Greenville's Greener Streets

A Compilation of Interdisciplinary Educational Programming Designed to Introduce Students to the Benefits of Trees in the Urban Environment Developed for Greenville, South Carolina

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Greenville's Greener Streets Program

A compilation of educational programming related to trees in the urban environment developed by the Livability Educator for the City of Greenville.

Though often overlooked, trees are an essential part of a healthy urban environment. Trees clean our water and air, cool our homes, help our streets last longer, provide habitats for animals, and much more. Helping students develop a familiarity with and an appreciation for the benefits that trees provide us will enhance their connection to the place where they live, and encourage them to protect and conserve trees.

The lessons, information, and materials in this program have been compiled from the Urban Naturalist Program and the Community Quest Program, part of the Curriculum for Sustainability that was developed by the Livability Educator for the City of Greenville. This compilation was developed as part of a Green Streets Grant from TD Bank.

Acknowledgments

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TD Green Streets

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Introduction

About Greenville's Greener Streets Program

The Urban Naturalist Program and the Community Quest Program are both place-based interdisciplinary curriculum supplements developed through the Connections for Sustainability project by the Livability Educator for the City of Greenville, SC. Greenville's Greener Streets combines materials, background information, and activities from both of these programs as well as other lessons developed by the Livability Educator with a focus on trees in the urban environment.

Though primarily excerpted from the Urban Naturalist and Community Quest Programs, the materials presented in this compilation can be utilized as a stand-alone series, or as part of a wider program of study.

Program Objectives

- Introduce students to the concept that trees are an important part of the urban environment
- Develop an appreciation for trees and an understanding of the benefits that trees provide people and the environment
- Foster a sense of responsibility for the trees and our environment
- Learn very basic tree identification and care
- Fully integrate sustainability principles and conservation ethics into lessons in both the classroom and the field

Photos page 4: Top: *A Jr. Urban Naturalist draws a tree in his field notebook.* ***Bottom:*** *A community center student shows off her tree collage.*

Photos page 5: Top*: A first grade class works on leaf rubbings following a lesson about trees.* ***Middle:*** *Urban Naturalists identify a tree near the Swamp Rabbit Trail in Greenville, SC.* ***Bottom****: This American Beech Tree in Falls Park is a great example of the power of a tree's root system to hold soil in place.*

How to use Greenville's Greener Streets Program:

The lessons and materials in this compilation were written to be used by teachers in formal and informal educational programs with a range of grade levels. It is up to the individual educator to determine how they wish to use the programming. A wide range of suggested activities, writing prompts, and background information has been provided in order to make this program as flexible as possible.

Program Components:

- Background information - the background information provided in Greenville's Greener Streets Program is intended to provide the educator with the background information that they need in order to teach the program, including links to extra resources. It is suggested that teacher's read the program in full before deciding how they wish to convey the information to their class
- Word Bank - the word bank list can be used as a vocabulary list, as a word bank for writing prompts, as a research tool, or for reference. Not all of the word bank words can be found in the Program, but are related to the topic. Some are common vocabulary, while others are specific to the fields of science related to trees.
- Journal Prompts - the journal prompts are meant to be ideas for creative writing exercises that tie into these lessons.
- Student Handouts - where appropriate, student handouts are available for print, or to be saved and provided to the students electronically.
- Activities - rather than providing lesson plans, this program offers suggested activities that relate to the background information provided in each section. Activities are meant to be a starting point, and can be altered by the individual educator however needed to fit their classroom objectives.

State and local organizations with programs dedicated to protection, conservation, and promotion of trees. For more information, resources, possible service learning projects, speakers or field trip opportunities.

South Carolina Forestry Commission
The mission of the South Carolina Forestry Commission is to "protect, promote, enhance, and nurture the forest lands of South Carolina in a manner consistent with achieving the greatest good for its citizens." This includes rural and urban forests and their amenities (timber, wildlife, water and air quality, soil protection, and aesthetics.
http://www.state.sc.us/forest/

Trees SC
Trees SC, formerly known as the South Carolina Urban and Community Forestry Council, is a non-profit organization founded in 1991, promoting urban and community forest stewardship through emphasizing education, advocacy, and network. Their goals include increasing knowledge and awareness of the value of trees, facilitating information exchange about urban forest management, and encouraging active citizen participation in caring for urban forests. Their website has plenty of resources available about how to care, plant, establish, and protect trees.
http://www.treessc.org/

U.S. Endowment for Forestry and Communities
The U.S. Endowment for Forestry and Communities core objectives include education, especially for forest-reliant communities, and public-interest projects regarding forest management in timber-reliant communities. This mission of the Endowment is to foster public-private partnerships to advance sustainable change and management for the health and vitality of forests.
http://www.usendowment.org/home/staff.html

Greenville Tree Foundation
This organization, founded in 1980, enhances funding for tree planting within the City of Greenville. The Parks and Recreation Department of the City manage the Greenville Tree Foundation, and through it, more than 8,000 acres of trees have been planted. All donations are additionally tax deductible. Please see the link below for more information.
http://www.greenvillesc.gov/PlanningZoning/landscaping.aspx

Trees Greenville
Founded in 2005, Trees Greenville is a membership-based non-profit organization, whose mission is to plant, promote, and protect trees in Greenville County. They plant trees throughout Greenville, while teaching citizens how to properly plant and culitivate healthy urban forests. Trees Greenville also has a model middle school tree garden at League Academy.
http://www.treesgreenville.org/

What Is a Tree?

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

Word Bank

Plant
Conifer
Deciduous
Gymnosperm
Angiosperm
Seed
Cone
Photosynthesis
Carbon Sink
Vascular Plant
Xylem
Phloem
Roots
Bark
Branches
Trunk
Crown
Canopy
Botany
Stomata
Fruit

WHAT IS A TREE?

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.

What is a Tree Writing Prompts

Pretend that you have met an alien who is unfamiliar with life on Earth. Describe a tree to him.

List the main components of a tree and describe their functions and importance in your own words.

What characteristics of trees allow them to live longer than other types of plants?

In your own words, describe the differences between angiosperms and gymnosperms. Which type of tree is better suited to live in Greenville? Explain your answer.

Write a haiku about trees.

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.

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

Collecting and Preserving Botanical Specimens:

You may wish to have students collect leaves, flowers, fruit, or twigs from trees during your tree study. Pressed botanical specimens can be used to create individualized dichotomous keys, local area tree guide books, scrap books, collages, and many other fun and educational projects.

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. A simple press can be created in the classroom using lots of newspaper, cardboard, and heavy books, or you can build a plant press for the classroom or field. Once the pressed specimen is dry, it can be glued onto a piece of acid free herbarium quality paper in order to preserve it.

Bark is an important part of a tree and can be a distinguishing feature used in identification, especially when the bark is distinctive like the trees above.

Above: Bark of Flowering Dogwood
Middle: Bark of Loblolly Pine
Bottom: Bark of Sycamore

Top: Leaves, twigs, and flowers from trees like this Tulip Poplar make great botanical specimens.
Center: Students learn to press botanical specimens in a simple plant press.
Bottom: A pressed botanical specimen can be glued to paper for display or collection.

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. Do not open the press before the drying time is complete, or you may damage your pressed specimens.

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.

