.

- Many insects will fly away quickly!
- Do not worry if you lose some insects, it happens!
- Using aquatic nets will be covered in the stream bioassessment lesson.

Observing the insects that they caught is always a favorite activity of young Urban Naturalists

Traps: The easiest insect trap to make is a *pit fall trap*.



Making a pitfall trap can be as simple as digging a hole in the ground, placing a jar in the hole, and waiting.

Covers, baits, screens, and killing agents can be added but are not necessary.

Other tools for collecting insects:

Aspirator: If you do not have access to an aspirator, a simple one can be made with a piece of flexible tubing and a screen as a filter. The screen should be placed over the end that will be used as the mouthpiece to prevent insects from being sucked into your mouth. Tape the screen piece down and if you want to, add a slightly larger diameter piece of hose over the mouthpiece end and tape securely so that it is air tight. Use the aspirator to suck insects in the open end of the tube and then blow out to gently push them out of the tube into a container for observation.

Pan and clipboard: To use a pan and clipboard place the pan beneath a plant, and use the clipboard to shake the plant vigorously so that insects fall into the pan.

Sheet: Place the sheet on the ground beneath a small tree or shrub and vigorously shake the plant so that insects fall onto the sheet. Then use an aspirator or forceps to collect insects from the sheet, or place containers over the insects: insects will usually crawl up the sides, allowing you to slip the lid on the container while it is upside down.

Black light

Forceps

Collection vials

Hand lens or magnifying glass

For more simple instructions and ideas: http://www.uky.edu/Ag/Entomology/ythfacts/bugfun/collecti.htm

Photography for insect collection and identification: For non-scientific collections, photographs of insects allow us to appreciate and document the insects that we see without killing them. In 2010, 26% of the insect species evaluated were named as threatened for extinction (IUCN Red List of Threatened Species 2010.1). Insects play important roles in most ecosystems, including being a major food source for a lot of animals and helping to break down dead and decaying organic matter.

It is important that we protect and conserve insects, and one way to do this is to “collect” them with pictures.

Insect Identification Checklist

Characteristics for Insect Identification: Answer as many of the questions as you can to help identify the insect to Order

How Many Legs?

Wings: Yes or No?

1 or 2 PAIRS of wings?

If 2 pairs: Are the front and hind wings the same size?

If 2 pairs: Are the front and hind wings the same texture?

If 2 pairs of wings with different textures, describe the textures.

How are the wings held when the insect is resting? (Draw)

Does the insect have antennae?

If the insect has antennae: describe them (Draw)

Is the insect fuzzy?

Is the insect's abdomen longer than its thorax?

If you can see the insect's mouth parts, describe them.

Does the insect have extra-large hind legs modified for jumping?

Does the insect have extra-large front legs modified for grabbing?

Does the insect have a "waist" between the thorax and abdomen?

Look at the end of the insect's abdomen. Are there any modifications? (hairs, bristles, or stingers) If so, Draw it.

What are the main colors of the insect

Simple Dichotomous Key to common insect orders

1a. The insect has wings……Go to 2
1b. No wings, and more than 6 legs……not an adult insect

2a. The insect has 4 wings (two pairs)……Go to 3
2b. The insect has only 2 wings (one pair)……Go to 12

3a. The wings are covered with tiny powdery scales……**Butterflies and Moths**
3b. The wings are not covered with scales……Go to 4

4a. At least one pair of wings is thick and hard or leathery……Go to 5
4b. Both pairs of wings are thin and clear, like plastic wrap……Go to 9

5a. Mouth parts are rolled into a tube for sucking……**True Bugs**
5b. Mouth parts for chewing or biting……Go to 6

6a. Body of the insect is flattened……**Roaches**
6b. Body of the insect is round……Go to 7

7a. The front pair of wings is hard and shell like without veins……**Beetles**
7b. The front pair of wings is leathery but still has wing veins……Go to 8

8a. The hind legs are large and modified for jumping……**Grasshoppers, Crickets**
8b. The front legs are large and modified for grabbing……**Preying Mantids**

9a. Mouth parts rolled into a tube for sucking……**Bugs and Aphids**
9b. Mouth parts for biting and chewing……Go to 10

10a. Abdomen has a thin “waist” and a stinger at the end……**Bees and Wasps**
10b. No stinger or thin waist between abdomen and thorax……Go to 11

11a. Very small insect, long antenna and wings folded flat on body……**Termites**
11b. Larger insect, short antenna and wings held away from body……**Dragonflies**

12a. Hind wings missing, and small knobs present in their place……**Flies**

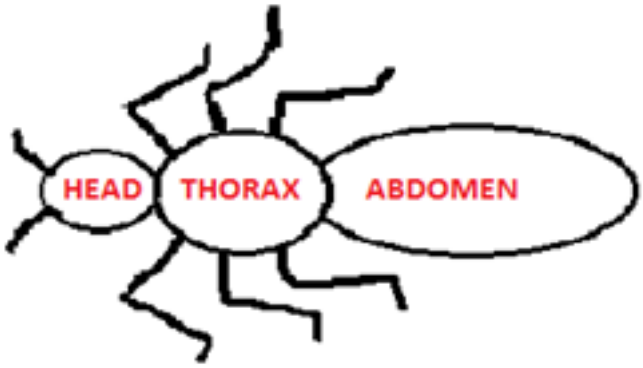
There are a lot more insects, but this is all that we will learn today!

Introduction to Insects

A few facts about Insects

- Insect comes from the Latin word for "segmented." Insects have bodies that are segmented into 3 main parts and adults have 6 segmented legs.
- All insects have a hardened outer layer called an exoskeleton.
- Some insects have wings, while others do not.
    - Insects with wings may have one pair of wings, or two pairs of wings.
    - Sometimes when insects have two pairs of wings, the front pair has been modified to become a protective covering.

General Insect Body Plan:



Most insects go through a set of changes as they grow. These changes are called metamorphosis. In addition to other changes, because the exoskeleton is hard and cannot grow, the insect has to ***molt***, or shed its exoskeleton during metamorphosis.

- Some insects go through complete metamorphosis
- Some insects go through incomplete metamorphosis
- Other insects go through gradual metamorphosis.

Insects do not breathe through their mouths but through small holes in their exoskeletons on the abdomen and thorax called spiracles.

Insects come in a variety of shapes and sizes and live in almost everywhere on Earth. Insects have adapted both physically (shape, size, color, wings, etc.) and behaviorally to live in a variety of habitats and make use of a wide variety of food types.

Insect Classification:

We have identified and classified (named) around 1 million insect species, and scientists believe that there are a lot more insects that have not been identified yet. Scientists are constantly learning new things about insects.

For our purposes, we will learn to identify insects to Order. An order is the broadest grouping of different types of insects. There are 31 Orders of Insects, but we will just learn the 15 that we are most likely to come into contact with.

Order	Common Name
Ephemeroptera	Mayflies
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Blattodea	Cockroaches
Hemiptera	Bugs, Leafhoppers, Cicadas, Scales, Aphids
Coleoptera	Beetles
Neuroptera	Lacewings and Antlions
Hymenoptera	Bees, Wasps, and Ants
Tricoptera	Caddisflies
Lepidoptera	Butterflies and Moths
Diptera	Flies

Identifying Insects:
We will use a dichotomous key to identify insects that we find to order. The key we are using will help identify the 15 orders of insects in the table above by their ADULT form. We will also learn some important characteristics that can be used to identify insects while in the field.

*Remember that insects are everywhere, and that many are highly adapted to their environments. Often that means that they are camouflaged to blend in and may be hard to see. ***Never pick up an insect with your bare hands*** without first making sure that you have correctly identified it (get help from an adult!). Many insects can bite, and others may release chemicals that itch or smell bad as a way to keep from being eaten.

An identification check list has been provided to help you with insect identification. You will not always be able to answer all of the questions on the list, but the more that you can answer the easier it will be to identify your insect.

Capturing Insects for Observation or Collection
There are a variety of methods and materials used for capturing insects. If you are trying to catch a specific type of insect, it helps to know a little bit about that insect's behavior in order to know how and where to catch one. For example, you cannot catch a butterfly by turning over a log, but that may be a great place to find beetles or termites!
We will discuss some of the most common tools used to capture insects including aerial nets, sweep nets, aspirators, and traps.

Introduction to Insects Activities

Set up practice insect identification stations with live, pre-caught specimens in the classroom. Go through the introduction to insects presentation with the students and then allow them to practice using the dichotomous key to identify live insects.

Make your own insect nets: you need strong wire (a coat hanger will do), a net (for aerial nets, purchase netting at a craft store and sew into a bag shape: for sweep nets, old pillow cases that can be bought at a thrift store work great!), and a handle (old broom or rake handles, or heavy duty dowel rods)

*the following steps can be used to make a sweep net out of an old pillow case, wire coat hanger, and dowel rod.

1. Cut a small hole in the outer edge of the pillow case hem on the open edge
2. Unwind the wire coat hanger and bend body into a circle
3. Feed coat hanger wire through the hem of the pillow case so that either end sticks out
4. Bend the ends of the wire 90 degrees
5. Carve channels into either side of the dowel on the end that the net will be attached
6. Place the wires on either side of the dowel rod and secure (if you can, drill a few holes through the dowel and use more wire to attach. Duct tape over the wire ends to keep them from sticking out: do not rely on the duct tape to hold the net onto the handle)

Go on an insect collection expedition. Go over collection techniques and safety with the students before hand and then see what you can find.

Utilize digital cameras to take pictures of insects for the field notebooks and capture select live specimens to identify using the simple dichotomous key or the more detailed dichotomous key from Clemson University found here: http://media.clemson.edu/public/sclife/lesson_plans/adult_insects/student_handout_terr_insects.pdf

Beneficial Insects Field Notebook Suggestions

Make a list of ways that insects benefit people.

Take photographs of beneficial insects for the field notebook.

Identify insects found during a field expedition and classify them as either a pest, predator, parasitoid, pollinator, or neutral.

Research one of the beneficial insects native to South Carolina and write a paragraph describing the insect, its behavior, and habitat.

Make a list of types of qualitative and quantitative data that you might generate when observing insects.

Draw pictures of beneficial insects that you have observed and label the parts of the insect,

BENEFICIAL INSECTS

Key Concepts and Skills:

- Insects are all around us. Though some insects are considered pests because they cause harm, damage, or annoyance to people, many insects are beneficial to both people and the natural environment.
- Two important categories of beneficial insects are natural enemies and pollinators.
- Students will learn to recognize some of the common beneficial insects found in Greenville, SC.

Background Information

Insects live in almost every conceivable habitat; there are insects that live in soil, in water, inside plants, and even insects that live inside other insects. Insects benefit people and the environment in many ways.

Insects that are natural enemies kill pest insects and help protect people, our crops, and our homes. Pollinators, such as bees, are essential for food production. Some people eat insects, as do lots of animals and even some plants.

Many of the products that people use are made by or from insects, like honey, silk, dyes, confectioners glaze, and wax. Insects are can be odd looking or very beautiful. Butterflies are sometimes released at weddings, and some beetles are made into jewelry.

Insects aerate the soil, helping ecosystems stay healthy and playing an important role in nutrient cycling. Many insects feed on dead and dying organic matter while others help keep the planet clean by feeding exclusively on dung. Insects play important roles in many food chains both as predators and prey.

The two major categories of beneficial insects are natural enemies and pollinators.

Natural Enemies:
Natural enemies are insects that prey on pest organisms, such as fungi and insects that cause damage to crops. There are two main categories of natural enemies; predators and parasitoids.

- **Predators**

  Insects that eat pest organisms are known as predators. The most well-studied insect predators are usually generalist feeders, meaning that they have a varied diet as opposed to specialist predators that prey on a specific organism.

Some Examples of Predators Native to Greenville, SC:

Lady Beetles (also called Ladybird Beetles and Lady Bugs) – there are around 400 species of Lady Beetles native to North America

- Pink Spotted Lady Beetle (Coleomegilla maculate): A native lady beetle and voracious predator. Both the adult and the larval forms eat aphids and eggs of other insects. Pollen is an important food source, especially for adults, so companion planting native plants that flower throughout the summer is important to attracting these insects.
- Convergent Lady Beetle (Hippodamia convergens): 0 – 13 spots, the convergent lady beetle is highly variable in size and color, but all have white stripes that converge behind the head.

Praying Mantids (Order Mantodae)– Mantids are predatory insects with raptorial forearms that are generalist feeders. They will eat anything that is the right size that comes into reach, including other mantids, pollinators, and predators.

Minute Pirate Bugs – small insects 2-3mm long in the Order Hemiptera (true bugs). Adults have white patches on the wings near the attachment point with the thorax and piercing/sucking mouthparts. They are generalist feeders that eat soft bodied insects such as thrips, aphids, whiteflies, leaf hoppers, eggs, and small caterpillars. They feed on pollen whenever prey is not available, so native flowering plants are essential for keeping them around.

Assassin bugs and Wheel bugs (Order Hemiptera, Family Reduviidae): Like most Hemipterans, Assassin bugs have piercing/sucking mouth parts and hemelytra (front wings that are thickened and leathery in front and membranous at the tip). They also have raptorial front legs used to grasp prey. Both nymphs and adults are generalist predators. Some actively hunt prey, while others wait in ambush. Most inject a paralyzing agent into their prey and their bites can be painful to humans.

Spined Soldier Bugs (Podisus maculiventris Order Hemiptera): Mottled brown in color and around 9-13 mm long as adults. They have prominent spines on the "shoulder" and a dark line on the tip of the membranous portion of the hemelytra. Many stink bugs are plant feeders, but the spined soldier bug is a generalist predator that feeds on at least 100 different pests, including a number of economically important agricultural pests including cabbage looper, corn earworm, potato beetles, armyworm, and others. Native to the US, this insect has been used successfully in biological control programs both here and through introduction in Asia.

Lacewings (Order Neuroptera : Green Lacewing - Chrysoperla carnea. Brown Lacewing – Hemerobius spp.):

- Probably the most common lacewing in our area is the Green Lacewing. Adults only eat nectar, pollen, and honey dew but larvae are predators that eat a variety of common garden pests including aphids, whiteflies, spider mites, thrips, beetle larvae, and eggs. Small white eggs are laid on thin stalks. The green lacewing can have several generations during the growing season and overwinter as adults.

The beneficial insect predators above were photographed during Urban Naturalist expeditions at a school garden.

A variety of flower color and shapes help attract a variety of insects to yards and gardens.

- Brown lacewings are predators as adults and larvae, and feed mostly on aphids and adelgids.

Syrphid Flies (Flower flies/Hover Flies Order Diptera): often mistaken for bees or wasps, due to their bright yellow/orange and black striped abdomens, Syrphid flies feed on the nectar or pollen of flowers and their larvae feed on aphids and other soft bodied insects. Dipterans (Flies) have a single pair of wings with the hind pair modified into small knobs, while wasps and bees have two pairs.

Wasps (Paper Wasps and others, Order Hymenoptera): Many solitary wasps hunt and either kill or paralyze insects then lay their eggs on the host body. When the larvae hatch, they will use the host as food. Paper wasps build nests and will actively hunt caterpillars, taking all or part back to their nest and feeding bits of chewed caterpillar to their young until the young pupate, sealing the chamber. Though rarely found in high numbers, solitary wasps and paper wasps do help keep pest insect populations down.

Tips for protecting and attracting native predators:

Do not purchase lady bugs from garden centers and release them. Most of the insects for sale on a non-commercial scale have been harvested from the wild and will bring any parasitoids or pathogens they are infected with along for the ride, possibly introducing a new disease or parasitoid into your area. Secondly, many beetles are harvested from their over-winter sites, and following release from winter dormancy, lady beetles migrate, so releasing them into your garden even in the midst of an aphid infestation, will do no good, because they will migrate before feeding.

If you do choose to purchase natural enemies and release them into your garden, do your research. Make sure that the insects you are purchasing are insectary raised and not wild caught, make sure that they are native to your area and make sure that you are releasing them at an appropriate time. But, do not be surprised if they fly away. The best way to make sure that predators find your garden is to make it a hospitable atmosphere for them.

Make sure that there are a variety of sizes and colors of pollen-producing native plants in hedgerows or patches throughout and/or around your garden, a diversity of habitat types, and some sort of shallow (preferably running) water source available. Even insects need to drink water. Also, reduce the use of pesticides, choose as pest specific chemicals as you can find, and only apply the minimum dose, through spot application instead of broadcast spray.

Some predators, such as Spined Soldier Bugs, can be attracted through the use of pheromones; chemical signals that insects release in order to communicate.

- **Parasitoids**

Parasitoids are insects that lay their eggs in or on a “host” organism (usually another insect). The larval form of the parasitoid grows inside the host, either emerging to pupate or as an adult, and almost always killing the host insect. Some parasitoids paralyze their host, while others cannot be detected prior to emergence, and the host will continue to forage.

General characteristics of parasitoids:

- Small – almost always smaller than their host
- Highly specific – parasitoids are very specialized in which host they choose, sometimes even so much so that different parasitoids attack different life stages of the same animal
- All parasitoids have complete metamorphosis. Most are wasps or flies, though there are a few parasitoid beetle species.

Some examples

Ichneumonid wasps – up to 1.5 inches, much larger than other parasitoid wasps. Females often have very long (sometimes much longer than the body) ovipositors.

Brachonid wasps – small dark wasps, 6-8mm long. Parasitize larvae of moths, butterflies, flies, and beetles as well as pupae and some adults.

