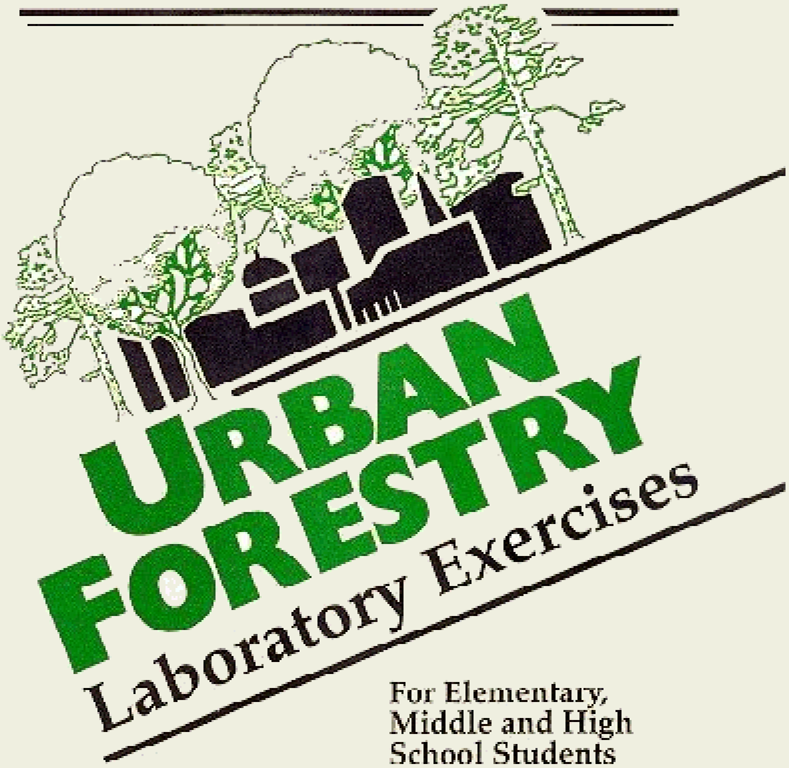

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Preface

Forests have always been one of our country's basic renewable natural resources. Forestry is therefore a career that one chooses to become a part of our nation's growth and heritage. From the time of the pilgrims to the present, our country's forests have not only been our pride, but a source of material wealth for the growth of this nation. The abundant wealth that is our forests, has been taken for granted for too long, and by too many. The way we have managed this natural resource has not always been the best for the nation as a whole. In our haste to build a better life, we have not always taken into account the plants, animals and soils we are destroying. Ultimately, biodiversity will be a key indicator of our society's progress.

The development of the Urban Forest is fast becoming a major concern. The population shift in our country from rural to urban is undeniable. People see trees as a barrier to the hot summer sun and harsh winter winds. They see trees as a source of natural aesthetic beauty. Trees are a resource for the renewal of inner peace and health. Trees are landscape essentials, increasing the value of property. The question has become 'What tree do I choose and what do I do to maintain it?'

The public needs to be educated, enabling them to choose the best possible tree for the site. We need to address the development of urban forests for our future use as a society. From the times of Robin Hood to the original native Americans, and then the Revolutionary War soldier, the forest has served as a haven of safety and escape. Awareness of trees has been developed through many programs during the last decade. Now we must develop the skills that anyone can use to help develop the Urban Forest. The job of urban reforestation is too large for any group to do on its own. With skills and resources available, many people can contribute to the reforestation process. This program has been developed as part of the conservation ethic that is now finding a rebirth in our nation.

Urban Forestry Laboratory Exercises has been developed as a supplemental activity guide that can be used in any science or interdisciplinary class. The hands-on activities are designed to be data gathering exercises leading the student to make judgments based on analysis and synthesis of the gathered data. The inventory necessary to complete the exercises is listed in this guide. The materials listed in the Forester's Trunk of Tools can be shared. During development of this curriculum, Forester's trunks were kept at the Morton Arboretum and shared by teachers from several districts. Establishing a similar relationship with an arboretum or library in your area, may be a good way to obtain the equipment and coordinate sharing among several schools. Teachers can modify the enclosed materials as needed. In the beginning, it will be most helpful if the teachers follow the activities as outlined, but later teachers may want to modify them as they gain experience with the materials and with their students.

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Plan for Urban Forestry

The curriculum in this program has been developed for the elementary, middle and high school levels. Each level builds on the other, and forms a thread of skills that are upgraded at each level. Each exercise is complete, enabling students to gather data about Urban Forests. The program has been divided into two components. The first component is for the development of your school's own arboretum, or tree walk, and herbarium. Tree planting should take place around Arbor Day in your state.

The second component of the program is the ability tiered curriculum presented in the form of student laboratory exercises and accompanying teachers' guides (Elementary school exercise format is altered slightly). Extrapolations called 'BLOWOUTS' for each exercise are noted, including a bibliography and source notation. Each of these exercises can be done on your school site. Repeated data collection on the same trees and shrubs is possible. An urban school site is not a natural habitat, but it is still an environment worthy of in-depth study. Students can measure dynamic growth of trees within the changing patterns of human habitation. **The guide has five areas of activity:**

1. Tree identification and inventory
2. Characteristics of the trees
3. Soil conditions for trees
4. Condition of the trees
5. Tree care and planting

A concluding field trip to some forested site (local park) would benefit the students understanding of the role of Urban Forestry in the total ecosystem. The idea of a half- or full-day field trip as a reward for work well done can be exciting for students. An appendix with additional or summative type activities is included. Exercises found in there are not limited to use by school systems and can be used by park districts, after hour's science clubs, gardening clubs, and state and local conservation programs.

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Philosophy

What is Urban Forestry? Urban Forestry is the comprehensive management of forests and related natural resources in populated areas, from the inner city, to the developing urban fringe, to small outlying communities. For too long, as urban areas have been developed, the forests of urban areas have been depleted or eliminated. We are now seeing an awakening to the needs of trees. Our society must not simply be developed in a technological way, but it must be developed in a natural sense for a balance to be brought to all of our lives.

Students need to interact with nature. They need to know that nature is not a stagnant entity, but is a dynamic living system. Day to day, month to month, year to year, nature is as catalogue of how we have treated ourselves. The quality of nature reflects our priorities as human beings. Nature can be described broadly as any setting from a woodlot to a vacant lot, a football field to a crack in the sidewalk, or a city park to the landscape around a school. Realizing this need, we have to interact and become a part of the forest. **Urban Forestry Laboratory Exercises** has been designed to reintroduce us to a vital missing part of the urban setting, an **Urban Forest**.

Society needs experts in many fields, but even more than this, our society needs members with a wealth of information and knowledge, equipped to make informed decisions. This program addresses this need by enhancing the science curriculum with additional resource material. This program illuminates nontraditional career opportunities that will become available as technological Urban Forestry is promoted.

Data gathering is a first step in the understanding of whether a problem exists, or is a figment of our imaginations. The intent of the program is to show how careers of all kinds are changing with technology, and to show the need to assimilate and share information when we develop new ideas. Grouping students to gather data is, in the best sense, a true scientific endeavor. Any good program of analysis and synthesis must have numerous data from which conclusions will be drawn. Growth in our technological society comes with the awareness one has of the interconnectiveness of environmental factors.

High school curriculum
Middle school curriculum
Mr. John Turner
Mr. Mark Prichard
HS District 88, Addison
Lisle Unit District 202, Lisle

Elementary school curriculum
Project coordinator
Mr. Joseph Cave
Mr. G. Kupkowski
Naperville District 203
HS District 88, Addison

Project supervisor
Project sponsor
Dr. Gary Watson
Dr. John Dwyer
The Morton Arboretum

US Forest Service, Evanston

The Research staff of the Morton Arboretum and the students that helped in the design of the curriculum.

Supported in part by grants from the USDA Forest Service North Central Experiment Station and the USDA Forest Service National Resource Conservation and Education Program.

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Objectives and Goals

Objectives

The Urban Forestry Unit has three primary objectives:

1. To educate and inform students and participants about how trees function in an urban setting.
2. To collect data on trees in their urban environment in order to determine how well the tree is surviving.
3. To provide an opportunity to participate in the development of an urban forest in your community.

Goals:

By the end of this **Urban Forestry Unit** the student will be able to:

1. Develop a map of the trees at or near the school by applying the classification scheme developed during the unit.
2. Recognize that one population of plants or animals can have an affect on others, even in an urban setting.
3. Understand that interactions among trees, soil and people are increasing in importance in urban settings.
4. Evaluate data collected to determine how trees are changing the environment.
5. Identify the current state and future of forestry as a career.
6. Identify the effect of planting and harvesting trees in an urban environment.
7. Know how scientific inquiry is influenced by beliefs, traditions, views, and actions of society as they pertain to trees in an urban setting.
8. Replicate the results of another student's experiment during this unit.

12. Demonstrate various ways to display the same data by use of computer generated graphs.
13. Apply quantitative observational methods to accumulate precise data about the trees on their school site.
14. Construct a classification scheme for the trees on the school site and demonstrate its use in class.
15. Evaluate and revise an inference based upon additional data gathered during the unit.
16. Revise a prediction on the basis of additional information.
17. Identify appropriate methods of measurement for a given task.
18. Analyze the results of each experiment.
19. Evaluate the interpretation of data collected during each experiment.

9. Recognize that experimental results must be open to the scrutiny of others; through the comparison of group results on the same trees.
10. Understand that data reflects the accuracy of the measuring devices for tree characteristics.
11. Demonstrate the ability to draw conclusions from collected data about the tree's environment.

20. Analyze an operational definition based upon a simple experiment.
21. Use direct observation to develop a question, and then answer it as part of the lab exercise.
22. Identify possible sources of error in measuring instruments, by comparing results of each group's measurements on the same tree.

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Trunk Equipment Inventory

Elementary School Level

Equipment:

1 Forester's trunk (Rubbermaid Acton Packer-24 gal. size) = $12.99 or $5 on sale - Ames
3 Light intensity meters (Environemental Concepts) = $120 Luxmeter - Terra Tech p.21
6 Air thermometers = $7.26 - AM p.8
4 Soil. Thermometers = $31.79 economy brand $16.06 - AM p.80
1 Soil probe (Oakfield Soil Samplers) = $34.20 - AM p.53
1 Fertilizer analyzer = $16.82 - AM p.54
2 pH soil analyzer = $16.82 - AM p.54
2 Soil moisture analyzer (Environmental Concepts) = $78-82 - AM p.54
4 Compasses (Taylor) = $9.99 - AM p.80
2 Sling psychrometer = $74 - BM
1 Increment borer (6"Suunto) and paraffin (wax) = $137 - BM
2 Cloth 1.5m measuring tapes = $33 - BM
2 500 gram field scales (Ohaus) = $415 - BM
8 Stakes = $5/ 4stakes - Hardwares stores
2 Wind meters (Dwyer) = $13.50 - BM
2 Balls of string = $1-2 - Hardware stores
1 Plant press (BioQuip) $18 Microware one - LVT OR $45 for standard - BM
1 Soil sieve kit (Hubbard) $65 - BM
1 Pruning shears (Hawkbill) = $10 - LVT

Educational Resources:

1 AUrban Forestry Laboratory Exercises@ = Free - PURP
10 Tree cookies = Free from local arborist
10 Tree cores in plastic tray
Dendrochronolgy kit (Lab-aids #52)
1 Carousel slide set of leaf parts = $15 - Staples
1 Set of pressed & identified plants
1 Set of forestry posters = Free from Georgia Pacific or US Forest Service
20 May Watts Tree Finder, M.T. Watts, Nature Study Guild, Berkeley, CA 1991
20 Selecting & Planting Trees, The Morton Arboretum, Lisle, IL 1990
3 Identifiy Trees & Shrubs by Their Leaves, E. Knobel, Dover Publ, NY 1972
1 A Field Guide to Eastren Trees, G. Petrides, Houghton Mifflin Co., Boston 1988
1 A Field Guide to Wildflowers, R.T. Peterson & McKenny M., Houghton Mifflin Co., Boston 1968
1 A Field Guide to Mammals, William T. Burt & Grossenheider, P., Houghton Mifflin Co., Boston 1980
1 Trees of North America, C. Frank Brockman, Bolden Press, NY 1986
1 Guide to Insects, R.H. Arnett, Jr., & Jacques, Jr. R.L. Simon & Schuster, NY 1981
1 A Field Guide to Birds, R. T. Peterson, Houghton Mifflin Co., Boston 1980

BM = Ben Meadows - 800-241-6401
AM = A.M. Leonard Tools that Work - 800-543-8955 (Free Catalog)
LVT = Lee Valley Tools - 800-871-8158

Note: You can order many of the books through Encore for a 10% discount. I like the National Arbor Day Foundation Tree ID books best for a handy pocket guide at 50 books for $25 or $3/book.

Middle School Level

Equipment:

1 Forester=s trunk (Rubbermaid Acton Packer-24 gal. size) = $12.99 or $5 on sale - Ames
1 Pruning shears (Snap-Cut) = $10 - LVT
1 Soil probe (Oakfield Soil Samplers) = $34.20 - AM p.53
4 Pocket compasses (Silva) = $14-50 - BM
2 Sling psychrometer-student (Hubbard) = $74 - BM
3 Diameter tapes-executive type silver = $38.50 - BM
1 Professional diameter tape with hook (Lufkin) - $39-50
4 Soil. Thermometers = $31.79 economy brand $16.06 - AM p.80
1 Increment borer (6"Suunto) and paraffin (wax) = $137 - BM
4 20 BAF prism (JIM*GEM) = $18-23 - BM
1 Plant press (BioQuip) $18 Microware one - LVT OR $45 for standard - BM
1 100 ft. tape measure = $16.36 - BM
2 Cloth 1.5m measuring tapes = $33 - BM
2 500 gram field scales (Ohaus)
3 Air thermometers (Nasco) = $7.26 - AM p.8
1 200 ft. surveyors rope (Keson)
4 Clinometers (Suunto) = $98 - BM
1 pH soil analyzer = $16.82 - AM p.54
1 Soil moisture analyzer (Environmental Concepts) = $78-82 - AM p.54
1 Fertilizer analyzer = $16.82 - AM p.54
6 Hands lenses = $6-20 - BM
2 Wind meters (Dwyer)
4 Jars (Ball & Mason) = $12 for box of 24

Educational Resources:

1 AUrban Forestry Laboratory Exercises@ = Free - PURP
10 Tree cookies = Free from local arborist
10 Tree cores in plastic tray
1 Carousel slide set of leaf parts with script = $15 - Staples
1 Set of pressed & identified plants
1 Set of forestry posters = Free from Georgia Pacific or USDA Forest Service
20 May Watts Tree Finder, M.T. Watts, Nature Study Guild, Berkeley, CA 1991
20 Selecting & Planting Trees, The Morton Arboretum, Lisle, IL 1990

BM = Ben Meadows - 800-241-6401
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Note: You can order many of the books through Encore for a 10% discount. I like the National Arbor Day Foundation Tree ID books best for a handy pocket guide at 50 books for $25 or $3/book.

High School Level

Equipment:

1 Forester=s trunk (Rubbermaid Action Packer- 24gal size) = $12.99 or $5 on sale - Ames
2 Pruning shears (Snap-Cut) $10-50 - AM

2 Soil probe (Oakfield Soil Samplers)
Pocket compasses (Silva) = $14-50 - BM
3 Clinometers (Suunto) = $98 - BM
3 Diameter tapes-executive type silver - $38.50 BM
4 Soil thermometers = $31.79 economy brand $16.06 - AM p.80
1 Soil sieve set (Hubbard) = $65 - BM
1 Increment boror (2"-Haglof) & paraffin = $137 - BM
1 Plant press (BioQuip) = $18 Microwave one OR $45 standard - BM
1 100 ft. tape measure
2 Cloth 1.5m tape measures (Ohaus) = $33 - BM
2 500 gram field scales (Ohaus)
3 Wind meters (Dwyer)
2 Sling psychrometer (Weksler)
3 Sling psychrometer-student = $74 - BM
3 Water meters (AMI Medical Elec.)
3 Sol pH meters (AMI Medical Elec.)
3 Water & light meters (AMI Med.)
6 Hands lenses = $6-20 - BM

Educational Resources:

1 AUrban Forestry Laboratory Exercises@ = Free - PURP
10 Tree cookies = Free from local arborist
10 Tree cores in plastic tray
1 Carousel slide set of leaf parts with script = $15 - Staples
1 Set of pressed & identified plants
1 Set of forestry posters = Free from Georgia Pacific or US Forest Service
2 Identifiy Trees & Shrubs by Their Leaves, E. Knobel, Dover Publ, NY 1972
20 May Watts Tree Finder, M.T. Watts, Nature Study Guild, Berkeley, CA 1991
20 Selecting & Planting Trees, The Morton Arboretum, Lisle, IL 1990
1 Dendrochronolgy kit (Lab-aids #52)
1 Tray of REAL tree cores

BM = Ben Meadows - 800-241-6401
AM = A.M. Leonard Tools that Work - 800-543-8955 (Free Catalog)
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Note: You can order many of the books through Encore for a 10% discount. I like the National Arbor Day Foundation Tree ID books best for a handy pocket guide at 50 books for $25 or $3/book.

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Smokey Bear Education Poster Series

AVAILABLE FROM THE UNITED STATES FOREST SERVICE

1. Mammal Footprints
2. Forest Insects
3. Forest Mammals
4. State Trees
5. Forest Mushrooms
6. Forest Birds
7. Forest Butterflies
8. Fish Need The Forest
9. Snakes Of The Forest
10. Wildflowers Of The Forest

These can be used as resources for discussion or beginning points for student projects or reports.

Contact your state government to see the which posters are available http://www.firstgov.gov/

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Establishing A School Arboretum or Tree Walk

At your school site, you will need to identify a minimum of 20 trees or woody shrubs that can be used by your students for the experiments in this Urban Forestry Unit. If there is not enough woody plant material available at your site, then a tree walk of the neighborhood could be designed.

Identifying all trees and shrubs on the premises

1. All students will use the tree identification key (May Watts Tree Finder from the Forester's Trunk) to identify a specific number of plants determined by the teacher.
2. A set of labeled tree and leaf parts on laminated tag board should be used to brief students on the plant part names they would experience in the field.
3. Make a map of the grounds with all the trees marked and numbered. The trees should be labeled with matching numbered tags to assure that the students are using the correct trees for their experiments.
4. Once all the trees on your site are identified and verified, a special identification key just for your site could be developed.
5. Make an inventory of all the woody species on the school grounds, for use in a data base at a later date.

Developing a School Arboretum

1. The school administration must agree to furnish an area on the grounds that can be developed into an arboretum.
2. New trees should be added each year. Donations from local arboreta or nurseries are often possible.
3. The arboretum can serve as a community resource. Develop contacts in the community to work towards this goal.
4. Identify areas near the school that could be used for forestry activities in future years (fields, empty lots, community parks, cemeteries, churches, nurseries). Private firms or utility right-of-ways can also be used.

If your school site is not suitable for establishing an arboretum, there maybe a public park nearby that can be used. Or you could develop a neighborhood tree walk.

Use of Park Facilities

1. Identify specific areas to be used.
2. Develop a list of short and long term benefits for the trees as a result of using the area.
3. Request permission for using the area.
4. Follow the same procedure as in the Identifying all trees and shrubs on the premises section.

Working with your city forester or park district to increase the number of species growing in the park is a valuable school exercise.

1. Activities your class could participate in:
    a. Arbor Day activities

    b. School/community activities on the site
    c. Earth Day planting or clean-up activities
    d. Others
2. Send students to local community groups to explain the project and what they hope to achieve with planting trees. The use of poetry or Bible passages can be a way to encourage people.
3. Develop a list of trees suitable for the site to be planted.

Tree Walk

1. Map out a walk that students can take within an allotted school period. (15 to 25 trees are needed)
2. Check whether the trees are in the parkway or the front lawns.
    a. Check with the city forester before using parkway trees.
    b. Approach home owners to explain what the students will be doing, and how it will be part of the school's curriculum.
    c. Develop an inventory of the trees with their site and address. The trees along the walk will involve the same experiments, so advance planning is very important.
3. Follow school rules governing students off campus.
    a. Specific instances may need to be discussed with the administrator in charge.
    b. Call JULIE (1-800-892-0123) before digging.
4. If a tree walk or park site is not a workable option, the development of the school arboretum with smaller habit plants may be an option.

Blowouts

1. Construct a classification scheme just for the trees at your site.
2. Map out one area of the school with all the dimensions standardized. Place all obstructions to trees, and objects that would cause trouble for trees (i.e., power lines, sidewalks, streets, areas that are salted in winter, water retention area, etc.).

This exercise does not require a student guide.

Parkway Tree Use Form

Dear Owner:

Please be advised that ________________________School wishes to include the tree(s) on your parkway in a study of trees in our town. The students will take several sets of measurements on your tree(s) each year. The measurements will be used to develop a rating system for the quality and longevity of the tree(s). When combined with others, the data from your tree will also help the students to develop a broad based set of data that can be used to develop possible courses of action for the future. The data will be made available to neighbors, and city officials, to assist them in determining the condition of the trees.

The students of ___________________________School do promise not to cause damage to your tree(s), and to provide you with yearly updates on the condition of your tree(s). Please sign and date the authorization below. Without your signature your tree(s) cannot be used in this study.

If you have any questions regarding the type of tests or measurements the students will perform, please call - name: ____________________ at phone: (_____)_________________, during school hours.

Thank you.

(detach here)

owner: ____ date: __________________

address: ____

city, state, and zip: _______________________________________

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Identifying Trees and Developing a Class Herbarium

Introduction

What do you see first when you look at a group of trees? They are not all alike. The easiest way to identify a tree is to use a tree key. There are many different structures you need to know in order to use the key correctly. The definitions are usually at the beginning of the tree identification key, accompanied by a picture to describe how to use them.

