Optimal Tree Utilization

LaCuKnoS Teacher Page (for MS and HS)

Lesson Objective(s)

After completing this lesson students will be able to understand basic concepts of how to turn trees into logs and make decisions about how to maximize the utilization of tree volume in accordance with mill specifications.

NGSS Standards for Middle School:

- MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

NGSS Standards for High School:

- HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Lesson Description

This lesson is divided into two class period sessions. Session 1 scaffolds basic knowledge about how trees are cut into logs and the concept of scaling diameter. Session 2 builds on previous knowledge and allows students to evaluate cutting a tree into logs for two different mills with the goal of maximizing volume used and presenting their solution using a concept map format.

LaCuKnoS Practice(s) being highlighted:

L1: Choosing language registers based on topic, purpose & audience

K2: Building place based social relationships through science to support knowledge relationships in science

K3: Building epistemic relations to support science knowledge integration

LaCuKnoS Tools used in lesson:

In this lesson we use four LaCuKnoS tools:

- Language Booster (tool L1-1)
- Multilingual Concept Cards (tool L1-3)
- Walking field trip guide (Tool K2-1)
- Concept map (tool L2-2)

Language Boosters (tool L1-1) - LaCuKnoS Language Boosters are short (1-2 page), high interest science readings that provide a "hook" to engage students, a conceptual overview of the investigation topic, introduce some key concepts that will be fundamental to the investigation, and make a connection between the ideas to be learned and related experiences that students may have had in some context outside of the classroom. The Language Booster closes with 2 or 3 questions or prompts to guide students' oral and written reflections with a partner.

Multilingual concept cards (tool L1-3) – LaCuKnoS concept cards define and explain a limited number (3 to 6) of important concepts, which are mentioned and highlighted in bold in the investigation -- often in the *Language Booster*. These cards provide the name, a brief "student friendly" definition and a picture of the concept, using both English and Spanish. The cards can be used flexibly, such as at the start of the lesson, as part of a word wall, to review in lab groups, or introduced as needed when working with the investigation.

Walking field trip guide (Tool K2-1) - Walking field trips around one's home, school or neighborhood provide important opportunities for students to make connections between science topics being studied in school and lived experiences and interests that students have outside of school. In this case, going outside with the woodland stick and looking at trees around the school can help students better understand the more abstract parts of this activity.

Concept Mapping Template (tool L2-2) – Concept maps are a multimodal communication tool for representing understandings of the relationships among concepts. LaCuKnoS concept mapping templates guide students to work in pairs to plan and construct concept maps to show their emergent conceptual understandings and emergent communication skills. Concept maps can support translanguaging and embodied learning such as by using our bodies and physical materials to construct human concept maps. Creating concept maps can support all three strands of the LaCuKnoS model.

Concepts for Concept Cards

- landing/cancha de madereo

- bucking/trozado
- log buyer/comprador de madera
- Scaling diameter/diámetro menor
- Log/trozo

Materials needed

- Lesson plan
- Woodland stick
- Introductory presentation
- From tree to forest products sheet
- Concept cards
- Language booster
- Plasticine
- Background Information
- Douglas-fir volume table
- Mill purchase orders
- Bucking worksheet
- Average tree profile

Advance Preparation:

Review the lesson plan and introductory presentation.

If needed, go through Lesson "Tree Detectives" for background on trees and conifer/broadleaf species.

It is recommended that the teacher go through the example provided.

Provide connection to current lesson or current event to make it relevant to students.

Have all materials ready including copies of handouts and plasticine.

Think about intentional grouping strategies.

Safety Recommendations:

Our science investigations are designed to be kid-friendly and in most cases use everyday materials that are not considered to be dangerous. However, it is important for you to assess potential risks or safety concerns in your particular setting when you teach this science investigation.

Other Recommendations:

This lesson can be expanded to consider log prices and transportation cost, which can make the outcome of the investigation change.

Optimal Tree Utilization

LaCuKnoS Language Booster

Have you ever stopped to think about all the different wood products we use every day? All the different things that are built out of wood? All the paper products we use? How many wood and paper products can you see from where you are sitting? It takes time and dedication to grow, harvest and fully utilize the wood that comes from trees to make the wood products we use everyday.

Think of a landowner who owns a mature stand of Douglas-fir. They hire a forester to help them find a logger to harvest the trees, and to determine what mill to use to make the best use of the logs and to get the most revenue. After the trees are felled and transported to a ***landing***, they are cut into ***logs*** of different sizes, during the process called ***bucking***. In this process, the ***scaling diameter*** of the logs is used to determine volume and value. The best bucking pattern to use is determined based on finding the combination of logs that result in the highest revenue as well as the lowest transportation cost.

Mills will pay a higher price for logs that best match the final products they make and sell. Commonly, a ***log buyer*** provides a purchase order that includes the log size specifications that the mill buys and their prices they pay for different sizes of logs. The forester obtains different purchase orders from different mills to find out what is the best option for the specific trees they have. We will learn about optimizing tree utilization, and how landowners, loggers and foresters in Oregon work together to efficiently harvest trees to produce the wood products we all use every day.

