

Step 1

Discover How Trees Produce and Conserve Energy

BASIC ACTIVITY

Classroom Activity:

- **Design an Energy Wise Community Using Trees**

Objectives:

Students will be able to:

- **trace the flow of energy in various forms, from plants to humans, by creating an energy chain.**
- **describe several ways trees provide energy for human use.**
- **describe several ways appropriately placed and planted trees can conserve energy.**
- **demonstrate best planting locations for different types of trees to conserve or produce energy.**

Time Recommended:

- **One 60 minute class period**

Materials Needed:

- **Copies of worksheets on pages 13-15**
- **Fan**
- **Small bucket of water**
- **Pictures of broadleaf trees with and without leaves and pictures of conifers**
- **11x17" or larger sheet of paper (one per student or group) and pencils**

National Science Education Standards Correlation:

Students will develop an understanding of:

- **transfer of energy.**
- **populations, resources, and environments.**
- **diversity and adaptations of organisms.**
- **designing a solution or product in light of information at hand.**

National Social Studies Education Standards Correlation:

As a result of the activity students should be able to:

- **explore the causes, consequences and possible solutions to persistent, contemporary, and emerging issues. (Global connections)**

Teacher Background Information:

Trees are widely appreciated for the bountiful products they produce and the beauty they contribute to our environment. Trees also provide many conservation benefits.

Tree roots grip and hold the topsoil, slowing runoff and reducing erosion and water pollution. Leafy tree canopies conserve moisture, slow the wind, keep the air clean, help quiet loud traffic noises, and provide shade from the hot summer sun. Trees also create a welcome home for birds and wildlife.

And trees are vital for converting and producing energy for human use, as well as conserving energy when properly placed in the landscape.

Energy is defined as the ability to do work; it powers everything in nature. Energy warms and cools our homes, fuels our cars, powers our TVs and DVDs, and runs our manufacturing plants. And it takes energy for us to walk, talk, digest our food and even breathe.

Many different sources of energy exist. Some energy sources are **nonrenewable** – fossil fuels like coal, oil, and natural gas. Once the supply of a fossil fuel has been depleted, it is gone forever. Some energy sources are **renewable** - like wind, sun, water...and trees and plants (biomass). These are energy sources that can be replenished through natural processes or careful management.

The following guidelines provide information about ways trees can produce and conserve energy while helping the environment. Some of this information is included in the student worksheet, but additional information is provided here for you to include as part of the classroom discussion.

Guideline 1: Plant Trees to Produce Food Energy for People and Wildlife

Trees and other green plants are the energy basis for all animal life to grow and function. Through the process of photosynthesis, plants convert light (solar energy) from the sun into chemical energy that is stored in the plant as carbohydrates (sugars) as it grows. All animal life,

including human life, depends on that stored energy. When you eat an apple, the chemical energy stored within the fruit becomes the energy “fuel” that allows you to work, play, run, and grow. Every living creature either gets its energy directly from plants or depends on other species that depend on plants.

Planting a wide variety of trees with high food value increases healthy food energy for people as well as diverse food and habitat for wildlife. It is important to select fruit and nut trees that will grow in the climate where you live. Trees or shrubs with high-energy food value for people or wildlife can include: apple, orange, cherry, peach, oak, hazelnut, plum, etc.

Guideline 2: Grow Trees as an Energy Crop

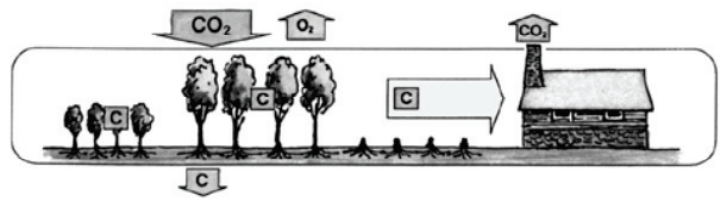
While the fruits, seeds and nuts of trees provide fuel (either directly or indirectly) to run our bodies, the wood from trees can be burned to release energy for heat to keep us warm or power to make things run. This energy is referred to as biomass energy. Two hundred years ago wood accounted for over 90 percent of the world’s energy/heating needs. Today, some nations still use wood as an important fuel source for cooking and heating, but in the United States wood and other plant-based biomass fuels account for less than 5 percent of the fuel used for energy production. The United States depends heavily on fossil fuels, which will run out eventually.

Biomass is a homegrown source of energy. Wood, animal waste, crops, even garbage can be used as a biomass energy source. Agricultural biomass crops like corn and soybeans can be burned directly or turned into other liquid fuels (ethanol, methanol and biodiesel) that can be used to power vehicles or machinery. When not burned efficiently, wood and other biomass products can cause air pollution, but modern heating/cooling systems, and even efficient wood burning stoves, burn the biomass at such a high temperature and so completely there is often less pollution with it than with conventional fuels like oil and coal.

Fast growing trees, like hybrid poplars, planted in fuelwood plantations can reach 40 feet in height in only 6 years. These trees can be cut a few inches from the ground, the wood burned to create energy, with new growth resprouting from the cut stump providing new fuel for subsequent harvests. As these trees grow, they are taking carbon dioxide (CO₂) out of the air, storing

carbon (C) in the wood of the tree, and releasing life-giving oxygen (O₂). When the trees are cut and burned, carbon recombines with oxygen and is released as CO₂. But because some of the carbon taken out of the air is still “locked up,” or sequestered, in the woody roots of the tree that are not burned, there is a net reduction of atmospheric carbon dioxide...one of the contributing causes of global warming. And unlike fossil fuels, gasses emitted from burning wood contain no sulfur dioxide (SO₂), a major pollutant in acid rain.