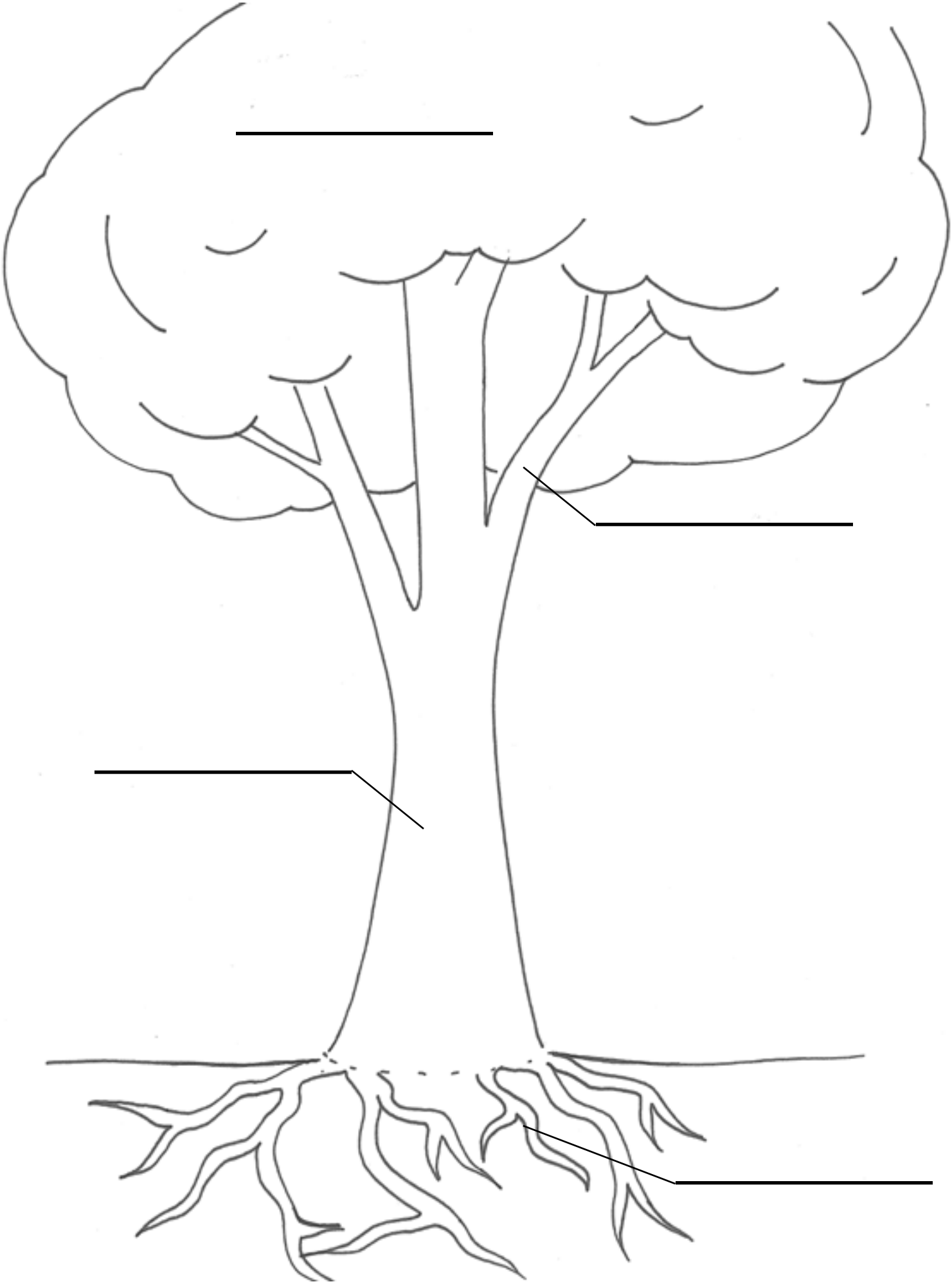
Do not take multiple specimens off of the same tree.

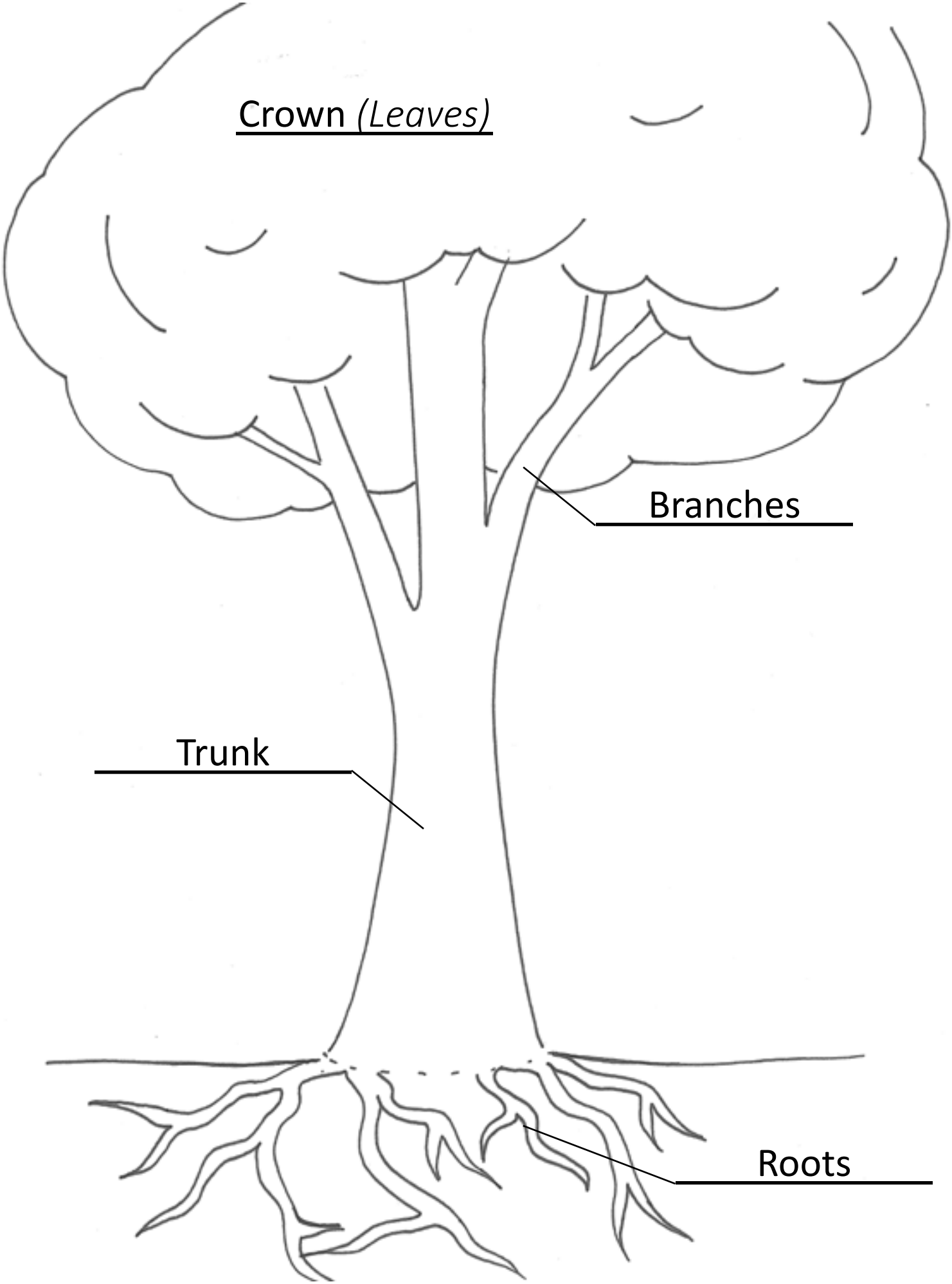
Leaves, flowers, and fruit that have already fallen off of a tree make great specimens, though if they are too dry, they may not press well. Encourage collection of botanical materials that do not require taking live specimens when possible.

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

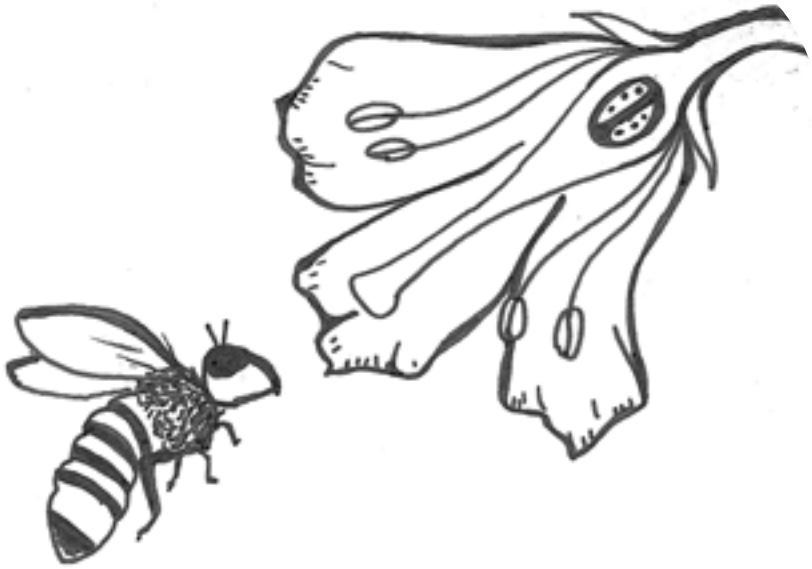
If you are using a large plant press, you may want to keep it in the classroom and have students collect and store plant specimens in folded newspaper inside file folders while in the field. OR have each student create their own simple press using cardboard, the same sandwich idea of newspaper, and place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

Plant presses are great for drying botanical specimens for scientific collection, herbarium specimens, gluing into a 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 to prevent mold.




Crown *(Leaves)*
Branches
Trunk
Roots

A Flower's Purpose



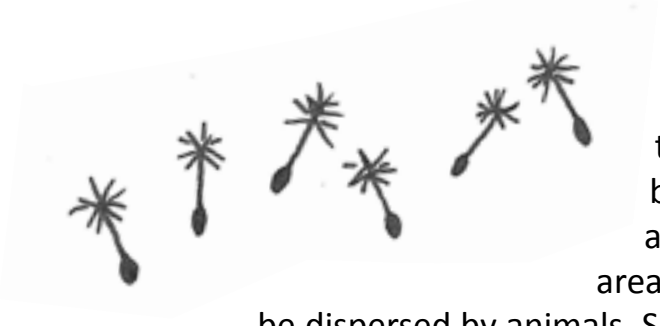
I am a beautiful flower.