Trichogramma wasps –very common and very tiny: less than 0.5 mm long, parasitize eggs. Extremely useful parasitoid because they prevent pests from ever hatching. They use scent to find suitable host eggs, and have multiple generations in a year due to a very short generation time (8-10 days). Host eggs when parasitized may change color. High frequency of parasitism: up to 98% has been reported.

Tachinid Flies

Feather Legged Fly (Trichopoda pennipes) - a tachinid fly that primarily attacks squash bugs and green stinkbugs. The fly lays its eggs on the back of the host, and the larvae burrows into the host, emerging as a much larger maggot to pupate on the ground. The host continues to eat and lay eggs for some time before the parasitoid emerges, killing the host.

Tips for protecting and attracting native parasitoids:

Keep them in your yard – limit pesticide and herbicide use. Make sure there are flowering plants available, especially those with small flowers or composite flowers such as marigolds and daisies. Studies on Brachonid wasps have shown that some species are much more successful as parasitoids if there are nectar/pollen sources available.

Parasitoids are often more susceptible to insecticides than their host, so natural parasitoid populations may be heavily affected by insecticides. Avoid broad spectrum insecticides.

Pollinators:

It is estimated that anywhere from 60-90% of the flowering plants in the world depend on animals for pollination (reproduction). The vast majority of pollinators are insects. Over 100 species of crop plants in North America rely on insect pollination.

Animal pollinators include bats, birds, flies, beetles, butterflies, moths, ants, wasps, and bees.

Beneficial insects come in all shapes and sizes.

Bees are very important pollinators for many different plants.

Bees:

Honey bees are not native to the US. Honey bees pollinate about 15$ billion in US crop plants each year. It is estimated that they pollinate about 15% of the most common crops worldwide. Honey bee numbers are declining, and as they decline, the relative importance of other pollinators (such as native bees) increases.

Native bees

Bees are important pollinators that have 2 main lifestyles; social bees, such as the honey bee, that live in colonies, and solitary bees. Most of our native bee species (approximately 4,000 in the US) are solitary bees. The only native social bees are bumblebees. Bumblebees preferred nest sites are in the ground, often abandoned burrows, but they will nest in any hollow cavity. They are generalist foragers, meaning that they gather pollen and nectar from a wide variety of plants and are active from February to November.

Many native bee species are in decline:

Some examples:

Bombus affinis: Rusty patch bumblebee

Native bees: major threats

- Introduction of Bees raised for commercial production: pathogens (diseases and bacteria) acquired in rearing facilities spread to wild population.
- Habitat alteration/ destruction: many bees live in the ground, in old burrows (solitary bees often will lay eggs in brush, inside old twigs, etc.) often small changes in habitat can destroy nesting sites. Large alterations, such as invasive plant infestations or landscape level clearing can remove the bees' food sources. This is especially a concern for solitary bees that may be specialist foragers.
- Herbicides – through directly harming bee populations or by killing plants that bees rely on for food and/or nest sites
- Insecticides– either through directly killing the bees or through "sub-lethal effects" such as reduction of foraging efficiency. Insecticides are rarely if ever tested for sub-lethal effects. Insecticides are often determined "safe" for pollinators by testing on honey bees. Because honey bees are social bees and reproduce relatively rapidly, the response of honey bee populations to insecticides are not necessarily a good indicator of the way native bees would respond. Solitary bees often have low reproductive rates, so populations affected by insecticides will take longer to recover than honey bees.

Butterflies – butterflies collect nectar from flowers. Some pollen is transferred by butterflies, but not nearly as much as by bees that have special structures on their bodies for collecting pollen.

Tips for protecting and attracting native pollinators:

Limit application of herbicides. Herbicides, though meant for plants, can also kill native insects. Scientific studies have shown that even

when herbicides don't kill pollinators, they can affect the foraging behavior of insects, such as bees, resulting in reduced pollination activity. If herbicide application is unavoidable, use spot treatment instead of an overall treatment, use the minimum dose needed, and avoid spreading the chemical beyond the agricultural boundary to natural areas that are refuges for native insects.

Limit application of insecticides. Choose insecticides that specifically target the pest that you are trying to control, when available, instead of a broad spectrum insecticide. If applying an insecticide, don't apply it when crops are flowering, as that is when bees are most likely to be visiting. Use integrated pest management techniques and planting techniques that help keep pest populations low, such as alternating rows, poly cropping, crop rotation, and companion planting in place of insecticides.

Plant a diverse type of native flowers: shape, color, flowering time. Clumps of flowers are more likely to attract pollinators than a single flower. A variety of shapes and colors will attract more diverse pollinators. Plants that flower at different times of the year will ensure pollinators are available throughout the growing season.

Provide a variety of non-vegetative habitats, such as bare ground, large rocks, sheltered, shaded flowers, and shallow, sloping water sources. Pollinators need water and nest sites.

Plant and preserve natural areas. Most native bees have a maximum foraging distance of 150 – 600 meters. Diverse natural habitats for nesting and foraging, as well as habitat connectivity, are essential for diverse pollinator populations.

Selective removal of non-native plant species, especially invasive species: Invasive plants alter ecosystem level processes, reducing the number of native plants available for food and refuge by insects, altering the hydrology (the way water flows) of ecosystems, reducing plant community diversity, altering food webs and nutrient cycling, and changing the way the ecosystem responds to natural events such as fire or flood. Removal of invasive plants benefits the whole ecosystem, and can help restore habitats and food essential to a diverse native insect population. When possible, choose mechanical removal. If herbicide application is absolutely unavoidable, spot treatment is better than a general application.

Photo Scavenger Hunt: Beneficial Insects

___ A bee
___ A pollinator on a flower
___ An insect predator
___ A larval insect predator
___ An insect that is neither a pest nor a beneficial insect
___ A butterfly
___ A predator with cryptic coloration
___ A pest insect
___ Evidence of a parasitoid

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___ A butterfly
___ A predator with cryptic coloration
___ A pest insect
___ Evidence of a parasitoid

Beneficial Insect Examples

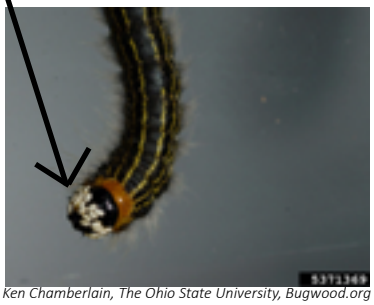
Predators

Basic Characteristics: Most useful tend to be generalist feeders. Variable in size, predators can be found in most insect Orders. Some insect predators only feed on other insects as larva, like the Green Lace Wing, others feed on other insects throughout life.

Examples include: Lady Bugs, Dragonflies, Solitary Wasps, Lace Wings, Praying Mantis, Assassin Bugs, Damselflies, Flower Flies, Hover Flies

Parasitoids

Basic Characteristics: Most parasitoids are very small, often microscopic. It is easier to find evidence of parasitoids; such as eggs on host species (pictured), pupa on hosts, and discolored insect eggs. Parasitoids are very host specific.



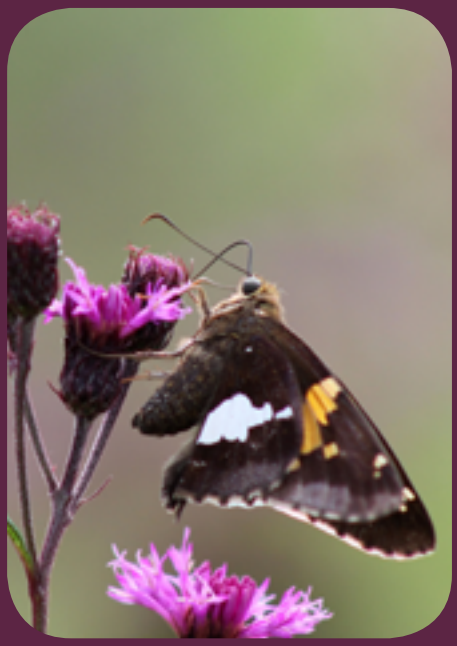
Ken Chamberlain, The Ohio State University, Bugwood.org

All Parasitoids go through complete metamorphosis.
Examples include: Braconid Wasps, Trichogramma Wasps, Tachinid Flies such as Feather Legged Flies

Pollinators

Most pollinators feed on plant pollen or nectar. Bees are the most common and important pollinators, but butterflies, flies, wasps, beetles, ants, and more can be pollinators. Some pollinators are generalists, specializing

in a single species of flower, while others are specialists.



An Urban Naturalist class searches for and photographs beneficial insects in a school garden.

Beneficial Insects Activities:

Create an educational poster about providing habitat for beneficial insects in your community

Choose native plants in landscaping
Resources:
Short list of native flowering plants that are good for native bees from the University of Georgia: includes months when blooming. http://www.ent.uga.edu/Bees/pollination/plants-year-round-forage.html

Brochure about pollinators: includes a longer list of native plants good for attracting native pollinators. http://www.pollinator.org/PDFs/Guides/SoutheastMixedForestrx5FINAL.pdf

The Ladybird Johnson Wildflower center has a database where you can search native plants by state, bloom month, color, habitat requirements, and more. http://www.wildflower.org/plants/

Use the ***beneficial insects scavenger hunt*** during a field expedition, and record findings in the field notebook.

Though pollinators and natural enemies are the two major categories that we studied, there are many more types of beneficial insects, and many ways that all insects are important to an ecosystem, including nutrients cycling, breaking down organic matter, ecosystem engineering, as part of the food chain, as indicators of water quality, and more.

Have students ***find, identify, and research*** an insect that is not in one of the two main categories we discussed and present it's importance to the class.

Chapter 6: Freshwater Ecosystems

A freshwater habitat is any concentration of above ground water with a very low salt content. Though around 70% of the Earth's surface is covered in water, less than 3% of the water on Earth is freshwater. Of that 3%, the majority is stored as in underground aquifers, polar ice caps, and permafrost, making it unavailable for consumption and use by most biological organisms. Yet, freshwater is extremely important. Many organisms live in water, some require water for reproduction, and all need water in order to survive.

Freshwater habitats and the biological communities that inhabit them are extremely diverse. Some of the many different types of freshwater habitats include ponds, lakes, streams, rivers, and many wetlands such as swamps, Carolina bays, and vernal pools.

The origin of most freshwater ecosystems is precipitation.

Freshwater ecosystems are some of the most sensitive and endangered systems in the world.

Word Bank

Freshwater
Wetland
Ecosystem
Benthic
Aquatic
Water Quality
Bioassessment
Biotic
Dissolved Oxygen
EPT
Macroinvertebrate
Riffle
Run
Pool
D-net
Velocity
Sensitive Species
Indicator Species
Solute
Ecotone

FRESHWATER HABITATS

Key Concepts and Skills:

- There are many different types of freshwater habitats, including Lakes, Ponds, Rivers, Streams, and Wetlands. Students will learn some of the characteristics of each of these types of habitats
- Water is essential for all biotic organisms, including people
- Many organisms inhabit freshwater habitats. Some live in water all of the time, such as fish and aquatic plants. Others live in water for part of their life cycle or need water to reproduce, like amphibians and many insects. Still others live and reproduce on land but spend significant amounts of time in water, like turtles, birds, and more
- Freshwater habitats are some of the most threatened habitats on Earth
- Students will go on an expedition to observe and identify organisms in an urban freshwater habitat

Background Information

Some main types of freshwater habitats include:

Lakes

Lakes are still bodies of freshwater that are deep enough that light doesn't reach the bottom of the lake. In the US, natural lakes formed as a result of glacier movement carving depressions in the land.

Freshwater Habitat Field Notebook Suggestions

Draw pictures of animals or plants found during the freshwater habitat expedition.

Identification of any plants or animals found during a freshwater habitat expedition.

A description of adaptations that allow animals to live in freshwater habitats.

Research and describe one of the most common freshwater habitats. What organisms would you expect to find there? What challenges face this type of habitat?

Write a paragraph about the importance of freshwater habitats.

There are no natural lakes in South Carolina, because glaciers never reached this far south. Instead, lakes in South Carolina are man-made by damming rivers and streams.

Ponds

The most important difference between a lake and a pond is the depth of the depression where the water sits. Ponds are shallower than lakes and sunlight reaches all the way to the bottom, so plants are capable of growing on the bottom of ponds.

Rivers

Rivers, as well as creeks, and streams, are flowing bodies of freshwater. Rivers are highly variable depending on where they originate, the geology, topography, and climate of the area where they flow. There are two different main types of rivers in South Carolina. Brown water rivers originate in the mountains of the upstate. They are usually fast flowing, starting with cold water streams from snow melt and precipitation in the mountains and carry a lot of sediment. Black water rivers originate below the fall line, are black in color from tannins in the abundant leaf debris and organic detritus that they carry, are slower moving, and slightly acidic in pH.

Wetlands

Wetlands are habitats where the soil is saturated by water at least some part of the year. Some examples include marshes, swamps, bogs, vernal pools, and Carolina Bays. Wetlands are considered ecotones, or transitional habitats between freshwater and terrestrial habitats that support organisms found in both, as well as organisms uniquely adapted to live in wetlands. Wetlands are some of the most ecologically important freshwater ecosystems. They act as filters for pollutants, nutrients, and sediment, recharge areas for groundwater aquifers, buffers for flood prevention, important habitats for many animals and plants, and more.

More information:

Sustaining America's Aquatic Biodiversity. Aquatic Habitats: Homes for Aquatic Animals http://pubs.ext.vt.edu/420/420-522/420-522_pdf.pdf

Biological Diversity in Freshwater Habitats

Freshwater habitat is a very general term. Each type of habitat could very well be its own expedition and lesson, but for our purposes, suffice to say that freshwater habitats support a number of biological organisms. Some of the organisms you may find include

Algae

Algae are a very varied group of organisms. There are two main types of algae grouped into the Green Algae and the Red Algae. They are aquatic, photosynthetic, and do not have leaves. Algae vary in size from microscopic single-celled organisms to large plant like fronds (kelp). Algae are the main primary producers in freshwater ecosystems, and the basis of many food chains, both aquatic and terrestrial.

Aquatic plants

Aquatic plants are plants that must grow in water during at least part of their life cycle. There are three main types of aquatic plants:

- Submergent plants are attached to a substrate but grow completely submerged in water
- Floating plants are free floating in the water
- Emergent plants that are attached to a substrate (usually the bottom of the water body) with submerged roots, come up through the water, and have stems and leaves above the water.

Most aquatic plants still create flowers above water. Some plants in freshwater ecosystems, such as wetlands, may not be truly aquatic, meaning that they don't need to grow in water, but instead have adaptations that allow them to survive in water for short periods of time.

Invertebrates

Many of the animals that you may find in a freshwater ecosystem are invertebrates. Including snails, leeches, worms, clams, freshwater shrimp, and insects, there are many aquatic invertebrates. Macroinvertebrates in cold water stream ecosystems are considered in the next section.

Fish

Most of the fish in freshwater ecosystems are members of the class Osteichtheyes, commonly called the bony fish. This is the largest class of vertebrates, with more than 20,000 species. Bony fish have gills, and a swim bladder than allows them to breathe in water and float.

Amphibians

Amphibians all live in water at some point in their life cycle. Depending on the time of year, you may find amphibian eggs, larva, or adults in and around freshwater habitats. Amphibians are highly sensitive to environmental pollutants.

Reptiles

Unlike amphibians, reptiles do not need to live in water, but many reptiles spend time in or near water, such as turtles, snakes, and lizards. Freshwater habitats provide opportunities for reptiles to hunt or escape from predators. Rocks or partially submerged logs are great spots for semiaquatic reptiles like turtles to bask in the sun. All reptiles nest on land.

Mammals

Aquatic and semiaquatic mammals include animals like beavers, muskrats, and river otters. Mammals are often the top of the food chain in aquatic habitats and some, like beavers, are also ecosystem engineers responsible for altering and even creating the freshwater habitat. Mammals that spend significant amounts of time in freshwater habitats have a variety of adaptations for survival including physical adaptations such as webbed toes, slender bodies, or paddle like tails and behavioral adaptations such as the lodges that beavers build to live in and protect their young.

Urban Naturalists explore the edges of a small urban freshwater habitat

Urban Naturalists use nets to catch animals in a freshwater stream at Paris Mountain State Park

Ducks are just some of the animals that inhabit this bioswale, a man-made freshwater habitat to manage storm water at the Kroc Center in Greenville.

This small urban garden pond contains a lot of life for Urban Naturalists to study and observe

Birds

Like reptiles, many birds may spend a lot of time on or near water but they nest in dry spots, either on land or in trees. Many birds feed on fish and other animals found in aquatic habitats. Adaptations that allow birds to survive and thrive in freshwater habitats include beaks modified into spears for catching fish or flattened bills for dabbling, webbed feet for swimming, and widely spread toes for walking on muddy bottoms.

The following guides may be useful for identification of organisms that you come across during your freshwater habitat expedition:

- Guide to Aquatic and Wetland Plants of West Virginia http://www.wvu.edu/~agexten/wildlife/803.pdf
- South Carolina's Guide to Freshwater Fishes http://www.dnr.sc.gov/aquaticed/pdf/FreshwaterFishPocketGuide.pdf
- Reptiles and Amphibians of South Carolina and Georgia http://srelherp.uga.edu/herps.htm

Urban Freshwater Habitats

Freshwater habitats can be found throughout urban areas, but most of these differ significantly from freshwater habitats found in undeveloped areas.