Once you think you have identified your tree, the pictures in the book will help you to see if you are correct. An even better method is to start a herbarium collection at your school so that you can compare your sample to locally grown specimens. This exercise is in four parts; collecting, identifying, pressing, and mounting the specimens.

Questions

1. What is the name of this tree?
2. Can I match it with our resource books?

Hypothesis

Students should make up their own before continuing.

Objectives

1. Identify the trees found on your school grounds.
2. Identify the major parts of a tree needed for identification.
3. Demonstrate the proper technique for collecting and mounting a herbarium specimen.
4. Create a quality herbarium specimen for the class collection.

Materials

Pruning shears	Notebook for class data
Plant press	8.5" x 14" copy paper
Tree identification key	Newspaper
Tree and shrub books	White glue (Elmer's)
Hebarium stickers	2' x 2' plexiglass
Wax paper	

Procedure

Identification:

1. Find the tree assigned to you and use the tree identification key to identify the specimen.

Collecting:

2. Find a branch on the tree, with the leaves in good condition, that can be reached by one member of your group. Be sure to gather a twig and leaves that will fit on the piece of paper, and not larger.
3. Check with your teacher, then use the pruning shears to make the cut at a diagonal so

that the pith can be seen.

4. Place the samples on the inside of a half folded newspaper.
5. Data collected by the group is recorded on the attached sheet, or in your logbook. These records may be important if the identification of your specimen is questioned.
6. The date, location on the grounds, city, and person who identified it should be noted.

Pressing:

7. On returning to school with your specimens in the newspapers, the teacher will give each specimen a number before the sample is put in the press.
8. Specimens should not hang outside the newspaper when placed in the press, and should be piled neatly.
9. First put down one of the wood frames of the press, followed by 2 cardboard aerators. Next, place one blotting page before the newspaper containing the leaf, followed by another blotting page and the other leaves. Insert one or two cardboard aerators before the next layer.
10. Once all the collected materials are stacked, put two cardboard aerators and the wood frame on top.
11. Place the straps around each end and then pull as tight as possible.
12. The press can be left to dry slowly over 48-96 hours. Some type of device to heat air and blow it through the plant press can be used for faster drying, which preserves color better. Ovens are too hot. Leaves can tolerate a maximum temperature of 130^{o}F.

Mounting:

13. Once the plants are dried, they can be left in the paper, or can be mounted on 11 x 17 inch herbarium paper. Check to see if the pressed plants will fit on the paper before gluing. If necessary, prune to make the leaves fit correctly on the paper.
14. Secure the plant parts to the paper with a solution of 60% white glue and 40% water solution.
15. Place glue on a plexiglas or other large smooth surface and gently lay the specimen in the glue solution until all parts are covered.
16. Lift specimen carefully on to the paper and center it so that all parts are visible.
17. Apply the herbaruim labels, or place the needed information in the lower right hand corner.

Results:

1. Prepare a data sheet for the class inventory of all collected specimens. Include tree common name, genus and species name, code number, and the location where it was found on you school site.

Discussion Questions

1. We identified trees by leaves, what are three other plant parts that could be used to identify trees? Why?
2. What are three advantages of knowing how to identify a tree?
3. Describe the two most useful characteristics of tree identification that you used. Why?
4. Do you think that some closely related trees would be hard to identify? Explain.

Conclusions Write a statement explaining how much of your hypothesis was correct. Is there anything that occurred during this exercise that you didn't expect to happen? If you were to do this exercise again, how would you do it differently?

Terminology

(This is for all levels. Ask your teacher which words you need to know.)

Needle-like leaves	Broadleaf with net venation
scale-like	pinnate / palmate
bundles	alternate / opposite
tufts	compound / simple
single needles	stem
deciduous	length / hairy
drooping branches	main vein
sheath	rough texture
brittle margins	smooth / toothed
stiff	regular / irregular
4-sided	serrated / lobed
3-sided	entire / wavy
hairy twigs	venation
scales	palmate / pinnate
fan-shaped	parallel
shapes	heart / ovate

Leaf Morphology	Stem and Bud Morphology
blade	terminal bud
midrib	lateral bud
stipule	bud scale
stem	terminal bud scale scar
leaf	leaf scar
petiole	lenticel
bud	bundle trace
leaflet	pith

Herbarium_____________________ Scientific name_________________ ____________________________ Habitat_______________________ Locality______________________	Herbarium_____________________ Scientific name_________________ ____________________________ Habitat_______________________ Locality______________________

Collector______________________ Determined by__________________ No.___________________________	Collector______________________ Determined by__________________ No.___________________________

Herbarium_____________________ Scientific name__________________ ______________________________ Habitat_________________________ Locality________________________ Collector_______________________ Determined by__________________ No.___________________________	Herbarium_____________________ Scientific name__________________ ______________________________ Habitat_________________________ Locality________________________ Collector_______________________ Determined by__________________ No.___________________________

To Download Herbarium Worksheet PDF

Table A:

Group Name _________________________
Date___________________________

<u>Condition Key</u>:
H = healthy
B = bark damage
I = insect damage

Tree Codes and Inventory

Tree Number	Common Name	Scientific Name	Tree Type	Condition	Notes

To Download Table A PDF

Table B:

Group Name ________________________
Date__________________________

Key and Notes:

Tree Number and Structures

Tree Number	Bark Color	Twig Color	Leaf Shape	Flower Color	Fruit Type	Avg. Twig Growth 19__	Avg. Twig Growth 19__	Avg. Twig Growth 19__

To Download Table B PDF

Table C:
Student Tree Identification Chart

Group Name ________________________
Date__________________________

Specimen No.______________________
Common Name_______________________ Scientific Name_______________________

CHECK OFF THE IDENTIFIED CHARACTERISTIC:

EVERGREEN:

____ evergreen
____ Needle ____ deciduous ____ awl
____# of needles in bundle ____ scale ____ length of needles

Description of cone
____

Color of needles____

BROADLEAF:

____ evergreen ____ deciduous

Leaf:

____ opposite ____ alternate
____ simple ____ compound
____ palmate ____ pinnate

Margin:

____ entire ____ serated ____ wavy
____ lobed ____ # of lobes ____ other margins

Venation:

____ palmate ____ pinnate ____ parallel

Possible extra data:

____ tree height ____ tree spread
____ length of petiole ____ bud length ____ bark color
____ flower color ____ season ____ fruit size
____ fruit type _____ fruit color

To Download Student Tree Identification Chart - Table C PDF

Plant Parts Checklist:

Student Guide

____ Parallel ____ Palmate ____ Pinnate
____ Rosette ____Alternate ____Opposite

____ Entire ____ Serrated ____ Double serrated
____ Awl shaped ____ Lobed

____ Pinnately compound ____ Simple
____ Palmately compound ____ Blade

____ Petiole ____ Rachis ____ Leaflet
____ Ovate ____ Obovate ____Deltoid
____ Lanceolate ____ Spatulate ____Cordate

____ Needle ____ Petal ____ Sepal
____ Stamen ____ Pistal ____ Terminal bud
____ Bundle scar ____Bud scale ____ Lateral bud
____ Node ____ Leaf scar ____ Bud scale Scar
____ Internode ____ Lenticel

____ Dehiscent ____ Indehiscent ____ Berry
____ Multiple fuit ____ Pod

____ Pome	____ Drupe	____ Pith
____ Rhizome	____ Root hair	____Bulb

Numbered pressed materials illustrating some of these terms are included with the Forester's Trunk inventory. Preparing these samples could also be a class project to build on over several years.

To Download Plants Parts Checklist Student Guide PDF

Background Information
Once the students have accomplished the task of learning to use the tree identification key (*May Watts Tree Finder* from Forester's Trunk), they should be ready to develop the class herbarium. Following the student format, each student group should be assigned a specific number of specimens to collect.

Target Group
Elementary through high school, with modifications necessary in the amount of collecting each level completes.

Timeline:
This lab can be done with all the students at the beginning of the unit. The students need to understand and be able to use the tree identification key (*May Watts Tree Finder* from the Forester's Trunk). These keys are not all inclusive but the students can usually identify the species of the trees. Other resources are available in the trunk to check on their identification. Herbarium specimens from previous classes can also be used to confirm identification. This is one of the reasons to have one or more herbarium specimens for each of the trees identified on your site.

Placement of Lab in the Curriculum
This lab is appropriate at the time you are covering other data exercises or classification lessons from your text. It can also be used to get students to gather, organize and prepare data for future analysis. This lab is best if scheduled at the beginning of the year, especially since the trees are in full leaf at that time.

Student Learning Objectives
1. Compare living trees by applying a classification scheme to them.
2. Identify errors made in identification by other students.
3. Gather specimens for a herbarium.

Evaluation
Collection and preparation of herbarium mounts can be used as the major tool in assessment. The correct identification of the tree and/or tree parts can be used for pre- or post-evaluation.

Preparation and Teaching Tips
The teacher will need to provide newspaper for pressing the plants, white glue that has been mixed with water in a 60/40 solution for mounting leaves, and a smooth surface to spread the glue on. The best size paper for making the herbarium mounts is 8.5 x 14 inches. The teacher may have to instruct students on the proper method for collecting leaves without denuding trees. Assigning trees to student groups once they have been numbered can alleviate many collection problems and group concerns. The students need to be familiar with many of the terms in the lab exercise and the identification key. This can be accomplished by using the pressed samples and the slide set that is part of the Forester's Trunk inventory.

When filling in the Student Identification Chart (Table C), have the students list the pages in the tree identification key (*May Watts Tree Finder* from the Forester's Trunk) that they followed to identify the tree. This can be used to check their work. These can be kept with the pressed plant parts in folders for the students to check.

Discussion Questions and Conclusion Answers
The questions are all of a higher order nature, and can be done by the group or individually. Answers will vary.

Blowouts
1. Students can go into the community or to local forest preserve and develop herbarium sets for each area separately. Students can build a plant press and collect all the needed materials for continuing this exercise.
2. Use plant parts checklist to develop class set of materials, similar to the one found in the Forester's Trunk.

References
1. *May Watts Tree Finder*, May Watts Theilgaard. Nature Study Guild, Berkeley, CA. 1991.
2. *Selecting and Planting Trees*, The Morton Arboretum, Lisle, IL. 1990.
3. *Manual of Woody Plants*, Michael A. Dirr. Stipes Publishing Co., Chamapign, IL. 1975.

Plant Parts Checklist:
Elementary Level
Teacher Guide

_1__Parallel
____Rosette

_2__Palmate
_4__Alternate

_3__Pinnate
_5__Opposite

____Entire
____Awl shaped

____Serrated
_7__Lobed

____Double serrated
_6__Toothed

_8__Pinnately compound
_9__Palmately compound

_10__Simple
_11__Blade

_12_Petiole
____Ovate
____Lanceolate

____Rachis
____Obovate
____Spatulate

_13_Leaflet
____Deltoid
____Cordate

____Needle
____Stamen
____Bundle scar
____Node
____Internode

____Petal
____Pistal
____Bud scale
____Leaf scar
____Lenticel

____Sepal
____Terminal bud
____Lateral bud
____Bud scale scar

____Dehiscent
____Multiple fruit

____Indehiscent
___Pod

____Berry

____Pome
____Rhizome

____Drupe
____Root hair

____Pith
____Bulb

These are the numbered pressed materials in the kit, the remaining could be a class project to build on over the next several years.

To Download Plant Parts Checklist: Elementary Level PDF

Plant Parts Checklist:

Middle School Level
Teacher Guide

_1__Parallel	_2__Palmate	_3__Pinnate
_4__Rosette	_5__Alternate	_6__Opposite
____Entire	_10_Serrated	_____Double serrated
_9__Awl shaped	_7__Lobed	
_8__Pinnately compound	_11_Simple	
_12_Palmately compound	_13_Blade	
_14_Petiole	_15_Rachis	_16_Leaflet
_17_Ovate	____Obovate	_20_Deltoid
____Lanceolate	____Spatulate	____Cordate
_18_Needle	_24_Petal	_26_Sepal
_25_Stamen	_27_Pistal	_19_Terminal bud
_21_Bundle scar	____Bud scale	_22_Lateral bud
____Node	____Leaf scar	____Bud scale scar
____Internode	_23_Lenticel	
____Dehiscent	____Indehiscent	____Berry
____Multiple fruit	____Pod	
____Pome	____Drupe	_28_Pith
_29_Rhizome	_30_Root hair	____Bulb

To Download Plant Parts Checklist: Middle School Level PDF

Plant Parts Checklist:
High School Level
Teacher Guide

_1__Parallel	_2__Palmate	_3__Pinnate
_7__Rosette	_4__Alternate	_5__Opposite
_6__Entire	_10_Serrated	_8__Double serrated
_9__Awl shaped	_11_Lobed	
_12_Pinnately compound	_14_Simple	
_13_Palmately compound	_15_Blade	
_16_Petiole	_17_Rachis	_18_Leaflet
_19_Ovate	_22_Obovate	_25_Deltoid
_20_Lanceolate	_21_Spatulate	_24_Cordate
_23_Needle	_35_Petal	_36_Sepal
_37_Stamen	_38_Pistal	_26_Terminal bud
_29_Bundle scar	____Bud scale	_27_Lateral bud
_30_Node	_33_Leaf scar	_32_Bud scale scar
_31_Internode	_34_Lenticel	
_39_Dehiscent	_40_Indehiscent	_41_Berry
_44_Multiple fruit	_45_Pod	

_43_Pome	_42_Drupe	_46_Pith
_49_Rhizom	_47_Root hair	____Bulb

To Download Plant Parts Checklist: High School Level PDF

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Planting A Tree And Helping It To Grow

Introduction

Trees are very much a permanent part of the landscape and you must select the type of tree to plant very carefully. When the decision has been made to plant a tree, you must then do your homework and find out what types of trees will be suited for your site. Some of the information that you need to know about the tree is: how large will it get, how fast will it grow, how much sunlight does it need, and what type of soil conditions does it like? Once you have chosen that perfect tree for your school, park, or home, more information must be obtained about the site where the tree will grow.

Selecting the proper tree is as important as selecting the proper location in an urban environment. Drawing a map of the selected area is a good first step. Don't forget to include the direction and dimensions of all problems above and below the ground that you might encounter. Information you may have already gathered by doing the soils lab (What's Happening Below the Surface?) will be of great help in determining what must be done to allow the tree to thrive. Many books on tree selection are available. A resource list should be developed by the class.

Questions

1. How do we prepare for planting trees?
. What is the currently accepted method for successful tree planting?

Hypothesis

Students should prepare their own before continuing.

Materials

Shovels	Pruners	Ruler	Composted material
Mulch	Rakes	Stakes	Tree wrap
Water	String	Tree tag	Old hose sections

Procedure

Site Selection:

1. Using specific information about the conditions required for the tree to grow and a map of the site, choose 3 possible planting sites. Take soil core samples to determine what lies below the surface.
2. After developing a data table format for soil moisture, soil temperature, and pH readings at each site, gather the data. Map the area including measurements of the distance from buildings, sidewalk, power lines and shrubs that could affect the growth of the tree.
3. Bring this data into the classroom and place it on the board or overhead projector, so all students can make a case for each of the sites.
4. Choose the site that is most compatible with your tree.

Planting:

1. With a location determined, decide:

   a. How large the hole needs to be. (3x rootball diameter)
   b. How much organic matter should be placed in the hole with the tree.
   c. How much mulch should be placed over the soil around the tree. (to a depth of 4 inches)
2. Tree wrap should be applied to the tree, if needed, starting at the bottom and working up.
3. Bring this data into the classroom and place it on the board or overhead projector, so all students can make a case for each of the sites.
4. Watering is the **single most important** task of the planting procedure and must be carefully accomplished. When you plant the tree, add soil and water at the same time. Simply return the soil that was dug out, or substitute a mix of other soil. Both are acceptable.
5. Water the entire mulched area daily for the first week, then at least 3 times per week for the next month. Approximately 3-5 minutes of water from a hose, will be sufficient.
6. Check the soil moisture in the rootball by using a soil probe, or large piece of wire. Resistance to penetration indicates that the rootball is drying out.

Results

Using the data table and map of the area, each student group should respond how they would adapt the planting technique described above if the tree were placed:

1. Along a narrow parkway.
2. Underneath a much larger and older tree.
3. Underneath power lines.
4. Next to the school building.

Discussion Questions

1. Where would you plant a tree that has thorns?
2. How would you use a shrub you are told will never get larger than 4 or 5 feet.
3. If the school objected to the choice of tree (Crabapple), what could you do to make them understand that your choice is the right one?

Conclusions

1. Why do we need to plant trees in the urban areas of our country?
2. Why do you put woodchips underneath the tree?
3. If you were to plant a tree at your house, explain how you would change the procedure we used.

Terminology

define these words and phrases

bud
bare root
roots
balled and burlaped
growth rate
amending soil

cultivar
container plnats
rootball
mulching
compacted soil
backfilling the hole

leaves
pruning
fertilizing
watering
clay soil
drainage

power lines size of hole	light requirements	longevity

Background Information

Planting a tree and/or shrub on your school grounds can become an overwhelming event. The components must be well defined; map drawings, note taking, and picture sketching of how the planting procedure was accomplished. Every student will want to dig the hole. You must insist the job has to be done correctly, and we must do only those tasks assigned. You should try, to get help from the public to purchase materials by advertising this event.

Realize that the work to be done can be accomplished by many people in a short time if everyone works together. Task cards for each group can be used for assessment. If the task will take more than one class period, each hour of the day can have a few students working on each part of the task. Have students write questions for other classes to discuss, covering what has been done and how the job could be done more efficiently. Explanations and questions of the students can generally be answered by anyone who has read a tree planting reference (Selecting and Planting Trees from the Forester's Trunk).

The resource materials in the Forester's Trunk inventory will provide the students with much of the information about trees. Some extra library work may be required.

Target Group

Elementary through high school.

Hypothesis

Examples:

1. Determine the proper place to plant a tree?
2. Plant a tree correctly.
3. Demonstrate what must be done after planting the tree.

Timeline

Pre-lab preparation is accomplished for the most part, by completing the previous lab exercises in this unit. Gathering materials should begin early in the year. Check with the janitorial service about the possibility of borrowing equipment. Call the city or park district several weeks before the planting to make sure woodchips are available.

Tasks can include:

a. bringing assigned tools
b. lining out the site after school
c. mapping of the area
d. preparing a maintenance schedule
e. collecting 5 gal buckets for watering / moving mulch
f. testing the soil before planting the tree
g. acquiring plastic to put under the soil that is removed from the hole

Day 1 --	Student groups make all the site measurements and take soil cores to examine the characteristics of each site. Discussion back in the classroom as to which site is the best. What are the criteria for selection of a site?
Day 2 --	If the site can be marked with a stake, do so. If not, then spray paint on

	the ground can mark the area. Decide if a pre-digging day is necessary to complete the task with available tools, or if the hole will have to be dug outside of class time.
Day 3 --	Have the assigned groups gather their materials and head out to the planting site, where everyone performs their assigned tasks. If multiple classes are involved, break down the work into parts and discuss proper techniques that everyone can observe while work is being done.
Day 4 --	Check the site to determine the soil moisture, and whether the plant has settled. Discuss the kind of long term care required. Have students check their hypothesis to see how well they accomplished all their tasks.

Placement of this Lab in the Curriculum

This exercise is the summative experience for the entire Urban Forestry curriculum package.

This lab can be done anytime after the teacher has covered safety and procedures in a classroom, but it is better placed after the class has completed the other exercises. This is a culminating activity that should be used as a growth experience for the students, and not as a strictly graded exercise. Planting the tree should become an aesthetic and recreational activity along with educational. Point out to the students that these trees, if maintained, could live for over 100 years. Typical urban trees live 7-40 years, depending on the site.

The field work for this lab can be done at any point in the year, but the tree should be planted in the spring, not too close to the end of the school year, so that students can learn about maintaining the tree. Be sure to arrange for watering during the summer.

Student Learning Objectives

The students will be able to:

1. Understand the interaction among trees, soil, and people by participating in planting a tree.
2. Develop questions to be answered as part of the planting activity.
3. Explain the relationship between the new plantings and other organisms in the immediate area.
4. Evaluate the map and data to determine an appropriate planting site.

Evaluation

1. The on-time completion of assigned tasks with all the data can be the easiest method of assessment.
2. The pre- and post-test can measure increases in the student's understanding of the process.
3. A written response, including answers to the student discussion and conclusion questions, will provide some insight into the student's understanding of the planting process.

Preparation and Teaching Tips

A large amount of planning is necessary for this lab to be successful. The following committees will be needed:

1. A *site committee* to rope off the area and prepare it for the planting.

2. A *digging committee* responsible for measuring and staking the site, and digging the hole. Accurate measurements should be taken and noted in journals.
3. A *tree committee* responsible for the removal of the rope and burlap once the tree is situated properly in the hole. If the tree is in a container, the group must decide what method to use to remove the container.
4. A *mulching committee* responsible for gathering and moving the proper amount of mulch. City street crews or the park districts usually have mulch available and will drop it off at school.
5. A *tool committee* responsible for gathering and cleaning all the equipment. This includes shovels, rakes, buckets, hose, and stakes.
6. A *data committee* to measure the hole, the tree, and the rootball for inclusion in the data bank for future reference.

Discussion & Conclusion Question Answers

1-3. The answers to all of these are based on all previous work and your specific site requirements. Helping the students with hints may be necessary.

1-3. The answers will vary. These are also based on the previous readings and laboratory work accomplished by the students.

Blowouts

1. Students can go to local greenhouses to inquire about donations for other materials for plantings at the school for beautification.
2. Students could prepare small trees from seeds they collect in the fall and sell them to raise money for more plantings. These seedlings could also be planted in a nursery to be used in future years, or to give away to smaller children or shut-ins.