Guideline 2: Grow Trees as an Energy Crop



Wood manufacturing waste, street tree prunings, and thinnings from private woodlands can also be burned for fuel, which saves fossil fuels and landfill space. Biomass not only produces energy, it is good for the environment.

But only through wise use and proper forest management can wood and other biomass fuels be considered a renewable resource. Trees must be replanted as they are used. According to the National Renewable Energy Laboratory, more than 36 million acres of land in the United States, considered unfit to grow food, could be used to grow energy crops.

“Each generation takes the Earth as trustees. We ought to bequeath to posterity as many forests and orchards as we have exhausted and consumed.”

Arbor Day founder, J. Sterling Morton

Student Words to Know:

Conserve - save or protect

Biomass energy - energy from plants

Windbreak - rows of trees planted to slow the wind

Renewable - can be replaced by nature

Diversity - variety of different kinds

Conifer - trees that bear cones, usually evergreens

Broadleaf - trees with leaves that are thin, flat and usually shed annually

Step 1

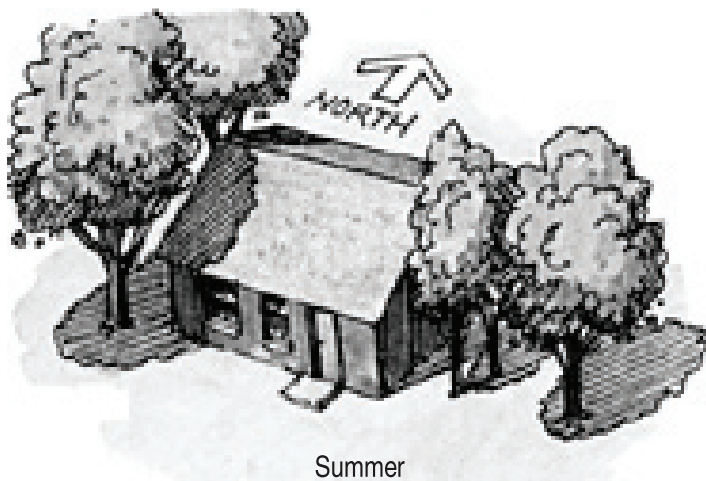
Discover How Trees Produce and Conserve Energy

BASIC ACTIVITY

Most people living in cities and towns don't have enough available land to grow their own individual biomass plantations to **produce energy**. However, by simply properly locating and planting a few trees around their home, they can **conserve energy**, lessen use of nonrenewable fossil fuels, save money, increase property value, and help the environment. Proper landscaping with trees and shrubs is often the best long-term investment for reducing heating and cooling costs while also bringing improvements to the community.

Guideline 3: Plant Trees to Shade Your Home

Carefully positioned trees can save up to 25 percent of a household's energy needs for heating and cooling. According to the U.S. Department of Energy, that can save the average household between \$100 and \$250 in energy costs each year. The most energy savings and the best use of shade generally comes from deciduous broadleaf trees planted about 10 feet from the walls to the west, east, or northwest of the house. These trees shade the house during the summer, reducing the energy needed for air conditioning. When they lose their leaves in the winter, trees correctly planted allow the sun to reach and warm the house, saving energy for heating. Select trees that are right for your site conditions.

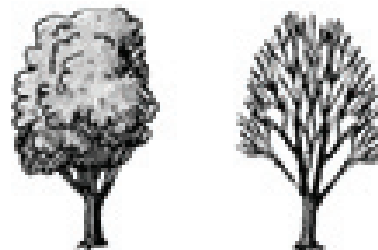


Summer

Because the sun is directly overhead in summer, trees planted on the south will not provide shade unless planted very close. Trees planted on the south also block beneficial summer breezes. Trees planted on the east, west and northwest sides of a house provide the best shade during the summer mornings and afternoons.

Broadleaf trees have leaves that are flat and thin. They are usually deciduous, shedding their leaves annually. Oak, ash and maple are several examples of broadleaf trees. Broadleaf trees generally provide the best summer shade.

Deciduous, Broadleaf Tree

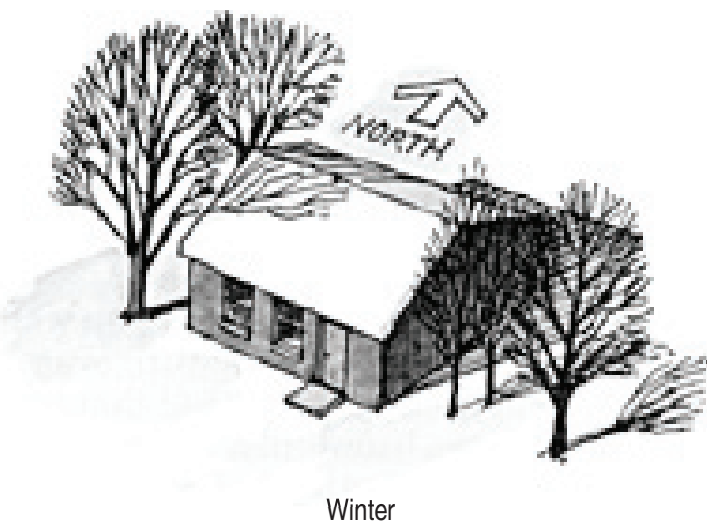


In Summer

In Winter

Trees planted in these locations provide the best summer shade during morning and afternoon hours. When they lose their leaves in the winter, they allow the sun to reach the house – making maximum use of winter solar heat.