Talk with your partner about the following questions and then write your answers.

1. You have probably seen log trucks carrying logs on the highway. What ideas do you already have about how trees are made into those logs?
2. Have you seen a lumber mill before? What did it look like? What did you see there?

Optimal Tree utilization
Group Exit Ticket

What things did you see during your walking field trip that are made out of wood? What did you observe about tree trunks as you look higher up the tree?
Why is the scaling diameter so important to make solid wood products?
Why do you think mills only accept logs of certain sizes? What do you think happens if the logs are the wrong size for what the mill wants?

Optimal Tree Utilization
Lesson Plan

Session 1--Introduction and activity groups:

- Provide students with the language booster. Have students read the language booster. This can be done as a class, in pairs, or individually.
- Have students get into pairs and discuss the language booster and answer the two associated questions.
- After students have had time to think about the language booster questions, allow time for student pairs to share out with the rest of the class.
- Provide students the sheet "from trees to forest products" and explain where in that cycle they will be focusing.
- If possible, have students go outside and measure diameter (DBH) and total height of a tree using the Woodland Stick. If this is not possible, take students outside and have them identify things that are made out of wood. This activity will help them make a connection to the following activity.
- Put students into groups of four, thinking about intentional grouping.
- Give each group a box of plasticine and have them make a tapered log.
- Explain to students the concept of scaling diameter (drawing on concept card) and why it is the diameter used to determine log volume.
- Ask students to find the way of obtaining the longest rectangle they can within the tapered log. Then they can cut the excess wood so they can visualize the rectangle.
- Students should have a good understanding of what the scaling diameter is and why it is the diameter used to determine log volume.
- Group Exit Ticket (pg. 11): have students discuss the given questions in their respective groups.

Before class period 2:

- Review student exit tickets to determine if students have a good understanding of scaling diameter and are ready to start the bucking process.
    - If they do continue to class period 2.
    - If they do not allow students to spend more time in their groups and provide individual group support.

Class Period 2—Optimizing tree utilization and presenting results:

- Allow students to get back in their groups.

- Provide students with background information, Douglas-fir volume table, Mill purchase orders, bucking worksheet and two copies of the average tree profile from the Mighty firs unit. The tree has height and diameter information every two feet.
- Students should now start looking at one of the sheets with the tree profile, and focus on one of the mills first. They should start trying the "large log" first since it is the one with the highest value. Then mark with a pencil, where the log ends and determine the scaling diameter. If the diameter meets the "large log" specification, they should write down the length and scaling diameter in the bucking worksheet. The teacher can follow an example for clarification in "example bucking" on page 19.
- Then, they should keep "bucking" the tree, as they are able to meet the log requirements for the mill. Once they have completed the process, they should look up the volume table and determine the volume of each log and write it down in the volume table of the bucking worksheet. The process ends by adding all the volumes to determine the total log volume for the whole tree.
- In the second step, students should go through the same process for the second mill.
- Students should end up with a total volume of the same tree for each mill. These volumes will be different although it is the same tree, but since each mill makes different products, they will utilize the tree in different ways. In this exercise, we want to send the logs to the mill that maximizes the volume utilization of the tree. The mill that gets the most volume out of the tree. *(this decision can change when there is price and transportation cost involved, if you would like that alternative for your students, please see the expanded section of this lesson).*
- Once all groups have completed their bucking, they should prepare to present their solution (i.e. explain where they would send their logs to) to the class or if there is not enough time to at least one other group.
- For the last activity, students work in pairs to create a concept map around the activity.
- Exit ticket: Concept map (pg. 18).

Landing/cancha de madereo

Area where trees are landed, cut into logs, decked in sorts and loaded onto trucks

Lugar en el cual los arboles llegan para ser trozados, los trozos apilados y luego cargados en camiones

The log trucks waited at the landing to carry the logs to the mill.

Concept Card

Bucking/trozado

To cut trees into log lengths

Trozado de árboles

Loggers should wear protective clothing when bucking trees.

Concept Card

Log buyer /comprador de madera

An individual who purchases logs for mills and can provide a the different log specifications and prices the mill has to offer

Un individuo que compra trozos para el aserradero y puede proveer las especificaciones y precios de trozos que el aserradero ofrece

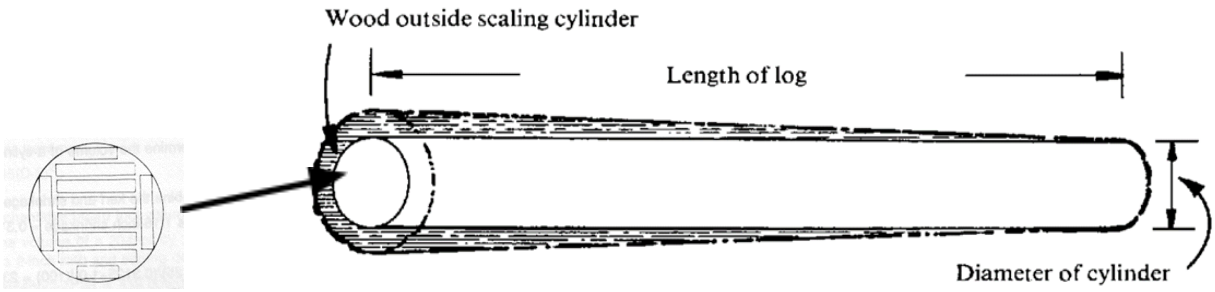
The log buyer told the landowner which logs his mill wanted to buy.

