

# Field Enhancement 1: Wood's Worth

## NUTSHELL

*In this lesson, with a tree of at least 10" in diameter, students make their own tree scale stick and use it to determine the number of board feet in a tree and the number of products that can be made from a tree. Afterwards, students go on a scavenger hunt to explore many ways that forests are valuable.*

### ENDURING UNDERSTANDINGS

- Wisconsin's forests have multiple economic values, including forest products, recreation, tourism, and jobs. Forests provide a variety of raw materials for many industries.
- Humans depend on forests for products and services that they use every day.

### ESSENTIAL QUESTION

- What information is needed to determine the board feet of lumber in a tree?

### OBJECTIVES

Upon completion of this lesson, students will be able to:

- Determine the number of board feet in a tree.
- Identify social, economic, and environmental values of trees.

### SUBJECT AREAS

Mathematics, Science, Social Studies

### LESSON/ACTIVITY TIME

**Total Lesson Time:** 150 minutes

- Pre-activity .....30 minutes
- Introduction .....10 minutes
- Activity 1 .....30 minutes
- Activity 2 .....40 minutes
- Activity 3 .....30 minutes
- Conclusion .....10 minutes

### STANDARDS CONNECTIONS

Standards for this lesson can be viewed online at the LEAF website ([www.leafprogram.org](http://www.leafprogram.org)).

### CLASSROOM LESSON CONNECTIONS

This lesson ties closely with *Classroom Lesson 5, We All Need Trees*.

### VOCABULARY TERMS

**Biltmore Stick:** A graduated rule used to estimate the diameter of standing trees.

**Board Foot:** Unit used to measure the volume of wood; one board foot equals one foot by one foot by one inch.

**Chain:** Unit used to measure distance; one chain equals 66 feet.

**DBH:** An acronym for diameter at breast height. Foresters measure diameter at breast height or 4.5 feet from the ground.

**Log:** Unit of measurement; one log equals 16 feet.

**Merchantable:** Being the appropriate size and condition to be sold.

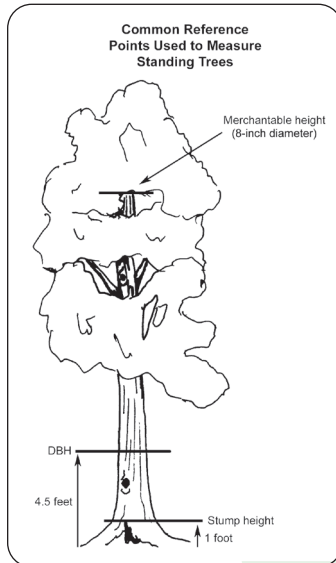
**Merritt Hypsometer:** A graduated rule used to measure the height of standing trees.

**Pallet:** A small, low wooden platform items are stacked on, usually for packing or shipping.

## BACKGROUND INFORMATION

Forests are valuable to us in several ways. Our economy, environment, and social well-being all depend on forests. To benefit economically, sometimes we need to harvest trees and use them to make products. However, in order to reap these benefits, forests need to be ecologically sound.

Trees hold value when harvested to make products. Wood and paper products are made from raw materials harvested from Wisconsin forests. Part of a forester's job is to estimate the volume of wood that could be obtained from trees if they were harvested. Volume can be calculated once the diameter and height of a tree are measured. There are a variety of tools available to foresters to make these measurements. Diameter is measured 4.5 feet above the ground and that is referred to as diameter at breast height (**DBH**). Many foresters use a diameter tape to do this. The tape is wrapped around the circumference of the tree, and is specially graduated to give the diameter.



## TEACHER PREPARATION

- Visit the teaching site in advance and decide on the boundaries you would like your students to work within.
- Mark three trees of varying diameter and height with flagging. The trees should be in an area open enough for students to clearly see the tree tops from 66 feet away.
- Make an example tree scale stick to show your class.

## MATERIALS LIST

### For Each Student

- One piece of lumber approximately 1" x 2" x 30"
- Sandpaper
- Fine-point permanent marker
- Calculator
- Clipboard or similar writing surface
- Copy of Student Page **1, Making and Using Measuring Tools**
- Copy of Student Page **4, How Many Products?**
- Copy of Student Page **5, Board Foot Table**

### For the Class

- Copies of appropriate sizes of the assembled Biltmore Stick Template
- Copies of appropriate sizes of the assembled Merritt Hypsometer Template
- Three pieces of flagging (ribbon, yarn, string, etc.)
- 100-foot tape measure

### For Every 2 Students

- Tape measure (inches)
- Three index cards or quarter-sheets of paper
- Copy of Student Page **6, Scavenger Hunt**

## SAFETY PRECAUTIONS

Visit the site ahead of time to locate any hazards such as hanging branches, protruding tree roots, holes, poison ivy, etc. Encourage students to walk, not run, at all times.

Another tool used to measure diameter is a **Biltmore stick**. This stick uses geometry to measure the diameter of trees. To take a reading from it, it is held against the side of the tree at 4.5 feet from the ground. There are a few different options for measuring height. A clinometer is a small instrument with a peephole. To use it, you stand a given distance from a tree. You look simultaneously at the tree and through the peephole at the scale inside the instrument. With a few quick calculations, you can determine the height of the tree. Another tool for measuring height is a **Merritt hypsometer**. Like the Biltmore stick, it uses geometry. Standing one **chain** (66 feet) from the base of a tree, you hold the stick at arm's length and parallel to the tree. A one-foot stump is left on the ground when a tree is harvested; thus, measurements start one foot off the ground. Logs less than eight inches in diameter cannot be milled, therefore, measurement ends and a reading is taken at the spot near the top of the tree where the diameter is eight inches. That point can be estimated by holding a pencil at arm's length. The place where the trunk of the tree appears equal to the pencil is the top of the **merchantable** height. In addition, some trees have forks, bends or other defects that reduce the usable height. These things should also be taken into consideration when measuring merchantable height. Tree height is measured in **logs** and fractions of logs. A log is 16 feet.