Because the sun is directly overhead at midday during the summer months, planting shade trees on the south is discouraged. Trees on the south will not shade the house unless planted very close to it and they will make unwanted shade in the winter when the sun is at a lower angle. Trees planted to the south of a home may also block beneficial summer breezes.



Winter

In winter, trees planted on the south side of a house may produce unwanted shade. Trees planted on the east, west and northwest sides minimize unwanted winter shade.

Heat Island Effect



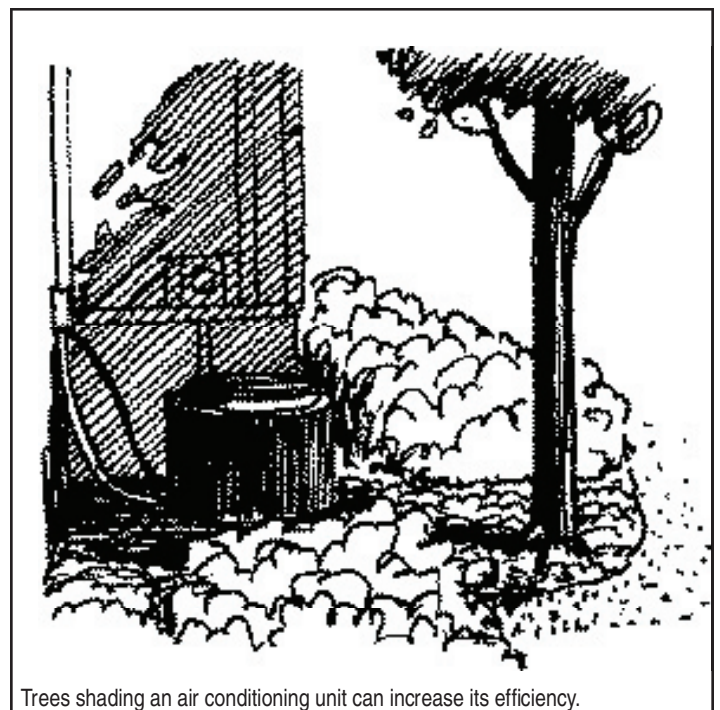
If it seems hotter downtown than in the suburbs, and cooler in the park than in your backyard, it is not simply your imagination. Cities are heat islands – zones of summer air temperatures that can be as much as 12 degrees Fahrenheit higher than surrounding areas.

Guideline 4: Plant Trees to Shade Air Conditioning Units and Paved Areas

Trees shading an air conditioning unit can increase its efficiency by as much as 10 percent. Trees shading paved areas like driveways and parking lots will greatly decrease surface heat.

Cities with unshaded stretches of concrete streets and parking lots are sometimes referred to as “heat islands” that are 5-12 degrees hotter than surrounding areas. Planting trees in these areas helps alleviate the heat island effect – which saves both energy and money.

The net cooling effect of a young, healthy tree is equivalent to ten room-sized air conditioners operating 20 hours a day. In the process of transpiration, water escapes from small openings in a tree’s leaves. This water evaporates in the hot weather. The evaporated moisture cools the air around the tree. Since cool air is heavier than hot air, this cool air moves toward the ground making us feel cooler. (The evaporation activity you will do with your students illustrates how this works.)



Trees shading an air conditioning unit can increase its efficiency.

Step 1

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BASIC ACTIVITY

Guideline 5: Plant Trees to Break the Wind and Reduce Blowing Snow and Dust

Windbreaks are barriers used to reduce and redirect wind. Planting a windbreak around a home can provide an energy savings of up to 30 percent and reduce blowing snow, noise and dust. Since most homes in the United States are heated by natural gas or electricity generated from burning coal, this energy savings means a reduction in fossil fuel use as well.

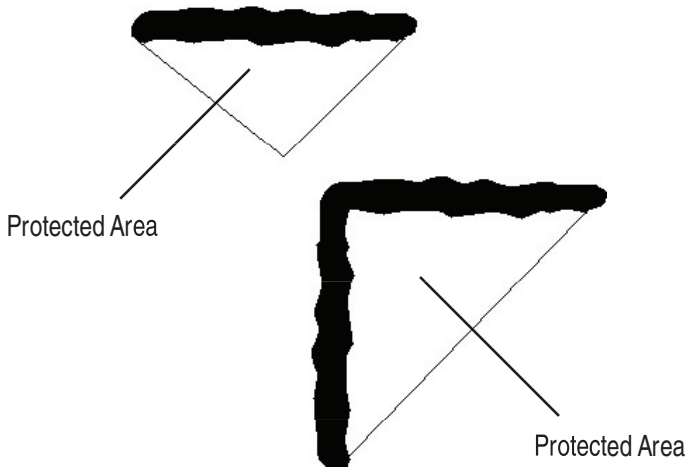
An effective windbreak should be planted at a right angle (perpendicular) to prevailing winds. In the southern United States hot, drying winds can erode soil and increase energy demands for cooling. Hot winds often come from the south or southwest, so an effective windbreak would be planted to the south and/or west of the home or housing development.

In the northern United States bitter cold winds can dramatically increase heating costs. Winter winds are often from the north or northwest, so an effective windbreak would be planted to the north and/or west of the home or housing development.

Since winds vary, multiple legs of windbreaks, or windbreak systems, often provide the best protection and greatest energy savings.

Evergreen conifers with branches close to the ground

Windbreak Design



Two-sided windbreaks offer protection over a larger area for greater energy conservation.

form the best windbreaks. Pine, redcedar, and Douglasfir are species often used in windbreak plantings. Choose trees adapted to your region.

