How Big Is That Tree?

Foresters do math outdoors. Find a tree and you can do outdoor math too.

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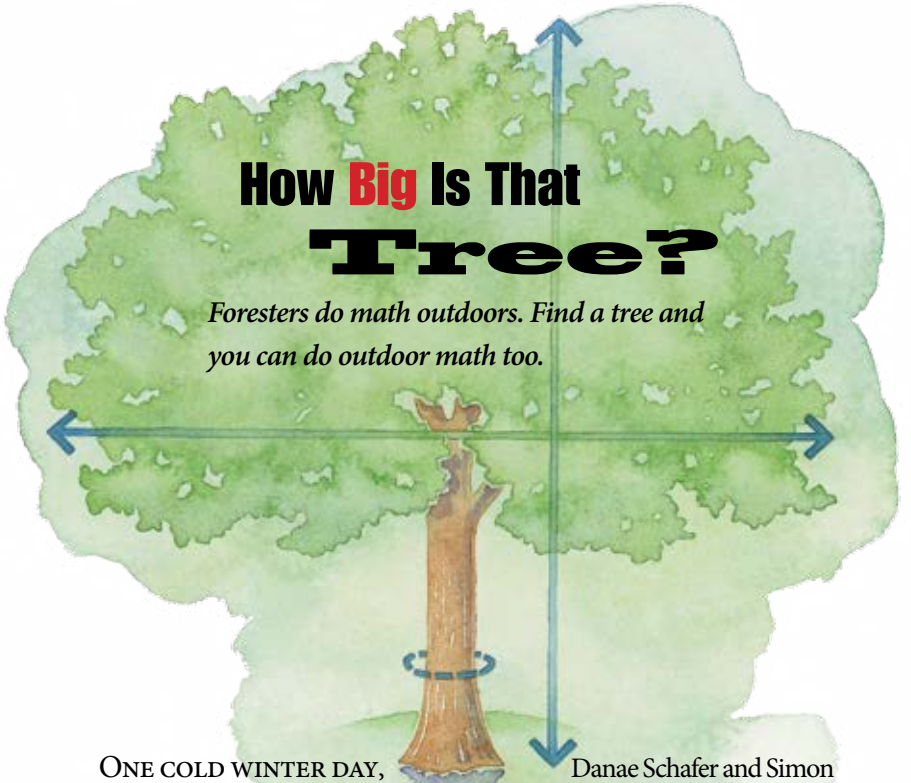
Illustrations by Bill Reynolds



One cold winter day, Danae Schafer and Simon Cain were walking among black spruce trees and tag alder shrubs in Koochiching State Forest in northern Minnesota. As foresters for the Department of Natural Resources, their job that day was to mark the area where trees would be cut down and sold. Simon had recently measured and analyzed trees for this timber sale. In the distance, they saw an evergreen tree that stood out like a giant.

"We noticed this tall, tall tree out in the swamp next to the timber sale area," Schafer said, "so we walked out to it and measured it."

The foresters measured the tree's height, the distance around its trunk, and the spread of its branches, or crown. The *coniferous* (cone-bearing) tree stood 84 feet tall, had a 52-inch waist (circumference), and spread its branches 18 feet wide. The foresters added up the numbers to see how the size of this black spruce *(Picea mariana)* compared with the size of other trees of the same species. It turned out to be the biggest black spruce in the state—a Minnesota champion.

Using math, foresters can gain information that helps them care for trees and *manage* forest lands—choose when and where to plant trees, which ones to cut down, and which ones to leave standing. Whether in a forest, a city park, or your yard, trees produce wood, give wildlife food and shelter, hold soil in place, provide shade, and look beautiful.

This story shows you some ways that you can do math outdoors to learn more about trees. Like a forester, you can calculate a tree's height, volume, and other physical dimensions. And who knows—maybe you'll find a champion.

How High Is It?

It's hard to measure the exact height of most trees by just using a measuring stick or tape. Climbing a tall tree or using a ladder to reach its top would be dangerous or impossible. Foresters use a tool called the *clinometer*, which measures the angle from your eye to the top of the tree to calculate tree height.

Without a clinometer, you can measure the height of a tree using the proportional method. This approach compares the height of a person in proportion to the height of a tree. You will need a partner, a ruler, and math.

Find a tree, then get to work.

1. Have your partner stand at the base of a tree that is on level ground.
2. Hold a 12-inch ruler (**A**) at arm's length and walk backward until the top and bottom of the ruler line up with the top and bottom of the tree.
3. Note where the top of your partner's head appears on the ruler (**B**).
4. Measure your partner's height (**C**).