Bright colors make me easy to see, and I smell terrific to the animals that make a special trip to visit me. I provide them with food, nectar or pollen as a gift because they do me a huge favor.

When an animal stops by, it picks up pollen from my stamens, and it transfers pollen from another flower's stamen to my stigma. This is how seeds are made.

Without me, my plant would have to rely on the wind to bring pollen to me, and my plant would need to produce a lot of pollen, like pine trees do.

Did you know that evey flowering plant species produces some kind of fruit? The fruits that you buy in the grocery store all started as part of a flower, but not all fruits are edible. When I make a seed, it is surrounded by tissue, and that tissue is called a fruit. Depending on what plant species I am attached to, the tissues surrounding the seed may be fleshy, thick and juicy, or even thin and dry. The type of fruit that I create also helps my plant to reproduce by helping to move my plant's seeds to new places. This is called dispersal, and without special dispersal mechanisms, my plant's seeds wouldn't go very far.



Some fruits are made to be dispersed by wind. These seeds may have sails or parachute-like attachments to help them fly. Some fruits are made to be dispersed by water and have an outer structure that is bouyant and acts like a small boat or is fluffy, with lots of surface area so that the fruit will float. Many seeds are made to be dispersed by animals. Some are meant to be eaten, like apples, while others have hooks that attach to fur or feathers, allowing the seed to hitchhike to a new place.

Flowers and fruit can be found on all trees that are angiosperms, and we come in all shapes, sizes, and colors. The next time you see a tree, look closely, and see if you can find me.

What is a Tree? Activities:

Go over the parts of a tree and their functions and the two major types of tree. Give students the tree sections coloring page worksheets to fill out.

In small groups, ask students to 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 and that students know what poison ivy looks like.

Discuss: Were students able to pick their tree? What about their tree made it possible for them to identify it?

Above: Plant part scavenger hunts with digital cameras can be a fun way to study trees
Middle: Leaves from most gymnosperms look like needles or scales in sharp contrast to leaves from angiosperm trees like this Maple leaf (Bottom)

Discuss the benefits of having flowers and fruit: ask students to read "A Flower's Purpose." Follow with discussion. Possible discussion or writing prompts include:

- The flower thinks that it gives a plant an advantage over gymnosperms. Do you agree?
- How does the flower help a plant reproduce?
- Not all flowers are brightly colored or smell very good. Why not?
- Why is seed dispersal so important to a plant?
- Name some fruits that you can eat that come from trees. Name some types of trees that produce fruit that you can't eat.
- The pollinator plant relationship is usually considered mutualistic, meaning that both the plant and the pollinator benefit from the relationship. This isn't always the case, though. Can you think of some instances where this relationship is not mutualistic? (ex; flowers shaped like insects to encourage mating behavior. More on mutualism between plants and pollinators here: https://www.boundless.com/biology/flowering-plants/mutualistic-interaction-between-plants-and-animals/mutualistic-interactions-between-plants-and-animals/)

Following discussion, examine some flowers and fruits from native trees. Compare them to cones from gymnosperms.

Some tree facts from NC State University:
http://www.ncsu.edu/project/treesofstrength/treefact.htm

Extra resources for lessons to tie into plant biology:
Wind dispersal lab:
http://www.botany.org/bsa/misc/mcintosh/dispersal.html

Flowers and fruits lab (high level, but includes useful information and could be altered to fit any grade level:
http://www.marietta.edu/~biol/introlab/Flowers%20and%20Fruits.pdf

Tree Identification

Key Concepts and Skills:

- Trees are plants that have a single woody trunk
- 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

*A companion Powerpoint presentation for tree identification is available for download with the Urban Naturalist Program on the Connections for Sustainability Educational Materials Website

Word Bank

Plant
Autotrophic
Monocot
Dicot
Photosynthesis
Producer
Vascular Plant
Dichotomous Key
Compound Leaf
Simple Leaf
Lobed Leaf
Toothed Leaf
Leaf Margin
Petiole
Vein
Pinnate
Palmate
Alternate Leaf
Opposite Leaf

Identifying Trees Journal Prompts

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.

Identify a tree to species using a dichotomous key and list the key characteristics that allowed you to identify that tree.

Chose a tree that you have identified and write a short story from that tree's perspective.

IDENTIFYING TREES

Background Information

A tree is a plant that has a single woody trunk.

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 Urban Trees Section.

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.

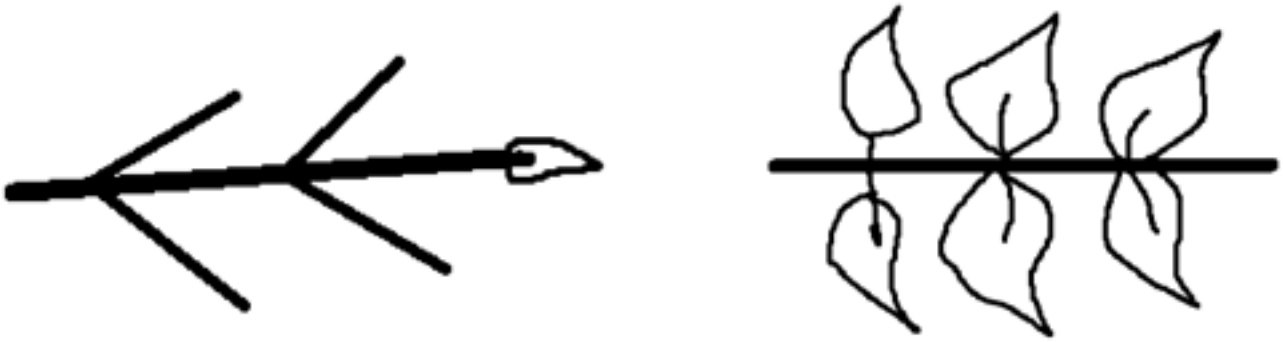
Vocabulary for using a tree key

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

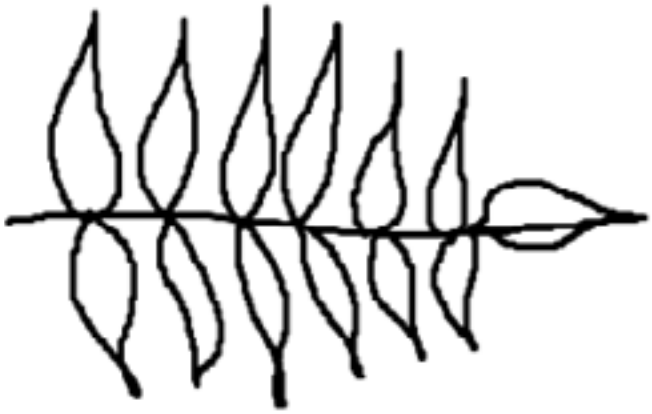
Alternate – a leaf or twig where two leaves or twigs grow in a zigzag pattern from different places on either side of a branch.

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

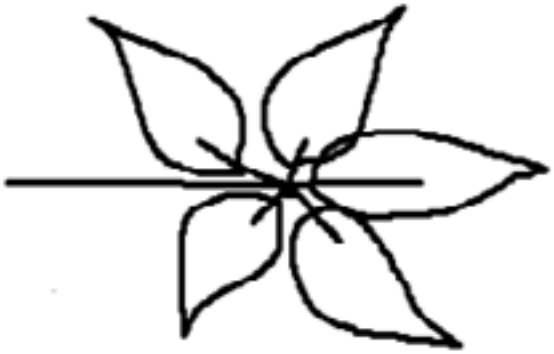


Simple Leaf – a single leaf coming from a leaf stem. The leaf stem becomes the midrib of the leaf.