Conifers bear cones and have needle-like or scale-like (awl-shaped) leaves. Most conifers are evergreen since they do not lose all their leaves at once. Pines, firs, cedars and spruces are conifers. Conifers generally provide the most effective buffer in windbreaks.



Effectiveness of the windbreak also depends on the density of the windbreak and its height. Three or more continuous rows of trees in staggered formation provide the best wind protection, but even a single row of trees will have an effect. Trees, bushes and shrubs are often planted together to better block the wind from ground level to the treetops. The tallest row of trees is often planted in the center. Trees should be planted fairly close together. Spacing between rows should be about 12 feet.

Windbreaks offer protection for a distance of up to 8 to 10 times the height of the mature trees. Snow and stagnant air can collect in the area directly behind a windbreak so, in regions that receive lots of snow, buildings to be protected should be located no closer than 100 feet from the windward row (front row facing the wind). A good rule of thumb is that the area to be protected should be within a downwind distance of 2 to 5 times the expected height of the tallest windbreak row. (For planning purposes, 20 feet is often used as the height of the tallest trees.)

The greater the number of trees in a neighborhood, the more effective the trees are in reducing the wind. New housing developments benefit from windbreak plantings that border the neighborhood.

Great information with examples of many tree species can be found at: www.arborday.org/trees

The Activity

Instructional Sequence

Step 1. Begin by asking students what comes to mind when they hear the word “tree.” Record responses on the board without comment. Remind students of additional things trees do for the environment if they are not already listed, then continue discussion by asking if energy should also be included on the list. After student discussion, explain that trees are vital for converting and producing energy for human use, as well as conserving energy when properly placed in the landscape.

Step 2. Write the words “**renewable energy**” and “**nonrenewable energy**” on the board. Have students think of sources of energy and work together to determine into which of the two categories each energy source falls. Tell students that most of the energy used today for transportation and in factories, offices, and homes comes from fossil fuels. Fossil fuels such as coal, oil, and natural gas take millions of years to form and are nonrenewable. Sun, wind, and water are renewable energy resources because supplies are not limited and, with proper management, we can always grow trees.

Step 3. Pass out copies of the Landscaping for Energy Conservation Guidelines Worksheets (pages 13-15). As you go through each of the landscaping guidelines, incorporate additional material provided in the Background Information section into the discussion. Show pictures of conifers and broadleaf trees as you discuss them and post those images on the wall.

- After reviewing Guideline #1 ask students to come up with other examples of energy food chains.

Evaporative cooling Example:

- Before reviewing Guideline #4 have students line up and file by the bucket of water. Ask each student to dip just one hand in the water to wet it then hold both hands briefly in front of the fan. After all students have tried this, ask which hand felt cooler, the wet hand or the dry hand? Explain that the warmth of your skin and the air from the fan caused the water to evaporate. That process cools your skin. Nature uses evaporative cooling everyday. When we sweat, our perspiration evaporates, cooling us off. When a tree transpires, releasing moisture, that moisture evaporates, cooling the air. Tell students that the net cooling effect of just one young, healthy tree is equivalent to ten room-sized air conditioners operating 20 hours a day. Amazing!

Step 4. Determine if you wish to have students work individually or in groups. Give students a large sheet of paper. Tell students to imagine they are community planners. They are going to have an opportunity to design a new neighborhood development. Their job is to create a plan on their sheet of paper that includes important community features (school, park, homes, small businesses) and also incorporates the five Landscaping for Energy Conservation Guidelines for producing or conserving energy for the development. Remind students to indicate north on their map and tell them if they have specific tree species they are planting in certain locations they should indicate that on the back side of the paper.

Step 5. When the landscaping projects are complete have students explain their plans and their choice of tree locations to the class. Provide the opportunity for peer review and redesign.

Follow up Enrichment Activity

Read the following imaginative description of biomass energy to your students. Encourage discussion of some of the references. Have students do their own creative writing about how trees can help the environment.



There sleeps on the land a mighty dragon, with power greater than all the energy contained in all of the oil and all of the coal and gas that we have used, and will yet use, for warmth and comfort and work.

The Dragon was the master of fire from the dawn of time until the industrial age. Now it naps in confidence, knowing that the secret of its might is self-renewal. It is immortal, and when the last fossil fuels have been consumed, it will awake to serve again in all of its strength and energy.

The Dragon is called BIOMASS and, while it naps, learn the secrets of its service and its importance to human kind. For it, along with the sun and wind and water, will again be one of our powerful protectors against the cold and darkness.

Step 1

Discover How Trees Produce and Conserve Energy

BASIC ACTIVITY

Assessment Rubric:

Hand out a copy of the rubric or put the rubric on the board at the start of the activity so students clearly understand the measured objectives.

GRADING OF THE LANDSCAPING FOR ENERGY PLAN

1-2 POINTS POOR PLAN	3-5 POINTS AVERAGE PLAN	6-8 POINTS GOOD PLAN	9-10 POINTS EXCELLENT PLAN
<ul style="list-style-type: none"> • Less than 40 percent of the Landscaping for Energy Guidelines are included and correctly placed in the community design. • Less than 40 percent of the ways that trees in the landscape design either produce or conserve energy can be correctly described. • Little diversity of broadleaf and conifers are included in the design. 	<ul style="list-style-type: none"> • Three of the Landscaping for Energy Guidelines are included and correctly placed in the community design. • 50 percent of the ways that trees in the landscape design either produce or conserve energy can be correctly described. • Broadleaf and conifers are included in the design with most trees correctly placed for good energy conservation. • Several aspects of a community are included. 	<ul style="list-style-type: none"> • Four or five of the Landscaping for Energy Guidelines are included and correctly placed in the community design. • 75 percent of the ways that trees in the landscape design either produce or conserve energy can be correctly described. • Broadleaf and conifers are included in the design with all trees correctly placed for good energy conservation. One or two specific tree species are identified. • Work is neat with several aspects of a community included. 	<ul style="list-style-type: none"> • All five of the Landscaping for Energy Guidelines are included and correctly placed in the community design. • All of the ways that trees in the landscape design either produce or conserve energy can be very well described. • Many broadleaf and conifers are included in the design with all trees correctly placed for good energy conservation. Three or four specific tree species are identified. • Work is very neat with many aspects of a community included.