Concept Card

Scaling diameter /diámetro menor

The inside bark small-end diameter of the log used to determine volume

El diámetro menor (medido dentro de la corteza) del trozo que se usa para determinar volumen



The scaling diameter determines the size of the lumber that can be cut from the log.

Concept Card

Logs /trozos

Section of a tree of a specific length, that are classified into sawlogs (for solid wood products) and pulp logs (to make paper/composite products)

Sección de un árbol de largo específico, se clasifican en trozos aserrables (para madera solida) y trozos pulpables (para productos de papel/tableros)

Sawlogs on a landing/Trozos asserrables en cancha de madereo

Logs that have been bucked are loaded onto trucks to take to the mill.

Concept Card

Optimal Tree Utilization
Background Information

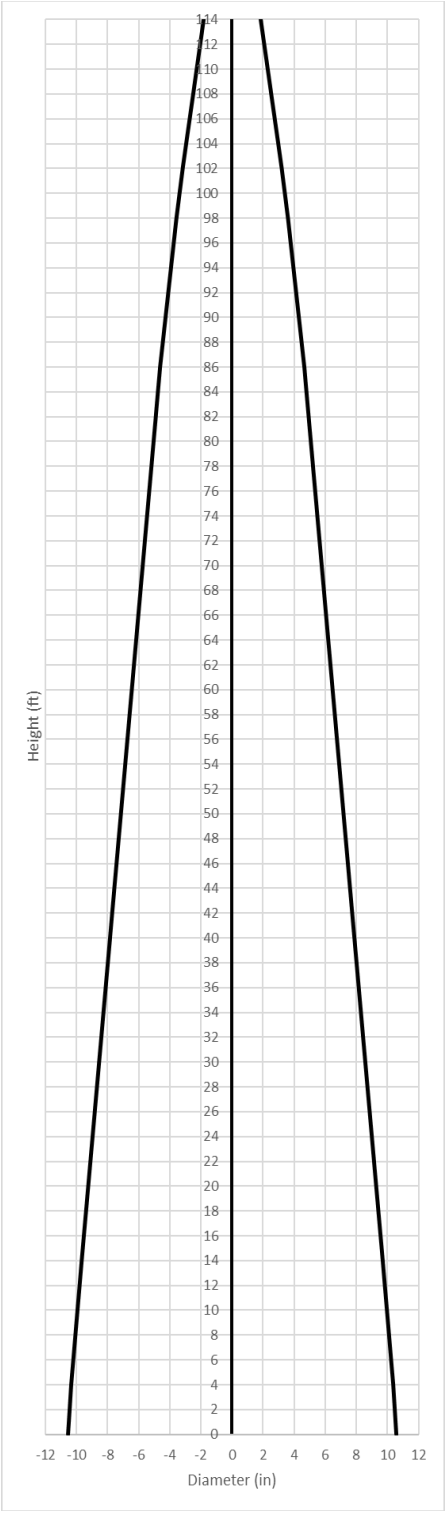
When trees are planted to produce timber, they reach a peak in their growing potential as well as economic return. This is the time when a final harvest occurs. At this time, the best and largest trees have reached their best value, and in the case of the *Mighty firs* unit, it is when the trees are 60 years old. These trees are now very valuable and can be sold and used for many different forest products.

The first step in the harvest process is tree felling. This happens in the forest unit. After trees are felled, they are transported into the ***landing***, which is an area in which they are ***bucked***, placed into different sorts (piles) and then loaded onto trucks to be delivered to a mill.

Bucking is a very important step in the harvesting process; this is where the value of timber the landowner has grown for 60 years is realized. Once a tree has been cut into logs, it cannot be undone! When the forester or logger makes the decision about cutting the logs, they need to take into account many factors, including: which will be the best mill to send the logs? How much does the mill pay? How much will it cost to transport the logs to the mill? All these decisions need to be made quickly, to ensure that the best value is obtained on each tree. It is also important to understand that depending on the mill, the amount of wood that can be utilized from any given tree can be different, this affects the maximum amount of wood that can be sent to the mill and what is left in the forest.

In this exercise, you will be given an average tree from the *Mighty fir* unit, and two possible mills to send those logs to. Using the information that will be given to you, find the best destination to send the logs to so you can maximize the amount of wood to be processed at the mill.