Examples of freshwater habitats in urban areas include decorative ponds, rivers and streams, and bioswales, man-made wetland areas that contain plants and help manage storm water. Urban freshwater habitats and the organisms that live in them face many challenges and are often very different from freshwater habitats in undeveloped areas. Some examples of this include:

Shape/purpose alteration

People change the land to suit their needs. Rivers may be dammed to create reservoirs to hold drinking water or for hydroelectric power. Dams alter downstream flow, natural flooding patterns, water temperatures, nutrient cycling, and block the movement of aquatic species both up and downstream.

Though often less dramatic than the effects of a dam, canalization also alters river flow rates and other abiotic properties of a freshwater system that may effect survival of aquatic organisms.

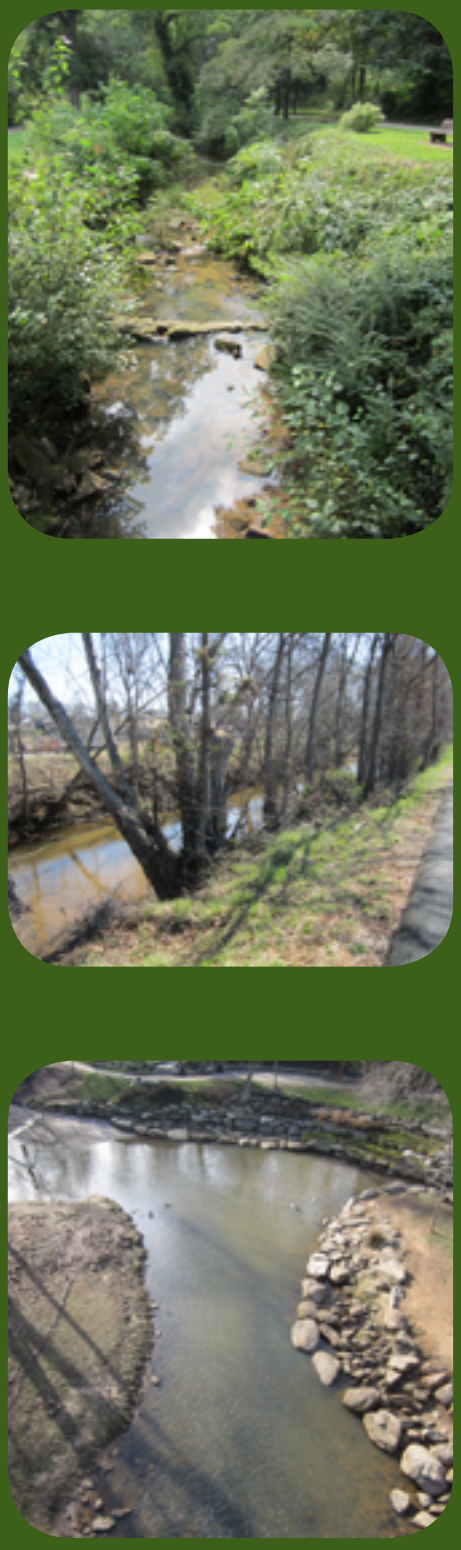
Many of the freshwater habitats that can be found in an urban area have been built by people for a variety of purposes. When people build a pond or pool for decoration or to retain and manage storm water, they may also add plants and animals that wouldn't be found in these habitats in the wild. Understanding the purpose of a freshwater habitat in an urban area is an important part of understanding why some biotic organisms may be found there and others may not.

Pollution/inputs from surrounding land

The amount of impervious surfaces (parking lots, roads, buildings) and impacted surfaces in an urban area contributes to high amounts of surface water runoff during and following rain storms. This water carries sediments, trash, oil, gasoline, fertilizers, pesticides, and more from roads, parking lots, and lawns directly into freshwater ecosystems.

When discussing pollutants in freshwater aquatic systems, it is important to note that a pollutant is anything out of place that causes harm to a biotic organism. Many of the things that act as pollutants in freshwater ecosystems may be harmless or even necessary in small quantities (such as sediment, nutrients, or warm water), but in large amounts these substances can harm and kill the animals and plants that live in aquatic ecosystems.

The impact that pollutants and storm water runoff has on urban freshwater habitats will vary based on many factors including the size, purpose, and design of the habitat and surrounding land. Planted areas alongside freshwater habitats, called riparian buffers, can help reduce the speed of storm water runoff and filter out some of the pollutants before they reach the water. Some urban freshwater habitats like bioswales and some rain gardens have been designed specifically to manage storm water, so they may not be negatively affected by storm water runoff.



Urban streams and rivers often look very different from their counterparts in more natural areas. These differences can be a starting place for discussion about the way that anthropogenic forces shape the land

Freshwater Habitats Activities:

Create an underwater viewer and go on an expedition to a freshwater habitat.

How to make a simple device for looking at animals and plants beneath the surface of the water:

- Use a can opener to remove both ends of a long coffee can.
- Cover one end with clear plastic wrap, making sure the surface is tight, and place a rubber band over the plastic wrap to hold it in place.
- Use heavy tape to secure the plastic wrap, covering the edges of the plastic to make it water tight.

Use the underwater viewer to look for animals and plants under the surface in a freshwater habitat.

Have students record their observations in the field notebook. If you have the opportunity, collect some samples to take back to the lab and look at them with magnifying glasses or microscopes.

Use nets or minnow traps to **catch animals** in a freshwater habitat (make sure to get permission and/or permits). Place the animals in a clear fish tank for students to observe, draw, and identify.

Identification help:
South Carolina's Guide to Freshwater Fishes http://www.dnr.sc.gov/aquaticed/pdf/FreshwaterFishPocketGuide.pdf

Reptiles and Amphibians of South Carolina and Georgia http://srelherp.uga.edu/herps.htm

****Chapter 3 in the Community Quest Program has more information and activity suggestions for lessons on Urban Water Quality and Conservation that would tie in well with this section.***

Take a field trip to Lake Connestee Nature Preserve to look for, **observe, and identify aquatic plants and animals.**

All of the organisms that live in aquatic habitats have special adaptations for survival. Have students observe the organisms that they find and describe what is special about them that allows them to survive in water.

Observe and discuss the differences between a freshwater habitat that students have observed in an urban environment and that same type of freshwater habitat in a natural environment.

How are the two different, and why? What do those differences mean for the plants and animals that may live in these habitats?

Some ideas for dicussion: water temperature, shade, input of water or debris, depth, type of substrate, openness.

Research water quality in your neighborhood:
A water body that is impaired is one that has poor water quality that negatively affects that water body's ability to support life or its use as a recreational or drinking water source.

The following source provides good background information on many different sources for impairment to water bodies.

http://scorecard.goodguide.com/env-releases/def/cwa_cause_class_def.html

Have students research a common impairment, and check scorecard to see if any nearby water bodies are impaired.

Brainstorming: impairment source and human behavior

List an impairment, and then ask the students to brainstorm where that impairment may originate on land, what human behaviors could cause it, and finally, what could be done to help reduce that type of pollution.

EXAMPLE:
Impairment - high levels of nutrients
Source - animal waste, fertilizer
Human behaviors that might lead to excessive nutrient levels in water - allowing pet waste to remain on the ground near rivers, placing excessive fertilizer on lawns near water, putting fertilizer out right before it rains
Ways to reduce the problem - pick up or bury pet waste so that it doesn't wash into rivers; only use the amount of fertilizer you need, and make sure you check the weather before applying fertilizer and don't apply it right before a rain event.

Some examples of impairments to list:

Plastic trash	Hot water
Sediment	Organic Debris
Pesticides	Gasoline
Toxic Chemicals	Oil
Nutrients	

Urban Naturalist Checklist

of Freshwater Organisms

FOUND	**Plants**	Identification	DATE
	A submergent plant		
	An emergent plant		
	A floating plant		
	Algae		
	ANIMALS		
	Amphibian		
	Reptile		
	Aquatic Insect		
	Mollusk		
	Fish		
	Mammal		
	Other Invertebrate		
	OTHER		

MACROINVERTEBRATE BIOASSESSMENT

Key Concepts and Skills:

- Macroinvertebrates are small animals without internal skeletons that can be seen without a microscope
- Aquatic macroinvertebrates have varying degrees of sensitivity to Dissolved Oxygen. This sensitivity allows scientists and lay people to use the presence and/or absence of different groups of aquatic macroinvertebrates as an indication of the relative health of cold water streams.
- Students will participate in a field expedition to perform a macroinvertebrate bioassessment.

Background Information

Stream health is extremely important for both people and the environment. Healthy streams provide a home for a wide variety of organisms.

Most municipalities get their drinking water from streams, lakes, or rivers.

Healthy streams contain a variety of microhabitats that are home to the juvenile stages of insects, fish, and other animals that are the basis of many terrestrial food chains.

Streams and rivers transport water and anything in the water downstream. We all live downstream from someone and someone else always lives downstream from us. It is important to know the quality of water that we are using and be aware of ways that we affect water quality in order to protect stream health and our natural resources.

Why Bioassessment?

It is common for people to wonder why they should study stream macroinvertebrates, rather than just take a water sample. The answer is simple: Water moves.

Since water is always moving, a water sample only gives a momentary snapshot of stream health. If a water body is being polluted, especially by non-point source pollutants, a water sample will only show contamination if you happen to take it at the right time, immediately following the introduction of the pollutant.

Stream macroinvertebrates live in the water, and many have relatively long life cycles (a year or longer), so the absence of a diverse and healthy macroinvertebrate community in a stream can indicate that there is a problem with the water quality even if pollutants are not present in the water at the time of the sampling.

Macroinvertebrate Bioassessment Field Notebook Suggestions

Bioassessment data.

Physical stream data.

Photos or drawings of macroinvertebrates.

Research one of the macroinvertebrates that you have found and list it's characteristics, habitat requirements, and any other important information.

Describe what "indicator species" means and why some macroinvertebrates are considered indicator species.

Draw and diagram a stream.

Macroinvertebrates vary in sensitivity to a variety of physical and biological parameters of their environment; most importantly, dissolved oxygen, but also temperature, sedimentation, nutrients and chemical and organic pollutants.

Macroinvertebrates are indicators of stream health, meaning that the presence or absence of sensitive species can be used to determine general health of a stream. It is still important to take physical and chemical data (such as pH, dissolved oxygen, chemical analysis, temperature, etc.) in order to know what is affecting the macroinvertebrate community.

- The diversity and abundance of macroinvertebrates in a stream will tell a scientist if the stream is being impacted by a pollutant.
- The chemical and physical data allows a scientist to understand more about what pollutants are present, where they may be coming from, and more.

Urban Naturalists use keys to identify macroinvertebrates

Urban Naturalists use nets to catch animals in a freshwater stream at Paris Mountain State Park

Urban Naturalists observe a crayfish that they caught while sampling a stream

Detailed information and protocol for Rapid Bioassessments developed by the US EPA is available on the EPA website: http://water.epa.gov/scitech/monitoring/rsl/bioassessment/download.cfm

Full data sheets for EPA bioassessments are also available: http://water.epa.gov/scitech/monitoring/rsl/bioassessment/upload/2001_03_08_monitoring_rbp_app_a.pdf

For the purpose of this program, you will be performing a simplified bioassessment and discussing the importance of stream health. Students should come away with the understanding that there is a wide variety of small animals living in streams that you rarely see, and that these animals' presence or absence can help determine whether or not a stream is healthy. If you have time and older students, this lesson could be expanded to perform a more in-depth stream health analysis or compare the biological communities in multiple streams or the biological community in the same stream at different places (such as upstream and downstream from a development or discharge point).

Important Terminology

Macroinvertebrate: invertebrates (animals without a back bone) large enough to be seen without the need for a microscope. Macroinvertebrates typically found in streams include aquatic worms, snails, clams, crayfish, aquatic insects, and immature stages of insects (larvae and nymphs). The most common macroinvertebrates found in streams are usually insect larvae and nymphs.

Benthic: the ecological zone that includes the sediment layer at the base of the stream. Often the term "Benthic Macroinvertebrates" or BMI is used as an acronym for the assemblage of stream macroinvertebrates that live on or close to the bottom of the stream

D-Net: a macroinvertebrate sampling device. A d-net is an aquatic net with the opening in the shape of a "D." The flat side is placed on the stream bottom while sediment upstream of the net is disturbed with the intention of capturing macroinvertebrates as they float downstream.

A single stream will have many different microhabitats. When sampling, make sure to visit multiple types of microhabitats, since different animals can be found in each.

EPT: the three orders of insects whose aquatic larval stages are most sensitive to dissolved oxygen concentrations in the water are the EPT: Ephemeroptera, mayflies; Plecoptera, stoneflies; and Tricoptera, Caddisflies. The richness, ratio, and other statistics involving these three orders of organisms is often used as a measurement of stream health.

Dissolved Oxygen (DO): the concentration of oxygen dissolved in water is referred to as D.O. Oxygen gets into the water through aeration, the movement of water through air, diffusion from the surrounding air, and photosynthesis by aquatic plants. Oxygen is used up through respiration.

Dissolved oxygen is necessary for aquatic life. The presence of sensitive macroinvertebrates (such as EPT taxa) in a stream is an indicator of a high level of dissolved oxygen and thus a healthy stream.

Most pollutants negatively affect the level of dissolved oxygen in the water. For example, excessive sediment in the water blocks light, causing aquatic plants and algae to not be able to perform photosynthesis. The lack of photosynthesis means that oxygen is not being put into the water as a photosynthesis by-product. In addition to this, without photosynthesis, eventually the plants will die. Bacteria then decompose the plants, using up more oxygen in the process, and the DO concentration drops more. Too much sediment in the stream for a long time, and the DO will drop so low that fish and other animals will die.

Sections of a stream

A stream or river is not a continuous habitat, but rather can be considered in sections based on the physical, chemical, and biological parameters found in a particular area. The variations between these microhabitats allow different aquatic organisms to survive in different places within the stream.

Riffles: This microhabitat is characterized by shallow and fast moving water. The substrate is usually coarse stones and gravel with areas where the substrate breaks the surface of the water.

Runs: This microhabitat is deeper than a riffle with fast to moderate speed water where no substrate breaks the surface of the water. Average depth measurements should be taken in runs.

Pools: Pool microhabitats are the deepest with a finer sediment bottom of sand and silt and slower moving water. Pools are bowl like depressions in the bottom of the channel.

How to perform a stream health analysis:

If you have very young students, or if you are sampling in a stream that you know will be contaminated, you may want to have an adult do the actual stream sampling and set up clear plastic containers of varying size containing stream water along with pipets, spoons, and forceps for sorting on the bank for the students to do the macroinvertebrate identification. Make sure that everyone is wearing shoes that can get muddy and wet.

Choose your stream ahead of time in order to make sure that it is accessible and safe, and contact property owners in order to make sure that you are

allowed access to the stream at your chosen site. When checking out the stream, remember to look around the banks for poison ivy, yellowjackets, and other potential hazards that you need to be aware of. Small streams with gently sloping banks are recommended when performing bioassessments with younger students.

Before going to a stream, make sure that everything you will be using is clean and dry (make sure that sampling equipment is washed between sites. The last thing you want to do is introduce a foreign animal, plant, or toxin into a stream). Emphasize to students that you must be careful to *disturb the stream habitat as little as possible when sampling.*

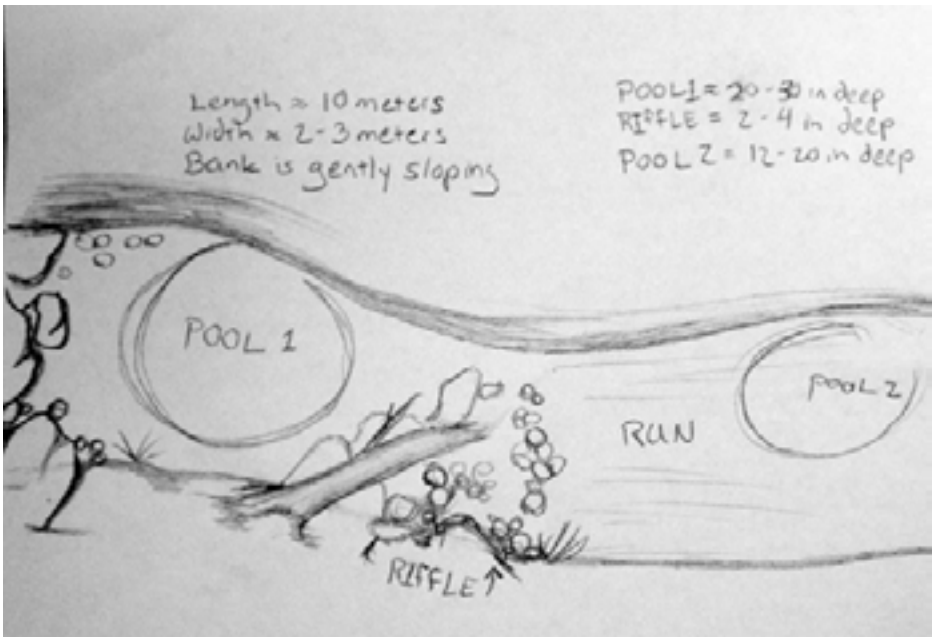
Once you are in the field:

Look at the stream: take note of the physical characteristics of the stream, stream bed, and habitats within the stream.

Collect data: have students draw a picture of the section of stream that you are sampling and label different microhabitats. Collect some physical data.