Once diameter and height have been measured, volume can be estimated. Volume of wood is measured in board feet. A **board foot** equals one foot by one foot by one inch. Volume can be estimated by referring to the table shown on Student Page **5, Board Foot Table**. To use this table, find the row that lists the diameter in inches of the tree you measured. Then locate the column that lists the number of logs in the tree. Note the number at the point where that row and column intersect; it is the board feet of merchantable timber in that tree. If the number of 16-foot logs falls between two numbers on the chart, use the average value for the two numbers. For example, a tree with a DBH of 10 that has 1.5 logs contains 35 board feet.

While trees can be valuable when harvested and used to make products, they are also valuable while standing in forests. Forests provide habitat for wildlife. Many animals depend on the forest for survival. Forests have other ecological values as well. Trees help keep our air clean. Shade from trees keeps the forest cool for its inhabitants. In addition, forests help prevent soil erosion. This, in turn, keeps our rivers and streams cleaner.

Trees standing in a forest also have social value. Forests offer recreational opportunities to help people relax and refresh themselves. From hiking and bird-watching to riding snowmobiles and all-terrain vehicles, recreational opportunities abound in our beautiful forests. Speaking of beauty, simply the aesthetics of our splendid forests adds to all of our social well-being.

**NOTES**

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## PROCEDURE

### Pre-activity - Making Your Tree Scale Sticks

1. In the classroom, show your students an example of the tree scale stick they will be making. Explain that the stick is a tool used by foresters to measure trees. Point out the two different scales on the stick. Explain to students that foresters use a Biltmore stick to measure the diameter of trees. They use a Merritt hypsometer to measure the height of trees. Tell students that they will each get a chance to make their own tree scale stick and learn how to use both to measure trees.
2. Give each student a 1" x 2" x 30" stick and a piece of sandpaper. Ask them to smooth out any rough edges on the stick with the sandpaper.
3. Hand each student a copy of Student Page  **1, Making and Using Measuring Tools**. Divide your students into pairs and give each pair a tape measure (inches). Explain that their Biltmore stick will be made especially for them based on their arm length. To measure arm length, one student should hold his or her stick straight out in front and parallel to the floor. His or her partner should use the measuring tape to measure the distance from the student's eye to the stick. The distance should be rounded off to the nearest inch and recorded on the stick holder's student page. When this is complete, ask the pairs to switch jobs.
4. Give each student a fine-tipped permanent marker, and place the Biltmore stick templates and the Merritt hypsometer templates that you have put together out for the students. Explain to your group how to choose which Biltmore stick template to use.

Students whose arm reach is:

- 20 inches or less: Use the 20-inch scale
- 21-24 inches: Use the 23-inch scale
- 25 inches or greater: Use the 25-inch scale

Show your students how to carefully line up the template next to their stick. The end of the template should line up with the left end of the stick. Explain to your students that they need to use their permanent marker to mark their sticks one through forty as precisely as possible using the template.



5. Explain that they will put the Merritt hypsometer on the reverse side of the Biltmore stick. That way, both diameter and height can be measured with the same stick.
6. Explain to your group how to choose which Merritt hypsometer template to use to mark the opposite side of their sticks.

Students whose arm reach is:

- 20 inches or less: Use the 20-inch scale
- 21-24 inches: Use the 23-inch scale
- 25 inches or greater: Use the 25-inch scale

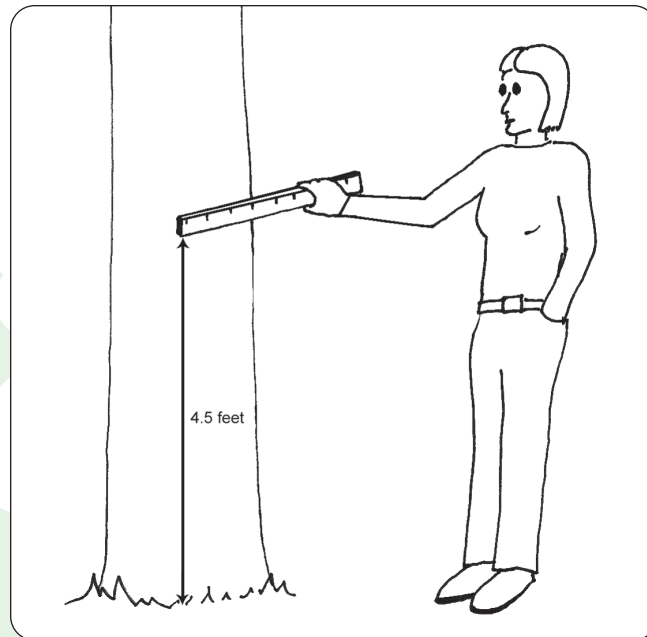
Show students how to carefully line up the template next to their stick. The top of the template should line up with the top of the stick. Explain to your students that they should use their permanent marker to mark their sticks as precisely as possible using the template. They should mark off logs on their sticks starting with one, one-and-one-half, two two-and-one-half, etc. Ask them to write their name in small letters on their stick.

### ALTERNATIVE STICK CONSTRUCTION

Copy the templates from Student Pages  **2A-C, Biltmore Stick Template**, and  **3A-C, Merritt Hypsometer Template**, and distribute one diameter scale and one height scale to each student according to their arm reach. Ask students to glue or tape the scales to their stick. Once this is complete, clear laminating paper can be applied over the top to keep the scales dry.