Authentic Assessment

Students will use the five guidelines to evaluate real plantings around the school building, area homes or business sites. They will determine if efficient use of tree planting was made to produce or conserve energy. They could select areas on the grounds where new trees might be planted on Arbor Day. If available, they can observe and comment on areas where windbreaks have been planted.

Other ideas!

- Take a field trip to a tree farm
- Invite a landscape architect to speak to the class
- Create a 3-D neighborhood in class using your examples



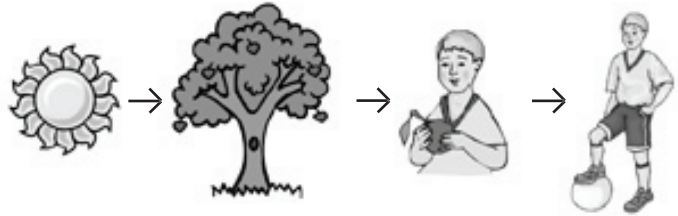
Landscaping for Energy Conservation Guidelines • Student Worksheet #1

DIRECTIONS – Imagine you are a city planner. Design a new, energy-saving city housing development for your neighborhood or city. Use the information and guidelines in this worksheet. Note: Make sure to indicate north, south, east and west on your design plan.)

Guideline #1: Plant Trees to Produce Food Energy for People and Wildlife

What you should know

Trees and other green plants are the source of energy for all animal life to live and grow. Through the process of photosynthesis plants change light energy from the sun into chemical energy that is stored in the plant as carbohydrates (sugars) as it grows. All animal life, including human life, depends on that stored energy. When you eat an apple, the chemical energy stored in the fruit becomes the energy “fuel” that allows you to work, play, run, and grow. Every living animal either gets its energy directly from plants or depends on other animals that depend on plants for food.



Energy Food Chain.

What you can do

Plant many different kinds of trees that have high food value. This will increase healthy food energy for people as well as provide food and habitat for many kinds of wildlife. Plant fruit and nut trees that will grow in the climate where you live. Trees or shrubs with high-energy food value for people or wildlife can include: apple, orange, cherry, peach, oak, hazelnut, plum, etc.

Guideline #2: Grow Trees as an Energy Crop

What you should know

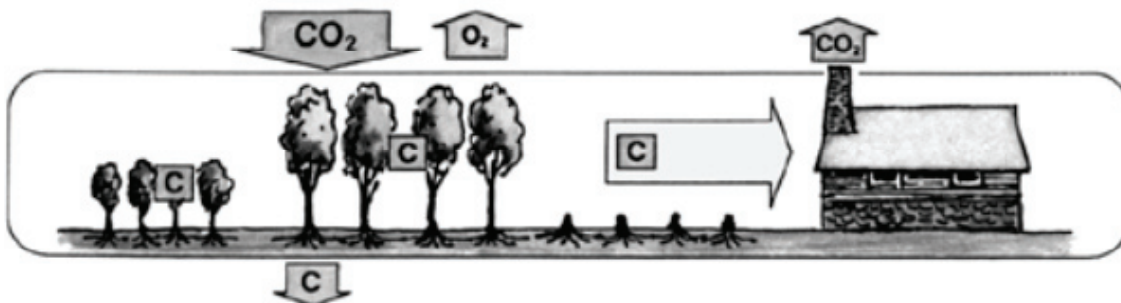
The wood from trees or waste from farm crops can be burned to make energy that keeps us warm or makes things run. That energy is called **biomass energy**...it is energy you can grow. Certain kinds of trees, like hybrid poplars, can grow 40 feet high in only six years. These six-year-old poplars can be cut a few inches above the ground. The cut poplar can be burned to create heat

energy. The poplar will grow back from the cut stump and, within 6 years, be ready for another energy harvest. Biomass not only produces energy, it is good for the environment.

What you can do

Plant trees or other biomass energy crops on land that is considered unfit to grow food crops. Plant new trees when trees are cut down. Take care of the soil in which our crops grow. With careful management, wood and other biomass fuels will always be a renewable resource.

Trees Creating Energy – Cleaning the Air



As a tree grows, the leaves of the tree take in carbon dioxide (CO₂), cleaning the air. Through the process of photosynthesis, CO₂ breaks into carbon (C) and oxygen (O₂). The carbon (C) is stored as wood in the trunk and the roots of the tree. The oxygen (O₂), a gas all animals need to breathe, is given off from the leaves into the air. When the tree is cut and burned for energy, some of the carbon (C) reconnects with oxygen and is released as CO₂, but some of the carbon (C) remains stored in the roots of the tree. Since more carbon (CO₂) is taken out of the air as the tree grows than is released when the tree is used for fuel, growing trees for energy is good for the environment.