Plug your three numbers (**A, B,** and **C**) in inches into this formula, or equation:

$$\frac{\textbf{A}\text{ (length of ruler)}}{\textbf{B}\text{ (height your partner appeared on ruler)}} = \frac{\textbf{X}\text{ (height of tree)}}{\textbf{C}\text{ (actual height of partner)}}$$

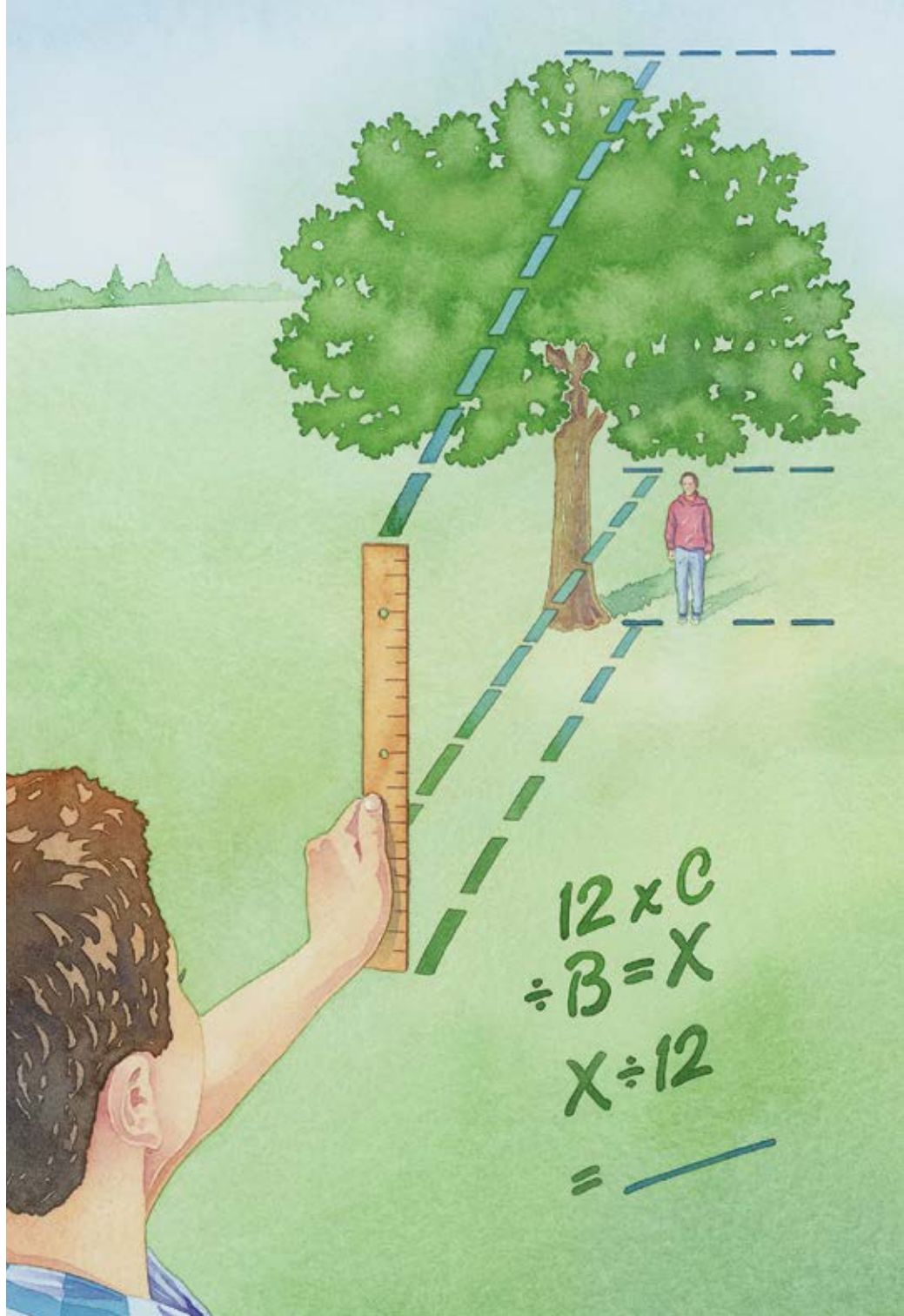
Solve for X

You can find or solve **X** by first cross-multiplying **A** times **C**. Then divide that number by **B**. The result is **X**, the height of your tree in inches. To find out how many feet tall, divide **X** inches by 12 (the number of inches in 1 foot). Convert remaining decimals to inches by multiplying by 12.