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"

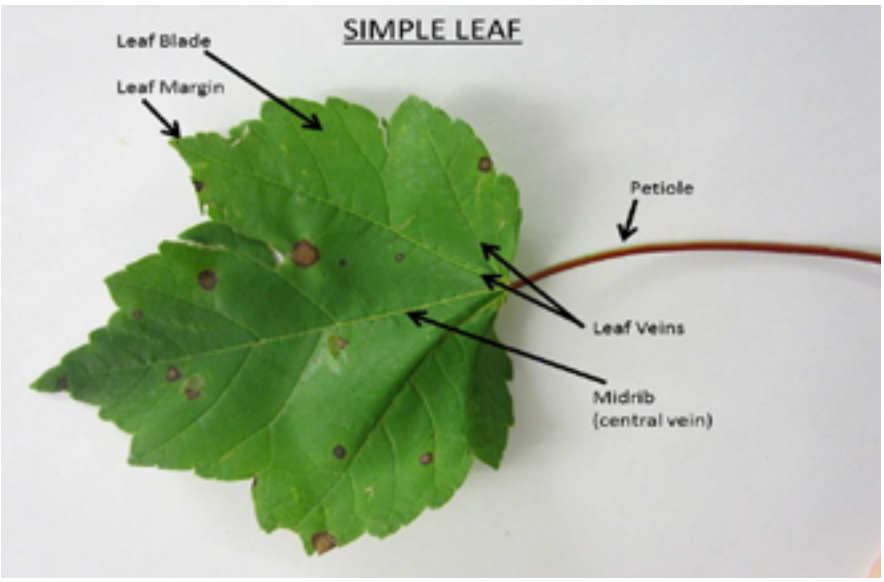
Smooth – refers to the leaf edge being smooth, without teeth

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

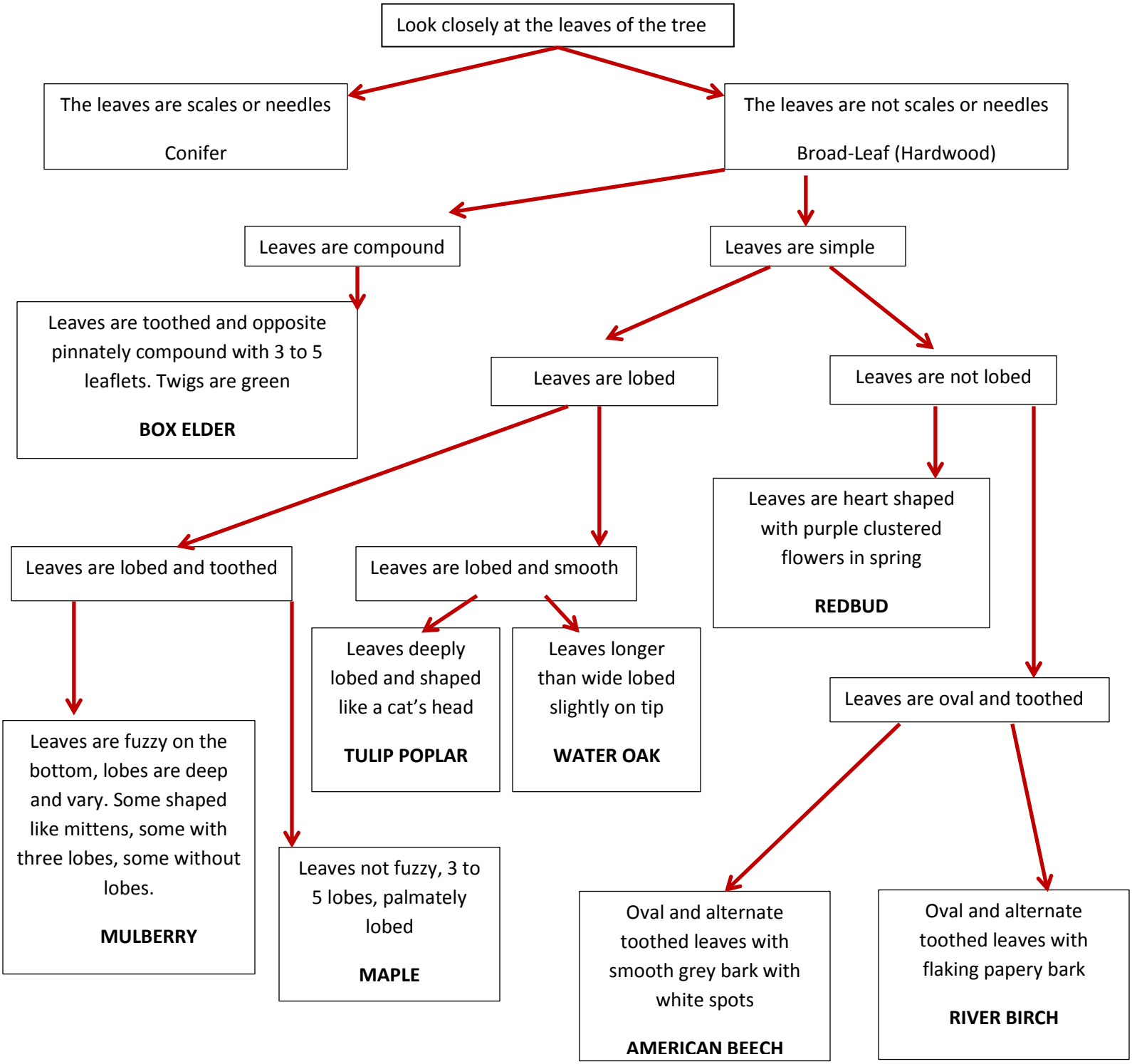
Leaf Margin - outer edge of the leaf

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.

A sample simple dichotomous leaf key that was developed along with lesson plans for the Urban Naturalist Program is available as a handout. You are welcome to use this 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

*Have students ***develop their own dichotomous tree key***. They may wish to use photos, leaf rubbings, botanical line drawings, or pressed specimens that they have created as part of their key.

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.

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.

Create botanical line drawings of parts of a tree that students have used in identification.

When creating a botanical line drawing, it is important to first observe the plant that you will draw and determine it's identifying features. Botanical line drawings don't have to be of the entire plant, but should instead show enough detail that they could be used for identification.

Observe characteristics of the tree and leaves such as shape, size, leaf margins, length of petioles, venation patterns, flowers or fruit, bud shapes, leaf scars, bark, and more.

Botanical line drawings are a combination of art and science and make great projects for students. Expand this activity by using the line drawings that the students create. Suggestions include:

- Create flash cards with tree names on one side and botanical line drawings of leaves on the other for study and memorization
- Develop your own dichotomous key using the line drawings
- Develop a guide to trees near your school. Combine photographs and botanical line drawings along with information that the students have found in their research of native trees
- Create a display of botanical drawings

Test the class' ability to use a dichotomous key through a ***photo scavenger hunt.***

Students should use a dichotomous key to identify trees and take pictures of the leaves. The resulting photos can be a part of a guide that the class creates, student made dichotomous keys, displays, and more.

Urban Trees

Word Bank

Non-point Source Pollution
Infiltration
Urban
Greenhouse Gas
Anthropogenic
Stomata
Gaseous
Pollutant
Absorption
Deposition
Organic Matter
Erosion
Storm Water Runoff
Riparian Buffers
Water Quality
EPA
Transpiration
Ecosystem
Emission
Evaporation
Transpiration
Mitigate
Urban Heat Island
Air Quality

Key Concepts and Skills

- Urban trees provide us with a variety of important benefits including soil stabilization, increased air and water quality, and shade
- Students will research a tree species native to Greenville, SC and report on the specific benefits that tree provides to people and the natural environment

Background Information

The benefits of trees in an urban setting have been mentioned throughout this program. This section is meant to provide more details about these benefits.

Trees are plants that have a single woody trunk.

Like most other plants, trees are able to make their own food from sunlight, carbon dioxide, and water through a process called photosynthesis. Trees in urban areas perform a variety of functions that are beneficial to people and the environment.

Trees absorb carbon dioxide and release oxygen

Photosynthesis takes place in the leaves of the tree.

Trees absorb CO_2 and other gaseous compounds in the air through small openings called stomata located mainly on the bottom side of the leaf.

The chemical equation for photosynthesis is $6CO_2 + 6H_2O$ + light energy → $C_6H_{12}O_6 + 6O_2$. What this equation means is that 6 molecules of carbon dioxide, 6 molecules of water, and light energy are used by the plant to create a single molecule of sugar (food) and 6 oxygen molecules are the by-product.

Carbon dioxide is the main greenhouse gas emitted due to human activities, primarily the burning of fossil fuels such as coal, oil, and natural gas for energy and transportation.

http://www.epa.gov/climatechange/ghgemissions/gases/co2.html

Trees absorb some airborne pollutants, reducing air pollution

When the stomata are open and air is taken into the leaf, gaseous pollutants (including and in addition to CO_2) are absorbed. Once inside the leaf, these compounds diffuse into the intercellular space.

Other airborne compounds "stick" to the outer surface of the tree leaves. Since these compounds do not get absorbed into the leaves, the tree is only a temporary holding place for these compounds. These compounds can be returned to the air by wind, washed off when it rains, or dropped to the ground when the leaves fall.

Trees stabilize soil and help prevent erosion

Tree roots physically stabilize soil by growing into the ground, but there are other ways that trees prevent erosion. When water runs over the surface of the ground, it picks up pieces of soil and organic matter as it moves. When water infiltrates the ground, soil and organic matter is deposited and erosion rates are reduced.

Trees aid in water infiltration in many ways. When rain drops hit the tree canopy, they are slowed down. By slowing the rain before it reaches the ground, trees give water more time to infiltrate the soil and help reduce the buildup of sheets of storm water runoff.