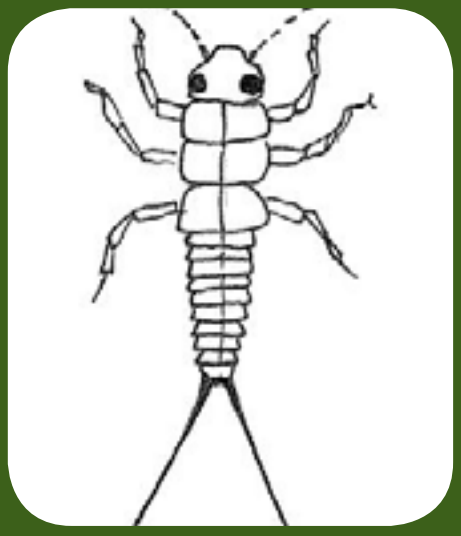
i. Depth
ii. Width
iii. Length
iv. Description of smell
v. Description of banks
vi. Presence or absence of vegetation

Example:



Simple items like bowls and plastic spoons are perfect for sorting macroinvertebrates.

The first A J Whittenberg Urban Naturalist Class on a field trip to Wild Cat Wayside to study a cold water stream.



Line drawing of a Stonefly found at Paris Mountain State Park.

Urban Naturalists collect and identify macroinvertebrates

If you have the capability, have the students **collect data about the water in the stream.** An extended project for older students would be to use this data and the macroinvertebrate data to compare two streams.

- Temperature
- pH
- Dissolved oxygen content
- Velocity (meter stick, ping-pong ball, and a stop watch: Have one person hold the meter stick while another holds the ball and stop watch. Place the ball on the surface of the water at the upstream end of the meter stick and start the time as soon as you let the ball go. Stop when the ball reaches the end of the meter stick. Make sure someone is ready to catch the ping-pong ball. Measure 3 times and average for velocity.)

Extension: Have the students make a hypothesis about the velocity of different areas of the stream. Discuss why we measure multiple times and use the average to report our measurements.

Collect Macroinvertebrate Samples

Divide the students into groups. Each group will be responsible for counting and identifying the macroinvertebrates in a sample. If you have limited time for this lesson, only sample riffle habitats, since these are the places where many macroinvertebrates are most likely to be found. Begin downstream and work your way upstream for each sample. That way you are sampling undisturbed areas each time.

Using a "D-net," the net holder will place the flat portion of the net directly onto the bottom of the stream with the net opening facing upstream. Wiggle the net until the flat end is flush with the stream and water is flowing through the net.

Determine the sample area: Each sample should be the width of the net and a predetermined length (1M is a good standard) or length of time (2 minutes).

The sampler should pick up any large rocks in the sample area and check for macroinvertebrates clinging to the rocks (snails, water pennies, caddisflies). These rocks can be placed directly into a sampling container (clear or white bucket or Tupperware container)

Once large rocks have been checked, the sampler will stand upstream of the D-net and disturb the bottom of the stream using their feet to stir up debris and sediment. The sampling portion should be timed for 2 minutes or measured for 1 meter. The sampler will make their way upstream, disturbing the bottom as they go, and the D- Net should be moved to stay close to the area that is being disturbed. At the end of 2 minutes or 1 meter, the net holder will lift the net from the stream and deposit the contents in a sampling container.

Place about 1-4 inches of stream water in a sampling container. Carefully turn the net inside out over the container. Using a spray bottle filled with stream water, a pipet, spoon, or forceps, examine the net for any stray macroinvertebrates and deposit them into the sampling container.

Stream Macroinvertebrate Bioassessment Data Sheet

Date:
Time:
Name:

Stream Name and Location:

Weather:

Physical Characteristics of the Stream:

Place an X next to each category of macroinvertebrates that you find

Highly Sensitive	Sensitive	Tolerant
___ Caddisflies ___ Mayflies ___ Stoneflies ___ Riffle beetles ___ Water pennies ___ Gilled snails	___ Dobsonflies ___ Alderflies ___ Fishflies ___ Crayfish ___ Crane flies ___ Scuds ___ Dragonflies ___ Clams ___ Damselflies ___ Sowbugs ___ Net spinning caddisflies	___Aquatic worms ___ Blackflies ___ Midges ___ Leeches ___ Lunged snails
___ Total # of x's	___ Total # of x's	___ Total # of x's
Total x3 = _____	Total x2 = _____	Total x1= _____

Add the three numbers together. Total Index Value = _____

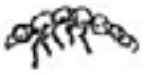
Water Quality (circle the correct answer)

Excellent (more than 22) Good (17-22) Fair (11-16) Poor (less than 11)

Aquatic Macroinvertebrates
Dichotomous Key

1

A. The organism has segmented legs
.....BOX 2

B. The organism does NOT have segmented legs .....BOX 13

2

A. The organism has **6** segmented legs
.....BOX 3

B. The organism has more than 6 segmented legs .....BOX 12

3

A. Body is longer than it is wide (elongate)
.....BOX 4

B. Body oval or rounded .....WATER PENNY

4

A. The organism has **2 or 3** tails or filaments
.....BOX 5

B. The organism has no tail or a single filament.....BOX 7

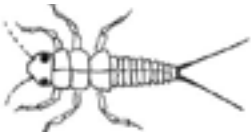
5

A. 2 or 3 hairlike tails (most often 3) and has gills along the side of the abdomen.
.....MAYFLY NYMPH

B. 2 or 3 hairlike tails with NO gills along the side of the abdomen.....BOX 6

6

A. 2 or 3 hairlike tails (most often 2),2 claws at the end of each leg, and NO gills alongside abdomen .....STONEFLY NYMPH



B. 3 broad leaf like tails and NO gills along the side of the abdomen
.....DAMSELFLY NYMPH

7

A. Hardened abdomen (covered by plates or hard) .....BOX 8

B. Soft flexible abdomen.....BOX 9

*This key will help to identify most but not all of the macroinvertebrates found in cold water streams in the upstate of South Carolina.

8

A. Wide abdomen, large eyes, and no tail .....DRAGONFLY NYMPH

B. Entire body hardened and stiff.....BEETLE LARVA

9

A. Fleshy extensions or thin filaments extending from **sides** of abdomen.....BOX 10

B. No filaments extending from sides of abdomen.....BOX 11

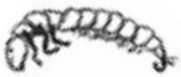
10

A. Fluffy or branched gill tufts under abdomen, large mouthparts short forked tail with hooks .....DOBSONFLY LARVA (HELLGRAMMITES)

B. No gill tufts **under** abdomen, thin filaments extending from sides of abdomen, one tail .....BOX 11

11

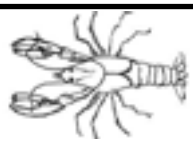
A. 2 small hooks on forked back end. Abdomen may have gills .....CADDISFLY LARVA



B. Abdomen that ends in a long tail or filament .....ALDERFLY LARVA

12

A. 10 segmented legs, large claws, body is lobster like .....CRAYFISH



B. Body shrimp-like, no claws .....SCUD (or Freshwater shrimp)

13

A. Fleshy body with no shell .....BOX 14

B. Fleshy body with a shell.....BOX 15

14

A. Fleshy caterpillar like body with fleshy finger-like extensions from one end .....CRANE FLY LARVA

B. Fleshy caterpillar like body that tapers to points on both ends .....FLY LARVA (horse and deer flies)

15

A. Has a single spiral shell.....BOX 16

B. 2 shells that open on a hinge .....FRESHWATER CLAM

16

A. When point of shell is up and opening is facing you, opening of shell is on right .....GILLED SNAIL

B. When point of shell is up and opening is facing you, opening of shell is on left .....LUNGED SNAIL

Macroinvertebrates found at Paris Mountain State Park
Top: Stonefly Nymph
Middle 1: Caddisfly Larvae
Middle 2: Caddifly Larvae in its case
Bottom: Dragonfly Nymph

Macroinvertebrate Bioassessment Activities:

Perform a macroinvertebrate bioassessment of a stream.

*To find the most macroinvertebrates, choose a cold water stream that is protected and in a natural area. Many South Carolina state parks have programs that include macroinvertebrate bioassessments and have trained personnel and the tools and materials that are needed in order to collect, observe, and identify macroinvertebrates. Contact a ranger to arrange a field trip. Paris Mountain State Park and Jones Gap State Park are good options.

If you don't have the ability to set up a field trip with a park, you still need to make sure that you have permission to sample in whatever stream you are using. Check with the property owner to make sure they will allow you to sample on their land.

Follow the procedures in the background information of this section, and use the macroinvertebrate bioassessment data sheet (modified from the Save our streams protocol) and the macroinvertebrate key (modified from the SC Master Naturalist macroinvertebrate key) to identify the animals that you find.

Using pipets, spoons, or forceps, the students should carefully go through the samples and place macroinvertebrates into petri dishes with water from the stream. Remind the students to take their time, be gentle, and look for movement.

Students will then use the keys provided to identify the macroinvertebrates. Each group should have a data sheet that they can use to record the number and type of macroinvertebrates that they found.

Other keys for macroinvertebrate identification are available online:

For practice using an online dichotomous key to identify macroinvertebrates: http://people.virginia.edu/~sos-iwla/Stream-Study/Key/MacroKeyIntro.HTML

For a "tree" style macroinvertebrate key that can be printed and used in the field (if you will be performing this analysis multiple times, laminate or protect with a sheet cover so that you can reuse the key): http://www.stroudcenter.org/education/MacroKey_Complete.pdf

http://www.dep.wv.gov/WWE/getinvolved/sos/Documents/Benthic/WVSOS_MacroIDGuide.pdf

When you are finished sampling, gently return the macroinvertebrates to the stream.

After performing the bioassessment and studying the stream, tally the students' results (or have each group tally separately and compare) to ***determine the relative health of the stream.***

Discuss your results. Some discussion prompts may include:

- In what category does the water quality in the stream fall?
- Is that what you would expect to find in this stream, and why or why not?
- Are there any land use impacts upstream of your sampling location (development, farms, logging, etc.), and how would you expect types of land use to impact the health of the stream?
- Did anyone find any organisms in the tolerant category? What do you think that means? (if only tolerant organisms are present, the water quality can be considered poor, but if a wide variety of organisms are present and some are tolerant, it doesn't mean that the water quality is poor)

The same Caddisfly larvae in it's case shown on page 116 in a plastic teaspoon

**Most macroinvertebrates are very small. Students should take their time while sorting and watch for movement in their sample. Remind them that these animals are well adapted to blend in to their environment and not to be discouraged if they don't see a lot of animals right away*

Compare and contrast the macroinvertebrate community in a natural and an urban stream.

Repeat the procedure for macroinvertebrate bioassessment at an urban stream and have students compare their results.

*Urban streams may be polluted enough to cause human health impacts, so especially with younger students, the instructor should do the actual sampling, and everyone should wear gloves and wash their hands well after working with organisms from an urban stream.

Chapter 7: Birds

Word Bank

Birds
Endothermic
Vertebrate
Adaptation
Scavenger
Insectivore
Frugivore
Feathers
Beak
Fused Skeleton
Cryptic Coloration
Plumage

BIRDS

Key Concepts and Skills:

- Birds are endothermic, vertebrate animals
- Most birds fly, and the major characteristics that all birds share are adaptations for flight
- Coloration of bird feathers is a physical adaptation for survival and varies between males and females in many species
- Students will practice observing birds
- Students will use an online guide to try and identify bird species

Background Information

Birds are warm-blooded (endothermic: meaning that they are capable of modifying their body temperature internally) vertebrate animals. The major defining characteristics of birds are that they have feathers and wings. In birds, wings are the modified front pair of limbs of the animal. Though not all birds are capable of flight, all birds have wings.

Physiologically, many of the distinguishing characteristics of birds are adaptations related to flight. Birds have feathers all over their bodies. Flight feathers are made up of a central vane and hundreds of barbs each with interlocking barbules. When a bird “preens” itself, it is often running its beak along the feathers to help the barbs lock into place or spreading oil from a special gland onto the feathers. This oil helps to prevent the growth of fungi and bacteria and helps repel water from the feathers. In addition to flight and protection, feathers also help birds regulate their body temperature by trapping air, and the colors of feathers aid in mating selection, camouflage, and species differentiation.

To aid in flight, birds’ skeletons are fused and rigid in many places, including the vertebrae. The breastbone is enlarged, providing more surface area for attachment of flight muscles. The flight muscles are large and located near the center of gravity while other muscles such as the jaw and hind limb muscles are reduced in size. Birds have bones that are full of air spaces and their lungs are aided by air sacs that are spread throughout the open spaces in the body. All of this air helps make birds light weight, as an adaptation for flight. Feathers and beaks are made up of keratin, the same strong lightweight material that makes up our fingernails and hair.

Body and beak shape in birds is highly varied as a result of adaptation to a variety of different habitats and diets. In addition to eating, birds use their beaks

Birds Field Notebook Suggestions

Draw pictures or take photographs of birds.

Identify a bird that you see at your bird feeder, and create a field notebook page for it.

Draw and label the parts of a feather.

Why do you think that some birds seem to live and survive very well in the urban environment and others do not?

List 10 different types of data that a scientist may need to collect if they were studying a population of birds and wanted to know why the population numbers seemed to be declining. Describe an experiment to determine if a bird population is in decline. How would you collect the important data?

for preening, gathering nest materials, feeding their young, communicating, courtship displays, and even the manufacture of tools. In relation to the size of their heads, birds have larger eyes than most other vertebrates. The eye is also fixed in place, meaning that birds must turn their heads to look in different directions.

Within ecosystems, birds play many important roles including:

Plant reproduction and dispersal

- Birds that drink nectar (such as hummingbirds) aid in pollination of plants.
- Birds that eat fruit aid in dispersal of those plants to new habitats and within habitats.
- Seeds "hitchhike" on the legs and down of birds from one place to another.

Nutrient cycling

- Birds that eat fish are essential in moving nutrients from aquatic to terrestrial habitats through droppings.
- Scavengers such as buzzards play an important role in the breakdown of dead and decaying materials.

Physical processes

- Birds act as "ecosystem engineers" through the construction of nests. Many nests represent micro habitats within an ecosystem and are used by other organisms.
- Birds affect population densities of other animals and plants through feeding. Especially useful to humans, birds that eat insects and small mammals help regulate pest populations.

The study of birds is called Ornithology.

When attempting to identify a bird, don't go straight to the bird book. Instead, watch the bird: try to answer the questions on this handout, listen to any calls it may be making, and watch it fly. Then, with all of that information at your disposal, you can go to the book or online guide and try to determine which bird it was.

Often, you may not see the bird. Many ornithologists learn to distinguish bird calls as a way to identify birds.

Male birds tend to have more ornate, colorful plumage while female birds are often more drab and cryptic in coloration. This is a physical adaptation for survival. The bright colors on the male aid in mate selection, possibly signalling to the female that the most brightly colored male is the most fit, since he has managed to avoid predators. The drab colors on the female allow her to blend into her habitat, making her harder to see so that she is less likely to be found by a predator, allowing her to sit on her nest and warm her eggs.

Identifying Birds

Start with **SHAPE**
Look at the body of the bird.

a. How big is it?
b. Is it plump or skinny?

Look at the bill of the bird

a. Is it short or long?
b. Is it pointed or rounded?
c. Is it straight or curved?

Look at the bird's wings.

a. Are the wings pointed or curved?
b. Are the wings long or short?

Look at the bird's tail.

a. Is the tail long or short?
b. Is the tail one part or forked into two parts?
c. What shape is the tail?

Tips
Size can be tricky to determine in the field, since few birds will sit still and let you measure them. Compare the birds you don't know to common birds that you do know.

Use the bird as a ruler.
To determine if a bird has a short beak or a long beak, compare the beak length to the length of the bird's head. Is the beak smaller than the head, the same length, or longer?

Next, determine **COLORS**

1) What is the main color of the bird?
2) Are there any other colors on the bird?
    a. Where are the other colors?
3) Does the bird have any distinctive markings?
    a. Does the bird have wing bars?
    b. Does the bird have patches of color on the wings or tail?
    c. Does the bird have eye markings?
4) What color are the bird's legs?

Finally, **WHERE** are you and **WHAT** is the bird doing?

Where is the bird: Where you see the bird is important because birds have specific ranges and prefer certain habitats. As an example, let's say you have a bird that you are trying to identify and you have narrowed your choice to two birds. You check the RANGE in your bird book and determine that one lives on the East Coast of the United States and the other lives only in California. Which bird do you think you have found?

If you are in the mountains or in the forest, you may see different birds than you would in a park. If you are at the lake or the ocean, you may see different birds than you would in your backyard.

What is the bird doing: Some birds prefer to eat specific types of food. Others have special mating behaviors or build their nests from specific types of material. Is the bird swimming, wading, eating at a bird feeder, hopping around on the ground, climbing a tree, hovering in mid-air, or catching a small animal for dinner? Behavior can tell us a lot about birds and help to identify the bird.

*If you are able to tell what sound the bird is making, that may also help. Many birds have a few distinct calls. Be careful though, the song you hear may be coming from a bird that you don't see!

Photo Scavenger Hunt: Birds

___ A bird eating
___ A male bird with bright plumage
___ A female bird with cryptic plumage
___ A migratory bird
___ A bird flying
___ A bird feather
___ A bird's nest
___ A bird that swims

Draw a picture of one place that you see a bird during your field expedition below:

Birds Activities

In order to create a good bird watching spot before the field expedition, have the students ***make bird feeders*** out of recycled materials at least a week before this lesson and then put them somewhere that is easy to watch. After discussing bird identification, have the students head in teams to their bird watching spots with their field guides to observe birds.