Average tree profile from the Mighty fir unit



Length (ft)	Diameter (in)
114	3.7
112	4.1
110	4.6
108	5.0
106	5.5
104	5.9
102	6.4
100	6.8
98	7.2
96	7.5
94	7.9
92	8.2
90	8.6
88	8.9
86	9.3
84	9.6
82	9.8
80	10.1
78	10.4
76	10.7
74	11.0
72	11.2
70	11.5
68	11.8
66	12.1
64	12.4
62	12.6
60	12.9
58	13.2
56	13.5
54	13.8
52	14.0
50	14.3
48	14.6
46	14.9
44	15.2
42	15.4
40	15.7
38	16.0
36	16.3
34	16.6
32	16.8
30	17.1
28	17.4
26	17.7
24	18.0
22	18.2
20	18.5
18	18.8
16	19.1
14	19.4
12	19.6
10	19.9
8	20.2
6	20.4
4	20.7
2	20.9
0	21.1

Mill purchase orders

Blue Mountain Mill		
	Min small end diameter (in)	Preferred Length (ft)
Small log	5	16
Large log	12	36

Fall Creek Mill		
	Min small end diameter (in)	Preferred Length (ft)
Small log	4	16
Large log	12	32

Bucking Worksheet

a) Blue Mountain Mill

Volume table

Log number	Log length (ft)	Scaling diameter (in)*	Log volume (b.f)
Total			

*Always round the diameter down (for example, a 12.7 inch diameter is a 12 inch scaling diameter)

b) Fall Creek Mill

Volume table

Log number	Log length (ft)	Scaling diameter (in)*	Log volume (b.f)
Total			

*Always round the diameter down (for example, a 12.7 inch diameter is a 12 inch scaling diameter)

Douglas-fir Log Volume Table (b.f)

	Log length(ft)		
Scaling diameter (inches)	**16**	**32**	**36**
4	10	20	20
5	20	30	40
6	20	50	60
7	30	60	60
8	30	70	80
9	40	90	100
10	60	120	140
11	70	140	160
12	80	160	180
13	100	190	220
14	110	230	260
15	140	280	320
16	160	320	360
17	180	370	420
18	210	430	480
19	240	480	540
20	280	560	630

Optimal Tree Utilization
Concept Map

In the last part of this activity, you will work with a partner to create a concept map to show your understanding of the topic: ***Optimal Tree Utilization.***

Your teacher will review with you an example of how to make a concept map.

Step 1—Partner discussion. Start by discussing the following questions with your partner:

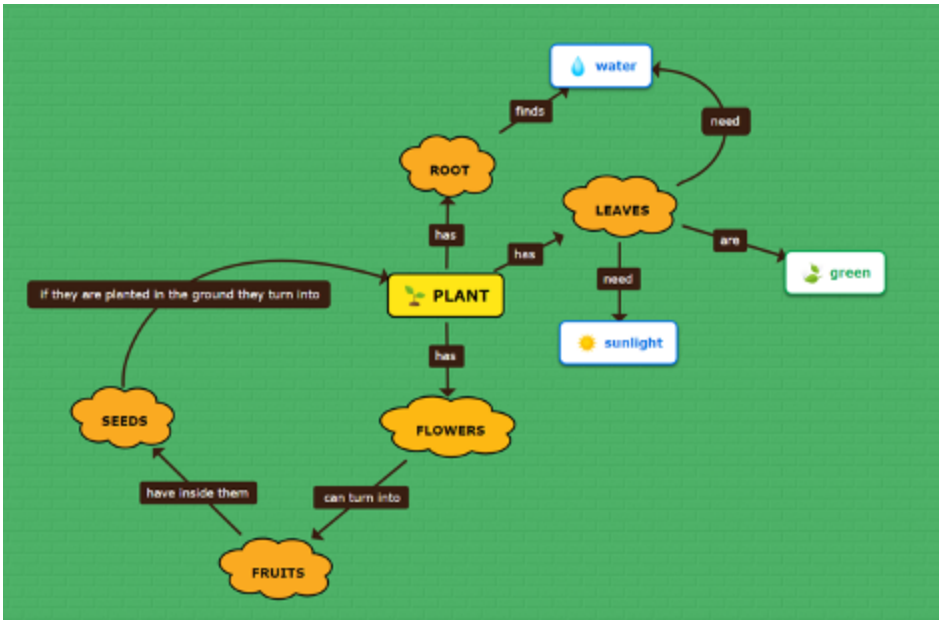
- What are the main ideas we should include in our concept map about Optimal Tree Utilization? List these main ideas below. The list already has a few concepts you may want to include. What other ones should you add?
- What are the relationships between these main ideas? How are they connected?

List of main ideas for our concept map	Notes on how these ideas are connected
• Scaling diameter • Log • Landing • Bucking •	• Every log has a scaling diameter • Bucking trees happens on the landing

Step 2—Create your own individual concept map. After your partner discussion, use the next page sheet of paper to create your own concept map. Be sure to include the main ideas you listed and how these ideas are connected to each other.