References

1. *Selecting and Planting Trees*, The Morton Arboretum, Lisle, IL. 1990.
2. *Manual of Woody Plants*, Michael A. Dirr. Stipes Publishig Co., Champaign, IL. 1983.
3. *The Right Tree in the Right Place*, Commonwealth Edison.
4. *Tree and Shrub Planting in Illinois*, Planting Shade Trees, Tree Care, Guide to Illinois Big Tree, Plant Illinois, Illinois Dept. of Conservation.
5. *Benefits of Trees, Trees and Turf, Tree Selection*, USDA Forest Service.
6. *Transplanting Trees*, Vocational Agricultural Service Bulletin 5002a.

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What's A Tree?

Introduction

Students will begin their investigation of trees by:

1. Brainstorming their existing knowledge of trees.
2. Developing criteria for tree identification.
3. Doing a simple school site tree inventory.

Questions

1. What do students already know about trees?
2. What criteria do we use to identify trees?
3. How many trees do we have on our school grounds?

Materials

Classification worksheet

Procedures

1. Begin by asking students what they already know about trees. This can be done using the K,W,L method (Know-Want to know-Learned), webbing, concept mapping, or any other brainstorming technique. Use this to introduce the unit and begin a discussion of what the students think they will be studying.
2. Have students cut out the shapes from the classification worksheet and then classify the objects according to a system of their choice. Write some of these on the board. Discuss the different systems. Encourage them to come up with even newer ones. Discuss the **attributes** of the objects (size, shape, pattern). From this discussion, ask students to list the **attributes** of trees (leaves, bark, buds, shape, etc.).
3. Go outside and walk the perimeter of the school grounds and note the trees there. You could simply count how many there are, or start to make a map with each tree. You could note shapes and how they are different, or compare natural areas to landscaped areas if you have both. The extent of your school inventory is up to you depending on student interest, time, etc.

Discussion Questions

Questions which come up at this time are great for research and for further discussions. Some you might expect:

1. Is this a tree or a bush?
2. What kind of tree is this?
3. How old is this tree?
4. How could we count the rings without cutting it down?

Blowouts

1. Expand the classification activity to teach the scientific naming system of Kingdom, Phylum, Class, Order, Family, Genus and Species.

Cut out the shapes and arrange them into groups which go together. Is there more than one way to arrange them? How many different ways can you think of?

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Watt's A Tree?

Introduction

Students will continue their investigation of trees by:

1. Further developing criteria for tree identification.
2. Identifying and categorizing trees according to these criteria.
3. Using the tree identification key (*May Watts Tree Finder* from the Forester's Trunk) to identify trees on the school grounds.

Questions

1. What criteria do we use to identify trees?
2. Can we use these criteria and the tree identification key (*May Watts Tree Finder* from the Forester's Trunk) to identify the trees on the school grounds?

Materials

Tree identification key (May Watts Tree Finder from the Forester's Trunk)
Other tree books
Herbarium sheets from the Forester's Trunk inventory

Procedures

1. Review your discussions from lesson 1 on the attributes of trees. Students should understand that scientists use a number of criteria to identify trees, but the simplest method is using leaves.
2. To use the tree identification key (*May Watts Tree Finder* from the Forester's Trunk), students will need to be familiar with several vocabulary terms such as opposite, alternate, pinnate, parallel, serrated, lobed, compound, simple, etc. You may choose to teach these terms ahead of time, or simply introduce them as the students encounter them. The set of slides showing the important terms with illustrations in the Forester's Trunk would be very helpful, if available.
3. Practice using the tree identification key. Using the leaves you have available, let the students attempt to identify the leaves using the tree identification key. Help them as needed. Once they have the idea of how to use it, take them outside to identify the trees on the school grounds. You may all work together, or have small groups responsible for certain trees, etc.

Helpful Hints

Not all landscape trees used here in the midwest will be in the tree identification key, because they do not normally grow around here. You might want to have a more comprehensive identification book available to help with those.

Someone in your school probably has the master landscape plan which you can use to be sure students get the correct answers.

Many times it is sufficient to have students identify only the genus, and not be concerned with the specific species (i.e. the ashes or oaks etc.). If scientific naming (binomial nomenclature) is part of your curriculum, this is a perfect place to introduce it. Students are often curious about the scientific names in books and will ask about them.

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How Big Is A Tree?

Introduction

One of the goals of the Urban Forestry program is to involve students in scientific research-type activities. Nearly all research is based upon data collection and analysis. Since all schools do not have access to beautiful natural areas, we would like to concentrate on the school site. As more and more schools participate in this study, we want to develop a network by which teachers from around the area can communicate and share ideas.

For this activity, we want participating schools to develop a data base which can be upgraded each year. To do this, you need to know the height and circumference of every tree on the your school site, and then chart the growth of those trees over the years.

Questions

1. How do we estimate the height of a tree?
2. How do we measure the circumference of trees?

Materials

Metric tape measures

Procedures

1. As part of Lab #1 , you may have started to develop a map of the trees on your school site. If you did not, you will need to have some way to keep a record of all existing trees and any new ones you plant.
2. Designate groups of students to gather data on the height and circumference of every tree on your site and record this information.
3. There are several methods by which your students can estimate or measure the heights of the trees. If your math curriculum includes Geometry, you may want to incorporate some of your math lessons here. If not, here is probably the simplest way:

a. Have students measure their own height (in cm).
b. Student A stands under a tree while student B stands a distance away. (about 20 paces)
c. Student B holds a pencil at arms length and covers part of the pencil so that the visible part is the same length as Students A's height.
d. Student B now moves the pencil up the tree and measures how many times taller the tree is than Student A.
e. Simply multiply this number times Student A's height and you have a good estimate of the tree's height. **Example:** Student A is 150 cm tall. Student B found that the tree is about four times taller than student A. So 150 cm x 4 = 600 cm. The tree is approximately 6 meters tall.

- Find the circumference of the tree by simply measuring. Tree circumference is usually measured at about chest height. To insure accurate measurements from year to year, you may wish to make a mark with paint in the bark to designate the exact place where the measurement is made.

Results

Please record your data on the forms provided.

Discussion Questions

1. What is the value of a "longitudinal" study?
2. Why is it necessary to study a tree for such a long time?

TREE HEIGHT DATA TABLE

Tree Number	Species	Height (ft)	Circumference (in)	Site Observations

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How Old Is A Tree?

Introduction

Minerals, water and nutrients travel from the soil to other parts of a tree by way of small tube-like tissues called **xylem**. A similar type of tissue, called **phloem**, carries food substances down from the tree's leaves. In between xylem and phloem tissue, is the tissue called **cambium**. Cambium is the growth tissue of the stem that produces new xylem and phloem cells. Each year, as a new layer of xylem cells grows, it wraps around the layer before it. Because each layer is one year's growth of xylem cells, these layers are called **annual rings**.

Most students already know that you can count the rings on a tree stump to get the age of a tree, but the annual rings contain more information and can be used by scientists to date old wooden structures, tell the weather, etc.

Questions

1. How can we demonstrate the function of xylem and phloem?
2. What do annual rings really tell us?

Materials

- Celery
  Plastic cups
  Food coloring
  Knife
  Lab-aids kit
  Trunk cross-sections (tree cookies)

Procedures

1. Give each group 2 plastic cups. Have students fill the cups about half full of water and add food coloring (two different colors). With the leaves still on the celery, cut a slit up the bottom of the stalk about half way up so that one half can be put in each of the two cups.
2. Let this experiment set overnight for best results.
3. Pass out the 'tree cookies' and let students practice counting the rings.
4. Complete the optional Lab-aids kit on dendrochronology. (Published by Lab-aids, Inc., not included in guide.) Intermediate-aged students will probably need some guidance as they go through the worksheet. However, the activity does give them some interesting insights, especially into archeology and the early history of our country.
5. The next day, examine the celery experiment.

Results

The leaves of the celery should show the two colors of the food coloring on their respective sides. Also, if you cut about a centimeter off the bottom of the celery, the colored xylem will show very well. Be sure that students see this.

Results

1. Why do the leaves turn the color of the food coloring?

Conclusion

The xylem of the celery will transport water up to its leaves. Since the water is colored, the coloring will show up in the leaves.

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Quadrat Studies

Introduction

The quadrat study is an in depth, scientific investigation of the plants, animals, soil, light and weather of a specific area. The quadrat is usually a square. The size varies according to the study. The plots should be large enough to contain significant numbers of plants and animals. A common quadrat size is 9 square meters.

Question

1. How do light, temperature, soil, animals and plants differ in four different habitats: lawn, open field, forest edge and forest?

Materials

Wooden stakes	String	Light meter
Ruler	Air thermometer	Soil thermometer
Sling psychrometer	Soil probe	Soil test kit
Compass	Diameter tape	Coat hanger

Procedures

Laying Out the Quadrat:

1. Assign each group of students an area that is far enough from each other so as to encourage work within the group and not between groups.
2. Have one student take the first stake, and while facing all the others of his/her group, gently toss the stake over one shoulder to start the quadrat.
3. From that point, the students should construct a square that is 3 meters (9 yds, if only rulers are available) on a side. Enclose the square with rope, laying it on the ground.
4. Minimize the work done within the quadrat, most of the work should be done from the outside, if possible.

STUDY ONE: Light Intensity

1. Take the light reading at the stake.
2. Hold the light meter just above the ground and record the results.
3. Record the present weather conditions.

STUDY TWO: Temperature

1. Take the temperature readings near the stake.
2. Using an air thermometer, take the temperature 5 feet above the ground. Leave the thermometer in position until it stops changing and record.
3. Using the same thermometer, take the temperature at ground level and record.
4. Gently push the soil thermometer about 2 inches into the ground. Leave the thermometer in the ground for about 5 minutes and record.
5. Repeat step #4 inserting the thermometer 6 inches below the surface and record.
6. If a sling psychrometer is available, following the directions for the instrument, measure and record the relative humidity.

STUDY THREE: Soil Sampling

1. Take a soil sample near the stake.
2. Carefully push the soil probe into the ground and remove a core of soil.
3. Count the number of different soil layers and record. (draw a sketch)
4. Measure the depth of each layer and record.
5. If a soil test is available, measure the pH, moisture and fertilizer.

STUDY FOUR: Animal Survey

1. The animal survey will be taken in the general area of the stake.
2. Look carefully at ground level and above the ground for evidence of animals. Try to identify the most abundant animal, and state what it is doing. Also, try to determine if its home is in the immediate area.

STUDY FIVE: Plant Survey
Trees: (12" or more in circumference)

1. Find the tree closest to the stake.
2. Use a diameter tape measure and record the circumference of the tree. This measurement should be done at chest height.
3. Measure (or estimate) the height of the tree.
4. Identify the tree species.

Saplings: (1" to less than 12" in circumference)

1. Find the sapling closest to the stake.
2. Record the circumference of the sapling at chest height.
3. Measure (or estimate) the height of the sapling.
4. Identify the sapling species.

Shrubs: (bushy wood stems less than 6' in height)

1. Find the shrub closest to the stake.
2. Measure (or estimate) the height of the shrub.
3. Identify the shrub species.

Herbs: (non-woody plant-ground cover)

1. Throw the squared coat hanger slightly away from the stake.
2. Using the coat hanger as the boundaries, identify the different plants inside the hanger and indicate their number. (If the plant is extremely abundant, like grass, record as abundant without specifically counting each blade.) Use the terms abundant for more than 10, frequent for 5-10, or scarce for under 5.

Results

Record data on the Summary Sheet.

Discussion Questions

1. What role do plants play in their community?
2. What are the major differences between the four ecosystems studied?
3. How are the four ecosystems similar?
4. Which ecosystem seemed the healthiest? The least healthy?

5. What is meant by the term "bio-diversity" and how does it relate to this study?
6. Did you see any relationships between light, temperature, soil, animal life and plant life?

Conclusions

1. Students will explain what they learned by doing this exercise.
2. Students can explain how any of the two groups of data they collected help explain the other.
3. Students can explain why there were or were not the signs of animal life.

NAME: ______________________________

QUADRAT STUDY SUMMARY SHEET

Light Intensity Data

Quadrat # _____ Time: _____ Amount of light: _____

Weather conditions: ____

Quadrat # _____ Time: _____ Amount of light: _____

Weather conditions: ____

Quadrat # _____ Time: _____ Amount of light: _____

Weather conditions: ____

Temperature & Humidity Data

Quadrat # _____ Temp/5 ft.: _____ Temp/surface: _____

Temp/2" below: _____ Temp/6" below: _____ Rel. humidity: _____

Quadrat # _____ Temp/5 ft.: _____ Temp/surface: _____

Temp/2" below: _____ Temp/6" below: _____ Rel. humidity: _____

Quadrat # _____ Temp/5 ft.: _____ Temp/surface: _____

Temp/2" below: _____ Temp/6" below: _____ Rel. humidity: _____

Quadrat # _____ Temp/5 ft.: _____ Temp/surface: _____

Temp/2" below: _____ Temp/6" below: _____ Rel. humidity: _____

Soil Test Data

Quadrat # ____ Color: _____ Depth of layer: _____
pH: _____ Fertilizer: _____ Moisture: _____

Quadrat # ____ Color: _____ Depth of layer: _____
pH: _____ Fertilizer: _____ Moisture: _____

Quadrat # ____ Color: _____ Depth of layer: _____
pH: _____ Fertilizer: _____ Moisture: _____

Quadrat # ____ Color: _____ Depth of layer: _____
pH: _____ Fertilizer: _____ Moisture: _____

Animal Life Data

List **only** the most abundant animal in each area.

Quadrat # _____ Type of animal: _____________ Location: ______________
Activity: ______________________________________ Home: ________________

Quadrat # _____ Type of animal: _____________ Location: ______________
Activity: ______________________________________ Home: ________________

Quadrat # _____ Type of animal: _____________ Location: ______________
Activity: ______________________________________ Home: ________________

Quadrat # _____ Type of animal: _____________ Location: ______________
Activity: ______________________________________ Home: ________________

Plant Survey Data

List the **most** abundant plant in each group.

	Trees (species)	Circumference	Height
Quadrat #1	_____________	_____________	______
Quadrat #2	_____________	_____________	______

Quadrat #3	______________	______________	______
Quadrat #4	______________	______________	______

	Saplings (species)	Circumference	Height
Quadrat #1	______________	______________	______
Quadrat #2	______________	______________	______
Quadrat #3	______________	______________	______
Quadrat #4	______________	______________	______

	Shrubs (bushy wood stems less than 6' high)	Height
Quadrat #1	____	______
Quadrat #2	____	______
Quadrat #3	____	______
Quadrat #4	____	______

	Herbs (non-woody plants-ground cover)	Number
Quadrat #1	____	______
Quadrat #2	____	______
Quadrat #3	____	______
Quadrat #4	____	______

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Optional Laboratory: The Nature Journal

Introduction

Children are not always good at observing the world around them, because they have not been taught how to observe. In their structured, suburban world, children do not often have a chance to go "play" in nature, and find frogs, worms, stones and insects. Also, they rarely see adults take time to enjoy nature. Consequently, children need to be taught to **see** and **observe** nature. The activity of drawing is unique in its ability to enhance the powers of observation.

Question

1. Can drawing enhance a student's power of observation?

Materials

Pencil
Sketching pad or paper

Procedures

Students will be taught and practice three techniques of sketching: contour drawing, gesture drawing and memory drawing. Remember, the goal is to increase power of observation, not to produce professional drawings. The teacher may wish to demonstrate each of these techniques for the students.

A. **Contour Drawing:**

1. After observing an object from nature for a few minutes, select one small part of an animal, a plant, a scene, etc.
2. Concentrate on this small part for a minute or so.
3. Now put your pencil on your paper and without looking at your paper and without lifting your pencil, trace the object in great detail. Do this for two minutes.

- **Gesture Drawing:** Here you are trying to capture the essence of the object.

1. Using the same object, now sketch it in 5 seconds. (Hints: hold the pencil about in the middle and hold it loosely)
2. Using the same object, now sketch it in 15 seconds.
3. Now sketch it a third time, for 30 seconds (you may be impressed by the quality of the drawing and remember, it was done in 30 seconds!)

- **Memory Drawing:**

1. Now move away from your object and take 3 minutes to draw it from memory. Try to concentrate on only one or two things (texture, color, form, space, etc.).
2. Hopefully, now you realize that you can sketch objects in nature, the key is observing.
3. If time permits, try to observe and sketch something of their own.

Discussion Questions

Students should begin to make sketches which they will be proud of. If they still seem intimidated and say things like "I can't draw, this is terrible!" Remind them that the goal is to make observations, not masterpieces, and that we are using sketching to observe. When taught these techniques most students begin to enjoy sketching and will begin to sketch on their own.

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Optional Laboratory:
Nature's Air Conditioner

Introduction

Students will observe the process of transpiration in leaves.

Question

1. How much water will a leaf give off in a 24-hour period?

Materials

Reclosable bag (quart size)
Several small clean pebbles
Tree in the sun
Graduated cylinder

Procedures

1. Find an average-sized leaf on a tree which receives good sunlight.
2. Put the pebbles in the bag and close it around the leaf.
3. Wait 24 hours.
4. Carefully remove the bag and measure the volume and mass of the water collected inside.
5. Estimate the number of leaves on the tree and multiply by the volume of water collected. (Teachers should check with their own math program for an approved estimation procedure.)

Results

1. Volume of water = ________ ml.
2. Estimated number of leaves x volume of water collected = total water lost

__________ x ____________ ml = _________ ml

Discussion Questions

1. How might transpiration of trees affect the temperatures and humidity in a forest?
2. Students can convert from the metric to the english system. (liters to gallons)
3. How much water does one tree give off in a year. (Average growing season in Illinois is 170 days; find out for your own area).
4. How much water is given off from the trees at your school, in one year?

Blowouts

1. Measure the temperature and humidity in a forest area. Compare with data gathered from a non-forested area.
2. What effect, if any, might trees have on weather and the atmosphere in a populated urban area? In an irrigated desert region?
3. What other implications are related to tree transpiration?

Conclusion

1. Students will note the large amount of water one tree gives off.

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Optional Laboratory:
Comparing Sun Leaves To Shade Leaves

Introduction

Trees need tremendous amounts of water on a daily basis. Even though it may not rain every day, a trees' roots spread through the ground absorbing water. A mature oak tree needs 40-60 gallons of water every day. Trees have ways of conserving water, because water is very precious to a tree. One way in which a tree helps to conserve water is to develop two kinds of leaves. There are sun leaves and shade leaves. Sun leaves are small, with less surface area, which reduces the amount of exposure to the sun and wind. A shade leaf is large, with greater surface area, which increases the amount of area exposed to the sun. Remember, it is important for a tree to have its leaves exposed to the sun so that photosynthesis (food making) can take place, but not so much that it loses too much water.

Questions

1. Where would you expect a shade leaf to be found? On the top or bottom of a tree crown?

Hypothesis

Students should make their own before continuing.

Materials

Hand pruner
Metric ruler
Ladder (optional)
Extension pruner (optional)
Pencil and paper

Procedure

1. Locate a small tree in an open field. Obtain three leaves from high on the south side of the tree. Measure the length and width of all three leaves and record them in your notes under the category of **top leaves**.
2. From the lowest part of the tree crown on the north side, obtain three leaves that appear to be growing underneath other branches. Measure the length and width of all three leaves and record them in your notes under the category of **bottom leaves**.
3. Compare the measurements. Which leaves were consistently larger? The top or the bottom? What would these leaves be called?
4. Which leaves were consistently smaller? The top or the bottom? What would these leaves be called?

Conclusions

Why does a tree have sun leaves that are small and shade leaves that are large. What are the relationships between needing sunlight, needing to reduce water loss, and the size of a leaf?

SUN LEAF / SHADE LEAF COMPARISON

NAME: ______________________________

Tree # _____ Tree Species: ______________________________
Location: ___________________________________

	TOP LEAVES		**BOTTOM LEAVES**	
Sample No.	Length (cm)	Width (cm)	Length (cm)	Width (cm)
AVE	ave	ave	ave	ave

CONCLUSION

Use format discussed by teacher.

Background Information

Every tree or plant has a daily need for water. The cell, as the basic unit of life, is 75% water. Therefore, if a tree is to live, its cells must have enough water. A tree loses water by a process known as evapo-transpiration. Evaporation of water is increased by heat and wind. Transpiration is the movement of water from the roots through the stem to the leaves where evaporational losses can be high. The leaves must have a continuous supply of water to avoid dehydration and to carry out photosynthesis.

The effect of heat and wind on leaf water loss is greatest at the top of the tree. A tree, or any other plant, has several strategies to reduce the inevitable loss of water. There is a waxy covering (cuticle) on the leaf to reduce desiccation. Stomata (leaf openings which are necessary for gaseous exchange, but do enhance evaporation) are concentrated on the underside of the leaf so as not to be directly exposed to the sun. Stomata guard cells close when evaporation conditions are most intense.

Shade leaves and sun leaves are different. Surface area is a key consideration in reducing water loss. The less surface area that is in contact with wind or heat, the less water is lost. In other words, small is good when in direct contact with the sun. When considering the entire set of leaves on the tree, one notices that some of the leaves receive direct exposure to the sun, and other leaves receive indirect sun because of shading by other leaves. Sun leaves are found on the top part of the crown. Shade leaves are found on the bottom part of the crown especially on the north side, and have a larger surface area.

Determining a ratio between shade leaves and sun leaves on a tree helps a forester or arboriculturist determine its tolerance or intolerance to shade. A tree that has a high ratio of shade leaves to sun leaves indicates it is tolerant to shade. In other words, the tree does not mind growing in the shade and is a species that is able to grow as a sapling under a dense forest canopy.

