Tools of the Trade: Methods for Measuring Trees

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Engineering Challenge:

Trees can be small, and trees can be big. How do we determine a tree's size? How can we size up one tree versus another? Use several different methods to measure and compare the sizes of trees.

Materials

Introduction:

- Paper (1 per person)
- Markers, crayons, or colored pencils (enough to share)
- Butcher paper or white/chalkboard
- Markers/chalk
- Magnets or other way to hang pictures (optional)

Data Collection:

- Notebook/paper to write on
- Writing utensils
- Flexible measuring tape or very long string, ~50-150 feet (one per group, or share)
- 12-inch ruler (1 per group)
- Clinometer
- Tree identification guide

Calculating, Sharing, and Analyzing Results:

- Butcher paper or white/chalkboard
- Markers/Chalk
- Notebooks or paper
- Writing utensils
- Calculators (optional)
- Projected computer spreadsheet/graphing software (optional)

Clinometer:

- Protractor (1 per student or group)
- Drinking Straw (1 per student or group)
- Washers, nuts, or binder clips (1 per student or group)
- Fishing line or strong thread, ~8-12 inches (1 piece per student or group)
- Clear Packing or Classroom Tape (~6 inches per student or group)
- Scissors (for cutting thread pieces and tape)

Tools of the Trade: Methods for Measuring Trees

Key Words/ Concepts:

Forester - a person who studies, plants, manages, and takes care of forests

Bole - the trunk or main stem of a tree

Breast Height - 4.5 feet above average ground level

Circumference – the distance around an object, such as the outer edge of a circle

Crown/Canopy - the leaves, branches, and other tree parts growing out from the bole of the tree

Drip Line/Drip Edge - the outermost edge of a tree's canopy or crown, where water first drips off of the tree and falls to the ground when it is raining

Crown Spread – the horizontal width from one side of the crown to the other, taken from drip line to drip line through the center of the tree, like slicing a circle in half

Average/Mean - the sum of a set of values divided by the number of values in the set
(a + b + c) / 3 = average

Clinometer - a tool used to measure the angle of a slope
Horizontal = 0 degrees. Vertical = 90 degrees

5-E Activity Plan

Engage

- Students draw a picture of the biggest tree have ever seen, or of their favorite tree. Ask students to share with each other, either with the class or in groups. Or hang the pictures up and ask students to discuss similarities and differences between all of the trees.
- Go for a walk. Ask students to notice the trees on the walk. What are their shapes? What are their leaves like? How can you tell one tree is bigger than another?
- Ask more lead-in questions: If you wanted to show someone that one tree is bigger than another, what evidence could you use to support this claim? In what ways can we measure a tree's size?

Explore

- Go out and measure! Round up your tools. Make a clinometer. Select one or several trees to measure. Assign tree numbers and identify species.
- Take a photo or make a sketch of the tree(s) selected.
- Focus on (1) tree bole, or trunk, circumference. Measure circumference at a consistent height above ground level. Scientists measure at breast height, or 4.5 feet above ground level.

Tools of the Trade: Methods for Measuring Trees

- Focus on (2) tree crown, or canopy, spread. Use people or stakes to measure the width of the crown from the tree's drip edge through the bole and to the drip edge on the other side. You can also take multiple measurements and average for a final number.
- Focus on (3) tree height. How can we measure a tree without climbing it? Use one or more of these methods to measure and calculate tree height: a) clinometer at 45 degree angle, b) partner and ruler ratio, c) tree and partner shadow ratio.
    - See Data Collection Handout for instructions using each method.

Explain

- Report out and record all of the class' tree measurements.
- Make tables and graphs to compare measurements and tree sizes. Do you notice any patterns? Is the crown cover a certain fraction of the tree height? What is the largest, smallest, and average bole circumference?
- Discuss and Debate: Which of these measurements – bole, crown, or height – seem most important for tree size? If measuring multiple trees, which tree is the biggest?
    - All three of these measurements – trunk diameter, crown spread, and height – can be used to determine a tree's size. And using them alone, several different trees might win in a tree size competition. Tree 1 might have the largest bole. Tree 2 might be tallest. Think about how to combine these measurements to represent a tree's overall size.

Elaborate (And Starter Ideas for Evaluate)

- Sizing Up Trees

    - We can use a formula to combine all three of these measurements and use that number to rank the size of a tree. Trees with more points are bigger:
        - Bole Circumference in Inches + Tree Height in Feet + (1/4)*Crown Spread in Feet = Total Tree Size Score
    - Calculate the total size points for your tree. Which tree is the biggest now?
    - Why do you think crown spread is multiplied by 1/4 and worth less points?