Feeling stuck? These questions might help you get started.

- What is the most important idea that should go in the middle of your concept map?
- Do all trees get bucked in the same way? Why or why not?
- Why do the mills care about the sizes of the logs they buy?
- Below is an example of what a concept map can look like. This one is about the parts of a plant but it can give you ideas about how to draw your concept map.



Step 3— Share and discuss your concept maps with a partner. After you finish your individual concept map, share and discuss your map with your partner or small group. Look for similarities and differences between your concept map and theirs. Why do you think your maps have the similarities and differences that they do? If you want to, you can use a second color to make changes or additions to your concept map.

Step 4— Turn in your concept map to your teacher.

Optimal Tree Utilization

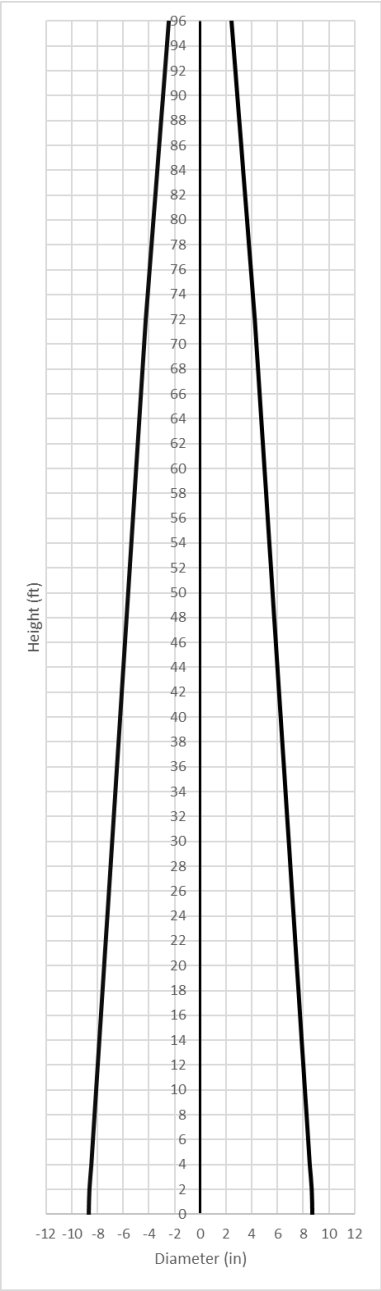
LaCuKnoS Concept Map Activity

Bucking Example

Utilizing the following mill, we will "buck" an example tree and determine its volume.

Blue mountain Mill		
	Min small end diameter (in)	Preferred Length (ft)
Small log	5	16
Large log	12	36

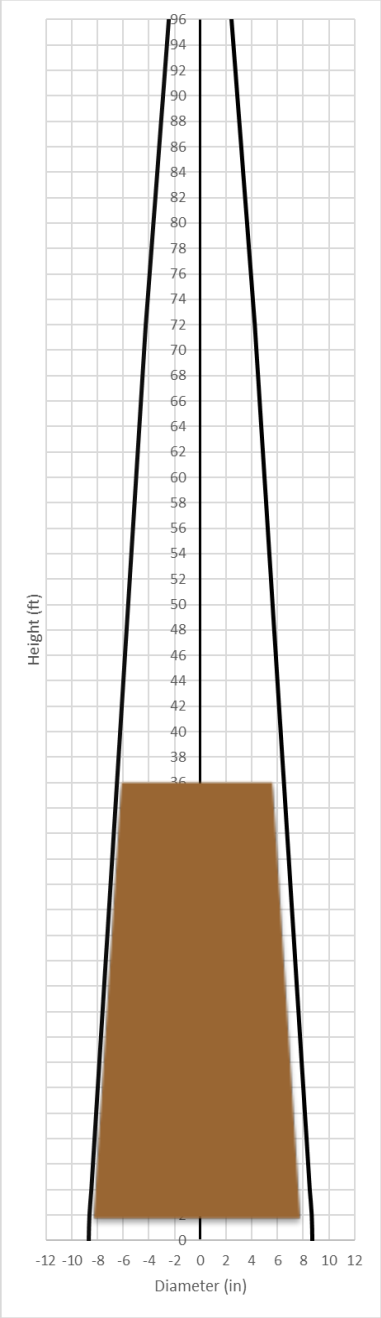
We will start with a bucking pattern that includes a high value log or "large log" at the bottom of the tree, since it has the highest value, and then see whether is possible to get a second one.



Length (ft)	Diameter (in)
96	4.9
94	5.2
92	5.5
90	5.8
88	6.1
86	6.4
84	6.7
82	7.0
80	7.3
78	7.6
76	7.9
74	8.2
72	8.5
70	8.8
68	9.0
66	9.3
64	9.5
62	9.8
60	10.0
58	10.3
56	10.5
54	10.8
52	11.0
50	11.3
48	11.5
46	11.8
44	12.0
42	12.3
40	12.5
38	12.8
36	13.0
34	13.3
32	13.5
30	13.8
28	14.0
26	14.3
24	14.5
22	14.8
20	15.0
18	15.3
16	15.5
14	15.8
12	16.0
10	16.3
8	16.5
6	16.8
4	17
2	17.3
0	17.4

A 36 ft log, leaves us at a diameter of 13 inches. This is what is called the "scaling diameter" and it is the one used to determine volume, and then value of the log.