Here's an example of how the formula works: Your measurements show that your friend, sighted at a distance, appeared 2 inches tall (**B**). She is actually 51 inches tall (**C**).

12 (**A**) times 51 (**C**) equals 612 inches. Divide 612 by 2 (**B**), and you find that the tree is 306 inches tall (**X**).

Divide 306 by 12 inches. The tree height is 25 feet, 6 inches.



What's Inside The Trunk?

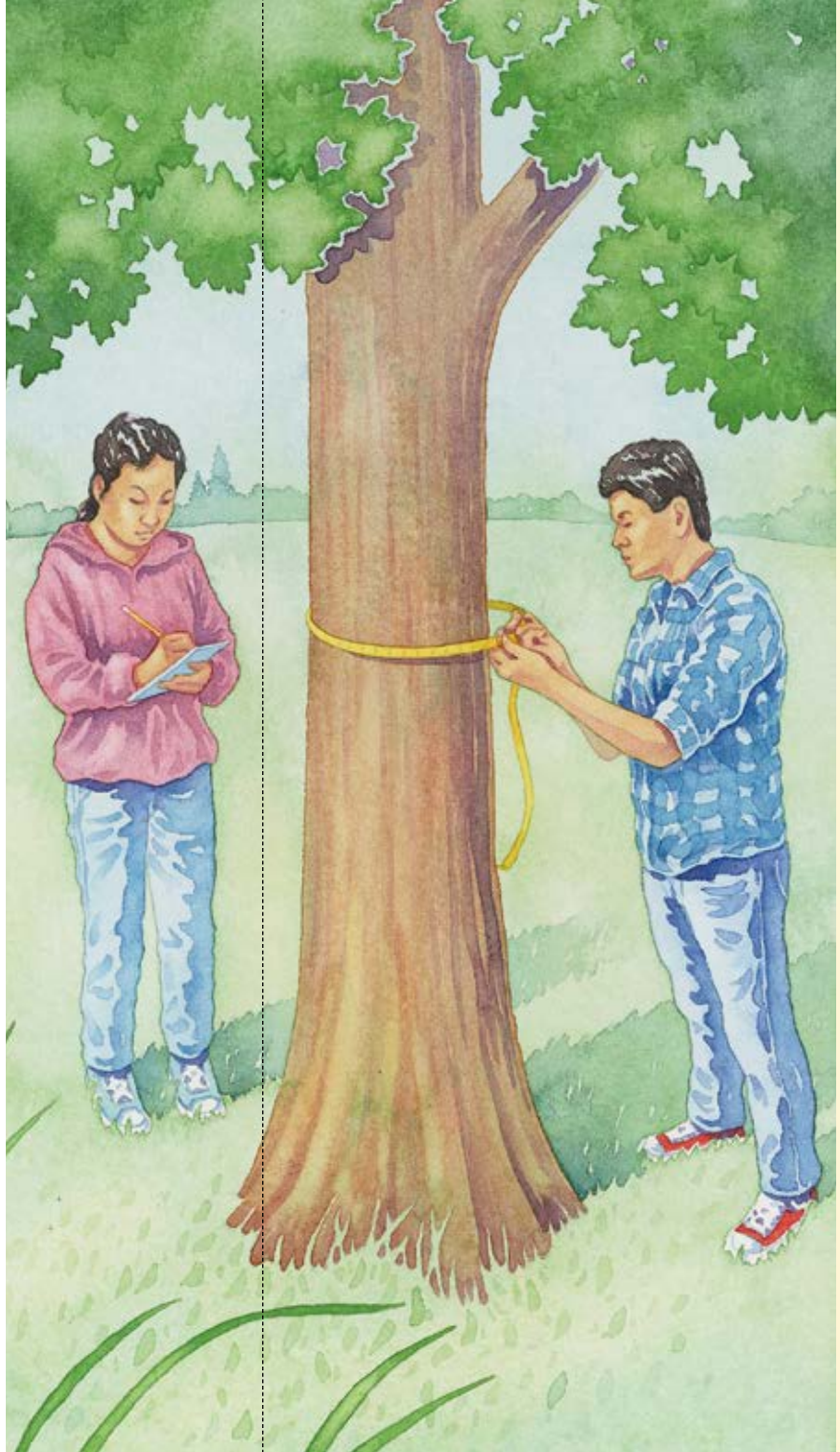
Imagine your tree has a hollow trunk. If you could fill it with water, how much would this cylinder hold? You can use math to estimate the tree's *volume*, which shows about how much wood is in the tree. By calculating a tree's volume, a forester gets an idea of how much lumber or paper could be made from the tree.