Directions to make a bird feeder from a plastic 2 Liter Bottle:
http://connections.greenvillesc.gov/forms/EdMaterials/PlasticBottleBirdFeeder.pdf

Directions to make a bird feeder from a milk carton:
http://www.iwla.org/index.php?ht=a/GetDocumentAction/i/4246

More bird feeder options:
http://www.artistshelpingchildren.org/

If a field trip is appropriate, Lake Conestee Nature Park http://conesteepark.com/ has been designated an "Important Bird Area" by the South Carolina Audubon Society, and is a great place to go bird watching.

During the field expeditions, have students ***observe*** birds and their characteristics and behaviors. Following the field study, have them utilize online guides to try and ***identify*** the birds that they saw.

The Cornell Bird Laboratory website is a great searchable online guide:
http://www.allaboutbirds.org/guide/search/ac

For more information and detailed diagrams of the parts of the birds body:
http://www.birding.com/bird_identification.asp

The Greenville County Bird Club has an online checklist of bird species for the upstate of South Carolina on their home page.
http://www.gcbirdclub.org/index.html

Urban Naturalists create and decorate recycled bird feeders in order to observe birds

Chapter 8: Reptiles and Amphibians

Word Bank

Reptile
Amphibian
Ectothermic
Oviparous
Ovoviviparous
Viviparous
Herpetology
Amniotic Egg
Cryptic Coloration
Porous
Gills
Metamorphosis
Keratin
Adaptation

REPTILES AND AMPHIBIANS

Key Concepts and Skills:

- Reptiles and amphibians are ectothermic vertebrate animals
- Amphibians have porous, soft skin, live at least part of their lives in water, require water for reproduction, have gills during some part of their life cycle, and many go through metamorphosis
- Reptiles have scaly, dry skin and lay amniotic eggs that have thick, leathery shells
- Students will go on a field expedition to observe and identify reptiles and amphibians
- Students will use an online guide to try and identify reptiles and amphibians

Background Information

Reptiles and amphibians are treated here together because they share some common characteristics. Both are ectothermic (commonly called cold-blooded), vertebrate animals. Many of the characteristics that distinguish reptiles and amphibians developed as adaptations to reptiles living away from water.

Reptiles and amphibians have a 3 chambered heart, except for the Crocodilians, which have a 4 chambered heart.

Most reptiles and amphibians lay eggs. A major exception are snakes. Snakes can be oviparous, meaning that they lay eggs outside of their bodies, ovoviviparous, meaning that they produce eggs but retain them inside of their reproductive tract and give birth to live young, or viviparous, meaning that the female snakes do not create separate eggs, the young develop inside the mother and they give birth to live young.

General Reptile Characteristics:

Includes snakes, alligators, crocodiles, lizards, and turtles

Scaly, thick, dry skin made of keratin that keeps them from losing moisture

Breath with lungs (do not have gills)

Produce a thick, leathery skinned amniotic egg which allows the egg to be laid on dry land and requires internal fertilization

Parental care of young evident in some species

General Amphibian Characteristics:

Includes salamanders, frogs, toads, and caecilians (tropical, legless amphibians)

Soft porous skin which allows them to absorb water directly through the skin. This is a characteristic that makes amphibians great indicators of environmental pollution. Since they absorb water through the skin, they are more likely than other animals to be affected by pollutants

Adults generally live on land but require water for reproduction

Have gills during at least some portion of their life cycle. The word amphibian means "double life" and refers to the fact that adult amphibians have lungs (many adult amphibians are terrestrial) while their juvenile forms have gills (eggs and juvenile amphibians are aquatic).

Most go through metamorphosis

Some reptiles and amphibians are extremely common in the upstate of South Carolina. You should be able to find Green Anoles almost anywhere. Skinks, slider turtles, and toads are also easy to find. Snakes, tree frogs, salamanders, and box turtles can all be found in the upstate, but are often harder to find. Many herps ("herps" is scientific slang for reptiles and amphibians) have cryptic coloration, meaning that they are camouflaged to blend in with their environment.

Amphibians can be found in every terrestrial habitat on the planet except for Antarctica and the high Arctic and fill important rolls in food chains, nutrient and energy cycles, and as natural pest control in a wide variety of ecosystems. Unfortunately, amphibian populations are declining globally. Due in part to the soft porous nature of their skin, amphibians are very susceptible to pollution and changes in their environment. In recent years, a toxic fungus has caused widespread population decline in amphibians. Climate change, habitat fragmentation and alteration, and pollution are all contributing to the continuing loss of amphibians.

Before this lesson, it is recommended that you spend some time familiarizing yourself with the common species that you are likely to encounter (links in the activities section) and conduct some test expeditions to determine where you are most likely to find reptiles and amphibians. Your field expedition will probably be most successful in late spring to early summer or in fall. Since they cannot regulate their body temperatures, many herps will be hiding from the heat in holes and burrows during late summer and hibernating in winter. If it is possible, older students may enjoy a night expedition.

Late spring/early summer is also a great time for finding tadpoles. Use a dip net to search the edges of ponds or wetlands for tadpoles. Place tadpoles in a clear plastic container with water for observation. It is extremely difficult to identify tadpoles, but students may enjoy trying. A full color field guide to tadpoles and amphibians of the southeastern coastal plain is available at http://fl.biology.usgs.gov/armi/Guide_to_Tadpoles/guide_to_tadpoles.html

Reptiles and Amphibians Field Notebook Suggestions

Draw pictures or take photographs of reptiles or amphibians.

Identify the reptiles or amphibians that you found during field expeditions.

Write a paragraph about the differences between amphibians and reptiles.

Describe the importance of metamorphosis in amphibians.

Some snakes lay eggs, some do not. Why do you think this is? Write an opinion paragraph about whether laying eggs or live birth is better for an animal's chance of survival.

What is cryptic coloration? Describe a reptile or amphibian that exhibits cryptic coloration and explain why cryptic coloration is beneficial to the animal.

Urban Naturalists observe amphibians placed in containers with water by the instructor before carefully letting them go where they were found

Handling reptiles and amphibians:
It is strongly suggested that unless you have been trained in proper handling techniques, to avoid picking up any snakes or snapping turtles. Lizards, salamanders, box turtles, and frogs are usually safe to handle if you are careful. Gently pick the animal up and place it in a container for observation. Once everyone has gotten to see the animal, gently release it where you found it. Students should not handle any animals without careful supervision.

Tips to share with your students:
Make sure that you have NO chemicals (lotions, insect sprays, perfumes, etc.) on your skin before handling amphibians or reptiles.

Make sure hands are moist before picking up salamanders or frogs.

Gently turn over logs and rocks to look for animals and then return them to their original position. If you find a salamander or other creature, do not place the log or rock on top of it. Place the animal beside the restored rock or log and allow it to crawl into shelter itself. This way you avoid accidentally squishing and killing the animal.

DO NOT tear apart rotten logs to look for animals and insects. These microhabitats are important homes and food sources to lots of creatures and should be left in the condition that they were found in.

Hold turtles gently and securely by the base of the shell on either side between the front and back legs. All turtles can bite, and many have claws that can scratch you. Keep the turtle's face pointed away from any body parts and be careful.

DO NOT pick up snapping turtles

DO NOT pick up turtles by the tail: this can damage their spines

DO NOT grab lizards by the tail. Many lizards respond to being grabbed by the tail by shedding their tail. This is a defensive strategy designed to make a predator pay attention to the still wriggling tail and allow the lizard to escape. The lizard then has to utilize a lot of energy to regrow its tail; energy that is needed for survival and reproduction.

While animals are in a container for observation, make sure that you do not leave the container in the sun. Keep animals for as short a time as possible and then return them where they were found. Remember that most herps are tiny and many are territorial. They will be safest and happiest if you can put them back where you found them.

Some amphibians and reptiles live in or near water while many others are terrestrial. If you find a salamander under a log, there is no need to "rescue" it by placing it in a stream. Instead, observe the animal and replace the log next to it (not on top of).

*Always make sure everyone washes their hands well after every field expedition!
The following handout is available to print and provide to students if you would like, or just as background information for instruction.

Amphibians and Reptiles

Scientists that study reptiles and amphibians are called Herpetologists.
Reptiles and Amphibians share some characteristics:

- Lay eggs (except some snakes)
- "Cold-blooded" or Ectothermic– cannot regulate their body temperature but must depend on the sun to become warm. This is why so many reptiles and amphibians can be found "basking" on rocks, logs, and roads when it is cool out, and why many retreat into water or burrows when it is hot out.

Amphibians

*Frogs, Toads, Salamanders, Newts

- Most adults live on land but must lay their eggs in water.
- Eggs are soft, without a shell
- Young amphibians live in water and breathe through gills. Most amphibians eventually go through a set of changes called metamorphosis where they grow legs and lose their gills, though there are some species that have gills as adults and stay in water their entire lives (Mudpuppy Salamanders).
- Most amphibians have soft porous skin which allows them to absorb water directly through the skin. This is a characteristic that makes amphibians great indicators of environmental pollution. Since they absorb water through the skin, they are more likely than other animals to be affected by pollutants.
- The largest known amphibian is the Japanese Giant Salamander which grows up to 6 feet long and 140 pounds.
- The state amphibian of South Carolina is the Spotted Salamander

Reptiles

*Snakes, Turtles, Lizards, Alligators

- Eggs are soft and leathery and are usually laid on land rather than in water.
- Skin is scaly and does not absorb water.
- When snakes and lizards stick their tongues out they are "smelling" the air by collecting scent particles and running them across a special sensory organ called the Jacobson's organ.
- The state reptile of South Carolina is the Loggerhead Turtle

Observing Reptiles and Amphibians:

- Many reptiles and amphibians are shy and secretive and may be hard to find. Patience is important.
- Look under logs or rocks in wooded and slightly damp areas for lizards, salamanders, and snakes. Be careful: check with your eyes first before turning the log or rock over, turn the log or rock over carefully with a stick, and turn it so that the opening is away from your body.
- Some frogs, snakes, and lizards are arboreal, meaning that they live in trees. Don't forget to look up!

- Remember that amphibians MUST lay their eggs in water, so it makes sense to look for adult amphibians near water. Check wetlands, floodplains, and streams for amphibians and remember to wear rubber boots or old shoes that can get muddy.
- Many amphibians and reptiles are nocturnal, so taking a trip in the evening or night time is a good idea. Bring a flashlight, a plastic container or small bucket, and your camera and wear rubber boots. ALWAYS have an adult with you when you go on a night expedition.
- Use a small net to carefully catch small frogs, lizards, and salamanders for observation. Place them gently in a clear container to observe, take pictures, and record field notes and then release them where you found them.

Common Types of Reptiles and Amphibians in Greenville, SC

Frogs	Toads	Skinks	Lizards
Turtles	Salamanders	Snakes	

"Collecting" Reptiles and Amphibians

In order to keep a record of any reptiles and amphibians you may encounter, photographs are the best option. If you cannot take a picture, make a quick sketch and record detailed information regarding color, shape, and habitat in your field notebook. For frogs and toads, recordings of their calls are also a good way to help identify the animal.

Photo Scavenger Hunt: Reptiles and Amphibians

___ A frog
___ A skink
___ A lizard
___ A reptile basking in the sun
___ A tadpole
___ A turtle
___ An adult amphibian near water
___ An egg from a reptile or amphibian

Draw a picture of a reptile or amphibian that you have found during a field expedition:

Reptiles and Amphibians Activities:

More information and guides:

The Savannah River Ecology Laboratory in Aiken, SC has a program dedicated to studying reptiles and amphibians found in South Carolina and Georgia. Their website contains photographs, range and habitat information, conservation status, and even some recordings of frog calls.
http://srelherp.uga.edu

The United States Geological Survey (USGS) has a searchable list of amphibian species for the Southeastern US that includes photographs, habitats, and life history information and an extensive glossary of amphibian related terminology available at http://fl.biology.usgs.gov/herps

South Carolina Department of Natural Resources (SCDNR) has more information regarding snakes in South Carolina, including a table of snake species present in the upstate.
http://www.dnr.sc.gov/wildlife/snakes/index.html

The Carolina Herp Atlas has an online database compiled by amateur herpetologists of sightings of reptiles and amphibians.
http://www.carolinaherpatlas.org
**If you find and identify any herps, it would be great to have students sign up and add their sightings to the list.*

SC DNR has published the following document that lists reptiles and amphibians of special concern for conservation in the Blue Ridge of South Carolina. If you are planning any mountain field trips, it would be beneficial to familiarize yourself with these species.
http://www.dnr.sc.gov/cwcs/pdf/BlueRidgeReptilesAmphibiansGuild.pdf

Some reptiles you may see on your expeditions.
Top: A Five Lined Skink found at Paris Mountain State Park
Middle: An Eastern Fence Lizard observed at Chestnut Ridge Heritage Preserve
Bottom: A black snake, unknown.

Examples of amphibians you may find on your field expeditions.
Top: Salamander from a stream at Wildcat Wayside
Middle: Frog seen at Ashford Heritage Preserve
Bottom: Tadpole in a garden pond at A J Whittenberg Elementary School

Present and discuss the common characteristics and the differences between reptiles and amphibians.

*Since reptiles and amphibians may be harder to find, it may be beneficial to combine field expeditions with another subject, or just take a general field expedition to look for reptiles and amphibians.

Chapter 9: Invasive Species

An invasive species is any exotic (non-native) plant, animal, or pathogen that out-competes native species and causes environmental, economic, or human damage in a new environment.

Word Bank

Native
Invasive
Exotic
Introduced
Beneficial
Naturalized
Pest
Biological Control
Vegetative Reproduction
Rhizome
Dispersal
Abundant
Resilient
Threatened Species
Endangered Species
Sensitive Species
Hydrology
Fire Regime
Nutrient Cycling
Rare
Microclimate

INVASIVE PLANTS

Key Concepts and Skills:

- An invasive species is a non native plant or animal that has been introduced into an area outside of its natural range and is causing (or has potential to cause) damage or harm
- Invasive species are a major environmental issue
- Invasive species are very common in the urban environment due to introductions by humans, including purposeful planting and release and accidental introductions
- Students will identify common invasive plants in Greenville, SC during a field expedition

Background Information

Many of the plants that can be found in an urban environment are non-native (exotic) plants. Non-native plants are commonly used in landscaping and many are cultivated as food crops.

Non-native plants become a problem if they “escape” cultivation and grow in the wild, out competing and displacing native species. When this occurs, these plants are considered invasive species.

Why do some plants become invasive?
There are a variety of reasons why some plants become invasive while others do not. Often, a combination of factors may result in a plant becoming an invasive species. A species may become invasive for any of the following reasons:

- It grows and reproduces faster than native species
- It reproduces in multiple ways (many invasive species can reproduce through seed and vegetatively through structures such as rhizomes, underground stems that sprout new above ground structures)

Invasive Plants Field Notebook Suggestions

Draw pictures or take photographs of invasive plants.

Research an invasive species found in South Carolina. When was that species introduced? How? Why? What is being done to control it? What impact has it had?

Press leaves from invasive plants and glue them into the field notebook. (Flowers and seeds are better left alone to avoid accidentally spreading the plant more)

Write a paragraph about what you can do to help control the spread of invasive plants.

- Its seeds or fruit are abundant, resilient, and easily dispersed
- Generalist species: It is well suited to a variety of habitats (or just very well suited to its new environment)
- Escape from competition, predation, or disease: In moving the plant into a new environment, it is no longer in contact with natural enemies (predators, pests, and diseases) or competitors that limited growth in its native environment
- Chemical warfare: Some invasive plants produce chemicals that limit the growth of competing plants

Why are invasive species a problem?
Invasive species alter the dynamics of an ecosystem, often having far ranging effects and consequences that are difficult to determine. Once established, invasive species can be very difficult to remove. Possible ecosystem effects include:

Loss of habitat for native animals and plants. Rare, sensitive, threatened, and endangered native plants and animals are especially vulnerable. The added impact of invasive species to other anthropogenic influences such as, habitat destruction and habitat fragmentation can drastically reduce available habitat with devastating effects.

Loss of food sources for animals.

Alteration of ecosystem processes such as:

- hydrology (the movement and cycling of water through an ecosystem)
- fire regime (the frequency, size, and/or impact of fire on plants and animals within an ecosystem)
- nutrient cycling (the pathways and rates at which nutrients move through an ecosystem)
- microclimates (small areas where the climate varies from the larger surrounding area)

In addition to ecosystem effects, invasive species have major economic effects. Invasive animals may prey on important native species or crop plants. Invasive plants and animals can endanger economically important ecosystem services and natural resources.

Examples: Approximately 2.5 million dollars a year is spent in South Carolina alone on controlling hydrilla, an invasive aquatic plant.

Economics of invasive species: The US spends more than 138 billion per year on invasive species. These costs come from a variety of places including:

- Controlling the spread of invasive species through removal projects
- Limiting the damage of invasive species, especially in agriculture through the use of pesticides, herbicides, and mechanical removal
- Prevention of the introduction of new invasive species or the spread of current invasive species through inspections of agricultural products and other imports and exports

How do invasive species invade?

Invasive species either enter a new environment naturally or through human introduction.