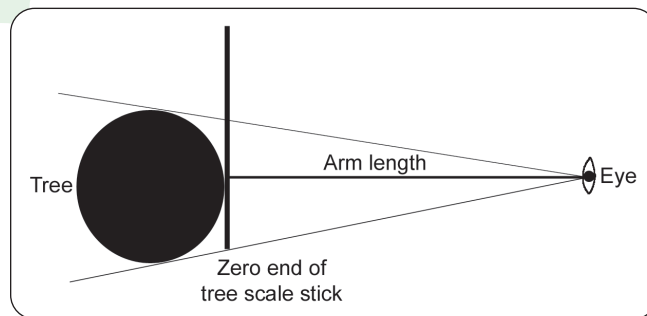
## Introduction - What Is Value?

Lead a discussion with students about what it means for something to be valuable. Ask your students to name something that is valuable to them. (*Possible answers include money, a cell phone, iPad, an autographed baseball, a photo, a favorite book, or a letter from a close friend.*) Ask if all the things they listed are worth a lot of money. (*No.*) Ask how something not worth a lot of money can still be valuable. (*It can be valuable because it is important to us or to our lives.*) Explain that there is more than one way for something to be valuable. Tell students that they are now going to learn about different ways forests are valuable.



## Activity 1 - Learning to Measure Trees

- Take students to an outdoor area where you have three trees marked and explain how to use their Biltmore sticks.
  - Show your students how to stand with their arm extended holding the stick horizontally against the tree at about 4.5 feet above the ground. Explain that this height is also called DBH, or diameter at breast height. The graduations should be on the upper edge of the stick. (Holding the stick from underneath prevents the graduations from being blocked by their hands.)
  - Explain that they need to look at the tree straight on, without turning their head while taking the measurement. In this position, show your students how to line up the zero end of the stick with the left edge of the tree. Now that the stick is in position, it should not move or rotate.
  - Show your students how to shift their eyes to look at the place where the right side of the tree crosses their stick. At that point, take a reading. This is the diameter in inches.



- Give your students time to practice. Ask them to measure all three marked trees. They should record these diameters on Student Page [1](#), ***Making and Using Measuring Tools***.

**“How could you not be hopeful if you’ve got a tree around?”**

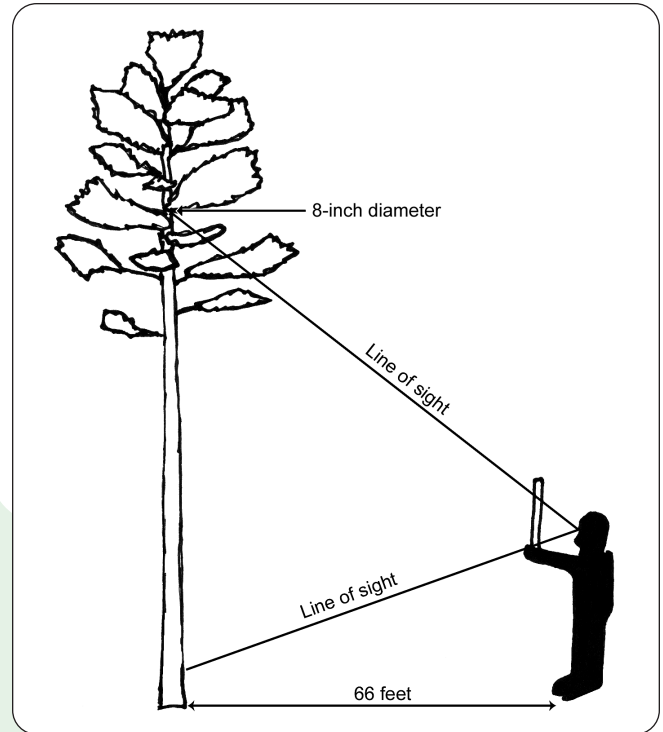
★ Ross Spears ★

3. Now show your students how to use a Merritt hypsometer. Explain to students that measurements taken with the Merritt rule need to be taken the distance of one chain from the tree. Define the word chain as a unit used to measure distance. One chain equals 66 feet.

- Ask one student to hold the end of a tape measure next to the base of a tree. Holding the other end of the tape measure, walk 66 feet from the tree in a direction from which you will have a good view of the tree. Ask the class to gather around you as you stand 66 feet from the tree.
- Explain to students that if this tree were to be harvested, not all of it would get used. In other words, the entire tree is not merchantable. Logs smaller than eight inches in diameter cannot be used for lumber. Show your students how to use a pencil to estimate where the tree is no longer eight inches in diameter (see “Background Information” on page 153 for more information).
- Also explain that trees are not cut right at ground level. There is usually a one-foot stump. This is where measurement begins.
- Hold the stick vertically at arm’s length. Adjust the stick so that the zero end of the stick lines up with stump height.
- Show students how to look up to the point where the tree is no longer eight inches in diameter. This is where they should read the number of logs in the tree from the Merritt rule on their stick. Round down to the nearest half log.

**NOTE:** Some trees have forks, bends or other defects that reduce the usable height. Explain that these things should be taken into consideration when measuring merchantable height.

4. Give your students time to practice. Ask them to measure the height of the three marked trees and record the number of logs on Student Page *1, Making and Using Measuring Tools*.



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### Activity 2 - How Many Products

1. Point out the boundaries you would like your students to work within for the activity. Explain that they will be using the skills they just learned to measure trees in this area. From the measurements, they will be figuring out how many products can be made from each tree. Hand out Student Page **4, How Many Products?** Show your students that there are five different types of trees on the Student Page. Explain that they need to try to find and measure one tree of each species listed. If they cannot find all the trees, they still need to measure five trees total. They should use the extra space provided for species that are not listed. Give your students time to work. **NOTE:** If you have not studied tree identification with your students, you can mark each species of tree for the students, provide field guides to assist them, or have them measure the trees and fill out the Student Page based on the assumption “If this tree was an oak, how many chairs...”
2. After your students have had time to locate and measure five trees, call the group back together. Show them Student Page **5, Board Foot Table**, and explain how to use it. Give your students time to find the number of board feet in each of the five trees they measured.
3. The final task is to calculate how many products could be produced from each tree if it were harvested. Explain that your students must multiply the number of board feet in their tree by the number of products per board foot. For species that are not listed (in the bottom table), ask your students to choose one of the five products given and figure out how many products could be made from that tree.
4. After students finish their calculations, call the group together to discuss what they found. Ask students what the diameter and height measurements were for each tree. (*Answers will vary.*) Ask how many board feet of lumber

could be harvested from each tree. (*Answers will vary.*) Ask how many of each product could be made from each tree. (*Again, answers will vary.*)