To figure out the tree's volume, you first need to know its *circumference*—how big around the trunk is.

1. Use a measuring tape to measure the circumference (**C**) at 4½ feet off the ground. All foresters measure tree circumference at this standard height, so they can compare trees accurately.
2. Next find the tree's *diameter* (**d**). Use the circumference and a special number known as *pi*. Pi and its symbol **π** represent the number 3.14—which is the ratio of the circumference to the diameter. The circumference divided by pi equals the diameter. Perform this equation: $\mathbf{d=C/\pi}$
3. Now find the *radius* (**r**), the distance from the center to the outside of the trunk. The radius is half the length of the diameter. Perform this equation: $\mathbf{r=d/2}$
4. Next take the height of the tree (**h**), which you found by using the method described on the previous pages. The tree's volume (**V**) equals **π** times the radius squared (radius times radius) times height. Use this equation: $\mathbf{V=\pi r^2 h}$

Here's an example of how the formula works:

1. Let's say we measured the circumference at 12 inches.
2. Divide 12 (**C**) by 3.14 (**π**) to arrive at a diameter (**d**) of 3.82 inches.
3. Divide 3.82 inches by 2 and you find the radius is 1.91 inches.
4. Multiply 1.91 times 1.91 ($\mathbf{r^2}$), which equals 3.648.
5. Let's say you found the tree's height (**h**) to be 160 inches. Multiply 3.648 by 160 to arrive at a volume (**V**) of 583.68 cubic inches of wood. That's enough to make about six baseball bats.



Teachers resources

School Forests Plus

About 130 Minnesota schools have school forests where students can apply math. In these outdoor classrooms, students can also study science, arts, and other subjects. The forests range in size from less than 1 acre to 300 acres. Rockford Middle School Forest, for example, covers 8 acres—about the size of three baseball fields. Seventh-grade math teacher J. Tucker Reeck often takes his students outside to measure trees there.

"I feel students have more insight and are more prepared with the skills and standards having done these tasks firsthand," he says. "It's greater than what students can learn between the four walls of the classroom."

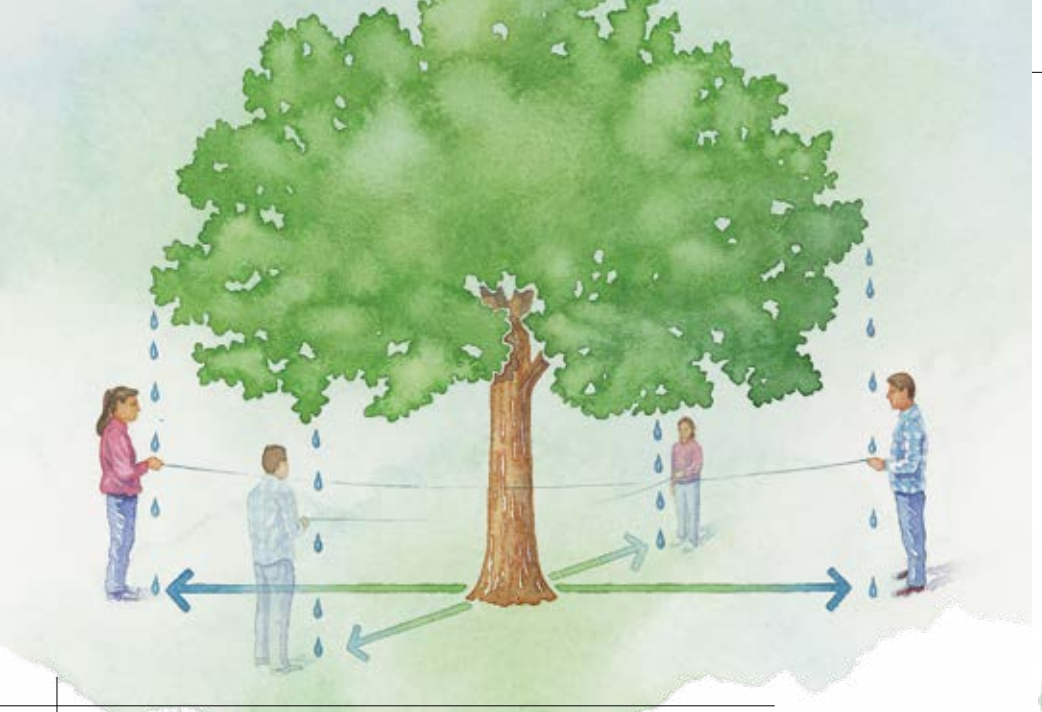
To learn more, visit *www.dnr.state.mn.us/schoolforest*.