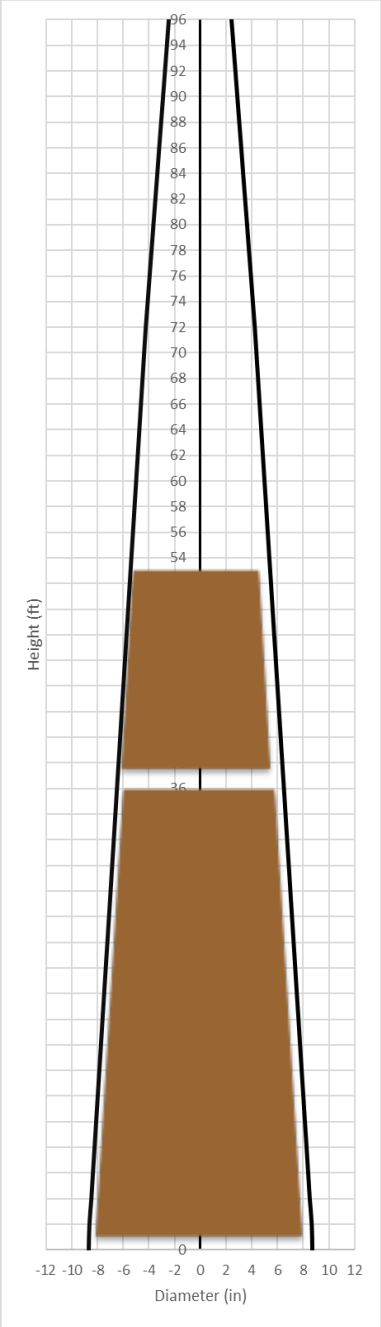
Since the mill's diameter limit for a "large log" is 12 inches, we know that it is not possible to obtain another "large log" within the mill's specification in this same tree. So our next step is to try for a "small log".



Length (ft)	Diameter (in)
96	4.9
94	5.2
92	5.5
90	5.8
88	6.1
86	6.4
84	6.7
82	7.0
80	7.3
78	7.6
76	7.9
74	8.2
72	8.5
70	8.8
68	9.0
66	9.3
64	9.5
62	9.8
60	10.0
58	10.3
56	10.5
54	10.8
52	11.0
50	11.3
48	11.5
46	11.8
44	12.0
42	12.3
40	12.5
38	12.8
36	13.0
34	13.3
32	13.5
30	13.8
28	14.0
26	14.3
24	14.5
22	14.8
20	15.0
18	15.3
16	15.5
14	15.8
12	16.0
10	16.3
8	16.5
6	16.8
4	17
2	17.3
0	17.4

Since the "small log" is 16 ft, we need to add 16ft to 36ft (the previous log length) to arrive to the scaling diameter of the next log. In this case, it is 11 inches.

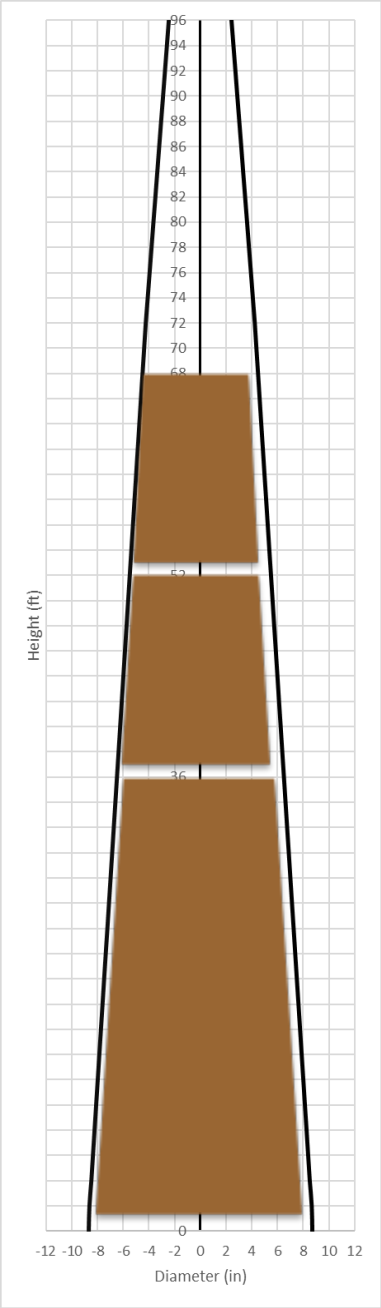
Now we have one "large log" with 13 inches scaling diameter and a "small log" with 11 inches scaling diameter. Can we fit another "small log"? we can certainly try! As long as the scaling diameter is over 5 inches.