Target Group

Sixth through eighth grade.

Timeline

This activity can be done between 30 and 45 minutes.

Student Learning Objectives

Students will be able to:

1. Differentiate between a shade leaf and sun leaf on a tree.
2. Understand a tree's strategy for reducing water loss.
3. Measure and compare leaves from the lower part of a tree and the upper part of a tree.

Procedure

A 20-30 foot high tree can be used for making a visual observation and comparison between the sun and shade leaves. Make sure the tree is out in the open (in direct contact with the sun), so that the tree is more likely to produce both shade and sun leaves. Shade leaves will be easier to find on the north side and on interior branches. If you can walk through a fairly dense forest, try to locate a young seedling who has just a few starter leaves on it and note that the leaves may be significantly larger than those found on a more mature tree of the same species. Locate a small tree (10-15 feet high) and obtain three sun leaves and three shade leaves. Measure the length and width of each leaf and then compare as a group for marked differences between them.

Blowouts

1. Find a 10-12 foot Sugar maple (Acer saccharum) growing under the canopy of a forest. Have the students get a ratio of shade to sun leaves on the tree. Find a 10-12 foot willow sp., cottonwood or oak sp., and have the students do the same. A sugar maple is very tolerant of shade while a willow is very intolerant. A shade tolerant tree commonly exhibits a high ratio between shade and sun leaves. It might have as many shade leaves as sun leaves. On the other hand, a shade intolerant tree will commonly exhibit a low ratio between shade and sun leaves. It might have very few, if any shade leaves, developing all sun leaves to trap as much sunlight as possible regardless of the amount of water that it might lose.

Glossary

evapotranspiration: the movement of water from the roots to the leaves of the tree with the eventual loss of water through the stomata of the leaves.

desiccation: loss of water by heat, wind, or a combination of both.

sun leaf: a leaf on a tree that is almost always in direct contact with the sun; usually on the upper crown.

shade leaf: a leaf that is entirely or partially shaded by other leaves on the tree; usually on the lower portion of the crown.

shade tolerance: the ability of a tree to endure shade.

References

1. *An Outline of Forest Hydrology.* Hewlett, J. and Nutter, W., University of Georgia Press, Athens, Georgia. 1969.
2. *Teacher, Why Are WE Planting These Trees?* Environmental Education Activity Sampler from Project Learning Tree, Project Wild and CLASS Project.

example data

SUN LEAF / SHADE LEAF COMPARISON

NAME: Joe Brown

Tree # 1 Tree Species: Sugar maple
Location: SE side of school parking lot

	TOP LEAVES		**BOTTOM LEAVES**	
Sample No.	Length (cm)	Width (cm)	Length (cm)	Width (cm)
1	1.8	2.3	2.7	3.2
2	1.9	2.3	2.8	3.5
3	2.1	2.1	3	3.5
AVE	1.93 ave	2.23 ave	2.83 ave	3.4 ave

CONCLUSION:

The leaf size is smaller at the top than at the bottom. Every species of tree may have a different ratio of sun and shade leaves. These ratios can be used as extensions to the lab exercise for the class, or as projects.

The teacher will need some experience to understand how this relates to a particular site.

REFERENCE INFORMATION ON SHADE TREE TOLERANCE

Shade Tolerance of Trees:

Definition - the ability of a plant to endure shade. Plants may also be drought tolerant, salt tolerant, etc.

Factors that affect shade tolerance:
Age (young>old)
Site quality (good>poor)
Available moisture
Available nutrients
Geographic portion of range

Some probable causes:
High photosynthesis rate under low light
Photosynthate used for development and maintenance of plant body - especially leaf area.
Modifications which increase efficiency of light absorption.
Maintenance of vigor at low metabolic rates.
Ability to minimize respiratory losses

Characteristcs of Tolerant and Intolerant Species:

Characteristic	Tolerant	Intolerant
Compensation point	Low intensity	High intensity
Saturation point	Low intensity	High intensity

Net assimilation	Low	High
Ratio: Shade/Sun leaves	High	Low
Tolerance to high temperatures at high light intensity	Low	High
Total foliage biomass	High	Low
Self-pruning	Poor	Good
Leaf area	High	Low
Juvenile growth rate	Slow	Fast
Response to release	Good	Poor

REFERENCE INFORMATION ON SHADE TREE TOLERANCE[1,2]

EASTERN CONIFERS

Very Tolerant

Red spruce
Eastern hemlock
Balsam fir
Northern white cedar
Atlantic white cedar

Tolerant

Red spruce
Black spruce
White spruce
Northern white cedar
Atlantic white cedar

Intermediate

Eastern white pine
Eastern redcedar
Pitch pine
Loblolly pine
Slash pine
Virginia pine
Baldcypress

Intolerant

Eastern redcedar
Red pine
Pitch pine
Shortleaf pine
Loblolly pine
Slash pine
Virginia pine

Baldcypress

Very Intolerant

Tamarack
Eastern redcedar
Pitch pine
Jack pine
Longleaf pine
Shortleaf pine
Baldcypress

EASTERN HARDWOODS

Very Tolerant

Eastern hophornbeam
American hornbeam
American beech
American holly
Sugar maple
Flowering dogwood

Tolerant

Rock elm
Sycamore
Red maple
Silver maple
Box elder *
Basswood
Tupelos
Persimmon ***
Buckeyes ***

Intermediate

Hickories
Yellow birch
Sweet birch
American chestnut
White oak
Red oak Tupelos
Black oak
Other oaks *
American elm
Rock elm
Hackberry ***
Magnolias **
Sycamore
Black cherry
Silver maple
Basswood
Persimmon **
White ash

Green ash
Black ash

Intolerant

Black walnut
Butternut
Pecan
Hickories
Paper birch
Red oak
Black oak
Yellow poplar
Sassafras *
Sweetgum
Sycamore
Black cherry
Honey Locust
Kentucky coffeetree **
Tupelos
Persimmon ***
White ash
Green ash
Black ash
Catalpas ***

Very Intolerant

Willows (S. bebbiana tolerant)
Quaking aspen
Bigtooth aspen
Osage orange ***
Cottonwoods
Gray birch
Black locust

---

*Very common
**Not common
***Floodplain

[1]In cases where considerable preference for other categories was expressed the name appears underlined.

[2]Baker, F.A. 1949. Journal of Forestry 47 (3): 179-181.

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Optional Laboratory: Measuring Tree Heights

Introduction

Foresters use tree height for many things. Tree height can give a clue as to how old a tree is. It can also reflect the quality or fertility of the site. The height of a tree can indicate a trees' dominance within the forest canopy, and is used in a very important calculation of lumber per tree.

Question

1. How is the Pythagorean theorem used to determine tree heights?

Hypothesis

Students should make their own before continuing.

Materials

Clinometer
100 foot tape
Pencil and paper

Procedure

1. Draw a large tree on your paper. Draw a person to the same relative scale as the tree. Superimpose a right triangle on the tree and person. Relate the equation $A^2 + B^2 = C^2$ to your drawing. A clinometer is based upon this equation.
2. One student should stand with the end of a 100 foot tape at the midsection of a tree to be measured. The other student should walk away from the tree on level ground, extending the tape. Mark the point 100 feet away.
3. Taking turns, students should look through the clinometer eyepiece towards the tree top and read the tree height on the right hand side of the clinometer. Record the measurement in the data table.
4. Practice on other trees.

TREE HEIGHT DATA TABLE

Tree No.	Species	Height (ft)	Crown Class	Site Observations

Background Information

Tree height is probably one of the two most important characteristics of a tree that a forester would need to know. Tree height gives clues as to how old the tree is; what kind of site the tree is growing on; the crown class of the tree; and is used in calculating the amount of wood in a tree.

Target Group

Sixth through eighth grade.

Timeline

Thirty minutes of classroom, plus 45 minutes - 1 hour field time. The information, procedure and activity should be completed within 45 minutes to an hour. Additional time may be needed for practice.

Student Learning Objectives

Students will be able to:

1. Use a clinometer correctly.
2. Locate the tree apex.
3. Develop a pacing stride for 50 or 100 feet.
4. Measure the tree height.

Materials

100 foot tape
Clinometer

Procedure

Choose a wooded area in which some large tree crowns are meshed into one another, and where there is a fairly distinct slope. Explain that a clinometer works on triangulation based on one of the sides of the triangle being 100 feet. Have a student hold the end of the 100 foot tape at the mid-section of a tree to be measured. Have another student run the tape out to 100 feet and mark the end of the tape. Make sure the second student did not go down slope or up slope from the tree. Make sure that the tree apex is discernible from the 100 foot mark. Have the student look through the clinometer eyepiece toward the tree apex. The student must keep both eyes open. One eye tracks the tree top while the other eye lines up the cross hair within the clinometer with the tree top. The student reads the measurements on the right-hand side of the clinometer. This is the tree height in feet. Groups of three to four students are recommended, so that measurements can be compared for accuracy.

Crown Classes in Even-Aged Stands

In even-aged forests a simple classification has long been standard in this country. It involves the recognition of five crown classes based on their position in the canopy.

1. Dominant trees. The crowns of dominant trees rise somewhat above the general level of the canopy so that they enjoy full light from above and also laterally.
2. Codominant trees. These are not quite as tall as dominants. Their crowns receive overhead light but they may be hemmed to a certain degree laterally by dominants. They comprise the main canopy of the forest.
3. Intermediate trees. These crowns occupy a definitely subordinate position, but may receive some direct overhead light through holes in the canopy.
4. Suppressed trees (or overtopped). These are definitely submerged members of the forest community having little free overhead light. They exist by virtue of the sunlight that filters through the canopy or the direct light that may be received through some

chance break.
5. Dead trees.

From: *Principles of Silviculture.* Baker, F.S., McGraw-Hill Book Co. New York. pgs. 72-73. 1950.

Blowouts

1. Have students pace along a 100 foot section of trail or pavement. Students should count either every other pace, or every pace; whatever they choose, they should be consistent. Have students continue pacing until they become comfortable with a fairly consistent count. This technique of having a 'built-in' pace will permit the student to measure tree heights without having to use a tape measure and still be fairly accurate. This technique also allows a student to measure the tree height alone without the aid of another student.

2. Choose a tree on a slope. Have the student pace out 100 feet across the slope to measure the tree height. Now have the student pace out 100 feet from the same tree either up or down the slope. Have the student read the tree height and compare it to the height when read across the slope. If the student paced out down the slope the reading will be higher and lower if paced up the slope. Reinforce the idea of trying to choose an 'across slope' direction when pacing out from the tree. There are conversion tables available to correct for slope when it is impossible to pace across the slope.

3. Choose a tree on a flat terrain to pace out 100 feet to measure the height. Now have the student go out 50 feet from the tree (use a tape since the student has not developed a 'built-in' 100 foot pace yet) and measure the tree height. Ask the student to compare the two measurements. The 50 foot reading should be approximately twice the 100 foot reading.

Glossary

tree apex: the tallest, uppermost part of the tree crown.

clinometer: a tool used to measure slope percentages and true heights

crown class: a classification system used to determine a trees position within a forest. Examples are **dominant** and **intermediate**.

crown: the portion of the tree which is made up of main branches, intermediate branches, twigs and leaves. The portion of the tree which rests upon the main trunk of the tree.

References

1. *Manual Of Forest Mensuration.* Beers, T. and Miller, C., T & C Enterprises, West Lafayette, Indiana. 1973.
2. *Earths Trees: Environmental Learning Series.* Earthwise. WP Press, Tucson, AZ. 1992.

example data

TREE HEIGHT DATA TABLE

Tree		Height	Crown	Site

No.	Species	(ft)	Class	Observations
1	White oak	68	co-dominant	SE facing slope - 10° slope mowed understory
2	Shagbark hickory	53	intermediate	
3	Bur Oak	75	dominant	
4	Basswood	48	intermediate	

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Optional Laboratory:
Calculating Board Footage In A Tree

Introduction

Trees are valued not only for their beauty, but also for their renewability and use as a construction material. Foresters that manage areas for lumber production often conduct volume cruises through a forest. At each sample point of a volume cruise, the forester makes only two measurements per tree. The forester measures the tree diameter and the tree height. From these two measurements a forester can determine how much lumber is in a tree, and thereby predict how much wood is in a particular timber area. The unit of wood that a forester wants to know is called a 'board foot'. A board foot is one foot by one foot by one inch thick. In 1988, 12.6 billion board feet of lumber were harvested from U.S. Forest Serivce lands.

Questions

1. How much lumber comes from one tree?
2. How many trees did it take to build the house or apartment you live in?

Hypothesis

Students should make their own before continuing.

Materials

Clinometer
Diameter tape / tree caliper
Pencil and paper
100 foot tape measure

Procedure

1. Measure the height of the tree you are studying.
2. Measure the diameter of the tree you are studying. Make sure you write these two measurements down very carefully on the data sheet.
3. Remember the formula to find the area of a circle is ($A=r^2$ x p). Area = radius squared times 3.14). Since a tree is almost circular, use this formula to find the area of your tree at DBH (diameter at breast height). Since the formula requires the radius of the tree and you just measured the diameter, divide the diameter by 2. Dividing the radius by 12 converts inches to feet.
4. Now use this number to calculate the area of your tree.
5. Don't relax now! We are only beginning! Use the formula in step 5 of the data sheet to find out how many cubic feet of lumber are in your tree.

Cubic Feet = Area (ft) X Height (ft) / 4
(note: 4 is used to account for the taper of the tree)

6. There are 12 board feet of lumber for every one cubic foot, so multiply cubic feet by 12. You have calculated how many board feet of lumber your tree has.
7. Practice on several other trees to get comfortable with this series of calculations.
8. Your teacher may have already measured and calculated board footage for the trees. Compare your own measurements with your teachers.

Board Footage Data Sheet

Tree # _____
Tree species: ___________________

1. Height _____ feet
2. Diameter _____ inches
3. Diameter in feet / 2 = ________ radius in inches / 12 = _____ feet
4. Area of tree cross-section = above number squared x 3.14 =______ sq.ft.
5. Volume of tree in cubic feet = above number x tree height / 4 = ______
6. Volume of tree in board feet = above number x 12 = _________

Tree # _____
Tree species: ___________________

1. Height _____ feet
2. Diameter _____ inches
3. Diameter in feet / 2 = ________ radius in inches / 12 = _____ feet
4. Area of tree cross-section = above number squared x 3.14 =______ sq.ft.
5. Volume of tree in cubic feet = above number x tree height / 4 = ______
6. Volume of tree in board feet = above number x 12 = _________

Tree # _____
Tree species: ___________________

1. Height _____ feet
2. Diameter _____ inches
3. Diameter in feet / 2 = ________ radius in inches / 12 = _____ feet
4. Area of tree cross-section = above number squared x 3.14 =______ sq.ft.
5. Volume of tree in cubic feet = above number x tree height / 4 = ______
6. Volume of tree in board feet = above number x 12 = _________

Tree # _____
Tree species: ___________________

1. Height _____ feet
2. Diameter _____ inches
3. Diameter in feet / 2 = ________ radius in inches / 12 = _____ feet
4. Area of tree cross-section = above number squared x 3.14 =______ sq.ft.
5. Volume of tree in cubic feet = above number x tree height / 4 = ______
6. Volume of tree in board feet = above number x 12 = _________

Background Information

As a renewable resource, trees are managed professionally for a variety of reasons. Forests are managed for recreation, watershed protection, animal habitats, and for products such as paper and lumber. Foresters have used silvicultural techniques to optimize lumber production for many decades, which would place trees in the category of a long term crop. When it is time to harvest a stand of trees, the U.S.D.A. Forest Service has traditionally offered the stand up for bidding between logging companies. In order for the loggers to accurately bid on the stand, they need to know how much wood is on the stump, or 'stumpage'. It is the job of the forester to conduct a pre-bid volume cruise in the stand of timber. Foresters express 'stumpage' as board feet. A 'board foot' of lumber is a board one foot by one foot by one inch. In a volume cruise, a forester will randomly select trees to measure. The forester will measure the height and diameter of a tree. A forester does not, however, calculate the board footage for each single tree that is measured because of the numbers of trees involved in a volume cruise. A forester has various formulas to determine board footage on large tracts of forests. This exercise, however, is designed to calculate the board footage of a single tree to give the student an idea of the process that a forester uses.

Target Group

Sixth through eighth grade.

Timeline

This activity can be completed within one hour in the field. Thirty minutes of classroom preparation time is needed to review tree height measurements and tree diameter measurements. It might be beneficial to go over the board footage formula in class also.

Student Learning Objectives

Students will be able to:

1. Gain experience at measuring tree heights and tree diameters.
2. Understand the standard unit of measurement for lumber.
3. Calculate the board footage of a given tree using a formula.
4. Relate the number of trees needed to build a small house.

Procedure

Make sure students correctly measure the tree height by avoiding the upslope and downslope position for the clinometer reading. If the students are not proficient at pacing 100 feet, then provide a 100 ft tape measure.

When a tree diameter is taken, make sure it is a true DBH. DBH (Diameter at breast height) is measured at 4.5 feet from the ground on the tree trunk. When a tree is on a slope, the 4.5 feet is measured on the up slope side of the trunk.

When students have made both tree measurements and are ready to plug numbers into the formula, make sure they use the radius measurement in feet. The measurement they took was in inches, so it must be converted into feet. For example, if a student measured a tree's diameter to be 14 inches, the radius would be 7 inches and the number to used in the formula would be 0.58 feet. (7 / 12 = 0.58)

A fairly straight pine tree is an ideal tree for this exercise.

Blowouts

1. A small ranch style house with 3 bedrooms (approximately 1000 square feet) would require about 3000 board feet of lumber to build. Have students arrive at the number of trees that would be needed to build the house they presently live in. Have the students make this calculation from their data (originally measured trees).
2. Conifers are the trees of choice for construction lumber. Have students research the products that are made from oaks, hickories and ashes.

Glossary

volume cruise: a set of randomly selected plots through a forest tract where trees are measured in height and diameter.

watershed: an area of land outlined by high ground where all the water that falls on the land leaves by one major waterway.

silviculture: the cultivation of forest trees.

stumpage: standing timber with reference to its value or the right to cut such timber on the land of another.

board foot: a piece of wood one foot by one foot by one inch.

DBH: diameter at breast height. Breast height is considered to be 4.5 feet from the ground.

References

1. *Earth's Trees: Environmental Learning Series.* WP Press, Tucson, Arizona. 1992.
2. *Illinois Council on Forestry Development.* A Long Range Plan for Illinois Forest Resources. 1990.
3. *Elements Of Forestry: With Special Reference to Illinois.* Department of Conservation, Division of Forestry, Springfield, Illinois. 1973.

example data

Board Footage Data Sheet

Tree # 3
Tree species: Red Oak
Height 60 feet
Diameter 14 inches
Diameter in feet / 2 = 7 radius in inches = 0.58 feet
Area of tree cross-section = above number squared x 3.14 = 1.05 sq.ft.
Volume of tree in cubic feet = above number x tree height / 4 = 15.75
Volume of tree in board feet = above number x 12 = 189

An Example of How Midwest Lumber Is Used

Production of Primary Wood-Using Firms, Illinois, 1984

Products	Firms producing (percent)	Average volume	Largest volume	Total	Percent of total volume
		(thousand board feet)			
Industrial lumber	64	180	3,000	29,200	20
Pallet lumber, cants	34	490	5,000	42,700	30
Grade lumber	23	395	2,400	23,600	16
Railroad ties	17	210	1,200	9,100	6
Mine timbers	11	530	3,000	15,200	11
Blocking	9	400	2,500	9,600	7
Other	--	--	--	14,600	10
Total		565	7,500	144,000	100

From: *A Long Range Plan for Illinois Forest Resources.* The Illinois Council on Forestry

Development. 1990.

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Optional Laboratory: Comparing Soil Temperatures In Sun And Shade

Introduction

Shade is one of the most recognizable characteristics of a tree. On a hot summer day, the outline of a shady area is probably more noticed than the tree itself. What are the effects of shade, other than cool comfort, as one escapes from the direct sun?

The shade from a forest tree creates a micro-climate suitable for many species of plants and animals to survive and flourish. Many small plants have adapted to the understory of a forest, and need protection from the direct rays of the sun. The forest soil is cool and moist, which is good for plants. The moist forest soil is also a good place for microorganisms to survive. Many of these microorganisms such as soil bacteria and fungi are beneficial to forest plants.

Soil temperature is a critical part of the survival of many organisms both big and small. Shade not only cools the subsurface, but also the air temperature above the ground which helps to stabilize the entire area. A city street lined with trees has sidewalks that are much cooler than a city street without trees. Many people suffer from heat related illnesses. People are more likely to show signs of heat stress in a city where there are few trees and shade. In this exercise, measuring soil temperature differences will illustrate the effects of shade from a tree.

Question

1. You probably have guessed that there will be a difference in soil temperature between sun and shade, but will there be a difference of 10 degrees or more?

Hypothesis

Students should make their own before continuing.

Materials

Soil thermometers
Data sheet

Procedure

1. If a long range study is planned, the school grounds are a good place to locate two permanent sites so that daily readings can made in a routine fashion.
2. The site in the sun should be well away from any structure because the structure might radiate heat onto the soil where the thermometer is located. The thermometer can be concealed and will not affect the reading because the tip of the probe is detecting the soil heat, not the round gauge on top of the probe.
3. The site in the shade should not be too close to a tree trunk.
4. Leave probes in the ground for at least a half hour to adjust to the soil temperature.

(Optional: if time permits)

5. Use thermometers to record air temperatures.
6. Use wind gauges to record wind velocity.
7. Use sling psycrometers to record humidity data.