### Activity 3 - Scavenger Hunt

1. Remind students that they just learned one way that forests are valuable. They learned how products we use every day are made from materials from the forest. Explain that there are other ways that the forest is valuable as well. They will learn about them during a scavenger hunt.
2. Divide your students into pairs. Hand each pair of students a copy of Student Page **6, Scavenger Hunt**, and three index cards. Ask students to walk around within the boundaries you have set and look for the values listed on their Scavenger Hunt list. When they find one, they should check it off their list. Point out the place that says “Something else that is valuable.” Explain to students that they should also be looking for valuable things that are not on the Scavenger Hunt list. The object is to collect as many values as possible during the allotted time. Before the time is up, they should choose three from their list and write each one on an index card. Send the pairs out on their hunt.

### NOTES

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3. When everyone has completed the list or when the time is up, call your students back together. Explain that their next job is to sort the values into the following categories: ecological values, economic values, and social values. Begin by asking one pair of students to share the value on one of their cards. As each is mentioned, discuss why it is valuable and decide which category the value falls under. Make three separate piles on the ground as you discuss the cards. Allow each group to share what they wrote on their cards. Notice how some values fall into more than one category. *(The following items are valuable ecologically: tree and plant roots hold the soil in place and keep it from eroding, shade keeps the forest cool for its inhabitants, forests provide places and materials for animals to make homes like nests, leaves take in CO<sub>2</sub> and give off O<sub>2</sub> which helps keep air clean. The following items are valuable socially: hiking or biking trails, tree swings, places for people to relax, and beautiful things to look at in the forest. The following things are valuable economically: fruit and wood provide raw materials for products, this creates jobs and income.)*

### Conclusion - Many Values Discussion

Remind your students that they figured out how many of a certain product could be produced from the trees measured. Review the steps used to determine this. *(Measured the diameter and height of the trees. Determined the volume of wood [board feet]. Calculated the number of products that could be made.)* Ask what tools foresters can use to measure diameter and height. *(A Biltmore stick is used to measure diameter and a Merritt hypsometer is used to measure height.)* Discuss with students how harvesting wood from our forests to make products is good for our economy. *(Harvesting trees and producing products creates jobs and economic income in the state.)* Ask your students if the forests are valuable in any other ways.

*(Yes) In what ways? (They are valuable to the environment and to our social well-being.)* Next ask your students how forests are valuable to our environment. *(Forests help keep our air and water clean and provide shade.)* Finally ask how forests are valuable to our social well-being. *(They give us beautiful places to hike or bike or relax in other ways.)*

### SUMMATIVE ASSESSMENT

Assign students to write an essay, poem, jingle, or song about forest values. Their creation should answer the following question: In your opinion, is there one forest value (economic, ecological, or social) that is more important than the others? If so, which is it?

### SOURCES

Bell, L. E. (September 1983). [Article] *How Much Lumber in That Tree?* Michigan State University Extension. Extension Bulletin 461, Natural Resources Series.

Mississippi State University Extension Service. World Wide Web: [www.msucares.com/pubs/pub1686.htm](http://www.msucares.com/pubs/pub1686.htm)

Ongna Wood Products, W3535 County Rd OO, Sheboygan Falls, WI 53085. [Phone call]

Solon, 1975 North River Road, Rhinelander, WI 54501. [Phone call]

Wiant, H. V. (1994). *Elementary Timber Measurement*. Ben Meadows Company.

Wisconsin Department of Natural Resources. World Wide Web: [www.dnr.state.wi.us/org/land/forestry/usesof/index.htm](http://www.dnr.state.wi.us/org/land/forestry/usesof/index.htm)

Wisconsin Paper Council. World Wide Web: [www.wipapercouncil.org](http://www.wipapercouncil.org)



# MAKING AND USING MEASURING TOOLS

My arm length is \_\_\_\_\_ inches.

## Biltmore Stick

DBH stands for \_\_\_\_\_.

DBH is measured \_\_\_\_\_ feet from the ground.

Diameter of tree #1 \_\_\_\_\_ inches.

Diameter of tree #2 \_\_\_\_\_ inches.

Diameter of tree #3 \_\_\_\_\_ inches.