Some natural means of invasion include:

- animal dispersal, especially migratory birds
- wind or water dispersal

Human caused (anthropogenic) means of invasion include:

- Introduction of a plant for agriculture or landscaping (wisteria, privet)
- Introduction of a plant as a food source for animals (kudzu)
- Introduction of an animal to control another pest
- Pet and aquarium trade: release of pets into the wild, dumping of aquariums into water bodies.
- Accidental introduction through import or export. Exotic plants and animals may "hitchhike" to new habitats in shipments of goods from other places.

*Scientists believe that the dumping of ballast water by ships was the source of introduction of the zebra mussel into the great lakes. Zebra mussels are killing native mussels, altering the ecosystem structure of the great lakes, and causing a huge economic impact on water and power plants by colonizing intake valves and other structures in the water.

What can we do to prevent the spread of invasive species?

Learn to recognize invasive species

Plant native species. Even though not all exotic plants have the potential to become invasive, using native plants in landscaping is a good way to make sure that you are not accidentally spreading an invasive species. In addition, native plants offer habitat and food for native animals and often need less water and care than exotics since they are already adapted to the environment.

Control current landscape plants to prevent their spread

Do not release pets or dump aquarium plants in the wild

Make sure that boats, trailers, fishing equipment, hiking equipment, etc. are cleaned after and before each trip. This minimizes the possibility that you may accidentally transport an invasive species to a new area.

A cross referenced list with photographs drawn from UGA's EDDMapS specific to Greenville County and the South Carolina's Exotic Plant Pest Council 2011 watch list of invasive plants for South Carolina is provided to be used for this lesson. The handout includes trees, shrubs, and vines.

For more information:
Link to a brochure from the South Eastern Exotic Plant Pest Council that lists and describes some of the most common invasive plant species in South Carolina:
http://www.se-eppc.org/southcarolina/scinvasives.pdf

The Eastern Forest Threat Assessment Center's list for South Carolina:
http://threatsummary.forestthreats.org/browse.cfm?stateSearch=SC

Common Invasive Plant Species in Greenville, SC

Chinaberry
Melia azedarach

ID: up to 50 ft tall with alternate leaves 2 or 3 times compound. Leaflets are 1-3In long with serrated margins. Flowers in Spring. Fruit are yellow or yellow-green.

Tree
Severe Threat

Native to Asia, Chinaberry was first introduced to the US in Charleston, SC in the 18th century. The fruit is poisonous to humans.

Tree of Heaven
Ailanthus altissima

ID: up to 80 ft tall with very large alternate compound leaves each 1-4ft long with 10-41 leaflets. Each leaflet has two or three small toothed lobes at the base. When crushed, the leaves smell nutty.

Tree
Severe Threat

Very common in urban, disturbed areas, Tree of Heaven produces chemicals that prevent other plants from growing nearby.

Tell it apart from native Sumac by looking for Sumac's fully serrated leaflet margin as opposed to the 2 or 3 lobed "boot" shape at the base of Tree of Heaven's leaf.

Princess Tree
Royal Paulownia
Paulownia tomentosa

ID: up to 60 ft tall with bark that alternates between smooth and rough. Large, heart shaped, opposite leaves that are shallowly lobed. Leaves are hairy on the bottom. Large clusters of violet flowers.

Tree
Severe Threat

Introduced in the 1840's, Princess Tree grows very fast and takes over disturbed areas. It spreads by seed and by resprouting from the roots. One plant produces an estimated 20 million seeds.

Common Invasive Plant Species in Greenville, SC

Mimosa
Albizia julibrissin

ID: small tree 20-40ft tall with doubly pinnately compound leaves with very small leaflets. Bark is almost smooth. Flowers are white to pink and look like "feathered pom-poms."

Tree
Significant Threat

Common in disturbed and urban areas, Mimosa is especially a problem alongside rivers. Introduced in 1745, Mimosa is still a popular landscape plant because of its attractive leaves and flowers

Chinese Parasol Tree
Firmiana simplex

ID: small tree 30-40ft tall with large simple 3-5 lobed leaves arranged alternately. Bark is green-ish with white stripes and smooth.

Tree
Significant Threat

Chinese Parasol Tree is a landscape plant in the chocolate family that grows very quickly.

White Mulberry
Morus alba

ID: small tree 30-50ft tall. Leaves glossy green, alternate and simple with very variable shape (lobed, mitten-like, ovate) often on the same plant. Blackberry like clusters of fruit.

Tree
Significant Threat

Originally introduced in an attempt to develop a silk worm industry in Colonial times.

Tell it apart from the native Red Mulberry: the top is glossy and the underside of the White Mulberry leaf is smooth while the Red is fuzzy.

Common Invasive Plant Species in Greenville, SC

White Poplar
Populus alba

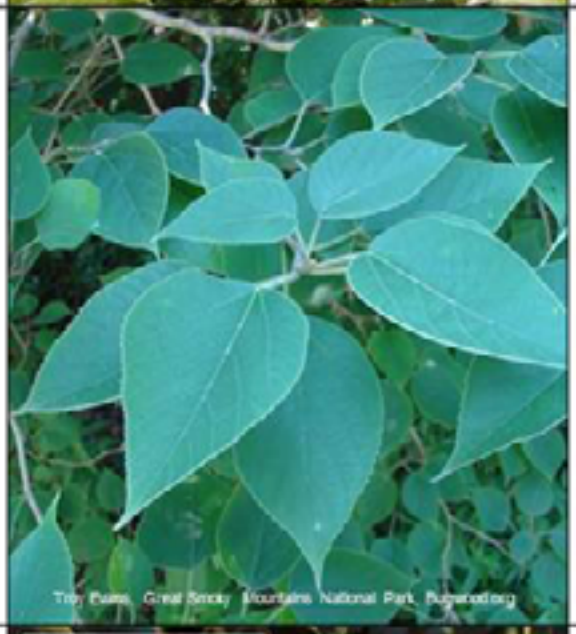
ID: large tree 60-100ft tall with alternate simple leaves that vary in shape from oval to 5 lobed. Leaves have undulate and toothed margins, and the underside is covered in thick white hairs. The petiole is also covered in hairs.

Tree
Significant Threat

White Poplar is native to Europe and Asia and was introduced for landscaping. It reproduces mainly through sprouts from the roots.

Paper Mulberry
Broussonetia papyrifera

ID: short tree 30-40 ft tall. Leaves are very variable: opposite, alternate or whorled on the stem, very hairy underneath heart and mitten shaped with sharply toothed margins and pink to orange fruit.



Tree
Significant Threat

Planted in the Southeast as early as 1900, the inner bark of the Paper Mulberry has been used since ancient times to make paper.
Tell it from native mulberry: not actually in the mulberry genus, Paper Mulberry has rounded ball shaped fruit and dull leaves on long petioles. Red Mulberry has shiny leaves and red to black hanging fruit.

Bradford Pear
Pyrus calleryana

ID: tree up to 60 ft tall. Leaves are simple and alternate on the stem. Ovate in shape. Clusters of white flowers appear before leaves in early Spring.

Tree
Emerging Threat

Introduced from China, the Bradford Pear is widely used in landscaping.

The flowers of Bradford Pear are very fragrant, in a bad way. It has been said that they smell "like fish."

Common Invasive Plant Species in Greenville, SC

Russian Olive
Elaeagnus angustifolia

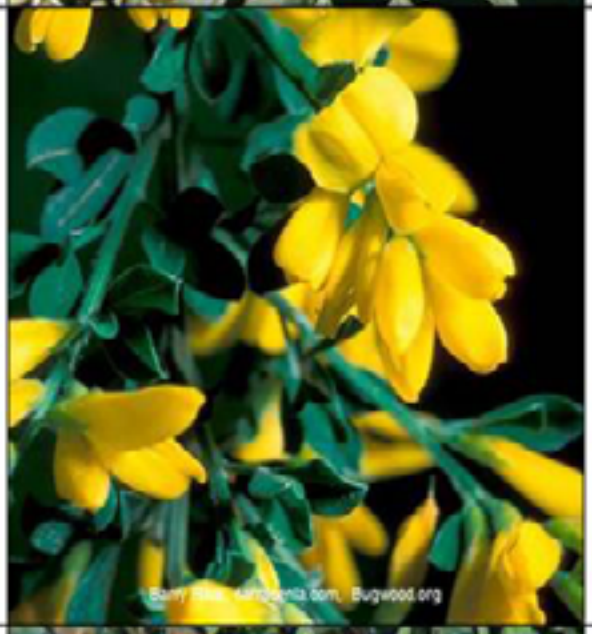
ID: Small tree or shrub up to 30 ft tall with thorny stems and leaves alternate and longer than wide, tapering to a rounded point with smooth edges. Yellow flowers, silvery fruits.

Tree
Alert

Mainly present in the Western and Central states, Russian Olive is invasive in North Carolina, and is on the alert list for South Carolina.

Scotch Broom
Cytisus scoparius

ID: Shrub up to 12 ft tall with slender green stems and compound leaves with 3 leaflets alternate on the branch. Leaflets less than 1 In long, dark green on top and pale and hairy beneath. Bright Yellow Flowers late Spring to Early Summer.

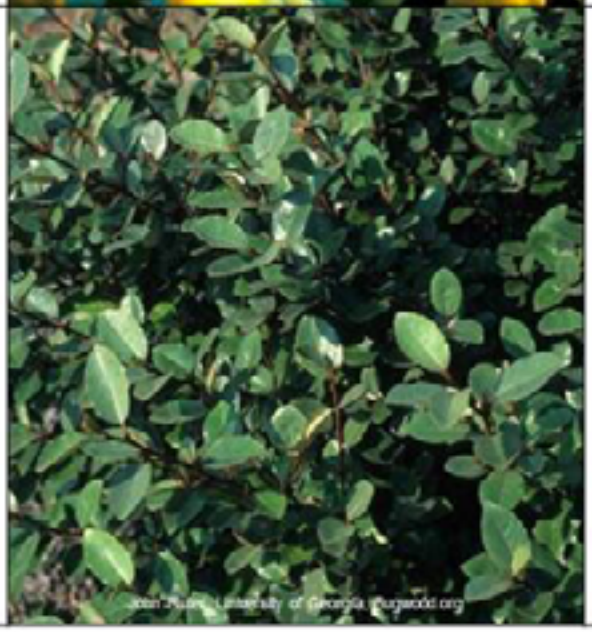


Shrub
Severe Threat

Scotch Broom forms dense thickets. It was introduced from Europe and sold as an ornamental.

Thorny Olive
Eleagnus pungens

ID: Shrub 3 – 25 feet tall with elliptical alternate leaves that are covered in small silvery scales. Branches are dark brown and have lots of thorns.



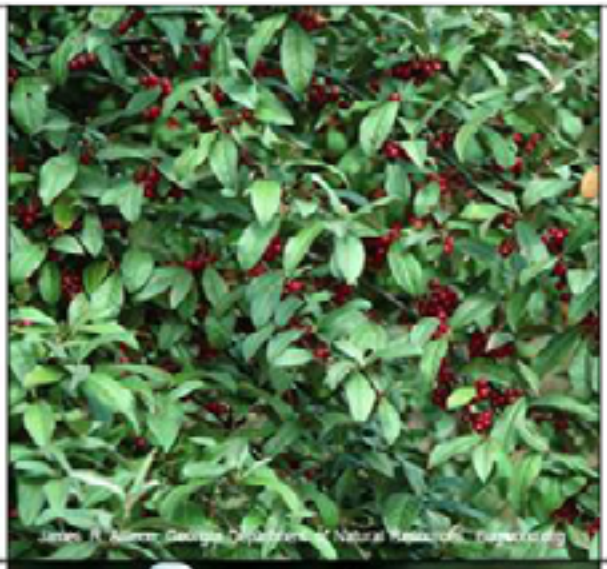
Shrub
Severe Threat

Thorny olive also looks like Russian Olive and Autumn Olive, both also invasive species for South Carolina.

Common Invasive Plant Species in Greenville, SC

Autumn Olive
Elaeagnus umbellata

ID: Shrub 3 – 20 ft tall. Leaves are alternate and elliptical with a silvery underside. Branches are a greenish brown in color and have many thorns. Fruit - many red berries in Fall.

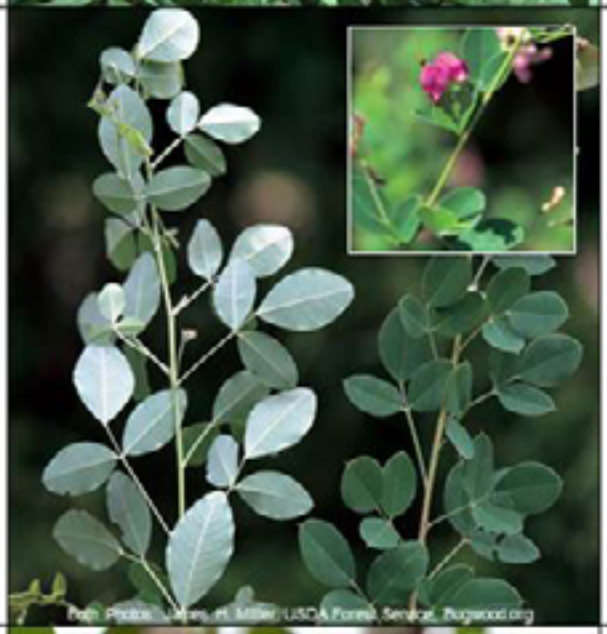


Shrub
Severe Threat

Autumn Olive was introduced to the US in 1830 from China and Japan and was planted for wildlife habitat. It has since been shown that native plants are better than exotics for wildlife.

Two Color Bush Clover
Lespedeza bicolor

ID: shrub 3 – 10 feet tall. Leaves are alternate and compound with 3 elliptical leaflets. Has small "Pea-like" purple to whitish flowers. Seeds are in pods, with a single seed to a pod



Shrub
Severe Threat

Introduced from Japan as an ornamental and planted widely as food for wildlife such as quail.

Privet
Ligustrum japonicum
Ligustrum sinense
Ligustrum lucidum
Ligustrum vulgare

ID: Shrubs up to 30 ft tall. Leaves are thick and leathery, opposite and simple with the tips coming to a point. Clusters of dark purple-black berries in late Summer to early Fall.

Shrub
Severe Threat

Widely planted as hedges, privet has become a major problem in natural areas in the South East. It takes over, preventing native plants from growing.

Common Invasive Plant Species in Greenville, SC

Japanese Knotweed

Polygonum cuspidatum

ID: Shrub with reddish brown reed-like stems, leaves arranged alternately leaves are thick and spade shaped with a sharp slope to the pointed tip.

Shrub

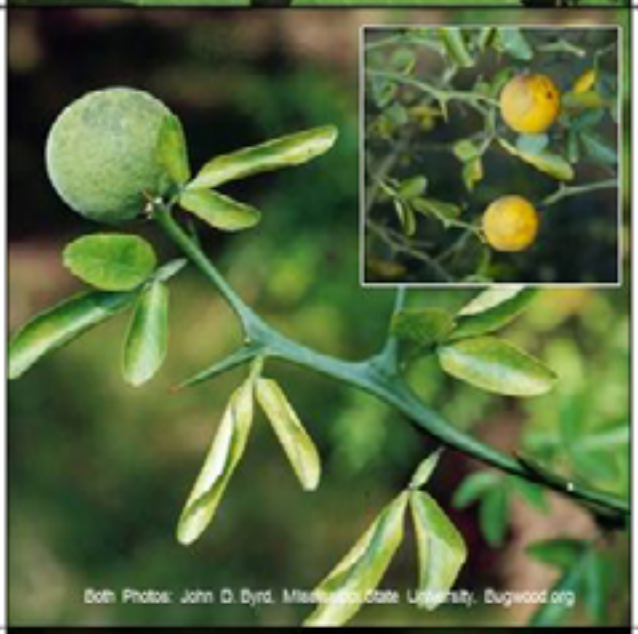
Significant Threat

Some people confuse Japanese knotweed with bamboo because it has reed-like stems that don't always die back in winter.

Trifoliate Orange

Poncirus trifoliata

ID: Shrub 8-30 ft tall with alternate compound leaves with 3 leaflets with "winged" petioles. Twigs are green with large thorns. Flowers white with 5 petals. Fruit yellow – orange and up to 2 in diameter



Both Photos: John D. Byrd, Mississippi State University, Bugwood.org

Shrub

Significant Threat

Many invasive plants have fewer natural enemies and herbivores in a new habitat than native plants. Due in part to its thorns, deer do not eat Trifoliate Orange but do eat native plants growing in similar habitats, giving Trifoliate Orange an advantage.

Multiflora Rose

Rosa multiflora

ID: Shrub up to 15 ft tall. Leaves are pinnately compound with an odd number of leaflets, alternate on the stem. Thorns are stiff, wide at the base, and curve backwards. Small white flowers in clusters.

James H. Miller, USDA Forest Service, Bugwood.org

Shrub

Significant Threat

Tell it apart from native roses: the base of the petiole of the Multiflora Rose has hairy, fringed stipules. Also, native roses tend towards pink flowers.

Common Invasive Plant Species in Greenville, SC

January Jasmine,
Sweet Breath of Spring
Lonicera fragrantissima

ID: Shrub up to 10 ft tall with many branching hollow stems. Leaves dark green and opposite. Flowers are tubes with flared petals at the end: yellow, pink, and white.

Shrub
Emerging Threat

Sweet Breath of Spring is a shrub that closely resembles the vining invasive Japanese Honeysuckle.