Blowouts

1. Urban heat islands are isolated pockets of increased temperatures located over city and urban areas. The heat pockets are greater because of the increased number of building structures and paved areas. Structures and pavements absorb and reradiate direct solar radiation. Find two sunny sites to place the soil thermometer probes where one is in the lawn and the other is next to a building wall. A south facing wall will provide the best results.

Fig. 1. Generalized cross-section of a typical urban heat island.
(Boundary Layer Climates. Oke, T.C., New York Methuen. p. 435. 1987.)

Soil Temperature Comparison: Sun / Shade

NAME: ____________________________

Location of Soil Thermometers: ________________________

					Soil Temp.	
Day #	Air Temp	Windy/Calm	% Humidity	Cloudy/Clear	Sun	Shade

Background Information

The quest for shade is one of the ultimate experiences in the summer. Escaping the direct rays of the sun is probably deeply rooted in our primal past, so that seeking shade has become a subconscious act. The shade tree in your backyard or your favorite park is a place of welcome shelter and enjoyment. The human benefit of shade is quite evident, but what about the more subtle attributes of forest trees and shade?

Shade helps to create a more favorable understory environment. Many herbs, shrubs and saplings require a cool environment to grow successfully. Shade also reduces the rate of soil moisture evaporation. Many animals such as small insects and worms depend on a high soil moisture content to survive. These small animals are food for other larger animals, which therefore become indirectly dependent upon the shade trees provide. Since shade promotes the growth of grasses, herbs and shrubs, shade also then can be linked to soil stabilization, because the roots of plants reduce soil erosion. One might look at a timber area and say that the tract is helping to control erosion. But if the understory vegetation is being grazed by livestock the forest tract is actually contributing to erosion. *Too often in rural areas, livestock are allowed to graze in woodlands, particularly along watershed drainages. An estimated 66 percent of erosion occurs because of heavy grazing. The resulting disturbance of forest duff and understory increases erosion and sedimentaiton into adjacent waterways.*[1]

Moderating solar radiation for a city or urban environment can have extensive benefits other than the immediate escape from the sun. A concept that forest researchers have used is the "Urban Heat Islands". Urban areas are often warmed by the heat generated by sources of reradiation such as paved parking lots, stone buildings and roads. It has been found that city parks within a community can be 2-6 degrees cooler than the rest of the urban heat island. Urban heat islands have also been blamed for increased health risks such as cardiovascular diseases and other heat-aggravated illnesses. Trees in city parks and streets have been attributed with reducing air conditioning costs. Shade that trees provide is a complex phenomenon, but often overlooked when discussing the benefits of planting and maintaining trees.

Target Group

Sixth through eighth grade.

Timeline

This activity can be a daily reading of the soil thermometers which takes only 10 minutes to read and record. Aquiring additional data such as humidity and air temperature might require more time. These can also be found in a newspaper, by calling a local weather recording, or they can be measured in the field.

Student Learning Objectives

The student will be able to:

1. Relate many shade benefits trees provide.
2. Read and record from a soil thermometer.
3. Calculate the difference between soil temperature in the shade and in the sun.
4. Relate other climatic conditions to the difference between soil temperature in the sun and shade.

Procedure

Setting up this data comparison seems quite simple, and it is! However, there are a number of interesting variations that could be used based upon imagination and time availabilty. This particular study is best suited for a long term study, so that interpretations can be made with reference to the other climatic conditions. However, the results from just one day of comparison can be very dramatic as the students see the big difference a shade tree(s) can make on soil temperature.

Select two spots on your grounds; one in the full sun and the other in the shade of a tree. One to two hours is enough time to take a reading and record a difference of 15 degrees. You can choose to install permanent thermometers for reading on the hour, or take them with you on your daily trips.

Blowouts

Mulch around the base of a tree is designed to trap rain and moisture and insulate the soil immediately below from direct radiation. In the full sun, place one soil thermometer in the grass and another through the mulch around a tree. Read in an hour.

Glossary

insulation: a barrier creating dead air space thereby reducing the tendency of cool or warm air to move from a high concentration to a low concentration (diffusion). Mulch is a type of insulation; so is a tree canopy.

References

1. *Chicago's Evolving Urban Forest.* McPhearson E. C., and Nowak. USDA Forest Service, Northeastern Forest Experiment Station. 1992.
2. *A Long Range Plan for Illinois Forest Resources.* Illinois Council on Forestry Development, Sept 1990.
3. *Boundary Layer Climates.* Oke, T.C. New York Methuen. p. 435. 1987.

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[1] *A Long Range Plan for Illinois Forest Resources.* Illinois Council on Forestry Development, Sept 1990.

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Optional Laboratory:
Forest Volume Cruise

Introduction

The professional forester who manages forests for a timber crop must often conduct a volume cruise. The volume cruise is used by loggers who wish to bid on a forest tract that is ready to be cut and taken to the saw mill. A volume cruise tells the logger how much available wood there is in the forest. The logger then decides how much he is willing to pay for the right to cut the trees, and gives the dollar amount to the forester on a piece of paper in a sealed envelope. More than one logging company bids on the forest tract, so the forester has several sealed envelopes with 'bids' inside. After the deadline, the forester opens all the envelopes and looks for the highest bid. The forester notifies the highest bidder that their logging company has won the logging rights to the specified forest tract. After the logging company has cut down the trees, it will sell the logs to a saw mill, who then cuts the logs into planks and boards.

The volume cruise is a very important task performed by the forester. If the volume cruise is not done properly, the logger may end up bidding too much and lose money. If it is underestimated, then the forester loses money. The forester must be accurate in all measurements to reduce the amount of error.

Questions

1. Now that you know how to calculate the board footage in one tree, can you perform a volume cruise to estimate how many board feet of lumber are there per acre? (how many thousands of board feet)?

Hypothesis

Students should make their own before continuing.

Materials

100 foot tape	Plot sheets
Clinometer	20 BAF prism
DBH tape	Compass
Map of forest	Plastic flagging

Data Gathering

As a class, you will decide what data to gather and develop a data table to use.

Procedure

1. Look at a map of the area you are about to 'cruise'. You will be told where the starting point for the transect will be. Mark it down on the map. Your teacher will tell you what compass reading the transect will follow. Write this down. You will be told how many plots will be located along the transect and how many feet are between each

plot. Write these numbers down. See figure A.

2. Walk to your starting point and tie some flagging on a tree branch, sapling or a stick driven into the ground. Set your compass to the predetermined azimuth. Stand directly over the starting point and sight along the compass arrow. Pace the predetermined distance along the compass route until you come to the first plot center. Drive a stick into the ground at plot center and tie a flag on it.

3. Standing over the plot center stake, and going clockwise from 0 degrees north, use the 20 BAF prism to determine which trees are 'in' the first plot. See figure B. For each tree that is 'in', measure its diameter and determine how many 'usable' or 'merchantable' (straight and unforked) 16 foot logs are in the tree. See figure C.

4. Standing over the first plot center, sight again along the compass arrow (same azimuth as before) and pace the predetermined distance to the second plot center. Follow the same procedure as you did in #3. Record the results on the second plot sheet.

5. Transfer your information from the plot sheets to the **Horizontal Point Sampling Cumulative Tally Sheet**. To understand how to do this, look at the example **Cumulative Tally Sheet**. f = the prism number. You will put 20 in this blank. N = the number of plots used. Look at the point count / tree tally at point box. The 4 next to the 1 means 4 trees were ' in' at plot #1; 10 trees were 'in' at plot #2, etc. Altogether there were 37 trees measured in this example cruise. Note that there are 37 slashes in the DBH/Log grid. If there were 23 trees measured in your cruise, then there will be 23 slashes in your tally sheet. Look at the 12 inch DBH class row. There are zero slashes in the 0.5 column which means there were no trees measured in the entire cruise that had a DBH of 12 with an 8 foot log. In the 1 log column for the 12 inch class, there are 2 slashes which means there were 2 trees in the entire cruise that had a 12 inch DBH and a 16 foot log of merchantable timber. In the 1.5 log (16 ft) column, there is 1 slash which means there was just one tree that had a 12 inch DBH and 1.5 16 foot logs. Altogether in the example cruise, 3 trees out of the 37 had a 12 inch DBH. Now read all the way across the 12 DBH row to the **Sum** column. The example number is 206 which is the result of adding together the **Highest** number slashed out from each of the 8 log columns. In this case, 122 was the highest number slashed out from the 1 log column and 84 was the highest number slashed out in the 1.5 log column. 122 + 84 = 206.

The next column to the right is labeled **Volume per Acre**. In the 12 DBH row, the number is 404. 404 is acquired by multiplying 206 by 1.96. 1.96 results from dividing the BAF number by the number of plots measured. The figure 9,707 at the lower right hand corner of the tally sheet is the board footage per acre that would be expected in any random acre of this particular forest stand.

Blowouts

1. Try to find out how many acres are in your forest tract and multiply the number of acres times the Volume Per Acre total from the tally sheet.
2. Remember that a ranch style house with 3 bedrooms (1000 square foot) would need 3000 board feet of lumber. How many houses could be built from your forest tract?

Plot Sheet

Name ________________________ Group__________________________

Type of Survey	xx		Subunit	x	
Forest	x		Stand	x	
Block	x		Elevation	xx	
Compartment	xx		Slope Position	x	
Subcompartment	x		Logged	x	

	Transect No.	xx																				
	Point No.	xx																				
	Tree No.	xxx																				
	Azimuth	xxx																				
	No. of Trees	xx																				
	Tree History	x																				
	Species	xxx																				
	DBH	xxx																				
	#16-ft logs	xx																				
	Age	xxx																				
	Height	xxx																				
	Crown Ratio	x																				
	Crown Class	x																				
	Defect Indicators	xx																				
	Damage	xx																				
	Tree/Crown Class	xxx																				
	Mgt. Tree	x																				
	GST	x																				
	Down Tree	x																				
6.8' Plot	Twig intersect	xx																				
	Branch intersect	xx																				
Duff	First duff	xxx																				
	Second duff	xxx																				
27.2' Plot	Sound 3"+	xx																				
	Rotten 3"+	xx																				
	Rotten 3"+	xx																				
	Slope	x																				
	Aspect	x																				
	Habitat type	xxx																				

Background Information

A **volume cruise** is one of the most important activities of the forester. The Forest Service is a branch of the USDA (United States Department of Agriculture). Since trees are considered a crop which can be harvested, foresters are therefore, the caretakers of the crop before it's harvested. Loggers are the harvesters of forest trees. When a forester decides a tract of forest is ready for harvest, it is put up for bid. Loggers make a bid for the forest tract where the highest bidder wins the right to cut and haul off the trees. However, before a logger can make an accurate bid, he must know approximately how much lumber is on the stump within the forest tract. It is the responsibility of the forester, to conduct a volume cruise to determine the amount of lumber the logger can expect. The volume cruise gives an estimated amount of lumber, expressed as board footage. The volume cruise also gives the logger an idea of what kind of tree species are on the tract, as certain trees are more desirable than others for lumber production.

Target Group

Sixth through eighth grade.

Timeline

This could be a culminating experience for the group where several days could be allotted for completing the volume cruise.

Student Learning Objectives

Students will be able to:

1. Understand the purpose of a volume cruise.
2. Locate a forest tract and determine a compass azimuth for a transect of sample plots within the forest tract.
3. Pace a determined distance to locate random sample plot centers.
4. Use a BAF prism to determine trees that are 'in' the plot.
5. Use a clinometer and DBH tape to calculate the BF (board footage) of 'in' trees.

Preparation and Teaching Tips

The teacher decides what data each class has the ability to successfully collect and build a data table accordingly. A copy of The Horizontal Point Sampling Cumulative Volume Tally Sheet is included.

Procedure

Obtain a map of a forest or forest preserve. Draw a circle around a distinct forest segment. Mark a point on the circle that would be the easiest place to use for a starting point. With a compass and the map, determine a direction (compass degrees) that would go through the middle of the forest tract from the starting point. Decide how many plots should be used, and how far apart the sample plots should be. Two hundred feet is a reasonable distance between plots, but the distance can be shorter if the forest is small. Two to three plots would certainly give the students a "taste" of what a volume cruise is like. Four to five plots would take approximately four hours.

Next, walk to the starting point. Randomly select a tree branch or sapling and tie a ribbon on it. The ribbon will represent the actual starting point. From the ribbon, students will pace out 200 feet along the predetermined compass reading. It would be helpful for students to have already developed a pace of their own. To do this, lay out a 100 foot tape on the ground for students to walk (pace) from 0 to 100 feet and count their steps in between. Have them do this several times till they come up with a consistent number. (Developing contests is a fun activity while students develop pacing accuracy. The teacher picks out landmarks for the students to pace to and then measures the distances to see which student was most accurate.)

When the student reaches 200 feet at the compass reading, the student places a stick at the 200 foot mark and ties a ribbon to the stick. This designates the plot center. Turning clockwise, from zero degrees north, use the BAF prism to designate the number of trees that are 'in' the sample plot. For each tree that is 'in' the sample plot, measure its diameter at breast height (DBH) and its total height. Record these measurements. Trees less than 5 inches DBH are not counted, neither are dead trees. If 4-5 students can be grouped together, the heights and diameters can be done simultaneously, or measurements can be double checked.

Have students calculate the board footage for each tree or choose tree #1 in each plot. If you are really energetic and enthusiastic, use the Horizontal Point Sampling Cumulative Volume Tally Sheet to determine the total board footage per acre in your forest. Try to estimate the number of acres in your forest. Instead of total tree height, you need to determine how many merchantable (usable) 16 foot logs are in each tree that is 'in' the plot. The example given on the Tally Sheet is 5 plots with a 9.8 factor prism, each diameter class Sum would be multiplied by 1.96 (see student procedure). So if your students used 3 plots with a 20 factor prizm, each diameter class SUM would be multiplied by 6.67.

Record the location of your starting point and compass reading for a follow up cruise the next year.

Blowouts

1. There is no way of ever calculating the exact board footage in a given forest because of the sheer numbers of trees and lack of time. Sample plots therefore become an efficient means to "estimate" a calculation. Sample plots are random measurements which are intended to accurately "represent" the whole. The more sample plots, the better the representation. Have the students randomly select another starting point and compass reading to record another set of sample plots (same number) and compare the board footage to the first transect line.
2. Have the students select another starting point and do just one sample plot to compare board footage to a 3 plot transect. Was the one plot a good representation?

Glossary

forest harvest: the periodic removal of usable trees for the purpose of paper, lumber, poles or wood derivatives.

azimuth: a compass direction such as 120 degrees southeast.

transect: a straight line that predominately bisects a given unit.

forest tract: a distinguishable forest area noted for its uniform distribution of tree species and spatiality of trees.

References

1. *Manual Of Forest Mensuration*. Beers, T. and Miller, C. T & C Enterprises, West Lafayette, Indiana. 1993.
2. *A Long Range Plan for Illinois Forest Resources*. Illinois Council on Forestry Development. Sept. 1990.

3. *Even-Aged Silviculture for Upland Central Hardwoods*. Agriculture Handbook 355. USDA Forest Service. Dec. 1968.
4. *Stand Examination Procedures*. USDA Forest Service Intermountain Region.

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Optional Laboratory:
Soil Particle Size And Texture

Introduction

Soil is the basic resource to all life. Without the proper soil, a tree will not grow to its optimum size or condition. We should learn all we can about the soil, such as how it affects animals, microorganisms, weeds, shrubs, flowers, people and trees. The size and texture of the particles plays a big part in how the soil functions.

Things to look for in soil are color, texture, structure, depth, and reaction (pH). A general soil profile is made up of a litter layer, A horizon, B horizon and C horizon. A soil sampling device allows you to gather data on the soil makeup on any site.

Questions

1. What texture class is this soil?
2. What is the particle size make-up of this soil?
3. Are there different soils on the school grounds?

Hypothesis

Students should make up their own before continuing.

Materials

1 Soil probe
1 Metric ruler
1 Quart jar with lid
1 Set index cards for diagrams

Procedure

1. Collect all needed materials and prepare data tables for this exercise.
2. Use the soil probe to collect soil cores as deep as possible from a site determined by your teacher.
3. For one of the cores, diagram and measure the depth of each layer or horizon in your sample. Make a representative diagram, if necessary.
4. Collect enough cores to fill the quart jar at least half and no more than two thirds full.
5. Fill the rest of the jar with water, seal tightly and shake vigorously for 10 minutes. You may want to share the task with your partners.
6. Let the jar stand for 24 hrs. Make sure it is labeled with your name and period.
7. The next day, mark the soil layers of each sample on an index card placed behind the bottle. Mark the top of the soil and the points where the layers change.
8. To find the percent of sand, silt and clay in your sample measure the marks on the card for: 1) entire height, 2) sand (bottom) layer, 3) silt (middle) layer, and 4) clay (top) layer. Then take the height of each layer by the total height and multiple by 100. Record the figures on the data sheet.
9. Make a diagram of the soil cores, soil profile from the quart jar and label both.

Analysis of Results

1. At which site was the soil the most sandy? silty? clayey?

2. Do you think that this is a trend and would be found at other sites? Explain.
3. What are some factors that may change the results of this experiment? Explain.

Discussion Questions

1. Is the soil at the site of each tree different? Is there some trend that you can see?
2. Look in one of the resources and find out what type of soil one of your trees require, and see how this compares.

Conclusions

1. Did you achieve your hypothesis? Explain.
2. What did you learn by doing this exercise?
3. If you were to look at more trees, what type of sites would you choose to visit? Give at least 3, with reasons for each.

Table A:

Soil Profile

Sample No.	Site	Litter depth	A horizon depth	B horizon depth	DEPTH of Change

Table B:

Soil Texture

Sample No.	Site	Stand	Silt	Clay	Total	% Sand	% Silt	% Clay

Background Information

Soil particles vary greatly in size. The largest particles settle to the bottom first. The fine particles settle slowly; some are suspended indefinitely.

Soil scientists classify soil particles into sand, silt and clay. Scientists use these three components and the calculated percentages on the texture triangle to determine the textural class of the soil at a given site. Using the information in the Understanding Soils Bulletin #4052, and information from the other three soils bulletins, the students can find the textural class of a soil from this exercise.

Size of soil particles is important. The amount of open space between the particles has much to do with how easily water moves through the soil. This also determines how much water the soil will hold, which has a major effect on the type of plants that can grow in the soil.

Target Group

This exercise can be done with only slight modifications, for almost any grade level.

Timeline

This exercise will take two days: one to collect materials and set up the jars; one to gather and calculate the data.

Placement of Lab in Curriculum

This can be done at any time, but preferably for comparing soils to tree species or area found. It is best used to show how different species will grow.

Student Learning Objectives

1. Understanding the interaction among trees, soil and people.
2. Gathering, comparing and analyzing data.
3. Prepare a written report of soil types found.

Preparation and Teaching Tips

1. Soils can be measured with the soil corer, or hand shovels can be used to dig small but deep holes to gather soil down at least to 15 inches. The deeper the soil core to be analyzed the better.
2. Fill a one quart Ball and Mason jar with water about two thirds of the way. Then add the soil until almost filled. (If in the field, put soil in the jar about 1/2 way and then fill with water back in the lab.)
3. Shake the jar vigorously for at least 10 minutes. Allow to settle over night.
4. Place a index card behind the jar and mark each of the layers on the card and then measure.
5. Finally, calculate the percentage clay, silt, and sand from the total and apply this to the texture triangle to determine the soil type.

References

1. Teaching Soil and Water Conservation: A Classroom and Field Guide. US Department of Agriculture Program Aid #341.
2. Understanding Soils. VAS Bulletin #4052.
3. Soil Texture. VAS Bulletin #4030.
4. Soil Color. VAS Bulletin #4029.
5. Soil Structure. VAS Bulletin #4028.

Discussion Question Answers

1. Answers will vary depending on the site.

(The teacher will have to do a "pre-analysis" of the site to be up to date with students when the exercise begins. Continued collection of data can be useful in data base development for any school site.)

Blowouts

The mass of the sample can be taken in a previously massed plastic bag using field scales. Soils can be dried and reweighed in the same plastic bag, for soil moisture calculations, if appropriate. This can provide comparisons with the soil meter readings. These meters are found with instructions in the Forester'sTrunk, or can be purchased at any garden supply store.

example data

Table A:

Soil Profile

Sample No.	Site	Litter depth	A horizon depth	B horizon depth	DEPTH of Change
006-34	forest	4 cm	34 cm	19 cm	4\38\57
006-22	field	6 cm	23 cm	10 cm	6\29\39

Table B:

Soil Texture

Sample No.	Site	Stand	Silt	Clay	Total	% Sand	% Silt	% Clay
tree 23	cy	3.96 cm	0.4 cm	4.4 cm	8.8 cm	45	5	50
tree 41	pw	2.04 cm	6.12 cm	2.04 cm	10.2 cm	20	60	20
grassy	field	1.75 cm	7.63 cm	4.62 cm	14.0 cm	12.5	54.5	33

Tree 23: soil is clay
Tree 41: soil is silt loam
Grassy: soil is clay loam

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Optional Laboratory: How Old Is This Tree?

Introduction

There are two ways to find out how old a tree is. The first is to wait until the tree is cut down and count the rings. The second is to use an increment borer and count the rings on a trunk cross section. The study of tree rings to calculate a trees' age is called **dendrochronology**.

In each method the tree sustains damage. To obtain a trunk cross section sometimes called 'beaver cookies', 'tree cookies', or 'hockey pucks', the tree must be killed. To get an accurate age of the tree, the rings must be near the base (ground) of the tree. The borer takes a small (0.200 inch diameter) straw-like sample from the **bark** to the **pith** of the tree. Though this hole is small, it can still introduce decay in the trunk.