Also, by absorbing water from the soil, tree roots essentially create small empty spaces in the soil, allowing for greater infiltration of water into the ground.

Trees help reduce water pollution in streams by absorbing storm water runoff through the roots and slowing runoff

The roots of trees absorb water. Especially during a rainstorm, this is important in an urban environment because it reduces the buildup of storm water runoff, a major source of non-point source pollution in water bodies.

When absorbing water, trees also take up nutrients and other compounds that are present in the water. This helps prevent those compounds from being washed into water bodies.

Wooded areas alongside streams are called riparian buffers, and are essential for maintaining good water quality in urban streams.

Trees provide shade

According to the United States Environmental Protection Agency (EPA), surfaces in the shade can be 20 - 45°F cooler at peak temperature than the same surface without shade.

Shade can significantly reduce electricity bills and energy needs during summer months, especially in the South.

Through shade and evapotranspiration, trees help mitigate the Urban Heat Island Effect

Through the process of transpiration, plants take up water through their roots and release it back into the atmosphere through the stomata in the leaves. The increased rate of evaporation of water helps cool the air. Shading and transpiration together lead to an overall decrease in air temperature during the summer, mitigating the urban heat island effect and reducing the amount of energy and resources need to cool buildings through air conditioning.

Urban Trees Journal Prompts

Why are trees important to have in a city?

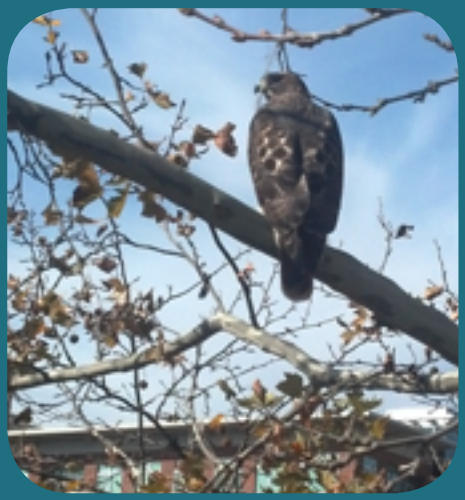
Can grass and flowers provide us with the same benefits as trees do? Why or why not?

Describe your favorite tree. What makes your tree special?

Write a haiku about trees.

Do you think that trees help people save money? Why or why not?

Shade is a benefit that urban trees provide. Do you think that shade is more important in a city or a rural area. Explain your opinion.



Top: A street tree in Greenville, SC
Middle: A hawk perches in a Sycamore tree in downtown
Bottom: Students utilize a simple dichotomous key available in the Urban Naturalist Program to identify trees on the Swamp Rabbit Trail near downtown Greenville, SC

Trees provide homes for animals

Trees offer shelter and food to a variety of animals including birds, lizards, small mammals, and insects. Increased biodiversity helps keep ecosystems intact, and the presence of carnivores such as hawks, insectivores, and carnivorous insects help reduce pest populations and control disease vectors. Urban trees can act as small habitat "islands" and can reduce the impact of habitat fragmentation and destruction for some animal species.

People use a lot of products that come from trees. Some examples include

- Oranges, apples, bananas, berries, maple syrup etc. as food
- Rubber and fibers for ropes
- Medicines
- Dyes
- Wood for building
- Fire wood and charcoal as fuel for heating and cooking
- Paper

Urban Trees Activities:

Ask students to close their eyes and picture a tree in the city.

Think about that tree for awhile. What does the tree look like? Where is it? What does it do? Do any animals live on or near the tree?

Have the students open their eyes and then ask them to list the benefits that their tree provides the city. Create a big list and then briefly discuss the benefits of trees in the urban environment.

Provide students with the list of trees of Greenville http://www.clemson.edu/extfor/publications/bul117/list.htm.
Either allow them to choose or assign each student or small groups of students a type of tree to ***research.***

Allow students to research trees for 10-15 minutes and then report on their tree to the class.

Some guided questions for research:

1) Is the tree native to Greenville County?
2) What does the tree look like?
3) In what habitats is that tree commonly found (requirements for growth)?
4) Is the tree used in landscaping?
5) Do people use parts of this tree for anything, and if so, what?

Websites for research:
http://www.duke.edu/~cwcook/trees/#trees

http://www.clemson.edu/extfor/publications/bul117/list.htm

http://www.fs.fed.us/database/feis/plants/tree/

Make a leaf rubbing collage.
Have students gather leaves (or bring in some leaves from different common trees).
Use crayons and white paper to create rubbings of tree leaves. (If you do this craft outside, students can also create rubbings of bark and other items that they find)
Cut out the leaf impressions and glue them onto a sheet of cardboard, foam board, or heavy construction paper to form a collage.
Gather twigs and use clippers (an adult should use the clippers) to trim them so that they are just a little bit larger than the collage.
Use twine or yarn to bind the corners of the sticks or bundles of sticks together.
Punch a hole in the top center and bottom of the collage and tie the pictures to the stick frame.

You can also expand this craft and have students use a leaf key to identify their leaves.

Examples of leaf rubbing collages

Perform an experiment to determine how shade trees affect temperature.

Materials
Clear plastic cups (pre marked with a line at 2 inches from the bottom of the cup)
Water
Thermometers

Procedure:

Each group gets four cups filled with water to the line.

Label your cups A, B, C, and D

Measure and record the temperature of the water in each cup. This is your baseline temperature.

Take the cups outside.

- Place cup A in the shade in a grassy area.
- Place cup B in the shade on a paved area.
- Place cup C in the sun on a grassy area.
- Place cup D in the sun on a paved area.

Create a hypothesis

Measure the temperature of the water in the cups throughout the day at regularly timed integrals.

Create a line graph of the results.

Questions for discussion or reflection
1. Does your data support your hypothesis?
2. Which cup of water got the hottest?
3. What had a greater effect on temperature of the water, the shade or the surface that the cup was sitting on? Why do you think that is so?
4. What do your results tell you about the importance of shade in urban areas?
5. Did the rate at which the temperature of the water changed vary between cups? How much, and what conclusions can you draw?

Print out the poem below, and cut into strips with each line on a strip. Give each student one strip of paper and ask them to come up with a movement or mime to communicate what is written on their strip of paper without using words.

Have the group stand in a circle and say the numbers in order. The students should step into the center of the circle and perform their movement when you call out their number.

Once the last person has finished, ask if anyone has figured out what the poem is talking about. Read it out loud and discuss all of the things that trees provide.

1. I stand tall
2. I give
3. Air that's clean to breath
4. Water where fish can swim
5. I bend
6.I give
7. Food for people and animals
8.Shelter where many live
9. I fall
10. I give
11. Healthy soil where plants can grow
12. Materials for building homes
13. Fire for cooking and staying warm
14. I grow
15. I give
16. Shade in the heat of summer
17. Beauty all year round

Nature crafts, making paper, and more are great ways to engage students and tie multiple disciplines together

A team acts out "trees provide shelter for animals" during charades

Adopt an urban tree.
Have students each "adopt" a tree. During the course of study, the students should visit their tree on a regular basis and keep a journal of their time with their tree.

Some ideas for journal assignments include:

- Draw a picture of your tree
- Sit quietly underneath your tree for five minutes and write about how you feel.
- Write a haiku about your tree.
- Describe your tree in detail: what color is its bark? How tall is it? How big around is it? What shape are its leaves?
- What is special about your tree?
- Identify your tree.
- Give your tree a name. Why did you chose the name that you chose for your tree?
- Describe the route that you take to get to your tree.
- Draw a map to help others find your tree.

Play tree charades. Create cards with a list of benefits of urban trees, things that trees provide, and important qualities of trees and play charades. Students should act out the thing on their card without making any sounds while their classmates try to guess.
Some simple suggestions for tree charades include:

Fire wood	Homes for animals
Paper	Clean air
Wood for building	Nuts
Fruit	Birds perch in trees
Trees are beautiful	Trees prevent erosion
Clean water	Shade
Trees sway in the wind	
Trees grow tall	Flowers
Fallen trees decompose into soil	
Christmas trees	Pine cones
Trees inspire art	

Green Space

Green spaces are an important part of the urban environment. Green spaces include any area in a city that is not developed, but is set aside as a park, garden, forest, or conservation area. Green spaces can be any shape or size, and vary widely to fill different rolls within the urban environment.

Whatever their primary purpose, green space provides us with a variety of social and environmental benefits that are essential to our quality of life.

Word Bank

Green Space
Park
Garden
Landscaping
Photosynthesis
Conservation
Aesthetic
Buffer Zone
Arboretum
Heritage Preserve
Greenway
Biodiversity
Open Space
National Park
Natural
Commons
Native

Key Concepts and Skills

Students will

- discuss and define the concept of an urban green space
- learn about the benefits of green space in an urban environment
- use the knowledge that they have developed about trees to draw connections between the importance of urban greenspace, land use, and water quality
- visit an urban green space and create a report about their experience

Background Information

What is Green Space?