Length (ft)	Diameter (in)
96	4.9
94	5.2
92	5.5
90	5.8
88	6.1
86	6.4
84	6.7
82	7.0
80	7.3
78	7.6
76	7.9
74	8.2
72	8.5
70	8.8
68	9.0
66	9.3
64	9.5
62	9.8
60	10.0
58	10.3
56	10.5
54	10.8
52	11.0
50	11.3
48	11.5
46	11.8
44	12.0
42	12.3
40	12.5
38	12.8
36	13.0
34	13.3
32	13.5
30	13.8
28	14.0
26	14.3
24	14.5
22	14.8
20	15.0
18	15.3
16	15.5
14	15.8
12	16.0
10	16.3
8	16.5
6	16.8
4	17
2	17.3
0	17.4

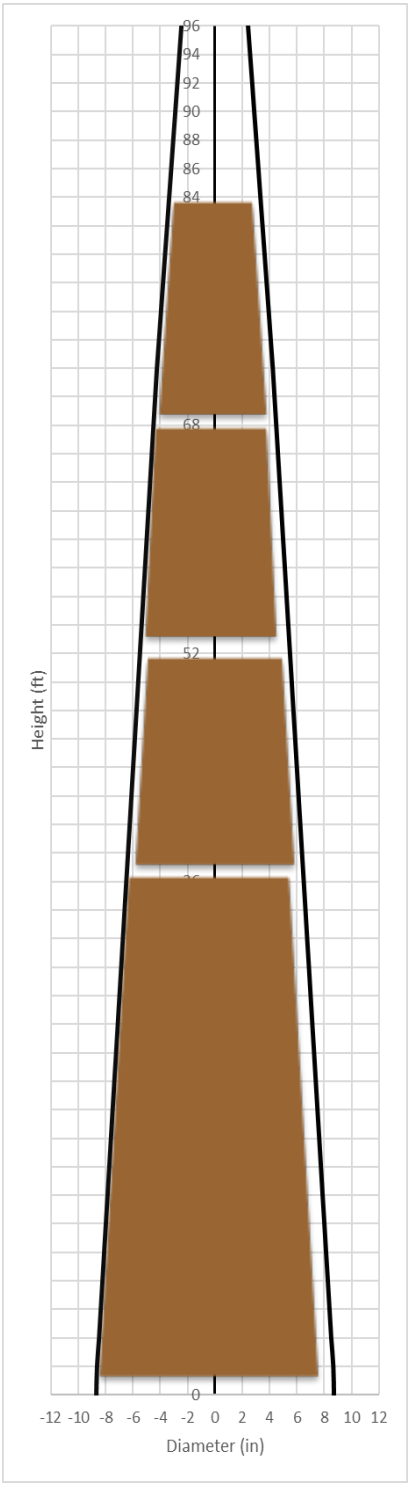
Starting from the previous point of height of 52 ft, we add another 16 ft. That leaves us at 68 ft, in which the scaling diameter is 9 inches.

At this stage, we have one “large log” and two “small logs”. Can we try a fourth?



Length (ft)	Diameter (in)
96	4.9
94	5.2
92	5.5
90	5.8
88	6.1
86	6.4
84	6.7
82	7.0
80	7.3
78	7.6
76	7.9
74	8.2
72	8.5
70	8.8
68	9.0
66	9.3
64	9.5
62	9.8
60	10.0
58	10.3
56	10.5
54	10.8
52	11.0
50	11.3
48	11.5
46	11.8
44	12.0
42	12.3
40	12.5
38	12.8
36	13.0
34	13.3
32	13.5
30	13.8
28	14.0
26	14.3
24	14.5
22	14.8
20	15.0
18	15.3
16	15.5
14	15.8
12	16.0
10	16.3
8	16.5
6	16.8
4	17
2	17.3
0	17.4

Starting from the previous point of height of 68 ft, we add another 16 ft. That leaves us at 84 ft, in which the scaling diameter is 6.7 inches, to determine volume and value we round the diameter down to 6 inches.



Length (ft)	Diameter (in)
96	4.9
94	5.2
92	5.5
90	5.8
88	6.1
86	6.4
84	6.7
82	7.0
80	7.3
78	7.6
76	7.9
74	8.2
72	8.5
70	8.8
68	9.0
66	9.3
64	9.5
62	9.8
60	10.0
58	10.3
56	10.5
54	10.8
52	11.0
50	11.3
48	11.5
46	11.8
44	12.0
42	12.3
40	12.5
38	12.8
36	13.0
34	13.3
32	13.5
30	13.8
28	14.0
26	14.3
24	14.5
22	14.8
20	15.0
18	15.3
16	15.5
14	15.8
12	16.0
10	16.3
8	16.5
6	16.8
4	17
2	17.3
0	17.4