Macartney Rose
Rosa bracteata

ID: Shrub up to 10 ft tall. Leaves are pinnately compound with 7 to 9 leaflets, alternate on the stem with serrate margins. Thorns curve backwards. Small white flowers with five petals in clusters.

Shrub
Emerging Threat

Introduced as an ornamental, and is very similar in appearance to the Multiflora Rose, another invasive plant.

Meadowsweet
Spiraea japonica

ID: Shrub 4 to 6 ft tall with alternate leaves up to 3 inches long and oval in shape with toothed margins. Flowers light to dark pink in clusters up to a foot wide. Flowers form on the tips of the stems.

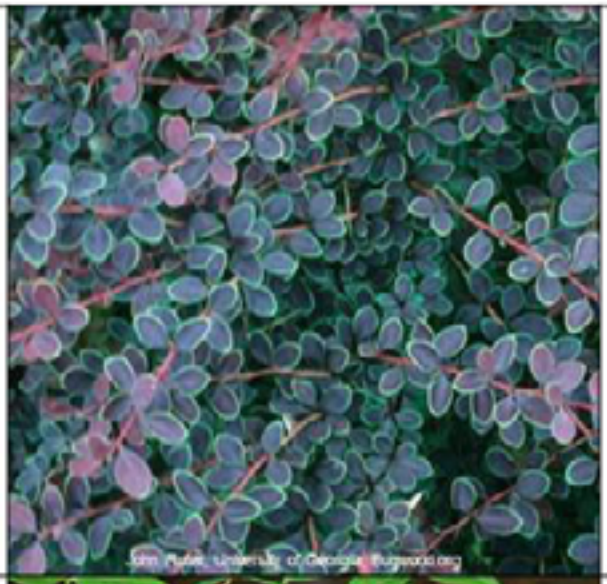
Shrub
Emerging Threat

Like many invasive plants, Meadowsweet is able to reproduce and spread quickly. One Meadowsweet plant can produce hundreds of seeds in a single growing season.

Common Invasive Plant Species in Greenville, SC

Japanese Barberry
Berberis thunbergii

ID: 2-8 feet high with thick zig-zag stems and small oval leaves green-blue to purple in color with smooth margins arranged in alternate clusters along the stem. Thorns. Bright red berries.



Shrub
Alert

Tell it apart from the native barberry: Japanese Barberry has smooth leaf margins while our native barberry has toothed leaves.

Nandina, Sacred Bamboo
Nandina domestica

ID: Shrub up to 8 ft tall. Leaves are large doubly compound arranged alternately and whorled on the stem. Stem is brown with overlapping sheaths, resembling bamboo. Bright red berries in clusters during winter.

Shrub
Alert

Introduced from Asia and used as an ornamental landscape plant, Nandina is now escaping into forests.

Wineberry, Wine Raspberry
Rubus phoenicolasius

ID: Shrub, stem up to 9 ft tall with purple hairs, appearing reddish. Compound leaves with 3 finely toothed and lobed leaflets. Leaves are hairy and silvery on the bottom. The fruit looks like a raspberry and is edible.

Shrub
Alert

Wineberry is considered invasive in North Carolina and is on the Alert list for South Carolina.

Common Invasive Plant Species in Greenville, SC

English Ivy
Hedera helix

ID: Evergreen woody vine up to 90 feet long. Leaves alternate with variable shape, typically with 3 or 5 lobes, smooth margin, and white veins. Vine forms thick mats on the ground or around trees.

Vine

Severe Threat

Tell it apart from native grapevines: native grapes have leaves that are similar in shape but not as thick and often hairy, while English ivy leaves are smooth.

Japanese Climbing Fern
Lygodium japonicum

ID: Vining fern up to 90 ft long with a very slender but strong stem. Leaves opposite on the vine, compound and highly variable in shape, and a lots of small lobes in the margin of the leaflets.

Vine

Severe Threat

The Japanese Climbing Fern produces spores that can be seen in two rows along the underside of the margins of smaller leaflets. These seeds are dispersed to new areas by the wind.

Japanese Honeysuckle
Lonicera japonica

ID: Trailing or climbing vine up to 80 ft long with oval leaves opposite in pairs along the stem. Flowers are long tubes: yellow, white, or cream in color. Stems are reddish brown and hollow. Fruit is blue-black berries.

Vine

Severe Threat

Tell it apart from native honeysuckles because young Japanese Honeysuckle vines are hairy while natives are smooth. Also, Japanese Honeysuckle grows very densely in thick, smothering mats, while natives do not.

Common Invasive Plant Species in Greenville, SC

Kudzu
Pueraria montana

ID: Woody vine with a thick stem. Leaves are alternate and compound with 3 leaflets. Middle leaflet has two lobes and each side leaflet has a single lobe. Pea-like flowers in clusters: purple in color.

Vine
Severe Threat

Introduced for erosion control and feed for cattle, Kudzu is a major problem in South Carolina, forming dense mats along roadsides, fields, stream banks, and forest edges.

Wisteria
Wisteria sinensis
Wisteria floribunda

ID: Thick woody climbing vine up to 75 ft long. Leaves are alternate and compound with 7-19 leaflets with a smooth but wavy margin. Large clusters of pink, white, or purple flowers. Very fragrant.

Vine
Severe Threat

Chinese and Japanese Wisteria are difficult to tell apart because they can cross breed. Infestations of Wisteria are common when the vine escapes from a place where it was planted for landscaping.

Periwinkle
Vinca major
Vinca minor

ID: Evergreen vine, growing along the ground up to 3 ft long and 1 ft high. Leaves opposite, glossy with slightly turned under smooth margins. Purple flowers with a central tube and pinwheel like petals.

Vine
Severe Threat

Tell it apart from Carolina Jasmine which is trailing and climbing, has reddish stems, widely spaced opposite leaves, and yellow flowers.

Common Invasive Plant Species in Greenville, SC

Chinese Yam, Air Potato

Dioscorea polystachya

ID: Climbing vine up to 65 ft long. Leaves are alternate and heart shaped, tapering to a point with long petioles and smooth margins. Small "potato-like" fruit at base of petioles.

Vine

Significant Threat

This vine dies back in the Winter but can quickly cover a tree in the Spring. The "Air Yam" fruit drop and grow into new plants, often spread into new areas by water.

Oriental Bittersweet

Celastrus orbiculatus

ID: Climbing and trailing vine up to 60 ft long with leaves alternate on the stem and glossy with finely toothed margins. Tiny greenish flowers. Fruits are yellow capsules with 3 red berries inside.

Vine

Significant Threat

Tell it from American Bittersweet: Oriental Bittersweet produces lots of berries along the stem at the leaf axils while American Bittersweet produces fewer berries in clumps at the end of the stem.

Yam-leaved Clematis

Clematis terniflora

ID: Climbing vine up to 30 ft long leaves compound with 3 to 5 leaflets with smooth margins, opposite on the vine. The stem of the vine sheds in strips. White flowers with four petals.

Vine

Significant Threat

Tell it apart from native Clematis vines: native Clematis have leaflets with toothed margins while the Yam-leaved Clematis leaflets have smooth margins.

Common Invasive Plant Species in Greenville, SC

Purple Crownvetch

Securigera varia

ID: Vine, grows along the ground up to 9 ft long. Leaves are compound with 9 to 25 leaflets. Long green stalks lead to a cluster of white, pink, or purple flowers.

Vine

Emerging Threat

Purple Crownvetch has underground stems called rhizomes that aboveground plants sprout from. A single plant can cover up to 100ft in 4 years.

Japanese Dodder

Cuscuta japonica

ID: Parasitic vine, highly branching with yellow fleshy stems. Leaves are tiny and scale like. Light yellow flowers in late Summer and early Fall.

Vine

Alert

Japanese Dodder is a parasite that feeds on the host plant. When enough is present, it kills the host plant.

This is a compilation of Trees, Shrubs, and Vines listed in the South Carolina Exotic Plant Pest Council's 2011 Terrestrial Exotic Invasive Plant Species List for the Piedmont and Mountain Region of South Carolina. Photographs were taken by J. DuRant unless otherwise credited.

Terminology (from SC-EPPC):

Severe Threat: known to cause a severe threat to natural areas in SC
Significant Threat: an invasive in SC that does not spread as easily as severe threats
Emerging Threat: a plant found in SC or neighboring states that forms infestations and is difficult to manage or is very widespread
Alert: a plant known to cause severe damage in neighboring states and is either not in SC yet or is present in a limited amount

Identification and accompanying information is presented using simple terminology for the amateur botanist. For more information, visit SC-EPPC and the websites listed in the reference section.

★: has been found in the wild in Greenville county (EDDMaps.org)

★: has been found in the wild in a neighboring county (Anderson, Laurens, Pickens, Spartanburg, or Henderson)

References:

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Going Native: Invasive Exotic Plants of the Southeast. NC State University. Accessed June 2012. http://www.ncsu.edu/goingnative/howto/mapping/invexse/index.html

Miller, James. 2003. Nonnative Invasive Plants of Southern Forests. Revised August 2003. Gen. Tech. Rep. SRS–62. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.
http://www.invasive.org/eastern/srs/index.html

The Plant Conservation Alliance's Alien Plant Working Group. Least Wanted: Alien Plant Invaders of Natural Areas Fact Sheets
http://www.nps.gov/plants/alien/trees.htm

USDA Forest Service: Forest Invasive Plants Resource Center. Accessed June 2012. http://na.fs.fed.us/spfo/invasiveplants/index.asp

Top: Students snack on Kudzu leaf chips
Middle: An Urban Naturalist shows off her kudzu vine crown
Bottom: An Urban Naturalist wears an invasive vine necklace

Invasive Plants Activities:

Perform an invasive plant removal project: Coordinate with the appropriate authorities and/ or property owners and get permission to remove invasive plants.

Kudzu and Wisteria are both good candidates for removal since they are vines. Make sure to wear safety equipment including long pants and gloves, and be careful that you are not removing native vines or poison ivy.

Eat kudzu chips: many of the introduced plants in the US are agricultural in nature. Though kudzu wasn't introduced as a food crop for humans, the leaves and blossoms are edible.

MAKE SURE IT'S KUDZU AND NOT POISON IVY!

- Choose younger, more tender leaves
- Wash thoroughly and soak in salted water
- Pat dry and place in dehydrator on medium/low heat
- Once crisp, add salt or herbs to taste and try some kudzu chips

Make baskets or wreaths with invasive vines. Kudzu works well, but so does wisteria, honeysuckle, and others. Once again, make sure that you aren't picking poison ivy. It's best to pick vines when they have leaves in order to make sure that they are safe.

Make a simple vine wreath by forming a circle and twisting the rest of the vine around and around the base vine. Add more vines, twisting continuously and tucking in the loose ends until you are satisfied with the size of your wreath. Set it aside to dry.

For a more complicated project, make a basket. Directions available here: http://www.knowitall.org/naturalstate/html/kudzu-basket/Kudzu-Picture.cfm

Go on an invasive species ***walk and identify*** the invasive species that you discover. Invasive plants are often common along road sides and corridors such as the swamp rabbit trail.

*The guide on the previous pages is only for trees, shrubs, and vines. You could have students do their own *research an* ***invasive animal or herbaceous plant not in the guide,*** present to the class, and then look for those as well.

Sites to begin research:
Invasive Aquatic Invertebrates: http://www.dnr.sc.gov/marine/sertc/invasive-inverts.htm

Invasive Aquatic Plants: http://www.dnr.sc.gov/marine/sertc/invasive-plants.htm

Noxious Weed List (Invasive Herbaceous Plants): http://plants.usda.gov/java/noxious?rptType=State&statefips=45

Animal Possibilities for Research Include (some are already established in SC, while others are threats):

Feral Pigs	Nine Banded Armadillo
Kudzu Bugs	Hemlock Woolly Adelgid
Asian Carp	Nutria
European Starling	Red Imported Fire Ant
Boll Weevil	European Gypsy Moth

Create an educational poster, flier, or commercial about the invasive species in your area.

Top: An Urban Naturalist takes photos of invasive vines during a nature walk
Middle: An Urban Naturalist field trip on the Swamp Rabbit Trail provides students with ample opportunities to observe invasive plants
Bottom: An Urban Naturalist identifies an invasive tree using the photo guide

Glossary

A

Abiotic
Not living.

Abundant
More than is essential; existing in a large amount

Adaptation
A physical, behavioral, or morphological trait that allows an organism to survive in its environment.
The adjustment of an organism over time in such a manner that it becomes more suited to its environment.

Adventitious Root
A root that has developed on a part of the plant other than the underground portion of the plant (where the root usually occurs)

Aerial
Relating to or occurring in the air.

Algae
A diverse group of photosynthetic, aquatic organisms that vary from unicellular organisms to large multicellular plant-like organisms (giant kelp).

Amniotic Egg
An egg with a hardened outer shell and amniotic fluid inside in which the embryo can develop. The amniotic egg is one of the adaptations that allowed reptiles to evolve to live away from water, as the egg makes it possible for the embryo to develop in fluid without having to be surrounded by water. All birds, most reptiles, and even some mammals have amniotic eggs.

Amphibian
A vertebrate animal that is ectothermic, has porous skin, and lives some part of its life cycle in water. Most amphibians go through metamorphosis. Due to their porous skin, they are highly sensitive to pollutants and are considered indicator species.

Angiosperm
A flowering plant in which the mature seeds are surrounded by some sort of tissue. This tissue is considered the plant's fruit and may be fleshy, such as the fruit of an Apple tree, hard, such as the fruit of an Oak, or dry and papery, such as the fruit of a Maple.

Antennae
A set of paired, often segmented, sensory organs found in Arthropods.

Anthropogenic
Of or relating to or caused by humans.

Anthropomorphism
To ascribe human characteristics, feelings, motivations, or behaviors to anything other than a human, such as a plant or an animal.

Appropriate
Correct or proper for the situation.

Aquatic
Relating to or living in or living on water.

Arachnid
A type of arthropod characterized by having four pairs of segmented legs and two main body parts, the abdomen and cephalothorax. Arachnids include spiders, ticks, mites, and scorpions.

Arthropod
An invertebrate organism with a segmented body plan, segmented appendages, and an exoskeleton. Arachnida, Insects, and Crustacea (Arachnids, Insects, and Crustaceans) are all Classes in the Phylum Arthropoda.

Aspirator
A tool used by scientists that uses suction to move or collect materials, such as bugs or serums.

Autotroph
An organism that is able to make its own food by turning organic substances into inorganic ones. Most plants are autotrophic.

B

Bark
The hard outermost protective layer of stems, shrubs, and roots of woody plants, covering xylem and phloem in nutrient transport.

Beak
The protruding mouth structure of a bird. Beaks are made up of keratin.

Beneficial Organism
A living plant or animal that has a positive impact on their environment from an anthropogenic point of view; a biological control agent that functions naturally as integrated pest management; by helping to control pest populations.

Benthic
The lowest layer of an aquatic habitat, namely of an ocean or lake, includes the sediment and sub-surface and all of the organisms that live there.

Bioassessment
A scientific study using biological organisms to determine the relative health of an ecosystem.

Biodiversity
The amount of different species of plants and animals in a region, including genetic diversity within a species. Biodiversity can also be expanded to include variation in genetics, ecosystems, communities, and complex assemblages of organisms.

Biological Control
The process of using a biological organism to reduce pest populations.

Biological Organism
An individual living thing that can react to stimuli; something that has a system with the ability to function and carry out the processes of life.

Biology
The scientific study of all living and nonliving things.

Biotic
Living

Birds
Vertebrate animals that are endothermic, have feathers, fused skeletons, beaks, wings, and lay amniotic eggs.

Blaze
A colored marking that denotes a trail.

Botanical
Relating to plants.

Botany
A branch of the biological sciences that studies plants.

Branches
A secondary set of woody shoots or stems extending from the trunk of a tree that helps provide structure and support, while promoting growth of the plant.

C

Canopy
The uppermost group of branches and foliage on trees. The canopy layer in a forest includes the branches and leaves of the tallest trees as well as the other plants and animals that live in this layer.

Carbon Sink
An item, often an area of vegetation, that is able to absorb more carbon than it produces.

Carnivore
An animal that only eats proteins coming from other animals (meat).

Climate
Description of the characteristic weather conditions in a particular geographic area, partially based on average temperature and rainfall.

Compass
A navigational instrument used for determining directions. It has a magnetized needle indicating a magnetic north and south.

Compass Rose
A pictorial representation drawn on a map that shows the correct orientation of the map.

Cone
The hard oval-shaped reproductive structure of a conifer.

Conifer
Gymnosperm trees that produce cones as reproductive structures, usually have needle or scale-like leaves, and often keep their leaves year round.

Conservation
The protection and management of resources and/or land to ensure longevity and preservation.

Crop
Plants that are intentionally cultivated in areas for purposes such as landscaping or food.

Crown
The uppermost part of a tree including the leaves, stems, and branches coming out of the trunk.

Cryptic Coloration
The camouflaged appearance of organisms that blend in with their environment.

D

Data
Individual bits of information used to represent ideas, theories, conclusions, or objects.

Deciduous
Type of trees and shrubs that shed their leaves annually, usually during the fall and winter. Most deciduous species are angiosperms, but some gymnosperms (Dawn Redwood, Cypress, Ginkgo) are deciduous.

Decomposer
A species that ingests and breaks down dead organic matter.

Defense
Something that acts to prevent or discourage attack or injury.

Density
The concentration of items or individuals per unit size. In city planning, density refers to the concentration of dwelling units per acre of land. In the biological sciences, density refers to the number of individuals in a specific area.