- Testing Tree Height Measurement Methods

    - For a single tree, measure and calculate tree height with each method, at least 3 times per method.
    - Look at variation between measurement methods. Are the final tree heights using a clinometer similar to the partner-and-ruler method? Does one method always result in a taller or shorter tree height than the other methods?
    - Look at variation within each measurement method. Are the tree height measurements using the clinometer precise, or similar to each other? Which method is the most precise, or produces the most similar results?
    - Can you think of settings where one method would be better or worse than another method? What would be best on a hillslope? On a cloudy day? Can you decide on the best method for measuring tree height?

Tools of the Trade: Methods for Measuring Trees

- Patterns Between Species
    - Take several measurements of different tree species (3-6 per species). Try to keep one measurement the same, for example look for trees that have similar bole sizes.
    - What patterns do you notice between the trees? Which species has the widest canopy? Which ones are the tallest?

- What Makes a Tree a Big Tree?
    - Look at the American Forests National Register of Big Trees. Find the Big Tree data for a species you measured. Compare the numbers: calculating percent or fraction differences, subtracting canopy widths.
    - Do more with the Register of Big Trees. Make graphs, charts, and maps. Notice patterns:
        - Is there a pattern for where Big Trees are found? One state or climate that has the most Big Trees?
        - What kinds of Big Trees are in California? Sierra Nevada? Central Valley?
        - Look at Pines and Oaks. Pines are coniferous and Oaks are deciduous. They tend to be found in different environments. Is one usually taller? Does one have a larger trunk or crown spread than the other? Do you notice any patterns within a certain species? Why do you think that is? For instance, is the crown spread equal to 2/3 the tree's height for an Oak but only 1/3 the height for a Pine?

- Thinking Bigger: Considering Forests & Ecosystems
    - As a forester, what kinds of decisions would you make with this information for managing a forest?
    - What lives in and around a tree? How do trees and water connect? What else do you think is important to consider when managing a forest?
    - Consider researching: How is a single tree or an entire forest an ecosystem? Would a big tree or a small tree would be more likely to survive in a drought?

Supports National Next Generation Science Standards:

Disciplinary Core Ideas

- LS1.A: Structure and Function
- LS1.B: Growth and Development of Organisms
- LS2.A: Interdependent Relationships in Ecosystems
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- LS3.B: Variation of Traits
- LS4.C: Adaptation
- LS4.D: Biodiversity and Humans

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Science & Engineering Practices:

- Asking Questions and Defining Problems
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts

- Patterns
- Scale, Proportion, and Quantity
- Systems and System Models
- Structure and Function
- Stability and Change

Performance Expectations:

- Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. 3-LS3-1
- Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. 4-LS1-1
- Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. MS-LS2-4
- Evaluate competing design solutions for maintaining biodiversity and ecosystem services. MS-LS2-5
- Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. 5-ESS3-1
- Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. 5-ESS1-2
- Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. 3-5-ETS1-2
- Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. MS-ETS1-3

Lesson Planning Resources:

1. How Big Is That Tree? from Minnesota Conservation Volunteer Magazine
   - *Sample activity description and lesson plan.*
   - *http://www.dnr.state.mn.us/mcvmagazine/issues/2015/jul-aug/young-naturalists.html*

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2. How Big Is Your Tree? from Project Learning Tree
   - *Sample activity description and lesson plan.*
   - *Full lesson available in PLT activity guide. Abbreviated version available online.*
   - *The PLT Activity Guide includes nearly 100 PreK-8 activities devoted to trees!*
   - *http://www.plt.org/family-activities-how-big-is-your-tree*

3. How to Measure a Big Tree, from Umatilla National Forest
   - *Sample activity description and steps.*
   - *Note: links in document are outdated.*
   - *http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5202838.pdf*

4. How Does Your Tree Measure Up? from Education World
   - *Sample activity description and steps.*
   - *http://www.educationworld.com/a_lesson/03/lp309-01.shtml*

5. Clinometer Technique for Tree Height Measurement, from GLOBE
   - *A simple way to measure tree height with a homemade clinometer.*
   - http://www.globe.gov/documents/355050/6b5f1481-0fa9-45f9-8241-70924466e92a

6. How to Make a Clinometer, from Instructables
   - *Instructions for making clinometers in your classroom. (Lots of other versions of this explanation are out there too.)*
   - *Instructables is a great resource for everything from making enchiladas to making your own PCR for genome sequencing.*
   - *http://www.instructables.com/id/How-to-Make-a-Clinometer/*

7. National Register of Big Trees, from American Forests
   - *Archive of registered Big Trees found here.*
   - *Compare the trees you measure to registered Big Trees, or compare different types of Big Trees to one another (rhododendron versus lodgepole pine, for instance)*
   - *Measurements you need to nominate a tree are the same ones used in this activity!*
   - *http://www.americanforests.org/our-programs/bigtree/*

8. Measurement Tools & Techniques Webinars, from American Forests
   - *Video series for tree measurement methods*
   - *https://www.americanforests.org/bigtrees/forestry-measurement-tools/measurement-tools-techniques-webinar-series/*