Green space is any area in an urban environment that is not developed.

Most commonly, green spaces are thought of as parks, gardens, and other landscaped or planned areas where plants grow.

Green space can include small areas, such as planted islands in the middle of roads up to very large spaces such as parks.

Green space in a city can be natural, landscaped, or a combination of both.

Some green spaces include trails and pathways that act as connections for people to get from one place to another.

Green Space Journal Prompts

Explain what Green Space is in your own words.

Why do people and cities need green space?

Is it important for a city to make its green space pretty? Why or why not?

Describe three different green spaces that you have visited. Which was your favorite, and why?

Are trees necessarily a part of green space? What qualities do trees add to or take away from green space?

Green spaces alongside rivers are known as riparian buffers, undeveloped areas that help to reduce the impact of storm water runoff on urban rivers and streams, keep the water shaded, stabilize the bank, and protect water quality.

Benefits of Green Space in a City

Environmental Benefits of Green Space

Plants absorb carbon dioxide from the air and through the process of photosynthesis convert the carbon dioxide to sugar that is used by the plant and stored in the form of cellulose in the plant's tissues.

During photosynthesis, plants give off oxygen, which is essential for animals, including people, to breathe.

Trees help shade buildings and pavement. Summer temperatures can be reduced drastically by shade trees.

- Cooler temperatures inside buildings means less energy is expended running air conditioning systems to keep buildings cool.
- Shaded parking lots, roofs, and other surfaces may help reduce the urban heat island effect.
- When rain water falls on pavements, roofs, and other impervious surfaces, that water absorbs some of the heat from the surfaces and transports it into rivers and streams through storm water runoff. Increased water temperatures leads to reduced levels of dissolved oxygen in urban water bodies. Shaded surfaces don't absorb as much heat, so through shade urban trees can passively help protect water quality.

Plant roots stabilize soil

- Without plants, soil is exposed to sun, wind, and rain. When soil is exposed, it is more likely to be carried away by wind and rain, leading to a loss of topsoil and reduced soil quality.
- Soil that is eroded is deposited in rivers and streams.
    - When soil enters rivers and streams, nutrients in the soil are introduced into the water body and the soil itself causes the water to become cloudy.
    - Nutrients in the soil increase the productivity of aquatic plants, causing more plants to grow.
    - Cloudy water reduces the ability for light to penetrate the water, meaning that underwater plants can't use light for photosynthesis. These plants die, and bacteria break them down, using up the oxygen in the water. Reduced oxygen levels lead to reduced water quality and a reduced ability for the water body to support life.
- Soil deposited in rivers and streams can lead to blocked water ways and flooding. Energy and money must be spent to dredge and clear water bodies.

Trees and plants in urban areas help reduce water pollution and protect water quality. Planted areas alongside rivers and streams, known as riparian buffers, have been shown to protect and increase water quality in urban environments.

- Plant roots absorb water, which reduces the amount of above ground runoff during rain events.
- Along with water, roots absorb nutrients and some pollutants that would otherwise enter water bodies.

Leaves and branches intercept water as it is falling during rain events. The canopy of trees slows the rain, and the roots, stems, and organic matter on the ground slows the speed of over ground flow. Reduced speed allows nutrients, metals, and soil to settle out of runoff before it reaches water bodies.

Green spaces provide habitats for native plants and animals. Depending on the size, green spaces can provide important refuges that allow animals and plants to survive in an urban environment.

Many green spaces include trails and paths that create connections for people using active transportation to get from one place to another. Increased use of active transportation helps reduce the use of automobiles, leading to reduced air pollution.

Aesthetic/Societal benefits

Green spaces are aesthetically pleasing. Studies show that people are more productive in environments that they find pleasant.

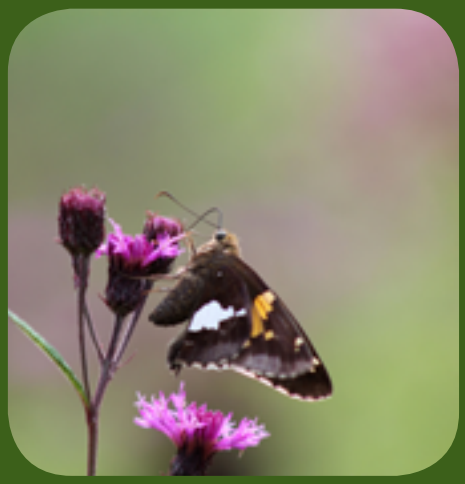
Green spaces provide places for recreation, relaxation, and social interaction.

- Spaces for recreation, as provided by parks and other green spaces, lead to reduced obesity and other health benefits for urban residents.

Green spaces encourage people to spend time outside. More individuals spending time outside leads to more people watching the area, which discourages criminal activity, leading to safer neighborhoods.

Some individuals cannot afford to own a car. For those individuals, the connections that green spaces and trails help create can help them reach jobs, grocery stores, and other essential services.

*Though green spaces do not have to include trees, many do, for the reasons already discussed in this program.



Urban green spaces provide habitats for many different animals and many benefits for people, including places to relax, recreate, and study.
Top: A Silver Spotted Skipper in the A J Whittenberg School Garden
Middle: A mother duck near the Kroc Center bioswale
Bottom: Students learn about trees on the Swamp Rabbit Trail

Digital cameras are a great option for integrating technology and art into the classroom through photo scavenger hunts.

Basics of Green Space Activities:

3 in 3 minutes: Web research and short presentation.

In small groups, assign or allow students to choose one of the covered research themes from the Green Cities: Good Health website that presents research findings compiled by the University of Washington and the United States Forest Service on the benefits of green space in the urban environment: http://depts.washington.edu/hhwb/Top_Introduction.html

Each group should read the information provided about their theme and decide amongst themselves how they will present their information to the class. Their presentation must be 3 powerpoint slides long. Each slide should take only 1 minute to present, have one photograph, and no more than 3 bullet points.

Follow the presentations with questions and discussion.

Green spaces photo quest:
*If students don't have access to a camera, this activity could be done as a web photo quest using your school's photo database.

Photo Quest Instructions: Take (or find) a photograph of each of the following

- An urban green space where people relax
- An urban green space with water
- An animal in an urban green space
- An urban green space where people are active
- An urban green space with lots of plants
- An urban green space with art
- Kids doing something fun in a green space
- A small green space
- A very large urban green space
- A green space that is not a park

Have each student ***write a list*** of the green spaces that they have seen in the City.

Make a master list on the board and then ask the students to ***compare and contrast*** the types of green space that they have listed. Are they all the same size? Are they similar in shape, in the plants that they contain, or in their function? If not, how are they different?

Jump start the brain storming with a few examples:

community gardens	lawns
back yards	parks
trees alongside the river	planted medians

Visit a green space.
As a class, in small groups, or as homework, have students visit a green space in the City of Greenville. You may wish to utilize the Discover Greenville: A Falls Park Activity Guide and visit Falls Park, take a walk on the Swamp Rabbit, visit Lake Conestee, or Linky Stone Children's garden.

Ask students to develop a report on their green space visit, or create a poster advertising their green space and what makes it special.

It is important to note that urban green space comes in all shapes, sizes, and functions.

Top: A J Whittenberg School Garden
Middle: Falls Park on the Reedy River
Bottom: Linky Stone children's garden

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. Trees are impacted by invasive species in many ways, including loss of habitat through competition, feeding by invasive animals, attack by invasive diseases and fungi, being killed by invasive vines and other invasive plants utilizing chemical warfare, and more.

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:

- 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

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.

Killing native plants through feeding, disease, shading, choking (vines) and more.

The hemlock woolly adelgid is a current example of the devastating effects that invasive species can have on trees and ecosystems. It is estimated that the invasive insect causes 90% mortality rates in hemlock trees. You only have to visit a cove forest in the South Carolina upstate to see the damage, and the damage to come (altered stream temperatures leading to reduced fish habitat, increased erosion, changes in the community composition, etc) are soon to follow.

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)
- change in 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:

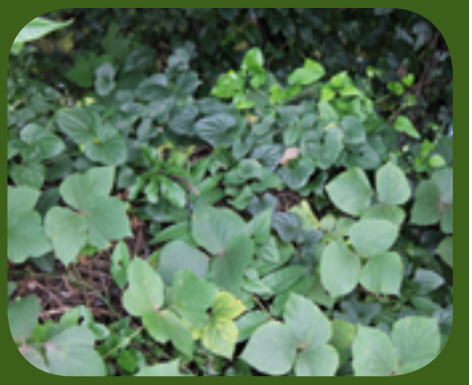
- Introduction of a plant for agriculture or landscaping (wisteria, privet)
- Introduction of a plant as a food source for animals (kudzu)
- Introduction of an animal to control another pest
- Pet and aquarium trade: release of pets into the wild, dumping of aquariums into water bodies.
- Accidental 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.