Detritus
Dead organic matter, usually including fallen leaves, sediments and the bodies of dead organisms.

Development
Human induced change of a land area intended to bring about growth. Includes the construction of buildings, zoning, building relocation, improving real estate, paving, excavating, etc.

Dichotomous Key
A tool used for identification that utilizes paired questions that lead to a final answer.

Dicot
An angiosperm (flowering plant) that has two seed leaves, called cotyledons. Dicots generally have broad leaves on stalks.

Direction
The way that something is facing or moving (North, South, East, West, etc.), or part of a set path for getting from a starting point to a destination.

Disease Vector
An agent such as a person, animal, or microorganism that aids in disease transmission; it carries a disease from an infected individual to an uninfected individual.

Dispersal
Movement of organisms away from a starting point.

Dissolved Oxygen
The amount of oxygen dissolved in water. This is especially important for aquatic animals as a high level of dissolved oxygen allows for many organisms to survive. Many pollutants negatively impact the concentration of dissolved oxygen in water.

D-Net
An aquatic net opening in the shape of a "D" used to collect macroinvertebrates. The flat side is placed on the stream bottom while sediment is moved around upstream.

Dormancy
A time or state of being in which physiological and biological processes are slowed down, often occurring during a time of environmental stress such as a wetland drying up or winter.

E

Ecology
A branch of biology studying the complex systems and relationships that exist among organisms and the abiotic factors that make up ecosystems.

Economics
The social science studying the production, consumption, distribution, and transfer of goods and services.

Ecosystem
All living and nonliving components of a community that interact to form an ecological system. Examples of ecosystems include deserts, grasslands, tundra, marshes, lakes, and tropical rain forests.

Ecosystem Engineer
An organism that alters and shapes the environment in a way that affects other organisms by constructing what it needs for survival. Examples: a bird building a nest, a beaver building a dam.

Ecotone
A habitat that is a transitional zone between two distinctly different ecosystems that contain organisms found in the bordering areas as well as organisms distinct to the ecotone. For example, many wetlands are ecotones between many aquatic habitats and terrestrial habitats.

Ectothermic
Organisms that depend on an external source, such as the sun, to regulate body temperature; also known as cold-blooded.

Elytra
The hardened front pair of wings to create a protective shell. A characteristic shared by all beetles.

Emergency
An unexpected and often dangerous situation or circumstance that requires immediate action to be taken.

Endangered species
A group of species that has a dwindling population or low number of individuals, and is under the threat of extinction.

Endemic
Naturally occurring in a region or specific to a particular area, ecosystem, or habitat.

Endothermic
Capable of self-regulating body temperature internally; also known as warm-blooded.

Environment
All living and nonliving factors that affect an individual throughout its life cycle.

EPT
Three insect orders whose larval stages are most sensitive to dissolved oxygen levels and stream health that are used in some bioassessments as indicators of stream health. E = Ephemeroptera (Mayflies) P= Plecoptera (Stoneflies) T= Trichoptera (Caddisflies)

Erosion
The movement of soil particles or sediments by wind or water.

Exoskeleton
The hard exterior shell of organisms such as insects and arthropods that provides protection and support

Exotic species
Any plant or animal that is not native to a region. Not all exotic species become invasive species, but all invasive species are exotic.

Expedition
A trip that has the specific purpose of discovery or learning

F

Feathers
The appendages on birds that are made up of beta keratin and consist of a hollow quill and central shaft from which vanes emerge. All birds have feathers.

Fern
A primitive group of vascular plants that reproduce by spores instead of seeds.

Filtration
The process or act of separating something. Usually the process or act of separating solids out of a liquid, and allowing the liquid to pass through.

Fire Regime
The characteristic fire patterns of a habitat, ecosystem, or region. Including the common frequency, size, and intensity of fire events.

Food Chain
An inter-related sequence of organisms in an ecosystem that denotes the flow of energy as organisms eat other organisms below them in the chain.

Forestry
The management of forests; includes developing, cultivating, growing, harvesting, transporting, and selling trees for commercial use and management of forest ecosystems for wildlife habitat, recreation, conservation, and other uses.

Freshwater
Water that has a very low concentration of dissolved salts. The initial source of most freshwater on Earth is precipitation.

Frugivore
An organism whose diet consists mainly of fruit

Fruit
The ripened ovary or ovaries of angiosperms that have some sort of covering and contain seeds.

Fungi
A Kingdom of eukaryotic organisms that are heterotrophic, have filamentous structure of mycelium, cell walls made of chitin, and reproduce through spores.

Fused Skeleton
The type of skeletal structure found in birds where bones have been joined together to create a stiffer structure.

G

Garden
A managed plot of land used to grow plants such as flowers, fruits, vegetables, and herbs.

Germinate
Begin to grow or sprout

Gills
Respiratory organs found in most aquatic animals that allow the animal to extract Oxygen from the water. Also, the plate-like structures on the underside of the cap in some mushrooms where spores form.

Growth Habit
A characteristic look or pattern of development.

Gymnosperm
A type of tree classification referring to plants that produce cones instead of flowers and fruit. Most gymnosperms keep their leaves, which are typically needle or scale-like, during the winter and are commonly called conifers and evergreens.

H

Habitat
The physical environment in which an organism, species, or population naturally dwells.

Habitat Destruction
The damage done to a natural habitat that renders it unable to support species present.

Halteres
The knob-like, reduced and modified second pair of wings found in Flies that aid in flight.

Herbaceous
Non-woody vascular plants that have leaves and stems.

Herbivore
An organism that gets all of its food and energy supply through consuming only vegetation.

Herpetology
The scientific study of reptiles and amphibians.

Heterotroph
An organism that is unable to make its own food, but instead depends on obtaining complex organic substances from external sources for nutrition.

Horizon
The far-out apparent intersection where the earth meets the sky.

Host
An organism that sustains the life of a pest, parasite, or infectious organism, usually at the detriment of that individual.

Hydrology
The movement of water through and over the land. Includes evaporation, precipitation, absorption, above and below ground flow, recharge, discharge, and other parts of the hydrologic cycle.

Hyphae
The branching, thread-like filaments that form the mycelium of a fungus.

I

Identification
The process of assigning specific scientific names to organisms as a way to categorize, remember, and recognize those same individuals later.

Indicator Species
A species that is a sign of the relative health or state of an ecosystem, either through the presence, absence, or well-being of the species in a particular habitat. Scientists use indicator species as guides for determining areas and issues that need further study.

Indigenous
Belonging and originating from a particular place, native.

Insect
Animals in the Phylum Arthropoda and the Class Insecta. All insects have an exoskeleton, segmented bodies with three distinct body parts; a head, thorax, and abdomen, as well as 3 pairs of segmented legs.

Insectivore
Animals that mainly eat insects; examples: moles, hedgehogs.

Instar
The developmental stage of an arthropod between molts, most often used to describe larval and young forms.

Introduced species
Species living in an area outside of its natural geographic range; they are either intentionally or unintentionally brought in to a new environment.

Invasive species
Any exotic (non-native) plant, animal, or pathogen that can out-compete native species and causes environmental, economic, or human damage in a new environment.

Invertebrate
An organism lacking a backbone. Examples include spiders, crabs, insects, etc.

K

Keratin
A structural protein that is tough and fibrous and makes up nails, horns, beaks, hooves, and hair.

Key
A designated portion of a map detailing map symbols and definitions. Something important that helps defining or unlocking something else.

Kingdom
A taxonomic category that groups like organisms at a very broad level. Some kingdoms include Plants, Animals, Fungi, and Bacteria.

L

Landscape
An expanse of natural scenery displaying all of its physical and visual characteristics.

Landscaping
The alteration of the appearance of the land through the planned placement and care of living and non-living features such as walkways, walls, gardens, lawns, fountains, ponds, and other design features. Most often used in conjunction with the built environment.

Larva
The immature stage of an insect that shows complete metamorphosis (holometabolous development). The larva differs greatly from the adult insect, with reduced features, few or no legs, and an absence of wings, and often lives in a different ecosystem than the adult.

Legend
A pictorial and text key to a map that shows what the symbols on the map represent.

Lichen
An organism that is a symbiotic relationship between a fungus and an algae where the fungus provides structure and the algae produces food through photosynthesis

M

Macroinvertebrate
Invertebrates (animals without a back bone) large enough to be seen without the need for a microscope.

Map
A pictorial representation of a place.

Metamorphosis
A state in which a biological organism changes physical form or structure in a dramatic fashion over a relatively short period of time.

Microclimate
Small areas where the climate varies from the larger surrounding area.

Migrate
When an organism moves from one habitat or region to another, often seasonally.

Mimicry
The ability of an organism to resemble natural objects in its surroundings, camouflage.

Molt
The process of losing or removing the outer skin, feathers, or exoskeleton.

Monocot
An angiosperm (flowering plant) that has a single seed leaf, called a cotyledon. Monocots generally have leaves with parallel veins

Moss
A non-vascular plant that reproduces by spores, has flagellated sperm, and needs moisture in order to reproduce.

Municipality
The governing body of a city or town.

Mushroom
The fruiting body of a fungus.

Mutualism
A relationship between two organisms in which both organisms benefit. For example, insects such as bees and butterflies depend on flowering plants nectar for their food supply and flowering plants depend on them for pollination. Each provides the service the other needs.

Mycelium
The main body of a fungus consisting of interwoven filamentous cells called hyphae with cell walls made of chitin.

Mycorrhizae
Fungi that form symbiotic relationships with the roots of plants where the fungus provides extra surface area and increased absorption of nutrients from the soil for the plant and the plant provides sugar from photosynthesis for the fungus. Some mycorrhizae are highly specific to plant hosts while others are generalists.

N

Native species
A population of plants or animals that originate from a specific region and/or habitat.

Natural
Something existing or occurring apart from human intervention or activity.

Natural Enemy
A biological organism that leads to the death of another organism.

Naturalized
A species that has been introduced and then fully adapts and is grafted into a particular community, region, or ecosystem.

Navigation
The act of utilizing a system to find your way from one location to another.

Niche
The specific role or function of an organism within its ecosystem.

Node
The point on a plant stem where leaves develop.

Non-point source pollution
Any pollution that comes from a diffuse source. Examples of non-point source pollution include storm water runoff from urban streets, excessive fertilizer from agricultural production, pet waste, faulty septic systems, and sediment from construction sites.

Nutrient Cycling
The process by which nutrients move through an ecosystem.

Nymph
An immature stage of an insect that goes through incomplete metamorphosis

O

Observation
The act of studying or learning more about an object or organism through one of the five senses.

Omnivore
An organism that gets its energy through consumption of both plants and animals.

Order
A sequence or ranking used to classify organisms, with those of similar characteristics. The taxonomic ranking system in order from broadest to most closely related goes Kingdom, Phylum, Class, Order, Family, Genus, Species

Orientation
The direction an object is facing.

Oviparous
A reproductive system in which eggs are laid externally and the young hatch from the egg.

Ovoviviparous
A reproductive system in which eggs are produced inside the body of the female and the young form inside the eggs, not receiving any nourishment from the body of the mother. Once they are fully formed, the young hatch from the eggs while still in the mother's body and are born live.

P-Q

Parasite
An organism that lives in or on its host and survives by obtaining nutrients at its host's expense without providing any benefit to the host. Examples include tapeworms and ticks

Parasitoid
Insects that live as parasites in or on the body of a host during its developmental stage as larvae and eventually lead to the death of the host. Examples include: parasitic wasps and tachinid flies.

Pathogen
A biological organism that causes disease.

Pest
A destructive insect, plant, or animal that is not wanted in a particular place, typically because it causes damage or disease. Examples include rats, mosquitos, and aphids.

Phloem
A tissue that is the part of the vascular system of a plant responsible for transporting sugars, or food, throughout the plant.

Photosynthesis
The chemical process that green plants undergo to make their own food. Energy from the sun is used to convert carbon dioxide and water to glucose for the plant, and oxygen is released as a by-product.

Plant
A photosynthetic organism that grows on its own, is typically anchored in soil, and usually has green leaves.

Plumage
A bird's feathers

Pollinator
An organism that moves pollen from one plant to another, aiding in plant reproduction.

Pool
A microhabitat in a stream or river that is deep with a fine sediment bottom of sand and silt and slow moving water. Pools are bowl like depressions in the bottom of the channel.

Porous
A substance that allows the passage of gasses or liquids via small holes or channels (pores).

Potential
Possible, having the capability to become something.

Predator
An organism that hunts and kills other organisms for its own survival.

Prey
Organisms in the food chain that are hunted and eaten by larger animals. Predation denotes a flow of energy between organisms in the food chain from the prey animal to predator.

Producer
An organism that is able to make its own food.

Pupa
The stage of life that occurs between larva and adult in insects that show complete (holometabolous) metamorphosis. During the pupal stage, the larva does not move or feed, but transforms completely from the larval to the adult form.

R

Rare
Something that is not seen often or does not occur frequently.

Reptile
An ectothermic, vertebrate animal. Reptiles have amniotic eggs and scaly non-porous skin and include snakes, turtles, lizards, and alligators.

Resilient
Able to easily resist or recover from a disturbance or shock.

Resource
A source or supply that can be taken from for support or use.

Respect
To value or admire someone based upon their abilities or qualities; to treat something as if it has value.

Responsibility
Something that you are accountable for.

Rhizome
A structure found in some plants that is an underground stem. Rhizomes may store extra food reserves for the plant and can be a source of vegetative reproduction, creating new sprouts and roots from nodes.

Riffle
A stream or river microhabitat that is characterized by shallow and fast moving water. The substrate is usually coarse stones and gravel with areas where the substrate breaks the surface of the water.

Roots
Part of a plant that extends from the trunk or main stem into the soil to help anchor the plant and absorb nutrients from the soil.

Run
A stream or river microhabitat with fast to moderate speed water where no substrate breaks the surface of the water.

S

Safety
Being protected from risk or danger.

Sample
A small piece or part of something that should be representative of the whole. To collect a small piece or portion of something for analysis in order to learn **something about the whole.**

Scale
A hardened plate-like structure that covers and protects the body of some animals including reptiles and fish.
Or
The relation in size between a distance on a map or model and the same distance in real life.

Scavenger
An animal that feeds on dead or decaying organic matter.

Seed
The fertilized ovule of a plant.

Sediment
Soil matter, such as sand, silt, clay, and minerals, that has been or is being moved by wind or water.

Sensitive Species
Any plant or animal classified as having the potential to become endangered in the near future due to living in a particular environment or being sensitive to change.

Shrub
A plant with multiple woody stems.

Solute
A substance that is dissolved in a liquid.

Species
The most basic taxonomic level. Organisms that share genetic heritage and can reproduce viable offspring.

Specimen
A part or individual selected as an example for scientific study or display.

Spider
A type of arachnid that has two main body parts (head and cephalothorax), eight legs, and an exoskeleton. Most spiders use venom to kill their pray and spin webs in order to capture insects.

Spore
A usually single celled, thick walled reproductive structure found in ferns, mosses, and fungi that gives rise to a new organism.

Stomata
Small openings located mainly on the bottom side of a leaf that allows trees to absorb carbon dioxide and other gaseous compounds from the air.

Storm Water Runoff
Surplus water runoff resulting from rainfall that does not seep into the earth. Impermeable surfaces in cities and the compaction of soil contribute to large amounts of storm water runoff

Sustainability
Meeting present needs without compromising our ability to supply for future needs. The ability to last a long time with minimal input. A way of living, growing, and developing as a society that takes into consideration the interaction and needs of the three P's: planet, people, and pocketbook.

Symbiosis
A mutually beneficial relationship between two organisms.
.

T

Terrestrial
Living primarily on the land.

Threat
Something likely to cause danger or damage

Threatened Species
A region's native species that is at risk of becoming endangered in the coming future.

Topography
A representation of earth's physical land surface including elevation, position, and slope.

Toxic
Poisonous

Trailing
To extend along the ground; a growth form in vining plants that involves growing along the ground.

Trunk
The woody base of a tree connecting the roots and the crown, usually the thickest part of the tree responsible for supporting the tree and carrying nutrients from the roots into the branches.

U

Urban
Of or pertaining to a developed area or a city.

Urban Heat Island
An area of human development that is warmer than the surrounding undeveloped area.

V

Vascular Plant
Any type of plant that has vascular tissues to transport water, nutrients, and other substances throughout the plant.

Vegetative Reproduction
A type of reproduction found in plants where a new individual is formed from the parent without the need for sexual reproduction (no seeds or spores). Vegetative reproduction often occurs by new plants sprouting from rhizomes.

Velocity
The rate of how fast and how far an object travels during a specific length of time.

Venom
A poisonous liquid secreted by certain animals, such as snakes or spiders, that kills or paralyzes prey by transmission following a bite or sting.

Vertebrate
A living organism having a backbone or spinal column.

Viviparous
A reproductive system where the young develop within the body of the mother, absorbing nutrients from the mother during development and are born live.

W

Water Quality
The physical, biological, and chemical characteristics of water that determine the suitability of water for any intended use.

Way Finding
The act of using maps, compasses, trail markings, and other tools for navigating from one point to another.

Weather
The state of the atmosphere (temperature, cloud cover, precipitation or lack thereof, etc.) at a specific time in a specific place. The weather of an area is always changing, while climate remains relatively constant.

Wetland
A habitat where the soil is saturated at least some part of the year.

X-Z

Xylem
Part of a plant's vascular system responsible for transporting water from the roots to the leaves.