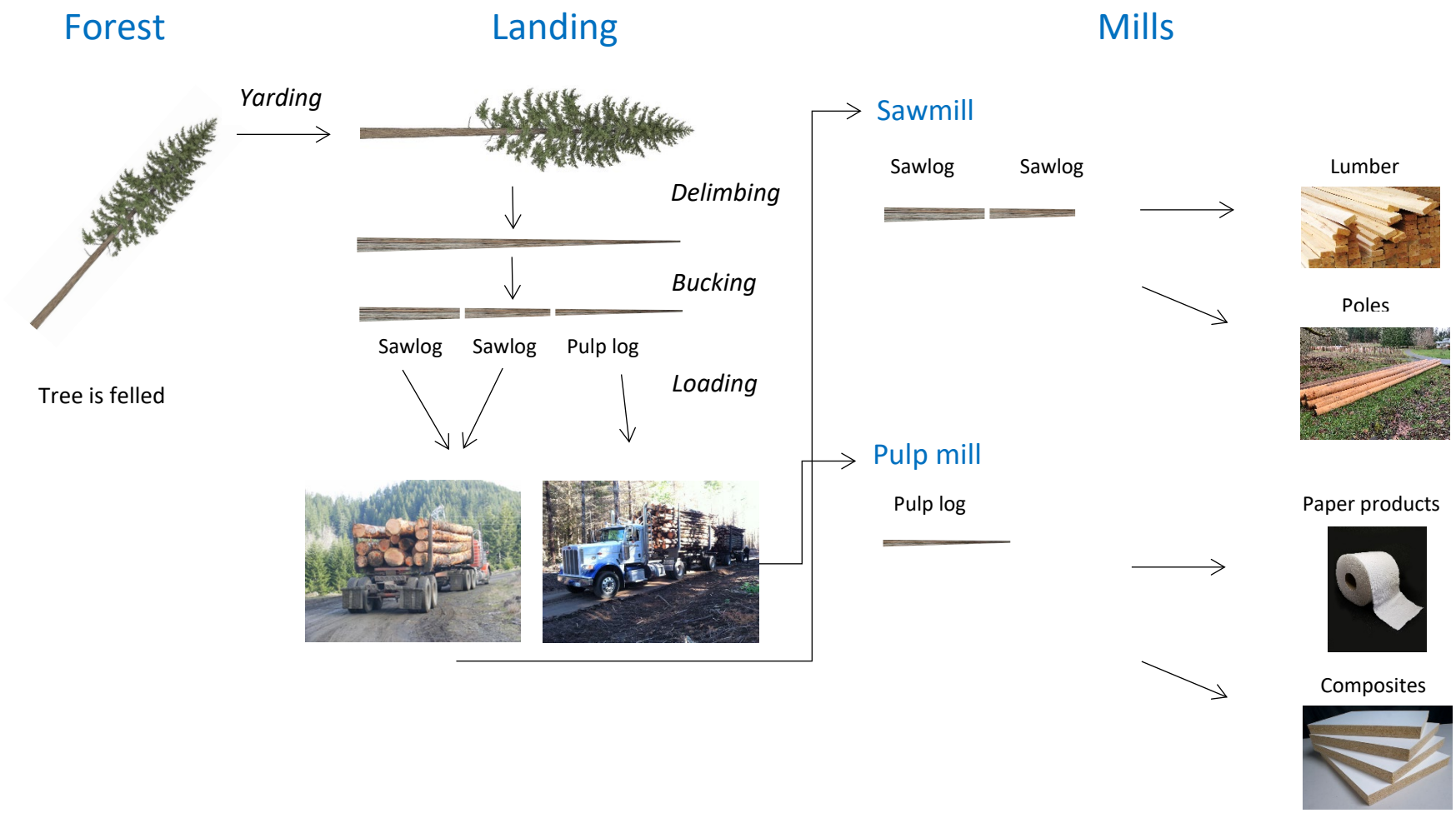
Starting from the previous point of height of 84 ft, we add another 16 ft. That leaves us at 100 ft, in which the scaling diameter would be less than 5 inches. That ends the bucking process for that particular mill.

Now we have finished our bucking pattern, and we now need to determine the volume of each log using the volume table:

Log number	Log length (ft)	Scaling diameter (in)	Log volume (b.f)
1	36	13	220
2	16	11	70
3	16	9	40
4	16	6	20
Total			**350**

The total volume of logs in the tree for the Blue Mountain Mill is 350 b.f.

From tree to forest products



llustration of tree [Matt Strieby, 2020]

De árbol a productos de madera

Bosque

El árbol se voltea

Madereo

Cancha de madereo

Desrramado

Trozado

Trozos aserrables

Trozos pulpables

Carguío

Planta de procesamiento

Aserradero

Trozos aserrables

Tablas

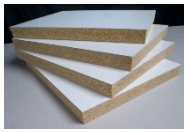
Postes

Planta de celulosa/tableros

Trozos pulpables

Productos de papel

Tableros



Ilustracion de árbol [Matt Strieby, 2020]