Many invasive vines like Kudzu and English Ivy can kill trees by choking them, preventing new leaf formation, and hindering growth. Though these vines are not parasitic, and do not feed on the tree, their presence still often leads to death.

Many invasive plants originally were introduced as landscape plants. They may be beautiful, but they can be devastating to the natural 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

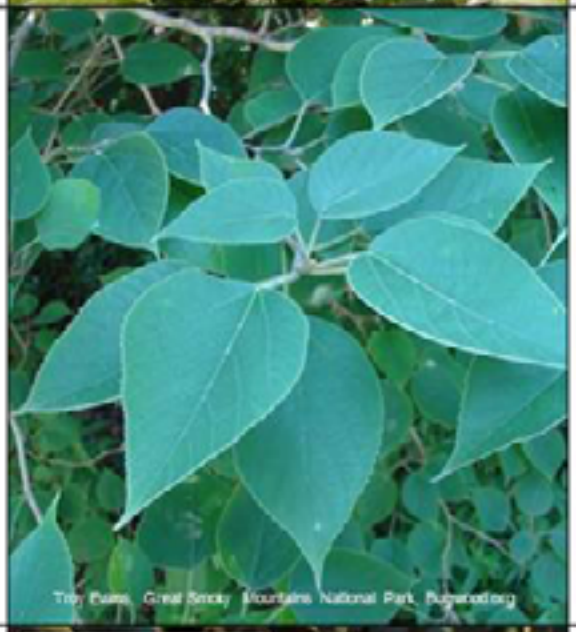
ID: large tree 60-100ft tall with alternate simple leaves that vary in shape from oval to 5 lobed. Leaves have undulate and toothed margins, and the underside is covered in thick white hairs. The petiole is also covered in hairs.

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

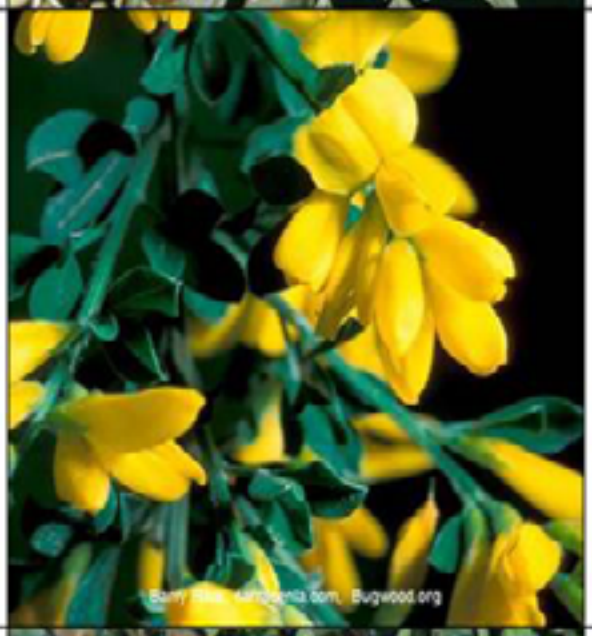
ID: Small tree or shrub up to 30 ft tall with thorny stems and leaves alternate and longer than wide, tapering to a rounded point with smooth edges. Yellow flowers, silvery fruits.

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.

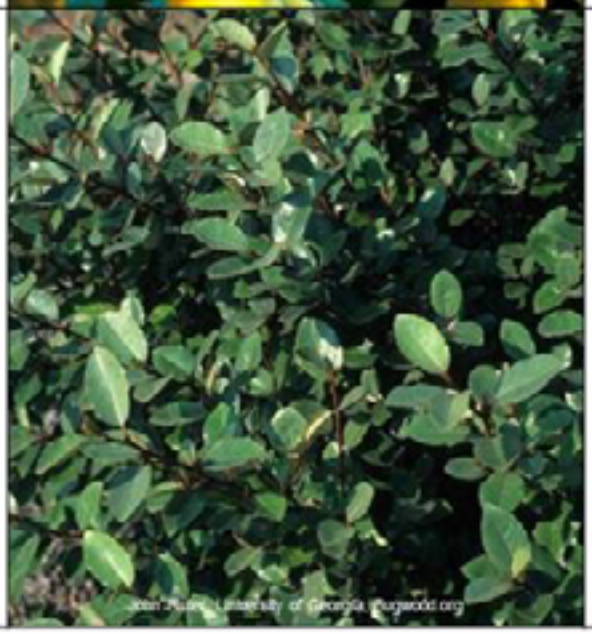


Shrub
Severe Threat

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

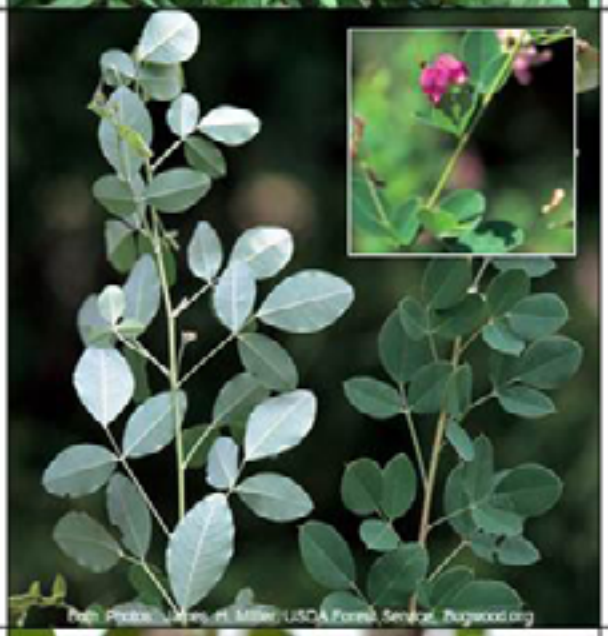
ID: Shrub 3 – 20 ft tall. Leaves are alternate and elliptical with a silvery underside. Branches are a greenish brown in color and have many thorns. Fruit - many red berries in Fall.

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

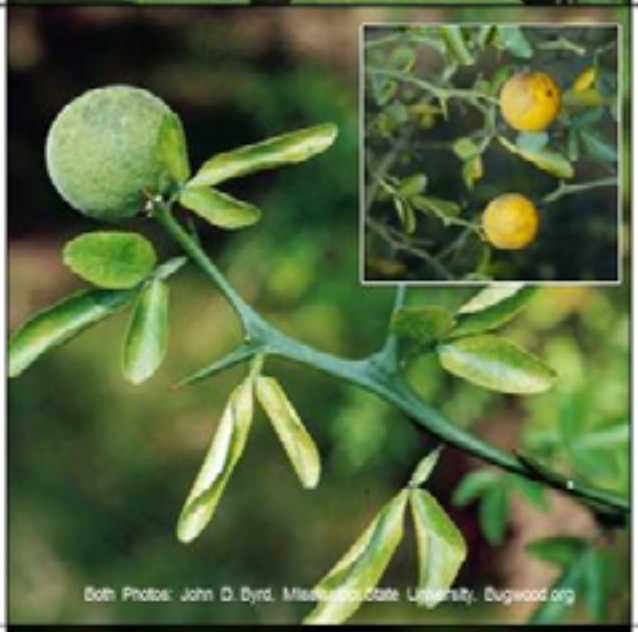
ID: Shrub with reddish brown reed-like stems, leaves arranged alternately leaves are thick and spade shaped with a sharp slope to the pointed tip.

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



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.

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

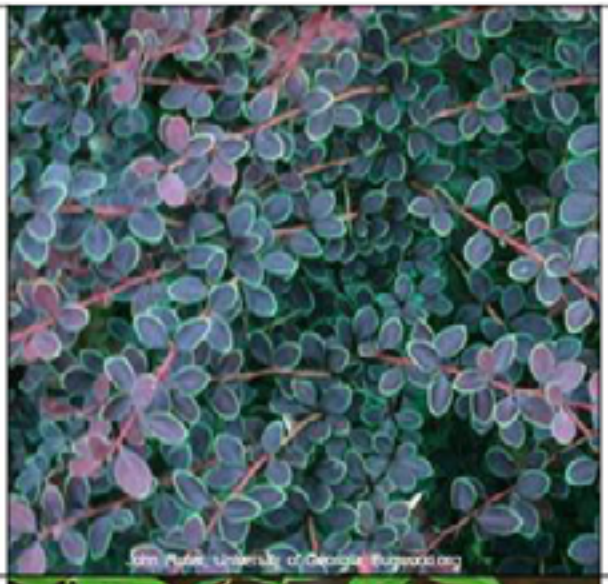
Emerging Threat

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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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 U.S. 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 on 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

Absorption
The uptake of substances by a tissue such as the ability of plants to take nutrients up from the soil through their roots.