## Merritt Hypsometer

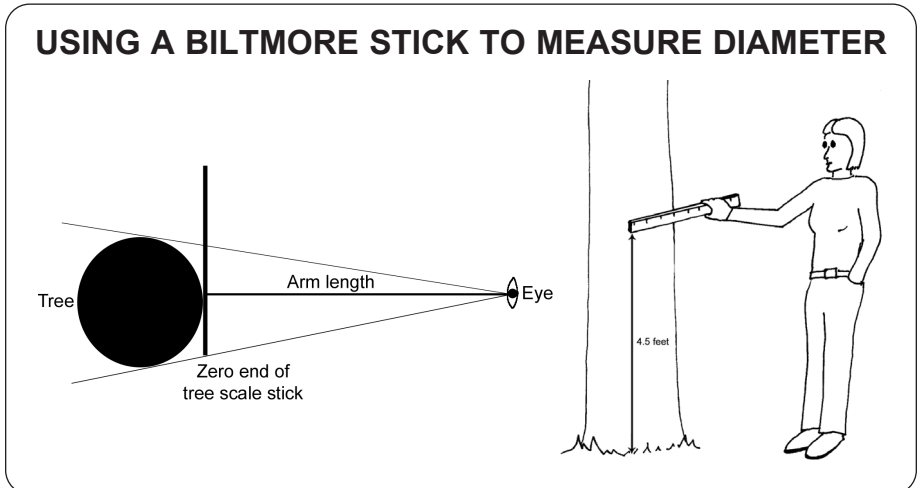
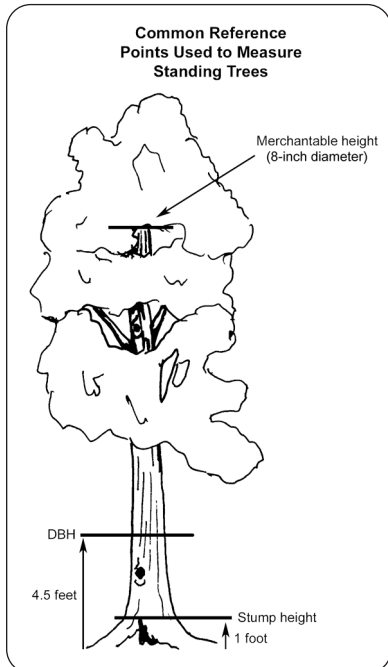
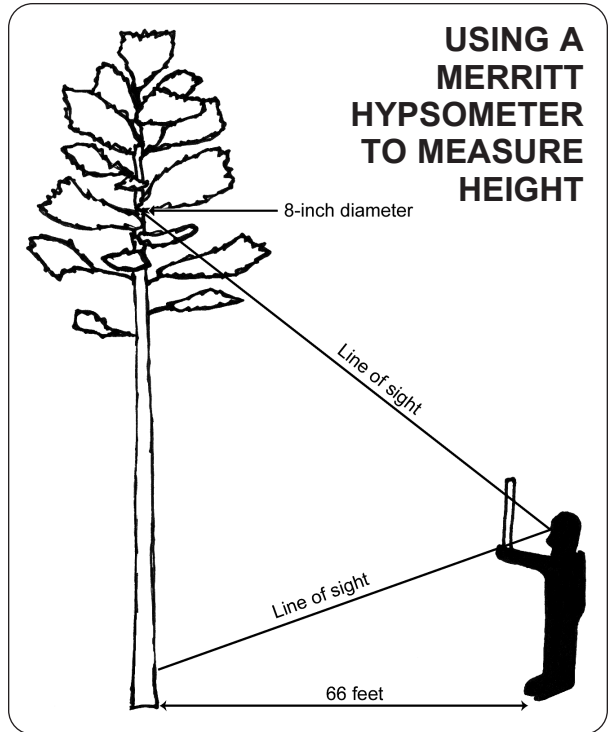
A chain is \_\_\_\_\_ feet.

A log is \_\_\_\_\_ feet long.

Number of logs in tree #1 \_\_\_\_\_.

Number of logs in tree #2 \_\_\_\_\_.

Number of logs in tree #3 \_\_\_\_\_.



# BILTMORE STICK TEMPLATE

## 20-inch Arm Reach INSTRUCTIONS

1. Cut the stick templates along the black lines.
2. Tape the ends together in alphabetical order.

20-inch Arm Reach

DBH (inches)

6 7 8

A

B

9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

C

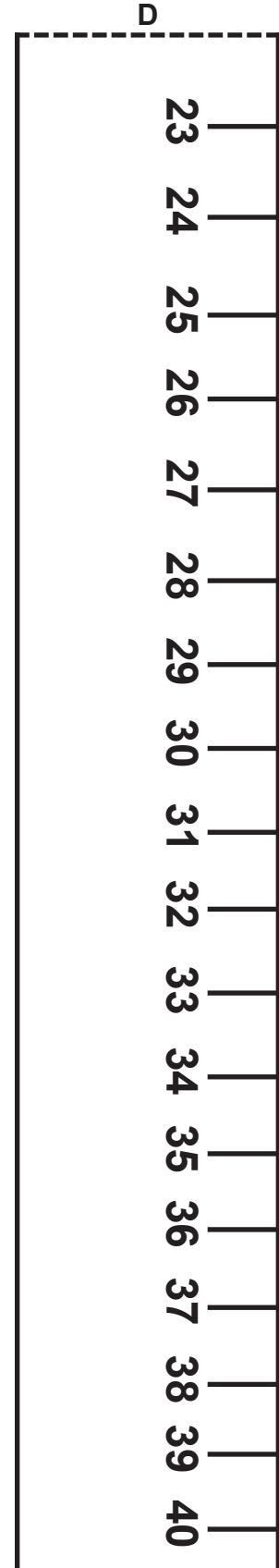
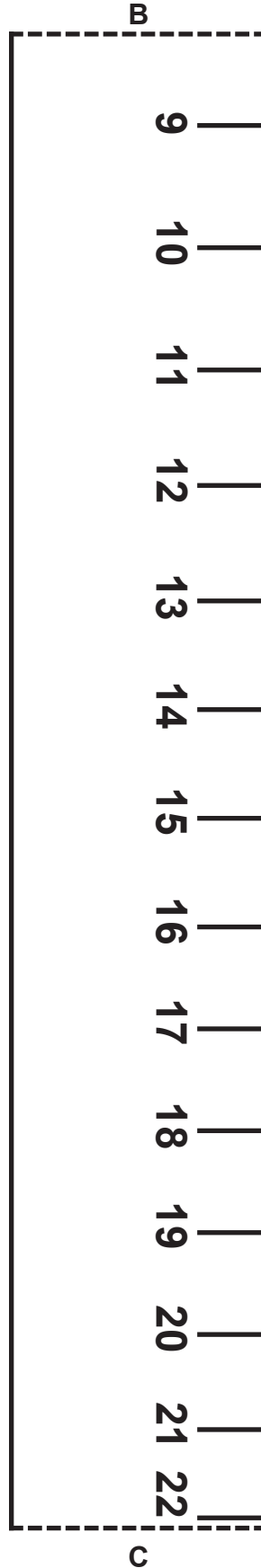
D