Landscaping for Energy Conservation Guidelines • Student Worksheet #2

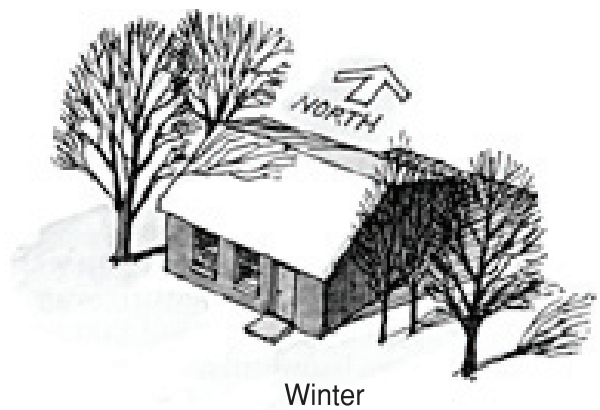
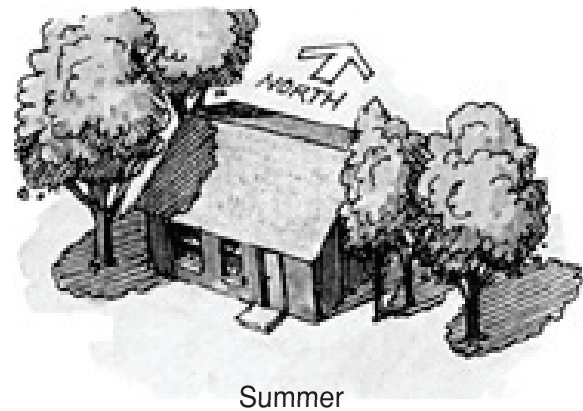
Guideline #3: Plant Trees to Shade Your Home

What you should know

Trees shading a home can reduce the need for air conditioning. Carefully placed trees can save up to 25 percent of an average household's energy needs for cooling...up to 65 percent in the case of mobile homes. According to the U.S. Department of Energy, proper placement of only three trees can save the average household up to \$250 in energy costs each year.

What you can do

The most energy savings and the best use of shade generally comes from deciduous broadleaf trees planted about 10 feet from the walls to the west, east or northwest of the house. These trees shade the house during the summer, reducing the energy needed for air conditioning. When they lose their leaves in the winter, trees correctly planted allow the sun to reach and warm the house, saving energy for heating as well.



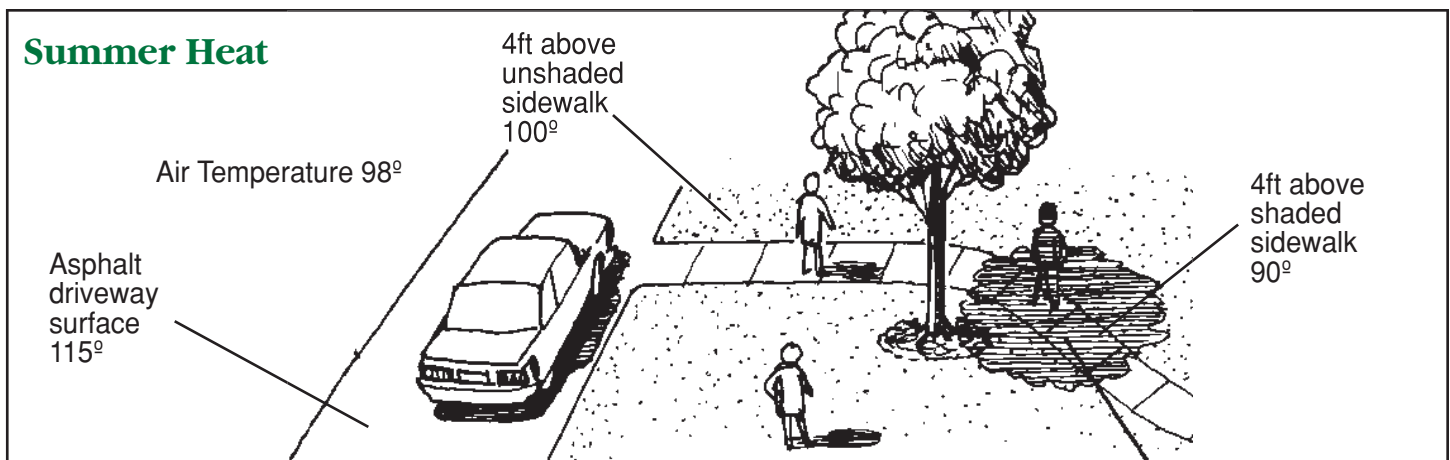
Guideline #4: Plant Trees to Shade Air Conditioning Units and Paved Areas

What you should know

Most types of air conditioners are much more efficient and use about 10 percent less energy when they are shaded by trees. Trees shading concrete or asphalt driveways and parking lots will greatly decrease surface heat. In the summer, a city area with trees shading paved areas can be 12 degrees cooler than one without trees.

What you can do

Plant trees or shrubs to shade air conditioners. Plant broadleaf trees near, but not right against sidewalks and driveways. Create areas in large parking lots or along city streets where trees can be planted for shade.