Abundant
Having more than enough, a large quantity or number.

Aesthetic
Visual qualities, usually pertaining to a sense of beauty.

Air Quality
The state of the air around us. A measurement of the pollutants in the air, such as nitrous oxides, ozone, carbon monoxide, and sulfur dioxide. Poor air quality negatively impacts human health.

Alternate Leaf
Leaves attached on either side of a branch at a staggered point. Single leaves extending from the stem of a plant in a zig-zag type pattern.

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.

Anthropogenic
Of or relating to humans.

Arboretum
Garden parks dedicated specifically to trees.

Autotrophic
An organism that produces its own food by turning organic substances into inorganic ones. Plants are autotrophic.

B

Bark
The hard outermost protective layer of stems, shrubs, and roots of woody plants. Bark contains vascular tissues and aids in nutrient transport and plays a role in plant defense, including the production of defensive compounds and by creating a hard barrier to herbivory and disease.

Beneficial
Helpful. Refers to something that assists another organism.

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 control of pest populations by introducing a natural predator or pathogen into the environment.

Botany
A branch of biology that studies plants.

Branches
A secondary shoot or stem extending from the trunk of a tree that helps provide structure and support, while promoting growth of the plant.

Buffer Zone
A neutral area between two different types of land use.

C

Canopy
The uppermost group of branches and foliage on trees.

Carbon Sink
An item that is able to absorb more carbon than it produces.

Commons
A resource shared by everyone and owned by no one; land managed by the public.

Compound Leaf
A leaf that has multiple leaflets on a single stem or stalk.

Cone
The hard oval-shaped reproductive structure of a conifer. Conifers have two types of cones, male and female. The male cones are small, often inconspicuous, and produce pollen. The female cones start out small but enlarge after pollination.

Conifer
Gymnosperm trees that produce cones. Many conifers have needle or scale-like leaves, and are evergreen (keep their leaves year round). Notable exceptions include the Bald Cypress and Dawn Redwood.

Conservation
The protection and management of resources or property to ensure longevity and preservation.

Crown
The uppermost part of a tree including the leaves, stems, and branches coming out of the trunk.

D

Deciduous
Type of hardwood trees and shrubs that shed their leaves annually, usually during the fall and winter.

Deposition
The act of settling, setting down, or placing something.

Dichotomous Key
A tool used for identification that utilizes paired questions that lead to a final answer.

Dicot
A classification of flowering plants, characterized by leaves in groups of four or five, an embryo containing two cotyledons, and thick primary veins that branch off to form a smaller network.

Dispersal
The act of spreading out, including the way that plant seeds are moved to different places. Modes of seed dispersal include insects, wind, water, animal ingestion and ejection.

E

Ecosystem
All living and nonliving components of a community that interact to form an ecological system. Examples include deserts, grasslands, tundra, marshes, lakes, and tropical rain forests.

Emission
The release of chemicals, particulates, or pollutants into the air.

Endangered species
A group of species with a dwindling population to the extent to which it is facing extinction.

EPA
The US Environmental Protection Agency, a regulatory organization that is part of the US Government system whose mission is to protect human health and the environment.

Erosion
The movement of soil particles or sediments by wind or water.

Evaporation
The process when liquid, such as water, is taken up into the atmosphere as a gas.

Exotic
An organism that is not native to an area.

F

Fire Regime
A classification of the role that fire plays in an ecological system which includes frequency, size, and/or impact of fire on plants and animals within an ecosystem.

Fruit
The ripened ovary or ovaries of angiosperms that contain seeds.

G

Garden
A managed plot of land used to grow plants such as flowers, trees, vegetables, and herbs.

Gaseous
Existing as a gas, rather than as a liquid or solid; lacking solidity

Green Space
Undeveloped areas of a city that are specifically set aside for recreation, aesthetic relief, or wildlife conservation.

Greenhouse Gas
A gas in the atmosphere that traps heat close to earth's surface. Examples include methane, carbon dioxide, water vapor, etc.

Greenway
A linear park that provides passive recreational opportunities, pedestrian and bicycle paths, and the conservation of open spaces.

Gymnosperm
A type of tree classification referring to plants that produce cones instead of flowers and fruit. Most gymnosperms keep their leaves, typically needles or scale-like, during the winter and are commonly called evergreens.

H

Habitat
The physical environment an organism, species, or population naturally dwells.

Heritage Preserve
Land areas designated to preserve the cultural and natural history of the region.

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.

I-K

Infiltration
The downward movement of water as it permeates the ground and moves into the subsoil.

Introduced Species
Species living in an area outside of its natural geographic range, they can be either intentionally or unintentionally brought in to a new environment.

Invasive species
Any exotic (non-native) plant, animal, or pathogen that out-competes native species causing environmental, economic, or human damage in a new environment.

L

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.

Leaf Margin
Outer edge of the leaf.

Lobed Leaf
A leaf having multiple deeply rounded edges.

M

Microclimate
Small areas where the climate varies from the larger surrounding area.

Mitigate
The ability to lessen or alleviate the impact of a situation but not solve it.

Monocot
A type of angiosperm characterized by having one cotyledon. An example would include blades of grass, as single blades form out of the seed with straight vascular tissues.

N

National Park
Land and coastal areas set aside by the federal government for protection and recreation due to their scenic, ecological, or historical significance.

Native
Belonging to or coming from a particular place, innate.

Natural
Something existing or occurring apart from human intervention or activity.

Naturalized
To be fully adapted and grafted into a particular community. Naturalized species are those that have been introduced and have adapted to living in a new area without becoming invasive.

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 pathways, processes, and rates by which nutrients travel through an ecosystem.

O

Open Space
A land area set aside by zoning that is to remain undeveloped. Open spaces are areas then used for recreation or resource protection and also provides visual relief to developed areas.

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

Organic Matter
Natural biological material that is nutrient rich, having the ability to decompose.

P-Q

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.

Park
Private or publically owned open-space land set apart for recreational, educational, cultural, aesthetic, and/or environmental use.

Pest
A destructive insect, plant, or animal that is not wanted in a particular place, typically because it attacks foods sources, animals, people, or their homes and belongings.

Petiole
The stem of a leaf.

Phloem
Part of the vascular system of a plant responsible for transporting sugars, or food, throughout the plant.

Photosynthesis
The chemical process all green plants undergo to make their own food. Energy from the sun, carbon dioxide, and water create glucose for the plant, and oxygen is released as a by-product.

Pinnate
Feather-like. In leaves, refers to the shape of a leaf along the leaf vein or the arrangement of leaflets around a stem.

Plant
An autotrophic organism that usually produces food through the process of photosynthesis, grows on its own, is typically anchored in soil, and usually has green leaves.

Pollutant
A substance out of its natural place or role in the environment that leads to contamination and/or harm. Carbon dioxide, and carbon monoxide are considered air pollutants. Pollutants are not necessarily harmful at all times, but may be harmful in context. For example, both soil and hot water can be water pollutants, but neither is innately harmful.

Producer
An organism that is able to make its own food. An autotrophic organism.

R

Rare
Something that is not seen or does not occur frequently.

Resilient
The ability to withstand and recover from a difficult environment.

Rhizome
Underground horizontal stems that sprout new above ground lateral shoots.

Riparian Buffer
A vegetated space alongside rivers or water sources that reduces the impact of storm water runoff by keeping water shaded, stabilizing the bank, protecting water quality, and providing a wildlife habitat.

Roots
Part of a plant that extends from the trunk or main stem into the soil to help anchor the plant and absorb nutrients.

S

Seed
The fertilized ovule of a plant, allowing for growth and development of new plants.

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.

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

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.

T

Threatened
A region's native species that is at risk of becoming endangered in the coming future.

Toothed Leaf
A leaf's edge that is not smooth but has small pointy "teeth."

Transpiration
The process in which plants take up water through their roots and release it back into the atmosphere through the stomata in the leaves.

Trunk
The base of a tree connecting the roots and the crown. Usually the thickest part of the tree responsible for carrying nutrients from the roots into the branches.
or people from one place to another.

U

Urban
Of or pertaining to a developed area or city.

Urban Heat Island
An area of human development that is warmer than the surrounding undeveloped area.

V

Vascular Plant
A plant containing vascular tissue (phloem and xylem): the phloem transports sugar throughout the plant and the xylem transports water.

Vegetative Reproduction
A form of asexual reproduction in plants in which multicellular structures detach from the parent plant and develop into new independent individuals, such as stems, leaves, rhizomes, or roots.

Vein
The tubular channels carrying necessary food and water for the plants survival. Veins can be seen in leaves as raised lines on the underside of the leaf.

W

Water Quality
The physical, biological, and chemical characteristics of water that determine the suitability of water for any intended use.

X-Z

Xylem
Part of a plants vascular system responsible for transporting water from the roots to the leaves.

connections
FOR SUSTAINABILITY