The increment borer is made of carbide steel which makes it a relatively expensive tool. The borer has three parts; the handle, the steel shaft and the extractor. Proper maintenance and operation are essential if the tool is to last. Borers come in different sizes and should be at least 75% the diameter of the tree you are boring. The instructions included with the increment borer provide many useful tips, and an expanded explanation that should be read before doing any boring.

Tree trunk growth results primarily from the **xylem** layers and is counted to determine the age. The tree produces large xylem cells in the spring and small cells of xylem in the summer, making it easy to note the difference between years. The tree rings are larger in wet years than in dry years. In some **hardwood trees**, the rings are so small that a hand lens and pins may be needed to count the rings. The size of the rings are now being used to determine past weather patterns, even with petrified trees. Trying to establish weather history is a very difficult process, and more than one or two samples of wood is needed.

The tree's age can therefore be obtained by counting the annual rings of either a 'core' or trunk cross section.

Question

1. Do tree core sample measurements follow the same pattern that tree cross sections do?

Hypothesis

Students should make their own before continuing.

Materials

Increment borer
Varied tree cross sections
Several tree core samples
Hand lenses
Rulers
Pins
Data tables

Procedure

1. Before beginning this lab, the student should be able to identify:

bark	pith	annual ring
xylem	phloem	summer xylem
heartwood	sapwood	spring xylem

2. Each pair of students should receive a labeled tree and core sample to age. Carefully remove the tree core from the straw and lay it on a piece of paper.
3. One student should measure (in millimeters) the length of the core sample and then draw a picture, labeling the bark and pith ends. Students should make sure to write down the tree species.
4. The other student should take the tree cross section, measure it's diameter (in millimeters) and draw a diagram, labeling the bark, heartwood, sapwood and pith areas.
5. Each student should count the number of rings on each sample and label the age of each tree on their diagram.
6. Record the ring width (in millimeters) for each of the last six years in Table A. Add all six years together to find a total growth for those six years.

Table A: Ring Widths for the Past Six Years - Tree Cross Sections (mm.)

Sample	19__	19__	19__	19__	19__	19__	Total

7. Students should get the data from two other groups and place the data in their data table.
8. Take the data from each year and divide by the total for all six years to find out what percentage of the total growth occurs each year. Place this data in Table B.

Table B: Percentage Growth - Tree Cross Section (mm.)

Sample	19__	19__	19__	19__	19__	19__	Total

Discussion Questions

1. On which sample was it easier to count and measure the rings? List several reasons why you think there is this difference?
2. What year had the largest growth by ring width (in mm)?
3. Is the variation in tree cross section the same each year? What are some of the reasons that you can give for the differences / the similarities?

Conclusions

1. Does the data support your hypothesis? Explain.
2. What do the results of this experiment tell you about trees as a homeowner / forester?
3. What experiment could you design to tell more about the effects that cause changes in ring growth?
4. What conditions do you think caused the difference in ring size and color?

Background Information

The study of tree age using annual growth rings is called dendrochronology. Either tree cross sections or core samples from an increment borer can be used. The easiest way, is to cut a tree that has fallen, into sections. The drawback to this method is that the tree must die. To get an accurate measurement, the section must come from very near the base of the tree. Samples from different heights of a single tree can simulate trees of different ages for this laboratory.

The booklet with more information about the increment borer is The Care and Feeding of an Increment Borer by the USDA Forest Service. The increment borers range in price from $85 to over $150 depending on the size. A tree is normally cored no more than every 6 to 8 years. This method is used by foresters, on large tracks of commercial property to determine the age of a stand. If the tree's health is in doubt, a 'tree doctor' can use it to tell if their is internal damage. The cores, if done correctly, can even be used for chemical studies in commercial labs to determine suitability of the trees for different purposes. In the urban areas, city or state foresters may use the core to determine not just the age, but the structural condition of the tree. A hollow tree may be hazardous and have to be removed.

Target Group

Ninth through twelvth grades, but can be used for elementary through middle school with minor modifications.

Timeline

This exercise will normally take two hours to complete. A half-hour for an explanation of the lab, a half-hour for data gathering and the analysis by each group, a half-hour to get data from three other groups, and at least a half-hour to get into a class discussion of the differences among species or sites.

Placement of Lab in Curriculum

This laboratory could be used when discussing tree or plant growth and the patterns they exhibit. It could also help to explain the growth differences between species. This lab can be scheduled as a data gathering and analysis activity at any time of the year. If the lab is not used as a direct part of the Urban Forestry unit, it can serve as a rain / indoor activity. Lab-aids #52 (Lab-aids, Inc.) can be used as a pre-lab exercise for the coring and ring counting.

Student Learning Objectives

1. Evaluate and analyze the data collected to determine how trees change over time.
2. Replicate the results of another student's data.
3. Revise a prediction (hypothesis) based on additional data.
4. Identify appropriate methods of measurement for this task.

Preparation and Teaching Tips

If a Forester's Trunk is not available, prepare matching cores and 'tree cookies', from several trees, and a data sheet with all the information to complete the lab. Include a short discussion on what tree rings are, and how they may have additional meaning for us in reference to historical events. The data sheet will include age, species, and the type of site the tree was found on (forest, field, urban).

Become familiar with the terms associated with the cross sections of a tree or core. Have students look at the tree cross sections and form a hypothesis as to what species of tree they think it is.

Blowouts

1. Use microscopes or hand lenses to measure the differences in spring and summer wood. Compare three different species over the last four years and then back 20 years.
2. Compare twig growth on a live tree of the same species as one of the 'tree cookies' to compare growth during similar years.
3. Call or write to a Forester to find out how chemical data for trees would be used.
4. Create more questions about tree rings that could help homeowners know more about their trees.
5. Have the students determine the wood densities of the tree species. Then relate this information to the uses of different woods.

References

1. *The Care and Feeding of Increment Bores*. USDA Forest Service. Agee, J.K., and M.H. Huff. 1986.
2. *Dendrochonology-Tree Ring Dating Kit*. Lab-aids No. 52. Lab-aids Inc., Ronkonkoma, NY.
3. *Tree Maintenance*. Pirone, P.P. Fifth Edition. Oxford University Press, New York. 1989.

example data

TABLES FOR INDIVIDUALS:

Table A:

AGE BY CORE SAMPLES

Ring Widths for the Past Six Years - Tree Cross Sections (mm)

Sample	1993	1992	1991	1990	1989	1988	Total
32	1.1	1.5	1.4	1.0	1.2	1.6	7.8
5	1	1.2	1.5	1.1	1.0	1.8	7.6

DIAGRAM & LABEL:
Students should place their own examples with proper labels here.

Table B:

AGE BY CROSS SECTIONS

Percentage Growth-Tree Cross Sections (mm)

Sample	1993	1992	1991	1990	1989	1988	Total
A	2	3.5	8	4	8	5	30.5
B	1.5	1.5	1	1.8	1.2	1	8

DIAGRAM & LABEL:
Students should place their own examples here.
Coloring the parts may help in identification.

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How Fast Does This Tree Grow?

Introduction

The process of knowing the trees in your neighborhood began the first time you walked outside and noticed the trees in bloom. Recognizing fall leaf color may have inspired you to make a collection. Not knowing what exactly to do with the leaves, they soon became dry and brittle; so much for the collection.

With age comes a greater appreciation of trees. Trees give us shade in the summer, a wind break in the winter, and a place for many types of small animals to live. We realize trees grow slowly, but live a long time. Many a poet has written about trees, and you can find innumerable passages in literature about them. Now with the ever changing urban habitat we need to learn even more about trees to find the ones that will serve us best.

With the tools of a Forester, and even some you can find in hardware stores, you can determine if a tree is growing well. Other tools are used by Foresters in a heavily wooded site compared to the urban forest we are examining. We start with simple measurements of **height, diameter at breast height, and twig growth**.

There are several different ways to evaluate the health of trees. The methods we are going to use here are just a few of the ways that growth data can be gathered.

Questions

1. How does the data collected about trees tell us more than just height, width or growth pattern?

Hypothesis

Students should make their own before continuing.

Materials

Metric ruler
Clinometer
Stool
100 ft tape
Tree identification key
Diameter tape
Journals (logbook)
Data tables

Procedure

1. The student group should practice using all the tools before going outside.
2. Each member of the group should calculate how many steps it takes to pace 100 ft. Each student should practice pacing several times to get an average. Make a small data table with this information.
3. Make sure you know how to use the clinometer before going outside. This data goes in Table B.
4. Each group should prepare a checklist of materials and a data table. A simple pocket calculator can be used to calculate the averages.
5. Each student should be able to identify terminal bud scars, since these are the points

that must be used to measure twig growth. This data goes in Table A. Add data from other groups.

6. Either a compass or a map with directions on it should be used to determine the directions for gathering data as accurately as possible. This data goes in Table A.

Table A:

TREE TWIG LENGTH

			TWIG GROWTH					
Tree No.	Tree Species	Direction N/S/E/W	19__	19__	19__	19__	19__	AVG

Table B:

TREE DATA

Tree No.	Tree Species	Tree Height	Tree Diameter

Discussion Questions

1. Which tree species had the greatest twig growth last year? Which tree species had the greatest average twig growth over the last five years? Why?
2. Is there a pattern to the data? What is the pattern that your group sees? Give three reasons for it.
3. Were any of your trees planted in the last five years? Which ones? Why?
4. What are two other methods or instruments that could be used for this exercise? Give the reasons you believe so?

Conclusions

1. If you were to do this exercise again, what technique would you change and why?
2. What other data would you need to make an accurate estimate of the health condition

of the trees you used for this exercise?

Blowouts

1. Do the trees in urban areas following typical growth patterns?
2. What problems do the Urban Forest have to contend with, in order to survive?

Background Information

Trees are living organisms just like our students. Tree growth is just easier to quantify, since they don't move at a fast pace. The data gathered in this exercise must be gathered over long periods of time (3 or more years), in order to draw conclusions. Long-term data gathering is not unusual. NutraSweet7 took 10 years of research before it was released into the market. The FDA requires much time and many studies before allowing a new drug on the market. Trees have now become a renewed area of study, searching for chemicals that may be useful to humankind, such as taxol. This chemical comes from the bark of the Pacific Yew tree, which for years was considered waste by the forest industry. Time is a key ingredient in science and this is a study which will help students to appreciate patience and persistence. Lumber companies and many state forestry departments publish information about tree programs that can be valuable in demonstrating the long-term commitment to trees.

Science does not happen in one hour of class time, nor does a tree grow to thirty feet tall in one year. The old adage was 'speed kills'. This is very true in plants. The faster the tree grows, the shorter its life expectancy. In urban areas we plant fast growing trees to get shade quickly, but then in 10 years the tree is too large for the spot and it is taken down. Tree growth can point this out dramatically and provide useful information for future plantings.

Target Group

High school. Designed for 50 minute sections, but can be used at lower levels, if the amount of data gathering is adjusted.

Timeline

Day 1 --	Discuss the tools to be used and their proper use. This will be a class data collection project and if proper use of the tools is not stressed, the data will not be valid. It would probably be useful to have some of the tree cross sections out for practice. An object that is 100 feet from the class windows could be measured for height and then used as practice. Prepare data tables, vocabulary and complete work in student 'Logbooks'.
Day 2 --	Students will take prepared data tables to the assigned sites for making measurements. Students will work in groups and every one should take data to check on the other's work.
Day 3 --	Students will work on the data in the classroom, gathering data from two other groups. Conclusions can then be drawn for completion of the experiment.

Placement of Lab in Curriculum

This is part of the Forestry Unit and will fit in with any unit on tree or plant growth. This is also a good measurement lab, where students will develop data tables for organizing information that others will check.

Student Learning Objectives

Students will be able to:

1. Evaluate data collected on trees.
2. Replicate the results of another student's experiment.
3. Demonstrate that data reflects the accuracy of the measuring devices used.
4. Apply quantitative observational methods to accumulate precise data about trees.
5. Evaluate the interpretation of data collected during each experiment.

Preparation and Teaching Tips

Once the trees have been tagged, assign trees (by number or site) to students for collecting data. Stress that this will be part of the school's permanent record on tree growth. If students are using maps with numbers, make sure that they all know where they are going and which tools should be with them. If each student prepared his/her own checklist for the equipment needed for this assignment, it would foster responsibility on the student's part.

Blowouts

1. Students can enter the data into a computer spread sheet for the entire class. Then each group display the data graphically in different ways to making comparisons of how well the trees are growing.
2. Students can look up the expected growth rate of the species they are examining and develop a hypothesis to explain differences in the data they accumulated.
3. Students can determine the year the tree was transplanted, or if it was always on the site.

References

1. *Project Wild*. Western Regional Environmental Education Council. 1986.
2. *Project Learning Tree*. EEAI.
3. *Field Biology for Secondary Students*. Burton Voss. University of Michigan Biology Station. 1988.

example table:

Table A:

TREE TWIG LENGTH

			TWIG GROWTH					
Tree No.	Tree Species	Direction N/S/E/W	1993	1992	1991	1990	1989	AVG
1	Red Maple	N	10 cm	7.5 cm	12.5 cm	10 cm	10 cm	10 cm

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What Effects Do Trees Have On The Environment?

Introduction

The environment affects trees, but trees can also affect the environment. A tree needs water, minerals, carbon dioxide, and sunlight. The pH, moisture content, type of soil, competition, and mankind all affect tree growth. This experiment is designed to help us understand how trees affect the environment around them.

Many other factors are now being investigated for trees the same way that they are for people. The forest is much different than an urban area. While taking measurements of these environmental factors, consider what other factors you could measure. Which of these factors do you think are important to a homeowner / forester?

Question

1. Does the soil moisture, soil pH, soil temperature and humidity vary from tree to tree?

Hypothesis

Students are to write their own before continuing.

Materials

Air thermometer	Soil thermometer
Sling psychrometer	pH meter/pH paper
Moisture meter	Meter sticks
15 cm rulers	Plastic bags

Possible option:
Balances / scales
Distilled water

Procedure

1. Students will work in groups to prepare the appropriate data tables.
2. Take the first set of air and soil temperatures at the base (bole) of the tree, and the second set at the drip line (measure the distance from the trunk). The final set should be taken at least 5 meters from the tree in full sun.
3. The pH should be measured using the pH meter at the same distances as the temperatures. If pH is to be tested, collect a soil sample, place in a plastic bag, and return it to the laboratory. In the lab, add an equal amount of distilled water to the soil sample, and then in three to five minutes (when the soil has settled) use the pH paper.
4. Measure the soil moisture with the meter at the same locations.
5. Measure the humidity in the same approximate locations.

Results

The data for your group's work should be checked with the teacher before it is entered in the class data table. Make sure of the units you are using and the number of places in your calculated results. The table should be labeled Table A with an appropriate key for any abbreviations.

The following abbreviations are used in data Table B to conserve space:

AT - air temperature
H - humidity
SM - soil moisture
ST - soil temperature
pH - acidity of soil

Combine data from at least three other groups (or as your teacher directs) in the Class Data Table B.

Table A:

STUDENT GROUP DATA

TREE #_____
SPECIES:________________________________

	Air Temp.	Soil Temp.	Humidity	pH	Soil Moisture
Base					
Dripline					
Outside					

Table B:

CLASS DATA

Tree No.	Species	Base AT ST H pH SM	Dripline AT ST H pH SM	Outside AT ST H pH SM

Discussion Questions

1. Which tree had the greatest difference in temperature between the base and the area outside the tree? Which tree had the least difference? What was the difference?
2. Was the difference in humidity between the base of the tree and the open area outside surprising to you? Explain.
3. Which trees had the greatest soil moisture at the base? at the drip line? Is there a difference? Why?

4. Do you believe that the pH difference is due to the species of tree? Explain your answer.

Conclusions

1. Does the data support your hypothesis? Why or why not?
2. What does the results of this experiment tell you about trees as a homeowner / forester?
3. What experiment could you design to learn more about the effects of trees on the environment?
4. How are the conditions under a tree different from outside its influence?

Background Information

While the micro-environment required by an organism may not seem important to the untrained observer, the micro-environment above and below ground can have a tremendous impact on all organisms. In the last 30 years, the availability of more sophisticated techniques are increasing our awareness of the micro-environment. We have been manipulating the macro-environment without realizing how the micro-environment is also being altered.

The chemistry of the soil and the tree are now being studied intensively by scientists. Scienctific journals are now availabe that specifically address the health and productivity of trees. The three factors chosen for this exercise can be measured and compared easily. Since trees live for many years, student data on the same tree can be compared over time. The trees we plant and take care of today can be here for many generations to come.

Target Group

High school or middle school level

Timeline

Day 1 -- Students should discuss their ideas on the macro- or micro-environment of a tree. This should include how far away from a tree we can measure the effect of the tree. The students need to discuss what factors are needed in their data tables. The students should then make their hypothesis by group and this should be checked before going out in the field. Demonstration of the equipment and its proper use are needed for accurate data recording. The student data table design should be checked, along with their equipment lists. The class data table should be a summary by groups.

Day 2 -- Students should go out to their two trees and gather the data. When finished, return to the lab and assimilate the class data. Work on calculations and discussion questions.

Day 3 -- Conduct a question and answer session after the class data has been collected and checked. Use a graphing program or have each group gather data from two other species of trees and make a graph for comparisons.

Placement of Lab in Curriculum

This exercise is part of the unit on trees and can be done once the preliminary work of organizing the science class has been accomplished.

This exercise would fit in an environmental or higher plant unit. The exercises are more effective as a coordinated unit over a two to three week period.

Student Learning Objectives

1. Recognize that one organism will have an effect on other plants in an urban setting.
2. Understand that the interaction among trees, soil and people is becoming increasingly important in the urban environment.
3. Understand that data reflects the accuracy of the measuring devices.
4. Apply quantitative observational methods to accumulate precise data about the trees at their site.
5. Analyze the results of the experiment.
6. Evaluate the interpretation of data collected during the experiment.

Preparation and Teaching Tips

The preparation for this experiment is the same as the preceding exercises in this unit. The need to prepare the area for the tree key exercise is the prelude to all the experiments. Once the field work of setting up the tree identification has been done by map or tree tag number, trees can be assigned to students. It is suggested that each group collect information on two trees. If there is time, or need, additional trees can be assigned. *Remember that too much data is as confusing as too little.*

Students should prepare a data table for the two trees they are going to study. The class data table should be the same format, so computer analysis can be done later.

The lab exercise can be done by one or two groups while other groups are doing the other labs in this packet. Plan ahead so that all the photocopied materials are prepared, and the students have prepared the proper tables and equipment lists for the exercise.

The data tables for the students are meant as an example that can either be used as is, or as a suggestion of how to set up a table. Since the organization of the data table used in the field is not important to the class, it may be prudent to let students design their own to gain experience with this process.

Blowouts

1. Compare and contrast the north side to the south side of the tree. East vs. west.
2. Compare different tree species.
3. Compare different aged trees of the same species.
4. Compare trees that have been mulched extensively to those that are surrounded by grass, or are in median strips of parking lots.

References

1. Biology: Living Systems. Alexander, P., et al. Prentice Hall Inc. 1989.
2. Field Biology for Secondary Students. Voss, Burton, editor. Unpublished. University of Michigan Biological Station. 1987.
3. Tree Maintenance. Pirone, P.P., 5th edition, Oxford University Press, N.Y. 1989.

Discussion Questions Answers

To accurately answer these questions the students have to review all the class data and examine all the possibilities. The answers will vary for all the groups, and the work should be designed so it is done as a group. Any type of indepth answer will suffice with the use of pictures or diagrams to support their positions. A final report to the class on each experiment could enhance their motivation to examine one area in detail.

Table B:

example 1

-- °C --

Tree No.	Species	Base AT ST H pH SM	Dripline AT ST H pH SM	Outside AT ST H pH SM
1	Silver maple	21 21 83 6.5 5	24 24 85 7.5 4	27 31 65 8.0 1
3	Pin oak	20 20 85 6.0 5	24 22 80 7.0 3	26 30 62 8.0 1

example 2

-- °F --

Tree No.	Species	Base AT ST H pH SM	Dripline AT ST H pH SM	Outside AT ST H pH SM
1	Silver maple	71 70 83 6.5 5	77 77 85 7.5 4	80 87 65 8.0 1
3	Pin oak	69 69 85 6.0 5	77 74 80 7.0 3	80 86 63 8.0 1

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What's Happening Below The Surface?

Introduction

Tree growth takes place not only above the ground, but below. The nutrients necessary for plant growth are available under only very specific conditions for each tree species. Trees have adjusted after great lengths of time to very specific environmental conditions that existed long before humankind came on the scene. When we place a tree in an urban setting, we need to see that its needs are met. The site that a tree lives in will be modified by the tree, if the situation is not hostile. Our intent here is to determine the soil conditions around trees that are already planted and growing.

Soils differ widely over even a small area. Good soil will be composed of 45% mineral and 5% organic matter with the other portion equally divided between air (25%) and water (25%). Large populations of microorganisms, insects and arthropods, also occupy the soil and need air to survive.

Soils are generally composed of more than one layer or horizon. The soil color and compostion distinguish these layers. Using the enclosed resources, or your textbook, find out more about the structure of soil. Soil texture refers to the size of the particles that make up the soil. These five (from large to small) are large stones, gravel, sand, silt, and clay.

This exercise will familiarize you with the technique of soil sampling. Measuring different soil layers will aid in determining the soil composition in your area.

Question

1. Is the soil beneath our trees all the same?

Hypothesis

Students should make their own before continuing.

Materials

21" soil probe	Plastic sample bags
Tape measure	Marking pen for bags
Notebooks and pencils	Small rulers (15 cm)
Bucket with replacement soil	Flags (stakes)
Field scale	Old newspaper & rolling pin

Procedure

DAY ONE

1. Before leaving the lab you should have prepared:
   a. the mass of each of the labeled sample.
   b. all the necessary data tables from examples below.
   c. all the necessary equipment.
2. When you arrive at each tree, stop and observe the tree, noting any special conditions to be entered in the data table. (ie. driveways, power lines, sidewalks, construction nearby, damage to the tree itself, etc.).