More resources:

Project Learning Tree, *www.plt.org*

For more on trees, see these Young Naturalists stories: "Sugar From Trees," "Ubiquitous Conifers," "Tree Guardians," "Tremendously Marvelous Trees," and "Changing Color."

Teachers guide, *www.mndnr.gov/young_naturalists*.



How Much Power in the Crown?

Did you know that trees have crowns? The *crown* is all of the branches and leaves extending from the main trunk. Sunlight is the tree's main source of energy for living and growing. By spreading out in all directions, the tree exposes more of its leaves to sunlight. A cottonwood tree 100 feet tall with a 100-foot crown spread could support an eagle's nest, a family of raccoons, hundreds of beetles, and many other creatures.

You and a partner can use measurements and math to figure out a tree's *crown spread*.

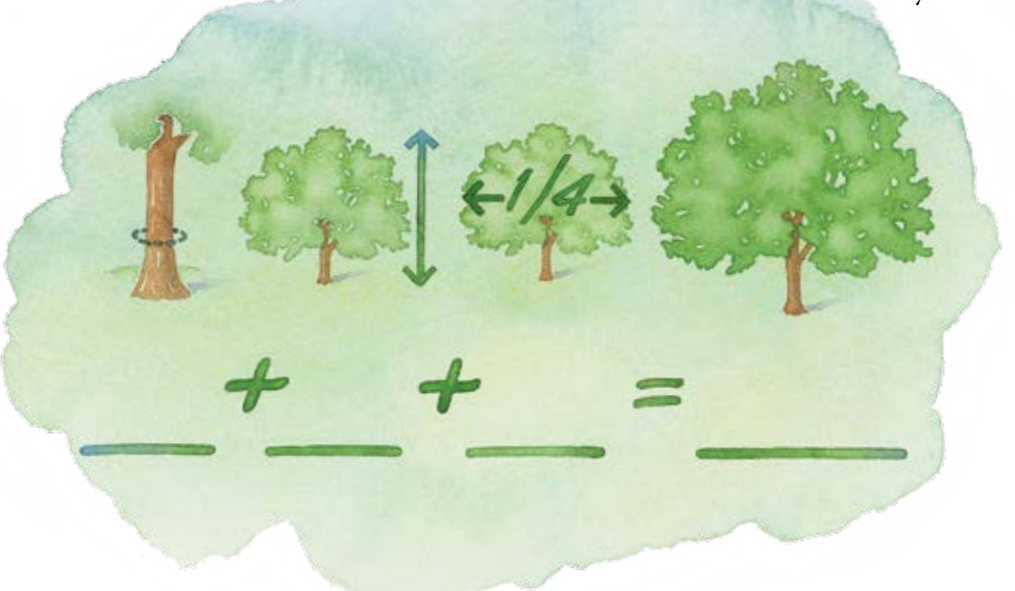
1. Look up and find the outermost edge of the crown above. Foresters sometimes call this edge the *drip line* since it's where water first drips onto the ground during a rainfall. Stand at the drip line, across the tree from your partner, under the narrowest part of the crown and measure the distance between you.
2. Find the widest part of the crown and measure the distance between you and your partner.
3. Add the two measurements together, then divide the total by 2. This *average* measurement is the tree's crown spread.

Points for Champions

Now that you know how to measure the height, circumference, and crown spread of one tree, you can tell how its size compares with the size of other champion trees.

The largest white spruce *(Picea glauca)* in the United States grows near the town of Littlefork in Koochiching State Forest, the same forest where foresters found the state-record black spruce. The white spruce champ is 130 feet tall, or about as tall as a 12-story building. Its trunk is 126 inches around at 4½ feet off the ground, and its crown spreads 30 feet.

Champion trees are measured on a point system that uses many of the measurements described in this story.



To calculate the white spruce champion tree's points, add:

1. The tree's circumference at 4½ feet off the ground, in inches
2. The tree's height, in feet
3. One-fourth its average crown spread, in feet.

How many points did the nation's giant spruce get? (Answer below.)

Maybe you have seen an especially large tree in your yard, in your town, or in a local forest. Anyone can nominate a tree for champion status at *americanforests.org/our-programs/bigtree*.

Learn more about Minnesota's champion trees at *dnr.state.mn.us/trees_shrubs/bigtree*.

Answer: 264 (rounded up from 263.5)