24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

# BILTMORE STICK TEMPLATE

## 23-inch Arm Reach INSTRUCTIONS

1. Cut the stick templates along the black lines.
2. Tape the ends together in alphabetical order.



# BILTMORE STICK TEMPLATE

## 25-inch Arm Reach INSTRUCTIONS

1. Cut the stick templates along the black lines.
2. Tape the ends together in alphabetical order.

25-inch  
Arm Reach

DBH (inches)

6 7 8

9 10 11 12 13 14 15 16 17 18 19 20 21

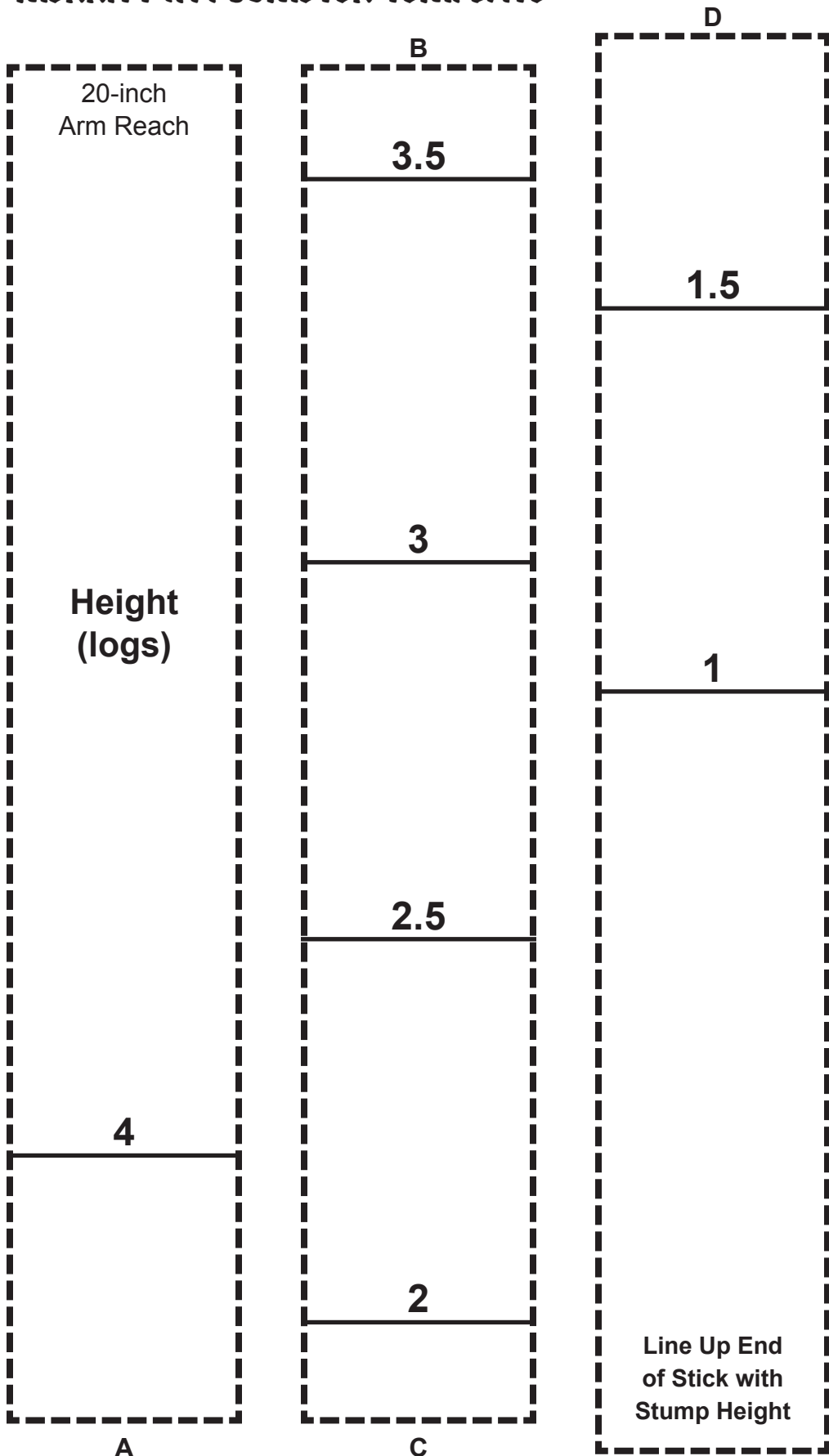
22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