3. At each tree, first determine which is the north and south side, and measure 0.5, 2, 4, 8, and 12 meters in each direction with the tape. (Note in the table wherever this is not possible).
4. At each spot, take a sample as deep as possible and then note the depth from the surface where the color changes. Record the maximum depth.

   Collecting Samples:
5.
   a. Draw and label a picture of each sample collected in your "logbook". (length, horizon, size of each section, color)
   b. Pop the sample out of the tube and cut off the top 5 to 8 cm including the grass roots. Place all the samples from the same side of the tree in the same bag marked with the tree number and direction of the samples, (ex. Tree #25 - south). Make sure the sample is kept in the bag, tied with a twist tie; record the mass when finished.
   c. Weigh the bag with the moist soil inside.

   Determining Soil Water Content:
6. Remove the sample from the bag and place it on newspaper to dry overnight.
7. The next day, replace the material in the bag to find the mass of the dried soil.
8. Calculate the % soil water content from Table B.

   Determining Soil Constituents:
9. Crunch or roll out all the lumps of soil using a rolling pin or other large, clean metal object. All foreign matter like leaves, twigs and roots should be removed, with as little contact with your hands as possible.
10. Samples can be run through the soil sieves, if all the soil aggregates have been properly crushed.
11. Shake the sieves for about 10 minutes, then separate them, and the mass of the soil on each sieve determined. (remember to mass the bag **before** you put soil into it to be massed. (*ex. total mass* - *bag mass* = *sample mass*)
12.
    a. Calculate the total mass and the percentage of each type of soil by dividing each mass by the total.
    b. From Table E take the three parts (sand, silt, clay) that apply to the soil texture triangle and find the **textural class** of soil in each sample.
13. Record the final results in Table E.

Table A:

SOIL SAMPLE CORE FIELD DATA

MEASURE AND RECORD DEPTH OF COLOR CHANGE AND LENGTH TOTAL OF SAMPLE:

SITE # ______	**Depth / Distance from Tree / Color**						
	Tree No.	0.5 m	2 m	4 m	8 m	12 m	notes

SITE KEY

Table B: SOIL FROM FIELD COLLECTION

Soil Sample Mass Tree #_______ Side______ Side______

A. Mass of bag ________ g ________ g

B. Mass of bag & sample ________ g ________ g

C. B-A= mass of sample ________ g ________ g

DAY TWO

D. Mass of dried soil ________ g ________ g

E. Difference of A-B=mass water ________ g ________ g

F. % water = C/A x 100 ________ g ________ g

Table C:

MASS OF SEPARATED SAMPLES
(RECORDED IN GRAMS)

Tree No.	side	rocks	gravel	sand	silt	clay	Total

Table D:

SOIL STRUCTURE BY PERCENTAGE
(SIEVE SEPARATION TECHINQUE / DATA FOR EACH TYPE).

Tree No.	side	rocks	gravel	sand	silt	clay	Total

Analysis of Results

Table E:

SUMMARY TABLE

Tree No.	side N/S/E/W	soil moisture	distance of first change	depth of color change	textural class	Tree name

Discussion Questions

1. Did any of your trees have more layers of soil than others? Compared to your classmates? Which ones?
2. Is there a difference in the distance at which there is a color change? Between different sides of trees?
3. Do you think there is any correlation between soil layers and the type of tree you are sampling? Why?
4. Is there any difference in the sides of the trees and/or tree types ?
5. Which tree has the most gravel and stones? What reason, using data, can you give for this?

Conclusions

1. Which tree had the most moisture in your group? In your class?
2. Does the data support your hypothesis? Why or why not?
3.
    a. If your hypothesis is supported by the data what would you do next if you were a scientist / forester?
    b. If your hypothesis was not supported by the data what would you do next?
4. What have you learned from this exercise about trees and soil? (be specific as possible)

Background Information

Tree growth and development is dependent on the soil below. The structure, texture, color, and condition of the soil all lead to successful tree growth. Poorly drained clay soils, that are usually found in new urban areas, require a different planting procedure from the dark crumbly type soils of a forest or older neighborhoods. To find the type of soil conditions trees require, consult the publications listsed in the references.

Soils in most urban or recently developed suburban areas have been changed dramatically from what they were before towns were built. The original soil, could have been anywhere from three to six feet in your area, and was most likely scraped off. Plants must grow in soils that are much less than adequate. Even if soils were not removed, the number of trucks or vehicles that moved across your property while the house was being built, may have compacted the soils. Soils piled into big mounds until they can be spread over the landscape have again changed chemically and biologically, more so with the passage of time. Without the proper ratio of water and air in the soil, trees will not grow well.

As sidewalks, curbs and streets are installed, the gravel and chemicals used also cause changes in the soil conditions. Trees have to overcome these changes to survive. Limestone driveways raise the soil pH. Compaction of soil slows water infiltration. Water runs off some areas and puddles in others, like the large holes just dug for the trees. Landscapes are designed to move water away from foundations, and plants may need extra watering. Soils are important to tree survival and we can even see that some trees will change the soils.

Soils differ widely in their characteristics and soil science is the study of soils. Most soil studies related to plant growth has been related to farming: grains in the midwest; citrus trees in Florida; cotton in the south; and fruit trees. The work with urban trees is just beginning, and relatively few people have spent careers working on Urban Forestry or its related fields.

A ringed or spiral notebook collection of tree related stories collected from magazines or newspapers should be kept yearly for class reference. The sources of information from the daily local newspaper will astound students. The local agricultural extension service, or city library, has books on trees and even more on gardening that can be useful resources. Landscape contractors in your area, or the city forester, could provide information for students. Hardware stores can also provide information if students look at resource books in the gardening sections. The variety of resources available are numerous.

Target Group

Ninth through twelfth grade students are the intended audience. Slight modifications can be made to increase the difficulty of data analysis, or simplify it for other groups.

Timeline

The amount of time needed to accomplish this particular project will depend on the number of trees and the number of times you wish to have data for trees reported. The exercise is intented for five days of work; one day of preparation, two days of field work, and two days of laboratory data analysis.

With groups of four, this exercise can be done in conjunction with other projects in this unit. Students need one day to collect data and another to calculate and check on other student groups. The student data work-up and the conclusion should be checked by other groups for comparison. A one day field trip would be good if it served as a culminating activity for all of these exercises.

Placement of the Project in the Curriculum

This can be placed in the ecology or plant section of your units; but ideally the entire Urban Forestry unit should be used together.

Student Learning Objectives

Students will be able to:

1. Understand the interaction among trees, soil and people.
2. Use equipment properly to gather data.
3. Accurately record gathered data.
4. Draw conclusions about the nature of soil at different sites for tree growth.
5. Evaluate each site for future tree growth.

Preparation and Teaching Tips

1. The previous exercise on labeling and mapping of your school site should have been completed.
2. Trees and shrubs at your school site should be tagged with an inventory number.
3. Review procedures for how many trees to use, how the data is recorded, what units to use, what level of accuracy is required, and how each of the tools is to be used.
4. Check with a school maintenance official to see if there is any buried cables to avoid. (cable TV is usually shallow)
5. Realize that for each class, and each time you go outside, it is a different teaching situation.
6. Use a checklist of materials, so students can check out all of their equipment.
7. Make sure each group of students is prepared and has written their hypothesis(es).

Expected Results

Results will vary with sampling site. See attached class data table examples.

Blowouts

1. Use a soil auger and take deep soil profiles for chemical analysis.
2. Dig a large soil pit 3' wide x 6' long x 5' deep so root structure and soil change is easily visible.
3. Measure the depths of soil horizons and compare to data for different types of natural environments, or with their own homes.

Discussion & Conclusion Question Answers

To accurately answer these questions the students will have to compare their results with other groups. A large classroom data table on butcher paper would open up many more avenues of discussion. There are no specific answers for these questions, they are all of higher order. The simple direct questions are on the pre- and post-quizzes.

1. Groups should have differences by specific types of trees.
2. The sample farthest away from an older tree should be more dramatic than for a newly planted tree in a field.
3. This question is asked if there is a field planted tree as compared to a group planted tree (forest) sample that was used.
4. There should be a difference between north and south.
5. The tree with the most gravel can tell about the construction techniques at your school site.
6. The same species of tree should show similarities.
7. Answers will vary. Important to the development of scientific thinking in students.
8. Same as above only they must use their data to support analysis.
9. Answers will vary and is a good place to also ask questions.

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8. *Field Biology for Secondary Students*. Voss, B.E., editor, Unpublished UMBS. 1988.

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Word Search Puzzles

Leaf Parts: Form A

NAME ____

```
F E D F E T I S O P P O T R C
S K Z F B F L A F S E S W A O
T I F A V P F E E T T J I C M
A L Y L U O L L A F P F G S P
L E C T A R D N U F R C S D O
K L O E Q E N T M I L U B U U
S A N R E I D S O R S E D B N
N C E N P L F E I D R E T U D
R S S A T S L N C M V C B S B
V L A T V O L Y A I P E H O S
D A J E K Y O K T W D L I P L
T Z R P M H Q T B B I U E N O
X T A X S T E E H A I S O U B
E T A M L A P J I E S X P U I
Q H G F H C E D O N D E M D S
```

LIST OF WORDS

PINNATE	PALMATE	VEIN
BUD	NODE	NEEDLES
TUFTS	DECIDUOUS	SCALE-LIKE
CONES	OPPOSITE	ALTERNATE
COMPOUND	SIMPLE	TOOTHED
LEAFLETS	TWIGS	STALKS
LOBES	BASE	BUD SCAR

Leaf Parts: Form B

NAME ____

```
S T A L K S R T P A L M A T E
G O O S H M C O M P O U N D C
P V X R T U F T S Z Y L F A X
B P A L T E R N A T E N I M N
O P P O S I T E N X D L C V T
S L Z Q C K N O D E V E I N N
E R H K P I N N A T E F U P K
E X K T W I G S N E G L L N K
Q D B W M E S C A L E L I K E
N E E D L E S L E A F L E T S
X R U R T Q S B U D S C A R O
I I Y T O O T H E D Q B A S E
O C O N E S J N L O B E S T G
H M Z Y C W K Q R S I M P L E
B U D C D E C I D U O U S Q M
```

LIST OF WORDS

PINNATE	PALMATE	VEIN
BUD	NODE	NEEDLES
TUFTS	DECIDUOUS	SCALE-LIKE
CONES	OPPOSITE	ALTERNATE
COMPOUND	SIMPLE	TOOTHED
LEAFLETS	TWIGS	STALKS
LOBES	BASE	BUD SCAR

Trees To Plant In Our Area: Form C

NAME ____

```
N N M L L J L I L A C A N Y N N Y Y P U
P E A R P E C A N F S W E B S N I K I G
T V T Z U H A Z E L N U T T K G S X U B
N B K W R I B U C K E Y E A X X D J F A
Z L M A G N O L I A G Y S W E E T G U M
I Z B R C H E R R Y Q T T G W F A X E R
F V B L U E A S H C I Q A P R I C O T M
K G O D M C I I N Y P L U M O Z K R D W
X F C O F F E E T R E E R Q X Y B X E V
D Z W N B U R O A K P Y J L N U O E U I
W I L L O W P A G O D A T R E E V D O V
O F F Q Y X F I Q T T W S R B F K G B C
A R H I C K O R Y E V B A G R X M E L M
B B B E E C H J W S C R A B A P P L E D
K V A I Z T O K M S O U R G U M L X X K
I Z T N I C Y E L L O W W O O D U S Z K
K T L R I B M O L N D R E D B U D F I C
T U L I P T R E E R E D M A P L E A Y L
I D O N G B U S O Z P O P L A R H X O K
C Y J C X N R J G D O G W O O D N X J C
```

<u>LIST OF WORDS</u>

BLUE ASH	COFFEETREE	LILAC
BUR OAK	SOURGUM	YELLOWWOOD
CHERRY	PLUM	PEAR
BEECH	ELM	MAGNOLIA
PAGODA TREE	SWEETGUM	BUCKEYE
CRABAPPLE	REDBUD	POPLAR
HAZELNUT	HICKORY	RED MAPLE
PECAN	TULIPTREE	APRICOT
DOGWOOD	WILLOW	

Trees To Plant In Our Area: Form D

NAME ____

```
V B A R T W E E R T A D O G A P W Q R S
T U I M O Z T U N L E Z A H I D L E Y W
G C L T O C I R P A O S H Q O M D T T E
H K O I N A C E P S V S D O U M G K Y E
X E N P D M Y U A G A J W L A P G R W T
Y Y G J L Q A Z B E T W P P N T O C W G
X E A K N W F Q U D O U L N K K M H Q U
E D M Q O R Z L P L X E A E C A Q P Z M
M L U Y A N B W L C J V G I K K O E W O
O H P E O G M E J D G V H C W I O R O W
J C P P N A Y V V U O M H E E F T A U L
L C L W A H O P K B E H W Y L N X I X B
V M I I M B V T L D C E R C W I D S K D
C U J L M X A P E E L X Y A B Y L G Z O
Z R F L M L W R K R R X Q X L E V A P O
I D I O Q J E R C M I X W R T P E X C W
```

```
A H S W C E E R T P I L U T N P O C L G
E E R T E E F F O C I U J G Q C T P H O
W J G C H W B V H C H E R R Y W X Z T D
M L S Q E D L M U G R U O S N V I J Q O
```

LIST OF WORDS

BLUE ASH	COFFEETREE	LILAC
BUR OAK	SOURGUM	YELLOWWOOD
CHERRY	PLUM	PEAR
BEECH	ELM	MAGNOLIA
PAGODA TREE	SWEETGUM	BUCKEYE
CRABAPPLE	REDBUD	POPLAR
HAZELNUT	HICKORY	RED MAPLE
PECAN	TULIPTREE	APRICOT
DOGWOOD	WILLOW	

Tree Key Words: Form E

NAME ___________________________________

```
X B E H B B H E E R T P I L U T H D Z S
E W C E L W B C O G L E O D G B K H Y U
T W U E J H S T U I R D I O Z D A T V G
G F R U Q I A F Q I J O D V N W O U I A
A W P O F T S A T K H H W U T H R P N R
D D S K O E P N F X V Q O Z W I U D O M
H G E H Y O E M V W Q P Q V L T B T S A
E H I T B A K Y R Q M G F D K E A T I P
H L E W A K N P D O F G W S M P L E O L
C S A A T R I E C M E T P H H I I L P E
H A A C R M R F E Y D L G I R N E F D E
E C B E S T B E S D N E P V N E R A D L
S I Y N U D W P S A L G C A M N N E S P
T W Z N P L U O E N P E D I M K A L S P
N I F I C A B B O C F W V E D D T T A A
U P T D D E U R B D A G O B B U E V E B
T H E Z Z F F T O T M N M O K O O R R A
E T A M L A P S E L D N U B D Q L U D R
Y P A R A L L E L L E A V E S T A A S C
P E T I O L E T I S O P P O A H G N P V
```

LIST OF WORDS

PALMATE	PINNATE	ALTERNATE	PECAN
OPPOSITE	ENTIRE	COMPOUND	POISON IVY
TWIG	NEEDLE	LEAVES	CRABAPPLE
BUNDLES	DECIDUOUS	WHITE PINE	CHESTNUT
SPRUCE	TULIPTREE	SUGAR MAPLE	PARALLEL
BLUEASH	SERRATED	LOBED	RED MAPLE
LEAFLET	BUD SCALE	HEARTWOOD	BUR OAK
SAPWOOD	PITH	PETIOLE	WHITE OAK

Tree Key Words: Form F

NAME ___________________________________

```
S K P A L M A T E J C G S Y Q W U E Q N
X K Z V X X Z P D E C I D U O U S W T K
C O M P O U N D J B L O B E D C X K X X
G J S P R U C E C H F P O I S O N I V Y
A L A D L E A V E S P E T I O L E H F T
```

```
Y R T S P A A N O V A B U D S C A L E A
K Z H C H Y D I L Q F T U L I P T R E E
S P A R A L L E L P I N N A T E P C E V
S U G A R M A P L E P I T H Y I J W I L
B D S D Z H O L E N L P S E R R A T E D
D V Z W C R A B A P P L E I T W I G T Z
C B L E A F L E T G L S B L U E A S H I
C H E S T N U T A L T E R N A T E J S B
K S V W H I T E P I N E V B A E I V G S
O J C N E E D L E L R E D M A P L E S H
S B U B W H I T E O A K E T W W X J I Z
Y E V Z J H E N T I R E O F H J H L W N
O E S A P W O O D B U R O A K Y H V W A
N E B H E A R T W O O D D B U N D L E S
T U E C V O P P O S I T E V A P E C A N
```

LIST OF WORDS

PALMATE	PINNATE	ALTERNATE	PECAN
OPPOSITE	ENTIRE	COMPOUND	POISON IVY
TWIG	NEEDLE	LEAVES	CRABAPPLE
BUNDLES	DECIDUOUS	WHITE PINE	CHESTNUT
SPRUCE	TULIPTREE	SUGAR MAPLE	PARALLEL
BLUEASH	SERRATED	LOBED	RED MAPLE
LEAFLET	BUD SCALE	HEARTWOOD	BUR OAK
SAPWOOD	PITH	PETIOLE	WHITE OAK

Return to the Table of Contents

Word Search Puzzles - Solutions

Pre/Post Quiz: Form A

NAME ___________________________

CHOOSE THE BEST ANSWERS:

A. LEAVES

1. Opposite / Alternate	A) Type of leaf
2. Compound / Simple	B) Type of vein organization
3. Pinnate / Palmate	C) Method of leaf organization on stem
4. Entire / Lobed	D) Type of margins on leaves

B. QUADRAT

5. Herbs	A) Non-woody plants
6. Shrub	B) Less than 6 feet in height at maturity
7. Tree	C) Less than 12 inches in circumference
8. Sapling	D) 12 inches or more in circumference

C. TOOLS

9. Soil probe	A) Used to sample and measure soil layers
10. Sling psychrometer	B) Measures amount of acid in soil
11. Light meter	C) Measure amount of moisture in air
12. pH meter	D) Measure intensity of sunlight

D. CHARACTERISTICS TO TOOL

13. Air speed	A) Hubbard screen sieve set
14. Soil temperature	B) Taylor soil thermometer
15. Soil make-up	C) Dwyer wind meter
16. Air temperature	D) Standard Taylor thermometer

Pre/Post Quiz: Form B

NAME ____________________________________

CHOOSE THE BEST ANSWERS:

A. LEAVES

1. Opposite / Alternate	A) Type of leaf
2. Entire / Lobed	B) Type of vein organization
3. Pinnate / Palmate	C) Method of leaf organization on stem D) Type of margins on leaves
4. Compound / Simple	

B. QUADRAT

5. Sapling	A) Non-woody plants
6. Shrub	B) Less than 6 feet in height at maturity
7. Tree	C) Less than 12 inches in circumference
8. Herbs	D) 12 inches or more in circumference

C. TOOLS

9. Sling psychrometer	A) Used to sample and measure soil layers
10. Soil probe	B) Measures amount of acid in soil
11. Light meter	C) Measures amount of moisture in air
12. pH meter	D) Measures intensity of sunlight

D. CHARACTERISTIC TO TOOL

13. Air temperature	A) Hubbard screen sieve set
14. Soil temperature	B) Taylor soil thermometer
15. Soil make-up	C) Dwyer wind meter
16. Air speed	D) Standard Taylor thermometer

Leaf and Stem Structures: Form A

NAME ____

CHOOSE THE BEST ANSWER:

1.______ Opposite	A. Place on twig where previous years bud scales were attached; used to age twig
2.______ Alternate	B. Leaf venation that has one main vein with
3.______ Needles	
4.______ Deciduous	

5.______ Scale-like
6.______ Compound leaf
7.______ Palmate veins
8.______ Pinnate veins
9.______ Bi-pinnately compound
10._____ Lobed
11._____ Parallel vein
12._____ Lenticels
13._____ Bud scales
14._____ Pith
15._____ Terminal bud
16._____ Entire
17._____ Node
18._____ Whorled

smaller branching veins

C. Leaflets of the Kentucky coffeetree are divided into smaller leaflets

D. Type of leaf margin that has no teeth and is a continuous smooth edge.

E. Large indentations in leaf that may go to the main vein

F. A single leaf that has a rachis or leaflets

G. One bud at a node; leaves come out on the stem one side then other

H. When three or more leaves are arranged in a circle around one point on the stem

I. Small dot-like structures on twig used for gas exchange

J. Spot on twig where buds had formed and a line or scar remains

K. Types of leaves found on most evergreens

L. Covering of a bud before it opens or grows

M. Center most material of a twig; used in identification of plants

N. Type of leaf found on arborvitae or cedar trees

O. Two buds at a node; two leaves come out either side of stem at same spot

P. Trees that have leaves that fall off once each year at about the same time

Q. Multiple veins running along side one another

R. Vein design on leaf that has more than one major vein coming from the base of the leaf

---

Leaf Stem and Structures: Form B

NAME ____

CHOOSE THE BEST ANSWER:

1.______ Opposite
2.______ Alternate
3.______ Needles
4.______ Deciduous
5.______ Scale-like
6.______ Compound leaf
7.______ Palmate veins
8.______ Pinnate veins
9.______ Bi-pinnately compound
10._____ Lobed

A. Place on twig where previous years bud scales were attached; used to age twig

B. Type of leaf margin that has no teeth and is a continuous smooth edge.

C. Spot on twig where buds had formed and a line or scar remains

D. Multiple veins running along side one another

E. Small dot-like structures on twig used for gas exchange

11.____ Parallel vein
12.____ Lenticels
13.____ Bud scales
14.____ Pith
15.____ Terminal bud
16.____ Entire
17.____ Node
18.____ Whorled

F. Types of leaves found on most evergreens
G. Type of leaf found on arborvitae or cedar tree
H. A single leaf that has a rachis or leaflets
I. Covering of a bud before it opens or grows
J. Center most material of a twig used in identification of plants
K. Two buds at a node; where 2 leaves come out either side of stem at same spot
L. Leaf venation that has one main vein with smaller branching veins
M. Vein design on leaf that has more than one major vein coming from base of leaf
N. One bud at a node; leaves come out on stem one side then other side
O. Trees that have leaves that fall off once each year at about the same time
P. Leaflets of the Kentucky Coffeetree are divided into smaller leaflets
Q. Large indentations in leaf that may go to the main vein
R. When three or more leaves are arranged in a circle around one point on stem.