Landscaping for Energy Conservation Guidelines • Student Worksheet #3

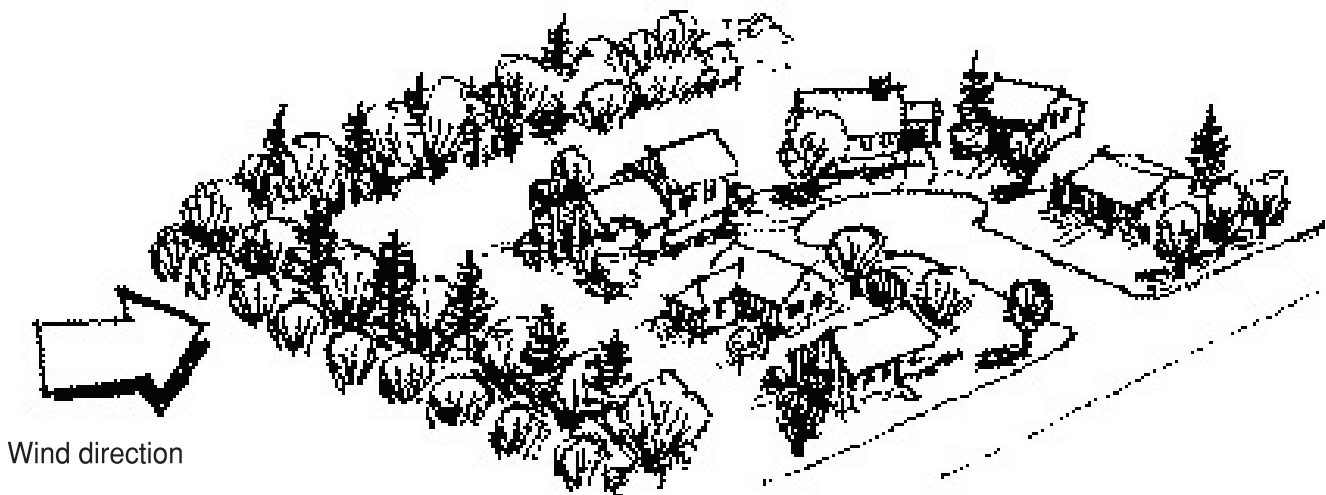
Guideline #5: Plant Trees to Break the Wind and Reduce Blowing Snow and Dust

What you should know

Windbreaks are usually rows of trees used to reduce the force and direction of the wind. Planting a windbreak around a home or housing development can provide an energy savings of up to 30 percent and reduce blowing snow, noise and dust.

Windbreaks should be planted in an L-shape (right angle) to the common wind direction. For best protection, windbreaks may be planted on more than one side of the

property. Effectiveness of the windbreak also depends on the density (thickness) of the windbreak and its height... three or more rows of trees in staggered formation provide the best wind protection. Conifers generally form the best windbreaks. Windbreaks are effective for a distance of up to 8 to 10 times the height of the mature, fully grown trees.

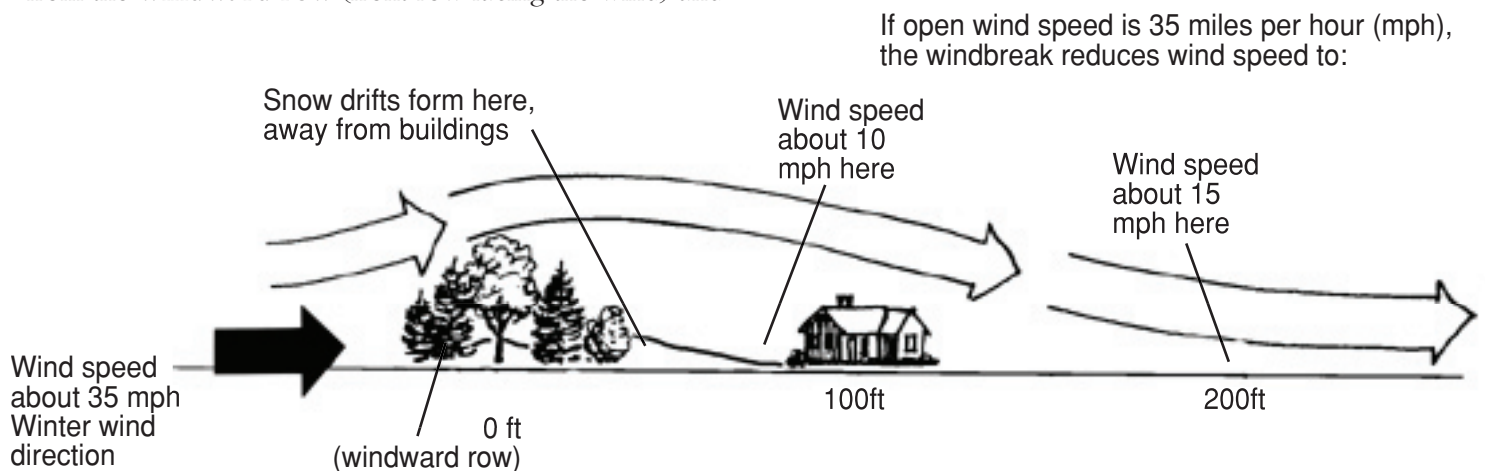


A well-placed windbreak can protect several homes or an entire development from chilling winter winds and drifting snow.

What you can do

Plant conifers, several rows deep, in a continuous line facing prevailing winds. Since snow and stale air can collect in the area directly behind a windbreak, buildings to be protected should be located no closer than 100 feet from the **windward row** (front row facing the wind) and

the area to be protected should be within a downwind distance of 2 to 5 times the expected height of the tallest windbreak row. (For planning purposes, 20 feet is often used as the height of the tallest trees.)



Step 1

EXTENSION ACTIVITY

Classroom Activity:

- Conduct temperature and transpiration experiments

Objectives:

Students will be able to:

- make predictions about how trees affect temperature.
- setup a scientific experiment.
- measure the difference in temperature in tree shaded and unshaded areas.
- demonstrate the process of transpiration.