A B C D

# MERRITT HYPSONOMETER TEMPLATE

## 20-inch Arm Reach INSTRUCTIONS

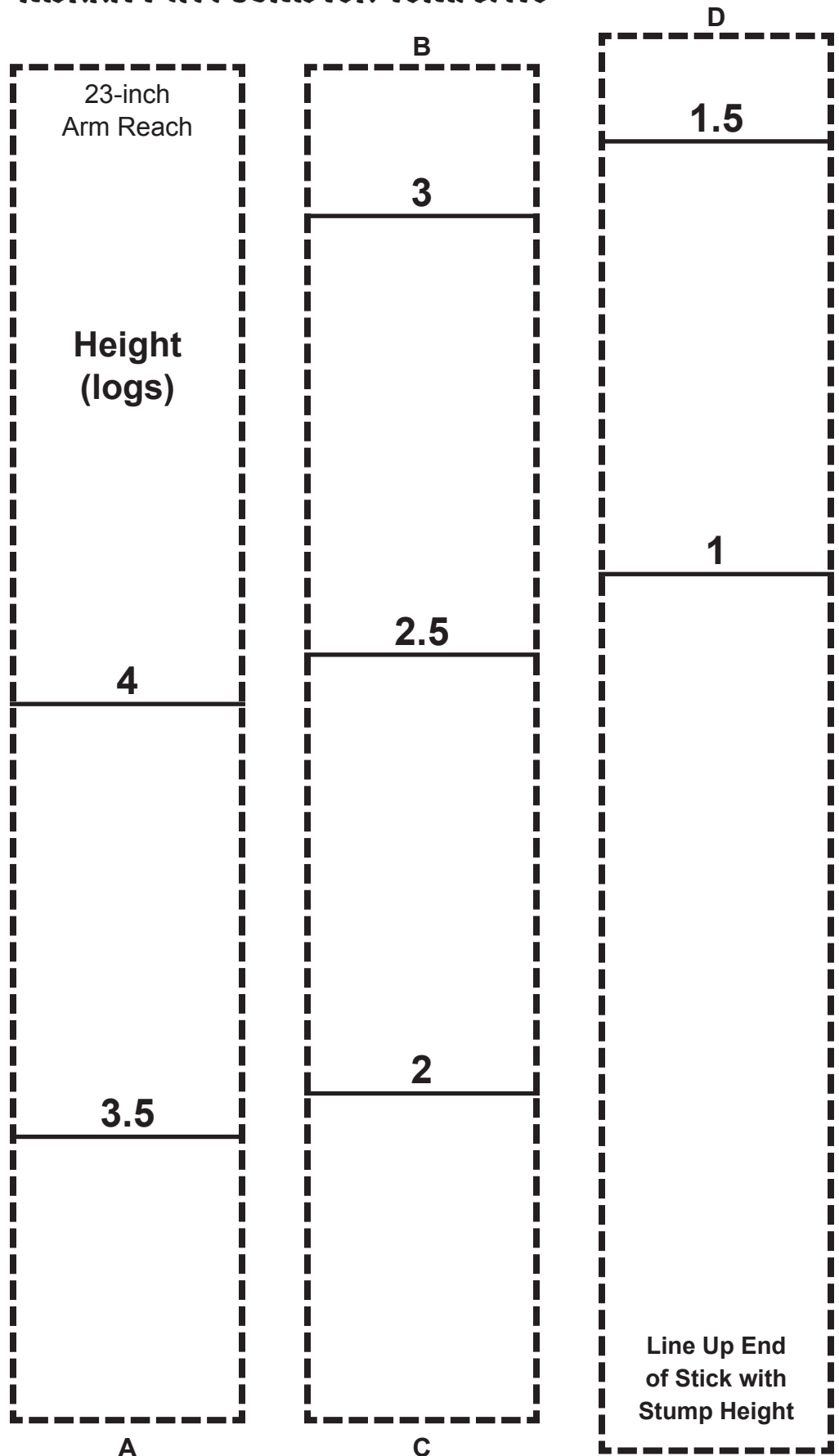
1. Cut the stick templates along the dotted lines.
2. Tape the ends together in alphabetical order.



# MERRITT HYPSONOMETER TEMPLATE

## 23-inch Arm Reach INSTRUCTIONS

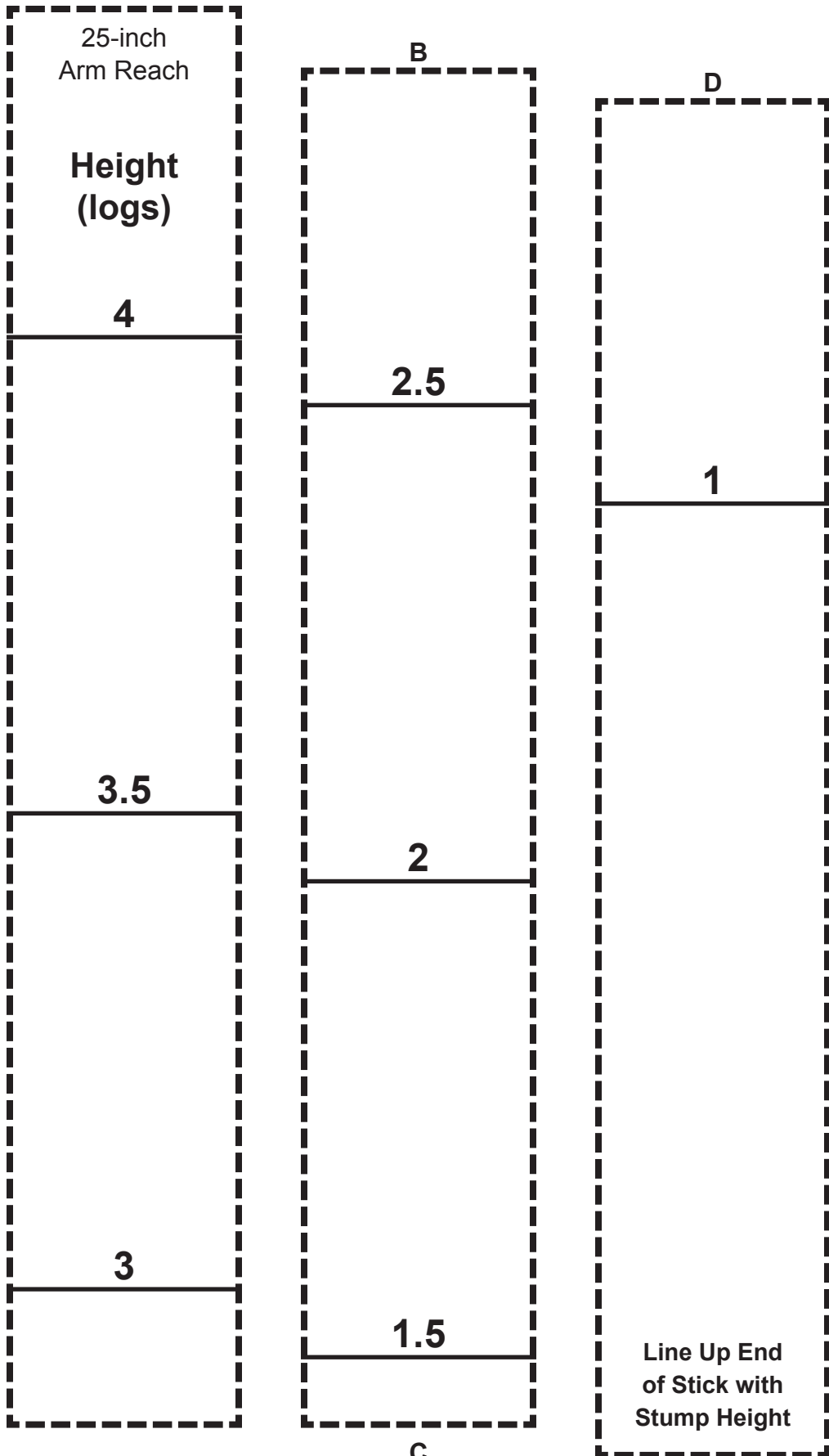
1. Cut the stick templates along the dotted lines.
2. Tape the ends together in alphabetical order.