Herbarium Specimens: Form A

NAME ____

CHOOSE THE BEST ANSWER:

1. _____ herbarium
2. _____ pruning shears
3. _____ vasculum
4. _____ notebook
5. _____ hand lens
6. _____ plant press
7. _____ corrugated cardboard
8. _____ newspaper
9. _____ herbarium paste
10. ____ tree key
11. ____ trowel
12. ____ botanical tape
13. ____ storage cabinet
14. ____ terminal bud
15. ____ preservative

A. Shovel or other digging device to get roots of small samples to be pressed
B. Placed between blotter paper to help press leaves
C. Liquid used to hold fruits or larger seeds in a jar
D. Vessel or container used for field storage of collected plant material
E. Plant part necessary in identification
F. Used to hold specimens while drying in plant press
G. Device used to hold plant specimens with bug repellent and dessicant
H. Used to trim and size plant specimens
I. Device used to maintain plant material in a flat condition for re-examination
J. Material used to hold down larger plant materials

that glue cannot

K. Identified collection of plants that is well preserved and accurate

L. Glue used to hold plant specimens to paper

M. Guide used to identify trees

N. Booklet used in the field to note data while collecting specimens

O. Tool used to identify small structures on plants needed for identification

---

Herbarium Specimens: Form B

NAME ____

CHOOSE THE BEST ANSWER:

1. _____ herbarium
2. _____ pruning shears
3. _____ vasculum
4. _____ notebook
5. _____ hand lens
6. _____ plant press
7. _____ corrugated cardboard
8. _____ newspaper
9. _____ herbarium paste
10. ____ tree key
11. ____ trowel
12. ____ botanical tape
13. ____ storage cabinet
14. ____ terminal bud
15. ____ preservative

A. Liquid used to hold fruits or larger seeds in a jar

B. Vessel or container used for field storage of collected plant material

C. Used to hold specimens while drying in plant press

D. Used to trim and size plant specimens

E. Device used to hold plant specimens with bug repellent and dessicant

F. Identified collection of plants that is well preserved and accurate

G. Glue used to hold plant specimens to paper

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J. Shovel or other digging device to get roots of small samples to be pressed

K. Guide used to identify trees

L. Material used to hold down larger plant materials that glue cannot

M. Booklet used in the field to note data while collecting specimens

N. Placed between blotter paper to help press leaves

O. Tool used to identify small structures on plants needed for identification

---

Tree Environment: Form A

NAME ____

CHOOSE THE BEST ANSWER:

1._____ acidic
2._____ compost
3._____ pesticide
4._____ broadleaf
5._____ conifer
6._____ deciduous
7._____ dendrology
8._____ bole
9._____ defoliation
10.____ silviculture
11.____ nutrients
12.____ sap
13.____ forest
14.____ crown
15.____ roots
16.____ buds
17.____ phloem
18.____ heartwood
19.____ growth habit
20.____ seed

A. underground part of tree that takes nutrients from the soil and air
B. stem or trunk of a tree
C. the foliage and flowering or fruiting part of the tree
D. the art of producing and caring for a forest
E. small, growing projections at the ends or sides of stems
F. the study of trees
G. a mixture of decayed organic matter used as a fertilizer
H. a chemical agent used to destroy pests (usually insects)
I. having a pH lower the 7
J. mineral elements and compounds which a plant uses for tissue growth
K. dead cells that give strength to the tree
L. plants that shed all of their leaves at the end of the growing season
M. trees that bear seeds in cones and have needle-like leaves
N. the shape that a tree takes when it is mature
O. trees that have wide, flat leaves
P. the body produced by flowering plants which can grow into a new plant
Q. a complex community of associated trees, shrubs, other plants, and animals
R. carries food from leaves to twigs, branches, trunk and roots
S. the liquid that circulates through the tissues of woody plants
T. loss of leaves, esp. prematurely

Tree Environment: Form B

NAME ____

CHOOSE THE BEST ANSWER:

1._____ acidic
2._____ compost
3._____ pesticide
4._____ broadleaf
5._____ conifer
6._____ deciduous
7._____ dendrology
8._____ bole

A. stem or trunk of a tree
B. having a pH lower than 7
C. the body produced by flowering plants which can grow into a new plant
D. the study of trees
E. a mixture of decayed organic matter used as a fertilizer

9._____ defoliation
10.____ silviculture
11.____ nutrients
12.____ sap
13.____ forest
14.____ crown
15.____ roots
16.____ buds
17.____ phloem
18.____ heartwood
19.____ growth habit
20.____ seed

F. trees that have wide, flat leaves

G. the liquid that circulates through the tissues of woody plants

H. the foliage and flowering/fruiting part of the tree

I. the shape that a tree takes when it is mature

J. underground part of tree that takes nutrients from the soil and air

K. mineral elements and compounds which a plant uses for tissue growth

L. a chemical agent used to destroy pests (usually insects)

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N. plants that shed all of their leaves at the end of the growing season

O. carries food from leaves to twigs, branches, trunk and roots

P. loss of leaves, esp. prematurely

Q. the art of producing and caring for a forest

R. small, growing projections at the ends or sides of stems

S. dead cells that give strength to the tree

T. a complex community of associated trees, shrubs, other plants, and animals

---

Soil Texture and Structure: Form A

NAME ____

CHOOSE THE BEST ANSWER:

1._____ screen sieves
2._____ aggregates
3._____ permeability
4._____ soil water
5._____ soil sampler
6._____ soil auger
7._____ monolith
8._____ soil color
9._____ soil profile
10.____ soil texture
11.____ silt
12.____ loam
13.____ texture triangle
14.____ soil structure
15.____ soil

A. drill-like device requiring a catcher to collect soil layers

B. tool for separating soils

C. speed at which water moves through a material

D. column of soil that is saved to demonstrate layers below the ground

E. a cross section of the soil usually seen by looking in a large pit or hole

F. the amount of water trapped between soil particles

G. long narrow cylinder that takes a soil sample from below ground in a column

H. large clumps of soil

I. is used to help us name the type of soil we find at a given spot

J. the amounts of sand, silt and clay determine this

K. soil that is a mixture of silt, sand and less clay

L. visual clue used to aid in the classification of soil

M. the outer portion of the earth's crust that supports plant growth

N. soil particles that are larger than clay but smaller than sand

O. arrangement of individual soil particles in various groups or clusters

---

Soil Texture and Structure: Form B

NAME ____

CHOOSE THE BEST ANSWER:

1.______ screen sieves
2.______ aggregates
3.______ permeability
4.______ soil water
5.______ soil sampler
6.______ soil auger
7.______ monolith
8.______ soil color
9.______ soil profile
10._____ soil texture
11._____ silt
12._____ loam
13._____ texture triangle
14._____ soil structure
15._____ soil

A. the outer portion of the earth's crust that supports plant growth

B. speed at which water moves through a material

C. visual clue used to aid in the classification of soil

D. large clumps of soil

E. is used to help us name the type of soil we find at a given spot

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G. a cross section of the soil usually seen by looking in a large pit or hole

H. arrangement of individual soil particles in various groups or cluster

I. drill like device requiring a catcher to collect soil layers

J. soil particles that are larger than clay but smaller than sand

K. the amounts of sand, silt and clay determine this

L. soil that is a mixture of silt, sand and less clay

M. the amount of water trapped between soil particles

N. column of soil that is saved to demonstrate layers below the ground

O. long narrow cylinder that takes a soil sample from below ground in a column

---

General Quiz: Form A

NAME _________________________________

CHOOSE THE BEST ANSWER:

1.______ acidic

A. the body produced by flowering plants which can grow into

2._____ compost
3._____ pesticide
4._____ broadleaf
5._____ conifer
6._____ deciduous
7._____ dendrology
8._____ bole
9._____ defoliation
10.____ silviculture
11.____ nutrients
12.____ sap
13.____ forest
14.____ crown
15.____ roots
16.____ buds
17.____ phloem
18.____ heartwood
19.____ growth habit
20.____ seed

a new plant

B. trees that have wide, flat leaves
C. mineral elements and compounds which a plant uses for tissue growth
D. a chemical agent used to destroy pests (usually insects)
E. carries food from leaves to twigs, branches, trunk and roots
F. having a pH lower than 7
G. the art of producing and caring for a forest
H. the shape that a tree takes when it is mature
I. the study of trees
J. underground part of tree that takes nutrients from the soil
K. a complex community of associated trees, shrubs, other plants, and animals
L. small, growing projections at the ends or sides of stems
M. plants that shed all of their leaves at the end of the growing season
N. the liquid that circulates through the tissues of woody plants
O. the foliage and flowering or fruiting part of the tree
P. loss of leaves, esp. prematurely
Q. trees that bear seeds in cones and have needle-like leaves
R. dead cells that give strength to the tree
S. a mixture of decayed organic matter used as a fertilizer
T. stem or trunk of a tree

General Quiz: Form B

NAME ____

CHOOSE THE BEST ANSWER:

1._____ acidic
2._____ compost
3._____ pesticide
4._____ broadleaf
5._____ conifer
6._____ deciduous
7._____ dendrology
8._____ bole
9._____ defoliation
10.____ silviculture
11.____ nutrients
12.____ sap
13.____ forest
14.____ crown

A. the liquid that circulates through the tissues of woody plants
B. the body produced by flowering plants which can grow into a new plant
C. a chemical agent used to destroy pests (usually insects)
D. loss of leaves, esp. prematurely
E. the shape that a tree takes when it is mature
F. trees that have wide, flat leaves
G. the foliage and flowering / fruiting part of the tree
H. a complex community of associated trees, shrubs, other plants, and animals
I. the study of trees

15._____ roots		J.	having a pH lower than 7
16._____ buds		K.	carries food from leaves to twigs, branches, trunk and roots
17._____ phloem		L.	stem or trunk of a tree
18._____ heartwood		M.	the art of producing and caring for a forest
19._____ growth habit		N.	small, growing projections at the ends or sides of stems
20._____ seed		O.	mineral elements and compounds which a plant uses for tissue growth
		P.	plants that shed all of their leaves at the end of the growing season
		Q.	a mixture of decayed organic matter used as a fertilizer
		R.	dead cells that give strength to the tree
		S.	underground part of tree that takes nutrients from the soil
		T.	trees that bear seeds in cones and have needle-like leaves

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Word Search Puzzles - Solutions

Pre/Post Quiz: Form A & B

Form A		Form B	
1.	C	1.	C
2.	A	2.	D
3.	B	3.	B
4.	D	4.	A
5.	A	5.	C
6.	B	6.	B
7.	D	7.	D
8.	C	8.	A
9.	A	9.	C
10.	C	10.	A
11.	D	11.	D
12.	B	12.	B
13.	C	13.	D
14.	B	14.	B
15.	A	15.	A
16.	D	16.	C

Leaf and Stem Structures: Form A & B

Form A		Form B	
1.	O-Opposite	1.	K-Opposite
2.	G-Alternate	2.	N-Alternate
3.	K-Needles	3.	F-Needles
4.	P-Deciduous	4.	O-Deciduous
5.	N-Scale-like	5.	G-Scale-like
6.	F-Compound leaf	6.	H-Compound leaf
7.	R-Palmate veins	7.	M-Palmate veins
8.	B-Pinnate veins	8.	L-Pinnate veins
9.	C-Bi-pinnately compound	9.	P-Bi-pinnately compound
10.	E-Lobed	10.	Q-Lobed
11.	Q-Parallel	11.	D-Parallel
12.	I-Lenticels	12.	E-Lenticels
13.	L-Bud scales	13.	I-Bud scales
14.	M-Pith	14.	J-Pith
15.	A-Terminal bud	15.	A-Terminal bud

16.	D-Entire	16.	B-Entire
17.	J-Node	17.	C-Node
18.	H-Whorled	18.	R-Whorled

Herbarium Specimens: Form A & B

Form A		Form B	
1.	K-herbarium	1.	F-herbarium
2.	H-pruning shears	2.	D-pruning shears
3.	D-vasculum	3.	B-vasculum
4.	N-notebook	4.	M-notebook
5.	O-hand lens	5.	O-hand lens
6.	I-plant press	6.	I-plant press
7.	B-corrugated cardboard	7.	N-corrugated cardboard
8.	F-newspaper	8.	C-newspaper
9.	L-herbarium paste	9.	G-herbarium paste
10.	M-tree key	10.	K-tree key
11.	A-trowel	11.	J-trowel
12.	J-botanical tape	12.	L-botanical tape
13.	G-storage cabinet	13.	E-storage cabinet
14.	E-terminal bud	14.	H-terminal bud
15.	C-preservative	15.	A-preservative

Tree Environment: Form A & B

Form A		Form B	
1.	I-acidic	1.	B-acidic
2.	G-compost	2.	E-compost
3.	H-pesticide	3.	L-pesticide
4.	O-broadleaf	4.	F-broadleaf
5.	M-conifer	5.	M-conifer
6.	L-deciduous	6.	N-deciduous
7.	F-dendrology	7.	D-dendrology
8.	B-bole	8.	A-bole
9.	T-defoliation	9.	P-defoliation
10.	D-silviculture	10.	Q-silviculture
11.	J-nutients	11.	K-nutrient
12.	S-sap	12.	G-sap
13.	Q-forest	13.	T-forest
14.	C-crown	14.	H-crown
15.	A-roots	15.	J-roots
16.	E-buds	16.	R-buds
17.	R-phloem	17.	O-phloem
18.	K-heartwood	18.	S-heartwood
19.	N-growth habit	19.	I-growth habit
20.	P-seed	20.	C-seed

Soil Texture and Structure: Form A & B

Form A		Form B	
1.	B-Screen sieves	1.	F-Screen sieves
2.	H-aggregates	2.	D-aggregates
3.	C-permeability	3.	B-permeability
4.	F-soil water	4.	M-soil water
5.	G-soil sampler	5.	O-soil sampler
6.	A-soil auger	6.	I-soil auger
7.	D-monolith	7.	N-monolith
8.	L-soil color	8.	C-soil color
9.	E-soil profile	9.	G-soil profile
10.	J-soil texture	10.	K-soil texture
11.	N-silt	11.	J-silt
12.	K-loam	12.	L-loam
13.	I-texture triangle	13.	E-texture triangle
14.	O-soil structure	14.	H-soil structure
15.	M-soil	15.	A-soil

General Quiz: Form A & B

Form A		Form B	
1.	F-acidic	1.	J-acidic
2.	S-compost	2.	Q-compost
3.	D-pesticide	3.	C-pesticide
4.	B-broadleaf	4.	F-broadleaf
5.	Q-conifer	5.	T-conifer
6.	M-deciduous	6.	P-deciduous
7.	I-dendrology	7.	I-dendroloy
8.	T-bole	8.	L-bole
9.	P-defoliation	9.	D-defoliation
10.	G-silviculture	10.	M-silviculture
11.	C-nutrients	11.	O-nutrients
12.	N-sap	12.	A-sap
13.	K-forest	13.	H-forest
14.	O-crown	14.	G-crown
15.	J-roots	15.	S-roots
16.	L-buds	16.	N-buds
17.	E-phloem	17.	K-phloem
18.	R-heartwood	18.	R-heartwood
19.	H-growth habit	19.	E-growth habit
20.	A-seed	20.	B-seed

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Glossary

WORD	DEFINITION
acidic	pH below 7
adsorption	process by which molecules become attached to the surface
annual ring	visible circle in x-section of tree produced by one year's growth
apex	the tip, furthermost part of something; strictly the pointed or angular summit as in shoot or root apex
azimuth	compass direction, i.e., 120 degrees is southeast
bare root	a tree without soil on its roots when transplanted
basic	pH between 7 and 14
bedrock	consolidated rock
biltmore	stick used to measure tree diameter and height
board foot	a standard unit of measure for lumber, (1"x1'x1') before surfacing or finishing
bole	a tree trunk
branch	a larger outgrowing stem that grows from the trunk
broadleaf	trees that have wide, flat leaves
buds	structures at the end and side stem that develops into a flower, leaf, twig or shoot
cambium	living cells that divide to form phloem and xylem
canopy	upper part of the forest, consisting of the crown of trees
chain	a tool used to determine horizontal distances
chlorophyll	the green pigments in plants that absorb the energy of sunlight for use in the manufacture of sugars from carbon dioxide and water
climatic range	geographic limits of growth for a particular type of tree
clinometer	a tool used to determine height of tree at given distance
commercial forest	trees grown for the production of lumber
compass	a tool used to determine direction
compost	a mixture of decomposing organic matter used as a fertilizer, mulch, or soil conditioner
conifer	trees that bear seeds in cones and have long needle-like leaves

cord	stack of wood 4'x4'x8' or the equivalent
crown	the upper branches and foliage of a tree
crown class	method of classifying a trees' position in the canopy
cruising	process of estimating the pulpwood or lumber in a stand of trees
DBH	diameter breast height; diameter of a tree trunk in inches 4.5 ft above ground
deciduous	plants that shed all of their leaves at the end of the growing season
defoliators	insects that remove leaves from trees
dendrochronology	the study of the age of trees by counting the rings of xylem growth
dendrology	the study of trees
dessication	the process of drying out
diameter tape	used to directly measure the diameter of a tree
drought	extended period of time when a significant lack of moisture persists
evergreen	plants that retain their green foliage throught out the year
feeder roots	hair-like roots through which the tree obtains water and nutrients
flower	the reproductive unit of a seed-bearing plant
forest	a large tract of land covered with trees and underbrush
forest harvest	periodic removal of trees for lumber
forest pathology	study of diseases in forest trees
forest tract	a particular set of trees
forestry	the science of managing trees, shrubs and animals
fruit	product of plant consisting of ripened seeds with a tissue around it
fungus	a large group of plants lacking chlorophyll like molds, mildews, rusts, mushrooms and smuts, subsisting upon dead or living organic matter
groundwater	subsurface water occupying the zone of saturation, the gravitational water below the water table
growth rate	how fast a tree will grow on an average site
heartwood	hard central wood consisting of dead cells that give strength to the tree (usually darker in color)
herbarium	an organized collection of dried of preserved plant specimens
humus	black or brown layer of composted organic matter

increment borer	auger-like tool used to extract cores from the tree trunk to find age
insulation	a barrier of dead air space to reduce change in temperature
lateral roots	grow horizontally and help keep the tree upright
leaf	single unit of foliage; usually the site of food manufacture by photosynthsis
lumber grades	system for determing potential uses of lumber
mulch	a covering such as wood-chips, straw, leaves, etc., spread on the ground around plants to prevent excess evaporation and to enrich the soil
NIMBY	Not In My Backyard
nutrients	mineral elements and compounds which a plant uses for tissue growth
outer bark	external covering which helps to protect a tree from injury
pace	number of steps for a specific distance (ie. 100ft)
percolation	the absorbtion of water into the soil; usually expressed as a rate
pH	a term used to indicate the degree of acidity or alkalinity
phloem	produced by the cambium and carries food from leaves to twigs, branches, trunk, and roots
photosysnthesis	process of making carbohydrate from water, carbon dioxide, chlorophyll and light
plant press	device for drying plant parts for preservation
BAF prism	device used to determine groups of trees of specific size
pruning	the selective cutting of branches from trees to remove old stems, dead wood, or give it better shape
psychrometer	tool with two thermometers used to find humidity
root ball	ball of soil containing the roots of a tree
root hairs	a hair-like tubular outgrowth from near the tip of a rootlet, functions in water and mineral absorption
root	underground part of a plant that extracts water, oxygen, and nutrients from the soil
sap	the liquid that moves through the tissues of plants
seeds	small body made by flowering plants which is capable of growing into a new plant
shade leaf	larger leaves found in the shade, capable of photosynthesis with indirect sunlight

silviculture	the art of producing and caring for a forest
site	spot where a tree will grow - consider soil, light and moisture
soil classification	system to describe the characteristics of a given soil
soil density	how much one cubic centimeter of soil weighs (weight per unit volume)
soil drainage	the speed and extent of water movement over and through the soil
soil horizon	layers of mature soils
soil profile	a diagram of the vertical section of soil noting the horizon layers i.e., A,B,C
subsoil	soil below the usual depth of cultivation, brown or reddish colored soil with more clay than surface soils
sun leaf	smaller leaves found growing exposed to full sunlight
tap roots	grow vertically downward and anchor the tree
topsoil	surface layer of mature soil, containing large amounts of organic material
transect	a straight line that bisects a given unit or area
transpiration	the release of water vapor by the leaves into the air
tree	a woody plant usually over 20 feet high at maturity
tree form	tree shape usually one of 8 types or habits
tree tolerance	the ability of trees to endure shade, salt, insects, weather, etc.
trunk	the main stem of the tree that transports nutrients
twigs	smaller stems that come from the branches
vasculum	field container for collecting plant parts
watershed	the land that drains into a given stream or pond
wind meter	device used to determine speed of wind
windbreak	vegetation planted across the prevailing wind direction to reduce windspeed
xylem	complex tissue in higher plants that carries sap from roots to leaves

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