Time Recommended:

- Two 30 minute class periods

Materials Needed:

- several plastic baggies with twist ties
- 2 or more different kinds of leafy plants if no available leafed-out broadleaf trees
- grow light or sun lamp (if no access to a sunny location)
- two or more thermometers with same scale (F or C)
- Pencil and Paper
- Microscopes with slides and cover glass
- Lettuce Leaf
- Iodine
- Eyedropper
- Forceps or tweezers

National Science Education Standards

Correlation:

Students will develop an understanding of:

- nature of science.
- populations and ecosystems.
- abilities necessary to do scientific inquiry.
- understanding about scientific inquiry.

Building off knowledge gained in the Basic Activity, these experiments are designed to show how trees can cool their surrounding spaces. If you choose to just do these Extension Activities rather than the Basic Activity, you may wish to include the evaporative cooling demonstration from the Basic Activity (page 11) here.

Teacher Background Information:

Temperature is a measurement of the degree of heat. Temperature is measured on a standard Fahrenheit or Celsius scale.

Transpiration is the process by which water evaporates from plant tissues, primarily leaves. Most plants in temperate climates transpire about 99 percent of the water taken in by the roots. The other one percent is incorporated into the plant's structure. The vast majority of the water transpired by trees escapes through small openings on the underside of the leaf, the side away from the sun. Different species of trees and plants transpire at different rates depending on temperature, wind, light and humidity. Plants in arid climates need to retain the limited moisture they take in, so their transpiration rate is much less than plants in more temperate climates.

Anticipatory Set:

The students will be setting up experiments using the scientific method. If students have not done any experiments, it will be important to review some of those terms with them. Write the words **hypothesis**, **variable** and **constant** on the board.

Tell students they are going to do two simple experiments. Explain that scientists have guidelines they follow when they set up experiments. They start with a question, then they make a prediction (educated guess) about what the answer might be. That prediction is called a **hypothesis**.

Next scientists determine the ONE specific thing they need to test and compare to prove their hypothesis. For example, a scientist may wish to see if corn grows faster using fertilizer. To test that a scientist will plant

corn. Half of the corn planted would not have any fertilizer while the other half of the corn would have fertilizer. The ONE thing that changes, or is different, is called the experiment **variable**. The one thing in this example that is different is fertilizer. Everything else in the experiment needs to be the same...or **constant**.

Using this same experiment example, ask students what things would need to be constant. List these things on the board. (Same brand of corn seed, same kind of soil, equal amounts of water, equal amounts of sunlight, same temperature, similar location area, same planting date.) Remind students that to prove that fertilizer makes a difference, everything else that affects the corn must be the same.

Temperature Experiment:

Tell students they are going to conduct experiments to see if trees do make a difference in the temperature of an area. Assign students to groups and help each group develop an experiment that has one variable involving temperature. One group might compare the temperature of grass in the sun to the temperature of grass in the shade. Another group might compare the temperature of a sidewalk surface in the sun to the sidewalk surface in the shade. A third group might measure the difference in temperature of asphalt in the sun to asphalt in the shade. (In each location, the variable is sun/shade.) Have each student make a prediction about what they think their own group results might be.

Remind students that everything else in their experiment needs to be constant. Have students brainstorm a list of what those constants need to be. The list might include time of day temperature is taken, amount of time they leave the thermometer before reading the temperature, the location site for each group...group one – grass; group 2 – sidewalk; group 3 – asphalt.

Go outside and find a spot for each group where there is the appropriate mix of sun and shade. Each group must record the temperature after a specified amount of time. (10 minutes is plenty.) When tests are complete, ask the groups to describe the results of their investigations to the whole class.

Transpiration Experiment:

Have each group wrap a leaf on the potted plant or a small portion of a leafy broadleaf tree branch that is exposed to full sun in a transparent plastic bag. Seal the end of the bag as tightly as possible. Do this on several kinds of plants or trees.

Have students check on the leaf periodically making notes on what they see. Ask them to record the results on how long it takes for water droplets to form inside the bag. Compare results from the experiment. Do different kinds of leaves transpire at different rates?

As students are waiting to check their leaves, discuss the process of transpiration with them. If you have not done the evaporative cooling demonstration with the fan and water from the Basic Activity, (page 11) you may wish to do that here. If you have done that, remind students of how the water that transpires from the leaves evaporates like the water on their hand, cooling the air around it.

Explain that plant leaves have tiny openings, called stoma or stomates. These little openings are where carbon dioxide enters the leaf and oxygen and water moisture leave the leaf. Surrounding each stomate are guard cells that open and close the stomate. Guard cells are shaped like two tiny green jelly beans on each side of the stomate. If a microscope is available, tell students they will have a chance to see a stomate and the surrounding guard cells.

If there are enough microscopes in the class for each group to use, you may wish to have each group prepare their own slide. Otherwise prepare the slide using the following procedure and allow each group a chance to come look at the slide.

If microscopes are not available, you can print off the illustration on page 18 by going to arborday.org/stoma and review that with your students.

“He who plants a tree loves others besides himself.”

Thomas Fuller

Step 1

How Trees Produce and Conserve Energy

EXTENSION ACTIVITY

Procedure:

1. Put one drop of iodine stain on the center of the slide.
2. Break the lettuce leaf and pull off the thinnest layer of epidermis possible.
3. Carefully spread out this thin layer in the iodine on the slide making sure it is flat and not folded over on itself.
4. Place a cover slip over the epidermis trying to avoid any air bubbles.
5. Carefully and slowly bring the slide into focus. Move the slide around until you find some stomates and guard cells.
6. Change the lens to high power to observe the stomates in more detail.
7. If time permits, draw a picture of what you see.

Authentic Assessment:

After students evaluate the two experiment results they will determine what other experiments they might like to do related to trees. Each student will describe their experiment idea, list a hypothesis, constants, variable, materials needed, and outline the procedure they would use.

Looking inside a leaf