# MERRITT HYPSONOMETER TEMPLATE

## 25-inch Arm Reach INSTRUCTIONS





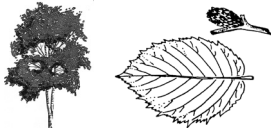
1. Cut the stick templates along the dotted lines.
2. Tape the ends together in alphabetical order.



Student Page 3C

## HOW MANY PRODUCTS?

1. Find each tree listed in the table below.
2. Measure the diameter and height of each tree.
3. Use the board foot table to find the board feet in each tree.
4. Multiply the number of board feet in the tree by the number of products that can be made per board foot to find out how many products can be made from each tree.

| Tree   | Size of Tree   | Multiply<br>(Board Feet x<br>Number of Products) | Number of<br>Products<br>Per Board<br>Feet                       | How many<br>products can<br>be made from<br>this tree? |
|--|--|--|--|--|
| Oak<br>     | Diameter _____ in<br>Height _____ logs<br>Board Feet _____ | x  | 0.03 rocking<br>chairs<br>per board foot                         | chairs   |
| Maple<br>   | Diameter _____ in<br>Height _____ logs<br>Board Feet _____ | x  | 0.01 tables<br>per board foot<br>(8-person dining<br>room table) | tables   |
| Pine<br>   | Diameter _____ in<br>Height _____ logs<br>Board Feet _____ | x  | 94.8 sheets<br>of paper<br>per board foot                        | sheets of paper  |
| Aspen<br> | Diameter _____ in<br>Height _____ logs<br>Board Feet _____ | x  | 0.06 pallets<br>per board foot                                   | pallets  |
| Birch<br> | Diameter _____ in<br>Height _____ logs<br>Board Feet _____ | x  | 520 popsicle<br>sticks<br>per board foot                         | popsicle sticks  |

If you cannot find the species above, use the space below to write in the species you can find. Choose any product from above to complete the chart.

|        | Species | Size of Tree   | Multiply<br>(Board Feet x<br>Number of Products) | Number of<br>Products<br>Per Board<br>Feet | How many<br>products can<br>be made from<br>this tree? |
|--------|---------|--|--|--|--|
| Tree 1 |         | Diameter _____ in<br>Height _____ logs<br>Board Feet _____ | x  |  |  |
| Tree 2 |         | Diameter _____ in<br>Height _____ logs<br>Board Feet _____ | x  |  |  |
| Tree 3 |         | Diameter _____ in<br>Height _____ logs<br>Board Feet _____ | x  |  |  |



## BOARD FOOT TABLE

| Diameter 4.5 Feet<br>from the<br>Ground (Inches) | Number of 16-foot Logs |     |     |      |
|--|------------------------|-----|-----|------|
|  | 1                      | 2   | 3   | 4    |
| 10   | 30                     | 40  |     |      |
| 11   | 40                     | 60  |     |      |
| 12   | 50                     | 80  | 100 |      |
| 13   | 60                     | 90  | 120 |      |
| 14   | 70                     | 110 | 150 |      |
| 15   | 80                     | 140 | 180 |      |
| 16   |                        | 160 | 210 | 250  |
| 17   |                        | 180 | 250 | 290  |
| 18   |                        | 210 | 280 | 330  |
| 19   |                        | 240 | 320 | 380  |
| 20   |                        | 270 | 360 | 430  |
| 21   |                        | 300 | 410 | 490  |
| 22   |                        | 340 | 460 | 550  |
| 23   |                        | 370 | 510 | 610  |
| 24   |                        | 410 | 560 | 660  |
| 25   |                        | 450 | 620 | 740  |
| 26   |                        |     | 680 | 810  |
| 27   |                        |     | 740 | 890  |
| 28   |                        |     | 800 | 960  |
| 29   |                        |     | 860 | 1040 |
| 30   |                        |     | 930 | 1120 |

## SCAVENGER HUNT

How many of these forest values can you find? Are there others?

- |   |   |
|---|---|
| <input type="checkbox"/> Tree or plant roots                  | <input type="checkbox"/> Bird                             |
| <input type="checkbox"/> Animals                              | <input type="checkbox"/> Fir or spruce tree for Christmas |
| <input type="checkbox"/> Hiking or biking trail               | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Shade                                | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Nest                                 | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Something beautiful                  | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Water source for animals             | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Leaves                               | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Spider                               | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Trees that can be made into products | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Place to go fishing                  | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Nuts or fruits for animals to eat    | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Insect                               | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Hole for animal to live in           | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Sugar maple tree for sap             | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Fruit tree                           | <input type="checkbox"/> _____                            |
| <input type="checkbox"/> Place for a tree swing               | <input type="checkbox"/> _____                            |